

PREVOST
COACH MANUFACTURER

MAINTENANCE MANUAL

X3 COACHES



PA1562
(2nd edition)

PA1562 2nd edition

Date: February 2008

Starting from vehicle: 8-9451

Featuring: Volvo D13 engine & DDC S60-2007 engine with Aftertreatment System

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Section 00: GENERAL INFORMATION

1. FOREWORD

This manual includes procedures for diagnosis, service, maintenance and repair for components of the X3 series coaches listed on the front cover page. This manual should be kept in a handy place for ready reference by the technician. If properly used, it will meet the needs of the technician and owner.

Information provided in Section 1 through 24 pertains to standard equipment items, systems and components as well as the most commonly used optional equipment and special equipment offered on the coach models covered by this manual. At the beginning of each section: a Table of Contents and a list of illustrations give the page number on which each subject begins and where each figure is located. Coach operating information is provided in a separate Operator's Manual. Audio/Video system operator instructions are also included in a separate manual.

More specific information on engine and transmission operating, maintenance, and overhaul information is contained in the applicable engine or transmission service manual published by the engine or transmission manufacturer. Engine and transmission parts information is contained in the applicable engine or transmission parts catalog published by the engine or transmission manufacturer. All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication approval. The right is reserved to make product changes at any time without notice.

NOTE

Typical illustrations may be used; therefore minor illustration difference may exist when compared to actual parts or other publications.

Prevost occasionally sends Maintenance Information, Warranty Bulletins, Safety Recalls or other literature to update users with the latest service procedures. They are issued, when required, to supplement or supersede information in this manual. Update sheet should be filled out and bulletins should be filed at the end of their respective section for future reference.

2. SCHEMATICS

Vehicle AIR SCHEMATICS are provided at the end of Section 12, "Brake". SUSPENSION AIR SCHEMATICS are provided at the end of Section 16, "Suspension". Moreover, ELECTRICAL SCHEMATICS are provided in the technical publications box. Refer to those schematics for detailed circuit information or during diagnosis.

3. PRECAUTIONS TO BE OBSERVED BEFORE WELDING



CAUTION

Precautions are to be observed before welding to minimize the risk of major and costly damage caused to the vehicle electronic components.

NOTE

For X3-45 Multiplex vehicles, also execute procedure no: PR060034 "MULTIPLEX MODULES DISCONNECTION PROCEDURE PRIOR TO WELDING" included at the end of this section.



CAUTION

For vehicles equipped with a WCL system, disconnect electronic controller connector.



CAUTION

Cover electronic control components and wiring to protect from hot sparks, etc.



CAUTION

Position welding machine ground clamp as close as possible to the work. Ensure that the welding machine ground return clamp is well secured and makes a good electrical contact with a large metallic area of the chassis located as close as possible to the welding point.



CAUTION

Do not use TIG welding process on the vehicle. This high frequency current process can seriously damage the electronic components.

STEEL – STEEL WELDING



CAUTION

Before welding, perform multiplex modules disconnection procedure.

NOTE

Welding surfaces must be free of scale, slag, rust, paint, grease, humidity or other foreign material that would render welding impossible.



DANGER

Only a qualified and experienced person must do welding.

- FCAW (Flux Cored Arc Welding) process ;
- Electrode wire conforms to A5.20 AWS (American Welding Society) specifications ;
- E4801T-9-CH, type electrode wire with 0,045" diameter (1,14 mm) ;

Material Thickness	Voltage	Current	Wire Feed Rate	Shielding Gas
1/8" to 1/2"	26 ± 2 volts	260 Amps	450 ipm. approx.	75% argon – 25% CO2 or 100% CO2

If necessary and with great care to prevent perforating the material, it is possible to use a conventional electric arc welding machine according to the following specifications:

- SMAW (Shielded Metal-Arc Welding) process ;
- Welding rod conforms to A5.1 of AWS (American Welding Society) specifications; E 7018 type welding rod with 1/8" diameter (3,2 mm).
- Current: 100 amperes to 150 amperes; optimum at 120 amps.

It is important to grind weld bead starts and stops and also to grind arc strikes from surfaces.

STEEL - STAINLESS STEEL OR STAINLESS STEEL - STAINLESS STEEL WELDING



CAUTION

Before welding, perform multiplex modules disconnection procedure.

NOTE

Welding surfaces must be free of scale, slag, rust, paint, grease, humidity or other foreign material that would render welding impossible.



DANGER

Only a qualified and experienced person must do welding.

- GMAW (Gas Metal-Arc Welding) process;
- Welding wire conforms to AWS (American Welding Standards) A5.9 specifications;
- 308LSi type welding wire with 0.035" diameter (0,9 mm);

STEEL - STAINLESS STEEL WELDING

Steel Thickness	SS Thickness	Voltage	Current	Wire Feed Rate	Shielding Gas
Less than 1/8"	Any type	20±1.5 volts	130±15 Amps	290 ipm approx.	90% He, 7.5% Ar, 2.5% CO2
1/8" and more	Any type	22±1.5 volts	160±15 Amps	330 ipm approx.	90% He, 7.5% Ar, 2.5% CO2

Section 00: GENERAL INFORMATION

STAINLESS STEEL - STAINLESS STEEL WELDING

SS Thickness	Voltage	Current	Wire Feed Rate	Shielding Gas
Any type	20 ± 1.5 volts	130 ± 15 Amps	290 ipm approx.	90% He – 7.5% Ar, 2.5% CO ₂

If necessary and with great care to prevent perforating the material, it is possible to use a conventional electric arc welding machine according to the following specifications:

- SMAW (Shield Metal-Arc Welding) process;
- Welding rod conforms to AWS (American Welding Standards) A5.4 specifications; 308L-17 type welding rod with 3/32" diameter (2,4 mm);
- Current: - 50 amperes to 90 amperes, optimum at 60 amperes.

It is important to grind weld bead starts and stops and also to grind arc strikes from surfaces.

4. SAFETY NOTICE


This maintenance manual has been prepared in order to assist skilled mechanics in the efficient repair and maintenance of PRÉVOST vehicles.


This manual covers only the procedures as of manufacturing date.


Safety features may be impaired if other than genuine PRÉVOST parts are installed.

Torque wrench tightening specifications must be strictly observed. Locking devices must be installed or replaced by new ones, where specified. If the efficiency of a locking device is impaired, it must be replaced.

This manual emphasizes particular information outlined by the wording and symbols:

	DANGER
Directs the operator's attention to unsafe practices which could result in serious personal injury or death.	

	WARNING
Directs the operator's attention to unsafe practices which could result in serious personal injury or severe damage to the vehicle.	

	CAUTION
Directs the operator's attention to unsafe practices where personal injury is not likely but damage to vehicle components could occur.	

NOTE

Indicates supplementary information essential to the proper operation of the vehicle. Although, the mere reading of such information does not eliminate the hazard, understanding of the information will promote its correct use.

4.1 DATA PLATES AND CERTIFICATIONS

Delay and confusion can be avoided by placing the complete vehicle identification number of the coach and the serial numbers of the engine on parts orders and correspondence. Also, the transmission, axles, power steering pump chassis and other major components are identified by serial numbers.

4.1.1 Engine

• **DDC Series 60 Engine**

The engine serial and model numbers are stamped on the cylinder block (as viewed from the flywheel end) on the left side just below the fire deck and above the cast-in Detroit Diesel logo (Fig. 1).

In addition, option plates made of laminated paper are located on the rocker cover (starter side). The engine serial and model number and a list of the optional engine equipment are written on the option plates. Refer to this information when ordering replacement parts (Fig. 1).

• **Volvo D13 Engine**

Volvo D13 engine serial and model numbers are stamped on the cylinder head (Fig. 2).

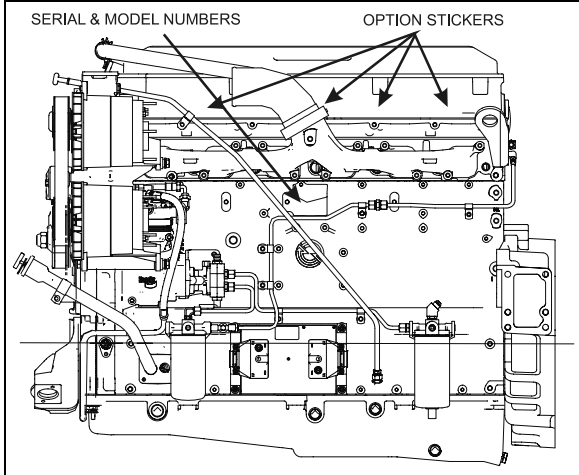


FIGURE 1 : DETROIT DIESEL SERIES 60 00043

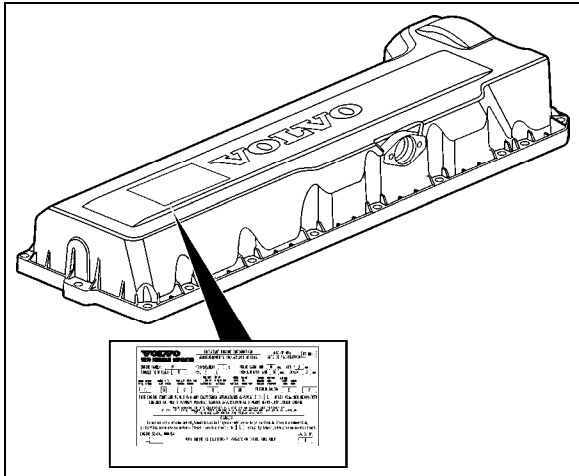


FIGURE 2: VOLVO D13 ENGINE DATA PLATE 00052

4.1.2 Transmission

The transmission identification plate is located on the oil level dipstick side of the transmission (WT) or on transmission, on the vehicle R.H. side (ZF) (Fig. 3 & 4). The identification plate shows the transmission serial number, part number (assembly number), and model number. Use all three numbers when ordering parts.

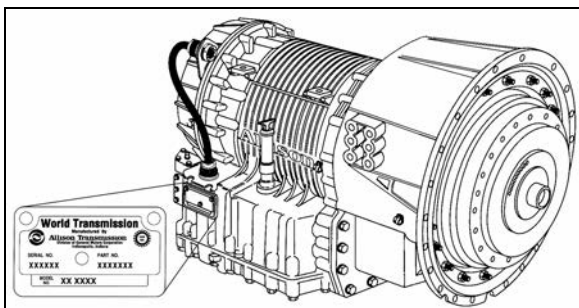


FIGURE 3: ALLISON TRANSMISSION 07076

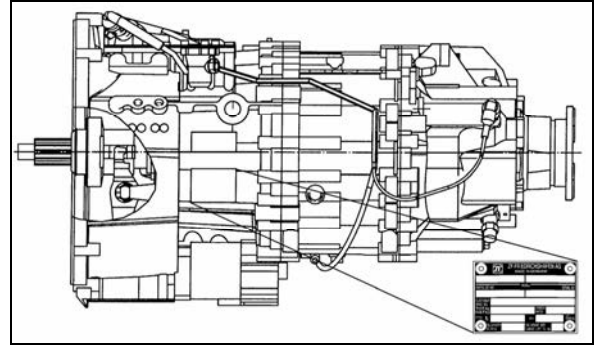


FIGURE 4: ZF-ASTRONIC TRANSMISSION 00040

4.1.3 Drive Axle

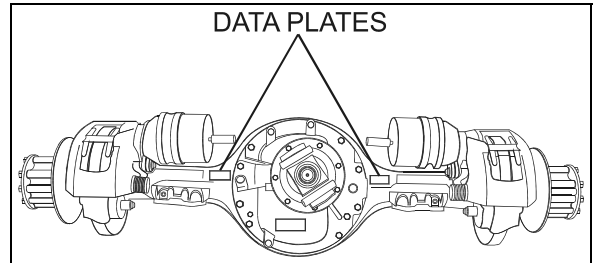


FIGURE 5: TYPICAL SERIAL & MODEL NUMBERS 00007

4.1.4 Front Axle

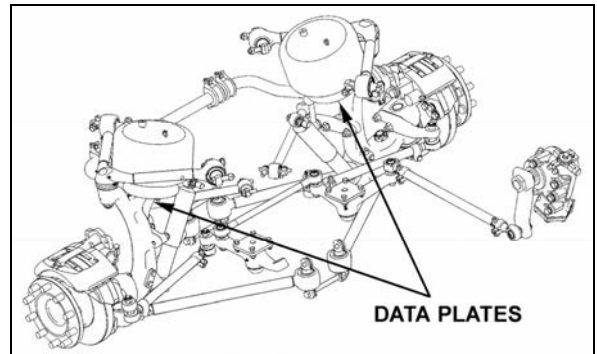


FIGURE 6: ISS TYPICAL SERIAL & MODEL NUMBERS 16136

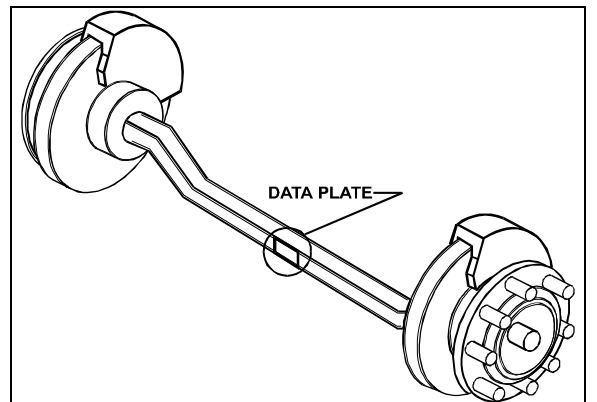


FIGURE 7: I-BEAM AXLE TYPICAL SERIAL & MODEL NUMBERS 00008

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4.1.5 Power Steering Pump

- **DDC SERIES 60 ENGINE**

Power steering pump serial number is located on a tag on the pump (Fig. 8). The pump is mounted on the engine beside the crankshaft pulley.

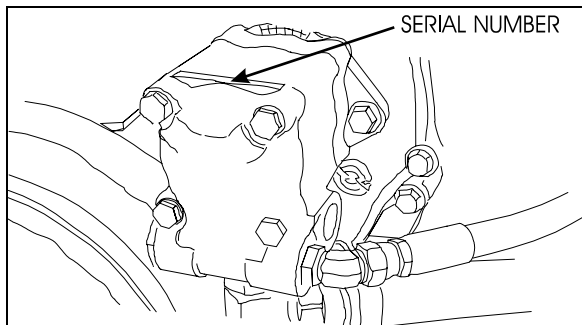


FIGURE 8 : POWER STEERING PUMP NAMEPLATE 00035

- **Volvo D13 Engine**

Power steering pump is mounted on the engine and located underneath the air compressor (Fig. 9).

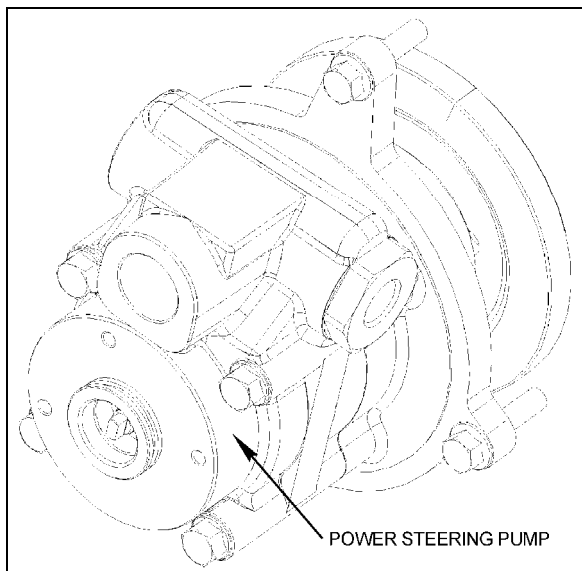


FIGURE 9: POWER STEERING PUMP

4.1.6 Coach Final Record

The Coach Final Record is a record of all data pertaining to the assembly of the coach. This record is included in the technical publication package supplied with the coach. Retain this record in the company records office for reference and safe-keeping.

4.1.7 Safety Certification

Coach components meet specifications and standards as follows:

- Material and parts conform to ASTM and/or SAE standards in effect at the time of manufacture.

- All factory-installed interior materials meet FMVSS 302 for fire resistance.

- Certified according to Provincial, State and Federal Safety standards (Canadian and US) BMCSS, FMVSS, and CMVSS.

Other applicable certification labels are affixed to the component.

4.1.8 DOT Certification Label

This certifies that coaches manufactured by Prevost Car Inc., comply with all Federal Motor Vehicle Safety Standards at the time of manufacture. Information such as date of manufacture, model year, gross vehicle weight rating, tire types and inflation pressure is also etched on this plate. The DOT Certification plate is affixed to the side of the L.H. control panel.

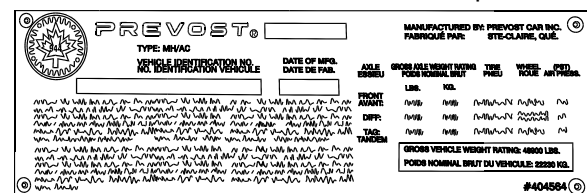


FIGURE 10: DOT CERTIFICATION PLATE 00016

4.1.9 EPA Engine Label

The exhaust emission certification label affixed inside the engine compartment above the lavatory maintenance service valves certifies that the engine conforms to federal and any state exhaust emission regulations. It gives the operating conditions under which certification was made.

4.1.10 Fuel Tank Label

The fuel tank label is molded on the side of the fuel tank. To read this label, unscrew the fuel tank access panel nuts located at the left in the condenser compartment.

4.1.11 Vehicle Identification Number (VIN)

The seventeen digit vehicle identification number (VIN) is located on a plate (Fig. 11 & 12) located on the windshield frame pillar (driver's side). The VIN is visible from the outside of the coach. Make sure the correct vehicle identification number is given when ordering replacement parts. Using the VIN when ordering parts will facilitate processing.

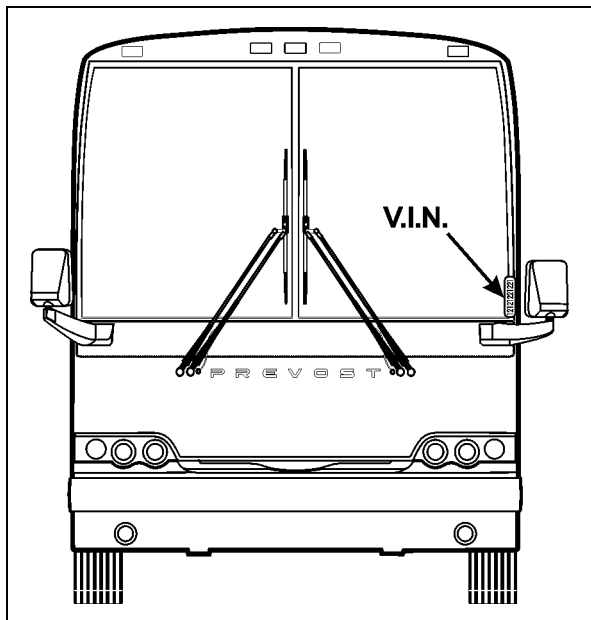


FIGURE 11 : VEHICLE I.D.

00048

NOTE

Record the VIN in the coach documentation and keep with company records. The VIN will normally be used for vehicle registration and for obtaining vehicle insurance coverage.

Section 00: GENERAL INFORMATION

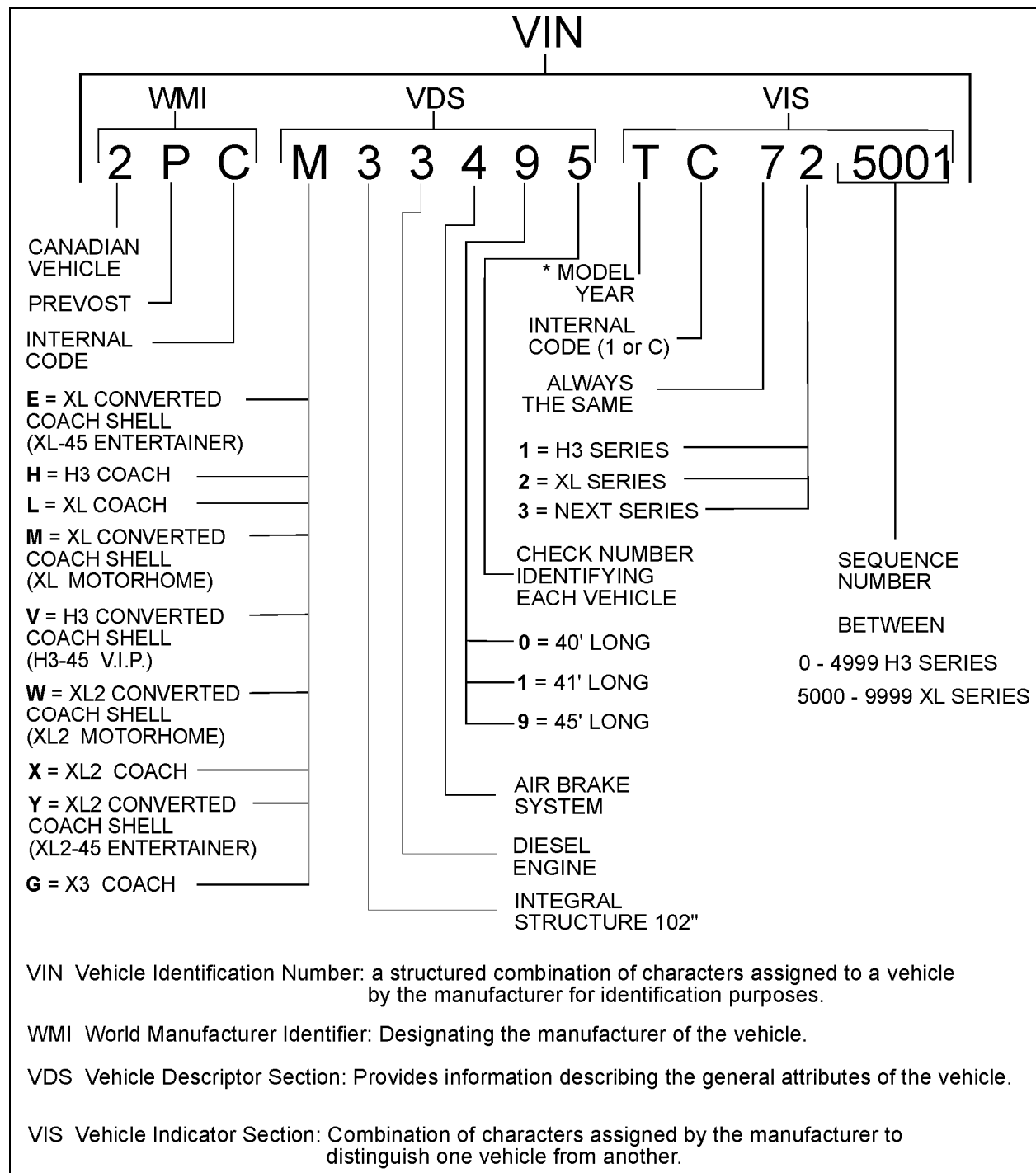


FIGURE 12 : VEHICLE IDENTIFICATION NUMBER

00050

YEAR	CODE	YEAR	CODE
2000	Y	2006	6
2001	1	2007	7
2002	2	2008	8
2003	3	2009	9
2004	4	2010	A
2005	5	2011	B

5. FASTENER STRENGTH IDENTIFICATION

Most commonly used metric fastener strength property classes are 9.8 and 10.9 with the class identification embossed on the head of each bolt. Customary (inch) strength classes range from grade 2 to 8 with radial line identification embossed on each bolt head actual grade (i.e., a grade 7 bolt will have 5 embossed radial lines on the bolt head). Some metric nuts will be marked with single digit strength identification numbers on the nut face. Fig. 14 shows the different strength markings. When replacing

metric fasteners, be careful to use fasteners of the same or greater strength than the original fasteners (the same number marking or higher). It is also important to select replacement fasteners of the correct size. Correct replacement fasteners are available through the parts division. Some metric fasteners available in after-market parts sources were designed to metric standards of countries other than the United States and may be of a lower strength, may not have the numbered head marking system, and may be of a different thread pitch.

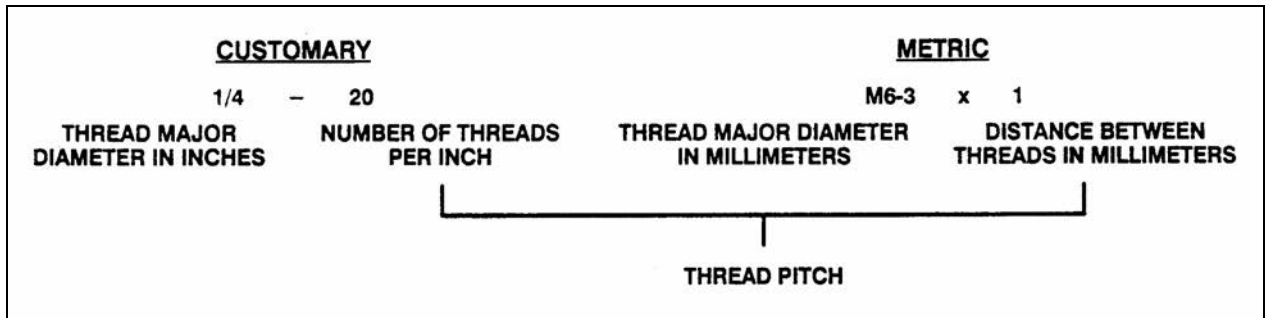


FIGURE 13 : THREAD NOTATION

00002

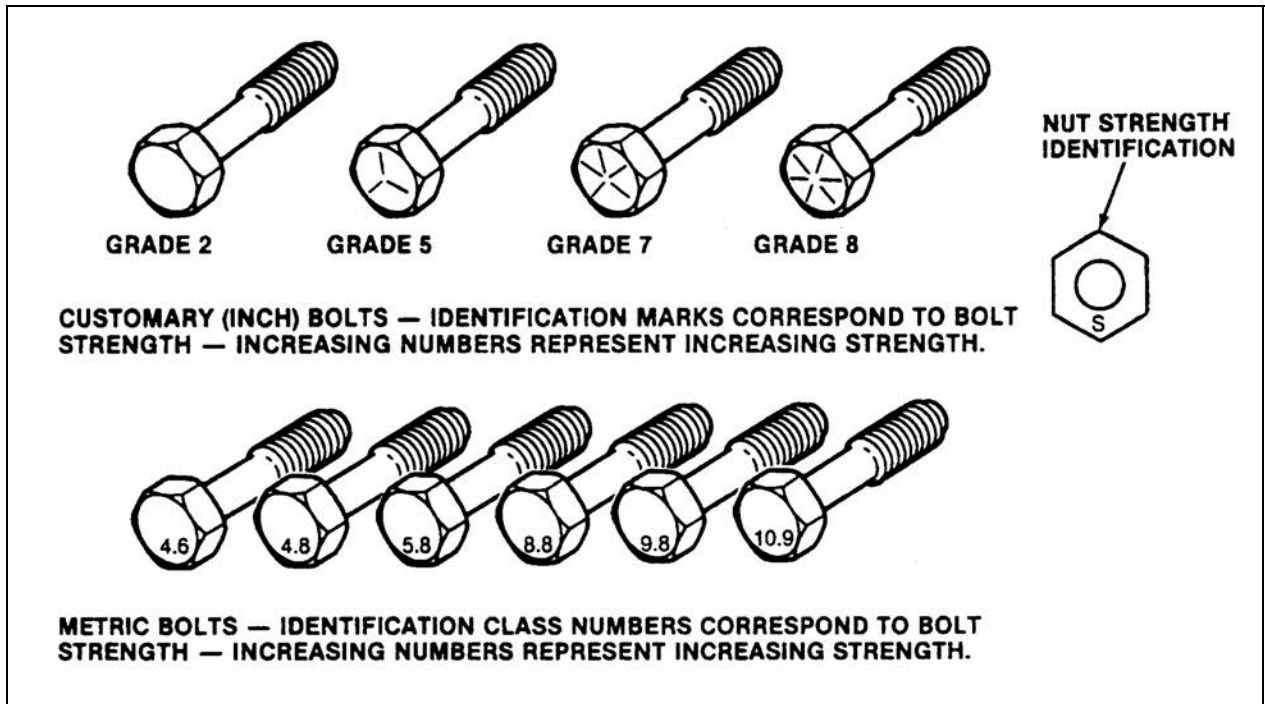


FIGURE 14: BOLT STRENGTH MARKINGS

00003

The metric fasteners used on the coach are designed to new standards and may not yet be manufactured by some non-domestic fastener suppliers. In general, except for special applications, the common sizes and pitches are:

- M 8 X 1.25;
- M 10 X 1.5;
- M 12 X 1.75;
- M 14 X 2;

Section 00: GENERAL INFORMATION

5.1 SELF-LOCKING FASTENERS

A self-locking fastener is designed with an interference fit between the nut and bolt threads. This is most often accomplished by distortion of the top thread of an all-metal nut or bolt or by using a nylon patch on the threads. A nylon insert or the use of adhesives may also be used as a method of interference between nut and bolt threads (Fig. 15).

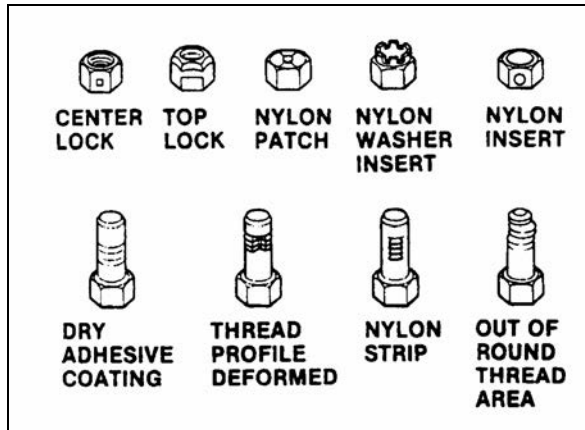


FIGURE 15 : SELF-LOCKING FASTENERS

00004

5.2 RECOMMENDATIONS FOR REUSE

Clean, unruined self-locking fasteners may be reused as follows:

- Clean dirt and other foreign matter from the fastener;
- Inspect the fastener to ensure there is no crack, elongation, or other sign of fatigue or overtightening. If there is any doubt, replace with a new self-locking fastener of equal or greater strength;
- Assemble parts and hand start fastener;
- Observe that, before the fastener seats, it develops torque per the chart in table two. If there is any doubt, replace with a new self-locking fastener of equal or greater strength;
- Tighten the fastener to the torque specified in the applicable section of this manual;

Fasteners which are rusty or damaged should be replaced with new ones of equal or greater strength.

SELF-LOCKING FASTENER TORQUE CHART

METRIC		6 & 6.3	8	10	12	14	16	20	
NUTS AND ALL-METAL BOLTS	Nm	0.4	0.8	1.4	2.2	3.0	4.2	7.0	
	Lbf-in	4.0	7.0	12	18	25	35	57	
ADHESIVE OR NYLON COATED BOLTS	Nm	0.4	0.6	1.2	1.6	2.4	3.4	5.6	
	Lbf-in	4.0	5.0	10	14	20	28	46	
US STANDARD		¼	5/16	3/8	7/16	½	9/16	5/8	¾
NUTS AND ALL-METAL BOLTS	Nm	0.4	0.6	1.4	1.8	2.4	3.2	4.2	6.2
	Lbf-in	4.0	5.0	12	15	20	27	35	51
ADHESIVE OR NYLON COATED BOLTS	Nm	0.4	0.6	1.0	1.4	1.8	2.6	3.4	5.2
	Lbf-in	4.0	5.0	9.0	12	15	22	28	43

5.3 SIX LOBED SOCKET HEAD

Six lobed socket head (Torx) fasteners are used in some applications on vehicles covered in this manual. The tools designed for these fasteners are available commercially. However, in some cases, if the correct tool is not available, a hex socket head wrench may be used.

Multiply	by	to get equivalent number of:	Multiply	by	to get equivalent number of:
	LENGTH			ACCELERATION	
Inch	25.4	millimeters (mm)	Foot/sec ²	0.305	meter/sec ² (m/s ²)
Foot	0.305	meters (m)	Inch/sec ²	0.026	meter/sec ²
Yard	0.914	meters			
Mile	1.609	kilometers (km)			
	AREA			TORQUE	
Inch ²	645.2	millimeters ² (mm ²)	Pound-inch	0.113	newton-meters (N·m)
Foot ²	6.45	centimeters ² (cm ²)	Pound-foot	1.35	newton-meters
Yard ²	0.093	meters ² (m ²)			
	VOLUME			POWER	
Inch ³	16	mm ³	Horsepower	0.746	kilowatts (kW)
Quart	0.016	cm ³			
Gallon	0.946	liters (l)			
Yard ³	3.785	liters			
		meters ³ (m ³)			
	MASS			PRESSURE OR STRESS	
Pound	0.453	kilograms (kg)			
Ton	907.18	kilograms (kg)	Inches of water	0.249	kilopascals (kPa)
Ton	0.907	ton (t)	Pounds/sq. in.	6.895	kilopascals
	FORCE				
Kilogram	9.807	newtons (N)			
Ounce	0.278	newtons			
Pound	4.448	newtons			
	TEMPERATURE			ENERGY OR WORK	
Degree Fahrenheit	(°F - 32) ÷ 1.8	Degree Celsius (C)			
			BTU	1	055.0 joules (J)
			Foot-pound	1.356	joules
			Kilowatt-hour	3	600 000.0 joules (J = one W's)
					or 3.6 x 10 ⁶
				LIGHT	
			Foot candle	1.076	lumens/meter ² (lm/m ²)
				VELOCITY	
			Miles/hour	1.609	kilometers/hr (km/h)



FIGURE 16: METRIC - US STANDARD CONVERSION TABLE

00005

DECIMAL AND METRIC EQUIVALENTS					
FRACTIONS	DECIMAL IN.	METRIC MM	FRACTIONS	DECIMAL IN.	METRIC MM
1/64	.015625	.39688	33/64	.515625	13.09687
1/32	.03125	.79375	17/32	.53125	13.49375
3/64	.046875	1.19062	35/64	.546875	13.89062
1/16	.0625	1.58750	9/16	.5625	14.28750
5/64	.078125	1.98437	37/64	.578125	14.68437
3/32	.09375	2.38125	19/32	.59375	15.08125
7/64	.109375	2.77812	39/64	.609375	15.47812
1/8	.125	3.1750	5/8	.625	15.87500
9/64	.140625	3.57187	41/64	.640625	16.27187
5/32	.15625	3.96875	21/32	.65625	16.66875
11/64	.171875	4.36562	43/64	.671875	17.06562
3/16	.1875	4.76250	11/16	.6875	17.46250
13/64	.203125	5.15937	45/64	.703125	17.85937
7/32	.21875	5.55625	23/32	.71875	18.25625
15/64	.234375	5.95312	47/64	.734375	18.65312
1/4	.250	6.35000	3/4	.750	19.05000
17/64	.265625	6.74687	49/64	.765625	19.44687
9/32	.28125	7.14375	25/32	.78125	19.84375
19/64	.296875	7.54062	51/64	.796875	20.24062
5/16	.3125	7.93750	13/16	.8125	20.63750
21/64	.328125	8.33437	53/64	.828125	21.03437
11/32	.34375	8.73125	27/32	.84375	21.43125
23/64	.359375	9.12812	55/64	.859375	21.82812
3/8	.375	9.52500	7/8	.875	22.22500
25/64	.390625	9.92187	57/64	.890625	22.62187
13/32	.40625	10.31875	29/32	.90625	23.01875
27/64	.421875	10.71562	59/64	.921875	23.41562
7/16	.4375	11.11250	15/16	.9375	23.81250
29/64	.453125	11.50937	61/64	.953125	24.20937
15/32	.46875	11.90625	31/32	.96875	24.60625
31/64	.484375	12.30312	63/64	.984375	25.00312
1/2	.500	12.70000	1	1.00	25.40000

FIGURE 17: CONVERSION CHART

00006

PREVOST

MULTIPLEX MODULES DISCONNECTION PROCEDURE PRIOR TO WELDING

PROCEDURE NO: PR060034

**REVISION 4
2007-05-31**

Material : N/A

Equipment(s) : Phillips-head screwdriver
Ratchet handle
3/8" socket
Electric tape
Long nose pliers

Reference schematics: N/A

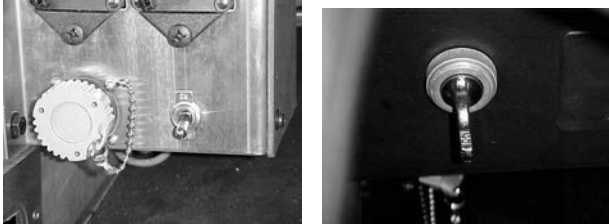
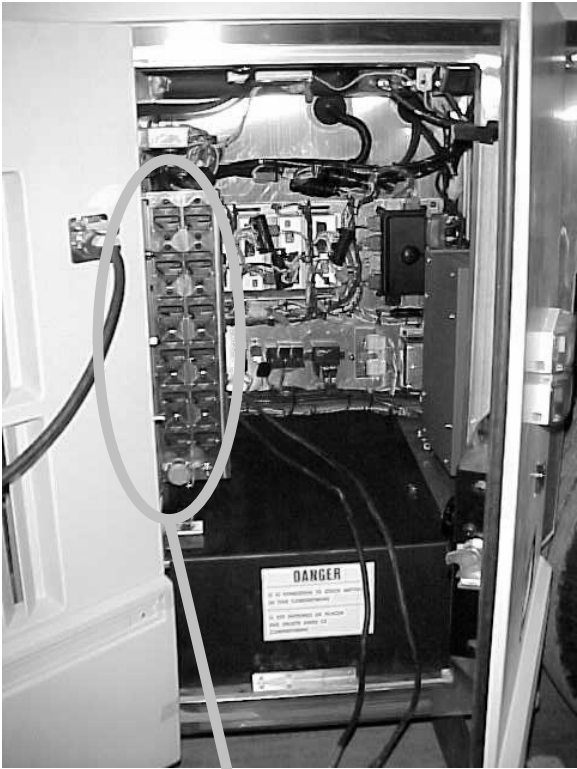
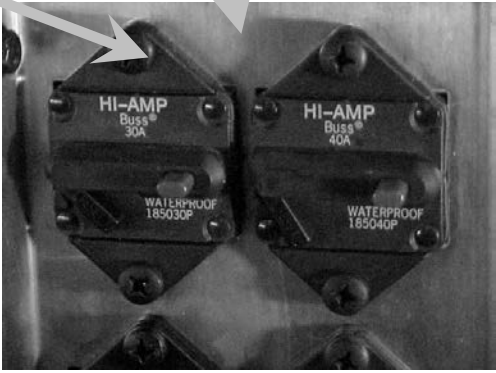
Safety rules :

- Wear safety goggles
- Set the battery master switch to the OFF position first

Recommendations: This procedure should be performed by qualified personnel only.

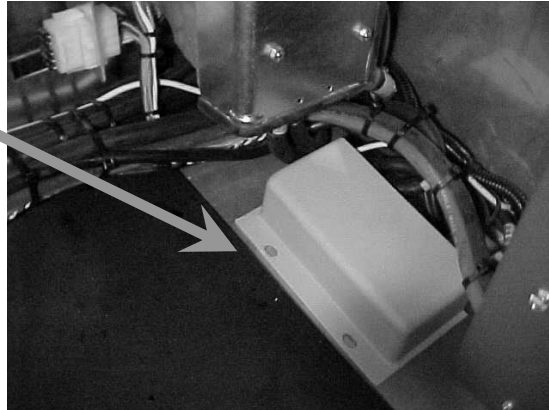
	Effective
Revision 0 : Issued with multiplex	
Revision 1 : Modified for Fire Protection System and also for VIP with multiplex	
Revision 2 : Step 5 modified for introduction of VIP with multiplex	-0436
Revision 3 : Step 1.15 added C397 Addition of SECTION 2 for X3 Coaches Addition of SECTION 3 for XLII MTH	
Revision 4 : Modified for introduction of CPC module for VIP,H3 Coach, X3	7-0942VIP 8-1037 H3 8-9282 X3

SECTION 1 H3 Coaches & VIP

<p>1.00 Location: Main power compartment and dashboard</p> <p>Set the battery master switch to the OFF position.</p> <p>Place the ignition switch to the OFF position.</p>	
<p>1.05 Location: Main power compartment</p> <p>Trip circuit breakers CB2, CB4, CB6</p> <p>Push the red button to open the circuit</p>	 

1.10 Location: Main power compartment

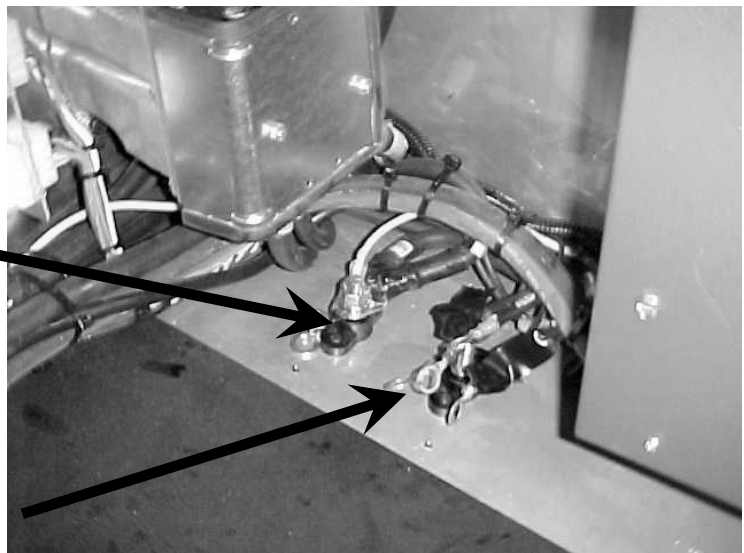
Remove the protective cover



△ WARNING △

LIVE WIRE

This 12-volt terminal remains energized

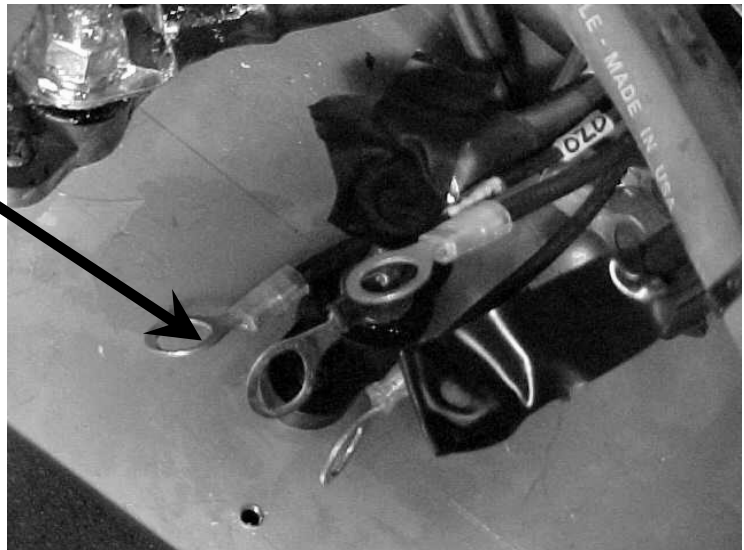


Disconnect the electronic ground terminals from the stud

Using electric tape, insulate the 2 largest gage wires. Make sure the ring terminals do not touch each others and the vehicle body.

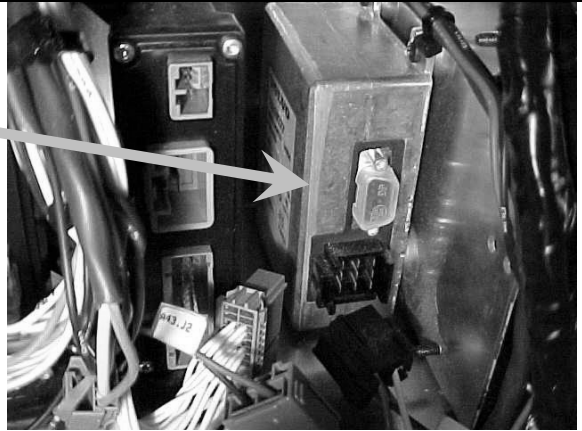
NOTE

With disconnection of the electronic ground terminals, disconnecting the engine ECM, transmission TCM and the dashboard electronic components (telltale module, HVAC module, radio, control head, ...) is not required.



<p>1.15 Location: Main power compartment</p> <p>Disconnect the electronic modules :</p> <hr/> <p>Disconnect the I/O A and I/O B modules</p> <p style="padding-left: 40px;">Disconnect C397</p> <p>Disconnect connector C717</p> <p>Unplug 3 connectors per I/O B modules</p> <p>Unplug 3 connectors on the I/O A module</p>	
<p>1.20 Location: Front electrical compartment</p> <p>VIP + COACH: Disconnect the I/O A, I/O B, ABS, master ID, CECM and CPC modules. Unplug connector C92</p> <p>VIP: Disconnect all keyless module connectors.</p> <p>Unplug 3 connectors per I/O B modules and 3 connectors per I/O A modules.</p> <p>Unplug 2 connectors from the ABS module</p>	

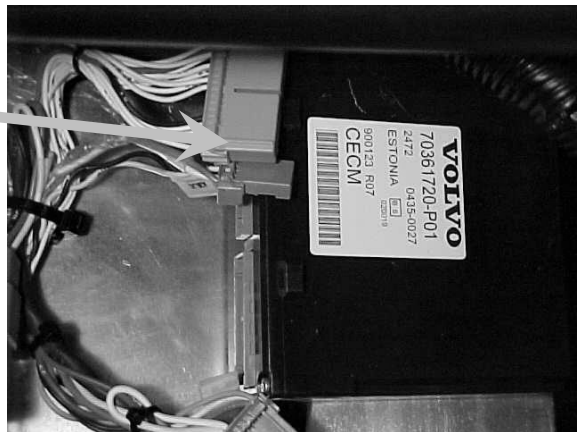
Unplug 1 connector from the master ID



Disconnect CPC connectors


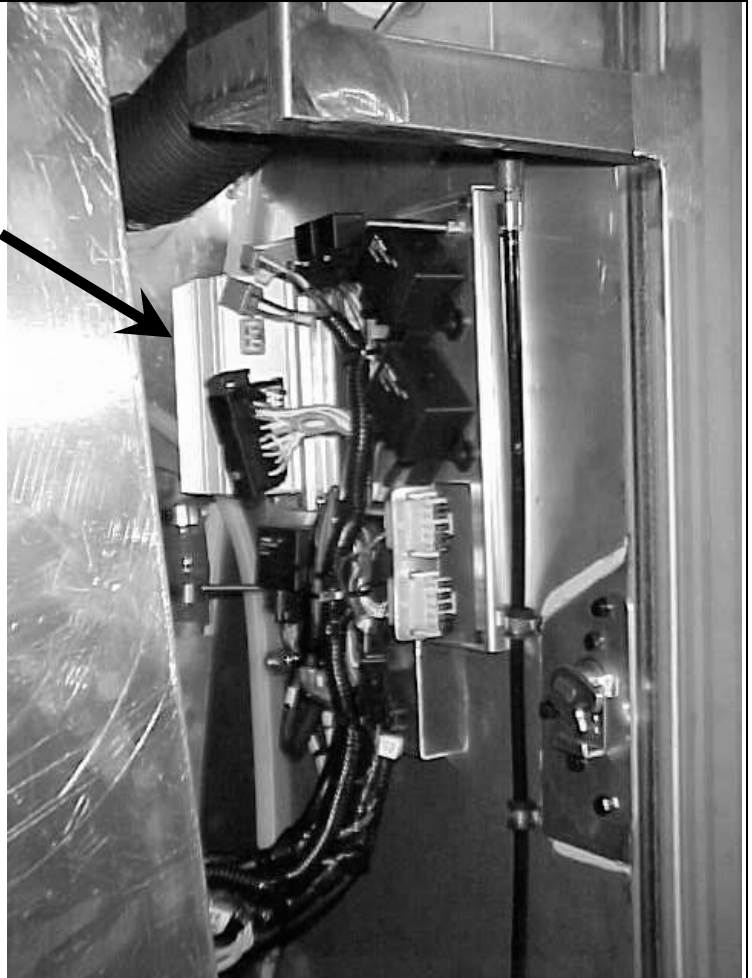


Unplug 3 connectors from the CECM



Unplug connector C92



<p>1.25</p>	<p>Location: pneumatic accessory panel inside right console</p> <p>Remove the access panel on the right console (R.H. side of dashboard)</p> <p>Disconnect both I/O B modules</p>	
<p>1.30</p>	<p>Location: Evaporator compartment</p> <p>Remove the protective cover and disconnect the I/O B module</p>	

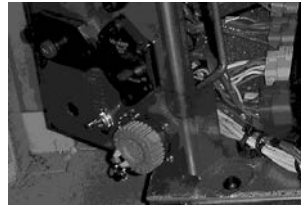
<p>1.40</p>	<p>Kidde Automatic Fire Detection and Suppression System (optional)</p> <p>Disconnect C466</p> <p>Kidde AFSS module is located on the lateral control panel.</p>	
<p>1.45</p>	<p>When all the previous steps are done, you can do welding on the vehicle</p>	<p>ENSURE THAT THE WELDING GROUND RETURN CLAMP IS WELL SECURED AND MAKES A GOOD ELECTRICAL CONTACT WITH A LARGE METALLIC AREA OF THE CHASSIS LOCATED NEAR THE WELDING POINT AS MUCH AS POSSIBLE.</p>
<p>1.50</p>	<p>When welding is completed, reconnect all the modules.</p> <p>Make sure that the connectors locking tab are well engaged</p>	<p>BE CAREFUL TO MAKE THE PROPER CONNECTIONS, IF NOT, SOME SYSTEMS OR COMPONENTS MAY NOT BE USABLE</p>

SECTION 2 X3 Coaches

2.00

Location: Rear electrical compartment and dashboard

Set the battery master switch to the OFF position.
Place the ignition switch to the OFF position.



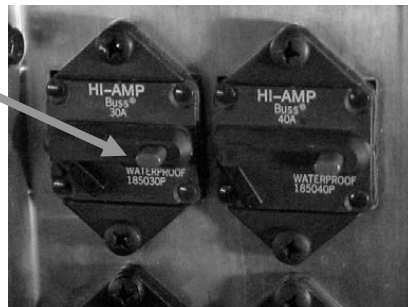
2.05

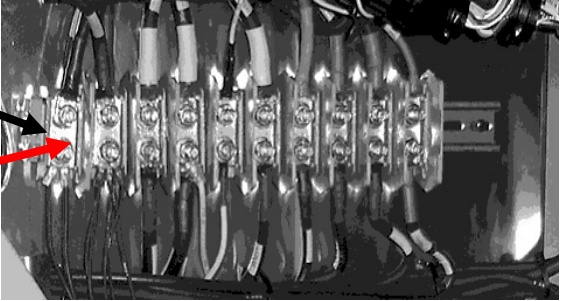

Location: Rear electrical compartment

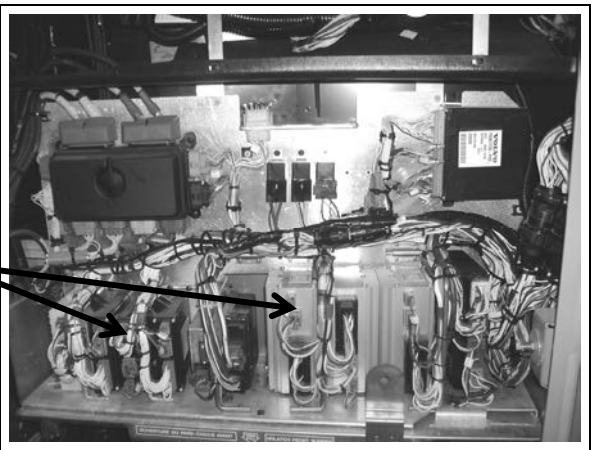
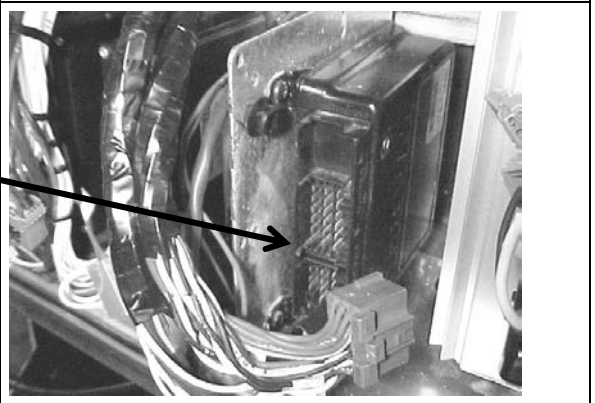
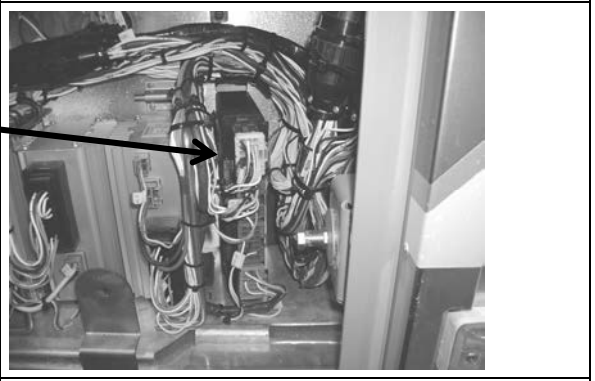
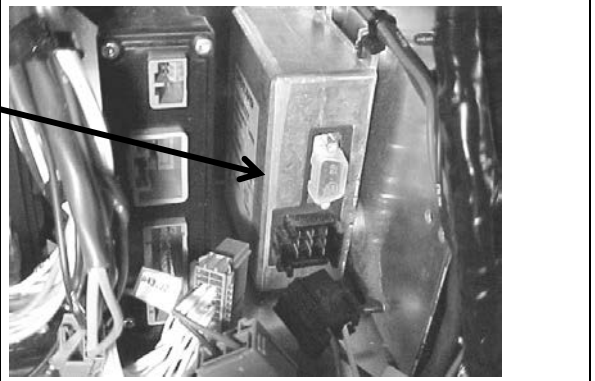
Trip circuit breakers CB2-CB4-CB6 located on rear junction panel

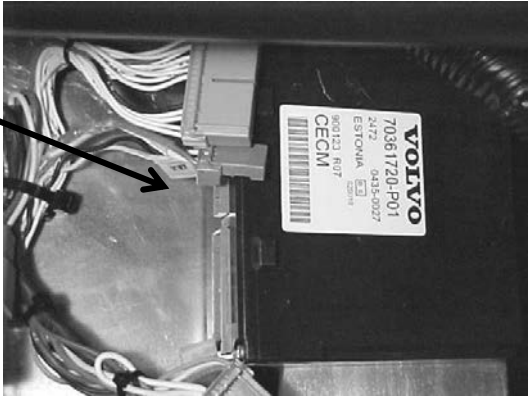




Push the red button in to open the circuit


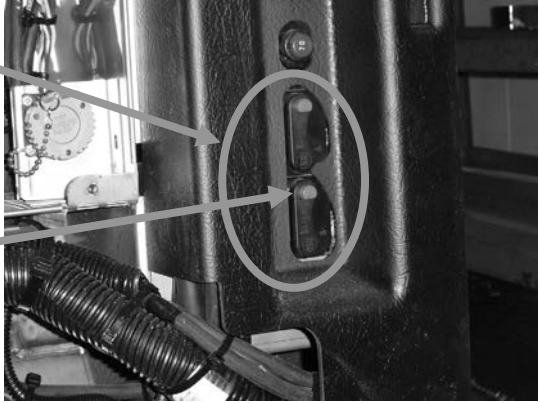
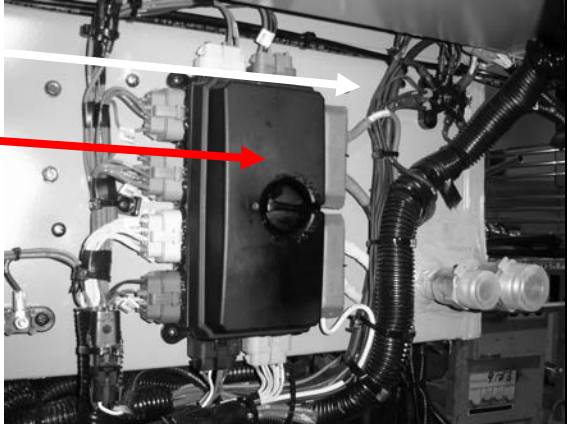


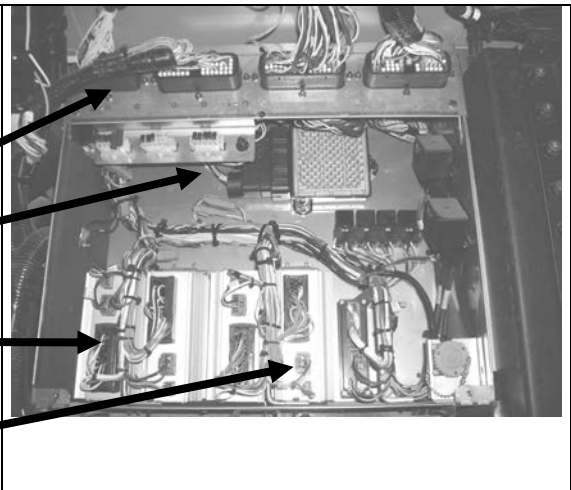
<p>2.10</p>	<p>Location: Rear electrical compartment</p> <p>Disconnect the electronic ground terminals from this stud</p> <div style="border: 2px solid red; padding: 5px; margin: 10px 0;"> <p>Warning: The remaining terminals may still be energized</p> </div> <p>Use electric tape; make sure that cables do not touch each others and the vehicle body.</p> <p style="text-align: center;"><i>NOTE</i></p> <p><i>With disconnection of the electronic ground terminals, disconnecting the engine ECM, transmission TCM and the dashboard electronic components (telltale module, HVAC module, radio, control head, ...) is not required.</i></p>	
<p>2.15</p>	<p>Location: Rear electrical compartment</p> <p>Disconnect the electronic modules:</p> <p>Disconnect all I/O A and I/O B modules</p> <p style="padding-left: 40px;">Disconnect C397 and C717</p> <p>Disconnect 3 connectors from each I/O B module</p> <p>Disconnect 3 connectors from each I/O A module</p>	

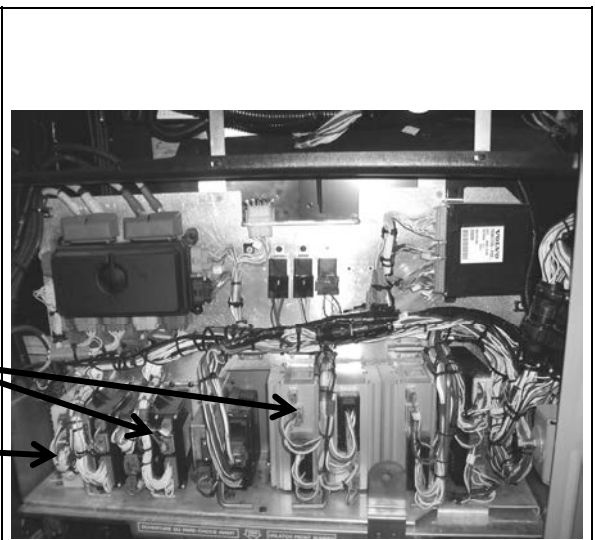
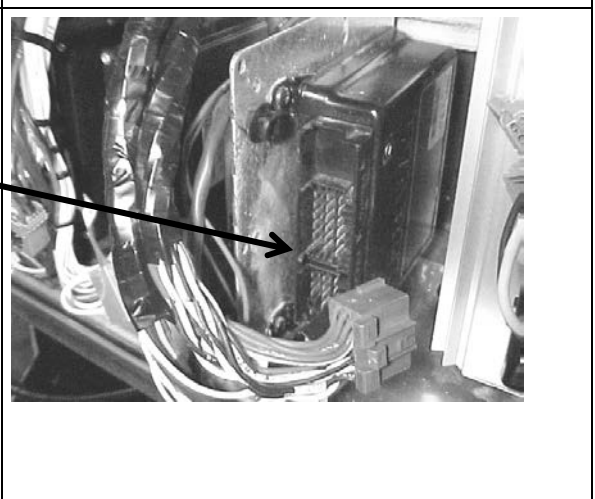
<p>2.20</p>	<p>Location: front electrical compartment</p> <p>Disconnect I/O A, I/O B, ABS, master ID, CECM and CPC modules and also disconnect connector C92</p> <p>Disconnect the 3 connectors from the I/O B and I/O A modules</p>	
	<p>Disconnect the 2 connectors from the ABS module</p>	
	<p>Disconnect CPC connectors</p>	
	<p>Disconnect connector from master ID</p>	

<p>Disconnect the 3 connectors from CECM</p>	
<p>Disconnect connector C92</p>	
<p>2.25 Location: Entrance door & wiper control panel Remove windshield wiper motor access panel and disconnect both I/O B modules</p>	
<p>2.30 When all the previous steps are done, you can do welding on the vehicle</p>	<p>ENSURE THAT THE WELDING GROUND RETURN CLAMP IS WELL SECURED AND MAKES A GOOD ELECTRICAL CONTACT WITH A LARGE METALLIC AREA OF THE CHASSIS LOCATED NEAR THE WELDING POINT AS MUCH AS POSSIBLE</p>
<p>2.40 When welding is completed, reconnect all the modules. Make sure that the connectors locking tab are well engaged!</p>	<p>BE CAREFUL TO MAKE THE PROPER CONNECTIONS, IF NOT, SOME SYSTEMS OR COMPONENTS MAY NOT BE USABLE</p>

SECTION 3 XLII MTH

<p>2.00</p>	<p>Location: Dashboard</p> <p>Place the ignition switch to the OFF position.</p>	
<p>2.05</p>	<p>Location: Engine compartment R. H. side area</p> <p>Trip circuit breakers CB1-CB2 located on circuit breaker panel.</p> <p>Push the blue button in to open the circuit</p>	
<p>2.10</p>	<p>Location: Rear Junction Box</p> <p>Disconnect the electronic ground terminals from this stud.</p> <div style="border: 2px solid red; padding: 5px; margin: 10px 0;"> <p>Warning: The remaining terminals may still be energized.</p> </div> <p>Use electric tape; make sure that cables do not touch each others and the vehicle body.</p> <p style="text-align: center;"><i>NOTE</i></p> <p><i>With disconnection of the electronic ground terminals, disconnecting the engine ECM, transmission TCM and the dashboard electronic components (telltale module, HVAC module, radio, control head, ...) is not required.</i></p>	

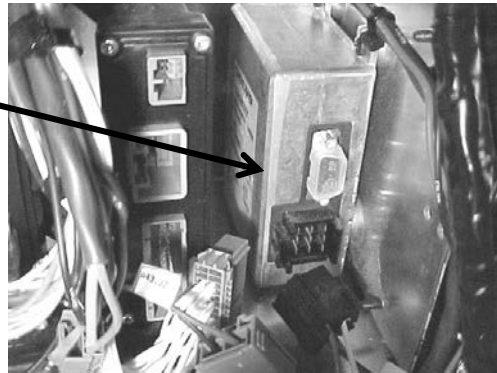
<p>2.15</p>	<p>Location: Rear Junction Box</p> <p>Disconnect the electronic modules:</p> <p>Disconnect all I/O A and I/O B modules</p> <p>Disconnect C397</p> <p>Disconnect transmission module (A1)</p> <p>Disconnect 3 connectors from each I/O B</p> <p>Disconnect 3 connectors from each I/O A</p>	
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<p>2.20</p>	<p>Location: Front Electrical Compartment</p> <p>Disconnect I/O A, I/O B, ABS, master ID, CECM, CPC, keyless modules and also disconnect connector C92.</p> <p>Disconnect 3 connectors from the I/O B and I/O A modules</p> <p>Disconnect connectors from Keyless module</p>	
	<p>Disconnect 2 connectors from ABS module</p> <p>██</p>	

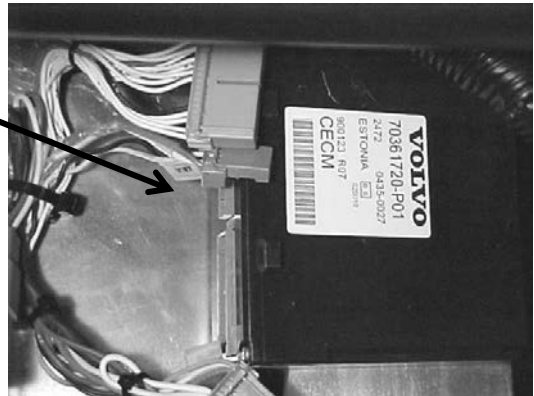
Disconnect connectors from CPC



Disconnect connector from master ID



Disconnect 3 connectors from CECM



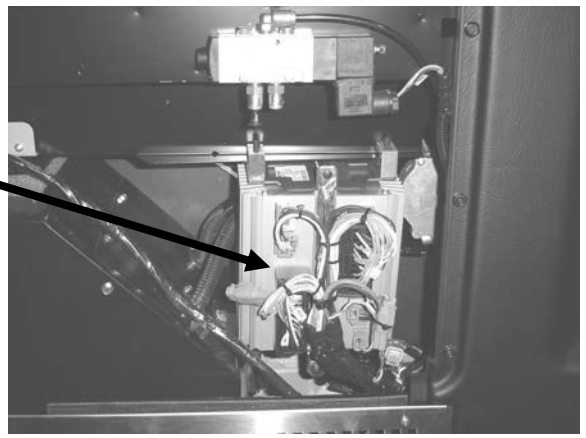
Disconnect connector C92



Location: Wiper Control Panel

Remove windshield wiper motor access panel

And disconnect I/O B modules



<p>2.30</p>	<p>When all the previous steps are done, you can do welding on the vehicle</p>	<p>ENSURE THAT THE WELDING GROUND RETURN CLAMP IS WELL SECURED AND MAKES A GOOD ELECTRICAL CONTACT WITH A LARGE METALLIC AREA OF THE CHASSIS LOCATED NEAR THE WELDING POINT AS MUCH AS POSSIBLE</p>
<p>2.35</p>	<p>When welding is completed, reconnect all the modules. Make sure that the connectors locking tab are well engaged!</p>	<p>BE CAREFUL TO MAKE THE PROPER CONNECTIONS, IF NOT, SOME SYSTEMS OR COMPONENTS MAY NOT BE USABLE</p>

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1. VOLVO D13 ENGINE

1.1 SYSTEM OVERVIEW

NOTE

The "Premium Tech Tool" (PTT) is the preferred tool for performing diagnostic work. Contact your local dealer for more information.

The Engine Management System (EMS) controls many engine functions such as: fuel timing and delivery, engine protection functions, engine brake operation, EGR valve function and the turbocharger nozzle function. The Engine Electronic Control Unit (EECU) along with other supporting control units and sensors are responsible for monitoring and controlling these functions. These control units communicate through the J1939 high speed serial data line to share data.

In addition to their control functions, the modules have on-board diagnostic capabilities. The on-board diagnostics are designed to detect faults or abnormal conditions that are not within their operating parameters. When the system detects a fault or abnormal condition, the fault will be logged in one or both of the modules' memory. The vehicle operator will be advised that a fault has occurred by the illumination of a malfunction indicator lamp and a message in the driver information display, if equipped. The module may initiate the engine shutdown procedure if the system determines that the abnormal condition could damage the engine. In some situations, the system will enter the "limp home" mode. Limp home mode allows continued vehicle operation but, the system may substitute a sensor or signal value that may result in reduced engine performance.

Fault codes logged in the system memory, can later be read to aid in diagnosing the fault. These faults can be read via a diagnostic computer or through the instrument cluster display, if equipped. The "Premium Tech Tool" (PTT) is the preferred tool for performing diagnostic work. Using a diagnostic computer (or PTT) connected to the Serial Communication Port, expands the technicians diagnostic capabilities with additional data and tests.

For diagnostic software, contact your local dealer.

The following is a list of engine sensors that provide input to the EMS:

- Ambient Air Temperature Sensor
- Ambient Pressure sensor
- Boost Air Pressure (BAP) Sensor
- Camshaft Position (Engine Position) Sensor
- Crankshaft Position (Engine Speed) Sensor
- Differential Pressure DPF Sensor
- EGR Differential Pressure Sensor
- EGR Temperature Sensor
- Engine Coolant Level (ECL) Sensor
- Engine Coolant Temperature (ECT) Sensor
- Engine Oil Pressure (EOP) Sensor
- Engine Oil Level (EOL) Sensor
- Engine Oil Temperature (EOT) Sensor
- Exhaust Temperature Sensor (DPF Sensors)
- Fuel Pressure Sensor
- Intake Air Temperature And Humidity (IATH) Sensor
- Intake Manifold (Boost) Temperature Sensor
- Throttle Position (TP) Sensor
- Turbo Speed Sensor
- Variable Geometry Turbocharger (VGT) Position Sensor

Sensors

Ambient Air Temperature Sensor

The Ambient Air Temperature Sensor is used to detect the outside air temperature. The sensor modifies a voltage signal from the ECM. The modified signal returns to the ECM as the ambient air temperature. The sensor uses a thermistor that is sensitive to the change in temperature. The electrical resistance of the thermistor decreases as temperature increases.

The Ambient Air Temperature Sensor is located in the front of the vehicle.

Ambient (Atmospheric) Pressure Sensor

The Ambient (Atmospheric) Pressure Sensor contains a pressure sensitive diaphragm and an electrical amplifier. Mechanical pressure applied to the diaphragm causes the diaphragm to deflect and the amplifier to produce an electrical signal proportional to the deflection.

Section 01: ENGINE

The Ambient (Atmospheric) Pressure Sensor is built into the Engine Management System (EMS) Module.

Camshaft Position Sensor

The Camshaft Position (Engine Position) Sensor is located in the rear face of the timing gear cover at the rear of the engine, near the bottom of the valve cover. It uses magnetic induction to generate a pulsed electrical signal. It senses the passage of seven (7) timing bumps on the edge of the camshaft dampener. Six of the holes correspond to the phasing of the electronic unit injectors, while the seventh hole indicates the top dead center position.

Crankshaft Position (Engine Speed) Sensor

The Crankshaft Position (Engine Speed) Sensor uses magnetic induction to generate a pulsed electrical signal. Notches are machined into the edge of the flywheel. When one of the notches passes close to the sensor, electric pulses result.

The Crankshaft Position (Engine Speed) Sensor also indicates when the crankshaft is at the top dead center position.

Differential Pressure DP Sensor

The differential pressure sensor is used for flow measurement of the Diesel Particulate Filter (DPF). This sensor has two pressure ports and senses the difference in pressure between the two ports. Measurement of the pressure before and after the DPF is used to calculate diesel filter regeneration.

The Differential Pressure DPF Sensor is located on the side of the Diesel Particulate Filter (DPF).

EGR Differential Pressure Sensor

The EGR differential pressure sensor is used for flow measurement of the Exhaust Gas Recirculation (EGR) valve. This sensor has two pressure ports and senses the difference in pressure between the two ports. Measurement of the pressure before and after the EGR valve is used to calculate EGR flow.

The EGR Differential Pressure Sensor is located on the left or right side of the engine.

EGR Temperature Sensor

The EGR temperature sensor detects exhaust gas temperature for EGR system. The sensor modifies a voltage signal from the control unit. The modified signal returns to the control unit as

the exhaust temperature of the EGR system to confirm EGR operation. The sensor uses a thermistor that is sensitive to the change in temperature.

The EGR Temperature Sensor is located near the EGR valve.

Engine Coolant Level (ECL) Sensor

The Engine Coolant Level (ECL) Sensor is a switch. If engine coolant level falls below a calibrated point the contacts open and the driver will be notified of the low coolant level.

The Engine Coolant Level (ECL) Sensor is located in the cooling system reservoir tank.

Engine Coolant Temperature (ECT) Sensor

The Engine Coolant Temperature Sensor is located at the front of the engine. The sensor will indicate a high coolant temperature caused by problems like radiator blockage, thermostat failure, heavy load, or high ambient temperatures. This sensor is also used for cold start enhancement and for fan clutch engagement.

Engine Oil Pressure (EOP) Sensor

The Engine Oil Pressure Sensor contains a pressure sensitive diaphragm and a electrical amplifier. Mechanical pressure applied to the diaphragm causes the diaphragm to deflect and the amplifier to produce an electrical signal proportional to the deflection.

The Engine Oil Pressure Sensor is located on the oil filter assembly. The sensor monitors engine oil pressure to warn of lubrication system failure.

Engine Oil Level (EOL) Sensor

The Engine Oil Level Sensor is located in the oil pan.

Engine Oil Temperature (EOT) Sensor

The Engine Oil Temperature Sensor is a thermistor whose resistance varies inversely to temperature. The sensor has a negative temperature coefficient, which means the sensor resistance will decrease as the engine oil temperature increases.

The Engine Oil Temperature Sensor is located in the oil pan.

Exhaust Temperature Sensor (DPF Sensors)

The exhaust gas temperature sensor detects exhaust gas temperature for DPF protection as well as DPF regeneration control. The sensor modifies a voltage signal from the control unit. The modified signal returns to the control unit as the exhaust temperature at that specific location of the exhaust. The sensor uses a thermistor that is sensitive to the change in temperature.

The Exhaust Temperature Sensors are located in the DPF assembly.

Fuel Pressure Sensor

The fuel pressure sensor contains a diaphragm that senses fuel pressure. A pressure change causes the diaphragm to flex, inducing a stress or strain in the diaphragm. The resistor values in the sensor change in proportion to the stress applied to the diaphragm and produces an electrical output.

The Fuel Pressure Sensor is located on top of the fuel filter housing.

Intake Air Temperature and Humidity (IATH) Sensor

The Intake Air Temperature and Humidity (IATH) Sensor contains a thermistor and a capacitive sensor. The resistance of the thermistor varies inversely to temperature. The output of the capacitive sensor increases as the humidity of the surrounding air increases. By monitoring the signals from both portions of the sensor, the Engine Management System (EMS) Module calculates the temperature and humidity of the air passing through the air filter housing.

The Intake Air Temperature and Humidity (IATH) Sensor is located in the air intake tube just downstream from the air filter canister.

Intake Manifold (Boost) Temperature Sensor

The Intake Manifold (Boost) Temperature Sensor is a thermistor whose resistance varies inversely to temperature. The sensor has a negative temperature coefficient, which means the sensor resistance will decrease as the inlet air temperature increases.

The Intake Manifold (Boost) Temperature Sensor is located in the intake manifold.

Intake Manifold Pressure Sensor

The Intake Manifold Pressure Sensor contains a pressure sensitive diaphragm and an electrical amplifier. Mechanical pressure applied to the diaphragm causes the diaphragm to deflect and the amplifier to produce an electrical signal proportional to the deflection.

The Intake Manifold Pressure Sensor is located on the air inlet pipe before the intake manifold.

Throttle Position (TP) Sensor

The Throttle Position Sensor is a potentiometer that is mechanically linked to the accelerator pedal. A potentiometer is a variable resistor whose resistance will change as the pedal is pressed. As the resistance changes, the signal voltage of the sensor changes indicating the accelerator pedal position.

The Throttle Position Sensor is located above the accelerator pedal. The sensor is designed to improve the driver's control by reducing sensitivity to chassis motion. This sensor provides the driver's fuel request input to the VECU.

Turbo Speed Sensor

The Turbo Speed Sensor informs the EMS of the turbo shaft speed. The sensor does not read from the vanes, but reads from the shaft. The Engine Management System (EMS) Module uses this signal in conjunction with the VGT position sensor signal to control the speed of the turbocharger and therefore optimize the intake manifold pressure.

The Turbo Speed Sensor is mounted in the center of the turbocharger.

Variable Geometry Turbocharger Smart Remote Actuator (VGT SRA)

The Variable Geometry Turbocharger Smart Remote Actuator (VGT SRA) takes the position commands from the EMS, moves the nozzle of the turbocharger to the desired position, and performs all of the diagnostics and self checks on the actuator.

Section 01: ENGINE

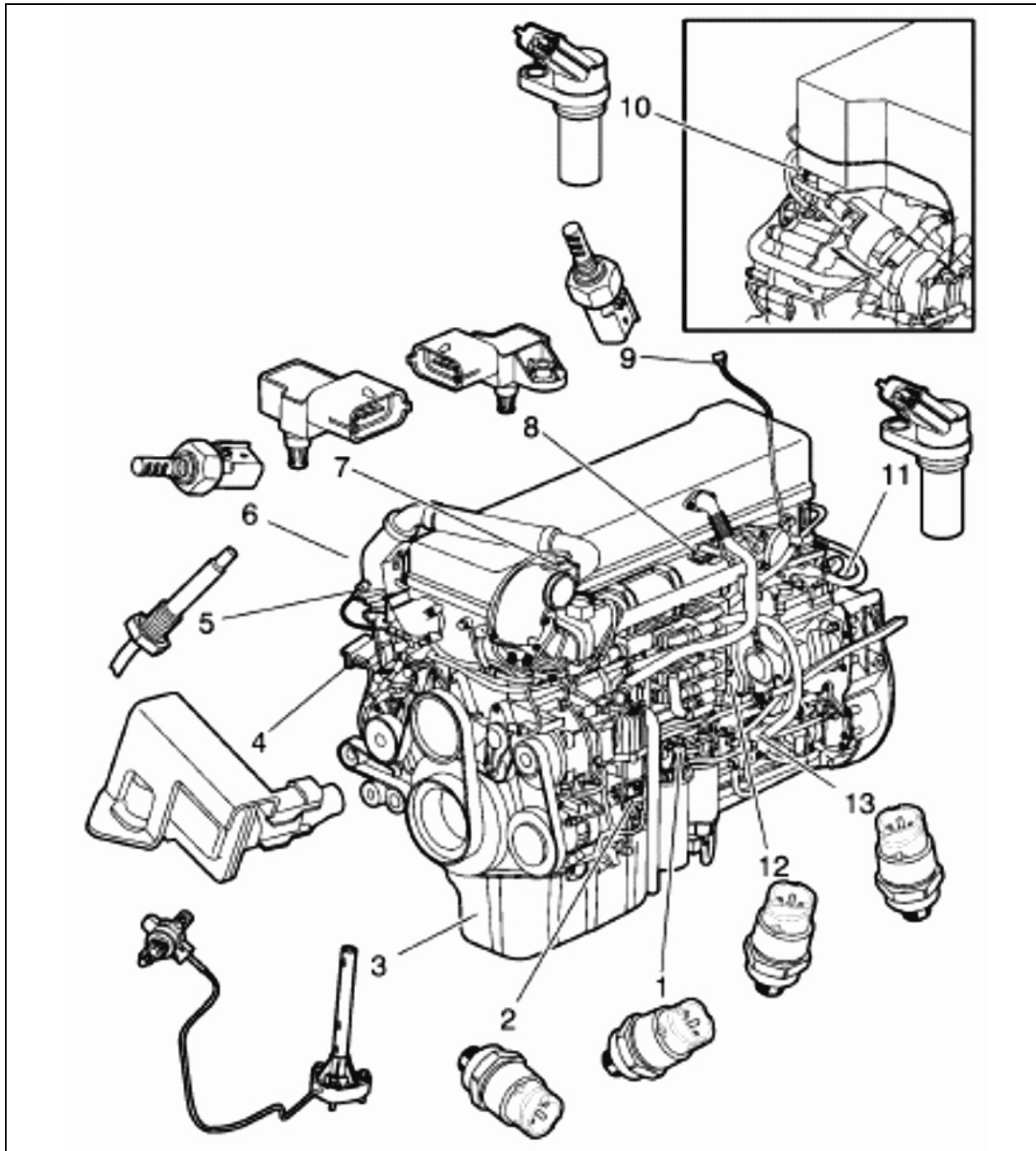


FIGURE 1: ENGINE SENSORS LOCATION

1	Fuel Pressure	8	Air Temperature
2	Crankcase Pressure	9	Humidity/Ambient Air Temperature
3	Oil Level/Temperature	10	Camshaft Speed
4	EGR Differential Pressure	11	Crankshaft Speed
5	EGR Temperature	12	Oil Pressure
6	Coolant Temperature	13	AFI Fuel Pressure
7	Boost Pressure		

1.2 ENGINE OVERVIEW

NOTE

For maintenance on or repair of engine components or engine-related components, please refer to Volvo Trucks Canada or Volvo Trucks North America Web Site under: Parts & Service, purchase engine literature, D13F engine.

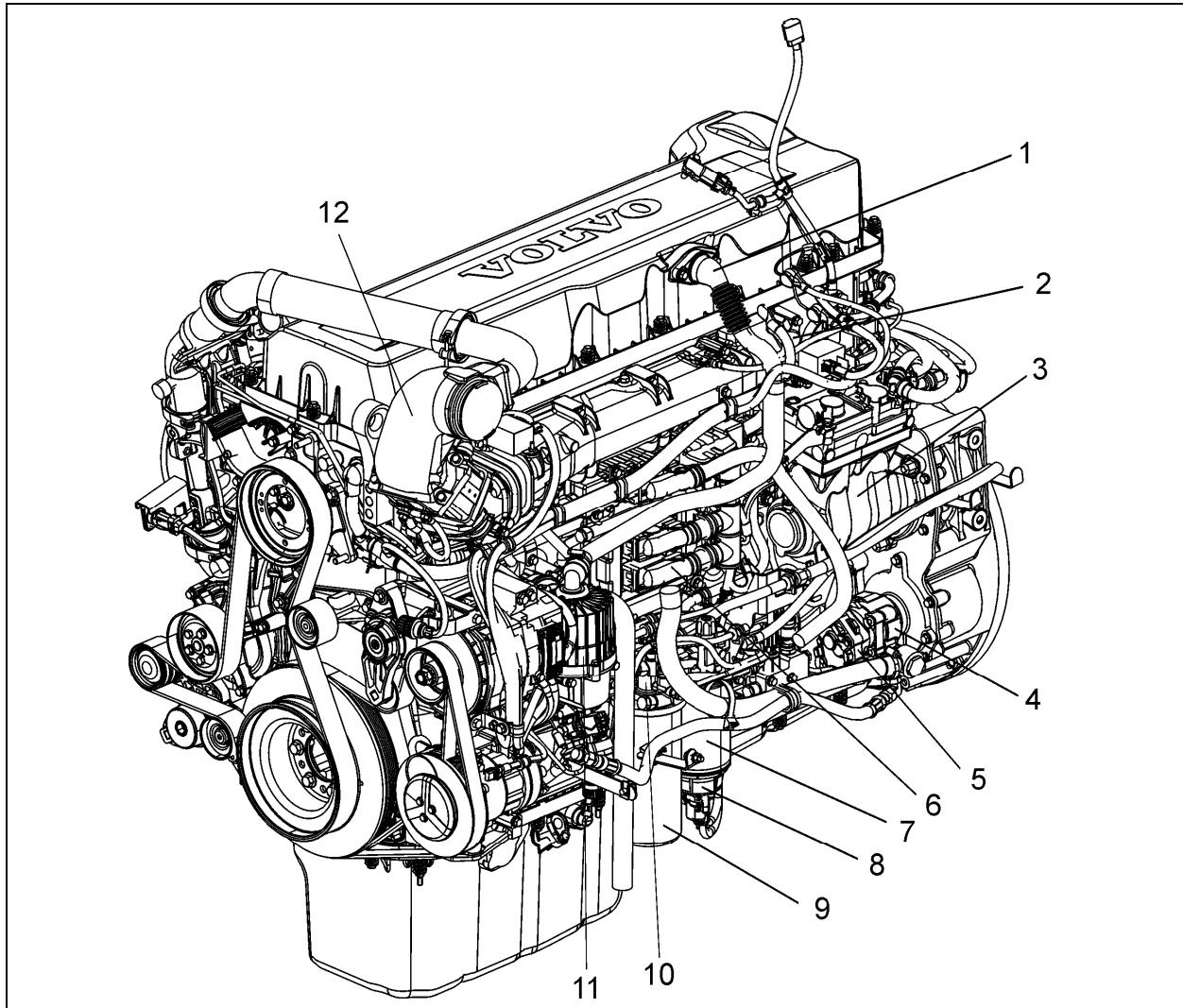


FIGURE 2: D13F ENGINE, ALTERNATOR SIDE (TYPICAL)

1. Breather Tube	7. Fuel Filter
2. Intake Manifold	8. Fuel/Water Separator
3. Air Compressor	9. Fuel Filter
4. Power Steering Pump	10. Hand-Priming Pump
5. Fuel Pump	11. Crankcase Ventilator
6. Engine Electronic Control Unit (EECU)	12. EGR Mixing Chamber

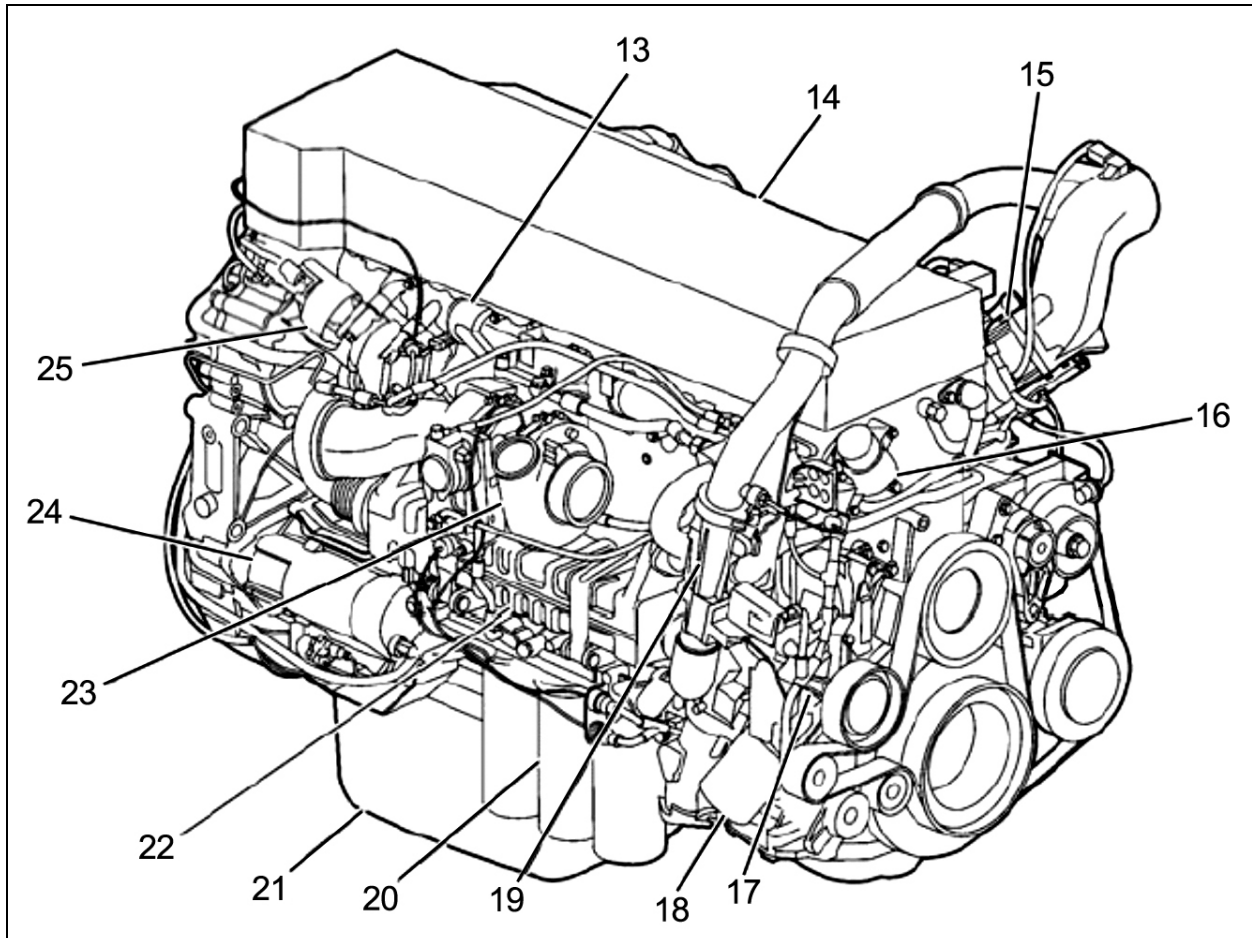


FIGURE 3: D13F ENGINE, TURBO SIDE (TYPICAL)

13. Exhaust Manifold	20. Oil Filters
14. Valve Cover	21. Oil Pan
15. Engine Pre-Heater Element (Optional)	22. EGR Cooler
16. DRV Valve	23. Turbocharger
17. Coolant Pump	24. Starter Motor
18. Coolant Filter	25. EGR Valve
19. Venturi Pipe	

1.3 ENGINE OIL

1.3.1 General

Keep the engine oil at the proper level and change it at the recommended intervals. Always replace the oil filters at the same time as when the oil is changed.

1.3.2 Oil Quality

Volvo North America recognizes engine oils that meet or exceed the standards given by American Petroleum Institute (API) for the oil classifications listed in this manual. Only oils licensed to carry the API symbol should be used. Lubricants meeting API standards have provided maximum engine life when used together with the recommended oil and oil filter change intervals.

EO-O Premium Plus (or VDS-4) diesel engine oil is mandatory for use in all 2007 emission compliant Volvo engines. Chassis equipped with a 2007 emission compliant engine, which can be identified by the presence of a Diesel Particulate Filter (DPF), also require the use of Ultra Low Sulfur Diesel (ULSD) fuel. EO-O Premium Plus oils exceed the new API service category CJ-4.



CAUTION

DO NOT add extra oil additives. Additives such as break-in oils, top oils, graphitizers, and friction-reducing liquids are not necessary and can harm the engine.

1.3.3 Oil Change Intervals

The length of time an engine can operate before an oil change depends on the quality oil used, the type of fuel used, fuel consumption, engine oil consumption, vehicle application, level of dust in the air, and fuel consumption. The change intervals given in this manual are maximum intervals. If the vehicle is operating in heavy-duty operation, dusty or off-road conditions, etc., reduce the intervals for more frequent oil changes.

NOTE

Use the information in the table below to determine the operating condition and usage applicable to your vehicle.

Engine Operating Condition	Medium	Heavy	Severe
Total Fuel Consumption (mpg)	More than 6	More than 4.7	More than 3.7
Total Fuel Consumption (L/100 KM)	Less than 39	Less than 50	Less than 64
Engine Oil and Filter Change Interval, miles (km) – 41 U.S. quarts (39L) Oil capacity	35,000 (55 000)	25,000 (40 000)	15,000 (24 000)

NOTE: If idle time is greater than 25%, use the next lower drain interval.

NOTE

Oil filters should always be changed when changing the oil.

1.3.4 Oil Filters

There are three filters on the engine, one of which is a bypass filter. This should be changed at the same time as the full-flow filter(s).



CAUTION

Volvo branded oil filters are designed to provide the proper level of filtration and protection for Volvo engines. Filters that do not meet the same stringent requirements may void engine warranty.

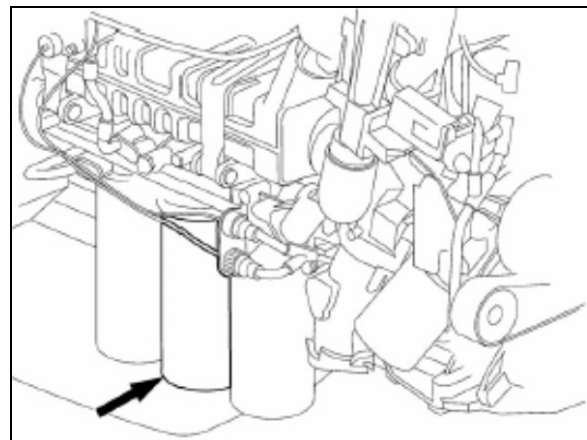


FIGURE 4: D13F OIL FILTERS

1.3.5 Synthetic Lubrication

Synthetic oils are offered by some oil suppliers as an alternative to the traditional, petroleum based oils for engines. These oils may be used in Volvo engines, provided they meet the quality

Section 01: ENGINE

levels specified on the previous pages, that is: both VDS-4 and EO-O Premium Plus.

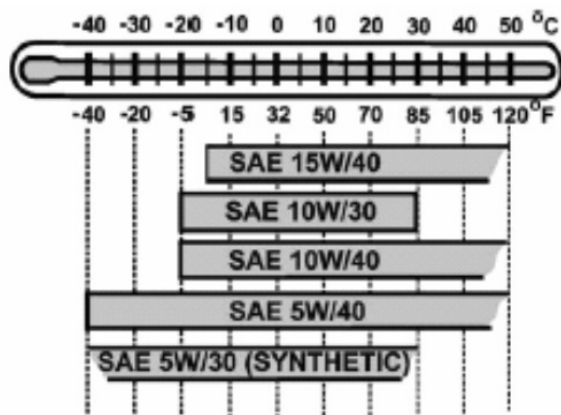
The use of synthetic oils does not permit the extension of the recommended oil change intervals.

1.3.6 Oil Viscosity

The viscosity grade defines the thickness of the oil. The oil must be thin enough at low temperatures for easy cold starts and thick enough to protect at high temperatures. An oil is not fully defined until both the API quality classification and the viscosity grade are specified.

Choose the viscosity grade for the typical ambient temperature for the application. Multigrade oils have a broad range that suit operation in changing temperature.

Volvo North America recommends the viscosities shown in the viscosity/temperature table for Volvo engines.



1.3.7 Oil Additives



CAUTION

Extra oil additives must never be added to any engine oil used. Additives such as break-in oils, top oils, graphitizers, and friction reducing liquids are not necessary and may even harm the engine.

Using oils to the quality standards recommended in this manual makes the use of extra oil additives unnecessary, as these oils already contain a balanced treatment of additives.

1.3.8 Oil Consumption

Once the engine is stopped, check the oil level daily. If the engine has just been stopped and it is warm, wait approximately five minutes to allow the oil to drain back to the oil pan before checking. Add oil as necessary.



CAUTION

DO NOT overfill engine with oil.

All diesel engines are designed to consume some oil, so it is normal to add oil periodically. An engine used in heavy-duty operation will consume more oil than one in normal operation.

1.3.9 Oil Change



WARNING

A hot engine or engine oil can be dangerous. Serious burns can result from contact with a hot engine or oil. Take precautions when draining the oil. Wear gloves or let the engine cool down before draining.



WARNING

When draining the oil, use the proper tools and keep away as far as possible. Raise the elbow so the forearm is parallel to the ground to prevent oil running down the arm, causing burns.



CAUTION

Always dispose of all lubricants (motor oil, coolant, gear box oils, etc) and filters according to Federal or local regulations. Used oil disposed of in nature or waterways contaminates our drinking water and kills wildlife.



WARNING

Prolonged contact with used engine oil may be harmful. Use rubber gloves when handling used oil. Wash skin thoroughly if it comes in contact with used oil.

It is important to drain as much oil as possible. Try to change oil immediately after driving, when the oil is warm. Always replace the oil filters when changing the oil.

Component	Capacity (L)
Oil pan	24 (min) – 32 (max)
Engine block	4.5
Filters (3)	6
Total oil fill (empty)	42.5

NOTE

Since about 4.5 liters of oil remains in the engine after draining, approximately 38 liters will be needed for a complete oil change.

1.3.10 Oil Filters Change



WARNING

Hot oil can cause severe burns. DO NOT allow hot oil to contact the skin. When changing oil, wear protective gloves.



CAUTION

Volvo-branded oil filters are designed to provide the proper level of filtration and protection for Volvo engines. Filters that do not meet the same stringent requirements may cause unsatisfactory results.

- Clean around the oil filter housing and remove the filters using the oil filter wrench or the oil filter socket.

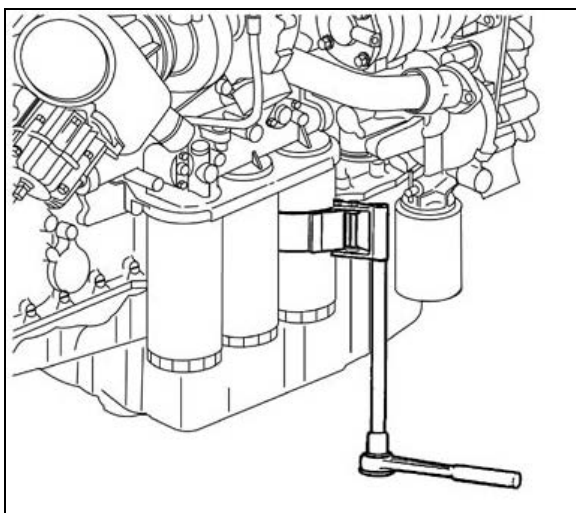


FIGURE 5: OIL FILTER WRENCH

- Prefill the new oil filters with approved engine oil. Also, lubricate the filter gaskets with engine oil (1). Hand tighten the oil filters until they contact the sealing surface of the oil filter housing (2). Manually tighten the oil filters an additional ¼ to 1 full turn (3).

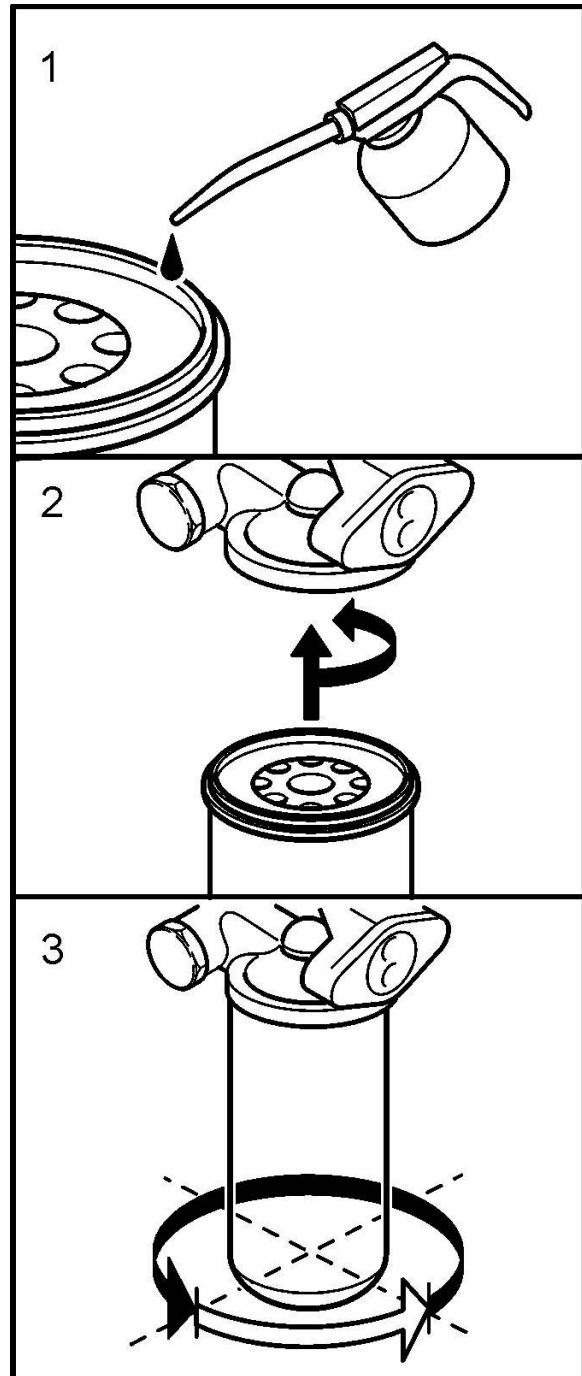


FIGURE 6: OIL FILTER REPLACEMENT

- Start the engine and check for leaks around the oil filter housing and filters.

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- Check the oil level. Add approved engine oil to the recommended level, if necessary. Do not overfill.

1.3.11 Checking the Oil Level

Ensure that the vehicle is parked on level ground before checking the oil level. Wait five minutes after shutting off the engine and then proceed with checking the oil.



CAUTION

DO NOT let the oil level fall below the marking on the dipstick. **DO NOT** overfill so the level is above the upper marking on the dipstick. This could lead to excessive oil temperature and/or poor crankcase breather performance. Add oil through the oil filler pipe as required in order to maintain level within the safe range.

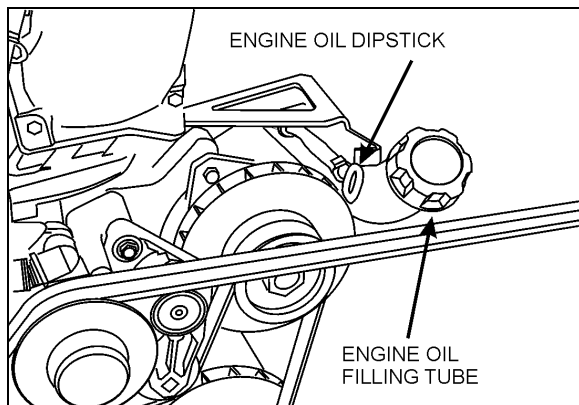


FIGURE 7: ENGINE OIL FILLING TUBE

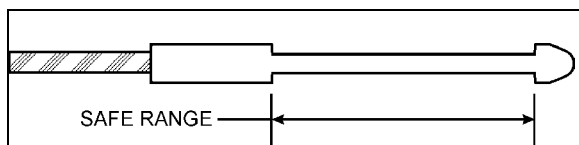


FIGURE 8: ENGINE OIL LEVEL DIPSTICK

1.4 POWER PLANT ASSEMBLY REMOVAL

To access the engine or engine-related components, the vehicle power plant assembly must be removed as a whole unit by means of a slide-out cradle. The power plant assembly includes the engine, transmission (including retarder if so equipped), air compressor, alternator and transmission oil cooler.

Remove the power plant assembly as follows:



CAUTION

Tag hoses and cables for identification before disconnecting in order to facilitate reinstallation. Plug all openings to prevent dirt from entering the system.

NOTE

No parts within the EECU are serviceable. If found defective, replace the EECU as a unit.

• First

1. Shut off the heater line shut-off valves.
2. Disconnect the battery or batteries from the starting system by removing one or both of the battery cables from each battery system. With the electrical circuit disrupted, accidental contact with the starter button will not produce an engine start.



WARNING

Due to the heavy load of the rear bumper assembly, it must be adequately supported before attempting to remove it.

3. Remove the rear bumper assembly complete with hitch if applicable from the vehicle. Refer to Section 18, BODY, under "REAR BUMPER REMOVAL".
4. Using the quick-connect drain hose, drain the engine cooling system. Refer to Section 05, COOLING under "DRAINING COOLING SYSTEM".
5. If applicable, disconnect the block heater connector located near the EGR mixing chamber.

• With Vehicle Raised

1. Using a vehicle lift or jack, raise vehicle to access transmission fasteners and wire harness.
2. Disconnect propeller shaft.
3. Partially remove L.H. side transmission protective panel to access connectors.
4. On vehicles equipped with an automatic transmission provided with a hydraulic output retarder, disconnect steel-braided airline from pressure regulator output. The

pressure regulator is mounted in the upper section of engine compartment backwall and is accessible through the engine compartment R.H. side door.

5. Untighten bolts A and C. Remove bolts B and D and pivot oil cooler towards transmission. Reinstall bolts B and D.

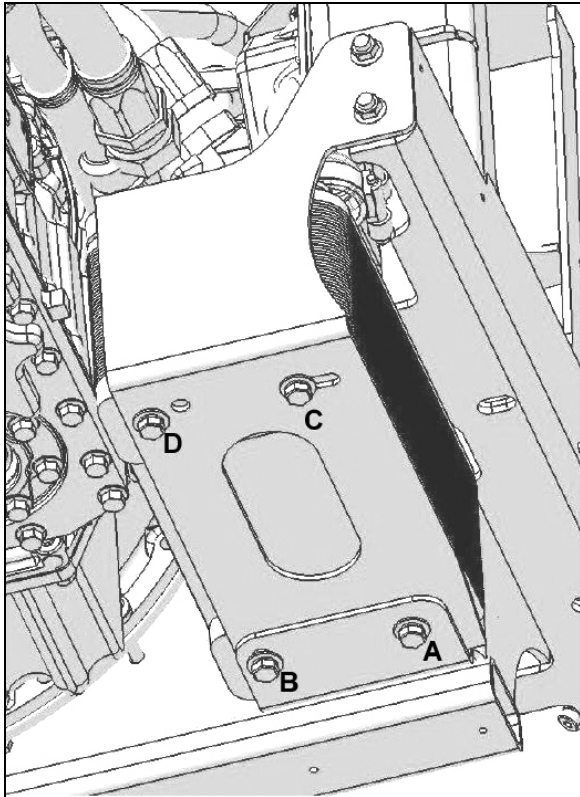


FIGURE 9: COOLER POSITION DURING ENGINE CRADLE INSERTION OR REMOVAL

6. From underneath, unfasten the bolts fixing the engine cradle.
7. Disconnect the engine coolant hose near the starter.
8. Disconnect air compressor suction and discharge hoses.

• **With Vehicle Lowered**

Lower the vehicle enough to access all components.

- Engine Compartment R.H. side
 - If applicable, remove auxiliary sump tank to ease access.
 - Disconnect cables from two chassis grounds located on diagonal member.

- Inside engine compartment, disconnect starter, alternators and heater cables. Also disconnect AFSS cable if applicable.
- Disconnect from engine, connector C398 and vehicle interface harness connector located above EECU connectors. Also disconnect DPF cable.
- Disconnect power steering pump hoses.
- Shut off fuel line shut-off valve.
- Close engine fuel supply shut-off valve on primary fuel filter or Fuel Pro. Disconnect the fuel line located above fuel filters and connected to inlet port. On vehicles equipped with the optional water-separator-fuel-filter, disconnect the connector and remove cable ties from cradle.
- Disconnect fuel return line located above fuel filters.
- Disconnect alternators cooling duct and put aside.

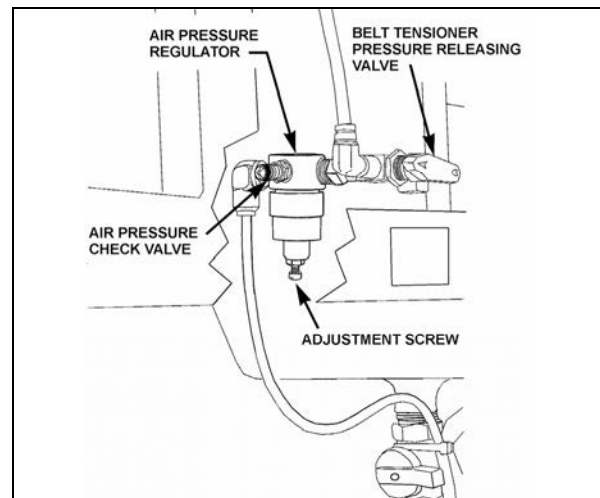


FIGURE 10: BELT TENSIONER VALVE 12200

- Locate the A/C compressor belt tensioner pressure releasing valve (Fig. 10). Turn pressure releasing valve handle counterclockwise in order to release pressure in belt-tensioner air bellows and loosen belts. Remove the belts.
- Disconnect and remove the engine-air intake duct mounted between air cleaner housing and turbocharger inlet.



CAUTION

To avoid damage to turbocharger, cover the turbocharger inlet opening to prevent foreign material from entering.

- Disconnect and remove the exhaust pipe mounted between the flexible coupling and the pipe going to the Aftertreatment Device (ATD). If necessary, refer to Section EXHAUST SYSTEM under "EXHAUST AND AFTERTREATMENT SYSTEM OVERVIEW".
- Disconnect and remove the air intake duct mounted between the charge air cooler outlet and the engine intake.
- Engine Compartment L.H. side
 - Disconnect fan driving shaft from radiator fan drive mechanism support.



CAUTION

To avoid damage to cooling fan right angle gearbox, make sure the power plant cradle clears the gearbox when pulling the engine out.

- Disconnect and remove section of coolant pipe assembly mounted between the radiator outlet and the water pump inlet.
- Disconnect and remove a section of coolant pipe assembly mounted between the thermostat housing and the radiator inlet.
- Disconnect the electric fan-clutch connector located near the cooling fan right angle gearbox.

- Disconnect and remove the air intake duct mounted between the turbocharger outlet and the air cooler inlet.
- Disconnect and remove surge tank hose connected to pump inlet pipe and hose connected to engine.
- Unfasten and put aside engine compartment lighting fixture and turbocharger fire suppression nozzle if applicable.
- Disconnect Aftertreatment Device (ATD) control cable.

• Last

1. Inspect the power plant assembly to ensure that nothing will interfere when sliding out the cradle. Check for connections or hoses not mentioned in this list as some vehicles are equipped with special or aftermarket components.
2. Make sure the ten retaining bolts, washers and nuts securing the power plant cradle to the vehicle rear subframe are removed (Fig. 13).

NOTE

Check if any spacer(s) have been installed between power plant cradle and vehicle rear subframe, and if so, note position of each washer for reinstallation purposes.

3. Using a suitable equipment with a minimum capacity of 4,000 lbs (1 800 kg), slightly raise the power plant cradle.
4. Pull engine out slowly from the engine compartment. Make sure all lines, wiring and accessories are disconnected and are not tangled.

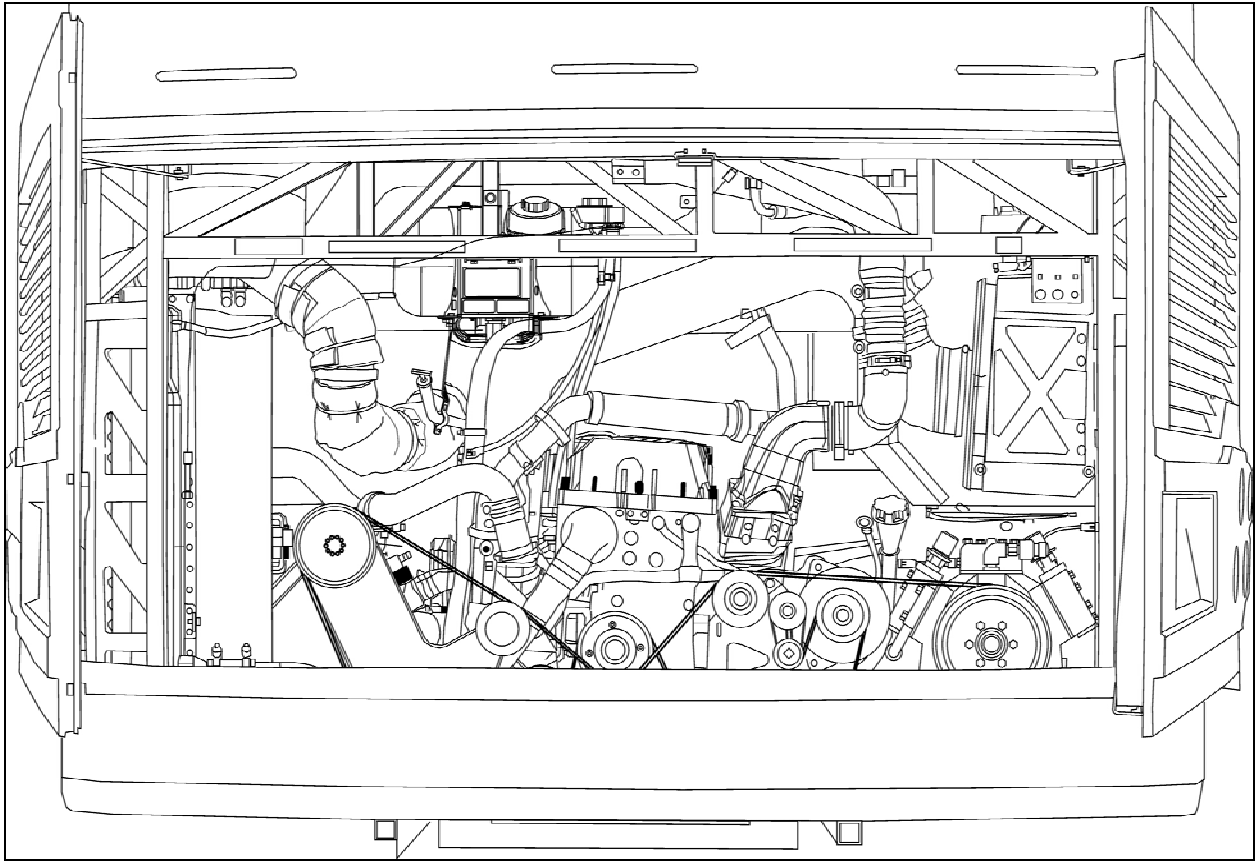


FIGURE 11: ENGINE COMPARTMENT X3 COACHES (TYPICAL)

01184_A

1.5 POWER PLANT ASSY. INSTALLATION

To install a power plant assembly, follow the same procedure as in "Power Plant Assembly Removal" except in reverse order, then proceed with the following:

1. Torque the power plant cradle mounting bolts to 190 lbf-ft (258 Nm).
2. Remove bolts B and D. Untighten bolts A and C then pivot oil cooler as per figure 12. Install bolts B and D and tighten all bolts.
3. Refill cooling system with saved fluid (refer to Section 05, COOLANT SYSTEM).
4. Once engine fuel system has been drained, it will aid restarting if fuel filters are filled with fuel oil (refer to Section 03, FUEL SYSTEM).
5. Start engine for a visual check. Check fuel, oil, cooling, pneumatic and hydraulic system connections for leakage. Test operation of engine controls and accessories.

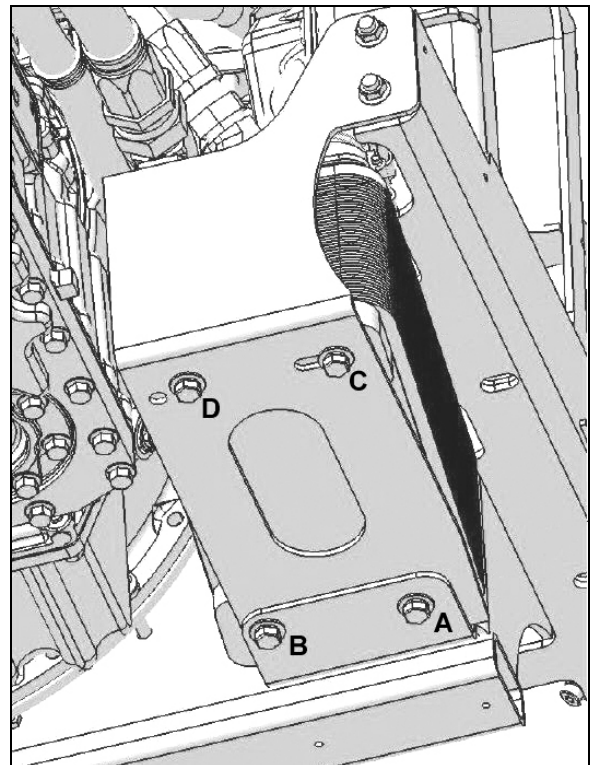


FIGURE 12: NORMAL OIL COOLER POSITION

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1.6 ENGINE MOUNTS

The power plant assembly is mounted to the cradle by means of rubber mounts and supports.

Two engine support brackets are used at the front of the engine while two rubber mounts are mounted underneath the engine & radiator fan drive mechanism support and the engine & alternator support (Fig. 13).

It is recommended that new rubber mounts be installed at each major overhaul.

NOTE

Refer to the table on the following page for engine cradle tightening torques.

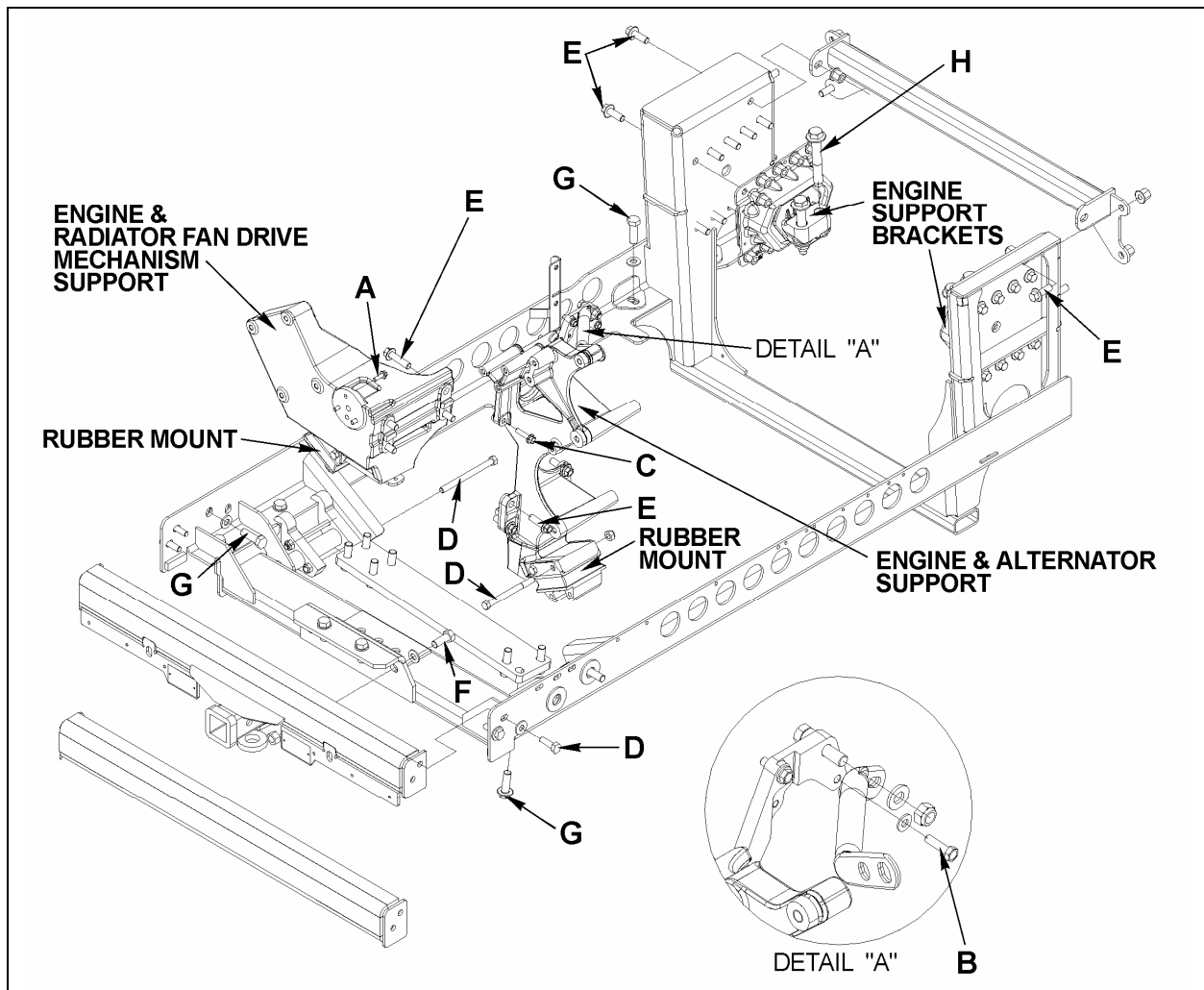


FIGURE 13: VOLVO ENGINE POWER PLANT CRADLE INSTALLATION

DRY TORQUES			
REFERENCE	DESCRIPTION	Lbf-Ft	Nm
A	SCREW, CAP HEXAGONAL HEAD M8 – 1.25 G8.8	16	22
B	SCREW, CAP HEXAGONAL HEAD M8 – 1.25 G10.9	22	30
C	SCREW, CAP HEXAGONAL HEAD M10 – 1.5 G10.9	43	58
D	SCREW, CAP HEXAGONAL HEAD M12 – 1.75 G8.8	60	81
E	SCREW, CAP HEXAGONAL HEAD M14 – 2.0 G8.8	90	122
F	SCREW, CAP HEXAGONAL HEAD M16 – 2.0 G8.8	140	190
G	SCREW, CAP HEXAGONAL HEAD M16 – 2.0 G10.9	190	258
H	SCREW, CAP HEXAGONAL HEAD M20 – 2.5 G10.9	450	610

2. DDC SERIES 60 ENGINE

Detroit Diesel series 60 engine is a 6-cylinder, four-cycle engine, equipped with an electronic control system (DDEC VI).

One engine displacement is used in the X3 Coaches Series 60 engines: 14.0 liters. Summary information on the Electronic Control System is given in this section.

Complete maintenance and repair information on the engine will be found in the current DETROIT DIESEL SERIES 60 2007 ON-HIGHWAY SERVICE MANUAL 6SE2007. This essential manual contains complete instructions on operation, adjustment (tune-up), preventive maintenance and lubrication, parts verification, repair or replacement. This manual's sections cover complete systems such as:

- Engine main assembly;
- Fuel system;
- Lubrication system;
- Cooling system;
- Fuel, lubricating oil and coolant;
- Air intake system;
- Exhaust system;
- Exhaust gas recirculation components;
- Electrical equipment;
- Operation and verification;
- Engine tune-up;
- Preventive maintenance;
- Storage;

Refer to Series 60 DDEC VI Troubleshooting Guide published by Detroit Diesel for more complete information on diagnosis of components and system problems.

Procedures for engine removal and installation are given at the end of this section. The DDEC system is self-diagnostic. It can identify faulty components and other engine-related problems by providing the technician with diagnostic codes.

2.1 DDEC VI SYSTEM

DDEC VI (**D**etroit **D**iesel **E**lectronic **C**ontrol) is a system that monitors and determines all values required for the operation of the engine. A diagnostic interface is provided to connect to an external diagnosis tester. Besides the engine related sensors and the engine-resident control unit, the Motor Control Module (MCM), this system has a chassis-mounted control unit for vehicle engine management, the Common Powertrain Controller (CPC). The connection to the vehicle is made via a CAN interface which digitally transmits the nominal values (e.g. torque, engine speed specification, etc.) and the actual values (e.g. engine speed, oil pressure, etc.).

DDEC VI controls the timing and amount of fuel injected by the electronic unit injectors (EUI). The system also monitors several engine functions using electrical sensors, which send electrical signals to the Motor Control Module (MCM). The MCM computes the electrical signals and determines the correct fuel output and timing for optimum power, fuel economy and emissions. The MCM also has the ability to display warnings or shut down the engine

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completely (depending on option selection) in the event of damaging engine conditions, such as low oil pressure or high engine temperature.

2.2 HARNESSSES

There are two major harnesses: the Engine Harness (EH) and the Vehicle Interface Harness (VIH). The Engine Harness is installed at the Detroit Diesel factory and is delivered connected to all engine sensors, the fuel injection system, and the MCM.

The OEM supplied Vehicle Interface Harness connects the CPC to other vehicle systems.

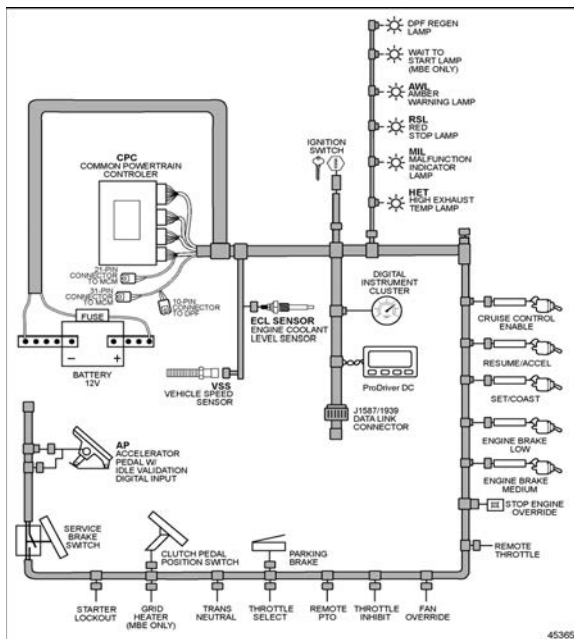
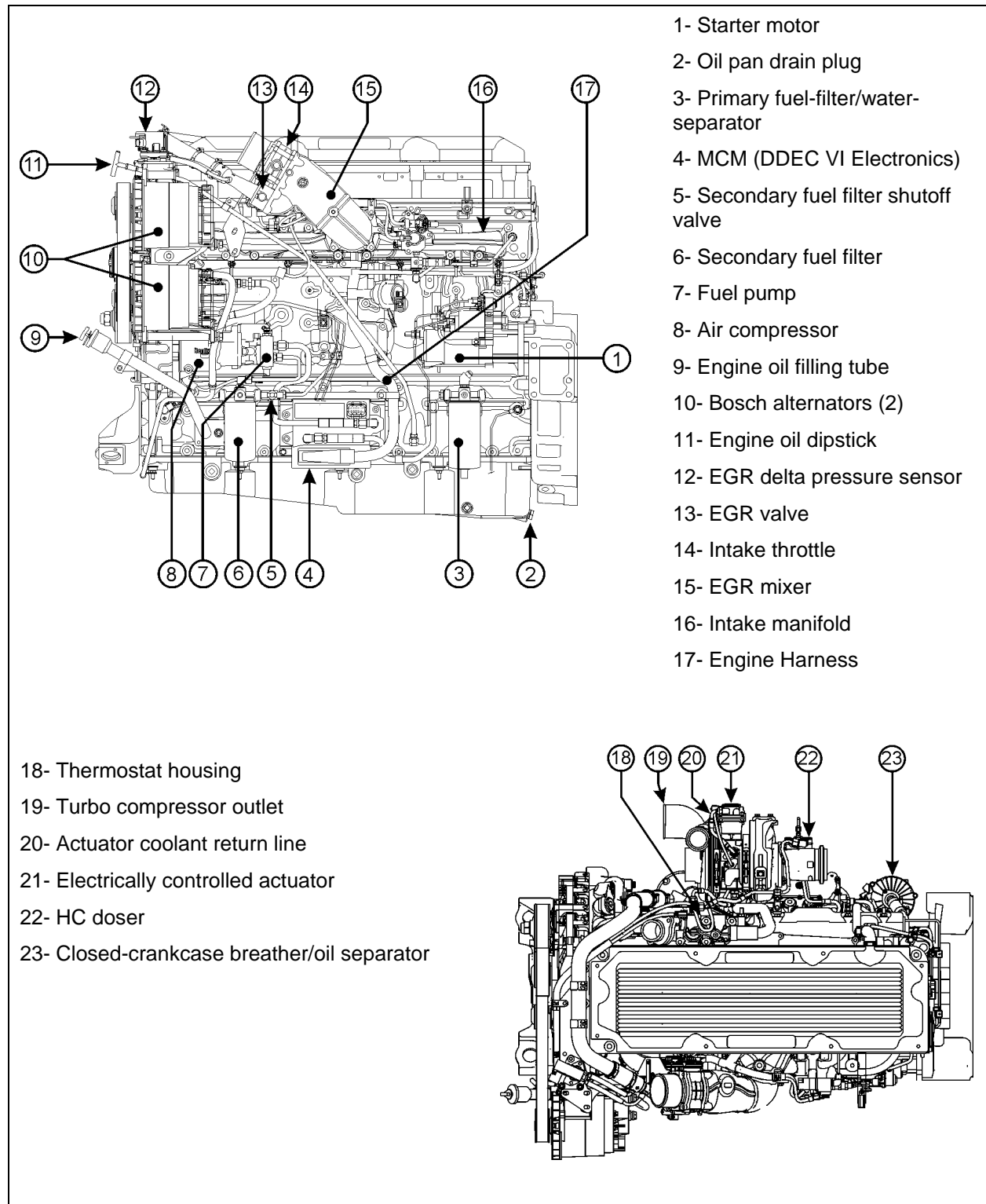


FIGURE 14: VEHICLE INTERFACE HARNESS (GENERAL APPLICATION SHOWN)

2.3 ENGINE OVERVIEW



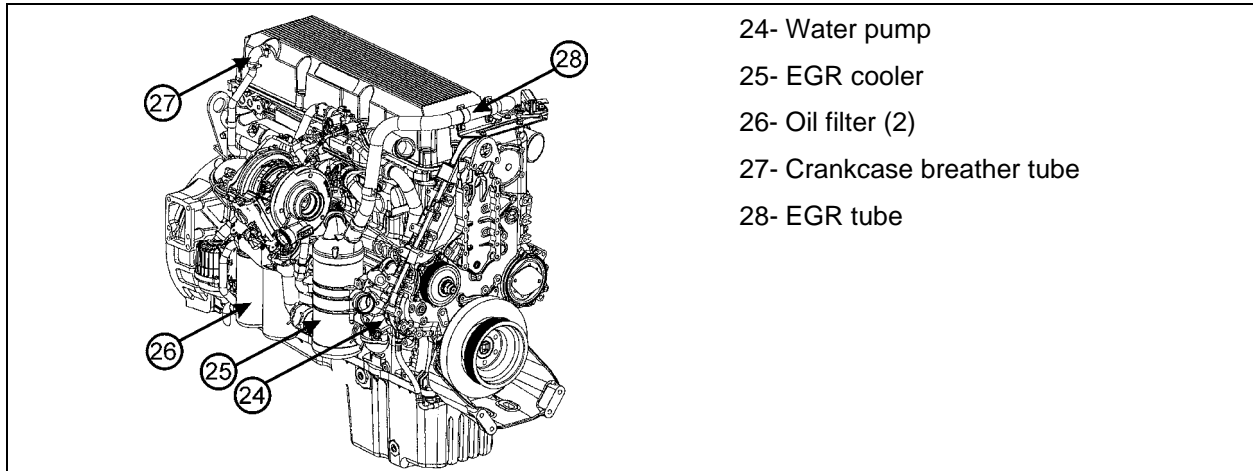


FIGURE 15: DETROIT DIESEL 2007 SERIES 60 ENGINE (TYPICAL)

01150

- 24- Water pump
- 25- EGR cooler
- 26- Oil filter (2)
- 27- Crankcase breather tube
- 28- EGR tube

2.4 DDEC VI SENSORS

- **Camshaft Position Sensor (CMP Sensor):** Indicates a specific cylinder in the firing order.
- **Crankshaft Position Sensor (CKP Sensor):** Senses crankshaft position and engine speed for functions such as fuel control strategy.
- **DPF Inlet Pressure Sensor** Measures pressure between the Diesel Oxidation Catalyst (DOC) and the Diesel Particulate Filter (DPF) in the aftertreatment assembly.
- **DPF Outlet Pressure Sensor:** Measures pressure on the outlet of the aftertreatment device in the exhaust system of the vehicle.
- **DPF Outlet Temperature Sensor:** Temperature measured at the outlet of the after-treatment system that is installed within the exhaust system of the vehicle.
- **DOC Inlet Temperature Sensor:** Temperature measured at the outlet of the after-treatment.
- **DOC Outlet Temperature Sensor:** Temperature measured between the DOC and the DPF in the aftertreatment assembly.
- **EGR Delta Pressure Sensor:** Senses EGR pressure for EGR control.
- **EGR Temperature Sensor:** Senses EGR exhaust temperature after EGR cooler. Used for EGR system diagnosis.
- **Engine Coolant Temperature Sensor (ECT Sensor):** Senses coolant temperature for functions such as engine protection, fan control and engine fueling.
- **Engine Oil Pressure Sensor (EOP Sensor):** Senses gallery oil pressure for functions such as engine protection.
- **Engine Oil Temperature Sensor (EOT Sensor):** Senses oil temperature for functions such as reducing variation in fuel injection and fan control.
- **Fuel Line Pressure Sensor:** Senses fuel line pressure.
- **Fuel Compensation Pressure Sensor:** Compensates fuel line pressure.
- **Intake Manifold Pressure Sensor (IMP Sensor):** Senses turbo boost for functions such as smoke control and engine protection.
- **Intake Manifold Air Temperature Sensor (IMT Sensor):** Senses pressure. The MCM uses this information to compute the amount of air entering the engine.
- **Supply Fuel Temperature Sensor (SFT Sensor):** Senses fuel temperature for functions such as engine fueling.
- **Turbo Compressor Temperature Out Sensor:** Senses turbo out air temperature.
- **Turbo Speed Sensor (TSS):** Monitors turbo speed for overspeed conditions.
- **VGT Position Sensor/EGR Valve Position Sensor.**
- **Intake Air Throttle Valve Sensor.**
- **Exhaust Valve Recirculation Valve (EGR) Sensor.**

2.5 OTHER SENSORS

- **Engine Coolant Level Sensor (ECL Sensor):** Senses coolant level for engine protection (mounted on coolant surge tank).
- **Turbo Compressor In Temperature Sensor:** Senses the air temperature at the turbo compressor inlet.

2.6 MOTOR CONTROL MODULE (MCM)

The Motor Control Module is mounted, on the starter side of the engine (Fig. 15). Considered the "Brain" of the DDEC VI system, it provides overall monitoring and control of the engine. It does so by comparing input data from the various sensors to a set of calibration data stored in the EEPROM (Electrically Erasable, Programmable, Read-Only Memory) within the Motor Control Module. After comparing the input data with the calibration data, the MCM sends high-current command pulses to the Electronic Unit Injectors (EUI) to initiate fuel injection. The MCM also receives feedback regarding the start and end of injection for a given cylinder. The EEPROM within the Motor Control Module is factory programmed by Detroit Diesel. Reprogramming must be done at a Detroit Diesel authorized service center. However, some changes may be performed to the cruise control and road speed limiter using a diagnostic data reader (see paragraph "DDEC VI Diagnostic Codes" in this section).

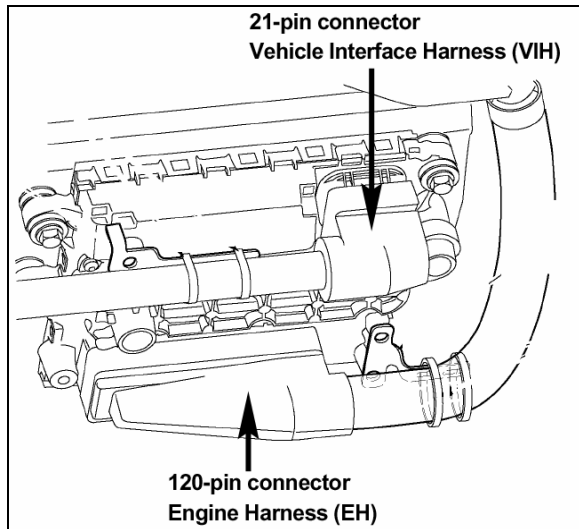


FIGURE 16: MOTOR CONTROL MODULE (MCM) 01145

2.7 COMMON POWERTRAIN CONTROLLER (CPC)

The CPC is the interface between the MCM and the vehicle/equipment for engine control and manages other vehicle/equipment functions.

Within the CPC, sets of data for specific applications are stored. These include idle speed, maximum running speed, and speed limitation. Customer programmable parameters are also stored here. The CPC receives data from the operator (accelerator pedal position, switches and various sensors) and other electronic control units. From this data, instructions are computed for controlling the engine and transmitted to the MCM via the proprietary data link.

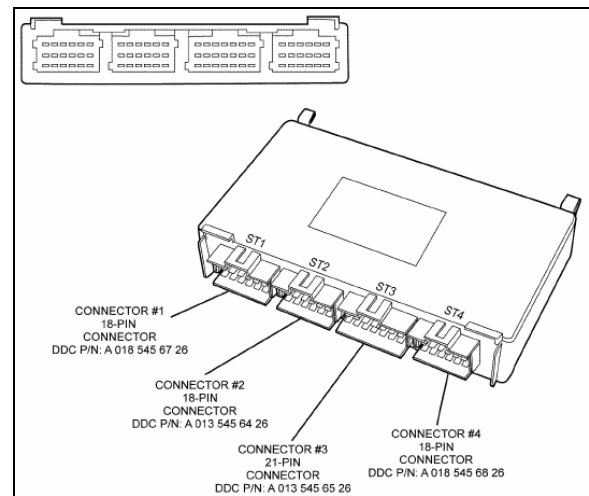


FIGURE 17: CPC

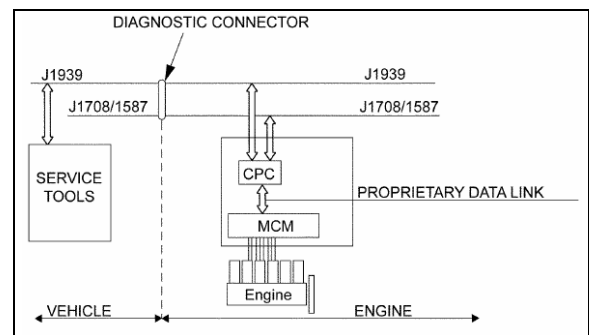


FIGURE 18: THE CPC COMMUNICATES OVER THE J1587 AND J1939 DATA LINKS TO THE VEHICLE

2.8 DDEC VI DIAGNOSTICS

2.8.1 Diagnostic system

Diagnostics is a standard feature of DDEC VI. The purpose of this feature is to provide information for problem identification and

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problem solving in the form of a code. The MCM and CPC continuously perform self diagnostic checks and monitor the other system components. Information for problem identification and problem solving is enhanced by the detection of faults, retention of fault codes and separation of active from inactive codes.

The engine-mounted MCM includes control logic to provide overall engine management. System diagnostic checks are made at ignition on and continue throughout all engine operating modes. Sensors provide information to the MCM and CPC regarding various engine and vehicle performance characteristics. The information is used to regulate engine and vehicle performance, provide diagnostic information, and activate the engine protection system.

The DDEC VI on-board diagnostic system accessories include the following:

- Check Engine telltale light (AWL);
- Stop Engine telltale light (RSL);
- Stop Engine Override switch (SEO);
- Diagnostic Data Link (DDL) connectors.

The AWL is illuminated and a code is stored if an electronic system fault occurs. This indicates the problem should be diagnosed as soon as possible. The CPC illuminates the AWL and RSL and stores a malfunction code if a potentially engine damaging fault is detected. These codes can be accessed in one of four ways:

- Commercially available J1587/J1939 diagnostic tools.
- Detroit Diesel Diagnostic Link® (DDDL 7.0).
- Flashing the AWL and RSL with the SEO/Diagnostic Request Switch.
- Dashboard's Message Center Display (MCD).

2.8.2 Check Engine Telltale Light (AWL)

The CPC illuminates the Check Engine telltale, mounted on the telltale light panel to indicate that a problem has been detected and that a code has been stored in the MCM memory. This light also has a 5-second bulb check when the ignition is first turned on.

2.8.3 Stop Engine Warning Light (RSL)

This light, also mounted on the telltale light panel, illuminates to indicate that a major engine problem is occurring (with the exception of a 5-second bulb check when the ignition is first turned on).

2.8.4 Stop Engine Override Switch (SEO)

This switch, mounted on the dashboard, may be used to extend the 30-second delay period before engine shutdown when the Stop engine telltale light is illuminated. This switch can be repeatedly depressed in order to move the vehicle out of traffic.

NOTE

The stop engine override switch will be operative only if it has been depressed before the end of the 30 second delay period.



CAUTION

The OVERRIDE switch must be used only in emergency cases, such as to move the vehicle out of traffic. Excessive use of this switch can cause serious damage to the engine.

This switch is also used for DDEC diagnostic code requests. Press this switch with the engine at idle or off but with the ignition in the "ON" position and active codes will be flashed on the CHECK ENGINE and STOP ENGINE telltale lights alternately.

2.8.5 Diagnostic Data Link (DDL) Connectors

A connector is mounted on the L.H. footwell wall. Another connector is located in the rear electric compartment. They allow the connection of the Diagnostic Data Reader (DDR) to read the codes or to access pertinent data on the condition of the engine. This enables a more complete analysis of any defect found in the DDEC system operation. For more information, see Detroit Diesel Troubleshooting Guide #6SE492.

2.9 READING DIAGNOSTIC CODES – FLASHING LIGHT METHOD:

DDEC VI makes use of two types of codes: Active and inactive. The difference between the two types of codes is as follows:

Active Codes: Codes that are currently keeping the Check Engine or Stop Engine telltale light illuminated. Active codes are flashed via the Stop Engine Light when checked with the stop-engine-override switch.

Inactive Codes: These are all the codes logged in the CPC, which have previously occurred, (whether or not they are currently turning on the Stop or Check Engine Light). Inactive codes are flashed via the Check Engine telltale light when checked with the stop-engine-override switch.

In most instances, only the DDR can provide the information necessary for a quick diagnosis of the problem. If you just need to read out codes, however, and do not have a DDR available, the following procedure will let you read out codes. Make sure the rear-starting switch (located in the engine compartment) is in the normal position. With the ignition ON, the engine idling or engine shut-off, momentarily depress the Stop Engine Override (SEO) switch. Active codes will be flashed on the stop engine telltale, followed by the inactive codes being flashed on the check-engine telltale panel. The cycle repeats itself until the operator depresses the stop engine override switch again.

Flashing codes provide a four digit number. Each fault code is flashed twice in order to help with counting the flashes. If there are no active faults or if there are no inactive faults the number "3" is flashed once followed by an ~3s delay.

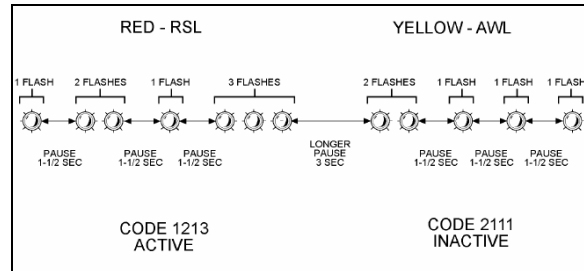


FIGURE 19: FLASHING FAULTS CODES

Refer to DDEC Troubleshooting Manual 6SE567 for more information and SAE codes.

NOTE

Active codes are flashed in ascending numerical flash code order. Inactive codes are flashed in most recent to least recent order.

NOTE

Fault codes can only be cleared using the DDR.

NOTE

The listed codes may not be used in all applications. A default value in the normal operating range is used by the MCM to provide for engine operation if a sensor failure is present.

2.10 DDEC VI CPC DIAGNOSTIC CODES LIST

SPN	FMI	PID/SID	PID/SID ID	FLASH CODES	FAULT DESCRIPTION
70	2	PID	70	2111	Park Brake Status Not Plausible (Vehicle Moving)
70	19	SID	234	2112	J1939 Park Brake Switch Signal from Source #1 is erratic
70	13	SID	234	2112	J1939 Park Brake Switch Signal from Source #1 is missing
70	19	SID	234	2112	J1939 Park Brake Switch Signal from Source #2 is erratic
70	13	SID	234	2112	J1939 Park Brake Switch Signal from Source #2 is missing
70	19	SID	234	2112	J1939 Park Brake Switch Signal from Source #3 is erratic
70	13	SID	234	2112	J1939 Park Brake Switch Signal from Source #3 is missing

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODES	FAULT DESCRIPTION
84	21	PID	84	2113	Vehicle Speed Failure
84	3	PID	84	2113	Vehicle Speed Sensor Circuit Failed High
84	4	PID	84	2113	Vehicle Speed Sensor Circuit Failed Low
84	2	PID	84	2113	VSS Anti Tamper Detection via Virtual Gear Ratio
84	8	PID	84	2113	VSS Anti Tamper Detection via Fixed Frequency Device
84	6	PID	84	2113	VSS Anti-Tamper Detection via ABS Vehicle Speed Comparison
84	19	PID	84	2113	J1939 Wheel-Based Vehicle Speed Signal from Source#1 is erratic
84	13	PID	84	2113	J1939 Wheel-Based Vehicle Speed Signal from Source#1 is missing
84	19	SID	84	2113	J1939 Wheel-Based Vehicle Speed Signal from Source#2 is erratic
84	13	PID	84	2113	J1939 Wheel-Based Vehicle Speed Signal from Source#2 is missing
84	19	PID	84	2113	J1939 Wheel-Based Vehicle Speed Signal from Source#3 is erratic
84	13	PID	84	2113	J1939 Wheel-Based Vehicle Speed Signal from Source#3 is missing
84	20	PID	84	2113	Vehicle Speed Sensor Drifted High Error (VSS signal not plausible)
91	13	PID	91	2114	Accelerator Pedal Learn Error
91	3	PID	91	2114	Accelerator Pedal Circuit Failed High
91	4	PID	91	2114	Accelerator Pedal Circuit Failed Low
91	8	PID	91	2114	Pwm Accelerator Pedal Signal 1 Frequency Out Of Range
91	14	PID	91	2114	Pwm Accelerator Pedal Not Learned
91	7	PID	91	2114	Pwm Accelerator Pedal Idle Not Recognized
91	31	PID	91	2114	Pwm Accelerator Pedal Learned Range to Large
91	3	PID	91	2114	Accelerator Pedal Signal Circuit Failed High
91	9	SID	231	2615	J1939 EEC2 Message is missing
98	0	PID	98	2115	Oil Level High
98	18	PID	98	2115	Oil Level Low
98	1	PID	98	2115	Oil Level Very Low
100	18	PID	100	2121	Oil Pressure Low
100	1	PID	100	2121	Oil Pressure Very Low
107	0	PID	107	2122	Air Filter Restriction High

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODES	FAULT DESCRIPTION
107	4	PID	107	2122	Air Filter Signal Circuit Failed Low
107	3	PID	107	2122	Air Filter Signal Circuit Failed High
110	16	PID	110	2123	Coolant Temperature High
110	0	PID	110	2123	Coolant Temperature Very High
111	18	PID	111	2124	Coolant Level Low
111	3	PID	111	2124	Coolant Level Circuit Failed High
111	4	PID	111	2124	Coolant Level Circuit Failed Low
111	1	PID	111	2124	Coolant Level Very Low
168	0	PID	168	2125	Battery Voltage Very Low
168	0	PID	168	2125	Battery Voltage High
168	18	PID	168	2125	Battery Voltage Low
168	14	PID	168	2125	Opt Idle Detected Charging System or Battery Failure
168	14	PID	168	2125	ECU powerdown not completed (Main Battery Terminal Possibly Floating)
171	2	PID	171	2131	Ambient Temperature Sensor Data Erratic
171	14	PID	171	2131	J1587 Ambient Air Temp Sensor Data Not Received This Ign Cycle
171	9	PID	171	2131	J1587 Ambient Air Temp Sensor Data Message Stopped Arriving
191	9	SID	231	2615	J1939 ETC1 Message is missing
191	19	SID	231	2132	J1939 Transmission Output Shaft Speed Signal is erratic
191	13	SID	231	2132	J1939 Transmission Output Shaft Speed Signal is missing
247	9	PID	247	2615	MCM Engine Hours Data not received or stopped arriving
247	10	PID	247	2615	MCM Engine Hours Data increasing at an implausible rate
247	0	PID	247	2615	MCM Engine Hours Data higher than expected
247	1	PID	247	2615	MCM Engine Hours Data lower than expected
523	19	PID	163	2133	J1939 Transmission Current Gear Signal is erratic
523	13	PID	163	2133	J1939 Transmission Current Gear Signal is missing
524	9	SID	231	2615	J1939 ETC2 Message is missing
527	9	SID	231	2615	J1939 CCVS Message from Source #1 is missing
527	9	SID	231	2615	J1939 CCVS Message from Source #2 is missing
527	9	SID	231	2615	J1939 CCVS Message from Source #3 is missing
558	2	SID	230	2134	Idle Validation Switch Inputs Reversed
558	5	SID	230	2134	Idle Validation Switch 2 Circuit Failed Low

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODES	FAULT DESCRIPTION
558	6	SID	230	2134	Idle Validation Switch 2 Circuit Failed High
558	4	SID	230	2134	Idle Validation Switch 1 Circuit Failed Low
558	3	SID	230	2134	Idle Validation Switch 1 Circuit Failed High
596	19	SID	244	2135	J1939 Cruise Control Enable Switch Signal from Source #1 is erratic
596	13	SID	244	2135	J1939 Cruise Control Enable Switch Signal from Source #1 is missing
596	19	SID	244	2135	J1939 Cruise Control Enable Switch Signal from Source #2 is erratic
596	13	SID	244	2135	J1939 Cruise Control Enable Switch Signal from Source #2 is missing
596	19	SID	244	2135	J1939 Cruise Control Enable Switch Signal from Source #3 is erratic
596	13	SID	244	2135	J1939 Cruise Control Enable Switch Signal from Source #3 is missing
597	2	SID	246	2141	Service Brake Status Not Plausible
597	19	SID	246	2141	J1939 Service Brake Switch Signal from Source #1 is erratic
597	13	SID	246	2141	J1939 Service Brake Switch Signal from Source #1 is missing
597	19	SID	246	2141	J1939 Service Brake Switch Signal from Source #2 is erratic
597	13	SID	246	2141	J1939 Service Brake Switch Signal from Source #2 is missing
597	19	SID	246	2141	J1939 Service Brake Switch Signal from Source #3 is erratic
597	13	SID	246	2141	J1939 Service Brake Switch Signal from Source #3 is missing
599	4	SID	243	2142	Cruise Control SET and RESUME Circuits Failed Low
600	19	SID	243	2143	J1939 Cruise Control Coast Switch Signal from Source #1 is erratic
600	13	SID	243	2143	J1939 Cruise Control Coast Switch Signal from Source #1 is missing
600	19	SID	243	2143	J1939 Cruise Control Coast Switch Signal from Source #2 is erratic
600	13	SID	243	2143	J1939 Cruise Control Coast Switch Signal from Source #2 is missing
600	19	SID	243	2143	J1939 Cruise Control Coast Switch Signal from Source #3 is erratic
600	13	SID	243	2143	J1939 Cruise Control Coast Switch Signal from Source #3 is missing
602	19	SID	242	2144	J1939 Cruise Control Accelerate Switch Signal from Source #1 is erratic
602	13	SID	242	2144	J1939 Cruise Control Accelerate Switch Signal from Source #1 is missing

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODES	FAULT DESCRIPTION
602	19	SID	242	2144	J1939 Cruise Control Accelerate Switch Signal from Source #2 is erratic
602	13	SID	242	2144	J1939 Cruise Control Accelerate Switch Signal from Source #2 is missing
602	19	SID	242	2144	J1939 Cruise Control Accelerate Switch Signal from Source #3 is erratic
602	13	SID	242	2144	J1939 Cruise Control Accelerate Switch Signal from Source #3 is missing
608	14	SID	250	2145	J1708 Data Link Failure
609	12	SID	233	2145	CPC2 Hardware Failure
615	9	SID	231	2615	J1939 DM1 Message from Transmission is missing
625	13	SID	248	2151	ECAN ID_1629 Diagnostic Message Not Received This Ignition Cycle
625	9	SID	248	2151	ECAN ID_1629 Diagnostic Message No Longer Being Received
625	10	SID	248	2151	ECAN ID_1629 Reporting Inconsistent Number of Frames
625	2	SID	248	2151	ECAN ID_1629 Diagnostic Message Reporting Data Not Available
625	14	SID	248	2151	ECAN ID_1629 Diagnostic Message Reporting an Unknown MUID
625	9	SID	248	2151	Incorrect MCM System ID Received
625	9	SID	248	2151	MCM System ID Not Received or Stopped Arriving
625	4	SID	248	2151	ECAN Link Circuit Failure
628	14	SID	254	2151	XFLASH Static Fault Code Memory Page Read Write Failure
628	13	SID	155	2615	20ms ECU OS Task Locked in an Endless Loop
628	13	SID	155	2615	20ms ECU OS Task Timed out Prior to Completion
628	13	SID	155	2615	1000ms ECU OS Task Locked in an Endless Loop
628	13	SID	155	2615	1000ms ECU OS Task Timed out Prior to Completion
629	2	SID	254	2151	CPC Hardware/Software Mismatch
629	12	SID	254	2151	DDEC Data Xflash Write Error. Replace CPC2.
630	2	SID	253	2152	EEPROM Checksum Failure
630	2	SID	253	2152	EEPROM Checksum Failure for the SCR Block
630	13	SID	253	2152	SCR Number Out of Range

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODES	FAULT DESCRIPTION
630	14	SID	155	2615	MCM Fault Codes Unavailable via J1939 and J1587
630	14	SID	155	2615	MCM Fault Code Table Inconsistent - Upgrade MCM Software
630	14	SID	155	2615	Insufficient Static Fault Code Storage Memory - Upgrade CPC Software
630	14	SID	155	2615	MCM Fault Code Table Inconsistent - Upgrade MCM Software
639	14	SID	231	2153	J1939 Data Link Failure
701	3	SID	26	2211	Digital Output 4 09 Circuit Failed High
701	4	SID	26	2211	Digital Output 4 09 Circuit Failed Low
702	3	SID	40	2212	Digital Output 3 17 Circuit Failed High
702	4	SID	40	2212	Digital Output 3 17 Circuit Failed Low
703	3	SID	51	2213	Digital Output 3 09 Circuit Failed High
703	4	SID	51	2213	Digital Output 3 09 Circuit Failed Low
704	3	SID	52	2214	Digital Output 4 07 Circuit Failed High
704	4	SID	52	2214	Digital Output 4 07 Circuit Failed Low
705	3	SID	53	2215	Digital Output 1 13 Circuit Failed High
705	4	SID	53	2215	Digital Output 1 13 Circuit Failed Low
706	3	SID	54	2221	Digital Output 3 10 Circuit Failed High
706	4	SID	54	2221	Digital Output 3 10 Circuit Failed Low
707	3	SID	55	2222	Digital Output 2 10 Circuit Failed High (CEL / AWL Lamp)
707	4	SID	55	2222	Digital Output 2 10 Circuit Failed Low (CEL / AWL Lamp)
708	3	SID	56	2223	Digital Output 3 12 Circuit Failed High
708	4	SID	56	2223	Digital Output 3 12 Circuit Failed Low
709	3	SID	257	2224	Digital Output 3 16 Circuit Failed High
709	4	SID	257	2224	Digital Output 3 16 Circuit Failed Low
710	3	SID	258	2225	Digital Output 4 06 Circuit Failed High
710	4	SID	258	2225	Digital Output 4 06 Circuit Failed Low
711	3	SID	259	2231	Digital Output 1 05 Circuit Failed High
711	4	SID	259	2231	Digital Output 1 05 Circuit Failed Low
712	3	SID	260	2232	Digital Output 1 04 Circuit Failed High
712	4	SID	260	2232	Digital Output 1 04 Circuit Failed Low
713	3	SID	261	2234	Digital Output 3 07 Circuit Failed High
713	4	SID	261	2234	Digital Output 3 07 Circuit Failed Low
713	5	SID	261	2234	Digital Output 3 07 Open Circuit
713	7	SID	261	2234	TOP2 Shift Failure
714	3	SID	262	2235	Digital Output 3 08 Circuit Failed High
714	4	SID	262	2235	Digital Output 3 08 Circuit Failed Low
714	5	SID	262	2235	Digital Output 3 08 Open Circuit
715	3	SID	263	2241	Digital Output 4 10 Circuit Failed High
904	9	SID	231	2615	J1939 EBC2 Message from ABS is missing

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODES	FAULT DESCRIPTION
904	19	SID	231	2242	J1939 Front Axle Speed Signal is erratic
904	13	SID	231	2242	J1939 Front Axle Speed Signal is missing
972	2	SID	203	2243	Throttle inhibit switch signal not plausible due to excess vehicle speed
973	9	SID	231	2615	J1939 EBC1 Message is missing
973	13	SID	231	2244	J1939 Engine Retarder Selection Signal Missing
973	19	SID	231	2244	J1939 Engine Retarder Selection Signal Erratic
974	2	PID	372	2245	Remote Accelerator Pedal Supply Voltage Out of Range
974	3	PID	372	2245	Remote Accelerator Pedal Circuit Failed High
974	4	PID	372	2245	Remote Accelerator Pedal Circuit Failed Low
981	0	SID	155	2311	PTO CC+ and CC- Switches Pressed Simultaneously
986	9	SID	231	2615	J1939 CM1 Message is missing
1267	4	SID	123	2312	Digital Output 4 10 Circuit Failed Low
1267	3	SID	123	2312	Digital Output 4 10 Circuit Failed Open
1321	4	SID	128	2314	Starter Lockout Output Shorted to Ground
1321	3	SID	128	2314	Starter Lockout Output Open Circuit
1590	19	SID	155	2615	Adaptive Cruise Control Message Not Received
1590	9	SID	231	2615	Adaptive Cruise Control Device Reporting Error
1624	9	SID	231	2615	J1939 TCO1 Message is missing
1624	19	SID	231	2315	J1939 Tachograph Vehicle Speed Signal is erratic
1624	13	SID	231	2315	J1939 Tachograph Vehicle Speed Signal is missing
1663	7	SID	123	2321	Optimized Idle Safety Loop Faulted
1716	9	SID	231	2615	J1939 ERC1 Message is missing
1845	9	SID	231	2615	J1939 TCFG2 Message is missing
2623	14	PID	91	2322	Pwm Accelerator Pedal GAS1 and GAS2 Signal Missing
2623	8	PID	91	2322	Pwm Accelerator Pedal Signal 2 Frequency Out Of Range
2900	9	SID	231	2615	J1939 ETC7 Message is missing
3510	3	SID	211	2333	Accelerator Pedal Supply Voltage Circuit Failed High
3510	4	SID	211	2333	Accelerator Pedal Supply Voltage Circuit Failed Low
3510	4	SID	211	2333	Pwm Accelerator Pedal Supply Voltage Missing
3510	3	SID	211	2333	Accelerator Pedal Supply Voltage Circuit Failed High
3606	9	SID	231	2615	J1939 ESS Message is missing

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODES	FAULT DESCRIPTION
3695	2	SID	155	2334	Manual DPF Regen and DPF Inhibit Switch Rationality Fault
3695	19	SID	155	2334	DPF Regen Inhibit MUX Switch Message Contains Data Error Indicator
3695	13	SID	155	2334	DPF Regen Inhibit MUX Switch Message Contains SNV Indicator
3695	9	SID	155	2334	DPF Regen Inhibit MUX Switch Message Stopped Arriving
3695	14	SID	155	2334	DPF Regen Inhibit MUX Switch Message Not Received this Ign Cycle
3696	19	SID	155	2335	DPF Regen Force MUX Switch Message Contains Data Error Indicator
3696	13	SID	155	2335	DPF Regen Force MUX Switch Message Contains SNV Indicator
3696	9	SID	155	2335	DPF Regen Force MUX Switch Message Stopped Arriving
3696	14	SID	155	2335	DPF Regen Force MUX Switch Message Not Received this Ign Cycle

2.11 DDEC VI MCM DIAGNOSTIC CODES LIST

SPN	FMI	PID/SID	PID/SID ID	FLASH CODE	FAULT DESCRIPTION
27	4	PID	27	1111	EGR Valve Position Circuit Failed Low
27	3	PID	27	1111	EGR Valve Position Circuit Failed High
27	2	PID	27	1111	EGR Valve Position Feedback Failed
27	0	PID	27	1111	EGR Valve Position Feedback Failed (High Box)
27	1	PID	27	1111	EGR Valve Position Feedback Failed (Low Box)
27	14	PID	27	1111	EGR Valve Position Positive Torque Error
27	7	PID	27	1111	EGR Valve Stuck Open
27	19	PID	27	1521	Smart Actuator Indicates EGR Position Error
51	4	SID	51	1112	Intake Air Throttle Circuit Failed Low
51	3	SID	51	1112	Intake Air Throttle Circuit Failed High
51	2	PID	51	1112	Intake Throttle Position Deviation Error
51	0	PID	51	1112	Intake Air Throttle Position High
51	1	PID	51	1112	Intake Air Throttle Position Low
51	7	PID	51	1112	Intake Throttle Auto Calibration Error
94	4	PID	94	1112	Fuel Compensation Pressure Sensor Circuit Failed Low
94	3	PID	94	1112	Fuel Compensation Pressure Sensor Circuit Failed High
94	1	PID	94	1112	Fuel Pressure Too High/Too Low
97	4	PID	97	1615	Water in Fuel Circuit Failed Low
97	3	PID	97	1615	Water in Fuel Circuit Failed High
98	1	PID	98	1114	Oil Level Circuit Failed Low
98	0	PID	98	1114	Oil Level Circuit Failed High
98	13	PID	98	1634	Oil Level Measurement, Configuration Error
98	14	PID	98	1634	Oil Level Measurement, Oil Level Too Low or Too High
100	4	PID	100	1114	Engine Oil Pressure Circuit Failed Low
100	3	PID	100	1114	Engine Oil Pressure Circuit Failed High
100	1	PID	100	1114	Engine Oil Pressure Low
100	2	PID	100	1114	Oil Pressure Plausibility - Engine Running
100	2	PID	100	1114	Oil Pressure Plausibility - Stop

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODE	FAULT DESCRIPTION
103	2	PID	103	1115	Turbocharger Speed Not Plausible
103	1	PID	103	1115	Turbo Charger Speed Below Threshold (High Box)
103	0	PID	103	1115	Turbo Charger Speed Above Threshold (Low Box)
103	4	PID	103	1115	Turbo Charger Speed Sensor Circuit Failed Low
103	3	PID	103	1115	Turbo Charger Speed Sensor Circuit Failed High
108	4	PID	108	1211	Barometric Pressure Circuit Failed Low
108	3	PID	108	1211	Barometric Pressure Circuit Failed High
108	2	PID	108	1211	Ambient Pressure Plausibility Fault (Low Box)
108	20	PID	108	1211	Ambient Pressure Plausibility Fault (High Box)
110	4	PID	110	1212	Engine Coolant Outlet Temperature Circuit Failed Low
110	3	PID	110	1212	Engine Coolant Outlet Temperature Circuit Failed High
110	0	PID	110	1212	Coolant Temperature High
110	14	PID	110	1212	Coolant Temperature / Engine Oil Temperature Plausibility Fault
110	2	PID	110	1212	Engine Coolant Sensor (OUT), General Temp. Plausibility Error
132	7	PID	132	1213	Intake Air Throttle Valve Closure Detection- Positive Torque
132	14	PID	132	1213	Intake Air Throttle Valve Closure Detection -Braking Condition
132	14	PID	322	1635	HC-Doser Fuel Pressure Not Plausible
132	1	PID	322	1213	Air Mass Flow Too Low
132	13	PID	132	1213	Air Mass Auto Calibration Failed
158	2	PID	43	1214	Ignition Switch Not Plausible
164	4	PID	164	1215	Rail Pressure Governor Sensor Circuit Failed Low
164	3	PID	164	1215	Rail Pressure Governor Sensor Circuit Failed High
164	0	PID	164	1215	Rail Pressure Governor (High Side) Error
164	0	PID	164	1215	Rail Pressure Governor (Low Side) Error
168	1	PID	168	1221	Battery Voltage Low
168	0	PID	168	1221	Battery Voltage High
171	4	PID	171	1222	Ambient Temperature Circuit Failed Low
171	3	PID	171	1222	Ambient Temperature Circuit Failed High
174	4	PID	174	1223	Fuel Temperature Circuit Failed Low
174	3	PID	174	1223	Fuel Temperature Circuit Failed High
174	2	PID	174	1223	Fuel Temperature Sensor, General Temp. Plausibility
174	0	PID	174	1223	Fuel Temperature Too High
175	4	PID	175	1224	Engine Oil Temperature Circuit Failed Low
175	3	PID	175	1224	Engine Oil Temperature Circuit Failed High
175	14	PID	175	1224	Engine Oil Temperature Sensor Plausibility Fault
175	2	PID	175	1224	Engine Oil Temperature Sensor, General Temp. Plausibility
190	2	PID	190	1225	Engine Speed High
354	4	PID	354	1231	Relative Humidity Circuit Failed Low
354	3	PID	354	1231	Relative Humidity Circuit Failed High
411	4	PID	411	1232	EGR Delta Pressure Sensor Circuit Low
411	3	PID	411	1232	EGR Delta Pressure Sensor Circuit High
411	0	PID	411	1232	EGR Differential Pressure Failed (High Box)
411	1	PID	411	1232	EGR Differential Pressure Failed (Low Box)
411	5	PID	411	1232	EGR Sampling Range Failed
411	13	PID	411	1232	EGR Delta Pressure Sensor Out Of Calibration
411	13	PID	411	1232	EGR Delta Pressure Sensor Out Of Calibration
412	3	PID	412	1233	EGR Temperature Sensor Circuit Failed High
412	4	PID	412	1233	EGR Temperature Sensor Circuit Failed Low
412	20	PID	412	1233	EGR Temperature Drift (High Box)
412	21	PID	412	1233	EGR Temperature Drift (Low Box)
412	2	PID	412	1233	EGR Temperature Sensor, General Temp. Plausibility Error

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODE	FAULT DESCRIPTION
412	0	PID	412	1512	EGR Temperature Very High
412	16	PID	412	1233	EGR Temperature Sensor / Temperature Too High
615	4	SID	155	1615	Reserved Monitoring Unit For Temperature Diagnostics, Circuit Failed Low MU_ISP_T_TBD4_SRL
615	3	SID	155	1615	Reserved Monitoring Unit For Temperature Diagnostics, Circuit Failed High MU_ISP_T_TBD4_SRH
615	4	SID	155	1615	Reserved Monitoring Unit For Temperature Diagnostics, Circuit Failed Low MU_ISP_T_TBD1_SRL
615	3	SID	155	1615	Reserved Monitoring Unit For Temperature Diagnostics, Circuit Failed High MU_ISP_T_TBD1_SRH
615	4	SID	155	1615	Reserved Monitoring Unit For Temperature Diagnostics, Circuit Failed Low MU_ISP_T_TBD2_SRL
615	3	SID	155	1615	Reserved Monitoring Unit For Temperature Diagnostics, Circuit Failed High MU_ISP_T_TBD2_SRH
615	4	SID	155	1615	Reserved Monitoring Unit For Temperature Diagnostics, Circuit Failed Low MU_ISP_T_TBD3_SRL
615	3	SID	155	1615	Reserved Monitoring Unit For Temperature Diagnostics, Circuit Failed High MU_ISP_T_TBD3_SRH
615	4	SID	155	1615	Catalyst Temperature Sensor Circuit High Input (Bank 1 Sensor 1)
615	3	SID	155	1615	Catalyst Temperature Sensor Circuit Low Input (Bank 1 Sensor 1)
615	4	SID	155	1615	Catalyst Temperature Sensor Circuit High (Bank 1 Sensor 2)
615	3	SID	155	1615	Catalyst Temperature Sensor Circuit Low (Bank 1 Sensor 2)
615	4	SID	51	1322	Water Pump 1 Circuit Failed Low
615	3	SID	51	1322	Water Pump 1 Circuit Failed High
615	5	SID	51	1322	Water Pump 1 Circuit Failed Open
615	4	SID	55	1331	Turbo Compound Valve Circuit Failed Low
615	3	SID	55	1331	Turbo Compound Valve Circuit Failed High
615	5	SID	55	1331	Turbo Compound Valve Circuit Failed Open
615	4	SID	259	1335	Turbo Brake Sleeve Circuit Failed Low
615	3	SID	259	1335	Turbo Brake Sleeve Circuit Failed High
615	5	SID	259	1335	Turbo Brake Sleeve Circuit Failed Open
615	4	SID	261	1355	Function 20 Circuit Failed Low
615	3	SID	261	1355	Function 20 Circuit Failed High
615	5	SID	261	1355	Function 20 Circuit Failed Open
615	3	SID	155	1451	Service Push Button Circuit Failed High
615	14	SID	155	1615	Turbocharger/Supercharger Boost System Performance
615	14	SID	155	1615	Starter Electronic Fault / ECU internal (Res)
615	14	SID	155	1615	Starter Jammed (Tooth to Tooth Jam)
615	14	SID	155	1615	Rail Pressure Governor, Valve Stays Open
615	14	SID	155	1615	MU_RPG_INT_MON_SRH, I Term Value Too High
615	14	SID	155	1615	Rail Pressure Governor, Leakage in High Pressure Too High
615	14	SID	155	1615	Rail Pressure Governor Sensor, Signal Drift
615	14	SID	155	1615	Rail Pressure Governor Sensor, Sensor Supply Line Broken
615	4	SID	155	1615	Compressor Differential Pressure Outlet Failed Low
615	3	SID	155	1615	Compressor Differential Pressure Outlet Failed High
615	14	SID	155	1615	Doser Metering and Safety Unit Valve Seals Check
615	14	SID	155	1615	High Pressure Pump, Leakage or TDC Position Wrong
615	4	SID	155	1615	Flap In Front of EGR Cooler Circuit Failed Low
615	3	SID	155	1615	Flap In Front of EGR Cooler Circuit Failed High
615	5	SID	155	1615	Flap In Front of EGR Cooler Circuit Failed Open
615	4	SID	155	1615	Water Pump 2 Circuit Failed Low

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODE	FAULT DESCRIPTION
615	3	SID	155	1615	Water Pump 2 Circuit Failed High
615	5	SID	156	1615	Water Pump 2 Circuit Failed Open
615	4	SID	157	1615	RCP Test Function 1 Circuit Failed Low
615	3	SID	158	1615	RCP Test Function 1 Circuit Failed High
615	5	SID	159	1615	RCP Test Function 1 Circuit Failed Open
615	4	SID	160	1615	RCP Test Function 2 Circuit Failed Low
615	3	SID	161	1615	RCP Test Function 2 Circuit Failed High
615	5	SID	162	1615	RCP Test Function 2 Circuit Failed Open
615	4	SID	163	1615	Volute Control Valve, Shorted to Ground
615	3	SID	164	1615	Volute Control Valve, Shorted to Battery
615	5	SID	165	1615	Volute Control Valve, Open Load
615	4	SID	166	1615	Volute Shut Off Valve, Shorted to Ground
615	3	SID	167	1615	Volute Shut Off Valve, Shorted to Battery
615	5	SID	168	1615	Volute Shut Off Valve, Open Load
615	4	SID	169	1615	Function 30 Circuit Failed Low
615	3	SID	170	1615	Function 30 Circuit Failed High
615	5	SID	171	1615	Function 30 Circuit Failed Open
615	4	SID	172	1615	Function 31 Circuit Failed Low
615	3	SID	173	1615	Function 31 Circuit Failed High
615	5	SID	174	1615	Function 31 Circuit Failed Open
615	14	SID	155	1453	Smart Remote Actuator 2, No Failsafe Mode, Motor Off
615	9	SID	155	1453	Smart Remote Actuator 2, Failsafe Mode, Motor Off
615	16	SID	155	1453	Smart Remote Actuator 2, Temperature Fault
615	7	SID	155	1453	Smart Remote Actuator 2, Failsafe Mode, Motor On
615	11	SID	155	1453	Smart Remote Actuator 2, Restricted Operability
615	15	SID	155	1453	Smart Remote Actuator 2, Temperature Warning
615	8	SID	155	1453	Smart Remote Actuator 2, Internal Test Running
615	31	SID	155	1453	Smart Remote Actuator 2, Unknown Error Code
615	13	SID	155	1454	Turbocharger Compressor Outlet Differential Pressure Sensor Out Of Calibration
615	13	SID	155	1454	Turbocharger Compressor Outlet Differential Pressure Sensor Out Of Calibration
615	19	SID	155	1637	Smart Actuator Indicates Actuator Position Error
625	2	SID	248	1234	Invalid Data on Engine CAN Link
625	9	SID	248	1234	No Data Received from Engine CAN Link
625	9	SID	248	1234	Engine CAN Low Wire Defect - (wire 1)
625	9	SID	248	1234	Engine CAN High Wire Defect - (wire 2)
630	12	SID	253	1452	EEPROM Read / Write Operation Failed
630	13	SID	253	1455	Calibration Data Not Plausible
630	13	SID	253	1455	Calibration Data Not Plausible (CPLD)
634	4	SID	40	1321	Constant Throttle Valve Circuit Failed Low
634	3	SID	40	1321	Constant Throttle Valve Circuit Failed High
634	5	SID	40	1321	Constant Throttle Valve Circuit Failed Open
636	1	SID	21	1235	Crankshaft Position Sensor Signal Voltage Too Low
636	3	SID	21	1235	Crankshaft Position Sensor Open Circuit
636	4	SID	21	1235	Crankshaft Position Sensor Short to Ground
636	8	SID	21	1235	Crankshaft Position Sensor Time Out
636	14	SID	21	1235	Crankshaft Position Sensor Pins Swapped

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODE	FAULT DESCRIPTION
636	2	SID	21	1235	No Match of Camshaft and Crankshaft Signals
641	4	SID	27	1542	Turbo Control Circuit Failed Low
641	3	SID	27	1542	Turbo Control Circuit Failed High
641	5	SID	27	1542	Turbo Control Circuit Open
641	14	SID	147	1241	Smart Remote Actuator 5 (VGT), No Failsafe Mode, Motor Off
641	9	SID	147	1241	Smart Remote Actuator 5 (VGT), Failsafe Mode, Motor Off
641	7	SID	147	1241	Smart Remote Actuator 5 (VGT), Failsafe Mode, Motor On
641	11	SID	147	1241	Smart Remote Actuator 5 (VGT), Restricted Operability
641	8	SID	147	1241	Smart Remote Actuator 5 (VGT), Internal Test Running
641	31	SID	147	1241	Smart Remote Actuator 5 (VGT), Unknown Error Code
647	4	SID	33	1334	Fan Stage 1 Circuit Failed Low
647	3	SID	33	1334	Fan Stage 1 Circuit Failed High
647	5	SID	33	1334	Fan Stage 1 Circuit Failed Open
651	14	SID	1	1242	Injector Cylinder #1 Needle Control Valve Abnormal Operation
651	10	SID	1	1242	Injector Cylinder #1 Needle Control Valve Abnormal Rate of Change
651	5	SID	1	1242	Injector Cylinder 1, Nozzle Control Valve or Spill Control Valve, Jammed Closed
651	7	SID	1	1242	Injector Cylinder 1, Nozzle Control Valve or Spill Control Valve, Jammed Open or Leakage
651	6	SID	1	1242	Injector Cylinder #1 Needle Control Valve, Valve Shorted Circuit
651	31	SID	1	1242	Engine Smoothness Control / Cylinder #1 Value Out of Range
652	14	SID	2	1243	Injector Cylinder #2 Needle Control Valve Abnormal Operation
652	10	SID	2	1243	Injector Cylinder #2 Needle Control Valve Abnormal Rate of Change
652	5	SID	2	1243	Injector Cylinder 2, Nozzle Control Valve or Spill Control Valve, Jammed Closed
652	7	SID	2	1243	Injector Cylinder 2, Nozzle Control Valve or Spill Control Valve, Jammed Open or Leakage
652	6	SID	2	1243	Injector Cylinder #2 Needle Control Valve, Valve Shorted Circuit
652	31	SID	2	1243	Engine Smoothness Control / Cylinder #2 Value Out of Range
653	14	SID	3	1244	Injector Cylinder #3 Needle Control Valve Abnormal Operation
653	10	SID	3	1244	Injector Cylinder #3 Needle Control Valve Abnormal Rate of Change
653	5	SID	3	1244	Injector Cylinder 3, Nozzle Control Valve or Spill Control Valve, Jammed Closed
653	7	SID	3	1244	Injector Cylinder 3, Nozzle Control Valve or Spill Control Valve, Jammed Open or Leakage
653	6	SID	3	1244	Injector Cylinder #3 Needle Control Valve, Valve Shorted Circuit
653	31	SID	3	1244	Engine Smoothness Control / Cylinder #3 Value Out of Range
654	14	SID	4	1245	Injector Cylinder #4 Needle Control Valve Abnormal Operation
654	10	SID	4	1245	Injector Cylinder #4 Needle Control Valve Abnormal Rate of Change
654	5	SID	4	1245	Injector Cylinder 4, Nozzle Control Valve or Spill Control Valve, Jammed Closed
654	7	SID	4	1245	Injector Cylinder 4, Nozzle Control Valve or Spill Control Valve, Jammed Open or Leakage
654	6	SID	4	1245	Injector Cylinder #4 Needle Control Valve, Valve Shorted Circuit
654	31	SID	4	1245	Engine Smoothness Control / Cylinder #4 Value Out of Range
655	14	SID	5	1251	Injector Cylinder #5 Needle Control Valve Abnormal Operation
655	10	SID	5	1251	Injector Cylinder #5 Needle Control Valve Abnormal Rate of Change
655	5	SID	5	1251	Injector Cylinder 5, Nozzle Control Valve or Spill Control Valve, Jammed Closed

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODE	FAULT DESCRIPTION
655	7	SID	5	1251	Injector Cylinder 5, Nozzle Control Valve or Spill Control Valve, Jammed Open or Leakage
655	6	SID	5	1251	Injector Cylinder #5 Needle Control Valve, Valve Shorted Circuit
655	31	SID	5	1251	Engine Smoothness Control / Cylinder #5 Value Out of Range
656	14	SID	6	1252	Injector Cylinder #6 Needle Control Valve Abnormal Operation
656	10	SID	6	1252	Injector Cylinder #6 Needle Control Valve Abnormal Rate of Change
656	5	SID	6	1252	Injector Cylinder 6, Nozzle Control Valve or Spill Control Valve, Jammed Closed
656	7	SID	6	1252	Injector Cylinder 6, Nozzle Control Valve or Spill Control Valve, Jammed Open or Leakage
656	6	SID	6	1252	Injector Cylinder #6 Needle Control Valve, Valve Shorted Circuit
656	31	SID	6	1252	Engine Smoothness Control / Cylinder #6 Value Out of Range
657	14	SID	7	1253	Injector Cylinder #7 Needle Control Valve Abnormal Operation
657	10	SID	7	1253	Injector Cylinder #7 Needle Control Valve Abnormal Rate of Change
657	6	SID	7	1253	Injector Cylinder #7 Needle Control Valve, Valve Shorted Circuit
657	31	SID	7	1253	Engine Smoothness Control / Cylinder #7 Value Out of Range
658	14	SID	8	1254	Injector Cylinder #8 Needle Control Valve Abnormal Operation
658	10	SID	8	1254	Injector Cylinder #8 Needle Control Valve Abnormal Rate of Change
658	6	SID	8	1254	Injector Cylinder #8 Needle Control Valve, Valve Shorted Circuit
658	31	SID	8	1254	Engine Smoothness Control / Cylinder #8 Value Out of Range
677	2	SID	39	1255	Starter Switch Inconsistent
677	5	SID	39	1255	Engine Starter Relay Circuit Failed Low
677	4	SID	39	1255	Engine Starter Relay Open Circuit
677	14	SID	39	1255	Starter Electronic Fault / ECU internal (Main)
677	7	SID	39	1255	Engine Starter Relay - Starter Does Not Engage
677	3	SID	39	1255	Engine Starter Relay Shorted to High Source
677	7	SID	39	1255	Engine Starter Relay Jammed
698	4	SID	58	1312	Gridheater Circuit Failed Low
698	3	SID	58	1312	Gridheater Circuit Failed High
698	5	SID	58	1312	Gridheater Circuit Failed Open
715	4	SID	263	1412	High Side Digital Output # 1 Circuit Failed Low
715	3	SID	263	1412	High Side Digital Output # 1 Circuit Failed High
715	5	SID	263	1412	High Side Digital Output # 2 Circuit Failed Open
716	4	SID	264	1413	High Side Digital Output # 2 Circuit Failed Low
723	1	SID	64	1415	Camshaft Position Sensor Signal Voltage Too Low
723	3	SID	64	1415	Camshaft Position Sensor Open Circuit
723	4	SID	64	1415	Camshaft Position Sensor Short to Ground
723	8	SID	64	1415	Camshaft Position Sensor Time Out
723	14	SID	64	1415	Camshaft Position Sensor Pins Swapped
729	4	PID	45	1421	Grid Heater Circuit Failed Low
729	14	PID	45	1421	Grid Heater Special Instructions
729	3	PID	45	1421	Grid Heater Circuit Failed High
729	7	PID	45	1421	Grid Heater Defect
729	0	PID	45	1421	Grid Heater Permanently On
1071	4	SID	60	1314	Fan Stage 2 Circuit Failed Low
1071	3	SID	60	1314	Fan Stage 2 Circuit Failed High
1071	5	SID	60	1314	Fan Stage 2 Circuit Failed Open
1072	4	SID	79	1422	Jake Brake Stage 1 Circuit Failed Low
1072	3	SID	79	1422	Jake Brake Stage 1 Circuit Failed High
1072	5	SID	79	1422	Jake Brake Stage 1 Circuit Failed Open

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODE	FAULT DESCRIPTION
1073	4	SID	80	1315	Jake Brake Stage 2 Circuit Failed Low
1073	3	SID	80	1315	Jake Brake Stage 2 Circuit Failed High
1073	5	SID	80	1315	Jake Brake Stage 2 Circuit Failed Open
1074	4	SID	81	1345	Exhaust Brake Circuit Failed Low
1074	3	SID	81	1345	Exhaust Brake Circuit Failed High
1074	5	SID	81	1345	Exhaust Brake Circuit Failed Open
1077	14	PID	164	1241	Rail Pressure Governor Error, Open Loop Error
1077	5	PID	164	1423	Rail Pressure Governor Error, Current Governor, Current Too Low
1077	7	PID	164	1423	Rail Pressure Governor Error, Pressure Governor, Pressure Not Plausible
1077	6	SID	155	1423	Rail Pressure Governor Error, Current Too High
1127	4	SID	273	1424	Turbocharger Compressor Outlet Pressure Circuit Failed Low
1127	3	SID	273	1424	Turbocharger Compressor Outlet Pressure Circuit Failed High
1172	4	PID	351	1425	Turbocharger Compressor Inlet Temperature Circuit Failed Low
1172	3	PID	351	1425	Turbocharger Compressor Inlet Temperature Circuit Failed High
1172	2	PID	351	1425	Coolant Temp/Compressor Inlet Temp Plausibility Error
1172	2	PID	351	1425	Turbocharger Compressor Inlet Temp. Sensor, General Temp. Plausibility Error
1176	4	SID	314	1431	Turbocharger Compressor Inlet Pressure Circuit Failed Low
1176	3	SID	314	1431	Turbocharger Compressor Inlet Pressure Circuit Failed High
1176	2	PID	314	1431	Compressor Pressure Plausibility Fault (High Box)
1176	5	PID	314	1431	Compressor Inlet Pressure Plausibility Fault (Delta)
1176	20	SID	314	1431	Compressor Inlet Pressure Plausibility Error, Pressure Too High (High Box)
1188	4	SID	32	1325	Waste Gate Circuit Failed Low
1188	3	SID	32	1325	Waste Gate Circuit Failed High
1188	5	SID	32	1325	Waste Gate Circuit Failed Open
1188	14	SID	32	1432	Smart Remote Actuator 1 (Wastegate), No Failsafe Mode, Motor Off
1188	9	SID	32	1432	Smart Remote Actuator 1 (Wastegate), Failsafe Mode, Motor Off
1188	16	SID	32	1432	Smart Remote Actuator 1 (Wastegate), Temperature Fault
1188	7	SID	32	1432	Smart Remote Actuator 1 (Wastegate), Failsafe Mode, Motor On
1188	11	SID	32	1432	Smart Remote Actuator 1 (Wastegate), Restricted Operability
1188	15	SID	32	1432	Smart Remote Actuator 1 (Wastegate), Temperature Warning
1188	8	SID	32	1432	Smart Remote Actuator 1 (Wastegate), Internal Test Running
1188	31	SID	32	1432	Smart Remote Actuator 1 (Wastegate), Unknown Error Code
1188	19	SID	32	1432	Smart Actuator Indicates Turbocharger Wastegate Position Error
1213	4	SID	257	1333	MIL Lamp Circuit Failed Low
1213	3	SID	257	1333	MIL Lamp Circuit Failed High
1213	5	SID	257	1333	MIL Lamp Circuit Failed Open
1323	31	SID	155	1433	Cylinder 1 Misfire detected
1323	14	SID	156	1434	Misfire Detected
1324	31	SID	155	1435	Cylinder 2 Misfire detected
1325	31	SID	155	1441	Cylinder 3 Misfire detected
1326	31	SID	155	1442	Cylinder 4 Misfire detected
1327	31	SID	155	1443	Cylinder 5 Misfire detected
1328	31	SID	155	1444	Cylinder 6 Misfire Detected
1329	31	SID	155	1445	Cylinder 7 Misfire Detected
1330	31	SID	155	1446	Cylinder 8 Misfire Detected
1351	4	SID	155	1615	Switchable Air Compressor Circuit Failed Low
1351	3	SID	155	1615	Switchable Air Compressor Circuit Failed High

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODE	FAULT DESCRIPTION
1351	5	SID	155	1615	Switchable Air Compressor Circuit Failed Open
1636	4	PID	105	1511	Intake Manifold Temperature Circuit Failed Low
1636	3	PID	105	1511	Intake Manifold Temperature Circuit Failed High
1636	2	PID	105	1511	Intake Manifold Temperature Plausibility Error
1636	21	PID	105	1511	Difference Intake Manifold Temperature and EGR Temp. Less Than Threshold (Low Box)
1636	2	PID	105	1511	Difference Intake Manifold and I Cooler Temperature Out Less Than Threshold (Low Box)
1636	2	PID	105	1511	Difference Intake Manifold and I Cooler Temperature Out Less Than Threshold (High Box)
1636	20	PID	105	1511	Intake Manifold Temperature Drift (Low Box)
1636	21	PID	105	1511	Intake Manifold Temperature Drift (High Box)
2629	4	PID	404	1513	Turbocharger Compressor Outlet Temperature Circuit Failed Low
2629	3	PID	404	1513	Turbocharger Compressor Outlet Temperature Circuit Failed High
2629	20	PID	404	1513	Turbocharger Out Temperature, Temperature Too High (Low Box)
2629	21	PID	404	1513	Turbocharger Out Temperature, Temperature Too Low (High Box)
2629	2	PID	404	1513	Turbocharger Compressor Outlet Temp. Sensor, General Temp. Plausibility Error
2630	4	SID	272	1514	Charge Air Cooler Outlet Temperature Circuit Failed Low
2630	3	SID	272	1514	Charge Air Cooler Outlet Temperature Circuit Failed High
2630	2	SID	272	1514	Charge Air Cooler Outlet Temperature Sensor Plausibility Error
2630	20	SID	272	1514	Charge Air Outlet Temperature Drift (Low box)
2630	21	SID	272	1514	Charge Air Outlet Temperature Drift (High box)
2631	4	SID	273	1515	Charge Air Cooler Outlet Pressure Circuit Failed Low
2631	3	SID	273	1515	Charge Air Cooler Outlet Pressure Circuit Failed High
2659	1	SID	277	1515	EGR Flow Target Error Diagnostic - Low Flow
2659	0	SID	277	1515	EGR Flow Target Error Diagnostic - High Flow
2791	4	PID	146	1521	EGR Valve Circuit Failed Low
2791	3	PID	146	1521	EGR Valve Circuit Failed High
2791	5	PID	146	1521	EGR Valve Circuit Failed Open
2791	7	SID	146	1521	EGR Valve Position Incorrect
2791	14	SID	146	1521	Smart Remote Actuator 3 (EGR), No Failsafe Mode, Motor Off
2791	9	SID	146	1521	Smart Remote Actuator 3 (EGR), Failsafe Mode, Motor Off
2791	16	SID	146	1521	Smart Remote Actuator 3 (EGR), Temperature Fault
2791	7	SID	146	1521	Smart Remote Actuator 3 (EGR), Failsafe Mode, Motor On
2791	11	SID	146	1521	Smart Remote Actuator 3 (EGR), Restricted Operability
2791	15	SID	146	1521	Smart Remote Actuator 3 (EGR), Temperature Warning
2791	8	SID	146	1521	Smart Remote Actuator 3 (EGR), Internal Test Running
2791	31	SID	146	1521	Smart Remote Actuator 3 (EGR), Unknown Error Code
2795	9	SID	269	1241	CAN3 Communication Error
2795	4	SID	269	1522	Position Waste Gate (VNT) Failed Low
2795	3	SID	269	1522	Position Waste Gate (VNT) Failed High
2795	2	SID	269	1522	VNT Valve Position Feedback Failed
2795	0	SID	269	1522	VNT Valve Position Feedback, Position Too Low (High Box)
2795	1	SID	269	1522	VNT Valve Position Feedback, Position Too High (Low Box)
2795	19	SID	147	1522	Smart Actuator Indicates Turbocharger Vane Position Error
2797	4	SID	317	1523	Injector Needle Control Valve Cylinder 1, 2, 3 Shorted to Ground
2797	4	SID	317	1524	Injector Needle Control Valve Cylinder 4, 5, 6 Shorted to Ground

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODE	FAULT DESCRIPTION
2797	4	SID	317	1615	Injector Needle Control Valve Bank 3, Shorted to Ground
2797	3	SID	317	1523	Injector Needle Control Valve Cylinder 1,2,3 Shorted to Battery
2797	3	SID	317	1524	Injector Needle Control Valve Cylinder 4,5,6, Shorted to Battery
2797	3	SID	317	1615	Injector Needle Control Valve Bank 3, Shorted to Battery
2798	4	SID	317	1615	Injector Spill Control Valve Cylinder 1, 2, 3 Shorted to Ground
2798	4	SID	317	1615	Injector Spill Control Valve Cylinder 4, 5, 6 Shorted to Ground
2798	4	SID	317	1615	Injector Spill Control Valve ("Amplifier") Bank 6, Shorted to Ground
2798	3	SID	317	1615	Injector Spill Control Valve Cylinder 1,2,3, Shorted to Battery
2798	3	SID	317	1615	Injector Spill Control Valve Cylinder 4,5,6, Shorted to Battery
2798	3	SID	317	1615	Injector Spill Control Valve ("Amplifier") Bank 6, Shorted to Battery
2988	4	SID	262	1411	EGR Water Cooling Regulator Circuit Failed Low
988	3	SID	262	1411	EGR Water Cooling Regulator Circuit Failed High
2988	5	SID	262	1411	EGR Water Cooling Regulator Circuit Failed Open
3050	0	SID	155	1525	Engine Air Flow Out of Range Low
3050	1	SID	324	1525	Active Regen Temp Out of Range Low
3058	13	PID	146	1615	EGR System Parametrization Failure
3064	13	SID	155	1615	DPF System Parametrization Failure
3242	4	PID	318	1531	DOC Inlet Temperature Circuit Failed Low
3242	3	PID	318	1531	DOC Inlet Temperature Circuit Failed High
3242	10	SID	318	1531	DOC Inlet Temperature Sensor Stuck
3242	2	SID	318	1531	DOC Inlet Temperature Sensor - Plausibility Error
3246	4	SID	320	1532	DPF Outlet Temperature Circuit Failed Low
3246	3	SID	320	1532	DPF Outlet Temperature Circuit Failed High
3246	14	SID	320	1532	Abnormal DPF Temperature Rise b)
3246	0	SID	320	1532	DPF Outlet Temperature High
3246	10	SID	320	1532	DPF Outlet Temperature Sensor Stuck
3246	2	SID	320	1532	DPF Outlet Sensor, General Temp. Plausibility
3246	31	SID	323	1532	Abnormal DPF Temperature Rise
3250	4	PID	322	1533	DOC Outlet Temperature Circuit Failed Low
3250	3	PID	322	1533	DOC Outlet Temperature Circuit Failed High
3250	14	PID	322	1533	Abnormal DOC Temperature Rise
3250	10	SID	322	1533	DOC Outlet Temperature Sensor Stuck
3250	2	SID	322	1533	DOC Outlet Temperature Sensor - Plausibility Error
3250	31	PID	322	1533	Abnormal DOC Temperature Rise
3250	0	PID	322	1533	DOC Outlet Temperature High
3251	0	SID	324	1534	DPF Pressure - Out of Range Very High
3251	1	SID	324	1534	DPF Pressure - Out of Range Low
3251	9	SID	324	1534	Abnormal Soot Rate
3251	16	SID	324	1534	DPF Pressure - Out of Range High
3358	4	SID	155	1535	EGR Pressure Failed Low
3358	3	SID	155	1535	EGR Pressure Failed High
3464	4	SID	59	1313	Intake Throttle Valve Circuit Failed Low
3464	3	SID	59	1313	Intake Throttle Valve Circuit Failed High
3464	5	SID	59	1313	Intake Throttle Valve Circuit Failed Open
3464	14	SID	59	1615	Intake Air Throttle Control Electrical Fault
3464	2	PID	51	1541	Intake Throttle Valve, Spring Response Time Not Plausible
3464	7	PID	51	1541	Intake Throttle Valve, Stuck

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODE	FAULT DESCRIPTION
3464	14	PID	51	1541	Intake Throttle Valve, Integrated Absolute Error Plausibility
3464	8	PID	51	1541	Intake Throttle Valve, Current Deviation Too High
3470	4	SID	57	1311	Actuator Turbo Compound Bypass Circuit Failed Low
3470	3	SID	57	1311	Actuator Turbo Compound Bypass Circuit Failed High
3470	5	SID	57	1311	Actuator Turbo Compound Bypass Circuit Failed Open
3471	4	SID	334	1323	HC Doser Circuit Failed Low
3471	3	SID	334	1323	HC Doser Circuit Failed High
3471	5	SID	334	1323	HC Doser Circuit Failed Open
3471	1	SID	155	1542	EDV Failed Self Test
3480	2	SID	332	1543	Doser Fuel Line Pressure Abnormal
3480	1	SID	332	1543	Doser Fuel Supply Pressure Abnormal
3480	14	SID	332	1543	Doser FLP Sensors Failed Self Test
3482	4	SID	56	1332	Fuel Cut Off Valve Circuit Failed Low
3482	3	SID	56	1332	Fuel Cut Off Valve Circuit Failed High
3482	5	SID	56	1332	Fuel Cut Off Valve Circuit Failed Open
3482	7	SID	155	1544	FCV Failed Self Test
3509	3	SID	212	1631	Multiplexer 1 Channel 1, Shorted High
3509	3	SID	212	1631	Multiplexer 1 Channel 2, Shorted High
3510	3	SID	211	1632	Multiplexer 2 Channel 1, Shorted High
3510	3	SID	211	1632	Multiplexer 2 Channel 2, Shorted High
3511	3	SID	211	1633	Multiplexer 3 Channel 1, Shorted High
3511	3	SID	211	1633	Multiplexer 3 Channel 2, Shorted High
3556	1	SID	155	1545	Regen Temperature - Out of Range Low
3556	0	SID	155	1551	Regen Temperature - Out of Range High
3563	4	PID	106	1551	Intake Manifold Pressure Circuit Failed Low
3563	3	PID	106	1551	Intake Manifold Pressure Circuit Failed High
3563	20	PID	106	1551	Ambient and Inlet Manifold Pressure Difference (Low Box)
3563	21	PID	106	1551	Ambient and Inlet Manifold Pressure Difference (High Box)
3563	1	PID	106	1551	Inlet Manifold Pressure Failed Low
3563	0	PID	106	1551	Inlet Manifold Pressure Failed High
3563	3	PID	106	1551	Inlet Manifold Pressure Sampling Range Failed
3563	20	PID	106	1551	Intake Manifold Pressure Plausibility (Low Box)
3563	21	PID	106	1551	Intake Manifold Pressure Plausibility Error, Pressure Too Low (High Box)
3588	4	SID	156	1552	Ether Start, Shorted to Ground
3588	3	SID	157	1552	Ether Start, Shorted to Battery
3588	5	SID	158	1552	Ether Start, Open Load
3597	3	SID	155	1553	Proportional Valve Bank 1 Circuit Failed Low
3597	3	SID	155	1615	Proportional Valve Bank 1 Circuit Failed High
3597	6	SID	155	1325	Current Flow on HS1 IM1 Too High
3598	4	SID	155	1615	Proportional Valve Bank 2 Circuit Failed Low
3598	3	SID	155	1615	Proportional Valve Bank 2 Circuit Failed High
3599	4	SID	317	1615	Switching Power Supply Voltage Failed Low
3599	3	SID	317	1615	Switching Power Supply Voltage Failed High
3609	4	PID	370	1554	DPF Inlet Pressure Circuit Failed Low
3609	3	PID	370	1554	DPF Inlet Pressure Circuit Failed High
3609	10	SID	370	1554	DPF Inlet Pressure Sensor Stuck
3609	20	SID	370	1554	DPF Inlet Pressure Sensor Drifted High In Range Fault (Low Box)
3609	2	SID	370	1554	DPF Inlet Pressure Sensor Drifted High In Range Fault (High Box)
3609	21	SID	370	1554	DPF Inlet Pressure Sensor Drifted Low In Range Fault (Low Box)
3609	21	SID	370	1554	DPF Inlet Pressure Sensor Drifted Low In Range Fault (High Box)

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODE	FAULT DESCRIPTION
3610	3	SID	371	1555	DPF Outlet Pressure Circuit Failed High
3610	4	SID	371	1555	DPF Outlet Pressure Circuit Failed Low
3610	0	SID	371	1334	DPF System Back Pressure Too High
3610	10	SID	371	1555	DPF Outlet Pressure Sensor Stuck
3610	2	SID	371	1555	DPF Pressure Sensors - Plausibility Error
3610	20	SID	371	1555	DPF Outlet Pressure Sensor Drifted High In Range Fault (Low Box)
3610	14	SID	371	1555	DPF Outlet Pressure Sensor Drifted High In Range Fault (High Box)
3610	21	SID	371	1555	DPF Outlet Pressure Sensor Drifted Low In Range Fault (Low Box)
3610	31	SID	371	1555	DPF Outlet Pressure Sensor Drifted Low In Range Fault (High Box)
3659	14	SID	362	1611	Injector Cylinder #1 Spill Control Valve Abnormal Operation
3659	10	SID	362	1611	Injector Cylinder #1 Spill Control Valve ("Amplifier") Abnormal Rate of Change
3659	6	SID	362	1611	Injector Cylinder #1 Spill Control Valve ("Amplifier"), Valve Shorted Circuit
3660	14	SID	363	1612	Injector Cylinder #2 Spill Control Valve Abnormal Operation
3660	10	SID	363	1612	Injector Cylinder #2 Spill Control Valve ("Amplifier") Abnormal Rate of Change
3660	6	SID	363	1612	Injector Cylinder #2 Spill Control Valve ("Amplifier"), Valve Shorted Circuit
3661	14	SID	364	1613	Injector Cylinder #3 Spill Control Valve Abnormal Operation
3661	10	SID	364	1613	Injector Cylinder #3 Spill Control Valve ("Amplifier") Abnormal Rate of Change
3661	6	SID	364	1613	Injector Cylinder #3 Spill Control Valve ("Amplifier"), Valve Shorted Circuit
3662	14	SID	365	1614	Injector Cylinder #4 Spill Control Valve Abnormal Operation
3662	10	SID	365	1614	Injector Cylinder #4 Spill Control Valve ("Amplifier") Abnormal Rate of Change
3662	6	SID	365	1614	Injector Cylinder #4 Spill Control Valve ("Amplifier"), Valve Shorted Circuit
3663	14	SID	366	1615	Injector Cylinder #5 Spill Control Valve Abnormal Operation
3663	10	SID	366	1615	Injector Cylinder #5 Spill Control Valve ("Amplifier") Abnormal Rate of Change
3663	6	SID	366	1615	Injector Cylinder #5 Spill Control Valve ("Amplifier"), Valve Shorted Circuit
3664	14	SID	367	1621	Injector Cylinder #6 Spill Control Valve Abnormal Operation
3664	10	SID	367	1621	Injector Cylinder #6 Spill Control Valve ("Amplifier") Abnormal Rate of Change
3664	6	SID	367	1621	Injector Cylinder #6 Spill Control Valve ("Amplifier"), Valve Shorted Circuit
3665	14	SID	368	1622	Injector Cylinder #7 Spill Control Valve Abnormal Operation
3665	10	SID	368	1622	Injector Cylinder #7 Spill Control Valve ("Amplifier") Abnormal Rate of Change
3665	6	SID	368	1622	Injector Cylinder #7 Spill Control Valve ("Amplifier"), Valve Shorted Circuit
3666	14	SID	369	1623	Injector Cylinder #8 Spill Control Valve Abnormal Operation
3666	10	SID	369	1623	Injector Cylinder #8 Spill Control Valve ("Amplifier") Abnormal Rate of Change
3666	6	SID	369	1623	Injector Cylinder #8 Spill Control Valve ("Amplifier"), Valve Shorted Circuit
3719	16	SID	155	1624	Soot Level High
3719	0	SID	155	1624	Soot Level Very High
3719	31	SID	155	1635	DPF Zone 2 Condition
3719	15	SID	155	1636	DPF Zone 3 Condition

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SPN	FMI	PID/SID	PID/SID ID	FLASH CODE	FAULT DESCRIPTION
3720	15	SID	155	1625	DPF Ash Clean Request
3720	16	SID	155	1625	DPF Ash Clean Request - Derate
4076	4	PID	110	1212	Engine Coolant Inlet Temperature Circuit Failed Low
4076	3	PID	110	1212	Engine Coolant Inlet Temperature Circuit Failed High
4076	2	SID	155	1615	Engine Coolant Sensor (IN), General Temp. Plausibility Error
4077	4	SID	332	1543	Doser Fuel Line Pressure Sensor Circuit Failed Low
4077	3	SID	332	1543	Doser Fuel Line Pressure Sensor Circuit Failed High
4077	14	SID	332	1543	Doser Fuel Line Pressure Failed Self Test
4226	4	SID	155	1615	Compressor Differential Pressure Inlet Failed Low
4226	3	SID	155	1615	Compressor Differential Pressure Inlet Failed High
4226	0	SID	155	1615	Turbocharger Compressor Inlet Differential Pressure Too High (Low Box)
4226	1	SID	155	1615	Turbocharger Compressor Inlet Differential Pressure Too Low (High Box)
4226	5	SID	155	1615	Turbocharger Compressor Inlet Differential Pressure Sampling Range Failure
4226	13	SID	155	1454	Turbocharger Compressor Inlet Differential Pressure Sensor Out Of Calibration
4226	13	SID	155	1454	Turbocharger Compressor Inlet Differential Pressure Sensor Out Of Calibration
4227	4	SID	53	1324	Electrostatic Oil Separator Circuit Failed Low
4227	3	SID	53	1324	Electrostatic Oil Separator Circuit Failed High
4227	5	SID	53	1324	Electrostatic Oil Separator Circuit Failed Open
4227	4	SID	155	1615	Oil Separator Circuit Failed Low
4227	3	SID	155	1615	Oil Separator Circuit Failed High
4227	7	SID	155	1615	Oil Separator, Max. Duration Time Reached
4228	16	SID	147	1241	Smart Remote Actuator 5 (VGT), Temperature Fault
4228	15	SID	147	1241	Smart Remote Actuator 5 (VGT), Temperature Warning

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2.12 ENGINE OIL LEVEL

 **MAINTENANCE**


Check the oil level daily with the engine stopped. If the engine has just been stopped and is warm, wait at least 10 minutes to allow the oil to drain back to the oil pan before checking. Wipe the dipstick clean then check oil level. The level should always be within the safe range on the dipstick (Fig. 20). Add the proper grade of oil to maintain the correct level on the dipstick. All diesel engines are designed to consume some oil, so a periodic addition of oil is normal.

 **WARNING**

Touching a hot engine can cause serious burns.

 **CAUTION**

Do not overfill. Oil may be blown out through the crankcase breather if the crankcase is overfilled.

 **CAUTION**

Clean end of tube before removing the dipstick to prevent oil contamination.

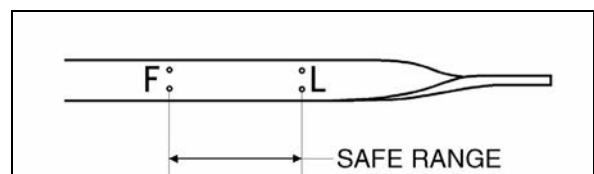



FIGURE 20: ENGINE OIL LEVEL DIPSTICK 01027

 **CAUTION**

If the oil level is constantly above normal and excess lube oil has not been added to the crankcase, consult with an authorized Detroit Diesel service outlet for the cause. Fuel or coolant dilution of lube oil can result in serious engine damage.

The vehicle may be provided with an oil reserve tank in the engine compartment. To adjust oil level, open the oil reserve tank drain valve and allow oil to discharge into the engine until the "Full" mark on the dipstick is reached then close the valve. Check oil reserve tank level and pour oil in the reserve tank if necessary (Fig. 21).

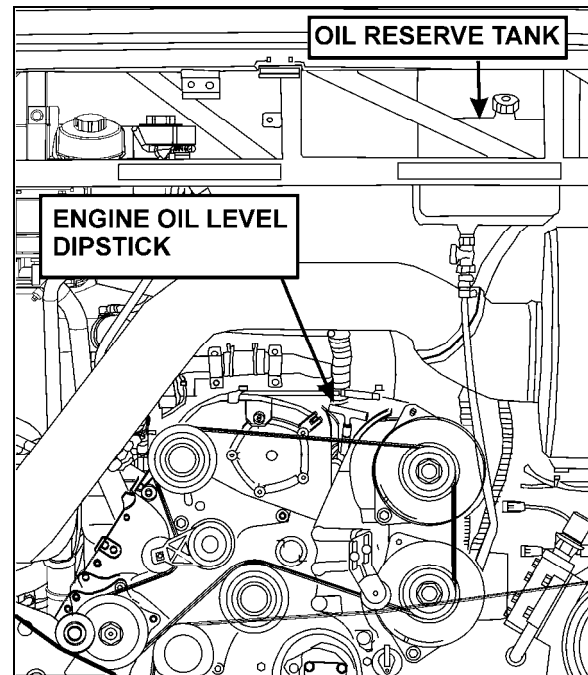



FIGURE 21: OIL RESERVE TANK 01187

2.13 ENGINE OIL AND FILTER CHANGE

 **MAINTENANCE**

Both the engine oil and filter should be changed according to the following maximum interval (based on an oil analysis program).

Short Haul: 15,000 miles (24,000km) or once a year, whichever comes first.

Long Haul: 30,000 miles (48,000km) or once a year, whichever comes first.

Oil analysis program may be used to determine whether this interval should be shorter, but should not be used to lengthen the interval.

Short haul: 6,000 miles (10,000km) to 60,000 miles (100,000 km) annual.

Long haul: over 60,000 miles (100,000 km) annual.

However, changes that are more frequent may be required when the engine is subject to high levels of contamination and/or overheating. Change intervals may be decreased or gradually increased with experience on specific lubricants until the most practical service condition has been established. Always refer to the lubricant manufacturer's recommendations (analysis of drained oil can be helpful).

**CAUTION**

Do not use solvents to dilute the engine oil when draining. Dilution of fresh oil can occur which may be detrimental to the engine.

Change engine oil with the vehicle on a flat and level surface and with the parking brake applied. It is best to drain the oil when the engine is still warm.

1. From under the vehicle, remove the engine drain plug on the oil pan. Allow oil to drain (Fig. 22).

**WARNING**

Hot engine oil can cause serious burns. Wear coveralls with sleeves pulled down and gloves to protect hands.

2. Reinstall the drain plug.
3. Remove the spin-on filter cartridge using a ½" drive socket wrench and extension.
4. Dispose of the used oil and filter in an environmentally responsible manner in accordance with state and/or federal (EPA) recommendations.

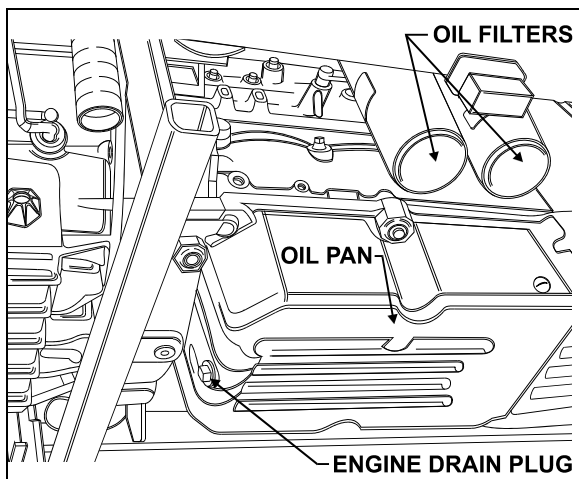


FIGURE 22: ENGINE DRAIN PLUG AND OIL FILTERS
01029

5. Clean the filter adapter with a clean rag.
6. Lightly coat the filter gasket (seal) with clean engine oil.
7. Install the new filter on the adapter and tighten manually until the gasket touches the mounting adapter head. Tighten full-flow filters an additional two-thirds of a turn manually. Then, manually tighten bypass filter one full turn.

**CAUTION**

Overtightening may distort or crack the filter adapter.

8. Remove the engine-oil filler cap and pour oil in the engine until it reaches the "FULL" mark on the dipstick (Fig. 20).
9. Start and run the engine for a short period and check for leaks. After any leaks have been corrected, stop the engine long enough for oil from various parts of the engine to drain back to the crankcase (approximately 20 minutes).
10. Add oil as required to bring the level within the safe range on the dipstick (Fig. 20).

**MAINTENANCE**

Engine oil temperature should be checked every 25,000 miles (40 000 km) to determine oil cooler efficiency. This check should be made by inserting a steel jacketed thermometer in the dipstick opening, immediately after stopping a hot, loaded engine. If the oil temperature exceeds the coolant temperature by more than 60 °F (33 °C), the oil cooler may be clogged.

For detailed oil specifications, refer to DETROIT DIESEL SERIES 60 2007 ON-HIGHWAY SERVICE MANUAL 6SE2007 under heading «*Lubricating Oil for Detroit Diesel Engines*».

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2.14 RECOMMENDED ENGINE OIL TYPE

To provide maximum engine life, lubricants shall meet the following specifications: SAE Viscosity Grade: 15W-40 API Classification: CJ-4.



CAUTION

Low ash oil formulation designated API CJ-4 is required in EPA-07 engines.

CJ-4 contains less than 1% ash which is the key to achieving maximum diesel particulate filter cleaning intervals. Use of high ash engine oils will reduce the cleaning interval on the Diesel Particulate Filter (DPF). DPF regenerates the combustible soot, but the ash (a product of the oil lubricant package) slowly accumulates in the channels of the DPF.

NOTE

Monograde oils should not be used in these engines regardless of API Service Classification.

NOTE

The use of supplemental oil additives is discouraged from use in Detroit Diesel Engines.

Synthetic oils: Synthetic oils may be used in Detroit Diesel engines provided they are API-licensed and meet the performance and chemical requirements of non-synthetic oils outlined previously. Synthetic oils do not permit extension of recommended oil drain intervals.

2.15 POWER PLANT ASSEMBLY REMOVAL

To access the engine or engine-related components, the vehicle power plant assembly must be removed as a whole unit by means of a slide-out cradle. The power plant assembly includes the engine, transmission (including retarder if so equipped), air compressor, alternator and transmission oil cooler.

Remove the power plant assembly as follows:



CAUTION

Tag hoses and cables for identification before disconnecting in order to facilitate reinstallation. Plug all openings to prevent dirt from entering the system.

NOTE

No parts within the MCM are serviceable. If found defective, replace the MCM as a unit.

1. Disconnect the battery or batteries from the starting system by removing one or both of the battery cables from each battery system. With the electrical circuit disrupted, accidental contact with the starter button will not produce an engine start. In addition, the Electronic Unit Injectors (EUI) will be disabled, preventing any fuel delivery to the injector tips.



WARNING

Due to the heavy load of the rear bumper assembly, it must be adequately supported before attempting to remove it.

2. Remove the rear bumper assembly from the vehicle. Refer to Section 18, BODY, under "REAR BUMPER REMOVAL".
3. Drain the engine cooling system. Refer to Section 05, COOLING under "DRAINING COOLING SYSTEM".

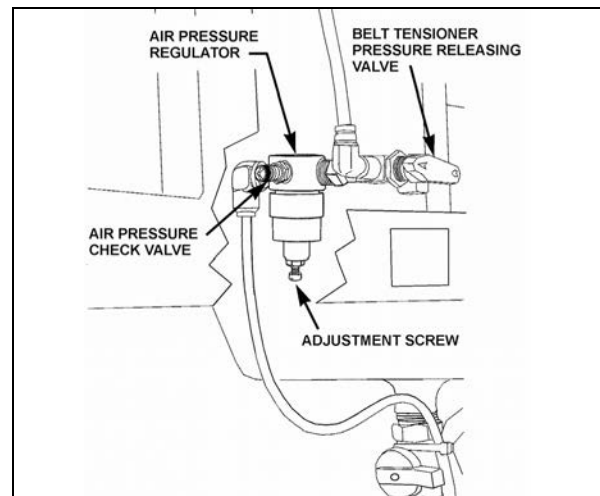


FIGURE 23: BELT TENSIONER VALVE

12200

4. Locate the A/C compressor belt tensioner pressure releasing valve (Fig. 23). Turn pressure releasing valve handle counterclockwise in order to release pressure in belt-tensioner air bellows and loosen belts. Remove the belts.
5. To release all pressure from the air system. Refer to Section 12, BRAKES & AIR SYSTEM for instructions.

6. Disconnect and remove the engine-air intake duct mounted between air cleaner housing and turbocharger inlet.

**CAUTION**

To avoid damage to turbocharger, cover the turbocharger inlet opening to prevent foreign material from entering.

7. Disconnect and remove the air intake duct mounted between the air cooler outlet and the engine intake.
8. Disconnect and remove section of coolant pipe assembly mounted between the radiator outlet and the water pump inlet.
9. Disconnect the coolant delivery hose located close to the water pump.
10. Disconnect the electric fan-clutch connector located near the cooling fan right angle gearbox.
11. Disconnect the cooling fan drive shaft.
12. Disconnect and remove the air intake duct mounted between the turbocharger outlet and the air cooler inlet.
13. Disconnect two vent hoses from the thermostat housing and from the coolant pipe assembly.
14. Disconnect and remove a section of coolant pipe assembly mounted between the thermostat housings and the radiator inlet.
15. Disconnect and remove the small hose connected to the heater line valve and to the water pump.
16. Disconnect the small heater hose located on the cylinder head at the back of the engine.
17. Disconnect and remove the exhaust pipe mounted between the turbocharger outlet and the flexible coupling. If necessary, refer to Section EXHAUST SYSTEM under "EXHAUST AND AFTERTREATMENT SYSTEM OVERVIEW".

**CAUTION**

To avoid damage to turbocharger, cover the turbocharger outlet opening to prevent foreign material from entering.

18. Disconnect the steel-braided airline from the A/C compressor air bellows.
19. Remove the power steering pump, leaving the supply and discharge hoses connected to it.
20. Disconnect the oil delivery hose from the valve located at the reserve tank drain .
21. Disconnect the block heater connector located near the power steering pump if applicable.
22. Close engine fuel supply shutoff valve on primary fuel filter. Disconnect the fuel line connected to inlet port. On vehicles equipped with the optional water-separator-fuel-filter, disconnect the connector and remove cable ties from cradle.
23. Disconnect the air compressor discharge, governor steel-braided airlines and manual filling airlines from compressor. Remove retaining clips.
24. Disconnect the hose connecting the compressor head to the sump tank.
25. Disconnect ground cables from rear subframe ground-stud located close to the starter motor.
26. Disconnect positive cable (red terminal) from starting motor solenoid.
27. Disconnect VIH (vehicle interface harness) connector from MCM.
28. On vehicles equipped with an automatic transmission provided with a hydraulic output retarder, disconnect steel-braided airline from pressure regulator output. The pressure regulator is mounted in the upper section of engine compartment backwall and is accessible through the engine compartment R.H. side door.
29. Disconnect fuel return line from bulkhead fixed on engine cylinder head end.
30. On vehicles equipped with an electrically operated cold-starting aid, disconnect the delivery hose from the starting-aid cylinder solenoid valve. Remove cable ties securing hoses.
31. Disconnect turbo boost pressure gauge airline from engine air intake.
32. Disconnect connectors from transmission. On the left side: four on rear side with one

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close to yoke. On right side: close to the solenoid valve of the output retarder.

33. From under the vehicle, disconnect the propeller shaft as detailed in Section 09, under heading "Propeller Shaft Removal".
34. Inspect the power plant assembly to ensure that nothing will interfere when sliding out the cradle. Check for connections or hoses not mentioned in this list as some vehicles are equipped with special or aftermarket components.
35. Remove the six retaining bolts, washers and nuts securing the power plant cradle to the vehicle rear subframe (Fig. 25).

NOTE

Check if any spacer(s) have been installed between power plant cradle and vehicle rear subframe, and if so, note position of each washer for reinstallation purposes.

36. Using a suitable equipment, with a minimum capacity of 4,000 lbs (1 800 kg), slightly raise the power plant cradle.
37. Pull engine out slowly from the engine compartment. Make sure all lines, wiring and accessories are disconnected and are not tangled.



CAUTION

Due to the minimum clearance between the power plant equipment and the top of the engine compartment, extreme care should be used to raise the power plant cradle, just enough to free the cradle. Clearance between power plant cradle and mounting rail should range between ¼" and ½" (6-12 mm).

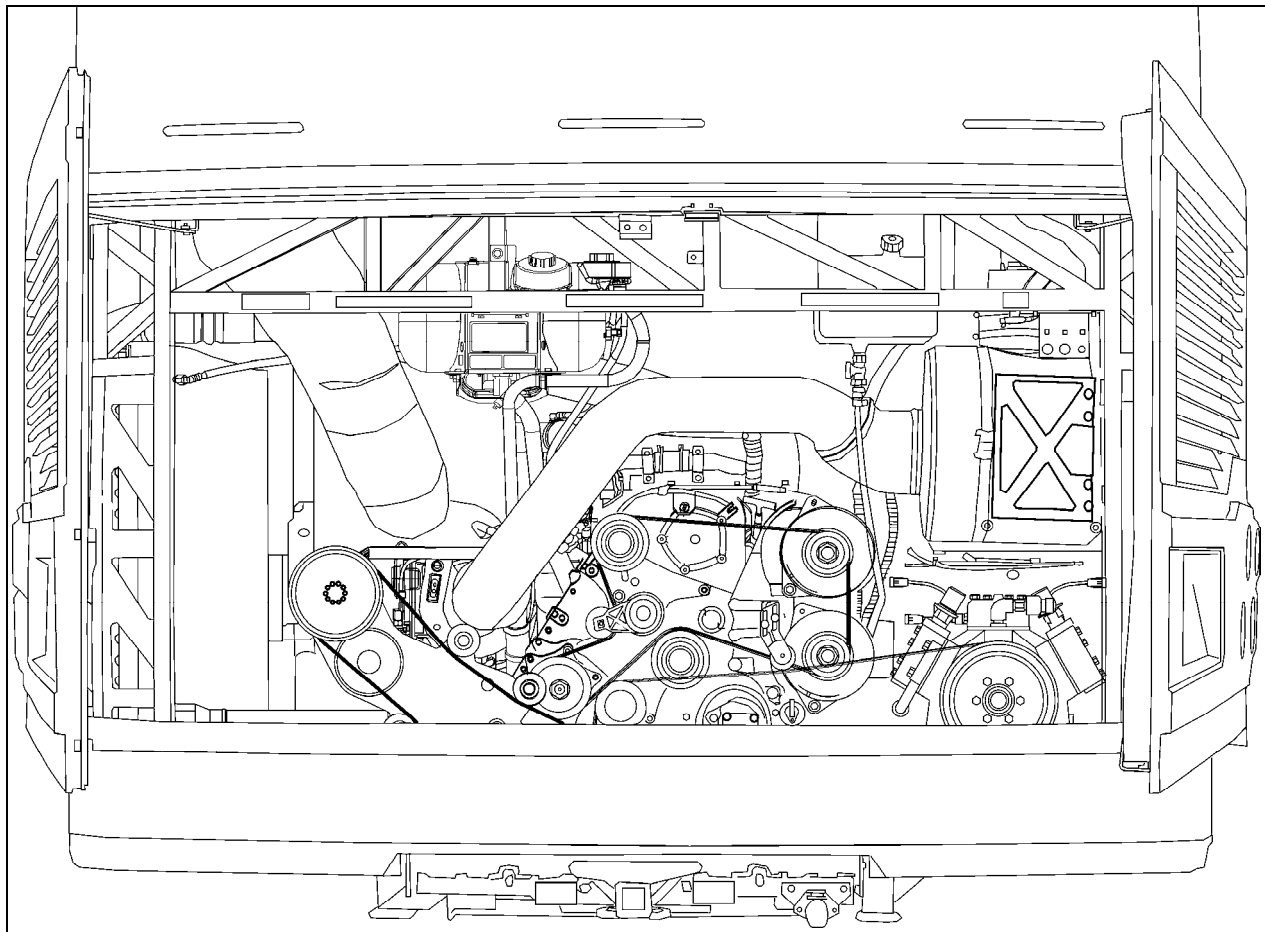


FIGURE 24: ENGINE COMPARTMENT X3 COACHES (TYPICAL)

01184_A

2.16 POWER PLANT ASSY. INSTALLATION

To install a power plant assembly, follow the same procedure as in "Power Plant Assembly Removal" except in reverse order, then proceed with the following:

1. Torque the power plant cradle mounting bolts to 190 lbf-ft (255 Nm).
2. If fan drive has been removed, reinstall and align as per Section 05, COOLING SYSTEM, under "FAN DRIVE ALIGNMENT".
3. Refill cooling system with saved fluid (refer to Section 05, COOLANT SYSTEM).
4. Once engine fuel system has been drained, it will aid restarting if fuel filters are filled with fuel oil (refer to Section 03, FUEL SYSTEM).
5. Start engine for a visual check. Check fuel, oil, cooling, pneumatic and hydraulic system connections for leakage. Test operation of engine controls and accessories.

2.17 JAKE BRAKE

Refer to both "The Jake Brake Troubleshooting and Maintenance Manual" and "Installation Manual for Model 790 Engine Brakes" for troubleshooting and installation procedures. They are annexed at the end of this section.

2.18 ENGINE MOUNTS

The power plant assembly is mounted to the cradle by means of rubber mounts.

Two rubber mounts are used at the front of the engine while two others are mounted on each side of the flywheel housing (Fig. 25).

It is recommended that new rubber mounts be installed at each major overhaul.

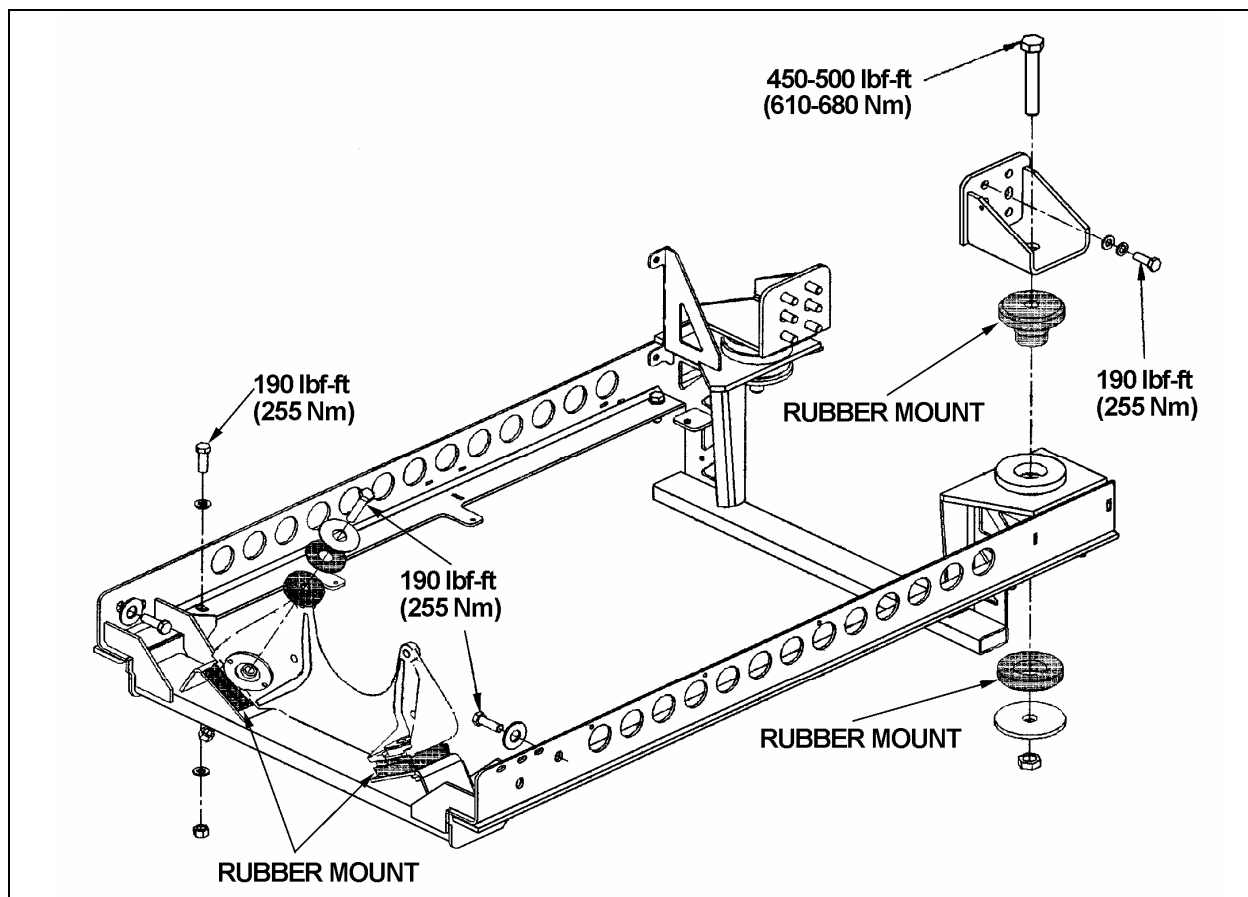


FIGURE 25: DDC SERIES 60 POWER PLANT CRADLE INSTALLATION

01140

3. ELECTRONIC FOOT PEDAL ASSEMBLY (EFPA) & THROTTLE POSITION SENSOR

The Electronic Foot Pedal Assembly (EFPA) connects the accelerator pedal to a Throttle Position Sensor (TPS). The (TPS) is a device, which sends an electrical signal to the Motor Control Module (MCM). The TPS varies in voltage depending on how far the pedal is depressed. The system is installed in the space normally occupied by a mechanical foot pedal. The (EFPA) has maximum and minimum stops that are built into the unit during manufacturing (Fig. 26). The (TPS) converts the operator's foot pedal input into a signal for the MCM.

When installed by the equipment manufacturer, the TPS should not require adjustment. If the TPS is suspected of being misadjusted, confirm that the sensor is installed in accordance with the manufacturer's specifications. It is recommended that the idle count be at 50 or higher with a full throttle count of up to 200.

The TPS is self-calibrating and therefore has no optimum closed throttle or wide open throttle count value. If the counts are within the 50 to 200 range, the sensor is properly set.

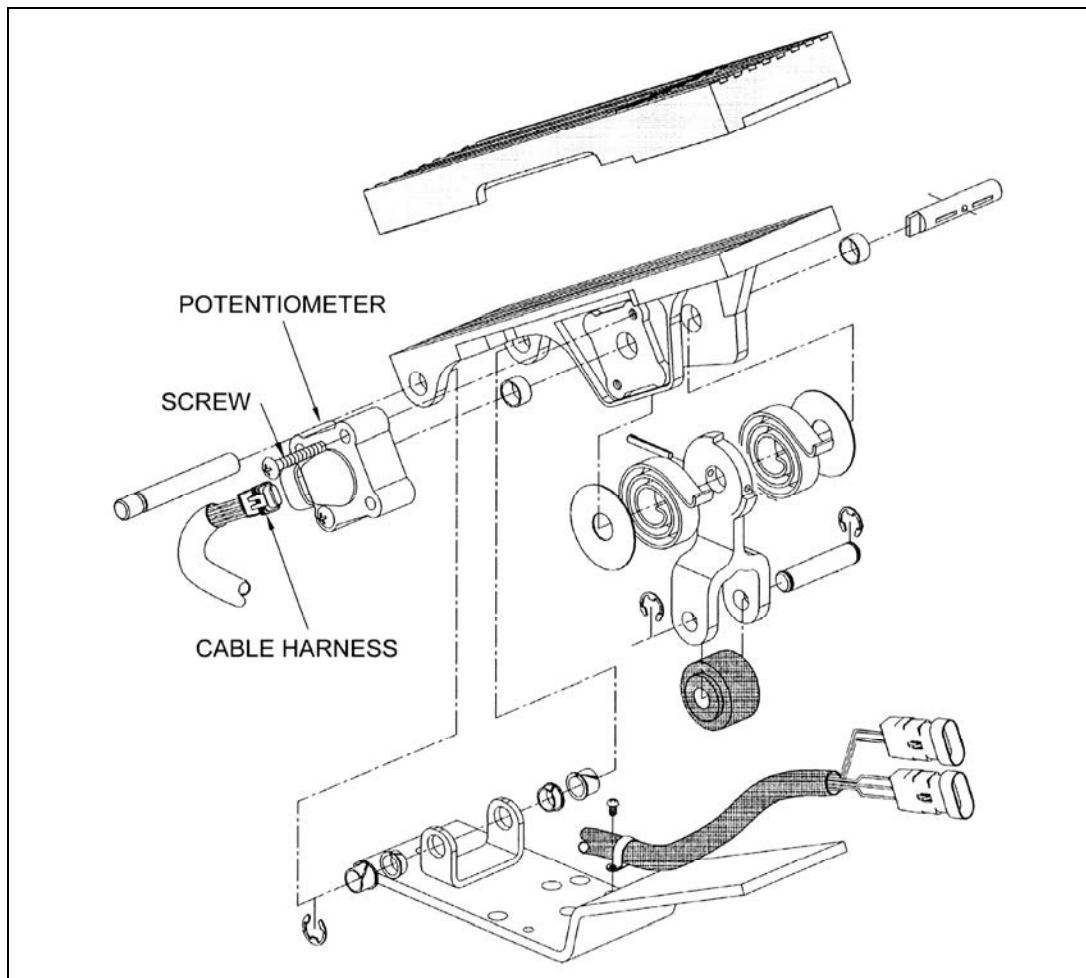
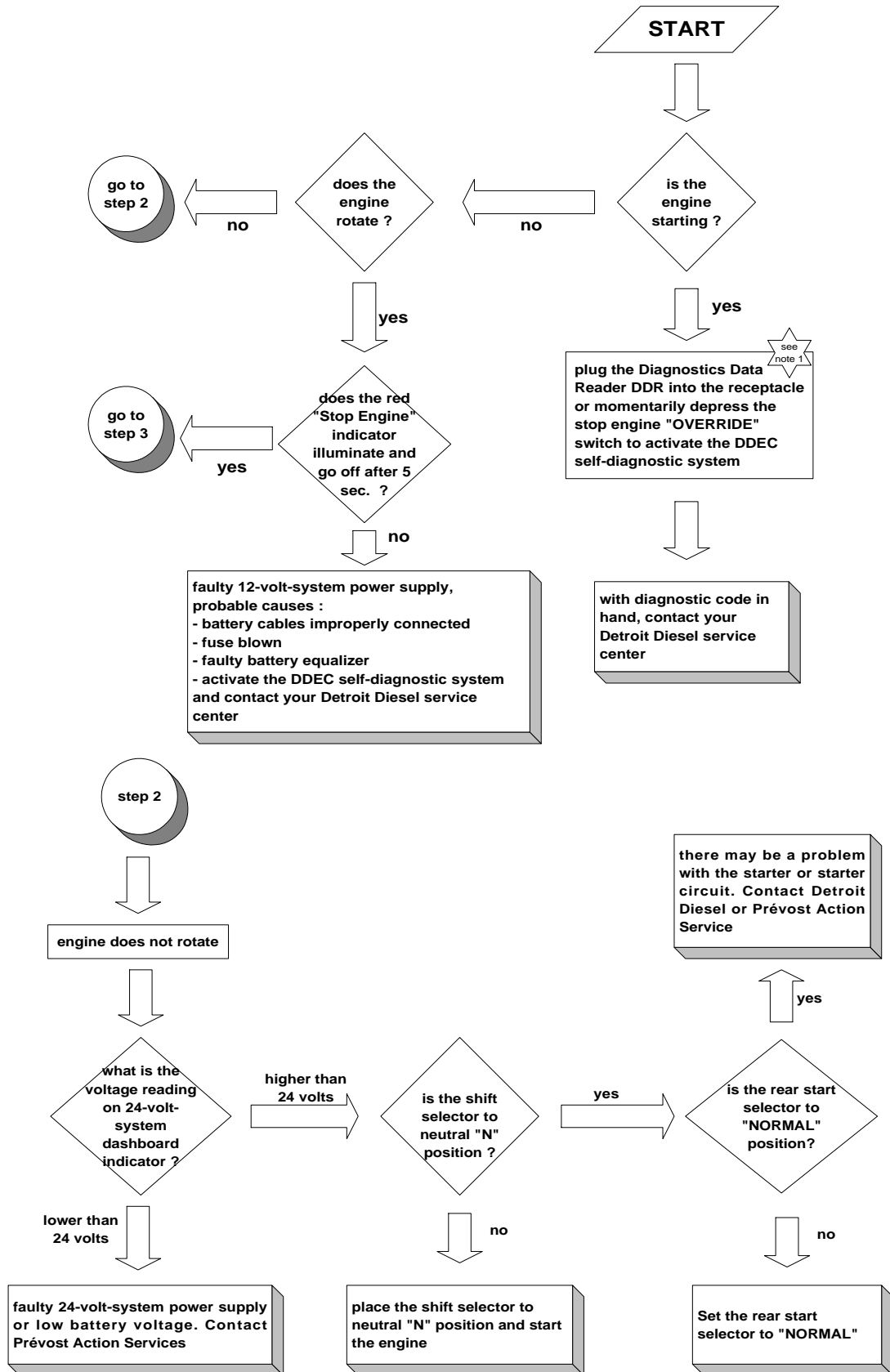


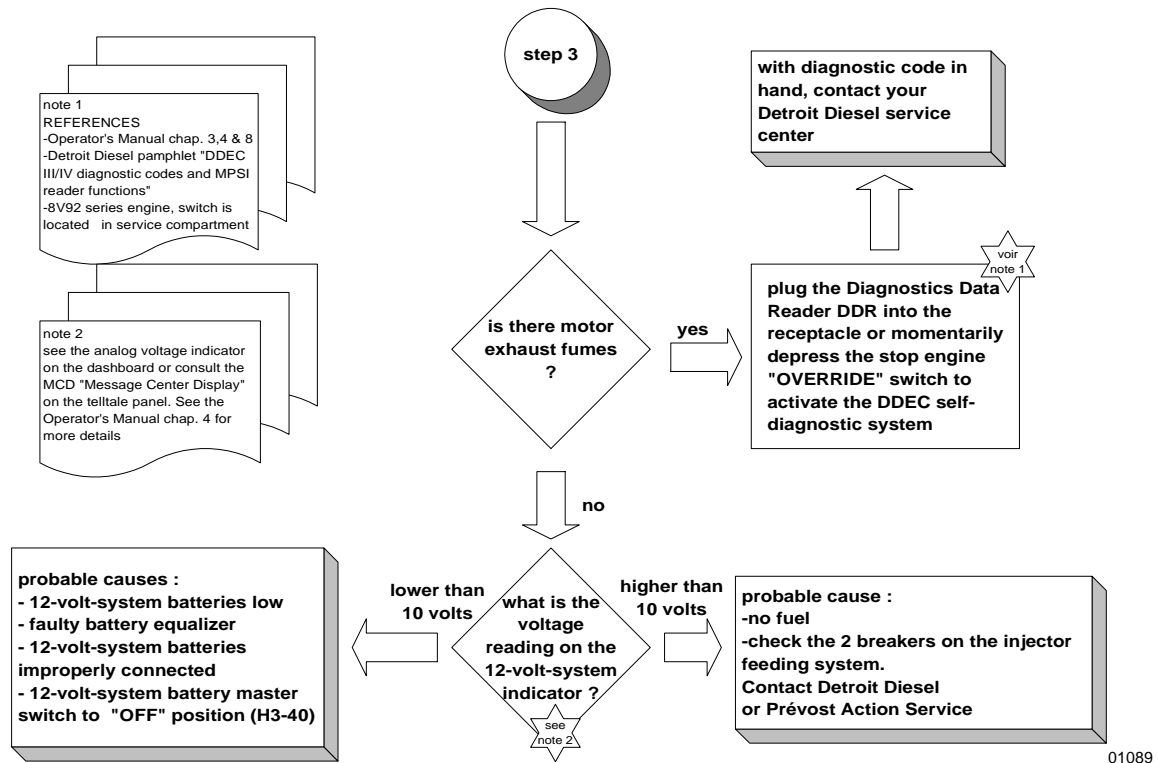
FIGURE 26: ELECTRONIC FOOT PEDAL ASSEMBLY 03035

Monitor the (TPS) at the controls as you move it through its full stroke. Be sure there is no misalignment or obstruction preventing the smooth movement of the TPS through the full stroke. Using a diagnostic data reader, check that the idle and full throttle position counts do not fall within the error zones. The error zones occur when the idle position is less than 14 counts, or when the full throttle position is more than 233 counts. Should these conditions occur, the CPC will signal diagnostic codes of 21-12 for idle error and 21-23 for wide-open throttle error.

4. ENGINE TROUBLESHOOTING GUIDE



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5. SPECIFICATIONS

Volvo D13 Engine

Make Volvo

Type Diesel four cycle/in-line direct injection engine

Description Turbo/Air to air charge cooled

No. of cylinders 6

Operating range 1400-1800 RPM

Peak Power Rating 435 HP (324 kW)

Peak Torque Rating 1650 Ft-lb (2237 Nm)

Low Idle 600 rpm

Fast Idle 2150 rpm

Maximum full load revolutions 1900 rpm

Engine oil level quantity

Oil Pan Capacity, Low Limit 25 quarts/24 liters

Oil Pan Capacity, High Limit 34 quarts/32 liters

Total Engine Oil Capacity with Filters 41 quarts/39 liters

Lubricating oil filter elements

Type By-pass

Prévost number 510938
 Type Full Flow
 Prévost number 488736

Torque specification

Engine oil filter..... Tighten ¾ of a turn to 1 full turn after gasket contact

Filters

Engine Air Cleaner Filter

Make Nelson # 70337-N
 Prévost number 530197

Engine Coolant Filter/Conditioner

Make Nalco Chemical Company # DDF3000
 Prévost number 20458771

Detroit Diesel Series 60 Engine

Make Detroit Diesel
 Type Diesel four cycle/in-line engine
 Description Turbo/Air to air charge cooled
 No. of cylinders 6
 Operating range 1200-2100 RPM
 Maximum RPM..... 2100

Detroit Diesel Series 60 engine ratings

Series 60 engine ratings used in Prevost Car Models are listed in the following tables. The standard engine ratings are written in bold, customer may easily switch from one rating to another within the same table by having the DDEC V system reprogrammed.

Coach Engine (14.0L)	
425 HP	@1800 rpm; 1450 lb-ft @1200 rpm
445 HP	@1800 rpm; 1450 lb-ft @1200 rpm

Capacity

Oil reserve tank 8.4 US qts (8.0 L)

Engine oil level quantity

Oil Pan Capacity, Low Limit 26 quarts/25 liters
 Oil Pan Capacity, High Limit 32 quarts/30 liters
 Total Engine Oil Capacity with Filters 38 quarts/36 liters

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Lubricating oil filter elements

Make..... AC Rochester Div. GMC # 25014505

Make..... A/C Filter # PF-2100

Type Full Flow

Prévost number 510458

Torque specification

Engine oil filter..... Tighten 2/3 of a turn after gasket contact

Filters

Engine Air Cleaner Filter

Make Nelson # 70337-N

Prévost number 530197

Engine Coolant Filter/Conditioner

Make Nalco Chemical Company # DDF3000

Make Detroit Diesel # 23507545

Prévost number 550630

<i>NOTE</i>
<i>For primary and secondary fuel filters, refer to Specifications in section 03</i>

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1. FUEL SYSTEM WITH DETROIT DIESEL SERIES 60 ENGINE

1.1 DESCRIPTION

Figure 1 shows a schematic of the fuel system. Fuel is drawn from the fuel tank through a manual shut-off valve, a primary fuel filter (fuel-filter/water-separator) before it enters the MCM and the fuel pump. If the vehicle is equipped with the optional "Davco Fuel Pro 382", this one replaces the primary fuel filter. Leaving the pump under pressure, the fuel flows through a secondary fuel filter and a shut-off valve, then to the cylinder head. The fuel reaches the injectors in the cylinder head through passages within the head. Excess fuel exits at the rear of the head just above the inlet, through a restrictive return fitting which maintains fuel pressure in the system. Finally, the fuel flows through the check valve and the fuel cooler before it returns to the fuel tank. One preheater is available: 104 000 BTU. If the vehicle is equipped with the 104 000 BTU preheater, the fuel is drawn from the fuel tank through the fuel filter to the preheater. Excess fuel returns to the fuel tank.

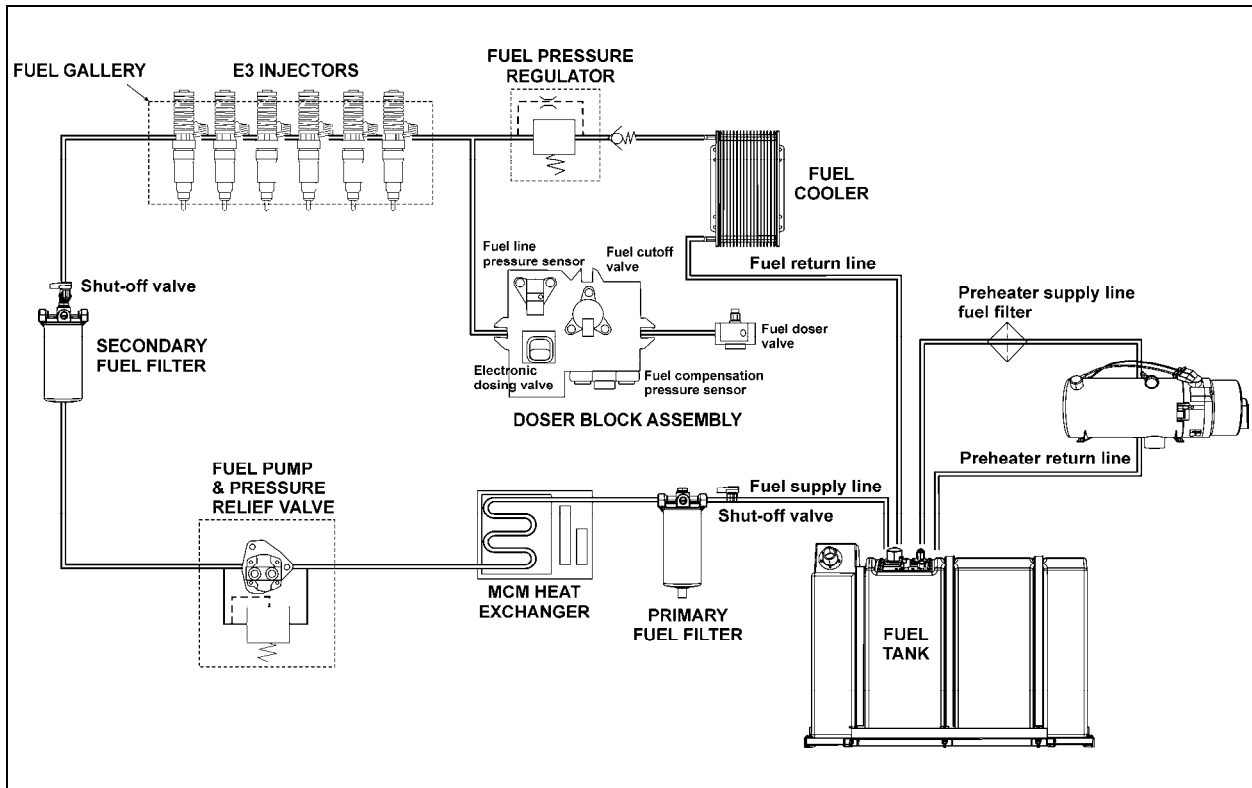


FIGURE 1: FUEL SYSTEM SCHEMATIC (DDC SERIES 60 ENGINE)

03075

1.2 FUEL VALVES

Manual shut-off valves on engine fuel-supply line are located on the R.H. side of engine compartment. A manual shut-off valve is located at the inlet side of the primary fuel filter under the starter or at the inlet side of Davco Fuel Pro 382 fuel filter. Another manual shut-off valve is located at the outlet side of the secondary fuel filter. Shut-off valve are designed to prevent loss of fuel prime at time of filter replacement. No manual valve is required on preheater fuel-supply line, since the positive-displacement fuel pump (located close to the fuel tank) prevents fuel flow when not activated.

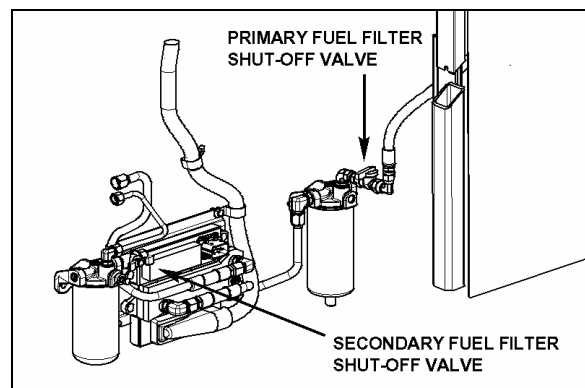


FIGURE 2: MANUAL SHUT-OFF VALVES LOCATION (DDC S60 ENGINE)

03072

Section 03: FUEL SYSTEM

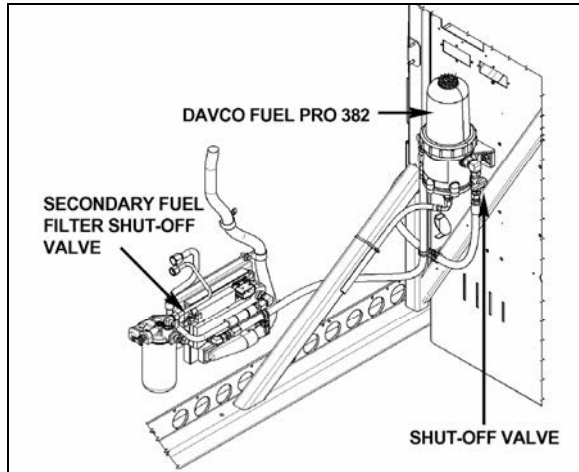


FIGURE 3: MANUAL SHUT-OFF VALVE WITH DAVCO FUEL PRO 382 (DDC S60 ENGINE) 03073

1.3 FUEL FILTERS

The fuel system is equipped with primary (strainer or optional fuel/water separator) and secondary fuel filters for additional protection of the injectors. A Racor fuel/water separator may be installed in primary filter location (Fig. 4).

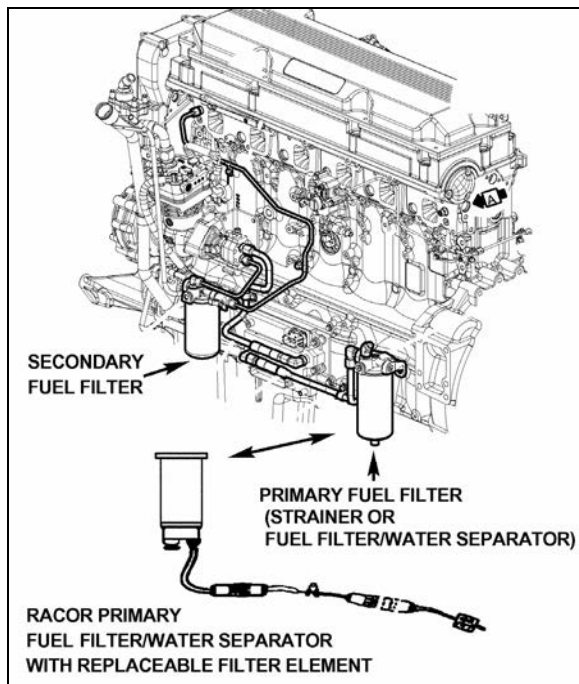


FIGURE 4: ENGINE R.H. SIDE 03069

NOTE

The operating conditions and cleanliness of type of fuel used determine the service intervals of the filter/water separator element and the secondary fuel filter cartridge.

NOTE

For information on the Davco Fuel Pro 382 fuel filter, refer to paragraph 3.

1.4 RACOR FUEL/WATER SEPARATOR SERVICING



MAINTENANCE

The Racor fuel/water separator should be drained periodically, or when the water separator telltale light on the dashboard illuminates.

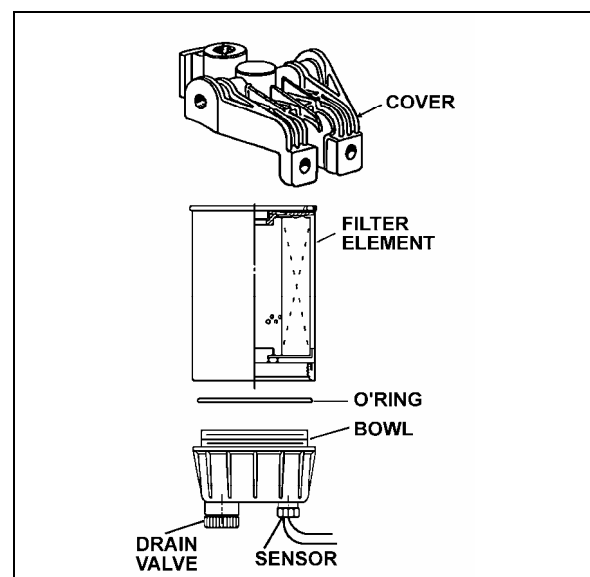


FIGURE 5: RACOR FUEL /WATER SEPARATOR 03025

Replace the fuel/water separator element as follows:


1. Drain the fuel /water separator by opening the drain valve.
2. With engine "OFF" and engine fuel supply line shut-off valves closed; remove the filter cartridge and bowl assembly from cover (for valve location, see "1.2. FUEL VALVES" in this section).
3. Separate bowl from filter cartridge. Clean bowl and O-ring groove.

NOTE


Bowl is reusable, do not discard.

4. Lubricate O-ring with clean diesel fuel or motor oil and place it in bowl groove.

- Screw bowl onto new filter cartridge snugly by hand.

 CAUTION
Do not use tool to tighten. Tighten by hand only.

- Lubricate filter seal with clean diesel fuel or motor oil.
- Fill filter cartridge with clean diesel fuel and attach onto cover. Handtighten an additional 1/3 to 1/2 turn after making full seal contact.
- Open shut-off valves of the engine fuel supply line.
- Run the engine and check for leaks.

 CAUTION
If the fuel/water separator continuously requires draining, it is possible that water or sediment has accumulated in the fuel tank. To correct this situation, open the drain plug under the tank when the fuel gauge indicates tank is 1/4 full in order to drain any contaminant.

1.5 SPIN-ON TYPE FUEL FILTER SERVICING (PRIMARY & SECONDARY)


The primary and secondary fuel filters are located on the R.H. side of the engine. The primary filter is located below the starter, and the secondary fuel filter is below the air compressor. The threaded sleeves that accept the filters body are different sizes to prevent mismatching. Primary filter thread is 1" X 12 while secondary is 13/16" X 12. The word "primary" or "secondary" is cast onto the top of the respective adaptor.

NOTE
<i>The fuel filter adaptors are mounted to the engine block with two bolts each. Torque these bolts to 43-54 lbf•ft (58-73 N•m).</i>

A method of determining when filters are clogged to the extent that they should be changed is based on the fuel pressure at the cylinder head fuel inlet fitting and the inlet restriction at the fuel pump. In a clean system, the maximum pump-inlet restriction should not exceed 6 inches of mercury (20.3 kPa) and must

not exceed 12 inches of mercury (41 kPa) with a dirty system.


At normal operating speeds and with the standard fuel pressure regulator, the fuel pressure at the cylinder head inlet is 58-72 psi (400-50 kPa). Change the fuel filters whenever the inlet restriction at the fuel pump reaches 12 inches of mercury (41 kPa) at normal operating speeds. Also, change whenever the fuel pressure at the cylinder head inlet fitting falls to the minimum fuel pressure given above.

 MAINTENANCE
The primary and secondary fuel filters are of a spin-on type and must be replaced every 12,500 miles (20 000 km) or once a year, whichever comes first. If the primary fuel filter is a fuel filter/water separator type, it is equipped with a positive seal drain-valve to prevent water infiltration in engine fuel system. To drain, loosen positive seal drain-valve below filter and tighten after water has been flushed out.

Change the filter cartridge(s) as follows:

NOTE
<i>Use a suitable band wrench or filter wrench, such as J22775, to remove the filters.</i>

- Stop engine, place a suitable container under the filter.
- Close the secondary and primary filter shut-off valve (for valve location, See paragraph 1.2. FUEL VALVES").
- Using a band filter wrench, unscrew and discard filters.
- Fill new filter cartridge(s) with clean fuel oil. Apply a thin coat of clean fuel oil on gasket.
- Install new filters. Tighten until filter is snug against the gasket, with no side movement. Rotate an additional 1/2 turn by hand.

 CAUTION
Mechanical tightening of the fuel filters is not recommended and may result in seal and/or cartridge damage. Tighten the fuel filters by hand only.

- Open engine fuel supply line shut-off valves.

Section 03: FUEL SYSTEM

7. Start the engine and check for leaks.

NOTE

There is a fuel system shut-off valve on the discharge side of the secondary fuel filter. This check valve is designed to prevent fuel loss at time of filter replacement.

1.6 FUEL PUMP INSTALLATION

The fuel pump is driven off of the rear of the air compressor.

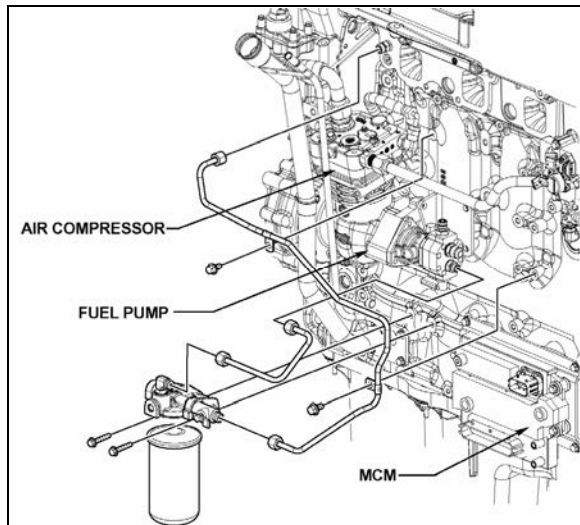


FIGURE 6: FUEL PUMP LOCATION

03070

1. If removed, install inlet and outlet fittings in the cover of the fuel pump.

NOTE

New fittings have sealant already applied. When reusing fittings, coat the threads lightly with Loctite Pipe Sealant, Detroit Diesel number J 26558-92, or equivalent, before installing. To prevent sealant from entering fuel system, do not apply to the first two threads of the fitting. Do not use Teflon tape or paste on the fittings.

2. Install drive coupling in drive hub of the fuel pump. Install a new gasket to the mounting flange of the pump.
3. Index the drive coupling with the drive hub on the end of the air compressor crankshaft and align the pump mounting bolt holes with those in the air-compressor rear cover.

NOTE

When correctly positioned, the outlet fitting on the pump should be in approximately an 8 o'clock position when viewed from the rear, and the drain opening in the pump body facing down.

4. Seat the fuel pump squarely against the air compressor. Pilot the flange on the pump body, in the opening in the rear cover of the compressor. Install three mounting bolts and tighten them to 22-28 lbf-ft (30-38 Nm).
5. Connect the fuel inlet and outlet lines to the fuel pump and tighten.
6. Prime engine fuel system before starting engine to ensure pump seal lubrication and prompt engine starting.

2. FUEL SYSTEM WITH VOLVO D13 ENGINE

2.1 DESCRIPTION

NOTE

For additional information concerning Volvo D13 engine components or engine-related components, consult Volvo Trucks Canada or Volvo Trucks North America Web Site under: Parts & Service. On Volvo web site, you will find detailed service procedures for parts replacement, repair and maintenance.

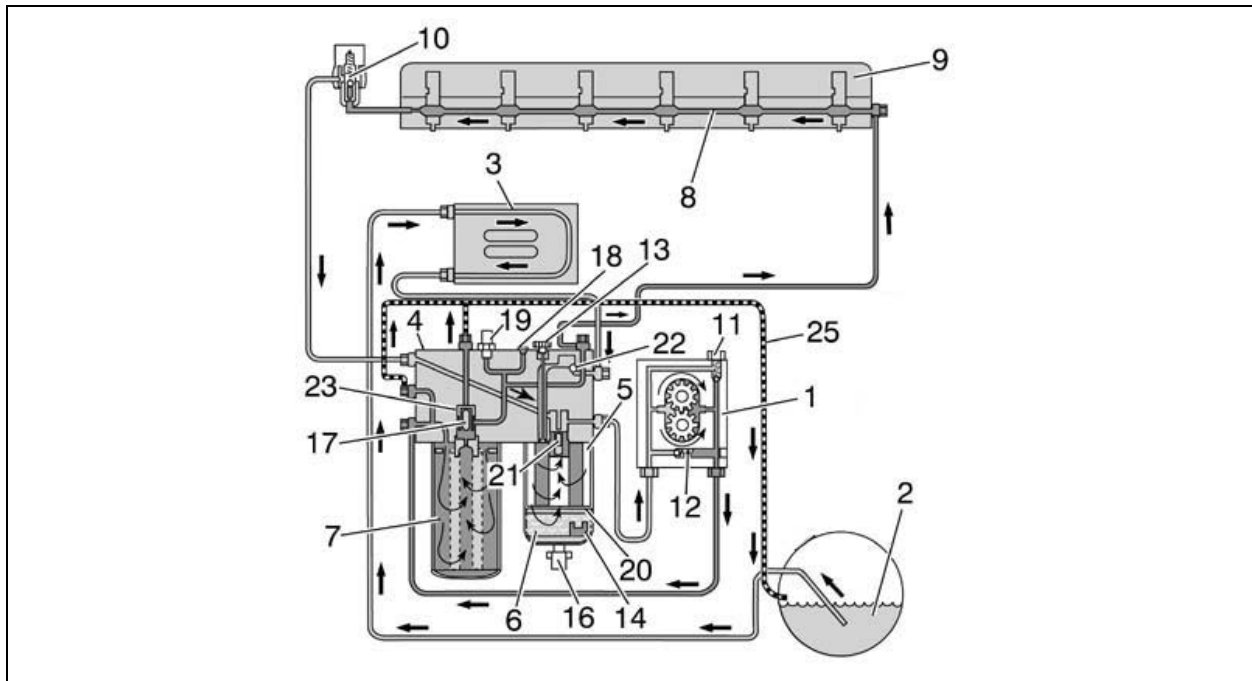


FIGURE 7: FUEL SYSTEM SCHEMATIC (VOLVO D13 ENGINE)

03086

Fuel is drawn up the fuel lines by the supply pump (1) through the pickup tube in the tank (2) and through the Engine Electronic Control Unit (EECU) cooling coil (3) and into the fuel filter housing (4). The fuel housing is equipped with a primary fuel filter (fuel/water separator) consisting of a filter cartridge and a water separation bowl.

The supply pump (1) forces the fuel into the fuel filter housing through the secondary filter (main) to a cylinder head longitudinal gallery (8). This channel supplies each unit injector (9) with pressurized fuel by a circular groove around each unit injector in the cylinder head. The overflow valve (10) controls the fuel supply pressure to the unit injectors.

The return fuel from the overflow valve (10) is returned back to the fuel filter housing and is mixed with the fuel from the fuel tank in a channel within the fuel filter housing (4).

Supply Pump Valves

Two valves are located in the supply pump (1). The safety valve (11) allows fuel to flow back to the suction side when the pressure becomes too high, e.g., if the fuel filter is blocked or is too restricted. The non-return valve (12) opens when the hand-priming pump is used.

Automatic Bleeding

If air gets into the system, it is bled when the engine starts. During bleeding, air is pressed out through the fuel filter housing over to the fuel tank through the return line (25). Bleeding for the filter replacement is controlled by valves (17) and (23).

Other

The fuel filter housing eliminates the need to drain the fuel when replacing the filter. The valve pegs (17) and (21) close when the fuel filter is

Section 03: FUEL SYSTEM

removed. It is not necessary to bleed the fuel system after replacing the filter, since this is performed automatically when the engine is started and runs for more than 2 minutes.

The plugged outlet (18) is fitted on the fuel filter housing. This outlet is used when measuring supply pressure after the fuel filter with an external pressure gauge. The pressure sensor (19) on the fuel filter housing monitors the supply pressure after the fuel filter. A fault code is displayed on the instrument cluster if the fuel supply pressure is less than the specified value.

Hand Priming Pump

The hand priming pump (13) is located on the fuel filter housing and is used to pump fuel (when engine is not running) after the fuel system has been drained for repair, etc. The non-return valve (22) for the hand priming pump is also located in the fuel filter housing.

2.2 FUEL VALVES

The manual shut-off valve on engine fuel-supply line is located on the R.H. side of engine compartment. A manual shut-off valve is located at the inlet side of the primary fuel filter or at the inlet side of Davco Fuel Pro 382 fuel filter. Shut-off valve is designed to prevent loss of fuel prime. No manual valve is required on preheater fuel-supply line, since the positive-displacement fuel pump (located close to the fuel tank) prevents fuel flow when not activated.

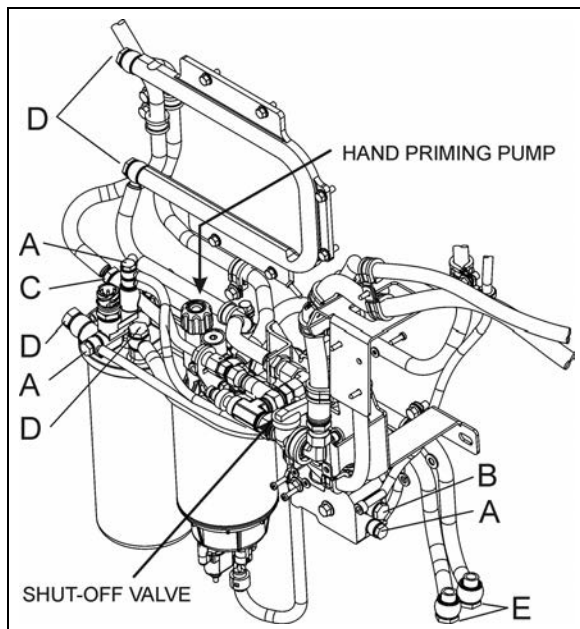


FIGURE 8: MANUAL SHUT-OFF VALVE (VOLVO D13 ENGINE)

03088

FUEL LINE FITTINGS – VOLVO D13 ENGINE		
A	13 ± 2 ft-lb	(18 ± 3 Nm)
B	20.5 ± 3 ft-lb	(28 ± 4 Nm)
C	22 ± 3 ft-lb	(30 ± 4 Nm)
D	26 ± 4 ft-lb	(35 ± 5 Nm)
E	29.5 ± 4 ft-lb	(40 ± 5 Nm)
F	35 ± 4 ft-lb	(48 ± 5 Nm)

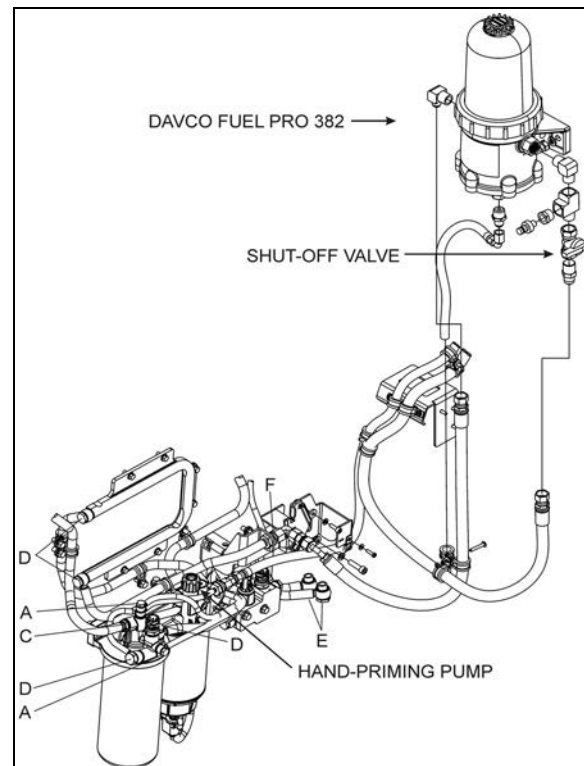


FIGURE 9: MANUAL SHUT-OFF VALVE LOCATION WITH DAVCO FUEL PRO 382 (VOLVO D13 ENGINE)

03087

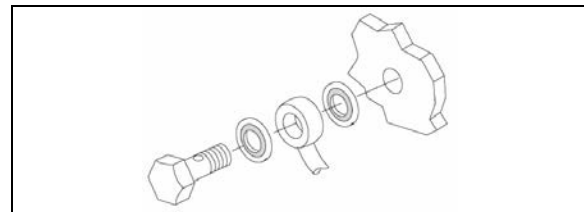


FIGURE 10: FUEL LINE COMPRESSION FITTING



CAUTION

Always replace the fuel line compression sealing washers when troubleshooting for fuel aeration or performing any service procedure that requires the removal of engine fuel lines.

2.3 FUEL FILTERS

A primary fuel filter is installed on the engine. This filter consists of a filter cartridge, a water separation bowl with a drain valve. It is used to prevent water from entering the fuel system.



MAINTENANCE

The primary and secondary fuel filters are of a spin-on type and must be replaced at **every engine oil change**.

The primary fuel filter should be drained periodically or when the telltale light on the dashboard illuminates if equipped with this system. To drain water, loosen the drain valve below the separator. Place an appropriate container under the filter. Close the drain valve when finished.

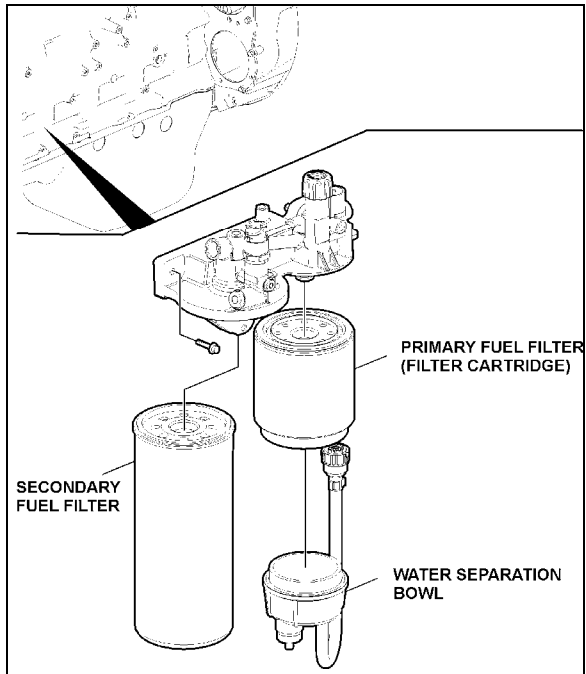
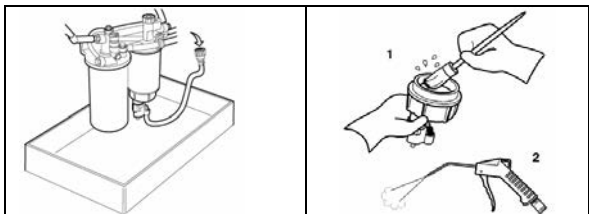


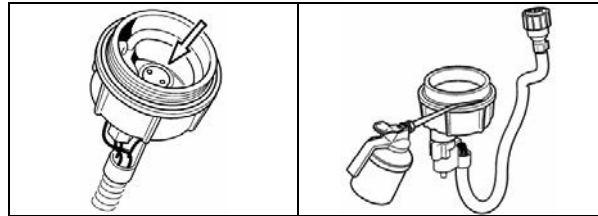
FIGURE 11: FUEL FILTERS WITH VOLVO D13 ENGINE
03085

2.3.1 Primary Fuel Filter Replacement

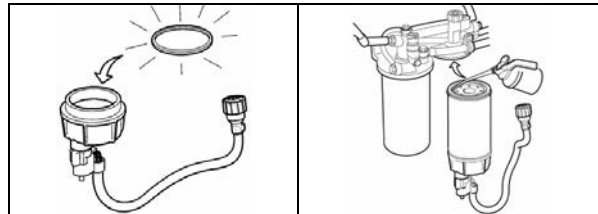
1. Stop engine, close the fuel supply line shut-off valve.
2. Place an appropriate container under the fuel filter housing, then drain the water from the water separation bowl.
3. Disconnect the fuel/water separator indicator electrical connector.



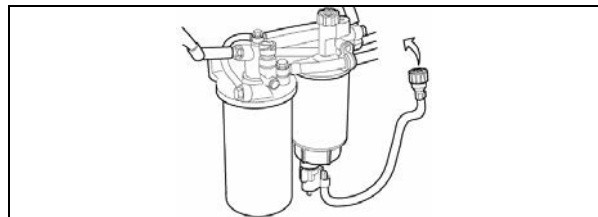
4. Unscrew and remove the primary fuel filter from the fuel filter housing. Drain filter.
5. Unscrew and remove the separation bowl from the filter cartridge.
6. Remove and discard the old gasket from the water separation bowl. Clean the bowl thoroughly and then blow dry with filtered compressed air.



7. Check that the drainage hole in the water separator bowl is not blocked.
8. Apply a thin coating of clean engine oil to the surface of the water separation bowl.



9. Install a new gasket to the water separation bowl and then reinstall the separation bowl to the new primary fuel filter cartridge.
10. Apply a thin coating of clean engine oil to the surface of the primary fuel filter, install the primary fuel filter to the fuel filter housing, then tighten the primary fuel filter 1/2-3/4 turn.



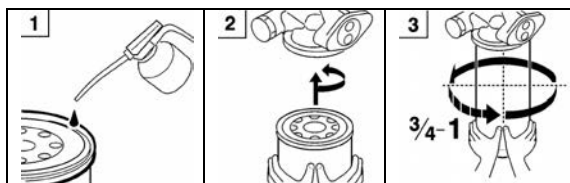
11. Connect the electrical connector for the water/fuel separation bowl indicator.
12. Open the fuel supply line shut-off valve.
13. Purge air from the filter by operating the priming pump to draw fuel and fill the filter. When using the hand priming pump, approximately 100 strokes will be required.

Section 03: FUEL SYSTEM

14. Start the engine and carry out a fuel-tightness check. Let the engine run for about 5 minutes to remove air pockets from the fuel system.

2.3.2 Secondary Fuel Filter Replacement

1. Stop engine, close the fuel supply line shut-off valve. Place an appropriate container under the fuel filter housing.
2. Clean around sealing area on fuel filter and housing.
3. Unscrew and remove the secondary fuel filter from the fuel filter housing.
4. Apply a thin coating of clean engine oil to the gasket of the secondary fuel filter. Screw the fuel filter into position. Tighten the filter $\frac{3}{4}$ to 1 turn after the gasket makes contact with the fuel filter housing.



CAUTION

Fuel in the old filter **must absolutely not** be poured into the new filter. This kind of contaminated fuel can damage the unit injectors.

5. Prime the fuel system by pumping the hand priming pump on the fuel filter housing until resistance is felt indicating that the system is full of fuel.
6. Start the engine and carry out a fuel-tightness check. Let the engine run for about 5 minutes to remove air pockets from the fuel system.

2.4 PRIMING THE FUEL SYSTEM

The fuel system will need to be bled if:

- The vehicle has run out of fuel.
- The engine has not been running for an extended period of time.
- Service work has been done on the fuel system, (tank, fuel lines, filters, valves, etc.) for example cleaning or replacing fuel filter cartridges.
- The engine is new or rebuilt.



CAUTION

When priming the system, movement of the primer pump should be as up and down as possible. Avoid putting any side load on the pump or causing a binding condition. Failure to follow these instructions could prematurely damage the primer pump.

NOTE

When the fuel system is empty, 200 or more pump strokes may be needed to properly prime system. There are no bleed nipples to be opened to prime the fuel system.

1. Stop engine;
2. Unlock the hand pump by turning the handle counterclockwise.
3. Prime the system by moving the primer pump in an up and down pumping motion. Avoid putting any side load on the pump or causing a binding condition.
4. Lock the hand primer pump by retracting it into the housing and turning it clockwise.
5. Start the engine and run it at an increased idle speed for approximately 5 minutes to remove any remaining air in the system. Check the fuel system for leaks.

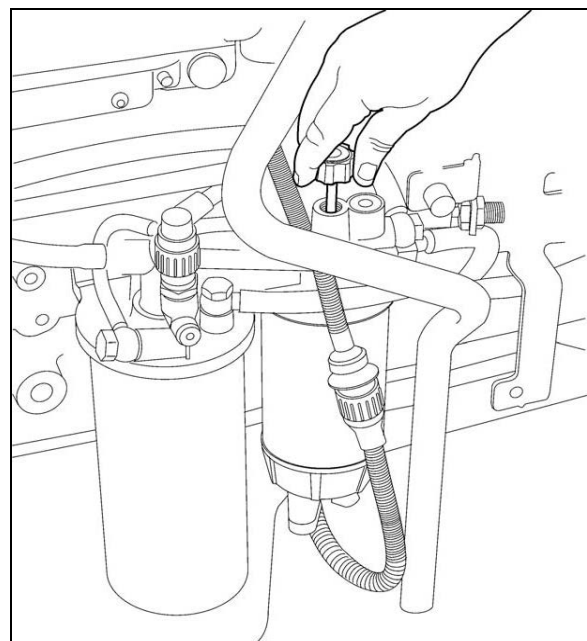


FIGURE 12: HAND PRIMING PUMP

2.5 FUEL PUMP REMOVAL AND INSTALLATION

The pump is located underneath the air compressor and is accessible through the engine compartment R.H. access door.

To remove the pump, proceed as follows:

- Clean around the fuel pump and fuel lines. Position a container to catch any fuel that might drain from the pump or lines.
- Remove the fuel pump.

NOTE

Only unfasten the bolts marked with arrows.

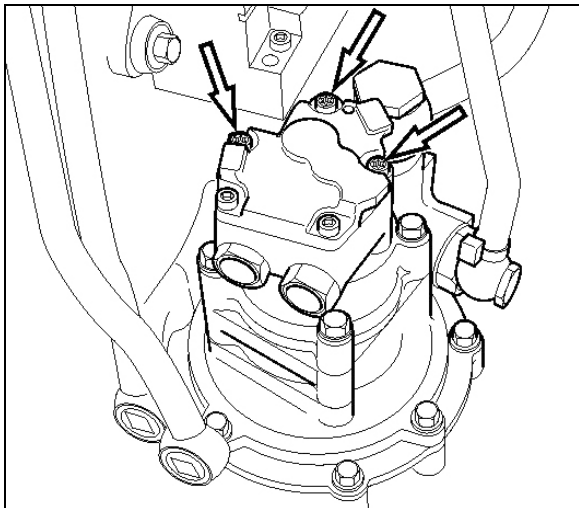


FIGURE 13: FUEL PUMP REMOVAL



CAUTION

Ensure to clean around the head of the bolts. Debris will prevent the tool from fitting properly and cause damage to the fasteners..

- Check that the adapter and fuel pump drive axle are not damaged.

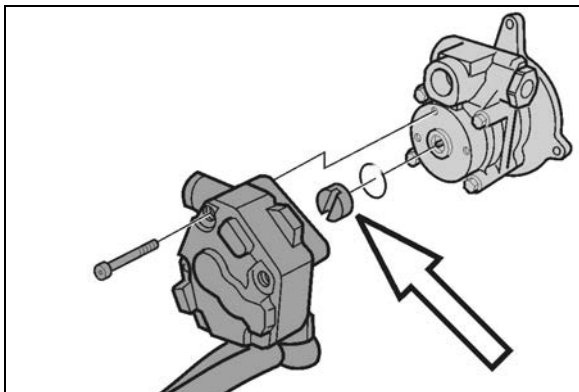


FIGURE 14: FUEL PUMP DRIVE AXLE

- Install the fuel pump. Torque-tighten bolts to specification.

NOTE

Use a new sealing ring. Check that the fuel pump drive axle sits correctly in the power steering pump.

- Using the hand primer on the fuel filter housing, prime the fuel system.
- Start the engine and let run for 5 minutes. Make sure that there are no leaks.

3. DAVCO FUEL PRO 382

The optional Fuel Pro 382 diesel fuel filter system consists of a permanently mounted fuel processor, a replaceable filter element, a filter element cover and collar and a fluid filter base assembly. This system is installed between the fuel tank and the fuel pump and is designed to be the only fuel filter in the fuel system. The filter serves as a water separator as well as a fuel filter (refer to figure 15).

The filter fibers used in the Davco Fuel Pro 382 element may cause the fuel level to read artificially high when the filter is first installed. Over the first few days, the filter fibers eventually become fully saturated and the fuel level will drop to normal levels. Do not be concerned about an abnormally high fuel level when a new Davco element is installed.

When new, the fuel level as seen through the clear cover in the 382 filter is very low. It rises as dirt collects on the filter from the bottom up. Restriction remains consistently low because fuel always flows through clean, new media.



MAINTENANCE

Replace Fuel Pro 382 filter element when the fuel level in the see-thru filter cover reaches the top of the filter element or after one year of service, whichever comes first.

Section 03: FUEL SYSTEM

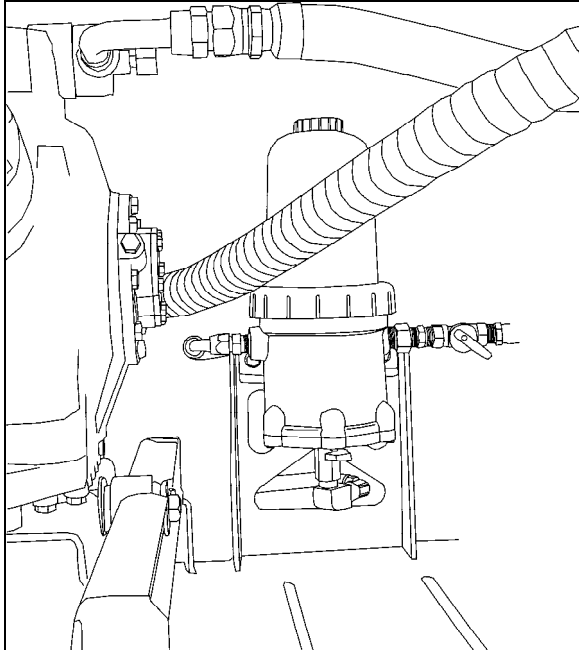


FIGURE 15: DAVCO FUEL PRO 382 FUEL FILTER 03062

Filter replacement:

1. Stop engine;
2. Place a suitable container under the fuel processor;
3. Close the shut-off valve at the inlet side of the fuel filter;
4. Open the drain valve at the base of the fuel processor and drain the fuel until it is below the level of the filter;
5. Untighten upper collar, remove cover, filter hold down spring, filter element and cover seal;
6. Dispose of used filter element;
7. Ensure the filter grommet is included at the base of the new filter element and then install the element onto the center stud;
8. Ensure the filter spring is installed at the top of the cover. If missing, the spring must be replaced to insure proper filter operation.
9. Wipe the cover lid and seal clean. After ensuring the seal is properly positioned at the base of the cover, install the cover and collar onto the fuel processor. Tighten the collar by hand until secure;
10. Fill the cover full of clean fuel through spin off cap located on top of cover. Install vent cap seal and then reinstall the cap and tighten by hand only;

11. Open the shut-off valve;
12. Start engine, raise rpm for 2-3 minutes, hand tighten collar again;
13. After the air is purged and with the engine still running, slowly loosen the vent cap on the filter cover. The fuel level in the cover will start falling. When the fuel level falls to the top of the collar, tighten the vent cap quickly by hand;
14. Shut down the engine and hand-tighten the collar again.

NOTE

Fuel Pro 382 also accepts standard secondary spin-on fuel filters.

ENVIRONMENTAL NOTICE

Diesel fuel is an environmentally hazardous product. Dispose in an environmentally friendly manner.

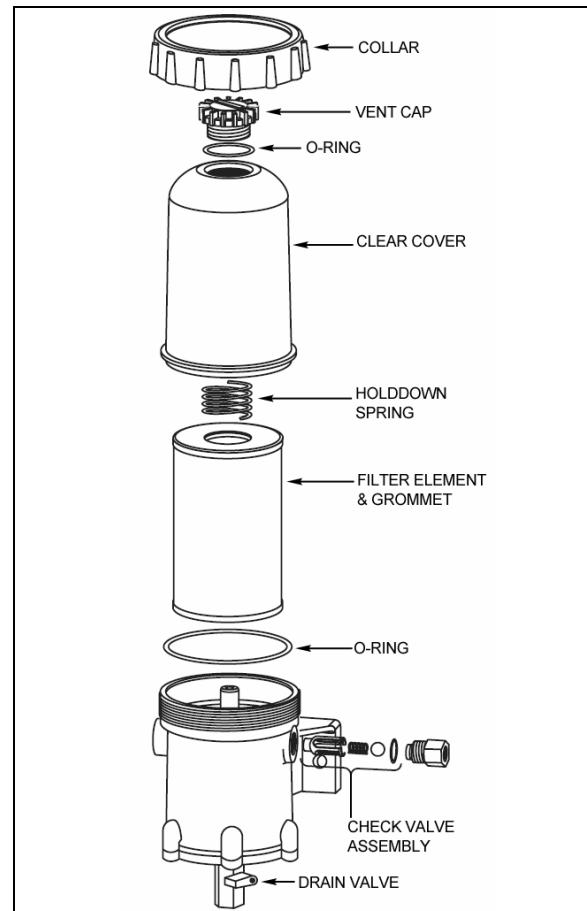




FIGURE 16: DAVCO FUEL PRO 382 EXPLODED VIEW 03034

4. FUEL LINES AND FLEXIBLE HOSES

Make a visual check for fuel leaks at all engine-mounted fuel lines and connections and at the fuel tank suction and return lines. Since fuel tanks are susceptible to road hazards, leaks in this area may best be detected by checking for accumulation of fuel under the tank. Engine performance and auxiliary equipment is greatly dependent on the ability of flexible hoses to transfer lubricating oil, air, coolant and fuel oil. Diligent maintenance of hoses is an important step in ensuring efficient, economical and safe operation of engine and related equipment.


 <p>MAINTENANCE</p>
<p>Check hoses daily as part of the pre-start-up inspection. Examine hoses for leaks and check all fittings, clamps and ties carefully. Make sure that the hoses are not resting on or touching shafts, couplings, and heated surfaces, including exhaust manifolds, any sharp edges or other obviously hazardous areas.</p>

Since all machinery vibrates and moves to a certain extent, clamps and ties can fatigue with age. To ensure continued proper support, inspect fasteners frequently and tighten or replace them as necessary. Refer to the schematic diagram of the fuel system (Fig. 1 & 7).

 <p>CAUTION</p>
<p>Oil level above the dipstick full mark or a decrease in lube oil consumption may indicate internal fuel leaks. Check oil level frequently.</p>

5. PREHEATER FUEL FILTER

The preheater fuel filter is located beside the preheater in the dedicated compartment above the rear wheelhousing, on the L.H. side of vehicle.

 <p>MAINTENANCE</p>
<p>Replace preheater fuel filter every 50,000 miles (80 000 km) or once a year, whichever comes first.</p>


6. FUEL TANK

X3-45 coaches are equipped with a high-density cross-link polyethylene fuel tank with a capacity of 208 US gallons (787 liters).

On all vehicles, fuel filling access doors on both sides of vehicle provide direct access to filler necks; offering the added advantage of refueling from either side of vehicle.

A pressure relief valve on the fuel tank connection-panel relieves high-pressure buildup and an overflow tube allows offset air in the tank to escape during filling. For 95% of the tank volume, 5% of tank inside space is kept filled with air with no exit opening, allowing for a fuel expansion safety margin. A drain plug, accessible from under the vehicle, is fitted at the bottom of the tank.

6.1 TANK REMOVAL

 <p>DANGER</p>
<p>Park vehicle safely, apply parking brake, stop engine and set battery master switch(es) to the OFF position prior to working on the vehicle. Before working under an air-suspended vehicle, it is strongly recommended to support the body at the recommended jacking points.</p>

<p><i>NOTE</i></p>
<p><i>Before removal, the fuel tank should be completely drained by unscrewing the drain plug. Ensure that the container used has a capacity equal to the amount of fuel remaining in the tank.</i></p>

1. Open the condenser door and remove the fuel tank access panel. The rear baggage compartment fuel tank access panel may also be removed to facilitate access to components.
2. If applicable, unscrew clamps retaining L.H. side filler tube to the fuel tank, then disconnect tube and remove it.
3. Unscrew clamps retaining R.H. side filler tube to fuel tank and filler neck. Disconnect tube and remove it.
4. If applicable, unscrew preheater supply line, preheater return line, auxiliary return line and/or auxiliary return line from fuel tank connection-panel.

Section 03: FUEL SYSTEM

5. Unscrew engine supply and return lines from fuel tank connection-panel, identify them for reinstallation.
6. Disconnect electrical wiring from tank on connection plate.
7. From under the vehicle, on R.H. side, unscrew the 4 bolts (2 in front, 2 in back) retaining the tank support to the frame.
8. From under the vehicle, on the L.H. side, unscrew the 2 bolts (1 in front, 1 in back) retaining the tank support to the frame.
9. Carefully remove tank from under the vehicle.



DANGER

Before removing the bolts securing the tank support to the frame, make sure the tank is supported adequately. Failure to do so could result in injury as well as damage to the tank.

6.2 TANK INSTALLATION

To install tank, simply reverse the "Tank Removal" procedure.

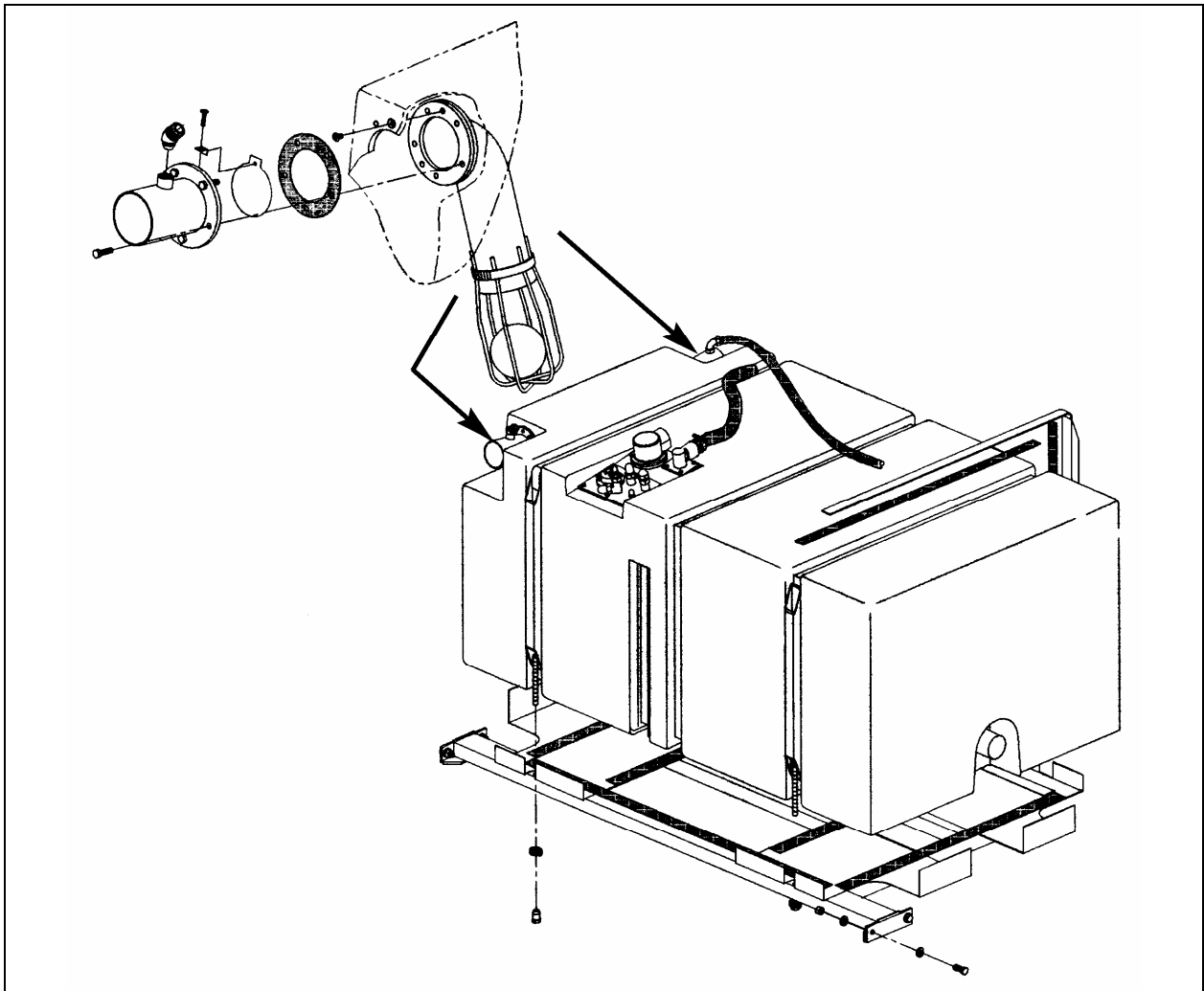


FIGURE 17: 208 US GAL. FUEL TANK

03063

6.3 FUEL TANK VERIFICATION

Inspect fuel tank from under vehicle for leaks or fuel traces. If a leak is detected, repair immediately as per "Polyethylene Fuel Tank Repair" in this section.

DANGER

Park vehicle safely, apply parking brake, stop engine and set battery master switch(es) to the OFF position prior to working on the vehicle.

Before working under an air-suspended vehicle, it is strongly recommended to support the body at the recommended jacking points.

6.4 POLYETHYLENE FUEL TANK REPAIR

NOTE

Fuel level must be lower than perforation to carry out this procedure.

DANGER

Park vehicle safely, apply parking brake, stop engine and set battery master switch(es) to the OFF position prior to working on the vehicle.

1. Locate perforation on fuel tank.
2. If necessary, remove fuel tank as per instructions in this section.
3. Drill perforation with a 23/64" bit. Make sure drill hole is perfectly round.
4. Insert a screw (Prevost #500196) and a washer (Prevost #5001244) into anchor nut (Prevost #500331).
5. Place assembly in drill hole. Tighten screw by 10 complete turns. Refer to Fig. 18.
6. Apply sealant on head plug (Prevost #507300) and seal hole with the head plug.

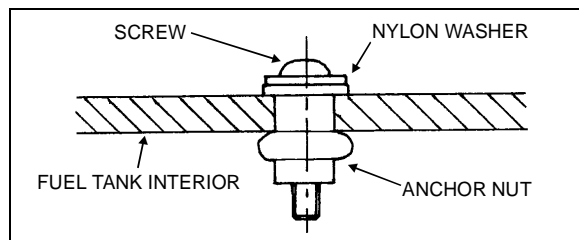


FIGURE 18: FUEL TANK REPAIR 03014

7. FUEL SPECIFICATIONS

The quality of fuel oil used for high-speed diesel engine operation is a very important factor in obtaining satisfactory engine performance, long engine life and acceptable exhaust emission levels.

The U.S. Environmental Protection Agency (EPA) has issued new standards to improve air quality by significantly reducing emissions through a combination of cleaner-burning diesel engines and vehicles.

To meet EPA standards, the petroleum industry produces **Ultra Low Sulfur Diesel** (ULSD) fuel, also referred to as S15, containing a maximum 15ppm (parts-per-million) sulfur.

On-highway diesel engines meeting 2007 emission regulations are designed to operate **ONLY** with ULSD fuel. ULSD fuel will enable the use of cleaner technology diesel engines and vehicles with advanced emissions control devices, resulting in significantly improved air quality.

7.1 FUEL TYPE

EPA-07 engines like the DDC 2007 Series 60 are designed to run on **Ultra Low Sulfur Diesel** (ULSD) fuel, which can contain no more than 15 ppm sulfur.

Fuel used must meet engine manufacturer's specification. For Detroit Diesel engines refer to "Diesel Fuel Specifications" as stated in DDC publication 7SE270 LUBRICATING OIL, FUEL, AND FILTERS. Similarly for Volvo engine.

CAUTION

ULSD fuel is necessary to avoid fouling the engine's Aftertreatment Device (ATD). Improper fuel use will reduce the efficiency of the engine's Aftertreatment System and may permanently damage the system.

CAUTION

Owners of 2007 and later model year on-highway diesel engine must refuel only with ULSD fuel.

Section 03: FUEL SYSTEM

NOTE

Burning Low Sulfur Diesel fuel (instead of ULSD fuel) in 2007 and later model year diesel engines is illegal and punishable with civil penalties.

NOTE

Engine and vehicle manufacturers expect ULSD fuel to be fully compatible with the existing fleet, including 2006 and earlier model year vehicles. In some instances, the introduction of ULSD fuel to older vehicles may affect fuel system components or loosen deposits in fuel tanks. As part of a good maintenance program, owners and operators of existing cars, trucks and buses are encouraged to monitor their diesel-powered vehicles closely for potential fuel system leaks or premature fuel filter plugging during the change-over to ULSD fuel.

NOTE

Like Low Sulfur Diesel fuel, ULSD fuel requires good lubricity and corrosion inhibitors to prevent unacceptable engine wear. As necessary, additives to increase lubricity and to inhibit corrosion will be added to ULSD fuel prior to its retail sale.

7.2 BLENDING

Only ultra low sulfur kerosene – No.1 diesel with no more than 15ppm sulfur may be blended with ULSD fuel to improve cold weather performance. With so many kerosene formulations on the market, care must be taken to select kerosene with a maximum of 15ppm sulfur.

Blend rates remain the same as with Low Sulfur Diesel fuel.

7.3 BIODIESEL FUELS

ULSD-B5 biodiesel may be used. B5 tells you the percentage of biodiesel mixed in with ULSD. B5 is 5% biodiesel and 95% ULSD.

Fuel used must meet engine manufacturer's specification for biodiesel fuel. For Detroit Diesel engines refer to "Diesel Fuel Specifications" as stated in DDC publication 7SE270 LUBRICATING OIL, FUEL, AND FILTERS. Similarly for Volvo engines.

Biodiesel fuels are alkyl esters of long chain fatty acids derived from renewable resources. Detroit Diesel highly recommends biodiesel fuels made from soybean or rapeseed oil through the proper transesterification reaction process. Other feedstock source of biodiesel fuels such as animal fat and used cooking oils are not recommended by Detroit Diesel. Biodiesel fuels meeting ASTM D6751 specification and from BQ-9000 accredited producer, prior to blending can be mixed up to 5% maximum by volume in petroleum diesel fuel. The resulting mixture must meet the fuel properties listed in Table 5-1 (see Detroit Diesel publication 7SE270 LUBRICATING OIL, FUEL, AND FILTERS.) and ASTM D975 specification. Failures attributed to the use of biodiesel fuel will not be covered by Volvo, Detroit Diesel or Prevost product warranty. Also, any engine performance problem related to the use of biodiesel fuel would not be recognized nor considered as Volvo, Detroit Diesel or Prevost's responsibility.

8. AIR CLEANER (DRY TYPE)

The vehicle is equipped with a dry-type replaceable element air cleaner, located in the engine compartment. Access the air cleaner through the engine R.H. side door. Engine air enters the air cleaner through (2) two intake ducts located just above engine side doors. It then flows through a pre-cleaner and finally through the air cleaner. The pre-cleaner removes dust and moisture by means of a discharge tube at the bottom of the element. It is in series with a replaceable impregnated paper filter element (air cleaner).

8.1 PRE-CLEANER SERVICING



MAINTENANCE

The pre-cleaner is designed to be self-cleaning; however, it should be inspected and any accumulated foreign material removed during the periodic replacement of the impregnated paper filter element.

8.2 AIR CLEANER SERVICING

Stop the engine, open the R.H. side engine compartment door, and loosen the wing nut retaining the air cleaner element to the air cleaner. Remove the element by pulling on the handle in the center of the air cleaner element.

Install cleaner element as follows:

1. Inspect the gasket-sealing surface inside the air cleaner. It must be smooth, flat and clean;
2. Install the air cleaner element;
3. Make sure that the element seals securely;
4. Inspect element cover gasket and replace if necessary.

Whenever it becomes necessary to remove the air cleaner assembly (dry type) for maintenance or other repair in this area, great care should be taken when installing air cleaner assembly.

The pre-filter should be installed snugly in the air duct and clamped tightly to the air cleaner inlet to prevent any dust infiltration into the air cleaner.

8.3 GENERAL RECOMMENDATIONS

The following maintenance procedures will ensure efficient air cleaner operation:

1. Keep the air cleaner housing tight on the air intake pipe;
2. Make sure the correct filters are used for replacement;
3. Keep the air cleaner properly assembled so the joints are air-tight;
4. Immediately repair any damage to the air cleaner or related parts;
5. Inspect, clean or replace the air cleaner or elements as operating conditions warrant. Whenever an element has been removed from the air cleaner housing the inside surface of the housing must be cleaned with a soft clean cloth;
6. Periodically inspect the entire system. Dust-laden air can pass through an almost invisible crack or opening which may eventually cause damage to an engine;
7. Never operate the engine without an element in the air cleaner assembly;



CAUTION

Do not ignore the Warning given by the air restriction indicator. This could result in serious engine damage.

8. Store new elements in a closed area free from dust and possible damage.

8.4 AIR CLEANER RESTRICTION INDICATOR

A resettable restriction indicator may be installed on the engine air-intake duct, clearly visible from the rear engine compartment. The indicator monitors the vacuum level between the air filter and the engine. A red marker is displayed when the air filter is clogged and must be replaced. Reset by pressing on the indicator's extremity.

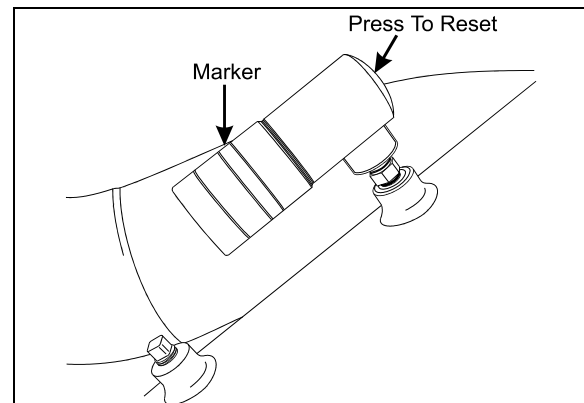


FIGURE 19: RESTRICTION INDICATOR

01052

9. FUEL COOLER – DETROIT DIESEL SERIES 60 ONLY

The fuel cooler serves to cool the surplus diesel fuel after it has exited the cylinder head, on its way back to the fuel tank. It is accessible through the engine radiator door, and is located in front of the charge air cooler (CAC) and the coolant radiator (Fig. 21 & 22).

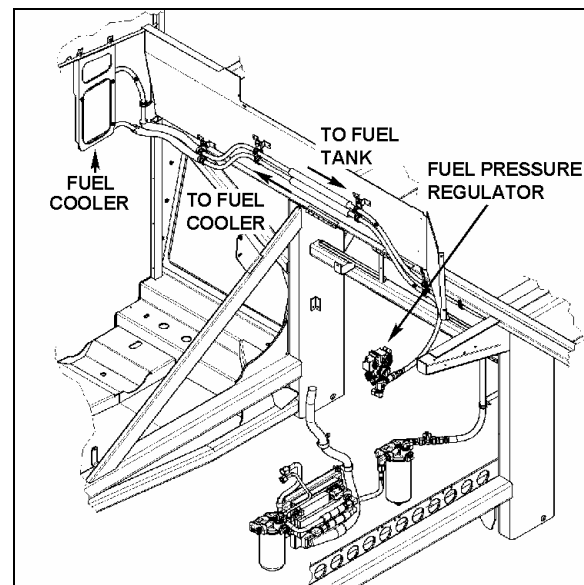


FIGURE 20: FUEL RETURN LINE

03078

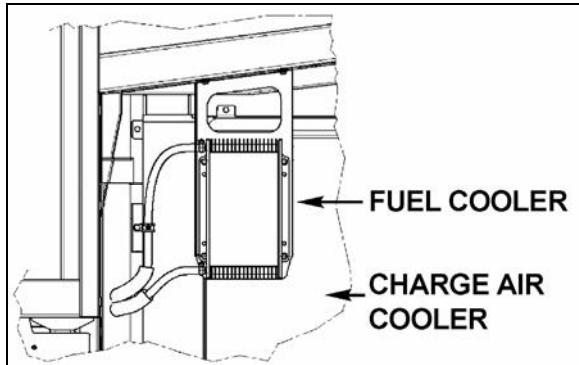


FIGURE 21: FUEL COOLER LOCATION 03079

10. FUEL PEDAL

The EFPA (Electronic Foot Pedal Assembly) connects the accelerator pedal to a potentiometer (a device that sends an electrical signal to the ECM, which varies in voltage, depending on how far down the pedal is depressed). The EFPA is installed in the space normally occupied by a mechanical foot pedal. It has maximum and minimum stops that are built into the unit during manufacturing.

10.1 FUEL PEDAL ADJUSTMENT

The EFPA contains a throttle position sensor that varies the electrical signal sent to the ECM. The sensor must be adjusted whenever an EFPA is serviced. In addition, the sensor should be adjusted any time codes 21 and 22 are flashed.

With the ignition "ON" and the proper diagnostic tool (DDR) (for information regarding the DDR, see "01 ENGINE" in this manual), check the throttle counts at idle and full throttle positions. Proper pedal output should be 20/30 counts at idle and 200/235 at full throttle. If adjustment is necessary, remove the potentiometer retaining screws and rotate the potentiometer clockwise to increase counts or counterclockwise to decrease. When correct output is confirmed, tighten retaining screws.

10.2 POTENTIOMETER REPLACEMENT

1. Disconnect cable harness connector.
2. Loosen the two screws and remove potentiometer. Retain for re-assembly.
3. Discard potentiometer (Fig. 23).



CAUTION

Note the routing and clamping locations of the cable before disassembly. Proper cable routing and fastening is critical to the operation of this system. Marking the foot pedal assembly to record cable routing is recommended.

2. Position new potentiometer. Press potentiometer onto the potentiometer shaft, matching cutouts in shaft to drive tangs of potentiometer. Apply hand pressure until potentiometer has bottomed out in housing. Reinstall screws (Fig. 23) and tighten just enough to secure potentiometer lightly. Tighten screws to 10 - 20 Lbf-in (1.13 - 2.26 Nm).
3. Reconnect electronic foot pedal assembly's cable harness to the ECM connector. If potentiometer calibration is necessary (see "FUEL PEDAL ADJUSTMENT" in this section).



CAUTION

Make sure the cable harness is routed correctly, and securely installed so that it does not become pinched, stretched, or otherwise damaged during vehicle operation.

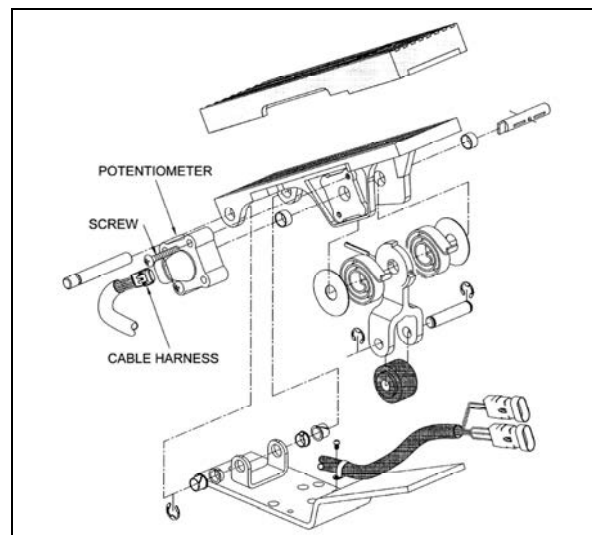


FIGURE 22: ELECTRONIC FOOT PEDAL ASSEMBLY 03035

11. SPECIFICATIONS

Davco Fuel Pro 382 Fuel Filter / Water Separator Element

Prevost number510795

Racor Primary Fuel Filter / Water Separator (optional)

(May be used instead of regular primary filter (never use with a primary filter).

Make Racor

Type Replaceable cartridge

ELEMENT

Prevost number531390

BOWL

Prevost number531389

DRAIN VALVE AND SEAL

Prevost number531397

O-RING

Prevost number531398

PROBE/WATER SENSOR

Prevost number531391

Primary Fuel Filter (Fuel/Water Separator) With Detroit Diesel Series 60 Engine

MakeAC

Type Spin-on

Filter No.T-915D

Prevost number032700

Element torque 1/2 turn after gasket contact

Primary Fuel Filter (Fuel/Water Separator) With Volvo D13 Engine

Part number20879806

Filter torque..... 1/2-3/4 turn after gasket contact

Secondary Fuel Filter With Detroit Diesel Series 60 Engine

MakeAC

Type Spin-on

Filter No.T-916D

Prevost number510794

Element torque 1/2 turn after gasket contact

Secondary Fuel Filter With Volvo D13 Engine

Part number20405160

Filter torque..... 3/4- 1 turn after gasket contact

Section 03: FUEL SYSTEM

Fuel tank Capacity

Standard (X3-45).....208 US gallons (787 liters)

Air Cleaner

Make Nelson

Prevost Number530206

Service Part No 7182 8N

Prevost number (element cartridge)530197

Air Cleaner Restriction Indicator

Make Donaldson

ModelRBX00-2220

Indicatesat 20" (508 mm) of water

Prevost number530161

Preheater Fuel Filter

Make Webasto

Prevost number871037

Fuel Cooler

Make Long Manufacturing

Prevost number531422

SECTION 04: EXHAUST SYSTEM

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Section 04: EXHAUST SYSTEM

1. EXHAUST AND AFTERTREATMENT SYSTEM OVERVIEW

The technology behind clean emissions technology is an exhaust **Aftertreatment Device (ATD)** which replaces today's muffler. The ATD primary function is to capture and oxidize (regenerate) the particulate matter (soot) in the engine exhaust gases. The ATD is split into two main sections. The exhaust gases first enter the **Diesel Oxidation Catalyst (DOC)** and then flow through the **Diesel Particulate Filter (DPF)**; together they capture and regenerate the soot on a regular or passive basis. Through constant monitoring of the exhaust gas temperature and the system back pressure, DDEC VI (Detroit Diesel) or EMS (Volvo) is able to manage regeneration.

The ATD is rubber mounted to the vehicle structure. This feature reduces the transmission of vibrations to the ATD thus resulting in extended life of ATD, brackets and also noise reduction.

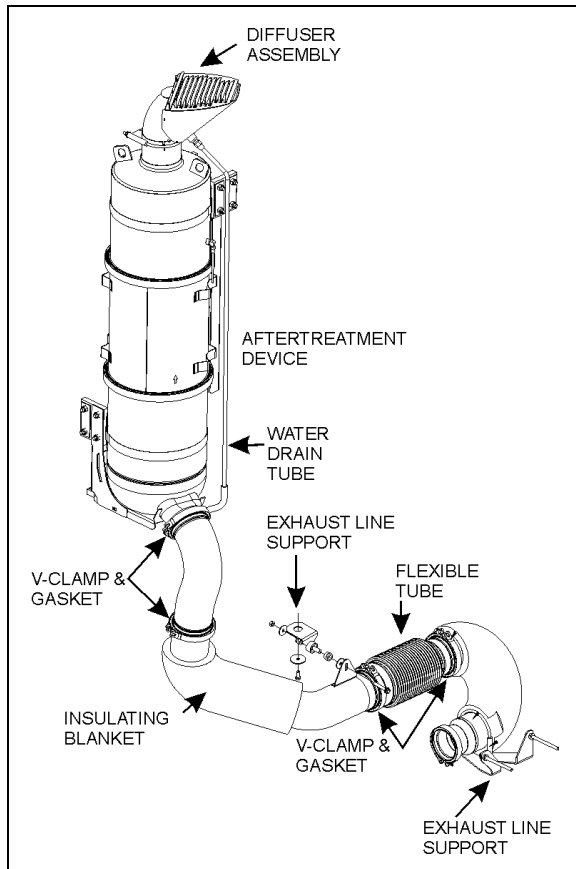


FIGURE 1: EXHAUST SYSTEM (DDC S60 SYSTEM SHOWN, VOLVO D13 SIMILAR) 04017

1.1 MAINTENANCE

Inspect the exhaust system periodically for restrictions and leaks. Figure 1 presents the major components of the exhaust system. Exhaust leaks are commonly the result of loose clamp bolts, corroded or punctured pipes. In addition to excessive noise, a leaking exhaust system could allow toxic gases to enter the vehicle. Damage to surrounding components from hot gases could result as well. Replace damaged or corroded exhaust components immediately.

Inspect the exhaust system as follows:

- At vehicle inspection intervals ;
- Whenever a change is noticed in the sound of the exhaust system ;
- When components close to the exhaust system get unnaturally dirty ; and
- Whenever the exhaust system is damaged.

Replace damaged or corroded exhaust system components without delay.

When operating the engine in a service garage or in a closed area, the exhaust must be vented to the outside. Place the shop vent hose over the exhaust outlet pipe.

DANGER

Avoid breathing exhaust gases since they contain carbon monoxide which is odorless and colorless but harmful. Carbon monoxide is a dangerous gas that can cause unconsciousness and can be lethal. If, at any time you suspect that exhaust fumes are entering the vehicle, locate and correct the cause(s) as soon as possible.

NOTE

The key to successful regeneration is high exhaust temperature for an extended period of time. For this reason, insulating blankets must remain permanently on the exhaust system.

If insulating blankets are removed from the system, the exhaust gases temperature may not be high enough to permit efficient particulate oxidation during passive regeneration, resulting in increased fuel consumption due to overuse of active or stationary regeneration.

1.2 FLEXIBLE COUPLING INSTALLATION

The flexible coupling contains a rigid interior pipe (Fig. 2). To allow appropriate flexibility once installed, be sure interior pipe is concentric to flexible part and that the flexible coupling is straight when installed. This piece of equipment handles vibration and thermal expansion.

CAUTION

Adequately support the exhaust system line. The load of the exhaust line **must not** be transferred to the turbocharger.

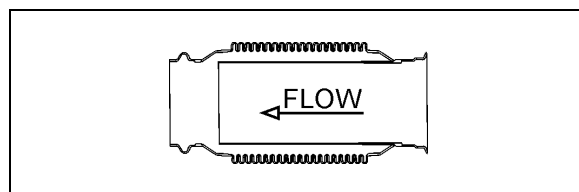


FIGURE 2: FLEXIBLE COUPLING 04022

2. AFTERTREATMENT DEVICE (ATD)

Besides trapping soot, the **DPF (Diesel Particulate Filter)** also traps the ash that has been generated when additives in engine oil are burned. However, unlike soot, ash cannot be oxidized. The ash that accumulates in the filter will eventually cause an increase in exhaust back pressure. DDEC VI or EMS will constantly monitor the ash accumulation and forecast the approximate time until DPF ash cleaning is required. This allows you the opportunity to plan for the DPF ash cleaning interval. If ash cleaning is not performed proactively, and the back pressure increases beyond the system limit, DDEC VI or EMS will flag the amber warning light on the telltale panel, notifying the operator that an ash cleaning is required. Clean remanufactured DPF cartridge will be available through Detroit Diesel on an exchange basis. For most vehicle applications and duty cycle, this will occur after approximately 200,000-400,000 miles (320,000-640,000 km) of operation.

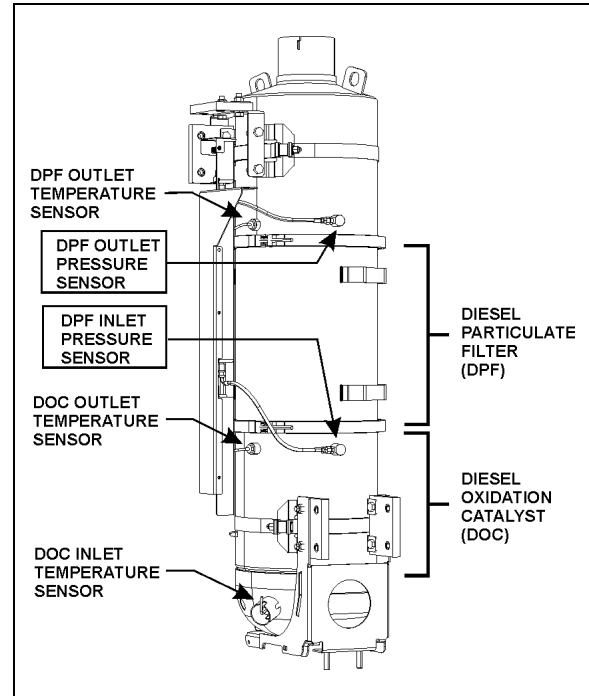


FIGURE 3: AFTERTREATMENT DEVICE (ATD USED WITH DDC S60 ENGINE SHOWN, ATD USED WITH VOLVO D13 ENGINE IS SLIGHTLY DIFFERENT 04016

WARNING

HOT SURFACES

Keep yourself clear of hot Aftertreatment Device surfaces, particularly during and after active or stationary regeneration. Hot surfaces can cause serious burns.

Make sure Aftertreatment System components are cold before handling.

WARNING

HOT EXHAUST

During stationary regeneration, exhaust gases temperature may reach up to 1200°F (650°C) at the DPF outlet. Do not direct at combustible materials. Before initiating stationary regeneration, make sure that the DPF outlet diffuser is clear of objects and that no one is working near the DPF outlet diffuser. Stationary regenerations must be undertaken outdoors only.

Section 04: EXHAUST SYSTEM



WARNING

TOXICITY

Do not initiate a stationary regeneration in a closed area like a garage. **Stationary regeneration must be undertaken outdoors only.**

2.1 DIESEL PARTICULATE FILTER (DPF) REMOVAL - BOTH ENGINES

To remove the DPF, proceed as follow:



CAUTION

External and internal temperatures remain hot long after engine has been shutdown. Allow the Aftertreatment Device and DPF to cool before handling. Wear protective clothing and glove while servicing.

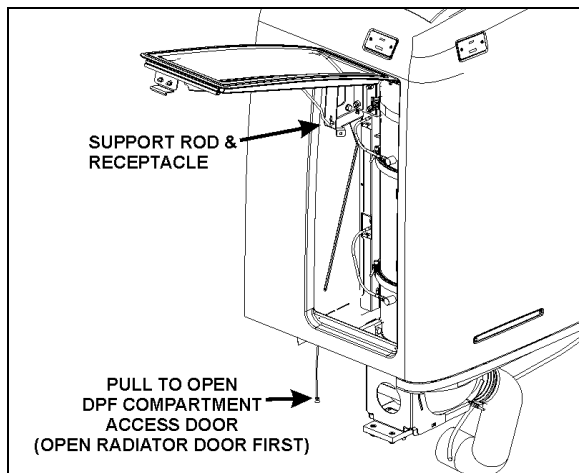


FIGURE 4: OPENING DPF COMPARTMENT ACCESS DOOR 04023

1. First, open the engine compartment door;
2. Under the ATD (Aftertreatment Device), on the left wall, pull the catch connecting rod to unlock the DPF compartment access door and lift the door open;
3. Hold the door open by inserting the support rod's free end into the receptacle located on the left side of the DPF;



CAUTION

After inserting the support rod into the receptacle, make sure the rod supports the door securely from falling down on to your head or body.

4. From under the ATD, loosen the water drain tube hose clamp to set free the tube as it will move up with the ATD later in this procedure.
5. To ease proper positioning of the ATD and the diffuser at the time of reinstallation, using a marker, draw a line along the support strap bracket on the ATD. This will be helpful to reposition the ATD exactly as it was before removal (figure 5).

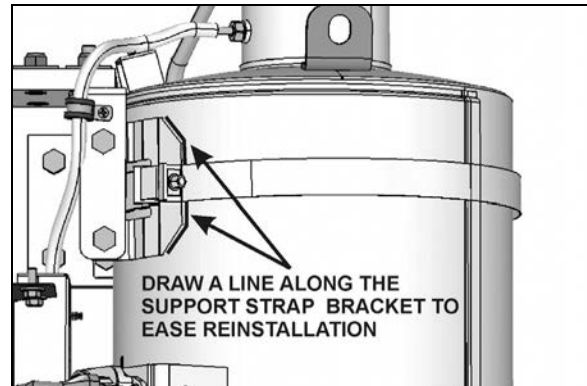


FIGURE 5: MARKING THE SUPPORT STRAP BRACKET 04024

6. **With Volvo D13 engine:** Disconnect the DPF inlet pressure pick-up tube, this will help to clear the way off for removal of the DPF cartridge from the compartment (figure 6).

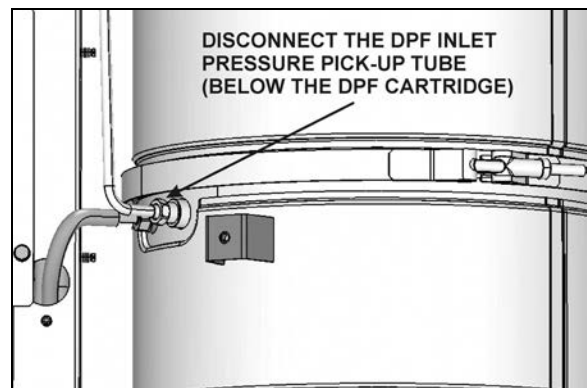


FIGURE 6: DISCONNECTING THE LOWER PRESSURE PICK-UP TUBE (VOLVO D13 ONLY) 04025

7. **With Volvo D13 engine;** Dismount the differential pressure sensor and detach the two hoses from the differential pressure sensor. Detach the two pressure pick-up tubes from the support bracket. This will help to clear the way off for removal of the DPF cartridge from the compartment (figure 7).

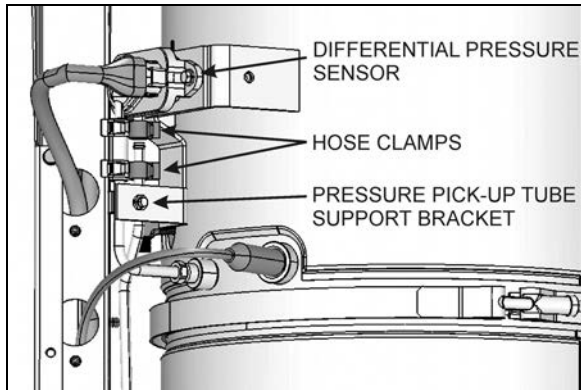


FIGURE 7: PRESSURE DIFFERENTIAL SENSOR AND TAKE UP TUBES (VOLVO D13 ONLY) 04026

8. Loosen the support strap surrounding the upper part of the Aftertreatment Device (ATD).
9. Loosen the upper V-band clamp joining the DPF to the upper part of the ATD. Slide the V-band clamp out of the way.

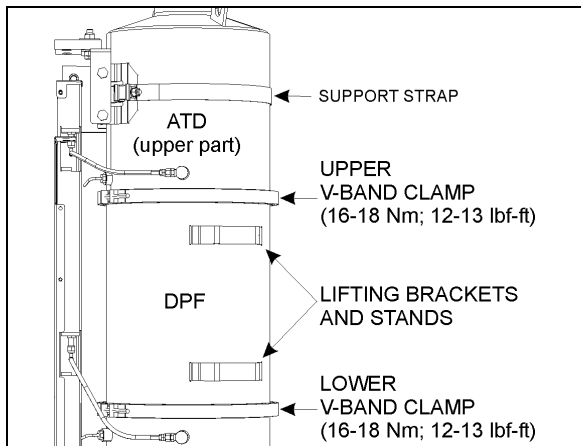


FIGURE 8: DPF REMOVAL 04019

10. Lift up the upper part of the ATD about 1" to 1 1/2" and then tighten the strap to maintain it in that raised position;

NOTE

On vehicles equipped with Volvo D13 engines, you can use the vehicle's hydraulic jack to lift the upper part of the ATD. Install the jack on a wood block inside the DPF compartment and lift the upper part at the differential sensor bracket. Use a 1 1/2"X1 1/2" angle to reach the bracket after having fixed it with a C-clamp on the bracket.

11. Loosen the lower V-band clamp and slide it out of the way;

12. Set the pressure pick-up tubes aside and pull the DPF cartridge out of the compartment. Use appropriate handling equipment.



CAUTION

HEAVY DEVICE

A suitable lifting or holding device is required. Properly support and attach lifting equipment to prevent the DPF from falling when servicing. The DPF cartridge weighs between 50 to 54 lbs.



CAUTION

FRAGILE - HANDLE WITH CARE

Use extreme care when handling DPF cartridge as it could be damaged or destroyed by dropping or sudden impact.

Clean remanufactured DPF cartridge will be available through Detroit Diesel on an exchange basis. For this reason, it is very important to maintain the cartridge in perfect condition. Damaged cartridge may not be refunded.

NOTE

When replacing the DPF cartridge, refer to the specifications on the DPF attached tag for proper replacement DPF selection.

Installation of the DPF is the same as removal, but in reverse order. However, take note of the following points:

1. To prevent exhaust losses, make sure that the DPF section is perfectly aligned with the DOC and the upper part of the ATD before tightening the V-band clamps.
2. **On Volvo D13 equipped vehicles**, the DPF cartridge is used with two gaskets. Before reinstalling the DPF cartridge, maintain the gaskets in position using masking tape. Place the masking tape outside the DPF cartridge shoulder in order to avoid tape residue inside the filtering cells. Take note that the definite DPF cartridge positioning is done by the use of pins and receptacles on the DPF cartridge and ATD upper and lower sections.
3. Properly tighten all fasteners.

Section 04: EXHAUST SYSTEM

- Be sure to return the support rod to its clip before closing the door, this prevents rattles.

3. DIFFUSER ASSEMBLY

During stationary regeneration, exhaust gases temperature may reach up to 1200°F (650°C) at the DPF outlet. The diffuser decreases the exhaust gasses temperature to 475°F (246°C) approximately, at 6 inches above the diffuser. The diffuser is an important component of the exhaust system and must remain on the vehicle at all times. Operating the vehicle without the diffuser may seriously damage the vehicle.

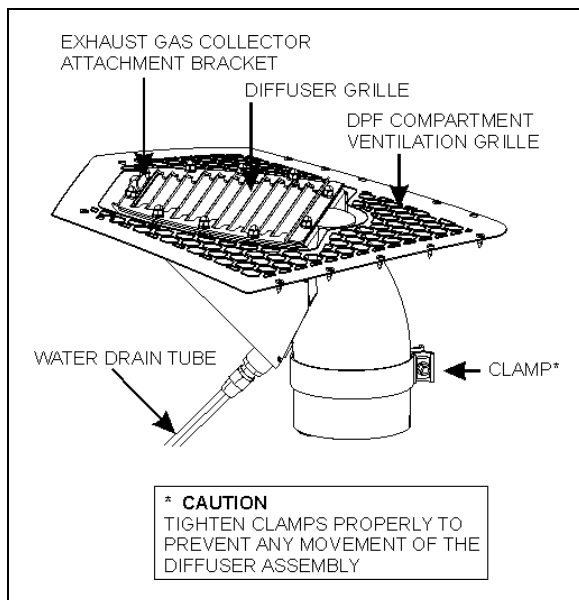


FIGURE 9: DIFFUSER ASSEMBLY

04014

3.1 DIFFUSER ADJUSTMENT

Should an adjustment of the diffuser position be necessary, first remove the DPF compartment ventilation grille.



CAUTION

To prevent damages caused by hot exhaust gases to the surrounding area, the diffuser grille must be flush with the roof surface or may not exceed the roof surface more than 1/4in (6mm).



CAUTION

Tighten clamps properly in order to prevent any movement of the diffuser assembly. An impact wrench is necessary.

- Loosen the clamp securing the diffuser assembly to the ATD.
- For proper angular position, make sure that the two edges shown on figure 10 are parallel with each other.

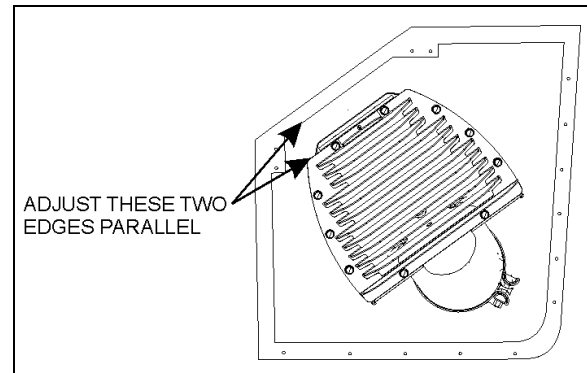


FIGURE 10: DIFFUSER POSITION ADJUSTMENT

04015_1

- Using a straightedge, adjust the diffuser assembly level. The top surface of the tag fixed on the diffuser grille must be flush with the roof surface (fig.9). It may exceed about 1/4in (6mm). Place the straightedge as shown on figure 11.

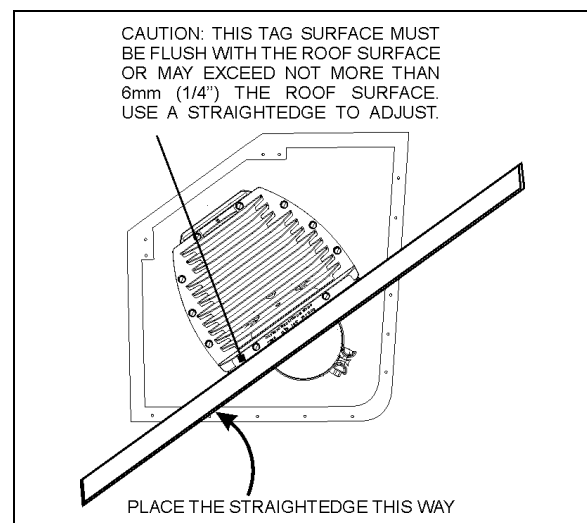


FIGURE 11: DIFFUSER POSITION ADJUSTMENT

04015_2

- Tighten the clamp securing the diffuser assembly to the ATD.
- Reinstall the DPF compartment grille. Put a small quantity of Sika 221 on screws (fig.12).

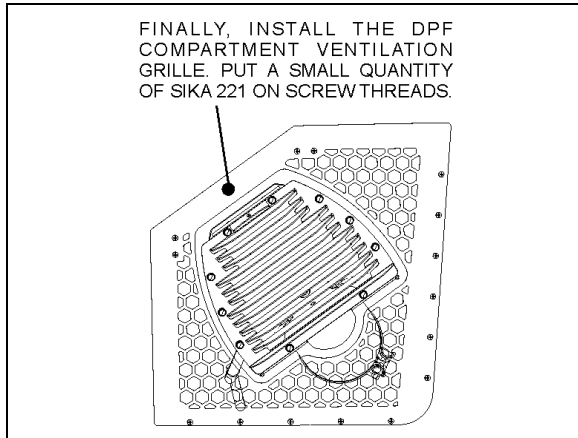


FIGURE 12: DIFFUSER POSITION ADJUSTMENT 04015_3

3.2 MAINTENANCE

Inspect the diffuser assembly as follows:

- At vehicle inspection intervals, inspect diffuser grille for stress cracking;
- Check for proper functioning of the rain cap inside the diffuser housing, make sure that it moves freely;
- Make sure that the water drain tube is not clogged. Pour a cup of water into the diffuser housing and assure that all the water is drained at once at the other end of the drain tube. If tube is clogged, remove tube and blow compressed air inside, in reverse flow.

3.3 DIFFUSER ADAPTER

A diffuser adapter (Prevost #040710) is available through Prevost Parts to permit connection with current exhaust gas collecting system.

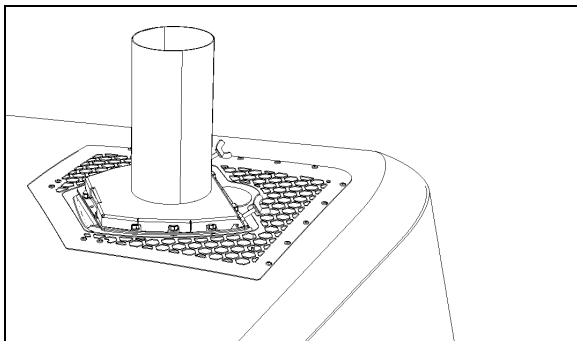


FIGURE 13: DIFFUSER ADAPTER 04020

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1. DESCRIPTION

A radiator and thermo-modulated fan are used to effectively dissipate the heat generated by the engine. A centrifugal-type water pump is used to circulate the engine coolant (Fig. 1).

Two full blocking-type thermostats are used in the water outlet passage to control the flow of coolant, providing fast engine warm-up and regulating coolant temperature.

The engine coolant is drawn from the lower portion of the radiator by the water pump and is forced through the transmission cooler before going through the oil cooler and into the cylinder block.

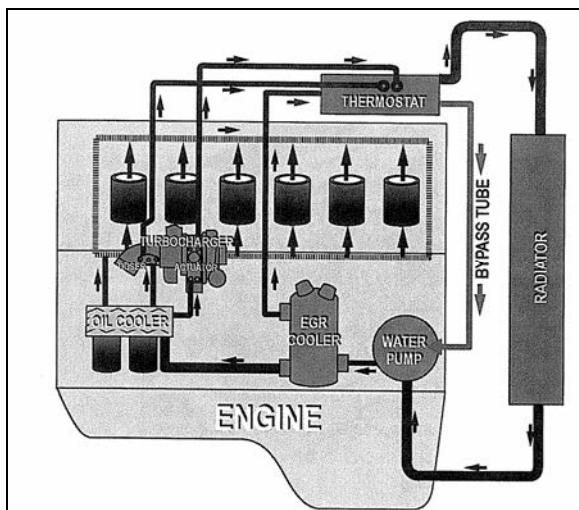


FIGURE 1: COOLANT FLOW SCHEMATIC (IMAGE DDC)

From the cylinder block, the coolant passes up through the cylinder head and, when the engine is at normal operating temperature, it goes through the thermostat housing and into the upper portion of the radiator. The coolant then passes through a series of tubes where its heat is dissipated by air streams created by the revolving fan and the motion of the vehicle.

Upon starting a cold engine or when the coolant is below normal operating temperature, the closed thermostats direct coolant flow from the thermostat housing through the by-pass tube to the water pump. Coolant is recirculated through the engine to aid engine warm up.

When the thermostat opening temperature is reached, coolant flow is divided between the radiator inlet and the by-pass tube. When the thermostats are completely open, all of the coolant flow is to the radiator inlet.

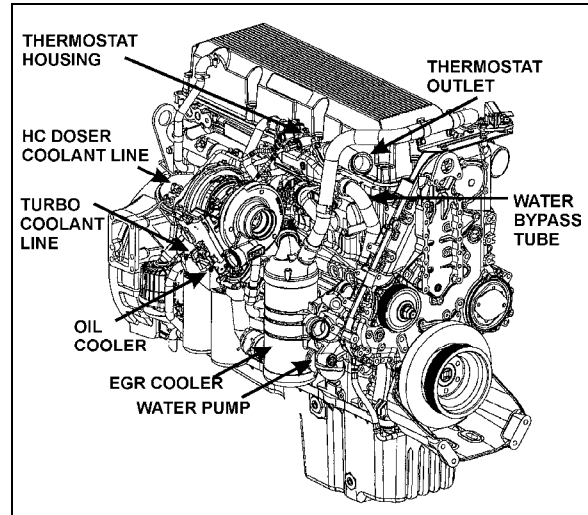


FIGURE 2: COOLING SYSTEM COMPONENTS (DDC S60 ENGINE) 05116

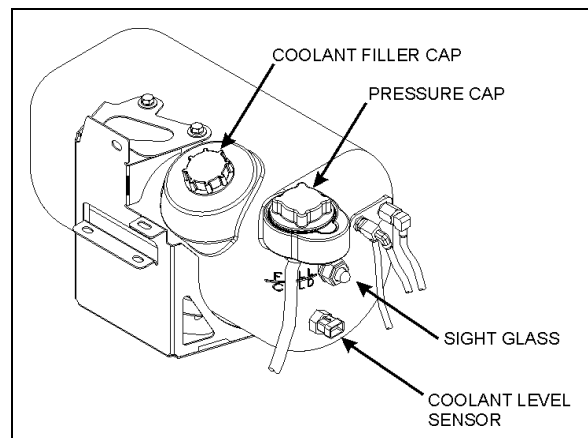


FIGURE 3: COOLANT SURGE TANK 05132

The cooling system is filled through a filler cap on the surge tank (Fig. 3). A pressure cap on top of the surge tank is used to maintain pressure within the system. When system exceeds normal pressure rating (14 psi - 96.53 kPa), the cap releases air and if necessary, coolant through the overflow tube (Fig. 4). Two thermostats are located in the housing attached to the right side of the cylinder head (Fig. 2). Furthermore, a water temperature sensor mounted on the cylinder head (radiator side) is also supplied for engine protection purposes (DDC S60).

The engine cooling system also provides hot coolant fluid for the vehicle heating system. Refer to section 22, "HEATING AND AIR CONDITIONING" in this manual for information relating to heating system water circulation.

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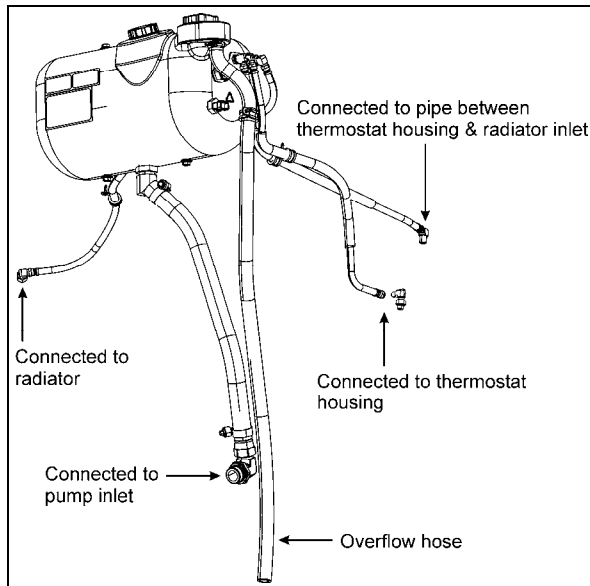


FIGURE 4: SURGE TANK (WITH DDC S60) 05115

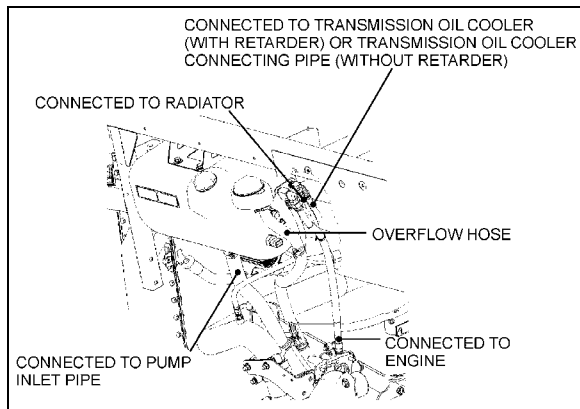


FIGURE 5: SURGE TANK (WITH VOLVO D13) 05143

2. MAINTENANCE

2.1 GENERAL RECOMMENDATIONS

A systematic routine inspection of cooling system components is essential to ensure maximum engine and heating system efficiency.

- Check coolant level in the surge tank daily, and correct if required. Test antifreeze strength.
- Check belts for proper tension; adjust as necessary and replace any frayed or badly worn belts.
- Check radiator cores for leaks and make sure the cores are not clogged with dirt or insects. To avoid damaging the fins, clean cores with a low-pressure air hose. Steam clean if required.

- Inspect the water pump operation. A leaky pump sucks in air, increasing corrosion.
- Repair all leaks promptly. Unrepaired leaks can lead to trouble. Inspect and tighten radiator mounts periodically. Test and replace thermostats regularly.

NOTE

In order to ensure the integrity of the system, it is recommended that a periodic cooling system pressure check be made. Pressurize the cooling system to 103-138 kPa (15-20 psi) using Radiator and Cooling System Tester, J24460-1. Do not exceed 138 kPa (20 psi).

Any measurable drop in pressure may indicate a leak. Whenever the oil pan is removed, the cooling system should be pressure checked as a means of identifying any incipient coolant leaks. Make sure the cause of the internal leak has been corrected before flushing the contaminated system.

Leaks at the thermostat housing hose connections may be caused by deformation of connections or by rough surfaces on the castings of the hose mounting surfaces. It is recommended that "Dow Corning RTV-102 Compound" or any equivalent product be applied on cast surfaces prior to hose installation.



CAUTION

Castings should be clean and free of oil and grease before applying compound. No other sealer should be used with RTV-102 compound.

2.2 VEHICLES EQUIPPED WITH DDC SERIES 60 ENGINE



MAINTENANCE

Maintain the prescribed inhibitor strength levels as required. Coolant and inhibitor concentration must be checked at each engine oil change, every 12,500 miles (20 000 km) or once a year, whichever comes first to ensure inhibitor strength. For vehicles equipped with coolant filters replace precharge element filter with a maintenance element filter as per "SPIN-ON COOLANT FILTER" in this section. If the vehicle is not equipped with a filter, add the recommended inhibitor concentration to the antifreeze/water solution.

**MAINTENANCE**

Drain, flush, thoroughly clean and refill the system every two years or every 200,000 miles (320 000 km), whichever comes first. For vehicle equipped with coolant filters, change the precharge element filter or the existing maintenance element filter for a new precharge element filter. If the vehicle is not equipped with filters add the recommended inhibitor concentration to the antifreeze/water solution.

NOTE

Do not add inhibitors to the antifreeze / water solution if vehicle is equipped with a coolant filter containing Supplemental Coolant Additives (SCA).

Coolant must be discarded in an environmentally safe manner.

2.2.1 Vehicles without coolant filters

Refer to Nalcool 3000 with Stabil-Aid bulletin annexed to the end of this section for preventive maintenance (at each oil change) and initial treatment instructions (each time the cooling system is drained and flushed).

2.2.2 Vehicles with coolant filters

Change the coolant precharge element filter for a maintenance element filter at initial oil change (see "Specifications" at the end of this section) and replace existing maintenance element filter with a new one as per "SPIN-ON COOLANT FILTER" in this section. A precharge element filter must be installed each time the cooling system is drained and flushed prior to installing a maintenance element filter.

NOTE

The precharge coolant filter contains inhibitors.

2.3 VEHICLES EQUIPPED WITH VOLVO D13 ENGINE**NOTE**

For additional information concerning Volvo D13 engine components or engine-related components, consult Volvo Trucks Canada or Volvo Trucks North America Web Site under: Parts & Service. On Volvo web site, you will find detailed service procedures for parts replacement, repair and maintenance.

**MAINTENANCE**

Drain, flush, thoroughly clean and refill the system with Extended Life Coolant (ELC) every four years or every 600,000 miles (1 000 000 km), whichever comes first. Change the coolant filter once a year or every 150,000 miles (240 000 km), whichever comes first. When using ELC, **do not** use a filter that contains Supplemental Coolant Additives (SCA).

3. HOSES

Rotten, swollen, and worn out hoses or loose connections are frequent causes of cooling system problems.

Serious overheating is often caused by an old hose collapsing or from rotten rubber shedding from hoses and clogging the coolant passages.

Connections should be inspected periodically and hose clamps tightened. Replace any hose found to be cracked or swollen.

When installing a new hose, clean pipe connections and apply a thin layer of a non-hardening sealing compound. Replace worn out clamps or clamps that pinch hoses.

3.1 CONSTANT-TORQUE HOSE CLAMPS ON COOLANT LINES – DDC S60 & VOLVO D13

All hose clamps of 1 3/8" ID and over, used on the heating and cooling systems, are of the "Constant-torque" type. These clamps are worm-driven, made of stainless steel, and supplied with a series of Belleville spring washers. They also feature an extended integral liner that covers the band slots to protect soft/silicone hoses from damage, and help maintain consistent sealing pressure.

This type of clamp is designed to automatically adjust its diameter to compensate for the normal expansion/contraction of a hose and metal connection that occurs during vehicle operation and shutdown. The constant-torque clamp virtually eliminates coolant losses due to "Cold flow" leakage and greatly minimizes clamp maintenance.

Section 05: COOLING SYSTEM

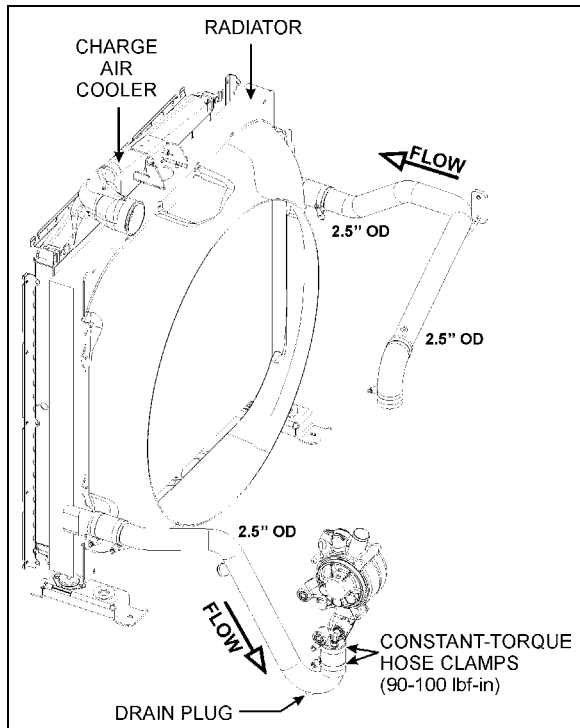


FIGURE 6: COOLANT FLOW TO RADIATOR (DDC S60)
05133

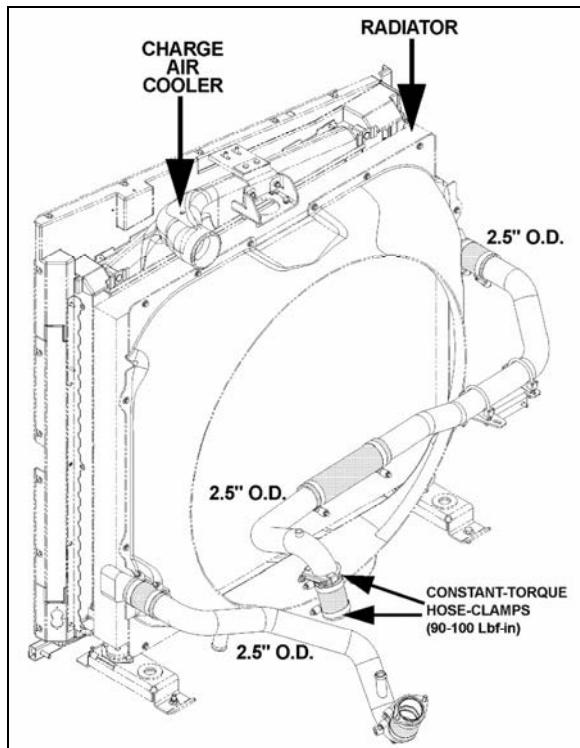


FIGURE 7: COOLANT FLOW TO RADIATOR (VOLVO D13)

3.1.1 Installation

A torque wrench should be used for proper installation. The recommended torque is 90 to

100 lbf-in. (10 to 11 Nm). The Belleville spring washer stacks should be nearly collapsed flat and the screw tip should extend 1/4" (6 mm) beyond the housing (Fig. 8).

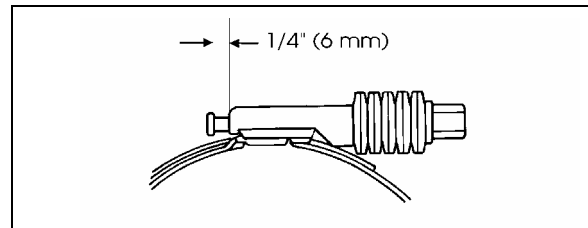


FIGURE 8: CONSTANT-TORQUE CLAMP

05037



CAUTION

The hose clamps will break if over-torqued. Do not over-tighten, especially during cold weather when hose has contracted.

3.1.2 Maintenance

The constant-torque clamps contain a "Visual torque check" feature. When the tip of the screw is extending 1/4" (6 mm) out of the housing, the clamp is properly installed and maintains a leak-proof connection. Since the constant-torque clamp automatically adjusts to keep a consistent sealing pressure, there is no need to re-torque hose clamps on a regular basis. During vehicle operation and shutdown, the screw tip will adjust according to the temperature and pressure changes. **Checking for proper torque should be done at room temperature.**

3.2 CONSTANT-TORQUE HOSE CLAMPS ON CHARGE AIR COOLER (CAC)

If for any reason such as an accident, hose clamps need to be changed; install and tighten hose clamps to 10±1 lbf-ft (dry) (Fig. 9 & 10).



CAUTION

The hose clamps will break if over-tighten. Do not over-tighten, especially during cold weather when hose has contracted.

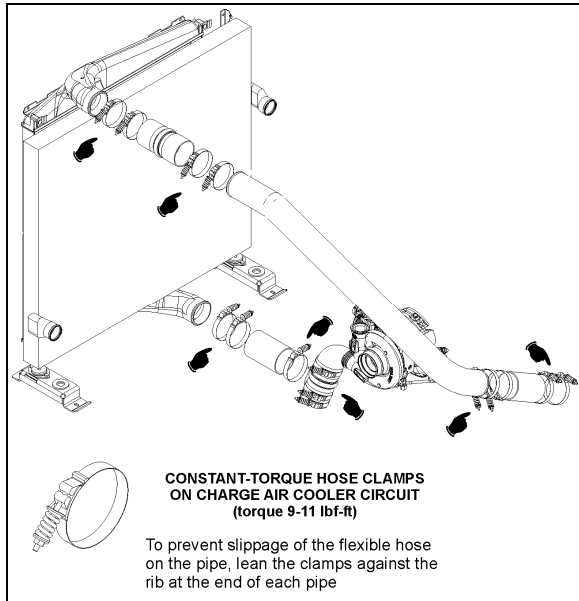


FIGURE 9: CHARGE AIR COOLER HOSE CLAMPS (DDC S60) 05134

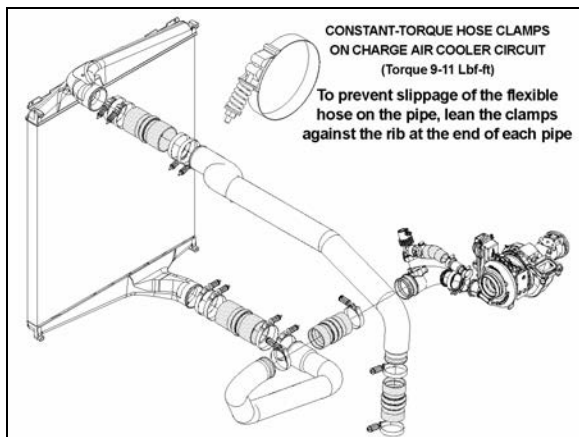


FIGURE 10: CHARGE AIR COOLER HOSE CLAMPS (VOLVO D13)

NOTE

Detroit Diesel Series 60 and Volvo D13 engines have similar CAC piping designs and they use the same constant-torque hose clamps. Tighten hose clamps as specified above.

3.2.1 Maintenance

Since the constant-torque clamp automatically adjusts to keep a consistent sealing pressure, there is no need to retorque hose clamps on a regular basis. During vehicle operation and shutdown, the screw tip will adjust according to the temperature and pressure changes.

Checking for proper torque should be done at room temperature.

4. THERMOSTAT OPERATION

4.1 DETROIT DIESEL SERIES 60 ENGINE

Coolant temperature is controlled by two blocking-type thermostats located in a housing attached to the cylinder head, on the turbo side of the engine (Fig. 11).

At coolant temperature below approximately 182°F-188°F (83°C-86°C), the thermostat valves remain closed and block the flow of coolant from the engine to the radiator. During this period, all of the coolant in the system is recirculated through the engine and directed back to the suction side of the water pump via a bypass tube. As the coolant temperature rises above 182°F -188°F (83°C-86°C) the thermostat valves start to open, restricting the bypass system, and allowing a portion of the coolant to recirculate through the radiator. When the coolant temperature reaches approximately 202°F (95°C) thermostat valves are fully open, the bypass system is blocked off and the coolant is directed through the radiator.

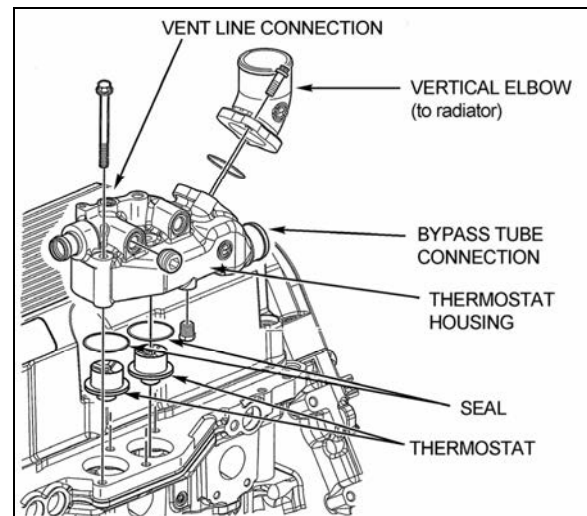


FIGURE 11: THERMOSTAT HOUSING (DDC S60 ENGINE) 05117

4.2 VOLVO D13 ENGINE

1. Drain the cooling system.
2. Remove the bolts, the thermostat housing and the thermostat. Carefully clean the thermostat seat and all cylinder head-to-thermostat housing mating surfaces.

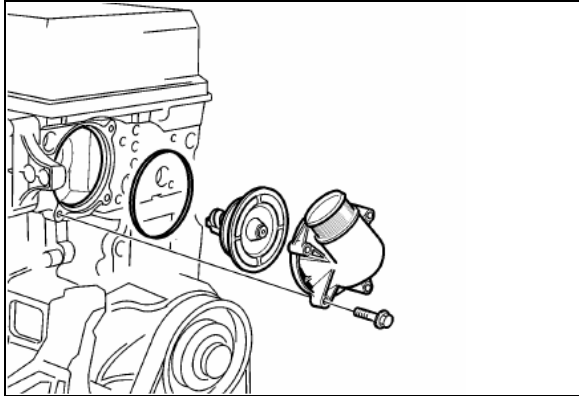


FIGURE 12: THERMOSTAT HOUSING (VOLVO D13 ENGINE)

3. Install the new thermostat. Make sure that the rubber seal remains properly seated.
4. Position the thermostat housing to the cylinder head, install the bolts and torque-tighten to 24 ± 4 Nm (18 ± 3 ft-lb).
5. Install the rubber radiator hose to the thermostat housing. Position the clamp and tighten to secure.
6. Fill the system with the recommended coolant.
7. Start the engine, check for leaks and proper operation. After shutdown, replenish fluids as necessary.

4.2.1 Thermostat Checking

A function check must be carried out before installing a new thermostat.

NOTE

Check to be sure that the thermostat closes fully. This can be done by holding it up to the light to check that there is no visible gap at the opening point. If the thermostat does not close properly, replace it.

1. Warm up water in a receptacle to 75°C (167°F) and immerse the thermostat in the water. Use a piece of wire attached to the thermostat.
2. After at least 30 seconds, check that the thermostat is still closed.
3. Now warm the water to 100°C (212°F). After at least 30 seconds at the boiling point, check that the thermostat has opened at least 7mm ($9/32$ in). If the thermostat has not opened, it must be replaced. A good thermostat starts to close at 95°C (203°F) and is fully closed at approximately 85°C (185°F).

5. COOLANT

5.1 COOLANT LEVEL VERIFICATION

Coolant level is correct when cold coolant is visible through the surge tank sight glass (Fig. 13). If coolant level is low, fill cooling system.

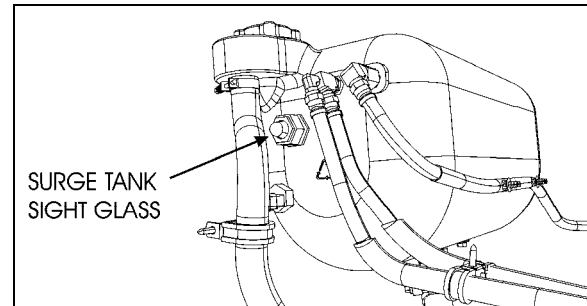


FIGURE 13: SURGE TANK SIGHT GLASS 05114

5.2 COOLANT LEVEL SENSOR

This warning device consists of a fluid level probe mounted on the surge tank. The probe sends a signal to the engine control module to indicate coolant level. If the coolant level drops below the probe, the "Check Engine" light flashes and a diagnostic code is registered (see section 01 "ENGINE").



CAUTION

Do not run engine with the "Check Engine" light flashing.

The level probe is mounted on the R.H. side of the surge tank.

5.3 THAWING COOLING SYSTEM

If the cooling system becomes frozen solid, place the coach in a warm area until the ice is completely thawed. Under no circumstances should the engine be operated when the cooling system is frozen, as it will result in engine overheating due to insufficient coolant.

Once thawed, check engine, radiator and related components for damage caused by expansion of frozen coolant fluid.

5.4 COOLING SYSTEM RECOMMENDATIONS

Always maintain cooling system at the proper coolant level. Check daily.

The cooling system must be pressurized to prevent localized boiling of coolant. The system must be kept clean and leak-free. The filler and pressure caps must be checked periodically for proper operation.

The coolant provides a medium for heat transfer and controls the internal temperature of the engine during operation. In an engine having proper coolant flow, some of the combustion heat is conveyed through the cylinder walls and the cylinder head into the coolant. Without adequate coolant, normal heat transfer cannot take place within the engine, and engine temperature rapidly rises. Coolant must therefore be carefully selected and properly maintained.

Select and maintain coolant in order to meet the following basic requirements:

- Provide for adequate heat transfer.
- Provide protection from cavitation damage.
- Provide a corrosion and erosion resistant environment within the cooling system.
- Prevent formation of scale or sludge deposits in the cooling system.
- Be compatible with the cooling system hose and seal materials.
- Provide adequate freeze protection during cold weather operation.

When freeze protection is required, a mixture of suitable water and antifreeze containing adequate inhibitors will provide a satisfactory coolant fluid.

Freeze protection down to:	percentage of antifreeze in mixture
-13°F (-25°C)	40%
-22°F (-30°C)	46%
-36°F (-38.5°C)	54%
-51°F (-46°C)	60%

5.5 COOLANT RECOMMENDATIONS FOR DETROIT DIESEL SERIES 60 ENGINE

A decal (052635) located on the surge tank provides information on recommended coolants.



Recommended phosphate free coolants for Detroit Diesel Series 60 engine:

- Prevost #685125;

- Detroit Diesel “DDC Power Cool” (P/N 23512138);
- Prestone AF977 (bulk), 72702 (3.78 L), 70119 (205L), 70102 (4L).

Combining suitable water with reliable inhibitors satisfies the first five requirements. When freeze protection is required, a solution of suitable water and antifreeze containing adequate inhibitors will provide a satisfactory coolant fluid. Ethylene glycol-based antifreeze is recommended for use in Series 60 engines. The cooling system capacity is 24 US gal (91 liters).

NOTE
In general, antifreeze does not contain adequate inhibitors. For this reason, supplemental coolant additives are required.

For a complete overview of engine coolants used with Detroit Diesel Engines, refer to "Coolant Selections" For Engine Cooling Systems Guide at the end of this section (#7se298).

1. Always use recommended antifreeze, inhibitor and water at proper concentration levels. A 50% coolant/water solution is normally used as factory fill. Antifreeze concentration over 70% is not recommended because of poor heat transfer capability, adverse freeze protection and silicate dropout. Antifreeze concentration below 30% offers little freeze, boilover or corrosion protection.
2. Use only ethylene glycol antifreeze meeting the Detroit Diesel #7se298 or TMC RP-329 "Type A" formulation.
3. Use an antifreeze solution year-round for freeze and boil-over protection. Seasonal changing of coolant from an antifreeze solution to an inhibitor/water solution is recommended.
4. Pre-mix coolant makeup solutions at proper concentrations before adding to the cooling system.
5. Maintain the prescribed inhibitor strength levels as required.
6. Do not mix different base inhibitor packages.
7. Always maintain proper coolant level.

Section 05: COOLING SYSTEM



CAUTION

Always test the solution before adding water or antifreeze.

8. If cooling system is not at the proper protection level. Mix coolant/water solution to the proper concentration before adding to the cooling system
9. Use only non-chromate inhibitors.
10. Distilled water is recommended.

5.5.1 Coolant Not Recommended

- All antifreeze and coolant containing phosphorous;
- Automotive type coolants;
- Methoxy propanol-base antifreeze;
- Methyl alcohol-base antifreeze;
- Sealer additives or antifreezes containing sealer additives.

5.5.2 Inhibitors

A coolant solution, which has insufficient inhibitors or no inhibitors at all, invites the formation of rust, scale, sludge and mineral deposits within the cooling system. These deposits can cause water pump seal wear and coat the interior of coolant system passages. Heat transfer is reduced as deposits build up, leading to an overheating condition. Continued operation with this condition can lead to serious engine damage: liner scuffing, scoring, piston seizure and cylinder head cracking. These damages can occur quickly or over a longer period of time, depending of location and amount of deposits. Improperly inhibited coolants can become corrosive enough to "eat away" coolant passages and seal ring grooves and cause leaks to develop. Hydrostatic lock can occur if leak is internal and accumulates on top of a piston. The result may be a bent connecting rod. Cavitation erosion may occur in improperly inhibited coolants. Cavitation erosion is caused by the implosion of tiny bubbles against localized surfaces of the system. Such implosion causes pinpoint pressures high enough to erode pump impellers, cylinder liners and cylinder blocks. In extreme cases, their surfaces are so deeply pitted that they appear to

be spongy, and holes can develop completely through them.

5.5.3 Inhibitor Test Procedures

Test Kits are commercially available to check engine coolant for nitrite concentration. Nitrite concentration is an indication of Supplemental Coolant Additive (SCA) level. Nitrite must be maintained within recommended levels. Coolant must be tested at each oil change to insure that inhibitor levels are maintained within the ranges shown hereafter:

DDC Fully Formulated Glycol Coolant Limits	
-30 -- 50(°F)	Freeze Point (°F)
125 -- 500 ppm	Boron (ppm)
800 -- 3200 ppm	Nitrite (ppm)
200 -- 750 ppm	Nitrate (ppm)
50 -- 250 ppm	Silicon (ppm)
0 ppm MAX	Phosphorus (ppm)
8.0 -- 11.0	pH
40 ppm MAX	Chlorides (ppm)
100 ppm MAX	Sulfates (ppm)

NOTE

Above SCA values with Detroit Diesel #7se298 or TMC RP-329 "Type A". Use Nalco Chemical Company nitrite test kits (CO-318). A factory coolant analysis program is available through Detroit Diesel distributors under part number 23508774.

5.5.4 Additives Not Recommended

- Soluble Oils;
- Chromates.



WARNING

Never remove filler cap while coolant is hot. When coolant is at ambient temperature, release pressure from system by turning the pressure cap counterclockwise 1/4 turn; then remove filler cap slowly. A sudden release of pressure from the heated cooling system can result in severe burns from the expulsion of hot coolant fluid.

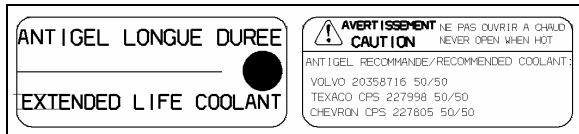
5.6 COOLANT RECOMMENDATIONS FOR VOLVO D13 ENGINE

Coolant mixture consisting of 50/50 antifreeze and deionized water solution should be used year-round to provide freeze and boil-over protection as well as providing a stable environment for seals and hoses.

When topping up coolant, use the same coolant mixture type as the mixture already in the cooling system. Do not mix two different types of coolant.

Do not use antifreeze formulated for automobile gasoline engines, these have a very high silicate content that will clog the radiator and leave unwanted deposits in the engine.

A decal (053487) located on the surge tank provides information on recommended coolants.



Recommended coolants for Volvo D13 engine:

- Prevost #685241 (pre-diluted 50/50 mixture);
- Texaco CPS#227998 (pre-diluted 50/50 mixture);
- Chevron CPS#227805 (pre-diluted 50/50 mixture);
- Volvo 20358716 (pre-diluted 50/50 mixture);

CAUTION

On Volvo D13 engine, use **only** Extended Life Coolant (ELC). **Do not** add supplemental coolant additives (SCA) to extended life coolant. **Do not** use a coolant filter containing Supplemental Coolant Additives (SCA).

CAUTION

Extended Life Coolant (ELC) will test as out of additives (SCA), but SCA should not be added. Shortened engine life may be the result of adding SCA.

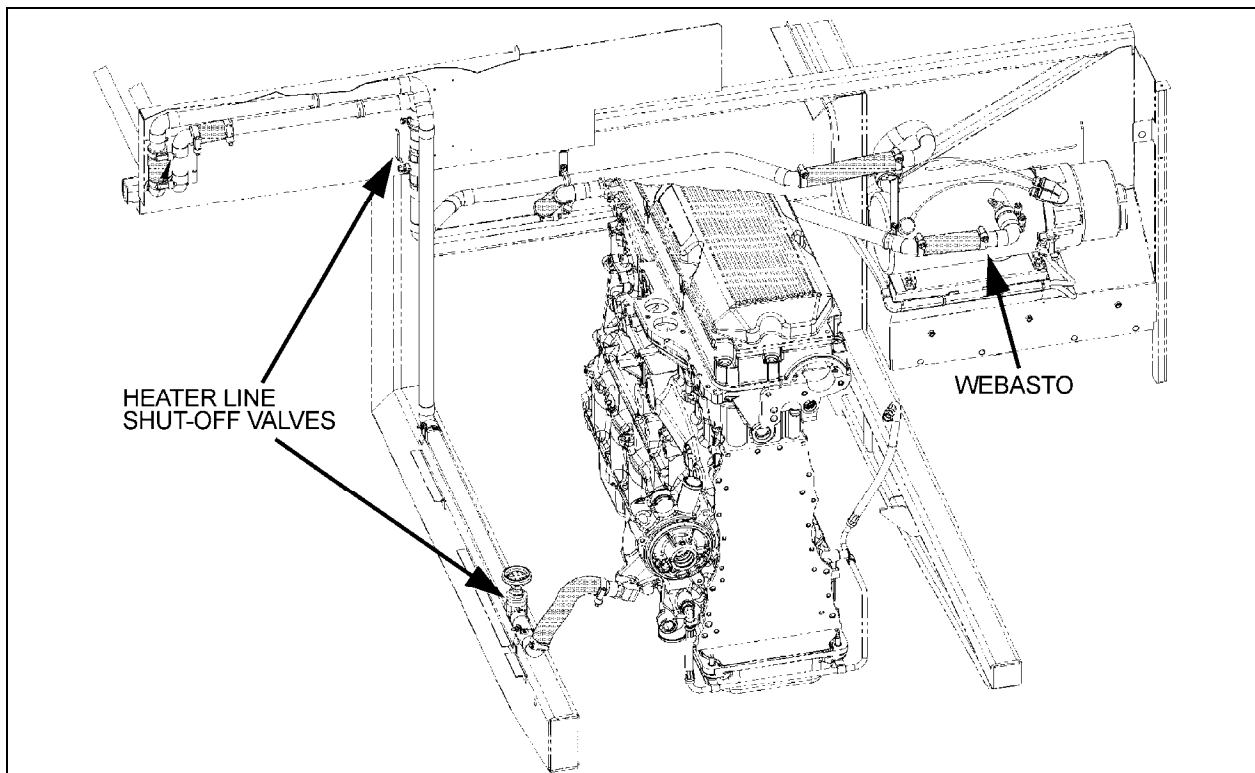


FIGURE 14: LOCATION OF HEATER LINE SHUT-OFF VALVES IN ENGINE COMPARTMENT

05105

Section 05: COOLING SYSTEM

6. DRAINING COOLING SYSTEM

Use the following procedures to drain the cooling system partially or completely.

To drain engine and related components:

1. Stop engine and allow engine to cool. Close both heater line shutoff valves.

On X3- 45 coaches, the valves are located in the engine compartment. One is located under the cooling fan right angle gearbox; another valve is on the L.H. side of the engine compartment in front of the radiator (Fig. 14).

NOTE

Refer to section 22 under "Preheating System" for information about preheater access and heater line shutoff valve.



WARNING

Before proceeding with the following steps, make sure the coolant has cooled down. The sudden release of pressure from a heated cooling system can result in loss of coolant and possible personal injury (scalding) from the hot liquid.

2. Close the shut-off valves on the coolant filter mounting head (if applicable) and remove filter (perform only if filter as to be replaced).
3. Open the shut-off valves on the coolant filter mounting head (if applicable) and drain the coolant into a suitable container. Close the shut-off valves.
4. Unscrew the surge tank pressure cap counterclockwise, ¼ turn to let air enter the system and permit the coolant to drain completely from system.
5. Unscrew the water pump housing inlet line drain plug (Fig. 15) plus the transmission oil cooler delivery line drain plug. Drain the coolant into an approved container.

NOTE

On Volvo D13 engine, the regular drain plugs are replaced by quick connect fittings to ease draining and filling of coolant system.

6. Open drain cock at bottom of thermostat housing to drain the coolant trapped above the thermostats (Fig. 11).
7. Open the radiator drain cock.

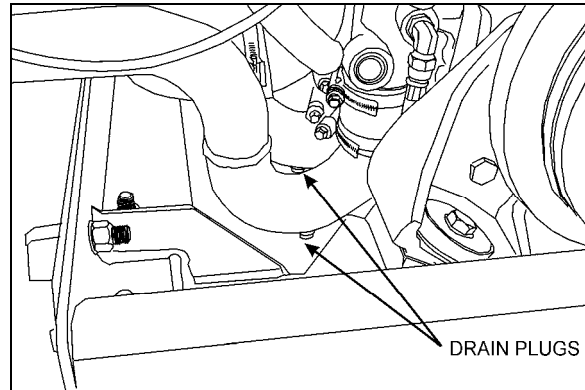


FIGURE 15: WATER PUMP DRAIN PLUG

05093

8. Remove the transmission oil cooler. Drain, flush and inspect. Refer to Section 7, "TRANSMISSION" for oil cooler maintenance or preventive replacement.



CAUTION

Drain water pump completely before extended storage to avoid possible water pump damage.

If freezing weather is anticipated and the engine is not protected with antifreeze, drain the cooling system completely when vehicle is not in use. Trapped water in the cylinder block, radiator or other components may freeze and expand resulting in damages. Leave the drain plugs open until the cooling system can be filled with coolant fluid. Do not run engine with cooling system empty.

To drain the entire system, do the previous steps while maintaining the shutoff valves in the open position; then follow the procedure under "Draining Heating System" in Section 22.

7. FILLING COOLING SYSTEM

If only the engine and related components were drained, maintain the two heater line shutoff valves in their closed position, then proceed as follows:

1. Close all drain cocks. Reinstall the drain plugs with new seals. Refer to draining procedure for the location of draining points.
2. Open the shut-off valves on the coolant filter mounting head (if applicable).
3. Refill cooling system from the surge tank filler cap inlet with the recommended ethylene glycol-based antifreeze and water solution of the required concentration.

NOTE

On Volvo D13 engine, the regular drain plugs are replaced by quick connect fittings to ease draining and filling of coolant system. Coolant system may be refilled by the use of the quick connect fittings.

NOTE

Make sure the purge lines are properly connected and not obstructed. The purge lines (thermostat housing dome, radiator top tank, transmission oil cooler or delivery line) are required to ensure complete engine fill and proper purging of air in the system.

NOTE

The coolant level should remain within two inches of the surge tank filler neck.

4. Install the filler and pressure caps, then start the engine and run it at fast idle until reaching normal operating temperature. Check for leaks.

NOTE

If for any reason, the coolant level drops below the surge tank level probe, the Check Engine warning light will illuminate.

5. Stop engine and allow cooling.
6. Open the two heater line shutoff valves, check the coolant level in the surge tank, and then add as required.



CAUTION

Never pour cold coolant into a hot engine. The sudden change in temperature may crack the cylinder head or block.

If the entire system has been drained, redo the previous steps while maintaining the two heater line shutoff valves in the "Open" position. With engine running, activate the driver's and central heating systems to permit coolant circulation. Complete the procedure by bleeding the heater cores as explained in Section 22, under "Bleeding Heating System".

8. FLUSHING

If the cooling system is contaminated, flush the cooling system as follows:

1. Drain the coolant from the engine.

2. Refill with clean water.



CAUTION

If the engine is hot, fill slowly to prevent rapid cooling and distortion of the engine castings.

3. To thoroughly circulate the water, start and run the engine for 15 minutes after the thermostats have opened.
4. Fully drain system.
5. Refill with clean water and operate for 15 minutes after the thermostats have opened.
6. Stop engine and allow cooling.
7. Fully drain system.

Vehicles without coolant filters:

Fill with a 50/50-antifreeze/water solution and add required inhibitors.

Vehicles with coolant filters (DDC Series 60 engine):

Replace the coolant filter with a precharge element filter; in this case do not mix inhibitors with antifreeze/water solution.

Vehicles with coolant filters (Volvo D13 engine):

Fill with a 50/50-antifreeze/water solution. Replace coolant filter as per the Lubrication And Servicing Schedule in section 24 if required.

Dispose of spent fluids in an environmentally responsible manner according to regulations in effect in your area.

COOLING SYSTEM CAPACITY (approximation)

Includes heating system: 24 US gal (91 liters)

8.1 COOLING SYSTEM DESCALERS

If the engine overheats and the fan belt tension, coolant level and thermostat operation have been found to be satisfactory, it may be necessary to de-scale and flush the entire cooling system.

Remove scale formation by using a reputable and safe de-scaling solvent. Immediately after using the de-scaling solvent, neutralize with a neutralizing agent. It is important that product directions be thoroughly read and followed.

Section 05: COOLING SYSTEM

After using the solvent and neutralizer, fully drain the system, and then reverse flush the engine and radiator (see "Reverse Flushing" in this section) before filling the system with coolant solution.

8.2 REVERSE FLUSHING

After the engine and radiator have been thoroughly de-scaled, they should be reverse-flushed. The water pump should be removed and the radiator and engine reverse-flushed separately to prevent dirt and scale deposits from clogging the radiator tubes or being forced through the pump. Reverse flushing is accomplished by hot water, under pressure, being forced through the cooling system in a direction opposite to the normal flow of coolant, loosening and forcing deposits out.

The radiator is reverse flushed as follows:

1. Remove the radiator inlet and outlet hoses and replace existing radiator cap with a new one.
2. Attach a hose to the top of the radiator to lead water away from the engine.
3. Attach a hose at the bottom of the radiator and insert a flushing gun in the hose.
4. Connect the water hose of the gun to the water outlet and the air hose to the compressed air outlet.
5. Turn on the water and when the radiator is full, turn on the air in short blasts, allowing the radiator to fill between blasts.

NOTE

Apply air gradually. Do not exert more than 138 kPa (20 psi) air pressure. Too great a pressure may rupture a radiator tube.

6. Continue flushing until only clean water is expelled from the radiator.

The cylinder block and cylinder head water passages are reverse flushed as follows:

1. Remove the thermostats and the water pump.
2. Attach a hose to the water inlet of oil cooler housing to drain water away from engine.
3. Attach a hose to the water outlet at the top of the cylinder head (thermostat housing) and insert the flushing gun in the hose.

4. Turn on the water until the jackets are filled, and then turn on the air in short blasts. Allow jackets to fill with water between air blasts.
5. Continue flushing until the water from the engine runs clean.

If scale deposits in the radiator cannot be removed by chemical cleaners or reverse flushing as outlined above, it may be necessary to remove the upper tank and rod out the individual radiator tubes with flat steel rods. Circulate the water through the radiator core from the bottom to the top during this operation.

9. SPIN-ON COOLANT FILTER

The optional engine cooling system filter is used to filter out impurities such as scale or sand from the coolant and it also eliminates the process of adding inhibitors to the antifreeze/water solution. The filter is mounted onto the cooling fan drive mechanism aluminum casting (Fig. 16 & 17).

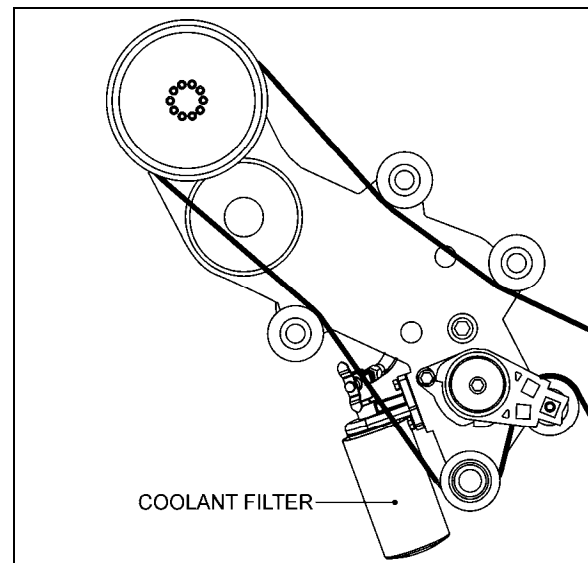


FIGURE 16: COOLANT FILTER (DDC S60 ENGINE) 05138

To replace a filter:

1. Close the two filter shutoff cocks (two on DDC S60, one on Volvo D13) on the filter mounting head and unscrew the old filter from mounting.



WARNING

Failure to relieve cooling system pressure may result in personal injury.

2. Remove and discard the filter. Recover the coolant remaining in the filter with a suitable container.
3. Clean the filter adapter with a clean, lint-free cloth.
4. Coat surface of gasket with clean antifreeze, tighten 2/3 to 1 turn after gasket makes contact with head.
5. Open the two filter shutoff cocks.
6. Start engine and check for leaks.



CAUTION

Do not exceed recommended service intervals.



MAINTENANCE

DETROIT DIESEL S60 ENGINE

The precharge element filter lasts for 12,500 miles (20 000 km) or one year, whichever comes first. Replace the precharge element filter with a maintenance element filter, which lasts for 200,000 miles (320 000 km) or two years, whichever comes first. Each time the coolant is renewed, a precharge element filter must be installed before installing a maintenance element filter.

PRECHARGE ELEMENT FILTER

Prevost number: 550629

MAINTENANCE ELEMENT FILTER

Prevost number: 550630

CORROSION INHIBITOR & COOLANT STABILIZER

Make: Detroit Diesel Number: 23507857

Make: Nalco Number: DD3000-15

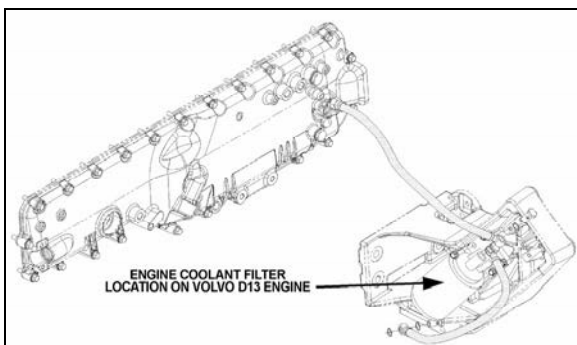


FIGURE 17: COOLANT FILTER (VOLVO D13) 05145



MAINTENANCE

VOLVO D13 ENGINE

Replace the coolant filter cartridge after 150,000 miles (240 000 km) or one year to prevent external rust damage to the filter walls. **Do not** use a coolant filter containing Supplemental Coolant Additives (SCA).

Coolant filter cartridge (Volvo D13): #20458771

10. RADIATOR

The radiator is mounted on the L.H. side of engine compartment. It is designed to reduce the temperature of the coolant under all operating conditions. It is essential that the radiator core be kept clean and free from corrosion and scale at all times.

10.1 MAINTENANCE



MAINTENANCE

Inspect the exterior of the radiator core every 25,000 miles (40 000 km) or once a year, whichever comes first. Clean with a quality grease solvent, such as a mineral spirits and dry with compressed air. Do not use fuel oil, kerosene, gasoline, or any caustic material. It may be necessary to clean the radiator more frequently if the vehicle is operated in extremely dusty or dirty areas. Refer to coolant system flushing and reverse flushing in this section for maintenance of radiator interior.

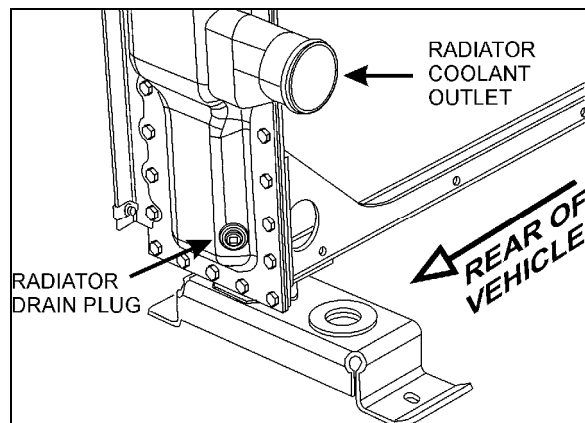


FIGURE 18: RADIATOR DRAIN PLUG 05139

Section 05: COOLING SYSTEM

11. CHARGE AIR COOLER LEAKAGE

Spec for CAC acceptable leakage:

“The CAC is considered acceptable if it can hold 30 psi (206 kpa) gauge pressure with less than 5 psi (34.5 kpa) loss in 15 seconds after turning off the hand valve.”

NOTE

This spec does not apply if there is any evidence that the leak was caused by a foreign object impact.

12. COOLING FAN DRIVE MECHANISM

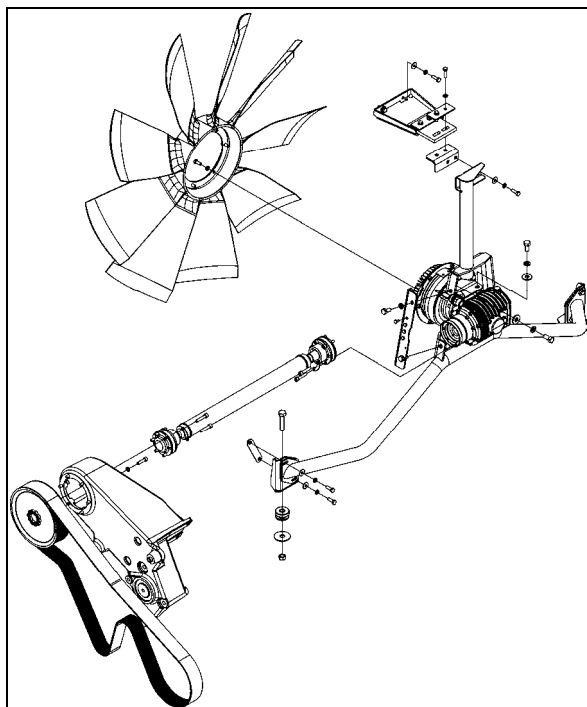


FIGURE 19: COOLING FAN DRIVE MECHANISM

12.1 DRIVE PULLEY AND UNIVERSAL JOINT SHAFT

To disconnect the universal shaft, proceed as follow:



WARNING

Set the ignition to the OFF position and remove the key from the contact switch to prevent accidental starting of the engine.

1. Unwrap the drive belt from around the pulley (see paragraph MOUNTING THE DRIVE BELT).

2. Dismount the drive pulley. Gain access to the 6 mounting bolts from behind the pulley, through the opening in the cast aluminum support (Fig. 15).
3. Unscrew and remove the universal joint shaft mounting bolts (6) at the right angle gearbox.
4. Slowly, move the shaft toward the rear of the vehicle.
5. Finally, dismount the universal joint shaft from the drive pulley (6 bolts).

Installation of the universal joint shaft is the same as removal, but in reverse order.

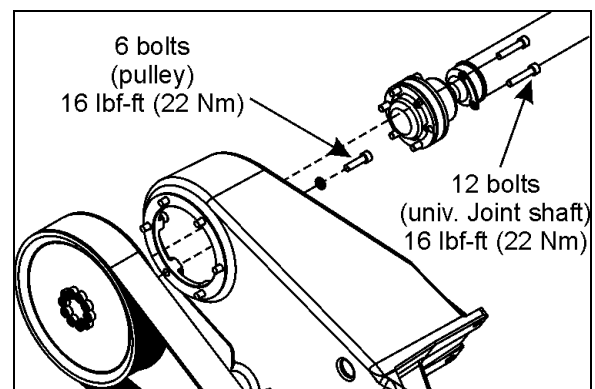


FIGURE 20: TIGHTENING SPECIFICATION

05123A

12.2 IDLER REPLACEMENT

If an idler is defective, replace as follow:



WARNING

Set the ignition to the OFF position and remove the key from the contact switch to prevent accidental starting of the engine.

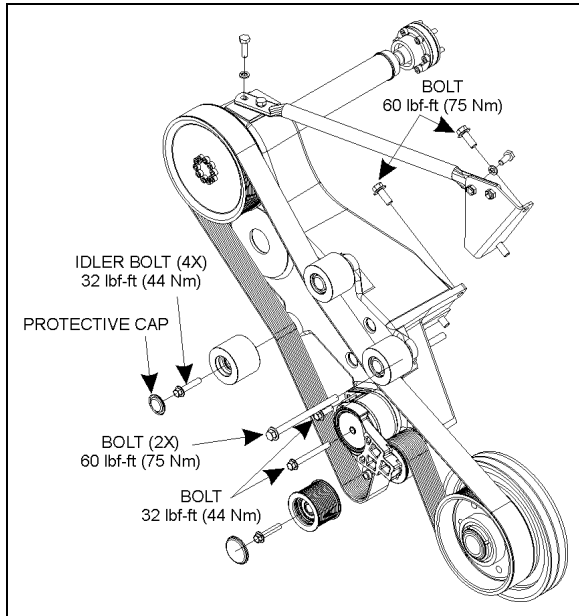


FIGURE 21: TIGHTENING SPECIFICATION (DDC S60 ENGINE)
05140

1. Remove the protective cap (replace with a new one).
2. Unscrew the idler mounting bolt.
3. Replace idler with a new one.

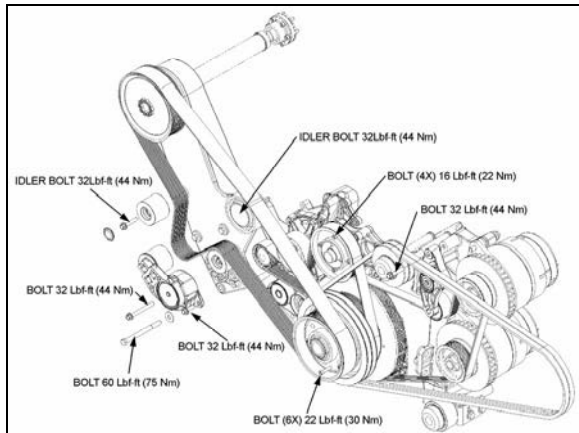


FIGURE 22: TIGHTENING SPECIFICATION (VOLVO D13 ENGINE)



CAUTION

When installing the idler, make sure it rests perfectly against the bearing surface on the cast aluminum support. If not, the drive belt may slip of the idler. See figure below.

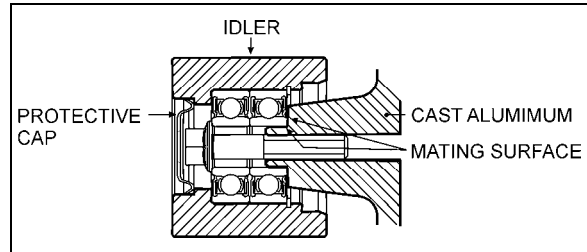


FIGURE 23: IDLER MOUNTED ON THE CAST ALUMINUM SUPPORT

4. Bolt the new idler on the cast aluminum support. Tighten to 32 lbf-ft (44 Nm).
5. Place a new protective cap.

13. VARIABLE SPEED COOLING FAN


The cooling fan clutch has two thermostatically controlled speeds, plus a neutral (clutch disengaged). The engine control module controls the speed by comparing data from engine coolant temperature, charge air temperature, Allison transmission oil temperature and small A/C High side pressure to a set of calibration data. The fan drive clutch is electromagnetic; the engine control module sends an electric current to regulate speed by activating one magnetic coil for the first speed and two magnetic coils for the second speed.

The settings are:

	Engine coolant temp.	Air intake temp.	Allison trans. oil temp.
temperature rising ↑	208°F: fan engages in HIGH SPEED	194°F: fan engages in HIGH SPEED	230°F: fan engages in HIGH SPEED
	203°F: fan engages in LOW SPEED	176°F: fan engages in LOW SPEED	216°F: fan engages in LOW SPEED
temperature dropping ↓	203°F: fan HIGH SPEED disengages	189°F: fan HIGH SPEED disengages	225°F: fan HIGH SPEED disengages
	198°F: fan LOW SPEED disengages	170°F: fan LOW SPEED disengages	210°F: fan LOW SPEED disengages

	Small A/C high side pressure
pressure rising ↑	170 psi: fan engages in HIGH SPEED
	120 psi: fan engages in LOW SPEED

Section 05: COOLING SYSTEM

pressure dropping 	130 psi: fan HIGH SPEED disengages
	90 psi: fan LOW SPEED disengages



WARNING

DO NOT work near the fan with the engine running or the ignition in the ON position. The engine fan can engage at any time without warning. Anyone near the fan when it turns on could be seriously injured.

13.1 LOCKING RADIATOR FAN FOR EMERGENCY OPERATION

13.1.1 Electrical Locking

If the cooling fan clutch does not function due to an electrical control system malfunction and the engine is overheating, execute the following procedure:

1. Set the ignition key to the ON position.
2. Activate the dashboard Telltale Light Test switch 3 times within 4 seconds.
3. In the engine compartment, set the starter selector switch to REAR START and then start the engine from the rear.



WARNING

Potential Accident Risk. Always use extreme caution when working in the vicinity of hot, rotating or moving parts.

While in this mode, the rear start push-button can be used to manually engage the fan clutch. The multiplex system knows when the engine is already running, and it will not activate the starter.

4. Press the push-button one time to engage the clutch to 1st speed, press a second time to engage to 2nd speed, press a third time to stop the fan, press once again to return to 1st speed.

NOTE

If the fan clutch does not engage using this procedure then the clutch is faulty or the wiring between the multiplex module and the clutch is faulty. Mechanically lock the fan as described in section 13.1.2.

13.1.2 Mechanical Locking

Once mechanically locked, the fan is rigidly connected to the drive mechanism and will rotate continuously, with no considerations for the cooling needs. This is an emergency situation and the vehicle shall not be operated in that situation for an extended period.

In case of a magnetic clutch malfunction:

1. Set the ignition to the OFF position and remove the key from the contact switch to prevent accidental starting of the engine.
2. Disconnect the fan clutch electrical connector.
3. Unscrew and remove the 4 spare bolts screwed to the angle on the fan gearbox mounting support.
4. Turn the fan blades in order to position the locking plate bores over the rotor's threaded sockets.
5. Screw in and tighten the spare bolts (Fig. 24).
6. Using the automatic belt tensioner, release tension on the drive belt in order to be able to rotate the fan clutch drive mechanism by hand.
7. Rotate the shaft to get access to the second locking plate and rotor threaded sockets.
8. Screw in and tighten the spare bolts.

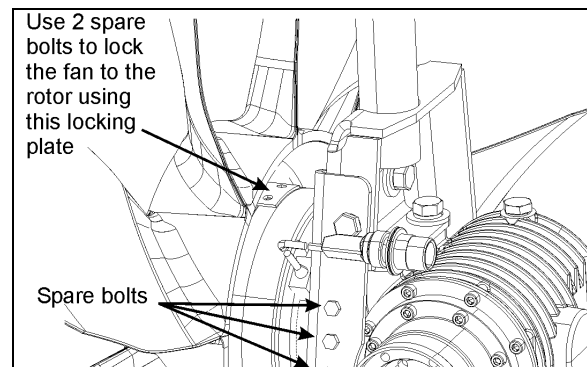


FIGURE 24: MECHANICAL LOCKING


05124

13.2 MAINTENANCE

1. Clean the fan and related parts with clean fuel oil and dry them with compressed air. Do not clean with steam or high-pressure jet.
2. Check the fan blades for cracks or other damage. Replace the fan if the blades are cracked or deformed.

3. Remove any rust or rough spots in the grooves of the fan pulley. If the grooves are damaged or severely worn, replace the pulley.
4. Do not restrict fan rotation during engine operation for any reason.
5. Do not operate fan-driving mechanism with a damaged fan assembly. Replace a damaged fan as soon as the fault is noted.
6. Immediately investigate and correct any operator complaint involving driving mechanism or cooling system performance.
7. When questions arise, obtain answers before proceeding. Assistance is available through the Prevest After-Sales Service Support serving your area.

13.3 INSPECTION



DANGER

Set the starter selector switch in engine compartment to the "Off" position to prevent accidental starting of the engine.

- Check security of fasteners securing fan blade assembly to fan clutch.
- Visually inspect fan driving mechanism, fan blade assembly, shroud, radiator, and surrounding area for evidence of contact between rotating and non-rotating parts.
- Check drive belt for fraying, cracking, and proper tension.
- Turn fan through at least 360° of rotation. It should turn smoothly with no resistance.

13.4 FAN REMOVAL / INSTALLATION

The fan is bolted to the magnetic clutch. To remove the fan:

- Unscrew and remove the mounting bolts and washers.

To reinstall the fan:

- If the fan is still in the radiator fan shroud, place 2 of the mounting bolts on the opposite side of the clutch, in reverse direction, in order to use them as guide pins to position the fan.

- Once properly positioned, screw the 4 remaining bolts back in and tighten properly (16 lbf-ft; 22 Nm).
- Finally, take the 2 bolts that were used as guide pins and screw them back in on the proper side of the clutch and tighten properly.

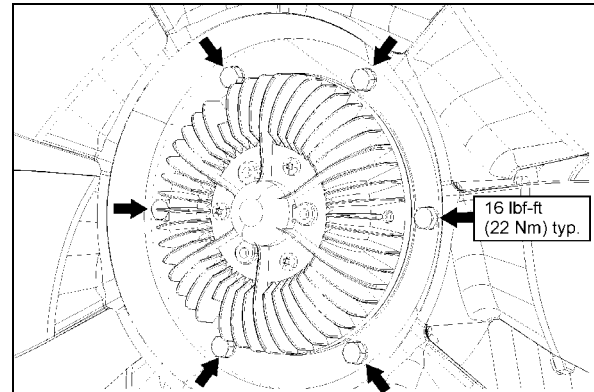


FIGURE 25: RADIATOR FAN MOUNTING BOLTS 05125

14. FAN RIGHT ANGLE GEARBOX

The radiator fan is belt driven from the engine crankshaft pulley through a drive belt, a universal joint shaft, a right angle gear and clutch assembly.

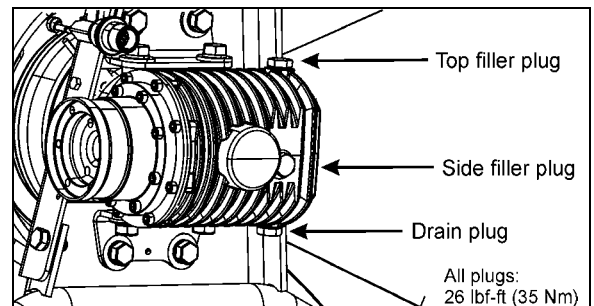



FIGURE 26: RIGHT ANGLE GEARBOX 05118

14.1 MAINTENANCE



MAINTENANCE

Change the right angle gearbox oil every 50,000 miles (80,000-km) or once a year, whichever comes first.

Use **Synthetic Gear Lubricant SAE 75W-90**.

14.2 OIL CHANGE

1. Stop engine and make sure that all engine safety precautions have been observed.

Section 05: COOLING SYSTEM

2. Set the ignition to the OFF position and remove the key from the contact switch to prevent accidental starting of the engine or set the rear start panel selector switch to the OFF position.
3. Remove the drain plug located underneath the right angle gearbox case and allow the oil to drain into a suitable container.
4. Replace the seal and screw the drain plug back in (torque: 26 lbf-ft).
5. Unscrew and remove the side filler plug.
6. Unscrew and remove the top filler plug.
7. Add gear lubricant. The oil level is correct once the top of the oil has reached the bottom of the side filling point.
8. Replace the seals and screw side and top filler plug back in (torque: 26 lbf-ft).
9. Clean gear case carefully.
10. Start the engine and allow running a few minutes. Stop the engine and check for leaks.

14.3 REMOVAL / INSTALLATION

To remove the right angle gearbox, proceed as follow:

1. Set the ignition to the OFF position and remove the key from the contact switch to prevent accidental starting of the engine.
2. Disconnect the fan clutch electrical connector.
3. Dismount the fan and lean it against the radiator (refer to previous paragraph).
4. Disconnect the universal joint shaft.

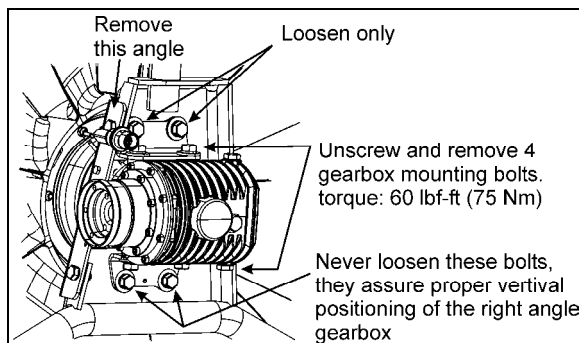


FIGURE 27: RIGHT ANGLE GEARBOX MOUNTING 05126

5. Dismount the angle (see fig. 27).

6. Loosen the gearbox support bracket top bolts.
7. Unscrew and remove 4 gearbox mounting bolts.
8. Slide the gearbox out of the support assembly.

Installation procedure is the same as removal but in reverse order. Tighten the 4 mounting bolts as specified.

15. COOLING FAN DRIVE BELT

15.1 MOUNTING THE DRIVE BELT

To install the cooling fan drive belt, proceed as follow:



WARNING

Set the ignition to the OFF position and remove the key from the contact switch to prevent accidental starting of the engine.



WARNING

Potential Accident Risk. Always use extreme caution when working in the vicinity of hot, rotating or moving parts.

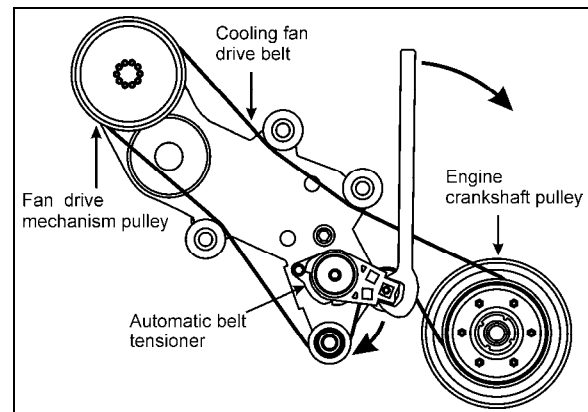


FIGURE 28: DRIVE BELT ROUTING (DDC S60 ENGINE) 05137

1. Wrap the new drive belt around the fan drive mechanism pulley, the idlers and the automatic tensioner idler as shown on figure 28 & 29.
2. Using the special tool included with your vehicle (see inside the Warning Reflectors box located in the first curb-side baggage bay), rotate the automatic tensioner in

clockwise direction to relieve tension on the belt and hold the tensioner in that position (Fig. 28 & 29).

3. Finally, place the drive belt around the engine crankshaft pulley.

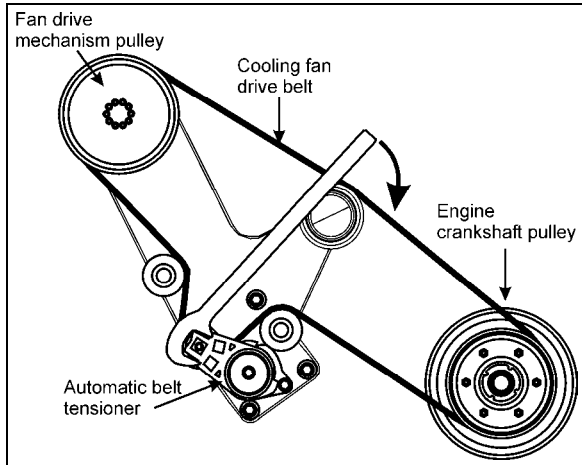


FIGURE 29: DRIVE BELT ROUTING (VOLVO D13 ENGINE)

4. Release the tensioner slowly and let it return to its natural position.

COOLING FAN DRIVE BELT

With Detroit Diesel Series 60 engine

Type: 14PK2605

Prevost number: 550926

With Volvo D13 engine

Type: 14PK2526

Prevost number: 5060097

16. SPECIFICATIONS

Cooling System Capacity (Approximation)

Includes heating system..... 24 US gal (91 liters)

Thermostat - Detroit Diesel Series 60 Engine

Number used.....2

Start to open182-188°F (83-86°C)

Fully open 202°F (95°C)

Section 05: COOLING SYSTEM

Thermostat - Volvo D13 Engine

Number used 1
Start to close 203°F (95°C)
Fully closed 185°F (85°C)

Cooling Fan Drive Belt - Detroit Diesel Series 60 Engine

Type Poly-Rib 14PK2605
Qty 1
Prevost number 550926

Cooling Fan Drive Belt – Volvo D13 Engine

Type Poly-Rib 14PK2526
Qty 1
Prevost number 5060097

Coolant - Detroit Diesel Series 60 Engine

Prevost Number 685125
DDC (Power Cool) 23512138
Prestone (Heavy Duty) AF977 (bulk), 72702 (3.78 L), 70119 (205L), 70102 (4L)

Coolant - Volvo D13 Engine

Prevost Number 685241
Texaco CPS 227998
Chevron CPS 2227805

Corrosion Inhibitor and Coolant Stabilizer - Detroit Diesel Series 60 Engine

Supplier number.....Detroit Diesel 23507857
Supplier number.....Nalco DD3000-15

Coolant Filter - Detroit Diesel Series 60 Engine

Number used 1
Make Nalco
Type Spin-on

MAINTENANCE ELEMENT FILTER

Supplier number.Detroit Diesel 23507545
Supplier number.....Nalco DDF3000
Prevost number 550630

PRECHARGE ELEMENT FILTER

Supplier number.....Detroit Diesel 23507189
Supplier number.....Nalco DDF60
Prevost number 550629

Coolant Filter Cartridge – Volvo D13 Engine

Number used 1
Type Spin-on
Prevost number 20458771



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Antriebstechnik

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Reparaturanleitung

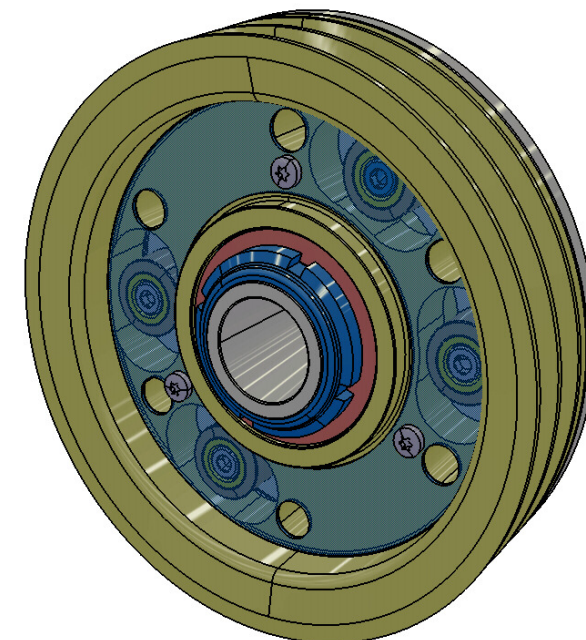
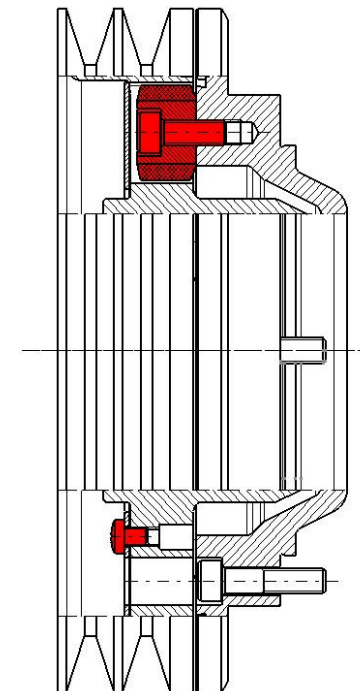
*LINNIG Drehschwingungsdämpfer LDD (außer LDD12)
Austausch Gummidämpfer 127.032 mit EB0112*

Repair instructions

*LINNIG Torsional vibration damper LDD (except LDD12)
Replacement of the rubber damper 127.032 with EB0112*

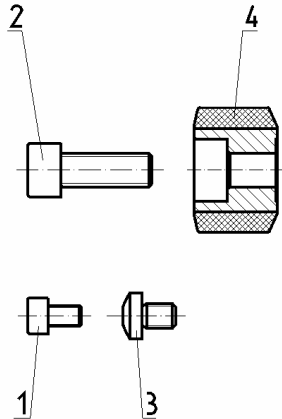
Instrucciones de servicio

*LINNIG Polea antivibratoria LDD (excepto LDD12)
Reemplazo de amortiguadores de goma 127.032 con EB0112*



Lieferumfang / Delivery / Volumen de suministro

Ersatzteilbaugruppe / Assembly group / Juego de refacciones EB0112



Schrauben 50.002 (Pos.1), 50.099 (Pos.2) und 65.003 (Pos.3) zusammen mit Gummidämpfer 127.032 (Pos.4) und Reparaturanleitung 142.219 (Pos.6) in Minigripbeutel 141.018 (Pos.5) verpacken.

Pos.5 und 6 nicht dargestellt.

6 × 127.032
Gummidämpfer
Rubber damper
Amortiguadores de goma

6 × 50.099
Zyl.-Schraube
Socket head cap screw
Tornillo cabeza allen

3 × 65.003
IN-STAR LIKO-Schraube
IN-STAR LIKO-screw
Tornillo IN-STAR LIKO

4 × 50.002
Zyl.-Schraube
Socket head cap screw
Tornillo cabeza allen

6	1	Stk	Reparaturanleitung LDD	Austausch Gummidämpfer 127.0	142.219
5	1	Stk	Minigripbeutel	220×150×0,050	141.018
4	6	Stk	Gummidämpfer		127.032
3	3	Stk	IN-STAR LIKO-Schraube	M6×8-8.8-A3C-P80	65.003
2	6	Stk	Zyl.-Schraube	DIN 912-M8×22-8.8-A3C	50.099
1	4	Stk	Zyl.-Schraube	DIN 912-M5×8-8.8-A3C	50.002

Pos.	Menge	Einheit	Benennung	Sachnummer/Norm-Kurzbezeichnung	Bemerkung
1	2	3	4	5	6
LINNIG Markdorf			Für diese Zeichnung behalten wir uns alle Rechte nach DIN 34 vor		Maßstab 1:1 DIN A4
2			17.06.04		Ersatzteilbaugruppe für LDD (außer LDD12)
1			27704		
Gew.:			0,360 kg		EB0112
Index			Änderungsnummer		Blatt
Date			Name		Bl.
Erst.zg.			EB0103/EB0112/EB01		Entst. aus EB0103



Achtung:

Je nach Ausführung des Drehschwingungs-dämpfers können evtl. Schrauben bzw. Gummidämpfer übrig bleiben !



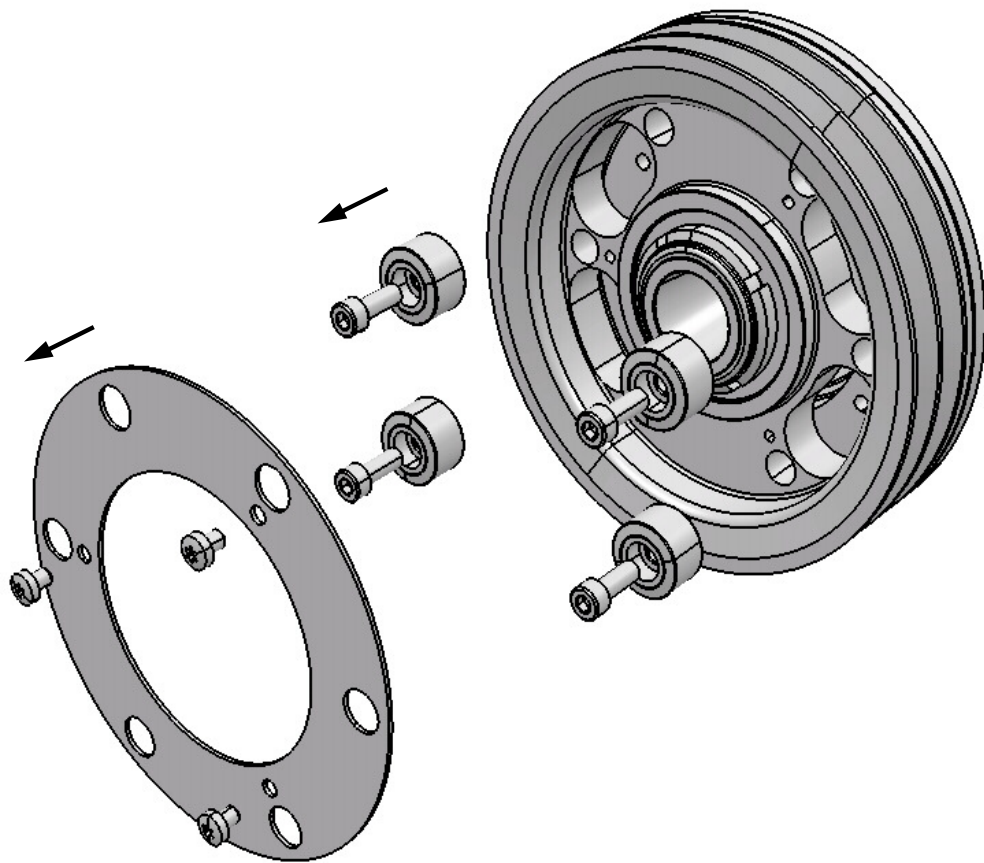
Attention:

Beause of differnt versions of the torsional vibration damper, it is possible that some of the delivered screws and rubber damper are not be used !



Atención:

Debido a las diferentes versiones de Poleas antivibratorias, es posible que algunos de los tornillos y amortiguadores de goma no se utilizen!



1.
4 Zyl.-Schrauben M5
bzw. 3 IN-STAR LIKO-
Schrauben M6 am
Deckel entfernen.

1.
Remove 4 socket head
cap screws M5 resp. 3
IN-STAR LIKO-screws
M6 on the cover.

1.
Retire los 4 tornillos M5
o 3 tornillos M6 IN-
STAR LIKO de la tapa
de la polea.

2.
Deckel entfernen.

2.
Remove cover.

2.
Retire la tapa.

3.
4 bzw. 6 Zyl.-Schrauben
M8 der Gummidämpfer
entfernen.

3.
Remove 4 resp. 6 socket
head cap screws M8 of
the 4 resp. 6 rubber
damper.

3.
Retire los 4 o 6 tornillos
M8 de los
amortiguadores de goma
de la polea.

4.
4 bzw. 6 Gummidämpfer
entfernen.

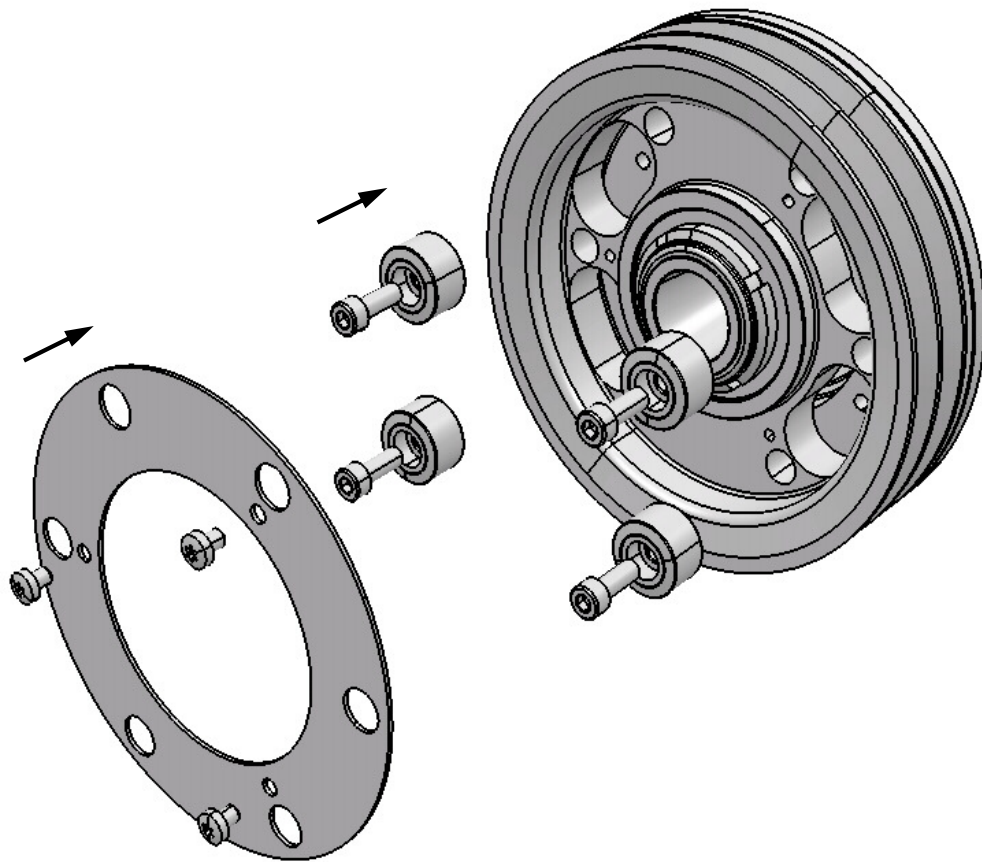
4.
Remove 4 resp. 6 rubber
damper.

4.
Retire los 4 o 6
amortiguadores de goma
de la polea.

5.
Nach Entfernen der
Gummidämpfer alle 4
bzw. 6 Gewinde M8
reinigen.

5.
After removing of the
rubber damper clean all
of the 4 resp. 6 threads.

5.
Después de retirar los
amortiguadores de goma
de la polea, limpiar las 4
o 6 roscas.



6.
4 bzw. 6 neue Zyl.-
Schrauben 50.099 mit
Loctite 270 versehen und
4 bzw. 6 neue
Gummidämpfer 127.032
an Nabe anschrauben.

Anzugsmoment
Ma = 25 Nm

6.
Protect 4 resp. 6 new
socket head cap screws
50.099 with Loctite 270
and attach the 4 resp. 6
new rubber damper on
the hub.

Tightening torque
Ma = 25 Nm
(18,5 lbs.ft)

6.
Aplicar Loctite 270
o equivalente a los
4 o 6 tornillos M8
nuevos (50.099), y
sujetar los 4 o 6 nuevos
amortiguadores de goma
a la polea.

Torque de apriete
Ma = 25 Nm
(18,5 lbs.ft)

7.
Deckelmontage:
Bei LK 4×90°:
4 neue Zyl.-Schrauben
50.002 (M5) mit Loctite
270 versehen und Deckel
an Riemenscheibe
anschrauben.

Anzugsmoment
Ma = 6 Nm

Bei LK 3×120°:
Mit 3 neuen IN-STAR
LIKO-Schrauben 65.003
(M6) Deckel an
Riemenscheibe
anschrauben.

Anzugsmoment
Ma = 10 Nm

7.
Mounting the cover:
Pitch circle 4×90°:
Protect 4 new socket
head cap screws 50.002
with Loctite 270 and
attach the cover on the
pulley.

Tightening torque
Ma = 6 Nm
(4,5 lbs.ft)

Pitch circle 3×120°:
Attach cover with 3 new
IN-STAR LIKO-screws
65.003 (M6) on the
pulley.

Tighening torque
Ma = 10 Nm
(7,5 lbs.ft)

7.
Montaja de la tapa:
Tapa con 4 tornillos:
Aplicar Loctite 270
o equivalente a los
tornillos M5 nuevos
(50.002) y colocar la
tapa de la polea.

Torque de apriete
Ma = 6 Nm
(4,5 lbs.ft)

Tapa con 3 tornillos:
Con los 3 tornillos M6
IN-STAR LIKO nuevos
(65.003) colocar la tapa
de la polea.

Torque de apriete
Ma = 10 Nm
(7,5 lbs.ft)

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1. GENERAL DESCRIPTION

This vehicle uses a dual voltage system to obtain two different voltages (12 and 24 volts) for various electrical controls and accessories. The main power source incorporates four maintenance-free "Volvo" model 20359831 batteries connected in parallel-series. All batteries are kept uniformly charged by means of a 100 amp battery equalizer (standard), giving a maximum possible output supply of 100 amps on the 12 volt system. Both the 12 and 24 volt systems are controlled through individual main battery relays. Two 24 volt self-rectified alternators are belt driven from the engine, and can be reached through the engine compartment doors.

1.1 WIRING DIAGRAMS

A master wiring diagram of the electric circuits, covering standard and optional accessories and systems, is located in the technical publications box. Usually, a separate wiring diagram page is provided for each major function or system. In some cases, more than one circuit may appear on one wiring diagram page; when this occurs, each circuit covered in this page is listed in the wiring diagram index. Moreover, a circuit may appear on several pages; in such case, the number(s) at the extremity of the diagram title will indicate the sheet reference number. Refer to the "*Wiring Diagram Index*" to ensure that the correct diagram is being used to trace the circuit in question. In addition to the major functions page reference, the wiring diagram index contains the following information pages.

- The Multiplexed Device Index,
- The Arrangement-Harness drawing showing the harnesses arrangement and harness number on the vehicle,
- Glossary,
- Circuit number listing,
- Circuit breaker code,
- Connector code,
- Diode number code,
- Resistor number code,
- Fuse code.

1.1.1 Using Wiring Diagrams

Three methods are used to "*work*" with electric wiring diagrams.

Situation: You have identified the defective part (breaker, diode, relay, etc.), and you wish to locate its corresponding circuit.

Problem: Circuit breaker CB12 is released (open circuit) and you don't know which circuit is affected.

- a) Refer to wiring diagram index, and look for "*Circuit breaker code*", pages **F**.
- b) At item CB12, you will find the location, the Prevost number, the breaker function, the breaker ampere rating and the page on which to find the corresponding diagram.
- c) Refer to page 3.1.
- d) When you have located CB12, follow the wiring up to the end and find the diagram page number and function on which the circuit continues.

Situation: You have a problem with a specific system and you want to find the corresponding diagram.

Problem: The last three (3) speakers on the R.H. side of vehicle are inoperative and you must trace the electric circuit.

- d) Refer to wiring diagram index and look for "*Sound system*".
- e) You will find on page 35.1 & 35.2 the components as well as the electric wiring, thus providing you with a complete understanding of this circuit.

Situation: Using the message center display (MCD), you check on arrival if there are active errors in the vehicle electrical system. With the SYSTEM DIAGNOSTIC menu, highlight FAULT DIAGNOSTIC, highlight ELECTRICAL SYSTEM to request a diagnostic of the electrical system and then press the enter key. If applicable, the MCD shows the fault messages or fault codes recorded. When more than one fault is recorded, an arrow pointing down appears on the right of the display. Use the down to see all the fault messages.

Problem: MCD displays the fault "Elec. Horn SW61 SW62; shorted to ground" as being active.

- a) Refer to wiring diagram index, and look for "*Multiplexed Device Index*", pages B1-B8.

- b) In first column DEVICE ID, look for device SW61, SW62.
- c) At device SW61,SW62, find the fault message, the minimum condition to activate, other inputs involved in logic, the multiplex module related to switch 61 and switch 62, the connector and pin number on the module and the page on which to find the corresponding diagram.
- d) Once the problem corrected, the MCD still shows the fault as being active. You have to leave the FAULT DIAGNOSTIC menu, wait approximately 20 to 30 seconds and then return to FAULT DIAGNOSTIC to request a new diagnostic of the ELECTRICAL SYSTEM from the CECM. The MCD should display the fault as being inactive.

1.1.2 Testing Circuits

A careful study of the wiring diagrams should be made to determine the source and flow of current through each circuit. When a circuit is thoroughly understood, a point-to-point check can be made with the aid of the applicable wiring diagrams. Any circuit can be tested for continuity or short circuits with a multimeter or a suitable voltmeter.

All electrical connections must always be kept clean and adequately tight. Loose or corroded connections can result in discharged batteries, difficult starting, dim lights and improper functioning of other electric circuits. Inspect all wiring connections at regular intervals. Make sure knurled nuts on all amphenol-type plugs are securely tightened. Knurled nuts on the plastic amphenol-type connectors will click into a detent when properly tightened. Line connectors, who have the side locking tabs, must have the locks latched in place to ensure a proper electrical connection.

1.2 WIRE SIZES AND COLORS

Each wire in the electrical system has a specific size as designated on the wiring diagram. When replacing a wire, the correct size must be used. Never replace a wire with one of a smaller size. The vehicle electrical system is provided with different voltages. The insulation on each wire is distinctly colored in order to determine visually the wiring voltage and to assist in making connectors. The wires are color coded as follows:

Yellow	Multiplex modules communication CAN-H (twisted with green)
Green	Multiplex modules communication CAN-L (twisted with yellow)
Orange	Connected to multiplex outputs
White	Connected to multiplex inputs
Red	24 volt system
Yellow	12 volt system
Black	grounded wire
Blue	110 V ac system (live)
White	110 V ac system (neutral)
Green	110 V ac system (ground)
Orange	speakers (+)
Brown	speakers (-)
Grey	spare wire

NOTE
Wires are identified at each 2-4 inch (5-10 cm) intervals by a printed number.

Each wire on a diagram is patterned to assist in tracing and testing circuits. The wire number identifies the voltage rating, the wire identification number and the basic wire gauge as illustrated in figure 1.

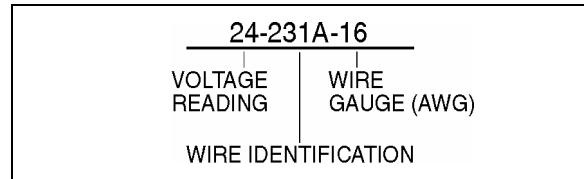


FIGURE 1: WIRE IDENTIFICATION 06048

1.3 SPARE WIRES

When the vehicle leaves the factory, and even in the case of a fully-equipped vehicle, an important number of unconnected spare wires are routed between the junction boxes. Consequently, for any connection of an additional accessory, refer to page D "Spare wires" in master wiring diagram to determine the number, the gauge and location of these wires.

CAUTION

Wire size is calibrated according to the breaker or fuse that protects it. When using a spare wire to replace a damaged wire, assure that the spare wire size is equal or larger than the wire being replaced. Using a wire too small for the breaker or fuse amperage might cause overheating of the wire.

Section 06: ELECTRICAL


NOTE

Spare wires are identified by a wire identification number and by the letters "SP", to designate "spare".

1.4 CLEANING CONNECTORS

When the pins and sockets of connectors become dirty, clean them with a good quality solvent containing HFC 134A refrigerant as its active ingredient. HFC 134A has two qualities that recommend it. First, it does not conduct electricity and therefore, will not cause shorting between connector pins and sockets. Second, it evaporates quickly, eliminating the possibility of condensation within the connectors.

Always shake out or gently blow out any excess HFC 134A before assembling a connector to its mating connector or hardware. HFC 134A trapped in the connector can affect the connector seal.



DANGER

HFC 134A is toxic. HFC 134A bases compounds should always be used in a well-ventilated area, never in a confined space. Use outdoor whenever possible.

1.5 CIRCUIT BREAKERS

Most electric circuits are protected by circuit breakers of the "Manual Reset" type. The main circuit breakers, as well as those protecting the A/C system, are located on the rear electrical junction panel in the rear electrical compartment, on L.H. side of the vehicle.

This type of circuit breaker deenergizes the circuit without disconnecting any wire. Simply press down the red tab on breaker to open the circuit, repair defective circuit, and afterwards depress black button in center of breaker to close the circuit.

Smaller circuit breakers may be located in the VECF of the front service compartment.

CIRCUIT BREAKERS			
CB1	Front distribution	24 VI	90 amps
CB2	Distribution	12 VD	90 amps
CB3	HVAC - evaporator	24 VI	90 amps
CB4	Sound system	12 VD	30 amps
CB5	Rear distribution	24 VI	150 amps
CB6	Distribution	24 VD	70 amps
CB7	HVAC - condenser	24 VI	70 amps

CB8	Rear distribution	12 VI	40 amps
CB9	WCL or other option	24VD	50 amps
CB10	Front distribution	12 VI	70 amps
CB11	Sound system	24 VD	50 amps
CB13	Galley or other option	24 VI	90 amps

VD= volts direct. The electrical components connected to these circuit breakers are direct-connected to the battery.

VI= volts indirect. Electrical power is supplied via master relay R1 which engages when ignition key is in the ON or ACC position and battery master switch (master cut-out) is set to ON.

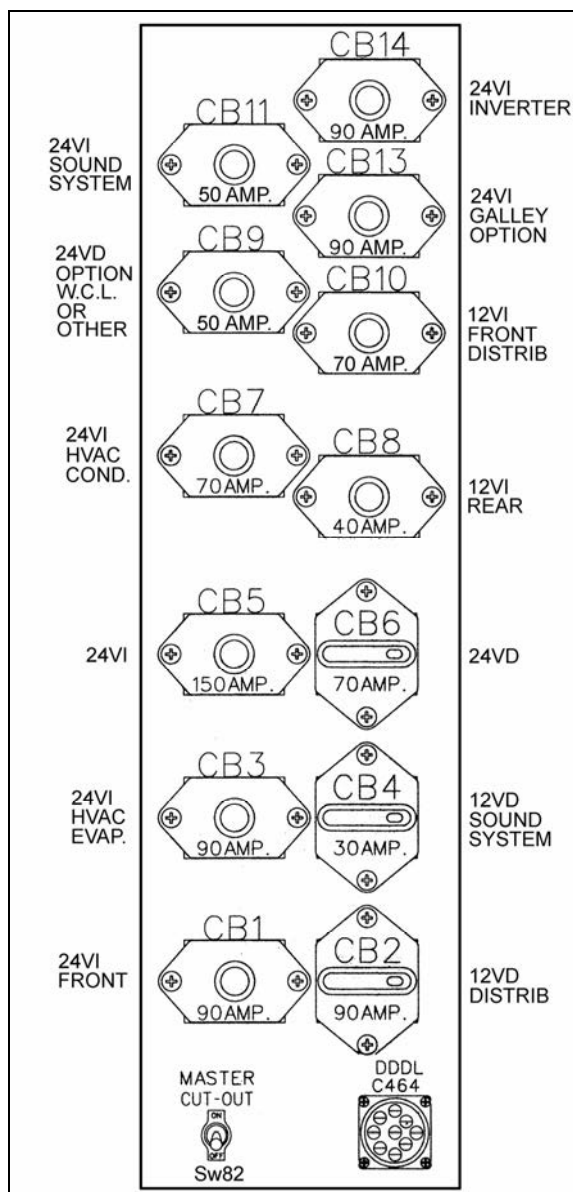


FIGURE 2: REAR ELECTRICAL JUNCTION PANEL 06621

1.6 MULTIPLEX FUSES

The multiplex outputs are protected in current by an internal "soft-fuse". Each output has programmed specific maximum amperage. When an output is shorted, the current gets above the limit and the soft-fuse intervenes to turn the output OFF. The output stays OFF until the "soft-fuse" is reset.

Turn the ignition key to the OFF position and turn to the ON position again. This resets all "soft-fuses".

There is also hardware fuses used to protect the incoming power to the multiplex modules. These fuses are located inside the VECF (Vehicle Electrical Center Front) and VECR (Vehicle Electrical Center Rear).

1.7 RELAYS

Relays are used to automatically energize or deenergize a circuit from a remote location. The relay draws a very low current to energize its coil. Once the coil is energized, it develops a magnetic field that pulls a switch arm closed or open, to either energize or deenergize a given component. As the control current required for the coil is very low, the relay allows a remote station to control a high energy circuit without running great lengths of costly high capacity cable, and also eliminates the need for high amperage switches and heavy connectors.

NOTE

Each relay is identified with "12V" or "24V" printed on its casing in order to identify the coil operating voltage.



CAUTION

The Multiplex vehicle uses a VF4 relay designed specially for Volvo that has different internal characteristics than the current VF4 relay. It is important to use only the new part marked Volvo as a replacement in Multiplex vehicles. Regular relays have an inadequate lifespan for Multiplex vehicles.

1.8 PRECAUTIONS



DANGER

Prior to working on a system inside vehicle, make sure to cut electrical power and air supply. A component could be supplied with electricity even if the ignition switch is set to

the OFF position and/or a component could be pressurized even if air tanks are emptied. Always refer to the appropriate wiring and pneumatic diagrams prior to working on electrical and/or pneumatic systems.

NOTE

When the ignition switch is set to the OFF position, the electrical components are not energized except for the CECM (Chassis Electronic Control Module), engine MCM, transmission ECU, instrument cluster module, the battery equalizer, the preheater system, the wheelchair lift system and some Multiplex modules which are energized during 15 minutes after the ignition has been set to the OFF position. Prior to working on one of these electrical components, set the master cut-out switch in the rear electrical compartment to the OFF position. If the vehicle will not be operated for a long period (more than 2 weeks), it is recommended, in order to prevent the batteries from discharging, to trip main circuit breakers (2, 4 and 6) located in the rear electrical compartment to stop the small current drawn by the radio preset station memory, the CECM memory and the instrument cluster clock. Note that the radio station presets will be erased, same thing for the diagnostic codes history and the instrument cluster clock will have to be reset.



CAUTION

Prior to arc welding on the vehicle, refer to "Multiplex Modules Disconnection Procedure Prior To Welding" in section 00 GENERAL of this manual to avoid serious damage to the vehicle components.

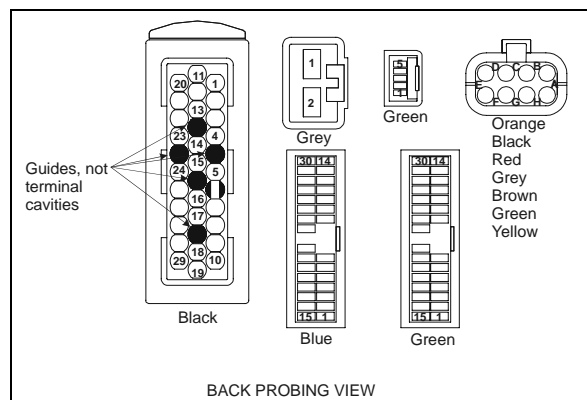
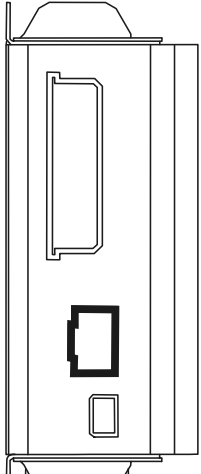
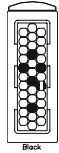
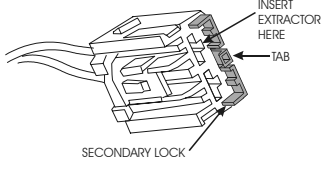
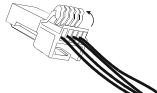
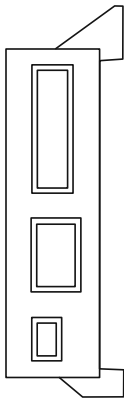
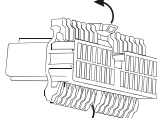
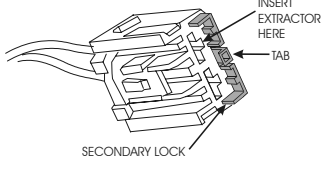
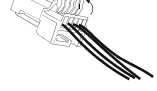
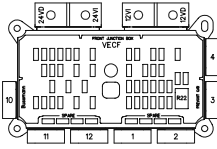
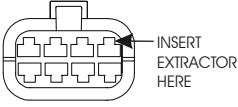


FIGURE 3: MULTIPLEX MODULE CONNECTORS PIN-OUT

06624

Section 06: ELECTRICAL

Multiplex modules	Connector type	Terminal removal
 <p>IO-B 06625</p>	 <p>AMP 06628</p>	<p>EXTRACTOR/TOOL: Prevost #683594</p> <p>Insert the extractor on the front of the connector. Remove the terminal by disengaging the flexible lock tabs on the terminal. Gently remove the terminal from the connector by pulling on the wire.</p>
	 <p>grey 06629 YAZAKI</p>	<p>EXTRACTOR/TOOL: Packard #12094430</p> <p>Using a small flat blade screwdriver, open the hinged secondary lock. Insert the extractor on the front of the connector, over the terminal cavity. Remove the terminal by disengaging the flexible lock tab on the terminal. Gently remove the terminal from the connector by pulling on the wire.</p>
	 <p>green 06630 JAE</p>	<p>EXTRACTOR/TOOL: Prevost #683766</p> <p>Using a small flat blade screwdriver, open the hinged secondary lock. Insert the extractor on the front of the connector, over the terminal cavity. Remove the terminal by disengaging the flexible lock tab on the terminal. Gently remove the terminal from the connector by pulling on the wire.</p>
 <p>IO-A 06626</p>	 <p>green, blue (CECM) JAE 06631</p>	<p>EXTRACTOR/TOOL: Prevost #683766</p> <p>Using a small flat blade screwdriver, open both hinged secondary locks. Insert the extractor on the front of the connector, over the terminal cavity. Remove the terminal by disengaging the flexible lock tab on the terminal. Gently remove the terminal from the connector by pulling on the wire.</p>
	 <p>grey 06629 YAZAKI</p>	<p>EXTRACTOR/TOOL: Packard #12094430</p> <p>Using a small flat blade screwdriver, open the hinged secondary lock. Insert the extractor on the front of the connector, over the terminal cavity. Remove the terminal by disengaging the flexible lock tab on the terminal. Gently remove the terminal from the connector by pulling on the wire.</p>
	 <p>green 06630 JAE</p>	<p>EXTRACTOR/TOOL: Prevost #683766</p> <p>Using a small flat blade screwdriver, open the hinged secondary lock. Insert the extractor on the front of the connector, over the terminal cavity. Remove the terminal by disengaging the flexible lock tab on the terminal. Gently remove the terminal from the connector by pulling on the wire.</p>
 <p>VECF 06627</p>	 <p>Orange Black Red Grey Brown Green Yellow BUSSMAN 06632</p>	<p>EXTRACTOR/TOOL: Prevost #682256 (Packard 12094429)</p> <p>Remove the terminal by disengaging the flexible lock tab on the terminal. Gently remove the terminal from the connector by pulling on the wire.</p>

2. X3 COACHES ELECTRICAL COMPARTMENTS

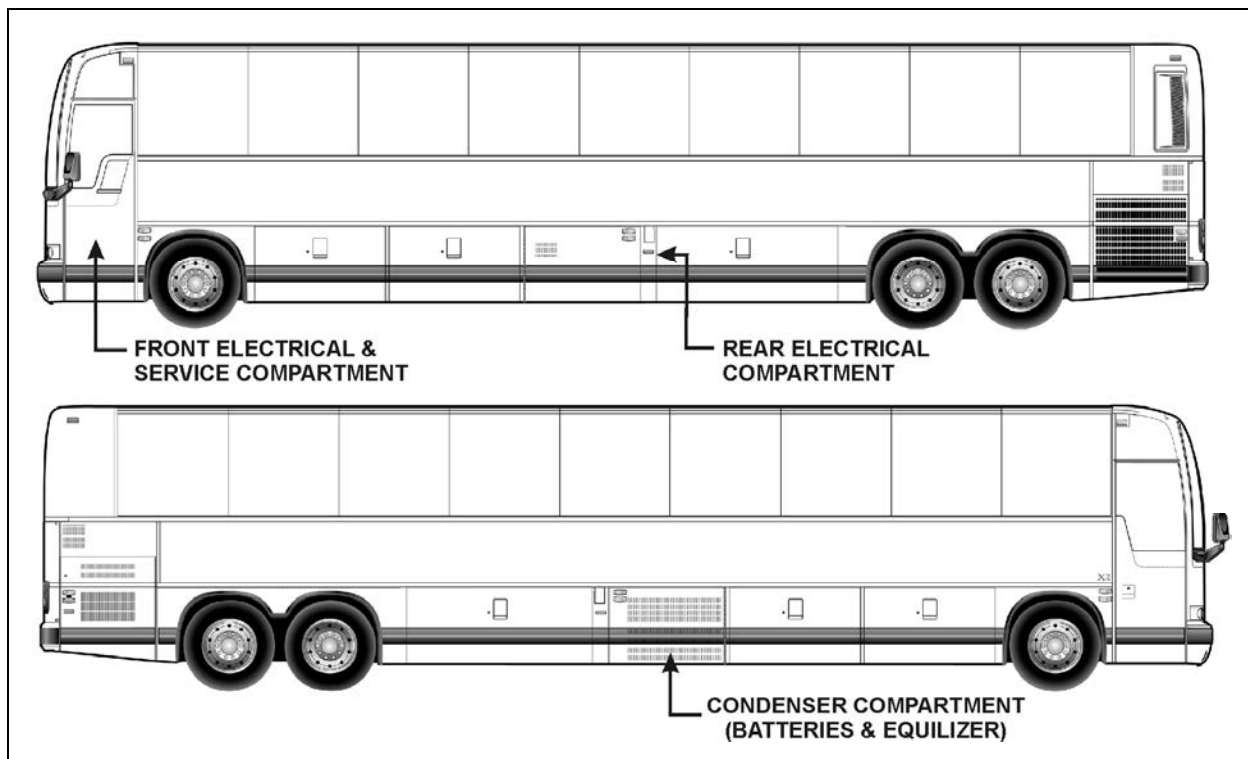


FIGURE 4: ELECTRICAL COMPARTMENTS (X3-45 COACH)

06672

2.1 MAINTENANCE

A Cortec VCI-238 corrosion inhibitor has been sprayed in all electrical compartments to protect components from corrosion. The life expectancy of this product is five years, so it is recommended to reapply it every five years. It is also recommended to spray it on new components when added or replaced.



CAUTION

Never put grease, Cortec VCI-238 or other product on the multiplex module connector terminals.



DANGER

Use VCI-238 in a well ventilated area. Do not smoke. Avoid prolonged contact with skin and breathing of spray mist. Harmful or fatal if swallowed. Do not induce vomiting. Call physician immediately.

the last baggage compartment (Super bay) on the driver side of the vehicle. The compartment is accessible from the last baggage compartment by removing a plastic access cover. The rear electrical compartment provides access to the following:

- Rear junction panel;
- Rear terminal block;
- Multiplex modules;
- Vehicle Electrical Center Rear (VECR)
- Battery charger;
- Relays and fuses;
- Transmission TCM;
- Battery master switch (Master cut-out);
- Diagnostic Data Reader (DDR) receptacle, (refer to "Other Features" chapter).

2.2 REAR ELECTRICAL COMPARTMENT

The rear electrical compartment is located in the space between the evaporator compartment and

Section 06: ELECTRICAL

Rear Electrical Compartment			
Multiplex Modules			
A49	I/O-A	A52	I/O-B
A50	I/O-B	A53	I/O-B
A51	I/O-B	A54	I/O-B
		Spare	I/O-B
Relays			
R1	Master relay	R15	Aisle & Emerg. Lts
R2	ZF Trans.	R17	12V Rr wake-up
R3	12V IGN & A/C	R20	Water Pump Relay
R5	Preheat / Charger	R26	Water Pre-heater Realy
R6	Direct lights	R21	Emergency cut-out
R8	Service brakes	R30	Luggage Door Lock
R10	Condenser Fan Sp. 2	R31	Luggage Door Lock
R11	ZF Trans. Ign.	R32	Luggage Door Unlock
R12	Evaporator Fan	R33	Luggage Door Unlock
R13	Indirect lights	Rxx	Spare
R14	Reading lights		
Fuses			
F50	Engine Pre-heating	F69	Overhead storage compartment lighting RH & LH
F51	Engine Pre-heating	F70	Customer (24VI)
F52	ZF Trans.	F71	Spare fuse
F53	Power Mux A54	F72	Power Mux A50
F54	Customer (24VD)	F73	Spare fuse
F55	Aisle & emergency lights	F74	ECM engine IGN
F56	Indirect lights	F75	ECU trans IGN
F57	Indirect lights	F76	Customer (12VI)
F58	Direct lights	F77	ECU transmission wake-up
F59	Direct lights	F78	MCM engine wake-up
F60	Reading Lamp RH	F79	MCM engine wake-up
F61	Reading Lamp LH	F80	Power Mux A51
F62	Lavatory night light	F81	Alternators excitation resistor
F63	Engine Pre-heater	F85	ZF Trans.
F64	Spare	F86	Spare fuse
F65	Power Mux Module RJB	F87	Spare fuse
F66	Radiator Fan Clutch	F88	Spare fuse
F67	Power Mux A54	F89	Spare fuse
F68	Power Mux A54		
Resistors			
RES13	Excit. res. ALT-1	RES16	Rear marker lights
RES14	Excit. res. ALT-2	RES17	Rear marker lights
Diodes			
D6	Master relay	D29	Unloader RH
D9	Water Pre-Heater	D31	Main A/C Clutch
D10	Water Pre-Heater	D33	Toilet flush pump
D11	Pass. Liq. Valve	D36	Fan Clutch 2
D15	Wake-up mode	D37	Fan Clutch 1

D17	Luggage 4-Cmpt	D49	Parcel Rack
D19	Luggage 2-Cmpt	D67	Rear Lights
D20	Luggage 1-Cmpt	D68	Rear Lights
D23	Condenser fans	D69	Rear Lights
D24	Condenser fans	D70	Rear Lights
D28	Unloader LH	DXX	Not used

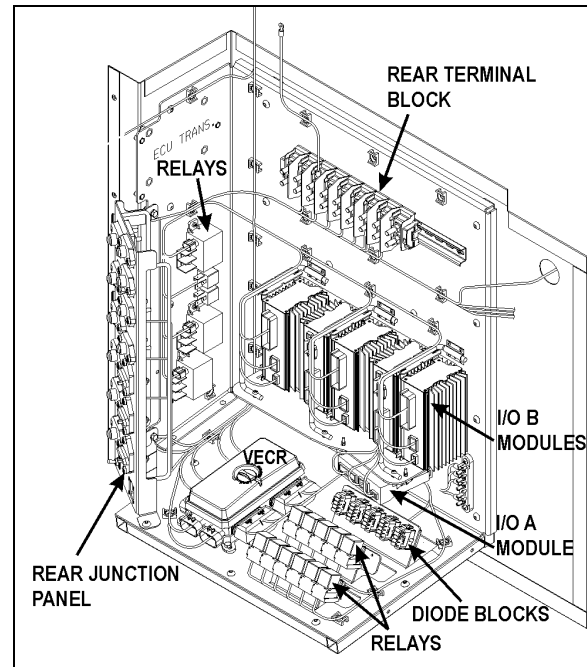


FIGURE 5: REAR ELECTRICAL COMPARTMENT 06634

2.3 FRONT ELECTRICAL AND SERVICE COMPARTMENT

The front electrical and service compartment is located on L.H. side of vehicle, under the driver's window. It contains the following components (Fig. 6):

- Front terminal block;
- CECM;
- Vehicle Electrical Center Front (VECF) and Multiplex Modules;
- Relays and fuses;
- ABS Electronic Control Unit (ECU);
- Common Powertrain Controller (CPC);
- VECU with Volvo D13 engine;

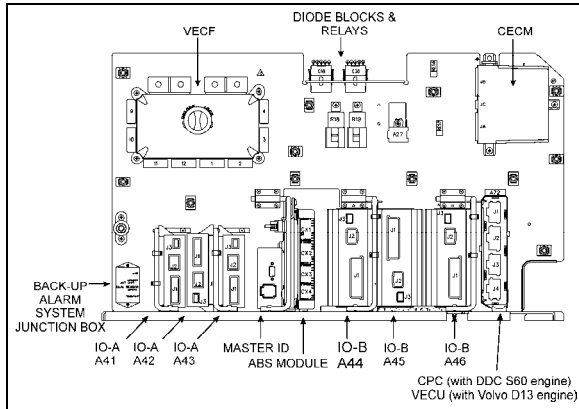


FIGURE 6: FRONT ELECTRICAL COMPARTMENT 06673

Front Electrical & Service Compartment			
Modules			
VECF	Vehicle Electrical Center Front	A43	I/O-A
A9	ABS-ECU	A44	I/O-B
A13	MASTER ID	A45	I/O-B
A36	CECM	A46	I/O-B
A41	I/O-A	A72	CPC
A42	I/O-A		
Relays			
R18	Wake-up 24V	R22	Engine brake
R19	Wake-up 12V	A27	Steering Control soft module
Fuses			
F1	CECM Power	F23	ABS
F2	Front start main switch	F24	Mirror
F3	Pre-heating & driver liquid solenoid valve	F25	Back-up camera
F4	Wireless microphone	F26	Spare fuse
F5	Wake-up mode 24V	F27	Customer
F6	Free/customer	F28	Driver's power window
F7	ABS & pre-heat control	F29	Instrument cluster & data reader
F8	Air horn	F30	Cigarette lighter & 12-volt accessory outlet
F9	Spare fuse	F31	Keyless entry module
F10	Spare fuse	F32	Spare fuse
F11	Sun visor	F33	Wake-up mode 12VD
F12	Power multiplex A41	F34	Wake-up mode 12VD
F13	Power multiplex A41	F35	12-volt accessory outlet
F14	Customer	F36	HVAC & telltale panel

F15	R22	F37	Spare fuse
F16	Defroster unit	F38	Digital Clock
F17	Spare	F39	Spare fuse
F18	Upper Defroster	F40	Spare fuse
F19	Pro Driver	F41	Spare fuse
F20	Witness red LED	F82	Lower wipers
F21	Power Mux A44	F83	Sound system
F22	ZF Steering Control	F84	Customer

Diodes			
D1	Accessories	D22	Service brake
D2	Driver Liq Sol Vlve	D44	Ignition
D12	Engine Brake	Dxx	Not used
D13	ABS		

2.4 ENGINE REAR START PANEL

This control panel is located in the R.H. side of engine compartment above the engine air filter. This control panel includes the engine starter selector switch, the rear start push button switch to start engine from engine compartment as well as the engine compartment lights switch.

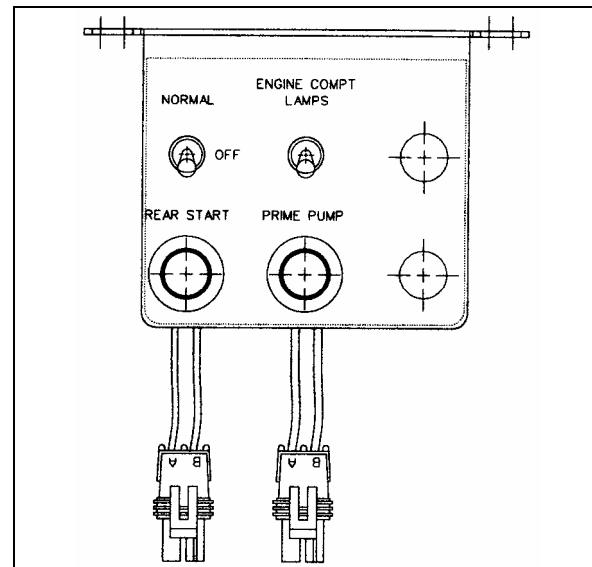


FIGURE 7: REAR START PANEL 06622

NOTE

When the ignition key switch is set to the "OFF" position, the electrical supply from the batteries is cut off, with the exception of the Fire Detection System, the Engine & Transmission Electronic Controls, the Auxiliary Heating System, the Battery Equalizers and the Digital Clock.

Section 06: ELECTRICAL

2.5 CONDENSER COMPARTMENT

The batteries are located inside the condenser compartment on the X3-45 coach.

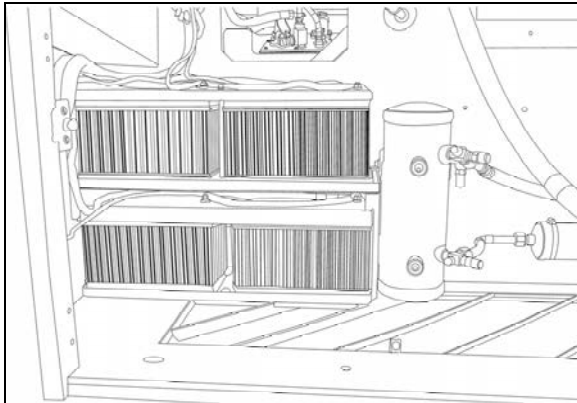


FIGURE 8: LOCATION OF BATTERIES IN CONDENSER COMPARTMENT 22300

2.5.1 Battery equalizer

On X3-45 coaches the battery equalizer is located on the L.H. side of the condenser compartment (Fig. 9).

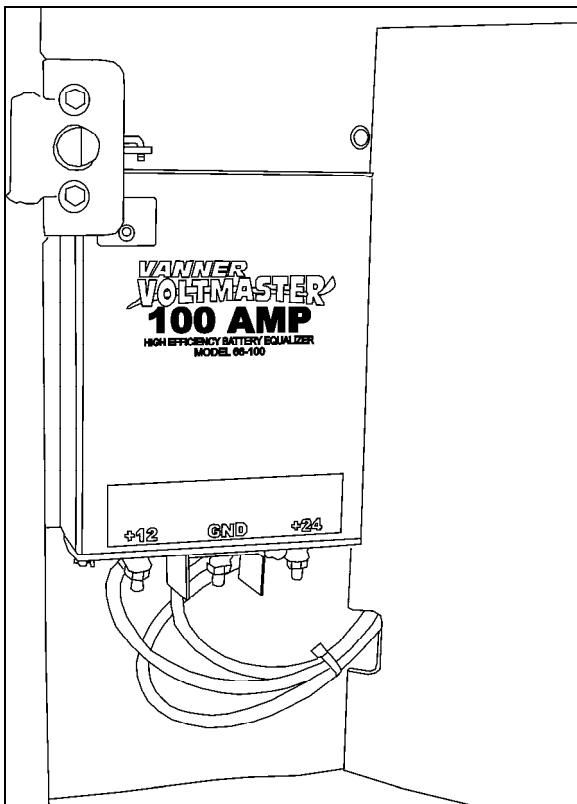


FIGURE 9: BATTERY EQUALIZER 06635

2.6 ENTRANCE DOOR & WIPER CONTROL PANEL

To access the entrance door & wiper control panel of the right console, remove the panel under the larger utility compartment at the base of the windshield.

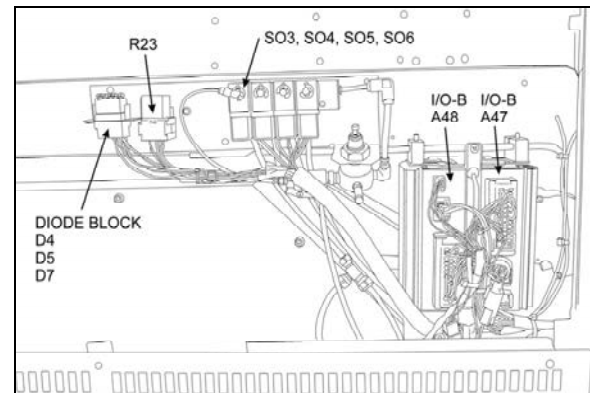


FIGURE 10: ENTRANCE DOOR & WIPER CONTROL PANEL 06619


Entrance Door & Wiper Control Panel			
Multiplex Modules			
A47	I/O-B	A48	I/O-B
Relays			
R23	Windshield wipers		
Solenoids			
SO3	Door unlock solenoid valve	SO5	Door opening solenoid valve
SO4	Door unlock solenoid valve	SO6	Door closing solenoid valve
Diodes			
D4	Windshield wipers speed 2	D7	Entrance door
D5	Windshield wipers speed 1		

3. BATTERIES

The vehicle is provided with four (4) maintenance-free 12 volt heavy-duty batteries connected in series-parallel (Fig. 8 & 11). The top-mounted negative and positive terminals are tightly sealed to prevent leaks. Water never needs to be added to this type of battery. There are no filler caps in the cover. The battery is sealed, except for small vent holes in the cover. The vents must not be restricted as they allow small amounts of gases produced in the battery to escape. The special chemical composition inside the battery reduces gassing to a very small amount at normal charging voltages. Besides reducing gassing, the special chemistry


greatly reduces the possibility of overcharge damage.

The vents require keeping the battery in an upright position to prevent electrolyte leakage. Tipping the battery beyond a 45° angle in any direction can allow a small amount of electrolyte to leak out of the vent holes.

 WARNING
DO NOT tip battery by more than 45° when carrying or installing the battery.

NOTE
<i>Evidence of electrolyte leakage does not necessarily mean the battery is defective.</i>

With special cables properly attached to batteries, the metal surfaces that carry the current are completely sealed from the atmosphere. This prevents terminal oxidation and corrosion that may cause starting and charging problems. If new cables are required, sealed terminal cable replacements should be used to retain the reliability of the original maintenance-free connections.

 DANGER
All lead-acid batteries generate hydrogen gas, which is highly flammable. If ignited by a spark or flame, the gas may explode violently, causing spraying of acid, fragmentation of the battery, which may result in severe personal injuries. Wear safety glasses and do not smoke when working near batteries. In case of contact with acid, flush immediately with water.

The battery has four (4) major functions:

1. Providing a source of current for starting the engine;
2. Stabilizing the voltage in the electrical system;
3. Supplying current for a limited time, when electrical demands of the equipment exceed the power output of the alternator;
4. Providing a limited source of power for connected accessories, when the engine is not running.

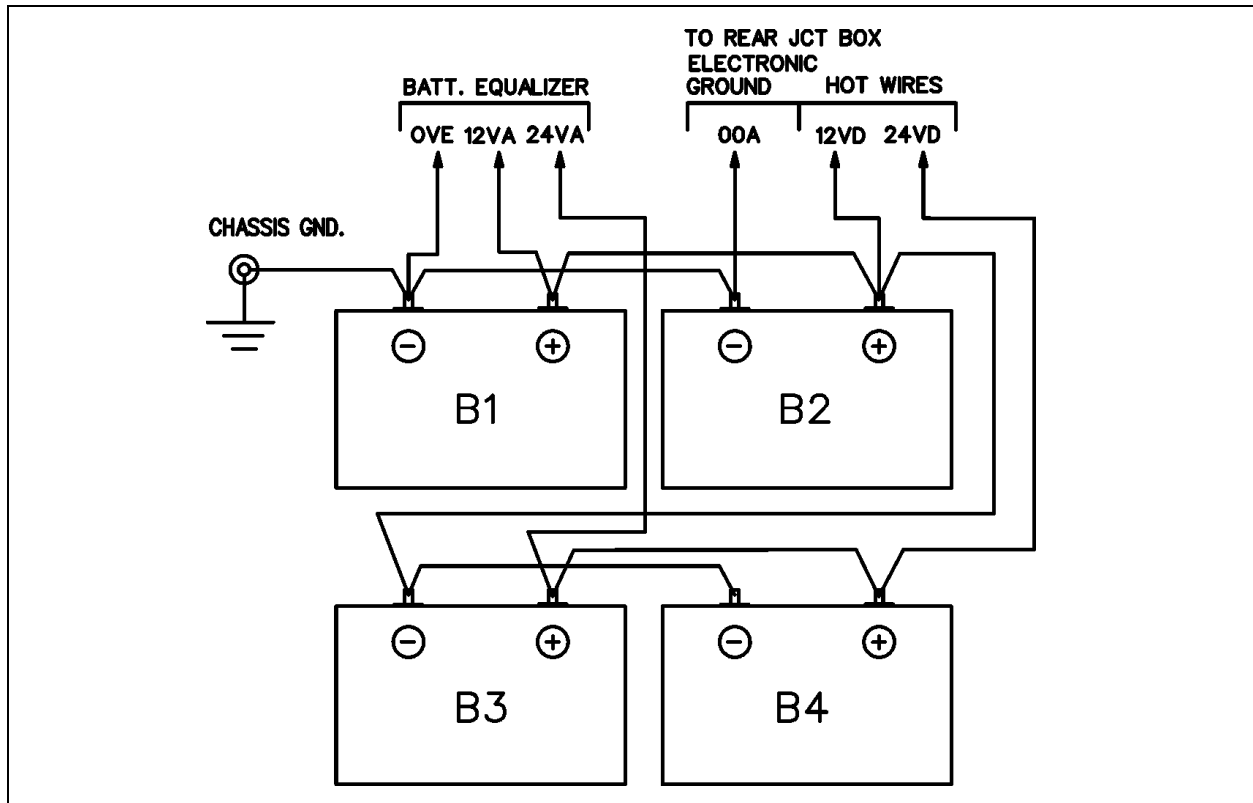


FIGURE 11: BATTERY CONNECTIONS

06636

3.1 BATTERY DISCHARGE PROTECTION

To prevent discharge of the batteries when the engine is not running, some functions are automatically switched off if the batteries voltage drops below 24.4 volts for more than 30 seconds. The "BAT" telltale light blinks while this protection mode is active. Set the ignition key to the OFF position and then turn the ignition key to the ON position to reactivate the functions for a period of 30 seconds before they switch off again.

If a prolonged use of the functions with the engine not running is necessary, connect the battery to a charger.

3.2 MAIN BATTERY RELAYS

Main battery (master) relays (12V and 24V) are provided for this vehicle. The relays are located in the rear electrical compartment. The 24-volt battery relay (R1) engages when ignition key is in the ON or ACC position and battery master switch (master cut-out) is flipped ON.

When the main battery relays (R1 & R3) are turned to the OFF position, all electrical supply from the batteries is cut off, with the exception of the following items.

- Battery equalizer check module;
- MCM;
- TCM (World transmission);
- Preheater electronic timer;
- Preheater and water recirculating pump;
- Sedan entrance door;
- Radio memory;
- CECM;
- Cluster memory.

3.3 BATTERY REMOVAL AND INSTALLATION

The batteries are located in the condenser compartment.

1. Remove the two quarter turn nuts to remove the protective cover (Fig. 8)

DANGER

To prevent possible electric shocks or sparking, the battery master switches should be in the "Off" position before disconnecting

cables from the batteries (see paragraph "3.8 Battery safety switches").

2. Remove the supports, and unscrew terminal nuts of each defective battery.
3. Remove battery cables from the batteries.
4. Remove batteries.
5. Installation is the reverse of removal.

NOTE

When the battery cables have been removed from the batteries, wrap the battery terminals and cable ends with electric tape to prevent accidental grounding. The ground cables should always be disconnected first and replaced last.

NOTE

In replacing batteries, only batteries of the same specification should be used. Refer to "Specifications" at the end of this section for further details.



CAUTION

Ensure that connections are not reversed when reinstalling batteries, since damage to electrical system components will result.

NOTE

When reinstalling batteries, battery connections must be tightened to 13-15 lbf-ft (18-20 Nm). A torque wrench is required to ensure an accurate tightening torque.



DANGER

To prevent possible electric shock or sparking, the battery master switch must be set to the "Off" position before tightening an electrical connection.

NOTE

A protective silicone free, coating should be applied on all terminals that have been disconnected. We recommend the use of Cortec VCI-238 (Prévost #682460) on all electrical connections.

3.4 BATTERY RATING

Each of the 12 volt batteries used on the vehicle has the following rating:

- Reserve capacity: 195 minutes
- Cold cranking (amps): 950 @ 0°F (-18°C)
- Cold cranking (amps): 745 @ -20°F (-29°C)
- Weight (filled): 59 lb (26,7 kg)

The reserve capacity is defined as the number of minutes a new, fully charged battery at 80°F (26,6°C) can be discharged at 25 amperes and maintain a minimum of 1.75 volts per cell (10.5 volts total for one 12 volts battery). This rating can be used as a basis for determining how long a vehicle might run after an alternator failure. The cold cranking rating is defined as the minimum discharge current a battery will deliver in amperes for 30 seconds at 0°F (-18°C) while maintaining a minimum of 1.2 volts per cell (7.2 volts total for one 12 volts battery). This rating can be used as a basis for comparing starting performance.

3.5 BATTERY TESTING

The maintenance-free battery has a strong ability to withstand the damaging effects of overcharge. The test indicator in the cover is used only to determine if the battery can be tested in case of a cranking problem.

The test indicator in the battery cover is to be used with accepted diagnostic procedures only. It must not be used to determine if the battery is good or bad, charged or discharged. The test indicator is a built-in hydrometer in one cell that provides visual information for battery testing (Fig. 12).

It is important when observing the test indicator, that the battery be relatively level and has a clean indicator top to see the correct indication. Some lighting may be required in poorly lit areas. Under normal operation, two indications can be observed.

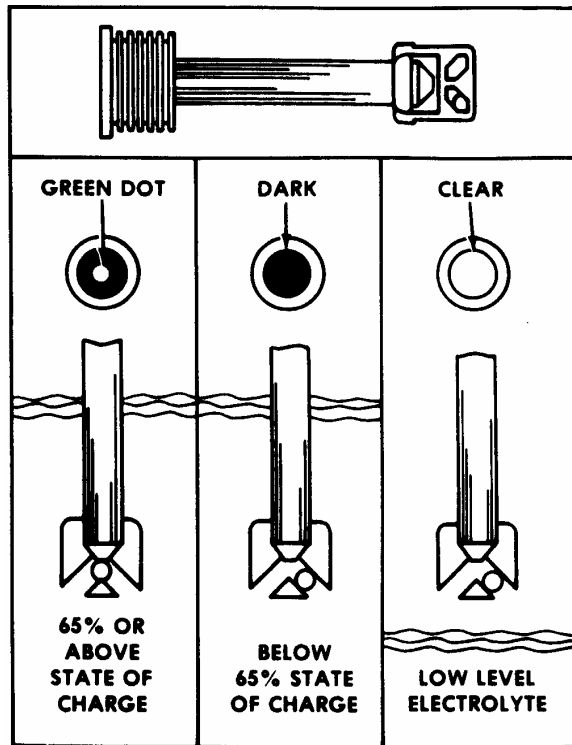


FIGURE 12: TEST INDICATOR 06096

Green Dot Visible

Any green appearance is interpreted as a "green dot", and the battery is ready for testing. On rare occasions, following prolonged cranking, the green dot may still be visible when the battery is obviously discharged. Should this occur, charge the battery as described under "Charging Procedure" in "Battery Charging" later in this section.

Dark - Green Dot Not Visible

If there is difficulty cranking the engine, the battery should be tested as described in this section. On rare occasions, the test indicator may turn light yellow. In this case, the integral charging system should be checked. Normally, the battery is capable of further service; however, if difficult start has been reported, replace the battery. **DO NOT CHARGE, TEST, OR JUMP-START.**

3.5.1 Visual Inspection

1. Check the outside of the battery for a broken or cracked cover or case that could permit loss of electrolyte. If obvious physical damage is noted, replace the battery.
2. Check for loose terminal posts, cable connections, damaged cables, and for

evidence of corrosion. Correct conditions as required before proceeding with tests.

3.5.2 Removing Surface Charge

Disconnect cables from the battery and attach alligator clamps to the contact lead pad on the battery as shown in figure 16. Connect a 300 ampere load across the terminal for 15 seconds to remove surface charge from the battery.

3.5.3 Load Test

This test is one means of checking the battery to determine its ability to function as required in the vehicle.

To make this test, use test equipment that will withstand a heavy electrical load from the battery, such as a carbon pile resistor or other suitable means.

1. Connect a voltmeter, ammeter, and a variable load resistance as illustrated in figure 13.

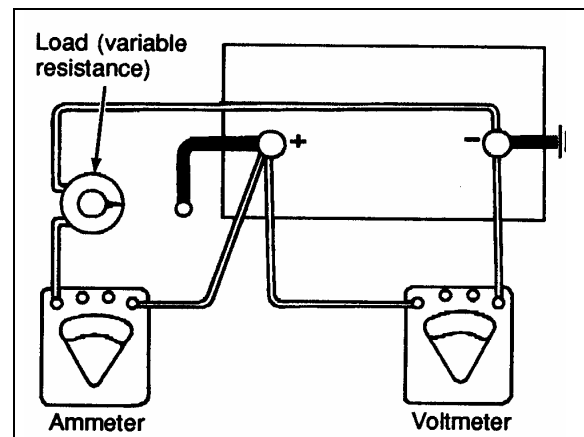


FIGURE 13: LOAD TEST 06064



CAUTION

Observe polarity of the meters and the battery when making connections, and select the correct meter range.

2. Apply a 290 amperes load to the battery for 15 seconds.
3. With an ammeter reading specified load, read voltage. The voltage should be at least 9.6 volts. Disconnect the load. If the voltmeter indicates 9.6 volts or more, the battery is good. If the voltmeter reading is less than 9.6 volts, replace the battery. This voltage is to be used for battery ambient temperatures of 70°F (21°C) and above. For

temperatures below 70°F (21°C), refer to the following "Voltage and Temperature Chart".

Voltage and Temperature Chart

Ambient Temperature	Minimum Voltage
70°F (21°C) and above	9.6
60°F (16°C)	9.5
50°F (10°C)	9.4
40°F (4°C)	9.3
30°F (-1°C)	9.1
20°F (-7°C)	8.9
10°F (-12°C)	8.7
0°F (-18°C)	8.5

NOTE

The accuracy of this test procedure is dependent upon close adherence to the proper load, time and temperature specifications.

3.5.4 Testing Battery Cables

Check all cable ring terminals and connections to determine if they are in good condition. Excessive resistance, generally caused by poor connections, produces an abnormal voltage drop which may lower voltage at the starter to such a low value that normal operation of the starter will not be obtained. An abnormal voltage drop can be detected with a low-reading voltmeter as follows:



DANGER

To prevent the engine from starting during these tests, remove fuses F78 and F79 located in the VECR of the rear electrical compartment. Once the tests are completed, reinstall F78 and F79.

1. Check voltage drop between grounded (negative) battery terminal and vehicle frame by placing one prod of the voltmeter on the battery terminal and the other on a good ground (unpainted surface) on the vehicle. With the starter cranking the engine at a temperature of 70°F (21°C), voltage reading should be less than 0.3 volt. If the voltage reading exceeds 0.3 volt, there is excessive resistance in this circuit.
2. Check voltage drop between the positive battery terminal and the starter positive terminal stud while the motor is operated. If the reading is more than 2.5 volts, there is excessive resistance in this circuit.

NOTE

If it is necessary to extend the voltmeter lead for this test, use a #16 (AWG) or larger wire.

3. Check voltage drop between the starter housing and a good ground on the vehicle. The reading should be less than 0.2 volt.



DANGER

Any procedure other than the following could cause personal injury or damages to the charging system resulting from battery explosion or electrical burns.

Wear adequate eye protection when working on or near the batteries. Ensure that metal tools or jumper cables do not contact the positive battery terminal (or a metal surface in contact with it) as a short circuit will result. Do not attempt to jump start a vehicle suspected of having a frozen battery because the battery may rupture or explode. Both the booster and discharged batteries must be treated carefully when using jumper cables. Follow exactly the procedure outlined later in this section, being careful not to cause sparks.

3.6 BATTERY CHARGING

The batteries used on this vehicle can be charged either on or off the vehicle; however, when they are removed from the vehicle, it is recommended that an adapter kit, which is available from any "A/C DELCO" dealer, be used in charging sealed-terminal batteries. Use the booster block to charge the batteries when they are left on vehicle and **make sure that the main battery disconnect switch is set to the "On" position.**



DANGER

During charging of the batteries, an explosive gas mixture forms in each cell. Part of this gas escapes through the vent holes and may form an explosive atmosphere around the battery itself if ventilation is poor. This explosive gas may remain in or around the battery for several hours after it has been charged. Sparks or flames can ignite this gas causing an internal explosion, which may shatter the battery.

1. Do not smoke near a battery which is being charged or which has been recently charged.

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2. Do not break live circuits at battery terminals because a spark usually occurs at the point where a live circuit is broken. Care must always be taken when connecting or disconnecting booster leads or cable clamps on chargers. Poor connections are a common cause of electric arcs, which cause explosions.
3. The electrical system on this vehicle is negative ground. Installing the batteries with the positive terminals grounded or incorrect use of the booster battery and jumper cables will result in serious damage to the alternator, batteries and battery cables.

The alligator clamps of the tester or charger must be placed between the terminal nuts and the lead pads of the terminal studs (Fig. 14) after the vehicle cables are detached. The alligator clamps should make firm contact with the lead pads.

NOTE

If this connection cannot be made because of the alligator clamp design, the load value for testing must be reduced from 290 to 260 amperes.

On rare occasions, such as those that occur following prolonged cranking, the green dot in the test indicator may still be visible when the battery is obviously discharged. Should this occur, a boost charge of 20 amperes-hour is recommended. Under normal operating conditions, do not charge battery if the green dot is visible. The battery should never be charged if the test indicator (hydrometer) is clear or light yellow. If this occurs, replace the battery.

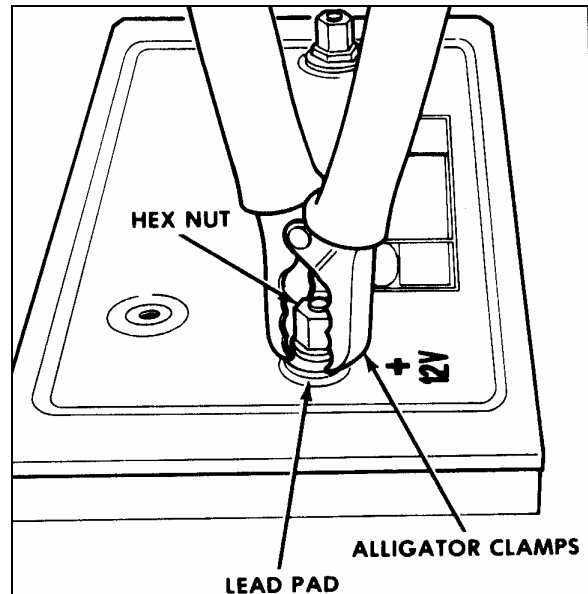


FIGURE 14: ALLIGATOR CLAMPS AND BATTERY 06065

A charge rate between 3 and 50 amperes is generally satisfactory for any maintenance-free battery as long as spewing of electrolyte does not occur or the battery does not feel excessively hot (over 125°F (52°C)). If spewing or violent gassing of electrolyte occurs or battery temperature exceeds 125°F (52°C), the charging rate must be reduced or temporarily stopped to allow cooling and to avoid damaging the battery. Battery temperature can be estimated by touching or feeling the battery case. The battery is sufficiently charged when the green dot in the built-in hydrometer is visible. No further charging is required. Shake or tilt the battery at hourly intervals during charging to mix the electrolyte and see if the green dot appears.



WARNING

Always turn off the charger before connecting or disconnecting to a battery.

NOTE

The charge rate must be doubled when the batteries are charged by the booster block, because of the series-parallel circuit.

Battery charging consists of a charge current in amperes for a period of time in hours. Thus, a 25 ampere charging rate for 2 hours would be a 50 ampere-hour charge to the battery. Most batteries, whose load test values are greater than 200 amperes, will have the green dot visible after at least a 75 ampere-hour charge. In the event that the green dot does not appear, replace the battery.

3.6.1 Battery Charging Guide

Fast Charging Rate

20 amps @ 3-¾ hours

30 amps @ 2-½ hours

40 amps @ 2 hours

50 amps @ 1-½ hours

Slow Charging Rate

5 amps @ 15 hours

10 amps @ 7-½ hours

The time required for a charge will vary according to the following factors:

Size of Battery

For example, a completely discharged large heavy-duty battery requires more than twice the recharging time of a completely discharged small passenger car battery.

Temperature

For example, a longer time will be needed to charge any battery at 0°F (-18°C) than at 80°F (27°C). When a fast charger is connected to a cold battery, the current accepted by the battery will be very low at first, and then in time, the battery will accept a higher rate as it warms.

State of Charge

For example, a completely discharged battery requires more than twice as much charge than a half-charged battery. Since the electrolyte is nearly pure water and a poor conductor in a completely discharged battery, the current accepted is very low at first. Later, as the charging current causes the electrolyte acid content to increase, the charging current will likewise increase.

Charger Capacity

For example, a charger which can supply only 5 amperes will require a much longer period of charging than a charger that can supply 30 amperes or more.

3.6.2 Emergency Jump Starting With Auxiliary (Booster) Battery.

DANGER

Off-board battery charger with a start boost facility must not be used to jump start the vehicle. This could damage the electrical system. Do not jump start vehicles equipped with maintenance-free batteries if the test indicator is light yellow.

Booster Block

On X3-45 coaches, booster block is located near the preheater in the engine compartment on the R.H. side and is accessible through engine R.H. side door (Fig. 15).

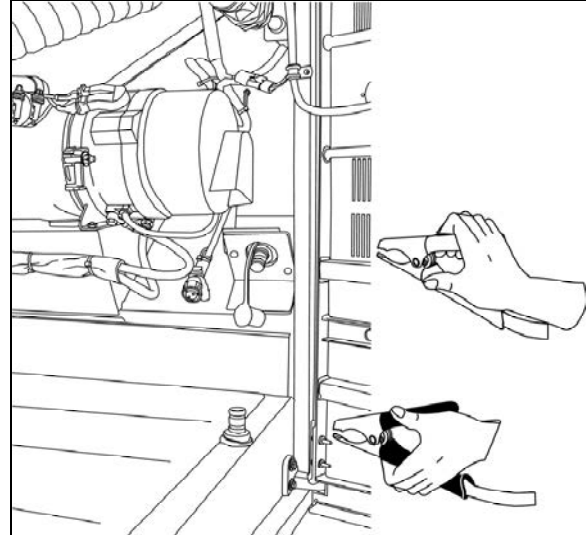


FIGURE 15: BOOSTER BLOCK

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Both booster and discharged batteries should be treated carefully when using jumper cables. A vehicle with a discharged battery may be started by using energy from a booster battery or the battery from another vehicle.

DANGER

Jump starting may be dangerous and should be attempted only if the following conditions are met:

The booster battery or the battery in the other vehicle must be of the same voltage as the battery in the vehicle being started, and must be negative grounded.

If the booster battery is a sealed-type battery without filler openings or caps, its test indicator must be dark or a green dot must be visible. Do not attempt jump starting if the test indicator of the booster battery or the discharged battery has a light or bright center.

DANGER


Follow the procedure exactly as outlined hereafter. Avoid making sparks.

Wear eye protection and remove rings, watches with metal bands and other metal jewelry.

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Apply parking brake and place the transmission shift lever or push-button pads in Neutral (N) position in both vehicles. Turn off lights, heater and other electrical loads. Observe the charge indicator. If the indicator in the discharged battery is illuminated, replace the battery. **Do not** attempt jump starting when indicator is illuminated. If the test indicator is dark and has a green dot in the center, failure to start is not due to a discharged battery and the cranking system should be checked. If charge indicator is dark but the green dot does not appear in center, proceed as follows:

1. Connect one end of one red jumper cable to the positive (+) terminal of the booster power source and the other end to the positive (+) post of the booster power block, located on the R.H. side of the engine compartment (refer to fig. 4).
2. Connect one end of the remaining negative jumper cable (black) to the negative (-) terminal of the booster power source, and the other end of the black jumper cable to the negative (-) post of the booster power block.
3. Make sure the clips from one cable do not inadvertently touch the clips on the other cable. Do not lean over the battery when making connections. The ground connection must provide good electrical conductivity and current carrying capacity.
4. Start the engine in the vehicle that is providing the jump start. Let the engine run for a few minutes, then start the engine in the vehicle that has the discharged batteries.
5. When removing the jumper cables, perform the above procedure exactly in reverse order, and replace protective caps on booster block terminals.

 DANGER
Any procedure other than the above could result in personal injury, property damage due to battery explosion, or damage to the charging system of the booster vehicle or of the boosted vehicle.

NOTE

Jumper cables must withstand 500 cranking amperes. If cable length is 20 feet (6m) or less, use 2/0 (AWG) gauge wires. If cable length is between 20-30 feet (6-9m), use 3/0 (AWG) wires.

3.7 CLEANING AND INSPECTION

The external condition of the battery and the battery cables should be checked periodically. The top of the battery should be kept clean and the battery hold-down clamp bolts should be kept properly tightened. For best results when cleaning the battery, wash first with a diluted solution of ammonia or soda to neutralize any acid present then wash out with clean water. The battery hold-down bolts should be kept tight enough to prevent the batteries from moving, but they should not be tightened to the point that excessive strain is placed on the battery hold-down cover (proper tightening torque: 45-55 lbf-in (5-6 Nm)).

To insure good contact, the battery cable ring terminals should be tight on the battery posts. If the posts or cable ring terminals are corroded, the cables should be disconnected and the posts and clamps cleaned separately with a soda solution and a wire brush. Install cable ring terminals on battery posts and tighten to a torque of 10-15 lbf-ft (13-20 Nm). Replace protective caps to prevent corrosion and sparks.

3.8 COMMON CAUSES OF BATTERY FAILURE

When a battery fails, the cause of failure may be related to something other than the battery. For this reason, when a battery failure occurs, do not be satisfied with merely recharging or replacing the battery. Locate and correct the cause of the failure to prevent recurrence. Some common external causes of battery failure are as follows:

1. A defect in charging system such as high resistance or a faulty alternator or regulator.
2. A malfunction within the 12 volts system (equalizer).
3. Overloads caused by a defective starter or excessive use of accessories.
4. Dirt and electrolyte on top of the batteries causing a constant drain.
5. Hardened battery plates, due to battery being in a low state of charge over a long period of time.
6. Shorted cells, loss of active material from plates.
7. Driving conditions or requirements under which the vehicle is driven for short periods of time.

8. A constant drain caused by a shorted circuit such as an exposed wire or water infiltration in junction boxes causing ground fault.
9. Extended operation of preheating system with engine not running.
10. Failing to close disconnect switches during the night.

3.9 TROUBLESHOOTING

If a battery is known to be good and then has not performed satisfactorily in service for no apparent reason, the following factors may reveal the cause of trouble:

1. Vehicle accessories and disconnect switches inadvertently left on overnight.
2. Defects in the charging system, such as high wiring resistance, faulty alternator, regulator or battery equalizer.
3. A vehicle electrical load exceeding the alternator (or battery equalizer) capacity, with the addition of electrical devices, such as CB radio equipment, a cellular phone or additional lighting systems.
4. Defects in the electrical system, such as shorted or pinched wires.
5. Extended driving at a slow speed while using many accessories.
6. Loose or poor battery cable-to-post connections, previous improper charging of a run-down battery, or loose hold-down clamp bolts.
7. High-resistance connections or defects in the cranking system.

3.10 "BAT" BATTERY VOLTAGE INCORRECT TELLTALE LIGHT

If the "BAT" (battery voltage incorrect) telltale light is illuminated, check the 24-volt voltmeter to determine if the battery voltage is too high or too low.

NOTE

According to the battery charging condition, it is normal that "BAT" telltale light illuminates upon starting the engine and stays illuminated for a few seconds. This is caused by the normal voltage drop of the battery during starting.

3.10.1 "Bat" Telltale Light Definitions

Voltmeter drops below 24.4 volts dc

Check alternator output.

Check voltage regulator.

Check battery connections.

Check battery cells.

- o Check battery equalizer connections.

Voltmeter exceeds 30 volts dc

- o Check alternator output.

- o Check voltage regulator.

- o Check battery connections.

Battery Balance

NOTE

Allow at least 15 minutes to balance batteries after any corrective measure has been taken.

1. Batteries out of balance (difference greater than 1.5 volts between the two battery banks).

- o Check battery equalizer connections.
- o Check equalizer cables for proper gauge.
- o Check battery connections.

2. Demand for 12-volt power exceeding rated amperage output of battery equalizers causing batteries to go out of balance.

- o Reduce 12-volt load or install additional battery equalizer(s).

4. TROUBLESHOOTING AND TESTING THE MULTIPLEX VEHICLES

4.1 ELECTRICAL SYSTEM DIAGNOSTIC

Using the message center display (MCD), check if there are active errors in the vehicle electrical system. With the SYSTEM DIAGNOSTIC menu, highlight FAULT DIAGNOSTIC and then highlight ELECTRICAL SYSTEM to request a diagnostic of the electrical system from the CECM. Press the enter key. If applicable, the MCD shows the multiplex device ID, the fault messages or fault codes recorded. When more than one fault is recorded, an arrow pointing down appears on the right of the display. Use the down arrow to see all the fault messages.

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Once the problem corrected, the MCD still shows the fault as being active. You have to leave the FAULT DIAGNOSTIC menu, wait approximately 20 to 30 seconds and then return to FAULT DIAGNOSTIC to request a new diagnostic of the ELECTRICAL SYSTEM from the CECM. The MCD should display the fault as being inactive. The CECM can store up to 20 faults, i.e. the first 10 and the last 10. Middle faults will be erased. If the breakers are tripped, the fault history will be erased from the CECM memory.

NOTE

It is of the utmost importance to have a MCD (message center display) in working condition because it is the most important tool to achieve troubleshooting on a multiplex vehicle.

4.2 PROBING VOLTAGE ON THE MULTIPLEX CIRCUITS

Some Multiplex modules are supplied by 12 volts while others are supplied by 24 volts. The 12-volt or 24-volt information is found on the modules symbol in the wiring diagram. Before taking voltage readings to track the source of a problem, first verify if the module is supplied by 12V or 24V, if not, residual voltage on the module inputs/outputs can draw an erroneous conclusion.

Inactive Multiplex output = Residual voltage of 18% to 33% of supply voltage.

Inactive Multiplex input = Residual voltage of 50% of supply voltage.

NOTE

- *Verify on the wiring diagram whether the voltage is 12V or 24V,*
- *For a 12V module: an active voltage would be 12V or 0V but not in between. If you measure the intermediate tensions (ex. 6V, 2V, or 4V) this must be interpreted as if the input or the output is inactive.*
- *For a 24V module: an active voltage would be 24V or 0V but not in between. If you measure the intermediate tensions (ex. 12V, 4V, or 8V) this must be interpreted as if the input or the output is inactive.*

4.3 CAN NETWORK

The CAN network wiring is separated in sections and uses connectors that are not shared with other circuits. This allows sections of the network to be isolated to help locate short-circuit on the CAN.

In case of a short-circuit on the CAN network, this affects all the modules and they all act as "No response" in the error messages of the "ELECTRICAL SYSTEM" menu. To locate a short-circuit, proceed by disconnecting one module zone at a time while verifying if this makes inactive the errors in the modules still connected. Connector C1 (front electrical & service compartment) disconnects all the modules at the rear of the vehicle from the network. Connector C5 (front electrical & service compartment) disconnects all the modules from the entrance door & wiper control panel. Connector C3 (rear electrical compartment) disconnects all the modules at the rear of the vehicle from the network.

Example: Disconnect C5 and C1 and then verify the status of the errors. If the front modules (A41 to A46) now give inactive errors, which means short-circuit is elsewhere than in the front electrical & service compartment.

4.3.1 Can Connection On The Telltale Panel And The Hvac Control Unit

The telltale panel module and HVAC module are linked to the CECM by a CAN connection. In case of a CAN connection default, the telltale panel LCD display shows "CAN", and on the HVAC control unit, the temperature display indicates "---". To confirm a CAN connection default, check that the fan speed on the driver's section HVAC control unit cannot be adjusted.

Moreover, specific error messages from these 2 modules can be read in the ELECTRICAL SYSTEM menu.

NOTE

While downloading a new vehicle program in the CECM from a computer, the CAN network is temporarily interrupted and therefore a CAN reference appears in the telltale panel LCD display.

4.3.2 Spare Can

A spare CAN network is installed between the front and the rear of the vehicle. It has connectors installed at each end to facilitate swapping from the regular CAN network to the spare CAN network. Refer to the vehicle wiring diagram and the section 4.6 for more information.

4.4 TEST MODE FOR SWITCHES AND SENSORS

The switch/sensor test mode provides useful information to diagnose problems complimentary to the electrical system diagnosis.

To enter this mode, activate the dashboard "Telltale Light Test" switch 3 times within 4 seconds. To exit the switch/sensor test mode, reactivate the test switch 1 time or turn OFF the ignition.

4.4.1 Information Available And Impact On The Functions In Switch/Sensor Test Mode

Telltale panel audible alarm emits a *beep* each time an OFF/ON transition is detected on a multiplex input. This allows quick verifying if the switches and sensors are detected or seen by the multiplex modules. When the vehicle is parked, the back-up alarm also emits a sound that allows verification of the sensors at the rear of the vehicle.

Certain inputs are doubled (ex. turn signal switch on multi-function lever, door operating buttons) and also other inputs activate at the same time (ex. kneeling switch and Kneeling proximity sensor switch). For these inputs, 2 *beeps* are emitted. If only one *beep* is heard, one of the inputs is defective.

SWITCHES AND SENSORS SUPPORTED BY THE SWITCH/SENSOR TEST MODE
HVAC control unit driver's section ON/OFF
A/C door ajar open sensor
HVAC control unit driver recirculate switch
HVAC overhead compartment fan switch
HVAC control unit passenger's section ON/OFF
Engine ether start switch
Radiator fan clutch switch
Engine front start enable switch
Engine rear start enable switch
Engine ignition front switch

Engine ignition rear switch
Entrance door inside closing switch
Entrance door outside opening /closing switch
Entrance door electric window down switch
Entrance door electric window up switch
Electric horn button
Kneeling down switch
Kneeling up switch
Lavatory emergency switch
Interior lighting switch, 2 positions
Driver's area lighting switch
Reading lights switch
Multi-function lever LH turn signal
Multi-function lever RH turn signal
Fog lights switch
Hazard warning flashers switch
Multi-function lever courtesy blinkers switch
Headlights switch, 2 positions
Multi-function lever headlights beam toggle switch
Baggage compartment door lock/unlock switch
Tag axle signal
Wheelchair lift activation switch
Windshield lower wiper
Multi-function lever windshield wipers intermit.
Multi-function lever windshield wipers speed 1,2
Windshield wipers backup switch
Windshield washer switch

The following inputs, either certain options or sensors which are difficult to activate, are not supported by the switch/sensor test:

- Low-Buoy switch,
- Starter Sensor,
- ABS Warning input,
- WCL switch,
- Driver's Power Window Switch (up & down),
- Fog Lights Switch,
- Alternator Sensors 1 & 2,
- Retarder Active Signal,
- Radiator fan speed 1 & 2 signals.

When in switch/sensor test mode, the A/C compressor HI and LO pressure values are displayed one after the other instead of the outside temperature in the telltale panel LCD display. This feature can be used when the vehicle is traveling to check the A/C compressor pressure values, but no *beep* can be heard.

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In test mode, with the parking brake applied and the passenger set point set to a value higher than 64°F (18°C), the circulator pump is not set to OFF as it would normally do when the outside temperature gets above 50°F (10°C). This feature allows verification of the pump when inside a garage. This is also useful when working on the heating system to remove air pockets trapped in the system.


When performing an A/C cooling test and having the water pump shut off in switch/sensor test mode is required, just set the passenger set point temperature to the minimum 64°F (18°C) to shut off the pump.

4.5 TEST MODE FOR ELECTRIC MOTORS

The test mode allows testing the motors and electric contactors without the need to have the engine running. Note that while in test mode, the engine cannot be started.

Prerequisite conditions for the motor test mode:

- A. The battery charger must be connected to a 110-120 volt power supply. If not, the test will be interrupted when the voltage drops below 24.4 volts,
- B. Engine not running,
- C. Parking brake applied,

 DANGER
Before starting the test sequence, make sure nobody is working in the evaporator or condenser compartment.

NOTE

A delay of 15 seconds during which the back-up alarm will sound is introduced prior the test start to advise people that may be working on the vehicle.

To enter this mode:

- Activate the dashboard Telltale Light Test switch 3 times within 4 seconds;
- Push the ON/OFF button on the driver's side HVAC control unit 5 times (that makes 3 transitions from OFF to ON),
- A *beep* can be heard indicating the motor test mode has started.

Using the test mode:

- During the entire test, the telltale panel audible alarm gives a signal each second to remind that the motor test mode is underway.

4.5.1 Test Sequence

Go to the condenser compartment.

- The condenser fans runs for 3 seconds at speed 1.
- 1 second delay.
- Speed 2 activates for 3 seconds.
- 3 seconds delay.
- Passenger's unit refrigerant solenoid valve activates 3 times at 1 second interval.

Then 5 beeps can be heard from the back-up alarm to indicate to go to the engine compartment (15 SECONDS DELAY).

In the engine compartment, the sequence is as follows:

- Toilet fan motor runs for 3 seconds.
- 1 second delay.
- A/C compressor clutch activates 3 times at 1 second interval.
- 1 second delay.
- Left compressor unloader activates 3 times at 1 second interval.
- 1 second delay.
- Right compressor unloader activates 3 times at 1 second interval.

5 beeps from the back-up alarm indicate to go to the engine radiator fan (5 SECONDS DELAY).

- Fan clutch is disengaged for 3 seconds (fan can be turned freely by hand).
- Fan clutch engages for 3 seconds in speed 1 (fan can be turned by hand but with a certain resistance).
- 3 seconds delay.
- Fan clutch engages for 3 seconds in speed 2 (cannot be turned but hand).
- 10 seconds delay.

- Auxiliary A/C clutch (parcel rack cooling system) activates 3 times at 1 second interval.

5 beeps from the back-up alarm indicate to go to the evaporator compartment (10 SECONDS DELAY).

In the evaporator compartment:

- Evaporator fan motor runs at speed 1 for 3 seconds then runs at speed 2 for 3 seconds.
- Hot water pump starts running for 5 seconds and hot water pneumatic valve activates 3 times at 1 second interval.

5 beeps from the back-up alarm indicate to go to the spare wheel compartment (20 SECONDS DELAY).

Inside the compartment:

- Driver's refrigerant solenoid valve activates 3 times at 1 second interval.
- 1 second delay.
- Driver's water solenoid valve activates 3 times at 1 second interval.

5 beeps from the back-up alarm indicate to go to inside the vehicle (10 SECONDS DELAY).

Inside the vehicle:

- Upper section defroster fan motor runs for 5 seconds.
- 10 seconds delay.
- Left and right overhead compartment fans start running one after the other for 5 seconds.
- 1 second delay.
- Overhead storage compartment refrigerant solenoid valve activates 3 times at 1 second interval.

This ends the test. Activate the dashboard Telltale Light Test switch one time to leave the motor test mode.

4.6 CAN NETWORK LAYOUT AND TROUBLESHOOTING

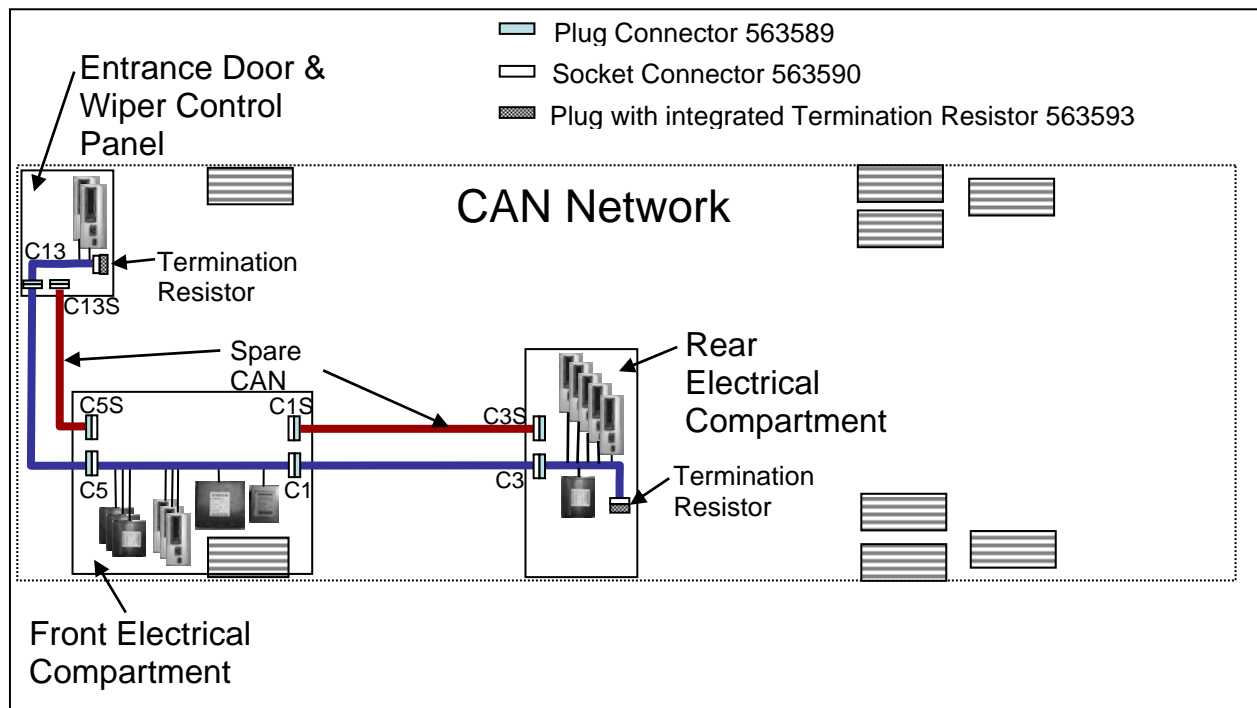


FIGURE 16: X3-45 COACHES CAN NETWORK LAYOUT

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4.7 TROUBLESHOOTING

Problem/Symptom	Probable Causes	Actions
<p>Vehicle does not Start</p>	<p>Rear Start selector switch is not in the NORMAL position</p> <p>Master cut-out switch in the rear electrical compartment is in the OFF position (down)</p>	<ol style="list-style-type: none"> 1. Check that the rear start selector switch is flipped up to NORMAL start position and master cut-out switch is flipped up to ON and retry cranking 2. Flip the rear start selector switch to "Rear Start" and start the vehicle from the rear
	<p>CAN network problem (Multiplex)</p> <p>Module A53 not powered or is defective</p> <p>Engine MCM does not receive the ignition signal</p> <p>Engine MCM is not powered</p>	<p>If the vehicle does not start from the rear:</p> <ol style="list-style-type: none"> 1. Verify that module A53 is powered: <ol style="list-style-type: none"> a) Check the SYSTEM DIAGNOSTIC menu of the message center display (MCD). Select FAULT DIAGNOSTIC and ELECTRICAL SYSTEM. The message "No Response ModA53, Active", indicates a power problem on the module or a CAN network problem. b) Check / reset circuit breaker CB5 c) Check / replace fuse F65 d) Probe gray connector on module to see if it is powered. 2. Verify that the engine MCM is powered and get the ignition signal <ol style="list-style-type: none"> a) Check / reset circuit breaker CB8 Check / replace fuse F74 b) Check / reset circuit breaker CB2 Check / replace fuse F78
<p>None of the Multiplexed functions are operating, including the basic limp-home functions (door opening, flashers, wipers in speed 1)</p> <p>Three dashes "---" appear in the telltale panel instead of the outside temperature</p> <p><i>Note: The sunshades are still functioning since these are not multiplexed</i></p>	<p>The program version in the CECM is different than the program in the I/O modules and the CECM is forcing all I/O modules to stay inactive</p>	<ol style="list-style-type: none"> 1. Engage the auto-programming of the I/O modules: Turn the ignition key to the OFF position, flip the master cut-out switch in the rear electrical compartment to OFF and ON and then turn the ignition key ON. The letters CAN will appear in the telltale LCD panel for about 3 minutes Everything shall get back to normal once the letters CAN are replaced with outside temperature display 2. Try disconnecting the green connector on the CECM and reconnect 3. If step 1 and 2 are ineffective, try disconnecting the Master ID module completely and repeat step 1

Problem/Symptom	Probable Causes	Actions
		4. Try disconnecting the CECM completely, leave it disconnected and see if the limp-home functions (start of the vehicle from the engine compartment, wipers speed 1, flashers, etc) are functioning
<p>Many secondary functions (not essential for driving) not functioning (interior lighting, driver's area lighting, wiper speed 2 and intermittent).</p> <p>Outside temperature display in the telltale LCD panel displays three dashes "---"</p> <p>Marker lights and clearance lights are turned ON when setting ignition to the ON position.</p>	<p>The CECM module does not receive 24 V power.</p> <p>The CAN network is not working. It could be caused by a short on the network, an open circuit, a problem with the CECM or the CECM being disconnected from the network.</p>	<p>1. Check / reset circuit breaker CB6 (3rd from the bottom on the right side column) Check / replace fuse F1</p> <p>2. Operate in limp-home mode by starting the vehicle from the engine compartment (REAR START). All functions essential to drive are available</p> <p>To close and lock the door, pull the door manually up to its closed position and it will lock by itself. The door opening button is still functioning</p>
<p>No temperature control in the passenger area</p> <p>Passenger temperature display indicates two dashes "--"</p>	<p>Problem with the temperature sensor located in the evaporator compartment air intake or the sensor wiring</p>	<p>Instruct the driver to manually control the temperature by playing with the passenger set point. Set above 22°C (72°F) to heat and below 22° C (72°F) to cool</p>
<p>Entrance door does not open nor close using the control buttons</p> <p>Defroster fan not functioning</p> <p>Windshield wipers not functioning in speed 1 or intermittent</p>	<p>Module A47 is not powered or is faulty</p>	<p>1. Check the SYSTEM DIAGNOSTIC menu of the message center display (MCD). Select FAULT DIAGNOSTIC and ELECTRICAL SYSTEM. The message "No Response ModA47, Active" indicates a power problem on the module. (A CAN network problem would show the same message but doesn't produce these symptoms).</p> <p>2. Check / reset circuit breaker CB6</p> <p>3. Check / replace fuse F5</p> <p>4. Probe gray connector on module to see if it is powered.</p> <p>5. Use the air release valves near the entrance door and in the front service compartment to lock / unlock the door</p>
<p>Windshield wipers not functioning in speed 1 or intermittent</p>	<p>No power on R23</p>	<p>Check / replace fuse F82</p>

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Problem/Symptom	Probable Causes	Actions
HVAC condenser fans not functioning in speed 1	Circuit breaker CB7 was manually tripped and not reset	Check / reset circuit breaker CB7
HVAC condenser fans not functioning in speed 2	Circuit breaker CB7 was manually tripped and not reset	Check / reset circuit breaker CB7
<p>Windshield washer not functioning</p> <p>Windshield upper section de-icing system not functioning</p> <p>Defroster fan is functioning but no heat or cooling available in the driver area.</p>	Module A46 is not powered or is faulty	<ol style="list-style-type: none"> 1. Check the SYSTEM DIAGNOSTIC menu of the message center display (MCD). Select FAULT DIAGNOSTIC and ELECTRICAL SYSTEM. The message "No Response ModA46, Active" indicates a power problem on the module. (A CAN network problem would show the same message but doesn't produce these symptoms). 2. Check / reset circuit breaker CB1 3. Check / replace fuse F12 or F13 4. Probe gray connector on module to see if it is powered.
<p>Low beam headlights and front flasher on left side not functioning</p> <p>Electric horn not functioning</p>	Module A45 is not powered or is faulty	<ol style="list-style-type: none"> 1. Check the SYSTEM DIAGNOSTIC menu of the message center display (MCD). Select FAULT DIAGNOSTIC and ELECTRICAL SYSTEM. The message "No Response ModA45, Active" indicates a power problem on the module. (A CAN network problem would show the same message but doesn't produce these symptoms). 2. Check / reset circuit breaker CB2 3. Check / replace fuse F33 and F34 4. Probe gray connector on module to see if it is powered.
Low beam headlights and flasher on right side not functioning	Module A48 is not powered or is faulty	<ol style="list-style-type: none"> 1. Check the SYSTEM DIAGNOSTIC menu of the message center display (MCD). Select FAULT DIAGNOSTIC and ELECTRICAL SYSTEM. The message "No Response ModA48, Active" indicates a power problem on the module. (A CAN network problem would show the same message but doesn't produce these symptoms). 2. Check / reset circuit breaker CB2 3. Check / replace fuse F33 and F34 4. Probe gray connector on module to see if it is powered.

Problem/Symptom	Probable Causes	Actions
<p>Rear flashers not functioning</p> <p>Stoptlights and center stoptlights not functioning</p>	<p>Module A51 is not powered or is faulty</p>	<ol style="list-style-type: none"> 1. Check the SYSTEM DIAGNOSTIC menu of the message center display (MCD). Select FAULT DIAGNOSTIC and ELECTRICAL SYSTEM. The message "No Response ModA51, Active" indicates a power problem on the module. (A CAN network problem would show the same message but doesn't produce this symptom). 2. Check / reset circuit breaker CB2 3. Check / replace fuse F80 4. Probe gray connector on module to see if it is powered.
<p>Engine is overheating and radiator fan clutch does not engage</p> <p>The A/C compressor clutch does not engage</p>	<p>Module A52 is not powered or is faulty</p>	<ol style="list-style-type: none"> 1. Check the SYSTEM DIAGNOSTIC menu of the message center display (MCD). Select FAULT DIAGNOSTIC and ELECTRICAL SYSTEM. The message "No Response ModA52, Active" indicates a power problem on the module. (A CAN network problem would show the same message but doesn't produce this symptom). 2. Check / reset circuit breaker CB5 3. Check / replace fuse F65 4. Probe gray connector on module to see if it is powered.
<p>Evaporator fan not functioning</p>	<p>Circuit breaker CB3 tripped</p> <p>Module A54 is not powered or is faulty</p>	<ol style="list-style-type: none"> 1. Check / reset circuit breaker CB3 2. Check the SYSTEM DIAGNOSTIC menu of the message center display (MCD). Select FAULT DIAGNOSTIC and ELECTRICAL SYSTEM. The message "No Response ModA54, Active" indicates a power problem on the module. (A CAN network problem would show the same message but doesn't produce this symptom). 3. Check / reset circuit breaker CB5 4. Check / replace fuse F67 , F68 5. Probe gray connector on module to see if it is powered.
<p>HVAC condenser fans not functioning in speed 1</p>	<p>Module A54 is not powered or is faulty</p>	<ol style="list-style-type: none"> 1. Check the SYSTEM DIAGNOSTIC menu of the message center display (MCD). Select FAULT DIAGNOSTIC and ELECTRICAL SYSTEM. The message "No Response ModA54,

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Problem/Symptom	Probable Causes	Actions
		<p>Active" indicates a power problem on the module. (A CAN network problem would show the same message but doesn't produce this symptom).</p> <ol style="list-style-type: none"> 2. Check / reset circuit breaker CB5 3. Check / replace fuse F67 , F68 4. Probe gray connector on module to see if it is powered.
Sound system not functioning	Circuit breaker CB4 or CB11 was manually tripped and not reset	Check / reset circuit breaker CB4 or CB11
Fire alarm telltale light and audible alarm always ON and there is no fire or high temperature in the engine compartment	Short-circuited fire sensor or defective sensor	Prior to start the vehicle, cycle the ignition key to the ON position, OFF position and then ON position again and then start the vehicle. This will deactivate the fire alarm function. This has to be repeated each time the vehicle is re-started
The vehicle is parked and the electrical horn is activated to indicate a fire in the engine compartment but there is no fire	Short-circuited fire sensor or defective sensor	Cycle the ignition key between the ON and OFF position twice within 3 seconds. This will deactivate the fire alarm function. This has to be repeated each time the vehicle is parked
A single light, a group of LED lights or another function of the vehicle is not functioning	The multiplex outputs are protected in current by an internal "soft-fuse". When an output is shorted, it turns OFF and stays OFF until the "soft-fuse" is reset	Turn the ignition key to the OFF position and turn to the ON position again. This resets all "soft -fuses"
No backlighting in the instrument cluster	Circuit breaker CB10 is tripped or fuse F20 blown	<p>Check / reset circuit breaker CB10</p> <p>Check / replace fuse F20</p>
The radiator fan clutch does not function and the engine is overheating		<ol style="list-style-type: none"> 1. Set the ignition key to the ON position. 2. Activate the dashboard Telltale Light Test switch 3 times within 4 seconds. 3. In the engine compartment, set the starter selector switch to REAR START and then start the engine from the rear. <p>While in this mode, the rear start push-button can be used to manually engage the fan clutch. The Multiplex system knows when the engine is already running, and it will not activate the starter.</p>

Problem/Symptom	Probable Causes	Actions
		<p>4. Press the push-button one time to engage the clutch in 1st speed, press a second time to engage in 2nd speed, press a third time to stop the fan, press once again to return to 1st speed.</p> <p>If the fan clutch does not engage using this procedure then the clutch is faulty or the wiring between the multiplex module and the clutch is faulty. Mechanically lock the fan clutch as described in section 05: COOLING SYSTEM of the maintenance manual.</p>

4.8 ESSENTIAL FUNCTIONS TO OPERATE THE VEHICLE

Even with a defective CECM (Chassis Electronic Control Module) or a CAN network problem, essential base functions are maintained to rear start the vehicle from the engine compartment and drive in a secure manner.

However, many secondary functions are lost. In this case, the following directives must be followed.

- Never connect a battery charger when the ignition is at the ON position on a vehicle with a CAN defective or certain functions will start up by themselves,
- Disconnect the charger before starting the vehicle, if not the default functions will not activate,
- If the default mode does not activate, try to turn the ignition OFF while ensuring that no charger is connected and then restart the vehicle.

4.8.1 Available Functions

- Startup: Turn on the ignition in the driver's area and rear start the vehicle from the engine compartment,
- Opening the door: Functions normally,
- Closing the door: Manually pull on the door and it will lock automatically,
- Windshield wipers: Wipers functions at 1st speed only,
- Headlights: Low beams only,

- Directional signals: Rear and front only,
- Stoplights: 2 upper stoplights + high-mounted stoplight are functional,
- HVAC: Functional with set point fixed at 70°F (22°C), evaporator and condenser fixed at speed 1, defroster fixed at speed 4.

4.9 LOWER PRIORITY MODULES FOR BREAKDOWN SERVICE

Modules A43 (IO-A) and A44 (IO-B) affect lower priority functions. These modules can therefore be used as spare parts for breakdown service while on the road.

Functions lost if A43 is removed and used as spare part:

- High beams,
- Ability to turn on the parking lights only,
- « Watch your step » sign,
- Driver's area lighting,
- Tag axle activation,
- Courtesy lights.

Functions lost if A44 is removed and used as spare part:

- Fresh air damper mix trap control,
- Driver's area and entrance overhead light,
- Front clearance lights.

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4.10 MULTIPLEX MODULES

4.10.1 CECM

The CECM plays the role of interface between the engine ECM, the transmission ECU, the telltale panel module and other IO-A, IO-B modules. When a multiplex module is being replaced, the CECM will inform the new module of its role and function accordingly to the vehicle options.

4.10.2 MASTER ID

The Master ID works in conjunction with the CECM. It keeps the specific back-up program of the vehicle. So, a specific Master ID cannot be removed from a vehicle and installed on another vehicle.

4.10.3 IO-A

IO-A modules receive inputs and control outputs. IO-A's are used for all outputs of 1 amp or less.

4.10.4 IO-B

IO-B modules receive inputs and control outputs. IO-B's are used for outputs up to 30 amps.

4.11 MULTIPLEX MODULES REPLACEMENT

IO-A, IO-B and CECM multiplex modules can be replaced and reprogrammed without having to connect a computer to the vehicle.

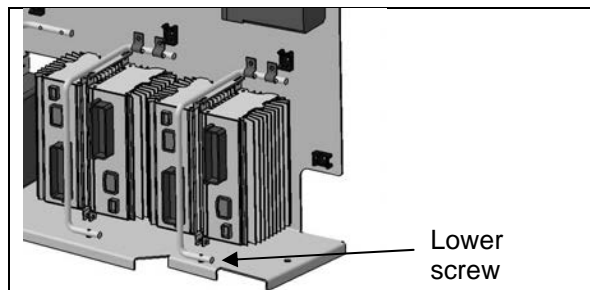


FIGURE 17: IO-B MODULE REMOVAL

06638

4.11.1 Replacing IO-A Or IO-B Modules

- Set the ignition key to the ON position and leave it in that position at all time while performing this procedure.
- Inside rear electrical compartment, trip circuit breaker CB6.
- Replace the module (for IO-B modules, disconnect the green connector first, then the grey one and finish with the black connector.

To disconnect the black connector, slide downwards the red latch. Remove the lower screw that holds the cable attachment rod onto the floor portion of the panel and flip the rod up, this will relieve the IO-B module, (see Fig. 17).

- Reset circuit breaker CB6. This engages the automatic reprogramming.
- The telltale panel LCD display indicates "CAN" until the reprogramming is complete. Once completed, "CAN" disappears and the temperature reappears.
- Check the SYSTEM DIAGNOSTIC menu of the message center display (MCD). Select FAULT DIAGNOSTIC and ELECTRICAL SYSTEM. Verify the fault message to be certain the module is reprogrammed. If the module is not reprogrammed, the message « Axx Not Responding » appears where Axx is the module number (Ex: A41, A42...etc).

4.11.2 Replacing The CECM Module


- Set the ignition key to the ON position and leave it in that position at all time while performing this procedure.
- Inside rear electrical compartment, trip circuit breaker CB6.
- Replace the module.
- Reset circuit breaker CB6. This engages the program transfer from the Master ID to the CECM module (the back-up program is inside the Master ID. The Master ID will identify the CECM as being new and will send the correct program to it). The telltale panel LCD display indicates "CAN" during 3 minutes approximately. "CAN" disappears and "---" is displayed alternately with "CAN" (during that sequence, "---" will be displayed up to 6 times and the audible alarm will ring). Wait until "CAN" is replaced by "---" that remains for more than 10 seconds. At this point the MasterID module has finished loading the program in the CECM.
- Go to the rear electrical compartment and trip circuit breaker CB6 once again. Wait 1 second and reset it. This engages I/O's modules automatic reprogramming.
- The telltale panel LCD display indicates "CAN" until the reprogramming is completed. Once completed, "CAN" disappears and the temperature reappears. Check the SYSTEM

DIAGNOSTIC menu of the message center display (MCD). Select FAULT DIAGNOSTIC and ELECTRICAL SYSTEM. Check the error messages. All modules appear in error but are not active. If an active error appears for a module, this one was not reprogrammed. In this case, trip CB6 once again. Wait 1 second and reset CB6. Re-verify the error messages when "CAN" disappears from the telltale panel LCD display.

- o Do an error reset to remove all errors (requires Password) from non-active modules, leave the SYSTEM DIAGNOSTIC menu and reopen to verify there are no more errors.

5. BOSCH ALTERNATOR

Two 24 volt 140A, self regulated, belt driven, air-cooled BOSCH alternators are used in the 24 volt electrical system.

 <h2 style="margin: 0;">MAINTENANCE</h2>
<p>Change the brushes and voltage regulator as per "Repair and Testing Instructions for T1 Alternator 0120 69 552" every 100,000 miles (160 000 fm) or once every two years, whichever comes first.</p> <p>Replace bearings as per "Repair and Testing Instructions for T1 Alternator 0120 69 552" every 200,000 miles (320 000 fm) or once every four years, whichever comes first.</p> <p>Refer to Bosh T1 Alternator Maintenance Manual Annexed at the end of this section.</p>

NOTE

Use Polyrex EM grease (684922) when repacking the bearings. Grease comes in 14.1 oz (400gr) cartridges.

5.1 TWIN BOSCH ALTERNATORS INSTALLATION (DDEC SERIES 60)

If the alternators needed to be removed, reinstall as follows. Refer to figure 18 for installation and to figure 19 for tightening specifications:

1. Install alternator mounting bracket (1, figure 19) to the gear case. Use the four flanged phosphor alloy bolts on the pulley end of the bracket and the flanged nuts at the transmission end of the bracket;

2. Bolt the upper alternator to the bracket using the 4 inch bolt at the top (2, fig 19) and two inch bolts at the lower mounting bosses (3 and 4, figure 19). Bolt the other alternator using the 6 inch bolt at the top (2a, fig 19) and two inch bolts at the lower mounting bosses (3a and 4a, figure 19);
3. On the drive shafts of both alternators, install key, pulley, spring washer and nut (5, figure 19);

NOTE

Final tightening of the pulleys can be performed once the belt is installed. This will help keep the pulley from turning when tightening.

4. Install the snubber bracket (fig. 20) using three flanged bolts. Do not tighten the adjustment bolts on the snubber until after final tightening;
5. Install the A/C compressor belt idler pulley (fig. 20) as shown. A stud inserts into one of the mounting holes of the pulley assembly. Fasten this one using a nut and bolts for the other two.
6. Install alternators belt (6, figure 19).

5.1.1 Alternator Drive Belt

Removal

1. Insert a ¾" socket drive into the automatic belt tensioner opening (Fig. 18).
2. Twist the tensioning arm to slacken belt.
3. Remove belt.

NOTE

Belts specifications may vary. For proper belt selection, always consult your vehicle Coach Final Record.

Installation

Installation of the alternator drive belt is the reverse of removal.

5.1.2 Adjustment

Correct belt tension is required to maximize belt life. The tensioning arm maintains proper belt tension, no adjustment is required.



MAINTENANCE

Check for wear and proper tension every 6,250 miles (10 000 km) or twice a year, whichever comes first.

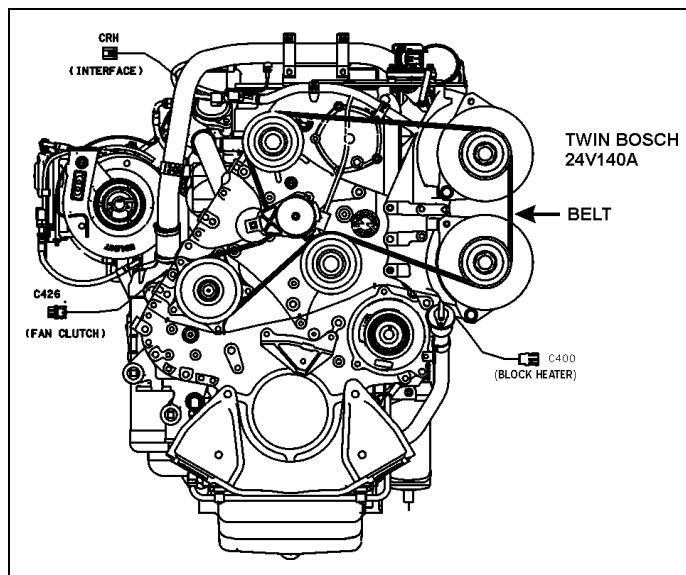


FIGURE 18: ALTERNATOR DRIVE BELT

01180

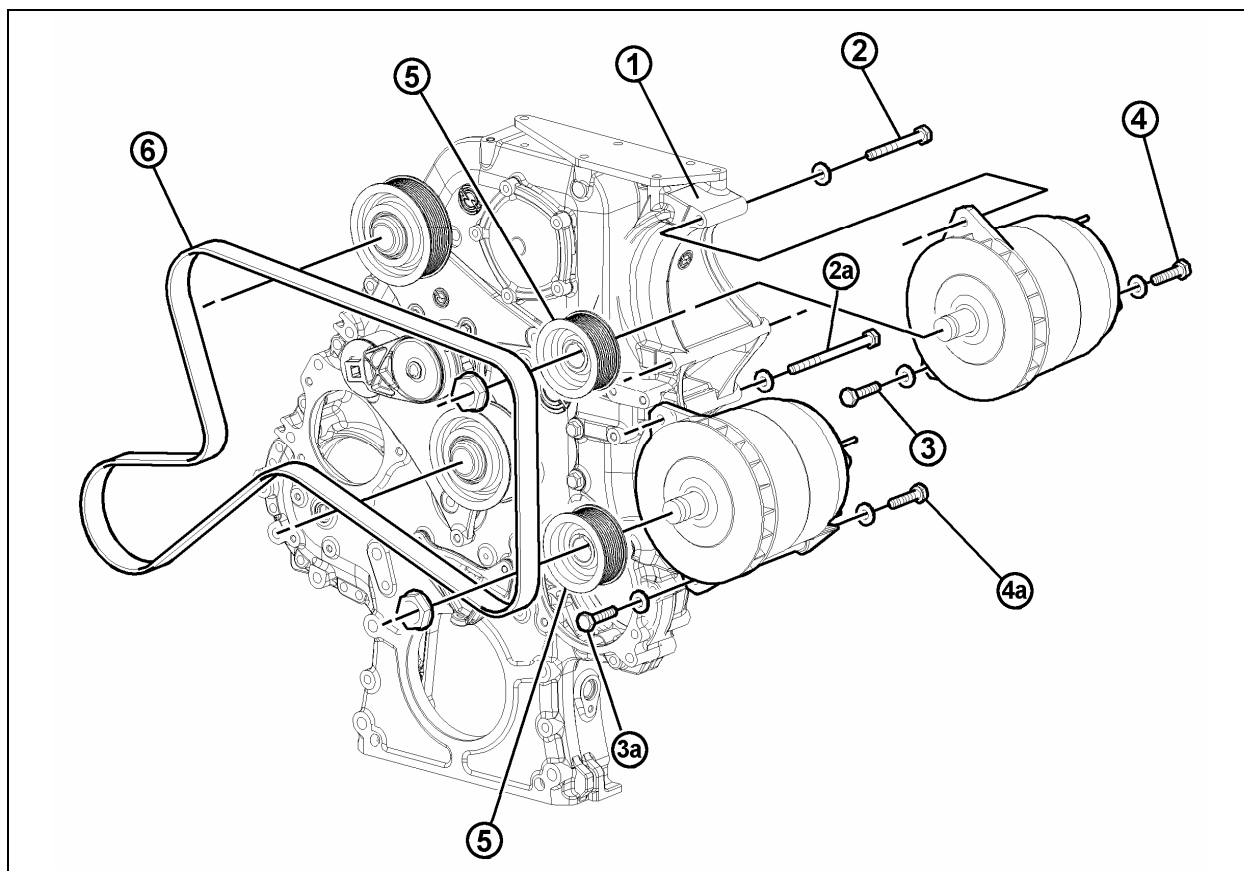


FIGURE 19: TWIN BOSCH ALTERNATORS INSTALLATION (DDEC SERIES 60)

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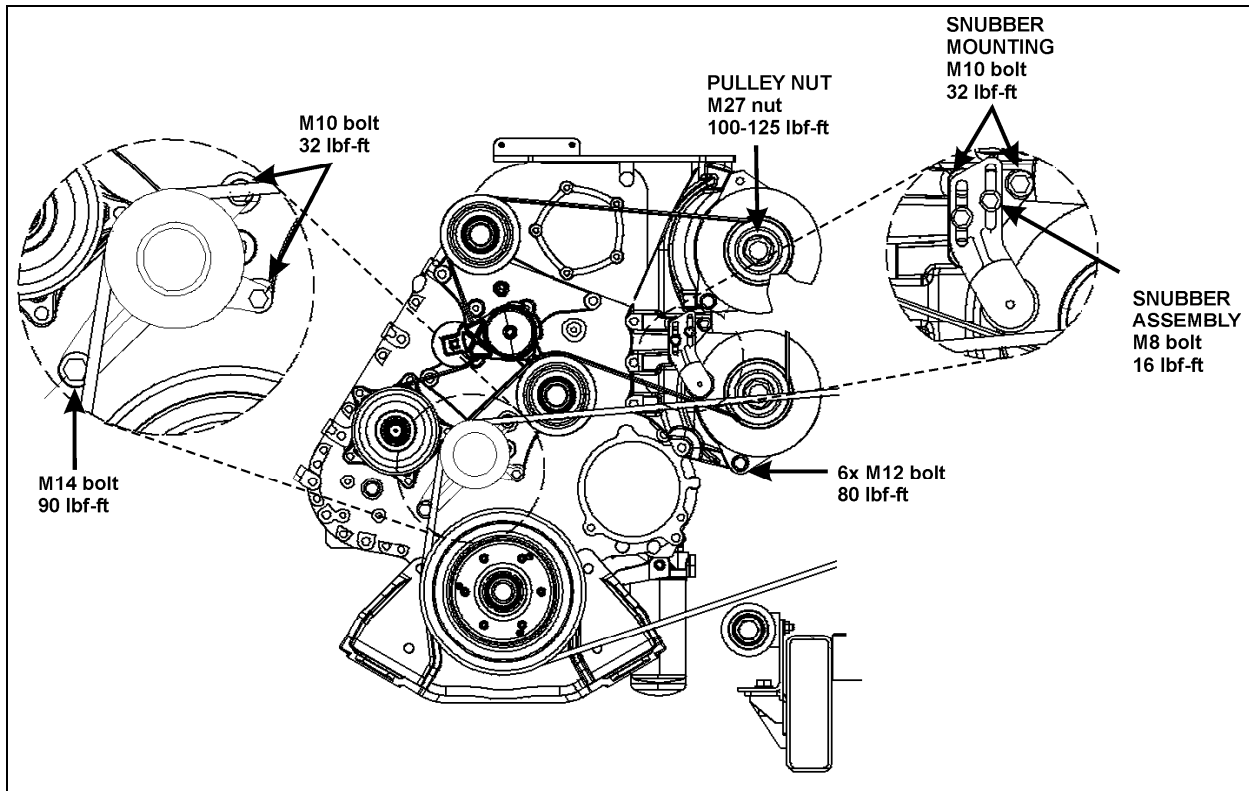


FIGURE 20: ALTERNATORS AND ACCESSORIES MOUNTING TORQUES (DDEC SERIES 60)

01182

5.2 TWIN BOSCH ALTERNATORS INSTALLATION (VOLVO D13)

If the alternators needed to be removed, reinstall as follows. Refer to figures 21 and 22 for installation and tightening specifications:

1. If not already done, mount the alternator brace to the engine and alternator support (figure 21);
2. Bolt the alternators to the bracket using one 3.5 inch bolt at the top and two 1¾ inch bolts at the lower mounting bosses (fig. 21);
3. On the drive shafts of both alternators, install key, pulley, spring washer and nut;

NOTE

Final tightening of the pulleys can be performed once the belt is installed. This will help keep the pulley from turning when tightening.

4. Install the alternators belt, the coolant pump belt, the A/C compressor belt and then the radiator fan driving mechanism belt (figure 22).

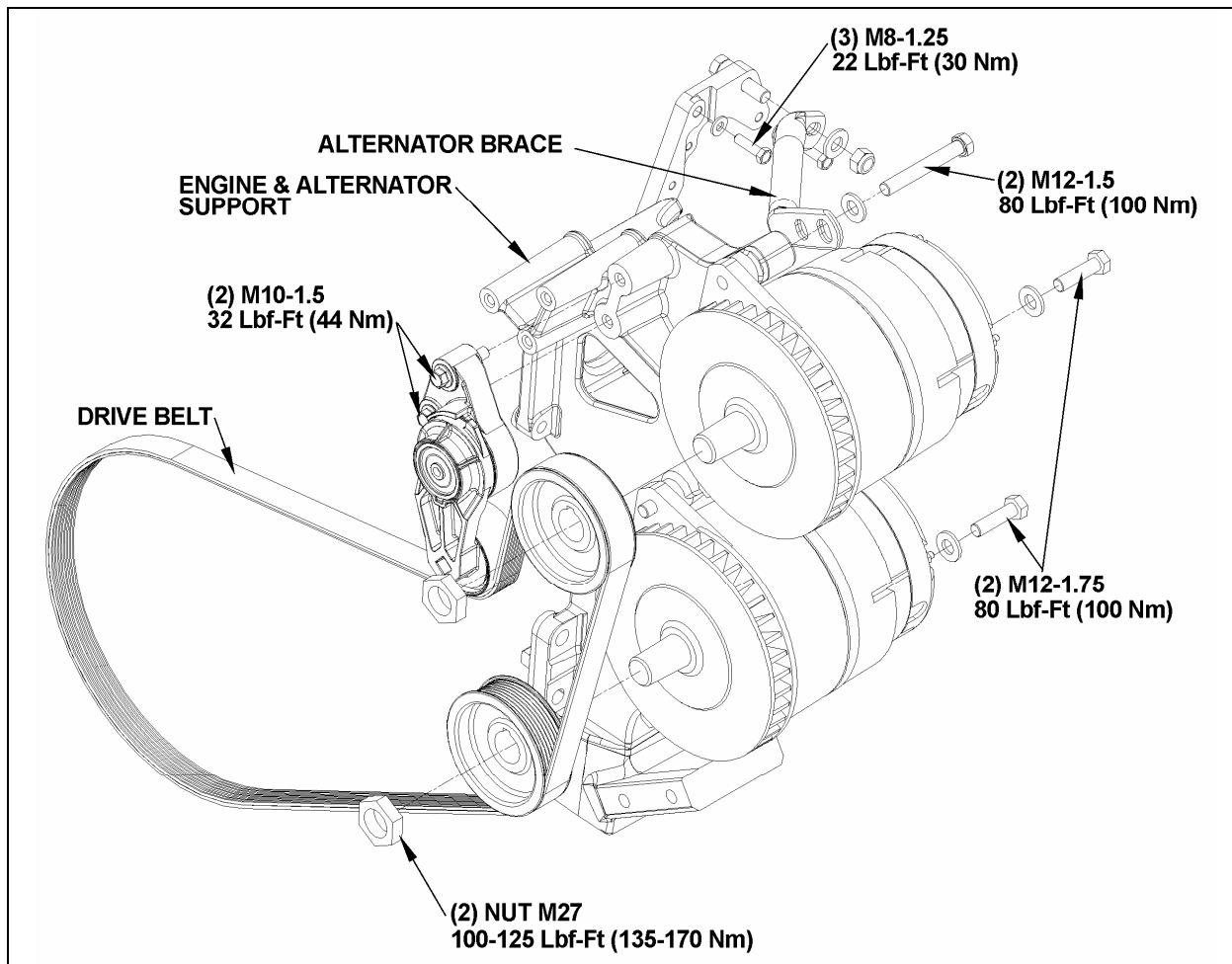


FIGURE 21: BOSCH ALTERNATORS MOUNTING TORQUES (VOLVO D13)

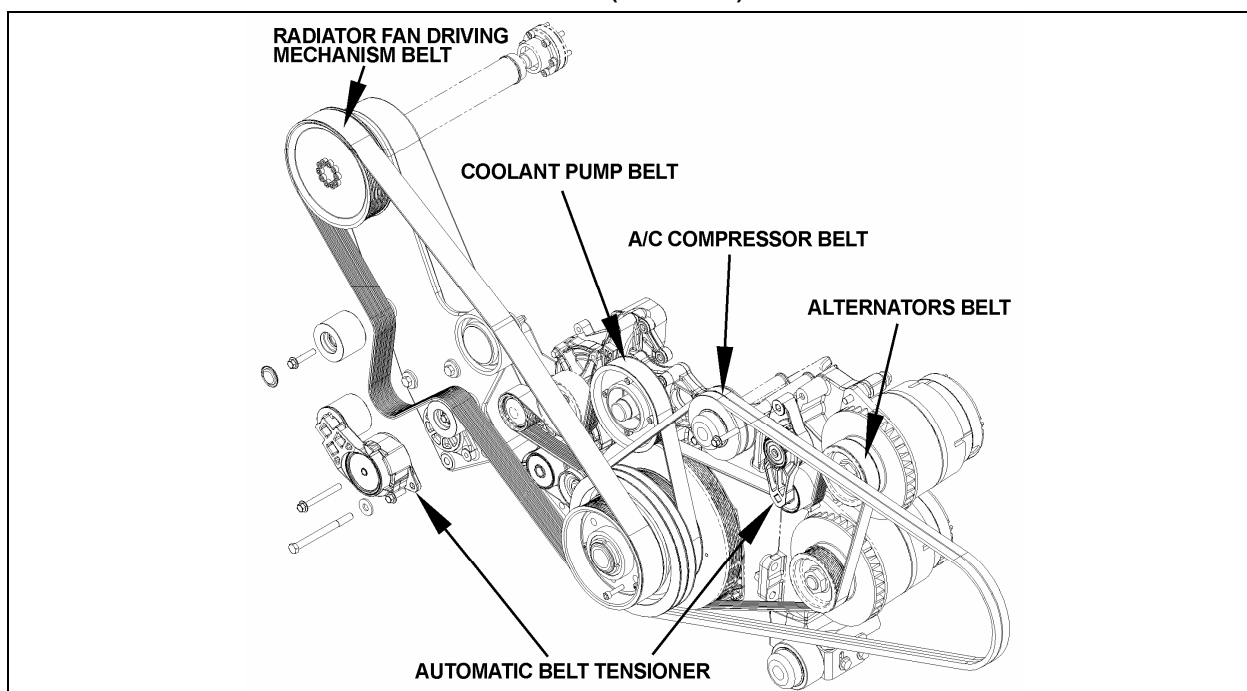


FIGURE 22: TWIN BOSCH ALTERNATORS INSTALLATION (VOLVO D13)

5.2.1 Alternator Drive Belt

Removal

1. Remove the radiator fan driving mechanism belt, the A/C compressor belt, and then the coolant pump belt.
2. Insert a 3/4" socket drive into the automatic belt tensioner opening (Fig. 22).
3. Twist the tensioning arm to slacken the alternator drive belt.
4. Remove belt.

NOTE

Belts specifications may vary. For proper belt selection, always consult your vehicle Coach Final Record.

Installation

Installation of the alternator drive belt is the reverse of removal.

5.2.2 Adjustment

Correct belt tension is required to maximize belt life. The tensioning arm maintains proper belt tension, no adjustment is required.



MAINTENANCE

Check for wear and proper tension every 6,250 miles (10 000 km) or twice a year, whichever comes first.

6. BATTERY EQUALIZER

VoltMaster Battery Equalizer Owner's Manual (100 amps) is annexed at the end of this section.

Refer to "Electrical Compartments" in this section, for location.

7. STARTER

Refer to Mitsubishi Electric Corporation (MELCO) Service bulletin ME003-P annexed at the end of this section for information and maintenance instruction on MELCO 105P70 starter.



CAUTION

DDEC SERIES 60 ENGINE ONLY

Prior to the installation of the Mitsubishi starter, the Flywheel Ring Gear must be examined for excess wear or damage. Service Bulletin A1-M1N-1729EN included at the end of Section 06 shows acceptable levels of wear, and illustrates the proper measuring procedure. Maximum wear is 0.5mm. Ring Gears with more than 0.5mm of wear or damage must be replaced before installing the new starter to prevent engagement and/or disengagement problems. Failure to do so will render the Warranty null and void.



CAUTION

Do not engage starter for more than 15 seconds at a time. If engine does not start within 15 seconds, release ignition key and let starter cool for one minute before attempting to restart.

8. ENGINE BLOCK HEATER

The vehicle may be equipped with an engine immersion-type electric block heater to assist cold weather starting. The heater male electric plug is easily accessible through the engine compartment R.H. side door (Fig. 23). To use it, connect the female plug of an electrical extension cord to the heater plug. The extension cord must be plugged into a 110-120 V AC power source only. The engine block heater should be used whenever the vehicle is parked for an extended period of time in cold weather and a suitable power source is available.

8.1 MAINTENANCE

This heater is non-serviceable except for the cord, and if faulty, must be replaced as a unit.

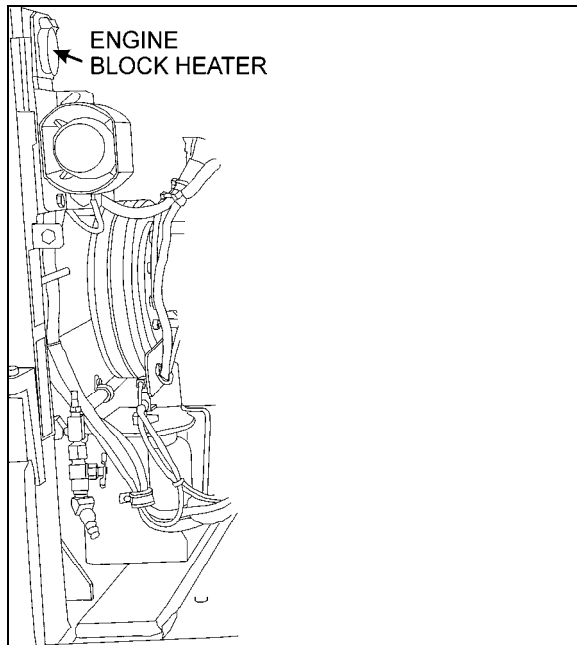


FIGURE 23: ELECTRIC HEATER PLUG LOCATION 06639

9. EXTERIOR LIGHTING

The circuit for exterior lights, as well as their control switches, relays and circuit breakers are shown on the applicable wiring diagrams. Wiring diagrams are located in the technical publication box.

9.1 HEADLIGHTS

Each headlight assembly consists of two headlamp module 90 mm (3½ inch) equipped with a 12-volt halogen bulb and one 100 mm (4 inch) 12-volt LED turn/signal lamp. Outer lamps have a double function (both low and high beam). Inner lamps are used for high beam or daytime running light. The inner or outer lamp uses the same single filament halogen bulb part number.

NOTE

If vehicle is equipped with optional Xenon headlamps, refer to paragraph 9.1.6.

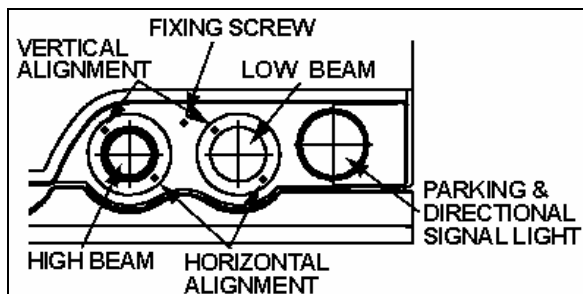


FIGURE 24: HEADLIGHT ASSEMBLY 06546

9.1.1 Headlight Beam Toggle Switch

The multifunction lever located on the steering column is used to select proper lighting. High beams or low beams can be selected by pulling the lever rearward. A high beam indicator on the central dashboard panel is illuminated when the high beam circuit is energized.

NOTE

Pulling the lever rearward while the lights are off will flash the headlights.

9.1.2 Maintenance

Clean headlights with soap and water and a good glass cleaner whenever dirty. For maximum illumination, headlight connections must be coated with a dielectric grease to prevent oxidation and proper voltage must be maintained. Low battery voltage, loose or dirty contacts in wiring system and poor ground contribute to a decrease in voltage. Check wiring and connections regularly and keep battery properly charged. When a headlight burns out, a new bulb must be installed. Headlights must be properly aimed to provide maximum allowable road illumination. When using mechanical aiming devices, follow manufacturer's instructions.

Headlight aim should be checked after installing a new bulb. Aiming can be performed without opening headlight assembly. Horizontal and vertical aiming of each module is provided by two adjusting screws that pivot the module in the housing for proper alignment (fig. 24). There is no adjustment for focus since the module is set for proper focus during manufacturing assembly.

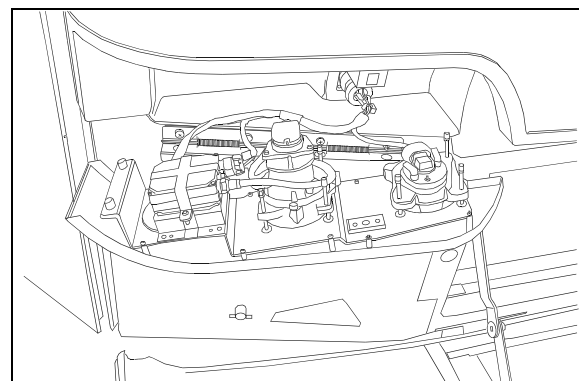



FIGURE 25: OPENING HEADLIGHT ASSEMBLY 06547

NOTE

Make sure headlight assembly is properly positioned into its housing before securing using fixing screw.

 CAUTION
Use a soft cloth to clean the parking and front turn signal lamp.

9.1.3 Headlight Adjustment

1. Headlight aiming and inspection can be accomplished by visual means. This is done on a screen located at a distance of 25 feet (7,6 m) of the headlights. It should be of adequate size with a matte-white surface well shaded from extraneous light and properly adjusted to the floor area on which the vehicle stands. Provisions should be made for moving the screen or its vertical centerline so that it can be aligned with the vehicle axis. In addition to the vertical centerline, the screen should be provided with four laterally adjustable vertical tapes and two vertically adjustable horizontal tapes.
2. The four movable vertical tapes should be located on the screen at the left and right limits called for in the specification with reference to centerlines ahead of each headlight assembly.
3. The headlight centerlines shall be spaced either side of the fixed centerline on the screen by 1/2 the lateral distance between the light source centers of the pertinent headlights. The horizontal tapes should be located on the screen at the upper and lower limits called for in the specification with reference to the height of beam centers and the plane on which the vehicle rests, not the floor on which the screen rests (Fig. 26).

TABLE 1 – VERTICAL BEAM AIM GUIDELINES

Headlight (centerline) Mounting Height	Nominal Vertical Aim	Aim Inspection Limits for Vertical Aim
56 to 90 cm (22 to 36 inch)	0 Vertical	10 cm (4 inch) up to 10 cm (4 inch) down
90 to 120 cm (36 to 48 inch)	5 cm (2 inch) down	5 cm (2 inch) up to 15 cm (6 inch) down
120 to 140 cm (48 to 54 inch)	6.4 cm (4 inch) down	4 cm (1.5 inch) up to 16.5 cm (6.5 inch) down

4. The nominal vertical aim position on lower beam headlights shall be adjusted based on the headlight mounting height, from the

ground to the light source center of the headlight, according to table 1.

5. High beam headlights are aimed so that the center of the high-intensity zone is located at the horizontal and straight ahead vertically (Fig. 26).
6. Low beam headlights are aimed so that the top edge (the cutoff) of the high-intensity zone is at the vertical location as per Table 1 and the left edge of the high-intensity zone is at the vertical centerline of the headlight (Fig. 27).
7. The inspection limits for high-beam headlights shall be with the center of the high-intensity zone from 10 cm (4 in) up to 10 cm (4 in) down; and, from 10 cm (4 in) left to 10 cm (4 in) right on a screen at 7.6 m (25 ft) (Fig. 28).

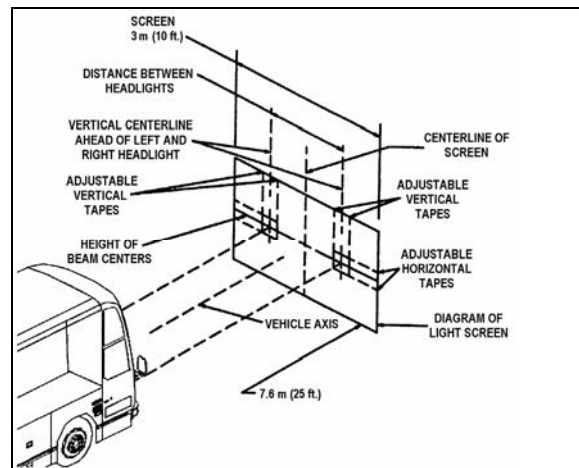


FIGURE 26: ALIGNMENT OF HEADLIGHT AIMING SCREEN 06502

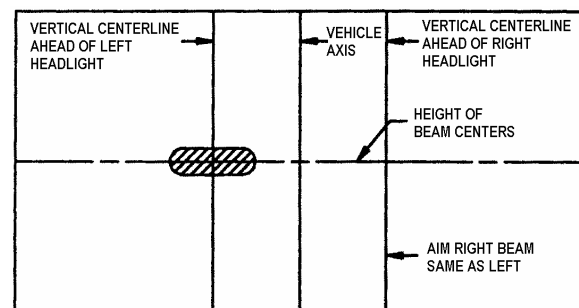


FIGURE 27: HIGH-INTENSITY ZONE (SHADED AREA) OF A PROPERLY AIMED UPPER BEAM ON THE AIMING SCREEN 7.6 M (25FT) IN FRONT OF VEHICLE 06503

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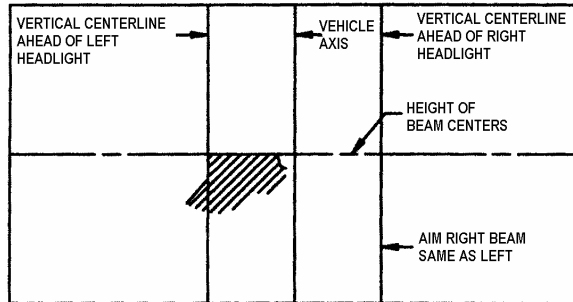


FIGURE 28: HIGH-INTENSITY ZONE (SHADED AREA) OF A PROPERLY AIMED LOWER BEAM ON THE AIMING SCREEN 7.6 M (25FT) IN FRONT OF VEHICLE 06504

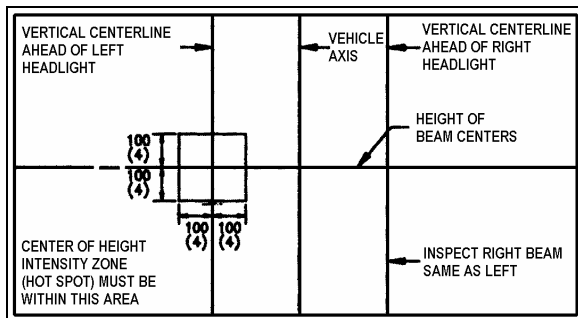


FIGURE 29: AIM INSPECTION LIMITS FOR UPPER-BEAM HEADLIGHTS 06505

- The inspection limits in the vertical direction for low-beam headlights or the low beam of a dual-beam headlight, shall be as described in Table 1. In the horizontal direction, the left edge of the high-intensity zone shall be located from 10 cm (4 in) left to 10 cm (4 in) right of the vertical centerline of the beam. The viewing screen shall be located 7.6 m (25 ft) in front of the vehicle (Fig. 30).

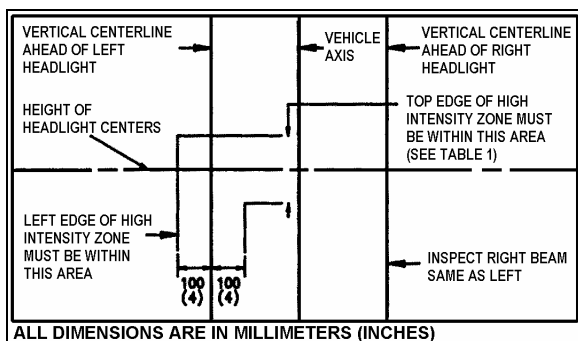


FIGURE 30: AIM INSPECTION LIMITS FOR LOWER-BEAM HEADLIGHTS 06506

9.1.4 Sealed-Beam Unit

Bulb Removal and Replacement

- Pull the release handle located inside the front service compartment to tilt down the entire bumper assembly.
- Remove the headlight screw fixing the headlight assembly, then tilt headlight assembly down (Fig. 24 and 25).
- Remove connector from headlight bulb.
- Remove the bulb by pushing and rotating it out of the socket.
- Install the new bulb by reversing the previous procedure.



CAUTION

During this step, avoid contacting the bulb with the fingers not to alter the bulb life.

NOTE

Do not disrupt headlight adjustment screws.

Module Replacement

- Pull the release handle located inside the front service compartment to tilt down the entire bumper assembly.
- Remove the headlight screw fixing the headlight assembly, then tilt headlight assembly down (Fig. 24 and 25).
- Remove connector from headlight bulb.
- Unfasten three metal clips attaching headlight unit to support.
- Install new module and fasten metal clips.
- Install wiring connector on back of new sealed beam unit.
- Tilt headlight assembly up into its housing then secure using fixing screw.

NOTE

Make sure headlight assembly is properly positioned into its housing before securing using fixing screw.

- Perform alignment procedure.

NOTE

The headlight aim must be checked and adjusted even if it was properly adjusted before the sealed beam unit was replaced.

9.1.5 Front Turn Signal

The front turn signal is part of the front headlight assembly. The turn signal is a sealed unit (LED) located on each front corner and should be replaced as an assembly. Turn signal is visible from both front and side.

Removal and Replacement

1. Pull the release handle located inside the front service compartment to tilt down the entire bumper assembly.
2. Remove the headlight screw fixing the headlight assembly, then tilt headlight assembly down (Fig. 24 and 25).
3. Partially unfasten back plate fixing screws, then remove signal lamp.
4. Remove socket from signal lamp.
5. Install wiring connector on back of new signal lamp then install signal lamp.
6. Fasten back plate fixing screws then tilt headlight assembly up into its housing then secure using fixing screw.

NOTE

Make sure headlight assembly is properly positioned into its housing before securing using fixing screw.

9.1.6 Optional Xenon Headlamp

The outer lamps of each headlight assembly may be equipped with the optional Xenon lamps. These lamps improve visibility and provide better lifespan.

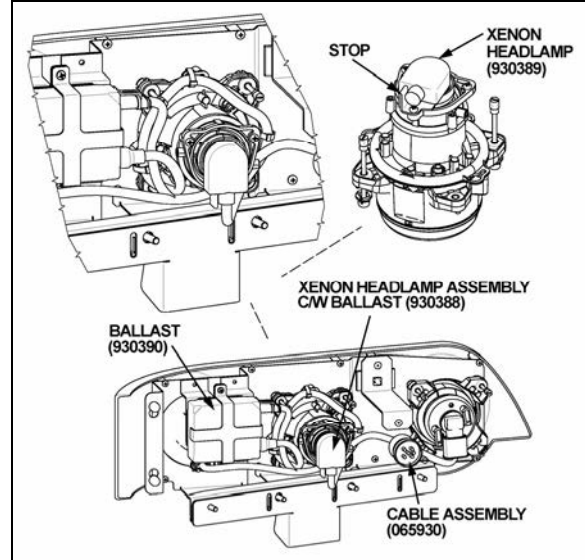


FIGURE 31: XENON HEADLAMP LOCATION 06549

Bulb Removal and Replacement

1. Pull the release handle located inside the front service compartment to tilt down the entire bumper assembly.
2. Remove the headlight screw fixing the headlight assembly, then tilt headlight assembly down (Fig. 24 and 25).
3. Remove main cable connector (066011).
4. Remove connector from headlamp bulb by turning counterclockwise.
5. Unscrew the three Phillips head screws, pull the retainer and bulb out.

**CAUTION**

To avoid breaking the bulb, make sure the socket is in proper position against the stop.

6. Install the new bulb by reversing the previous procedure.

**CAUTION**

During this step, avoid contacting the bulb with the fingers not to alter the bulb life.

NOTE

Do not disrupt headlight adjustment screws.



CAUTION

Never connect a voltmeter or V.O.M. to measure bulb voltage as instrument will be destroyed.

Troubleshooting and Safety

When switching on the Xenon headlamp using the rocker switch, a lamp short-circuit test is performed.

Current is detected in the lamp circuit before the ignition time and ignition prevented. Connection of the "hot" lamp to the body mass also prevents ignition. In both cases, the system is cut off within < 0.2 s and can only be restarted via the rocker switch.

In general, the maximum ignition time is < 0.2 s, which period is followed by cutoff. This would happen if a lamp was defected.

Lamp missing: system is cut off after < 0.2 s.

If lamp components or cables are damaged by force (accident) so that contact with hazardous parts is possible, the current in these lines is earthed by the vehicle body and - as with a defective household appliance - switched off when 30 mA are reached within < 0.2 s. the cutoff time is shortened by a more powerful defect current.

To protect the ballast, a counter in the electronic safety system ensures that a defective lamp can only be switched off 7 times consecutively after a successful ignition, after which the device is cut off. This prevents flutter and flashing. This counter is put out of action when the lamp cutoff time repetition interval is longer than 1.3 s so that temporary non-defect disturbances that result in immediate invisible re-ignition do not cause lamp cutoff.

A warning notice on the lamp plug makes you aware of the fact that the lamp is operated in this system on a higher voltage (you should therefore switch off the lamp before working on this part).

After taking out the lamp, the contact pins are in a practically idle state (< 34 Volt) after < 0.5 seconds so that there is no immediate danger of electric shock even if the warning is disregarded.

With this safety concept there is no danger to check the ballast with a new bulb. There is a

very high probability that the ballast is OK if the ballast can ignite the bulb.

One simple test to check the ballast would be to measure the Nominal current of 1.58 A after one minute for the 24V ballast.

9.2 STOP, TAIL, DIRECTIONAL, BACK-UP, AND HAZARD WARNING LIGHTS

A combination stoplight, taillight, directional signal light and back-up light assembly is mounted at the rear, on each side of the vehicle. Furthermore, when braking, two center stoplights (LED) and a cyclops light (LED) will illuminate simultaneously with the stoplights on the sides for increased safety. The L.H. and R.H. side center stop lights are also used as directional signal and marker lights.

The stop, tail, directional signal and back-up lights consist of individual LED lights mounted on the engine rear door, and each light is serviced individually as a complete unit. The back-up light uses a regular tungsten bulb.

The hazard warning flashing system uses the front, side and rear directional lights simultaneously. This system is energized by a switch on the L.H. dashboard.

9.2.1 Lamp Removal and Replacement

1. Open engine compartment rear door.
2. Remove the lamp support retaining screws (2), and then from the outside, remove the lamp and its support.
3. From the outside, install the new lamp with its support then fasten the retaining screws.

9.2.2 Center Stoplights and Cyclops Light Removal and Replacement

These (LED) lights are sealed unit and should be replaced as an assembly in accordance with the following procedure:

1. Unscrew both "Phillips" light screws then remove the light assembly.
2. Install new light assembly and secure using screws.

9.3 LICENSE PLATE LIGHT

Two LED units are mounted above the rear license plate(s) of vehicle. In case of burn out, the LED unit must be changed according to the following procedure.

1. Pry out the rubber seal with a small screwdriver. Pull on the LED unit and disconnect it.
2. Reconnect new LED unit, place rubber seal, and press on it until it is seated in position.

9.4 CLEARANCE, IDENTIFICATION AND MARKER LIGHTS

The vehicle is equipped with marker, identification and clearance lights (LED). The clearance lights are mounted at each corner of the coach near the top and the identification lights are in the upper center of rear and front sections.

The rear clearance and identification lights are red and the front ones are amber.

The amber marker lights are mounted along the sides of vehicle.

The side marker light is a sealed unit (LED) and should be replaced as an assembly in accordance with the following procedure:

1. Unscrew both “Phillips” light screws, and then remove the light assembly.
2. Position the new light assembly and install the “Phillips” screws.

9.4.1 Clearance and Identification Light Removal and Replacement

The clearance and identification light are sealed units (LED) and can be replaced in accordance with the following procedure:

1. Unscrew both “Phillips” light screws, and then remove the light assembly.
2. Position the new light assembly, and then install the “Phillips” screws.


9.5 FOG LIGHTS

Optional halogen fog lights can be mounted on this vehicle to give the driver better visibility in foggy weather, or to improve the range of vision just ahead of the coach.

9.5.1 Bulb Removal and Replacement

1. Pull on the release handle located in the front service compartment, near the door lower hinge. The bumper will lower gradually.
2. Unscrew the wing nut and pivot assembly upwards.

3. Unscrew the outer ring. Disconnect the light unit connection and remove the bulb.
4. Install the new bulb, reconnect the light unit and replace in its proper position.

	CAUTION
During this step, avoid contacting the bulb with your fingers. This could alter the bulb life.	

5. Reinstall the outer ring, pivot the assembly downwards.

Fasten the wing nut and securely close the bumper.

10. INTERIOR LIGHTING EQUIPEMENT

10.1 CONTROL PANEL LIGHTING

The instrument gauges and switches mounted on all control panels are energized whenever the exterior light switch is pushed to the first position. A control dimmer located on the dashboard is used to vary the brightness of the panel gauges, switches and indicator lights.

The gauge lights, panel lights, switch lights and indicator lights have a different bulb arrangement. Thus, the procedure to change a defective bulb can vary according to the application.

10.1.1 Switch Lighting

1. Slightly pull the switch with a defective LED away from the control panel.
2. Disconnect the electric cable from the switch.
3. To install a new switch, reverse the procedure (Fig. 33).

NOTE
<i>Switches are lighted by the use of LED. When lighting on a switch fails, replace defective switch as a unit.</i>

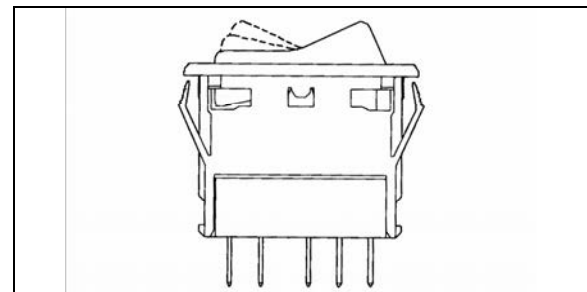


FIGURE 32: SWITCH

06321

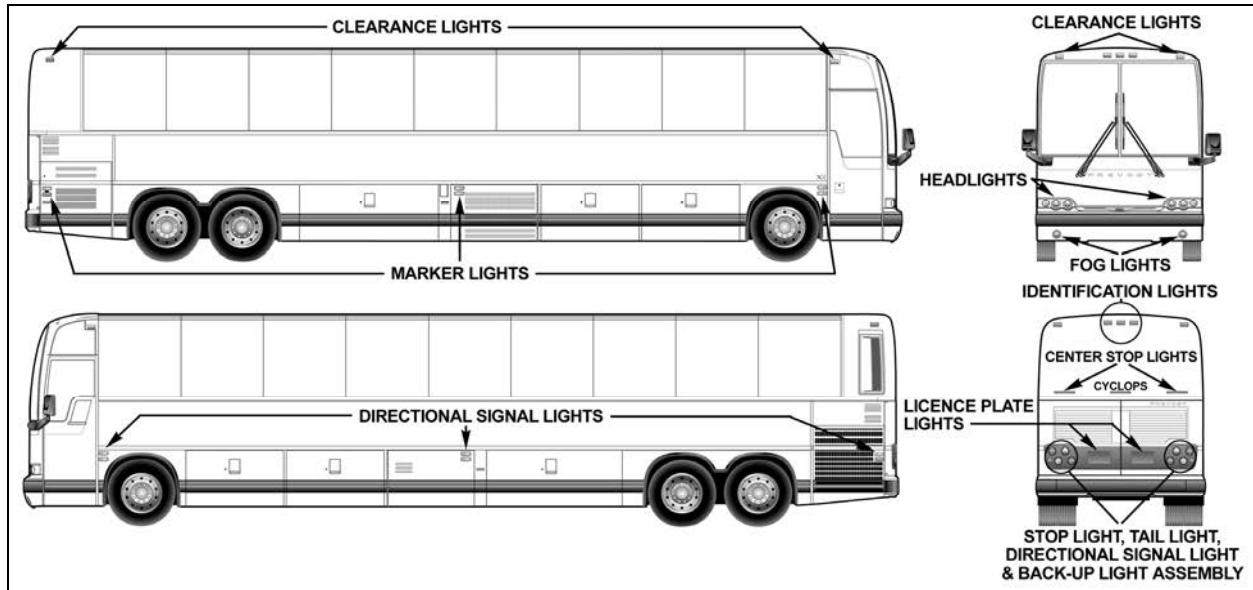


FIGURE 33: VARIOUS LIGHTS LOCATION

06640

10.1.2 Telltale Light Replacement

Telltale module is non-serviceable and must be replaced as a unit.

1. Unscrew and remove the top dashboard panel.
2. Remove the telltale back wire electric connectors.
3. Unscrew and remove the telltale module.
4. To replace the telltale module, reverse the procedure.

10.1.3 Gauge Light Bulb Replacement

1. For any gauge light bulb replacement, the dashboard panel must be removed in order to have access to the rear of gauges.
2. Remove bulb socket from the gauge, turn the defective bulb counterclockwise and pull it out of the gauge.
3. Push a new bulb and socket ASM and turn clockwise to lock in place.
4. Replace the rear dashboard housing.

10.2 STEPWELL LIGHTS

Two Stepwell lights are illuminated when the door opening system is activated.

10.2.1 Bulb Removal and Replacement

Proceed as follows to replace a defective bulb:

1. Unscrew the two Phillips-head screws retaining the lens to the wall, and remove it.
2. With the light lens removed, pull bulb from the lamp while applying lateral pressure.
3. Install the new bulb into the lamp.
4. Position the light lens and install it.

10.3 LAVATORY NIGHT-LIGHT

The lavatory night-light is illuminated as soon as the ignition switch is set to the "ON" position.

10.3.1 Bulb Removal and Replacement

1. Unscrew the two Phillips-head screws retaining the lens to the wall, and remove it.
2. With the light lens removed, pull bulb from the lamp while applying lateral pressure.
3. Install the new bulb into the lamp.
4. Position the light lens and install it


10.4 DRIVER'S AREA LIGHTS

Two halogen ceiling lights are installed over the stepwell and the driver's area. These lights are frequently used for night-time operation when passengers board or leave coach.

10.4.1 Bulb Removal and Replacement

1. Unsnap the lamp with a flat head screwdriver and remove it.
2. Pull the defective bulb out of the socket.

3. Install the new bulb by pushing it in position.
4. Replace the lamp by snapping it back in place.

 CAUTION
<p>Do not touch halogen bulbs with bare hands as natural oils on skin will shorten bulb life span.</p>

10.5 PASSENGER SECTION LIGHTING

The passenger section of coach is lit by two types of fluorescent tube lamps installed on the parcel racks. The aisle or indirect lights are located on front of parcel racks, and provide soft, indirect cabin lighting and parcel rack interior lighting. More powerful lighting for general and in-station applications is provided by fluorescent tubes located under the parcel racks, close to the windows. A dual power system is available for this lighting either from the 24 volt vehicle power supply or from a 110 volt outlet supply. In order to save batteries during extended periods of in-station lighting, no current is drawn from the batteries as soon as the 110 volt circuit is connected.

Moreover, adjustable reading lamps are installed under the parcel racks for passenger accommodation.

10.5.1 Fluorescent Tube Replacement

Indirect Fluorescent Light


1. Open the parcel rack access door, if so equipped, unscrew the two Phillips screws (one each end). Let the hinged cover down.
2. Remove fluorescent tube from light socket.
3. Install a new fluorescent tube.
4. Lift the hinged cover and replace the two retaining screws (Fig. 34).

Parcel Rack Interior Lighting

1. Open the parcel rack access door, if so equipped, unscrew the two Phillips screws (one each end). Pull the hinged cover down.
2. Push on the bulb, turn and then, pull it from the socket.
3. Install a new bulb.
4. Lift the hinged cover and replace the two retaining screws.

10.5.2 Removal and Replacement of In-Station Fluorescent Tubes

1. Start by pulling out the corner of the lens then delicately peeling it out of its seat.

 CAUTION
<p>The lens is fragile. Be very careful when removing and handling.</p>

2. Rotate and pull the fluorescent tube from its sockets.
3. Install a new fluorescent tube, rotating the tube to secure it in the sockets.
4. Replace the screen lens by first inserting one side in the seat, then push the other side in and snap it in place by running it in from one corner to the next.

10.5.3 Removal and Replacement of Reading Lamp Bulb

1. Engage the tool (#830164) over the lamp and turn one quarter turn counterclockwise. Then, remove the tool slowly.
2. Pull the bulb socket off the reading lamp unit.
3. Push and turn bulb counterclockwise, then pull it out of the socket.
4. Install new bulb in the socket, then push and turn clockwise to lock bulb in position.
5. Push the bulb socket in the reading lamp unit.
6. Position the reading lamp with the tool (#830164), turn one quarter turn clockwise.

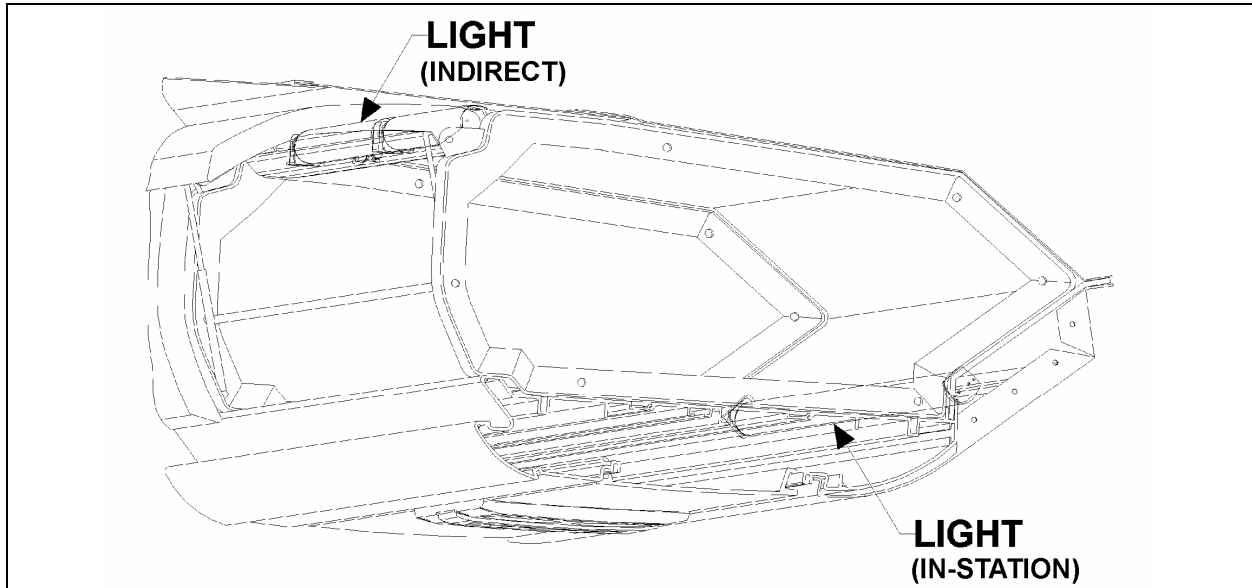


FIGURE 34: PARCEL RACK LIGHTING

06419

10.6 ENGINE COMPARTMENT LIGHTING

A switch located on R.H. side of rear junction box can be used to actuate the two oval engine compartment lights.

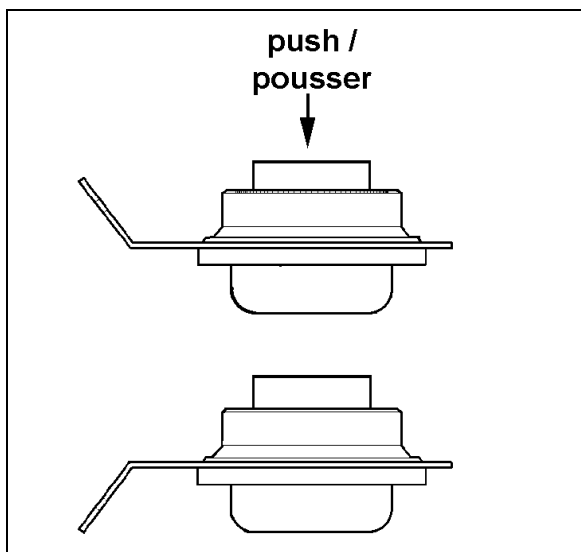


FIGURE 35: ENGINE COMPARTMENT LIGHT

Each light is sealed and can be replaced as follows:

1. Disconnect the light unit connection.
2. Remove the lamp.
3. Position new lamp.
4. Connect the light unit.
5. Make sure the retaining ring is installed properly.

10.7 LAVATORY LIGHT

The halogen lavatory light is installed on ceiling. A microswitch, mounted in the door exterior frame, is activated by the door lock mechanism upon locking to energize the circuit. This switch is readily serviced by removing the two Phillips-head screws securing the mounting plate to the door exterior frame.

Bulb removal and replacement:

1. Unsnap the lamp with a flat head screwdriver and remove it.
2. Pull the defective bulb out of the socket.
3. Install the new bulb by pushing it into position.
4. Replace the lamp by snapping it back in place.



CAUTION

Do not touch halogen bulbs with bare hands as natural oils on skin will shorten bulb life span.

11. LIGHT BULB DATA

When replacing a light bulb, special attention must be paid to the voltage rating (refer to light bulb data hereafter).

LIGHT BULB DATA					
APPLICATION	PREVOST PART NO.	TRADE OR SAE NUMBER	WATTS OR CANDLE POWER	VOLTS	QTY
EXTERIOR LIGHTING					
Hi/Lo-beam	930291	9004	65/45 W	12	2
Lo-Beam Xenon (optional)	930388	D2S	35 W	12	2
Docking & cornering	930319	9415	37.5W	12	4
Fog	930361	H3	55 W	12	2
License plate (sealed)	930266	TL 15206	---	12	2
Marker Light (red)	930340	Grote 47072-3	---	12	2
Marker Light (amber)	930341	Grote 47073	---	12	10
Identification (red)	930334	TL 25420R	---	12	3
Clearance (red)	930334	TL 25420R	---	12	4
Identification (amber)	930337	TL 25450Y	---	12	3
Clearance (amber)	930337	TL 25450Y	---	12	4
Front directional (hazard & marker)	562135	3057	32/3W	12	2
Rear directional	560589	1156	32 W	12	4
Stop	560589	1156	32 W	12	8
Back-up	560589	1156	32 W	12	4
Center stop	930330	HELLA 96208	---	12	2
Cyclops	930330	HELLA 96208	---	12	1
Tail	560123	67	4 W	12	4
Exterior compartment (except engine)	562278	6429	10 W	24	12
Engine compartment	930383	SEALED	25 W	12	2

LIGHT BULB DATA					
APPLICATION	PREVOST PART NO.	TRADE OR SAE NUMBER	WATTS OR CANDLE POWER	VOLTS	QTY
INTERIOR LIGHTING					
Instrument cluster lights	562838	2721 MFX	---	12	---
Telltale panel assy.	563333	---	---	---	1
Step light	562278	6429	10 W	24	2
Lavatory	830176	Q20MR16	20 W	12	1

Section 06: ELECTRICAL

LIGHT BULB DATA					
APPLICATION	PREVOST PART NO.	TRADE OR SAE NUMBER	WATTS OR CANDLE POWER	VOLTS	QTY
Parcel rack	560144	1820	1.6 W	12	A R
Driver's area	830176	Q20MR16	20 W	12	2
"EMERGENCY EXIT" decal	560601	456	2 W	24	A R
"LAVATORY OCCUPIED"	563108	168	3 W	12	1
"WATCH YOUR STEP"	561166	1820	1.6 cp	24	2
Aisle	560141	1251	3 W	24	A R
Reading	563349	303	6 W	24	A R
Fluorescent (In-Station)	830153	F32T8/SP41	32 W	---	A R
Destination sign fluorescent	830120	F30T8CW4	30 W	---	1
Fluorescent (Indirect)	830152	F13T5/CW	13 W	---	A R
Baggage Compartment	562411	#6424	5 W	24VDC	AR

12. SPECIFICATIONS

Battery

Make..... Volvo
Model..... 20359831
Type Maintenance-free
Terminal type Top Stud
Group size 31
Volts 12
Load test amperage 290
Reserve capacity (minutes) 195

Cold cranking (in amps)
-At 0°F (-18°C)..... 950 (each battery)

Maximum dimensions (inches/mm)
-Length (including flange) 13.0/330,2
-Width 6.7/169,3
-Height (including top posts) 9.3/237,0
-Approximate weight (lbs/kg) 59/26,7

* Battery tester cable clamps should be between terminal nuts and lead pads of terminals. If not possible, load value should be 210 amperes.

Torque specifications

Battery cable to post 10-15 Ft-lbs (13-20 Nm)
Battery cover 45-50 Ft-lbs (5-6 Nm)

Alternator

Make..... BOSCH
Model Number..... 0120689552
Series T1

Hot output
-Amperes..... 140 at 25°C (AMBIENT)
-Volts 28
-Approximate rpm..... 6000
Ground negative
Prevost Number 562752

Battery equalizer

Make..... Vanner
Model..... 66-100
Amperes 100 amps
Prevost Number 563334

Starter

Make..... Mitsubishi Electric Corporation (MELCO)
Model Number..... M009T82479
Type 105P70
Voltage 24
Prevost Number 510752

No-load test
-Volts 23.5
-Max. current draw 125 amperes
-Min. rpm 3000 rpm

Section 06: ELECTRICAL

Starter solenoid

Make.....Mitsubishi Electric Corporation (MELCO)
Model Number..... 1115557
Pull In Voltage 16 volts max.

Mitsubishi Electric Corporation (MELCO)

Service Bulletin ME003-P

STARTER MOTORS (105P70)

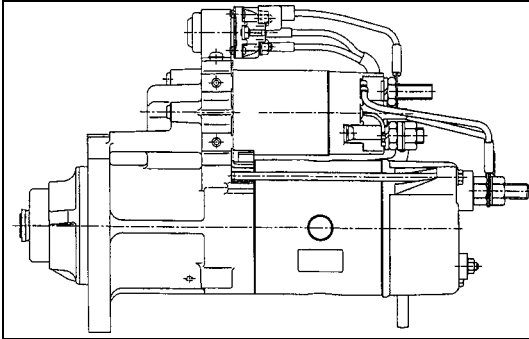


Figure 1 - 105P70 STARTER

A starter is one of the parts installed to the flywheel housing. MELCO's 105P70 starter uses the planetary gear reduction system, actualizing a compact and high-power starter. This starter weighs approximately 30 pounds (13.5 kg), extremely lightweight, and excels in handling.

In addition, this starter uses an overhung mechanism in the output shaft supporting structure designated to protect the inner starter parts from dust or water/oil splash.

1. Principle of operation

- * When handling the starting system, be sure to refer to the wiring diagrams issued by the vehicle manufacturer to insure an understanding of the whole starting circuit.

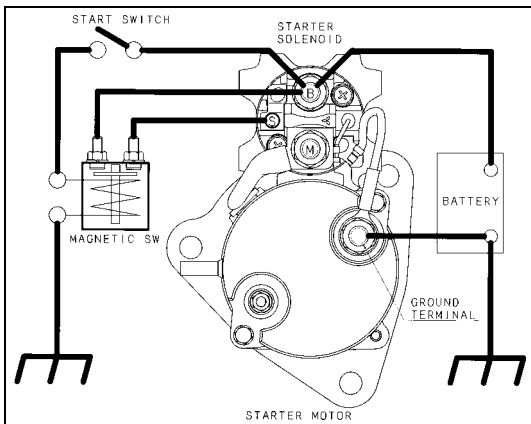


Figure 2 - BASIC STARTING CIRCUIT (GROUND-FLOAT TYPE)

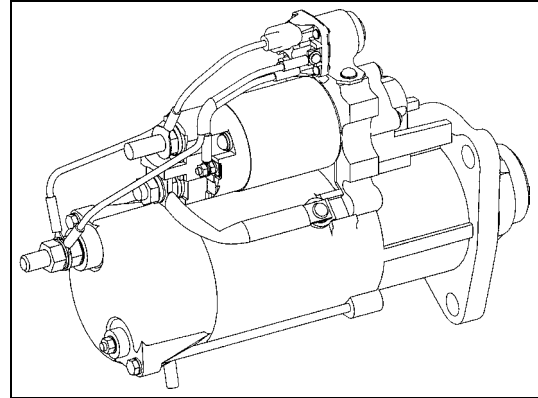


Figure 2 shows the circuit diagram for the 105P70 Ground-float type (sometimes referred to as Insulated or Isolated Ground).

The circuit diagram contains a start switch, a magnetic switch, and a starter solenoid.

When the start switch is closed, the current flows through the magnetic switch windings. The magnetic switch contacts are closed, enabling the current to flow through the windings in the starter solenoid. The clutch is thrust forward with the movement of the plunger and the lever (shown in figures 3), the pinion starts to rotate slowly by the above-mentioned current to engage with the ring gear. When the secure engagement is made, the main contacts in the starter solenoid are closed, and cranking takes place.

When the engine does not start during the initial cranking attempt, the start switch must be turned off within 30 seconds to protect the starter from excessive heat. If the starter motor is operated continuously for 30 seconds, it is necessary to allow the starter motor to be cooled off for at least 2 minutes before the next operation.

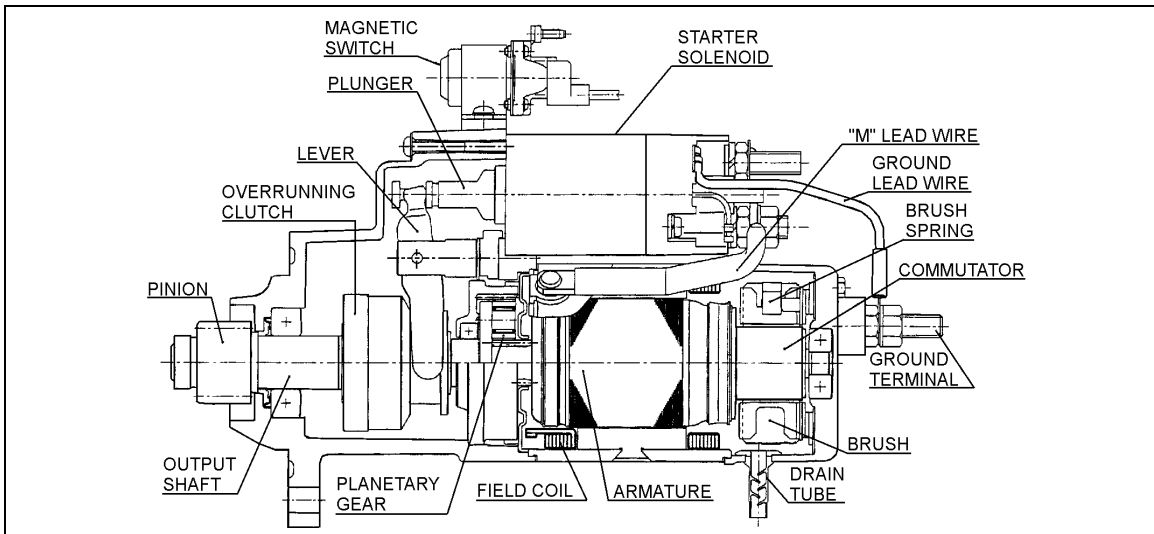


Figure 3 - CROSS-SECTIONAL VIEW (GROUND-FLOAT TYPE)

When the engine starts, the clutch prevents excessive overrun of the armature. Because the clutch is for a short-time rating, the start switch must be turned off immediately after the engine starts.

2. Troubleshooting the starting circuit

If the starting system is not functioning correctly, the following checks will assist in determining which part of the circuit is at fault.

2.1 Battery

To determine the condition of the battery, follow the testing procedure specified by the vehicle manufacturer. Ensure that the battery is fully charged. (If the battery is faulty, the other starting systems cannot be checked.)

2.2 Wiring

Inspect the wiring relating to the starting system for damage. Inspect all connections to the battery, start switch, magnetic switch, and starter solenoid for contact failure due to looseness or rust.

2.3 Magnetic switch (Directly attached to the starter)

Inspect the magnetic switch for its function with the start switch closed (i.e. key switch in the start position) by measuring the voltage between the S-terminal in the starter solenoid and the ground. The switch should

not be closed for more than 3 seconds. If this time is exceeded, the starter solenoid may be damaged.

2.4 Ring gear and pinion

If the battery, wiring, and magnetic switch are in satisfactory condition, it is assumed that a "stuck" condition may be found (this condition is the phenomenon caused when the pinion is caught by the ring gear, thereby resulting in neither pinion rotation nor thrust movement). This only occurs in very rare cases when the ring gear and pinion teeth are damaged on their end faces. Therefore, remove the starter and check the end faces on the ring gear and pinion for damage (burr). If necessary, replace the ring gear and starter.

2.5 Starter

2.5.1 Pinion movement and starter solenoid operation test

As described in figure 4, inspect that the pinion advances forward (no rotation will occur) when a voltage of 16 to 24 V is applied to between the S-terminal in the starter solenoid and the ground. Inspection must be done within 3 seconds for voltage application. If the pinion does not advance forward, replace the starter. The P-coil in the starter solenoid may be layer-shortened, or the pinion sliding area may be clogged.

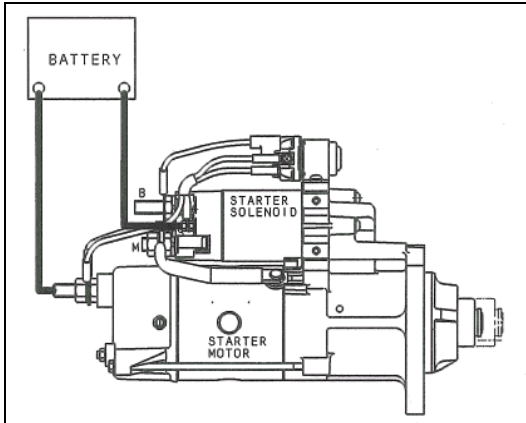


Figure 4 - TESTING PINION MOVEMENT AND PULL-IN WINDINGS (GROUND-FLOAT TYPE)

For the starter switch coils, refer to the switch circuit diagrams for the ground-wire type (ground-float type) shown in figures 5.

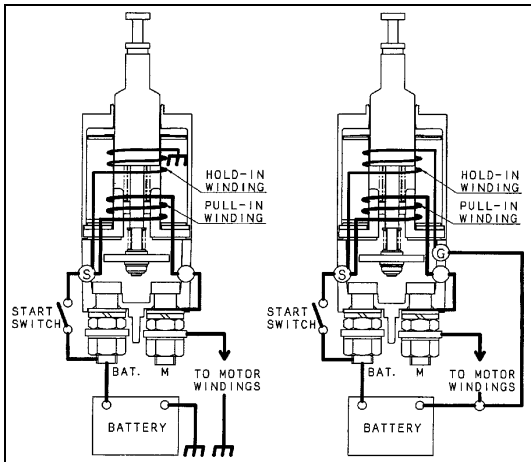


Figure 5 - SOLENOID CIRCUIT (GROUND-FLOAT TYPE)

If the pinion is performing properly, follow the procedure as described below to inspect the H-coil in the starter solenoid.

Remove the M-terminal nut as described in figure 6 and keep the lead wire end in contact with the M-terminal. Apply voltage between the S-terminal and the ground to let the pinion advance forward. Immediately after that, separate the lead wire from the M-terminal and check if the pinion stays in the advanced forward position while voltage is applied to the H-coil only. If the pinion returns, replace the starter. The H-coil is assumed to be layer-short.

* M-terminal nut tightening torque: 20 to 30 N·m

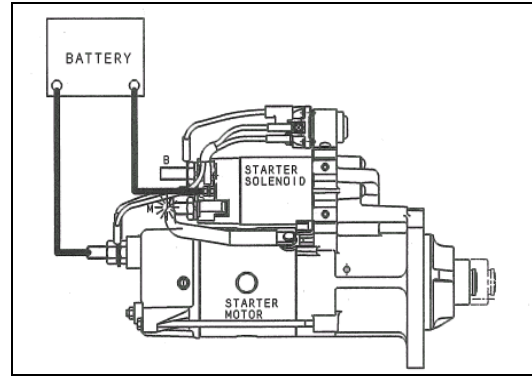


Figure 6 - TESTING HOLD-IN WINDINGS (GROUND-FLOAT TYPE)

Below are the resistance values for the P- and H-coils for reference.

Coil	Resistance (reference)
P-coil	0.072ohm at 68° F
H-coil	1.300 ohm at 68° F

2.5.2 No-load test

The no-load test makes it easy to inspect the starter for functional failure without disassembling. This test can also identify an open/short circuit that is difficult to check when disassembled.

As shown in figure 7, connect the starter, fully charged battery, ammeter, and voltmeter. If possible, connect a resistor suitable for voltage control in parallel with the battery. In addition, use an rpm indicator to measure the revolution speed of the output shaft.

Note: Attention should be given to the output shaft which advances forward to approximately 0.8" (20 mm) and rotates at that position when the starter is operated.

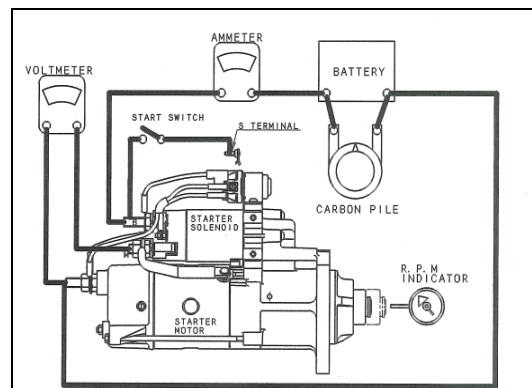


Figure 7 - NO-LOAD TEST CIRCUIT (BODY-GROUND TYPE)

- * If the output shaft does not move, stop voltage application. If voltage continues to be applied, excessive heat will occur in the starter solenoid and give thermal damage to the coil, thereby making it unserviceable.

Inspect that the current and revolution speed satisfy the following standards when the start switch is closed.

Voltage	Current	Speed
23.5 V	125 A max.	3000 rpm min.

It is not necessary to adjust the voltage to the exact value of 23.5 V. If the voltage is slightly higher, the rpm will be proportionately higher, while if the voltage is lower, the rpm will be proportionately lower. The current is independent of the voltage, and can be judged using the above standard.

- * Note that the starter solenoid will not operate unless the voltage between the S-terminal and the ground exceeds 16 V.

Test result and possible cause

1. Rated current draw and revolution speed indicate normal condition of the starter.
2. Low revolution speed and high current draw indicate:
 - a. Too much friction inside starter motor such as clogging, dirt, wearing, faulty bearings
 - b. Shorted circuit inside starter
3. No revolution of the output shaft indicates:
 - a. Grounded M-lead wire or field coils
 - b. Frozen bearings
4. No current draw indicates:
 - a. Open field coils
 - b. Open armature coils
 - c. Broken brush springs, worn brushes, or high insulation resistance between brushes and commutator
5. Extremely low revolution speed and low current draw indicate:

Poor connection between M-terminal and lead wire, or between bracket and brush holder screws (body-ground type only), damaged M-lead wire, damaged

brush pig tails, or poor contact between commutator and brushes

6. High revolution speed and high current draw indicate:

Shorted field coils

- * In case of symptoms 2 to 6, replace the starter, because of the possible failures mentioned above.

2.5.3 Output shaft play

Before reinstalling the starter to the engine, follow the procedure below to inspect the output shaft clearance.

1. Remove the M-terminal nut and keep the lead wire end in contact with the M-terminal.
2. Apply voltage to between the S-terminal and the ground to let the pinion advance forward. Immediately after that, separate the lead wire from the M-terminal. The pinion stays in the advanced forward position until the battery is disconnected.
3. As described in figure 8, measure the distance between the shaft pressed-in and pulled-out positions. The play should be within 0.004" to 0.118" (0.1 to 3.0 mm). If the measured value does not satisfy the standard, replace the starter.

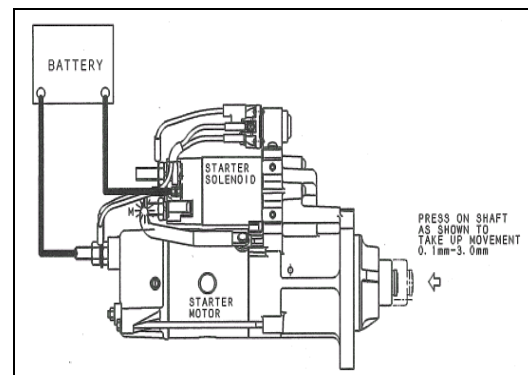


Figure 8 - CHECKING OUTPUT SHAFT CLEARANCE (GROUND-FLOAT TYPE)



Repair and Testing Instructions for T1 Alternator 0120 689 552



Modifications

Edition	Date	Name	Modifications
001	8/28/98	I. Serra	Original
002	12/4/98	I. Serra	Update 8.98 Instructions



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1 General

This manual contains repair and testing instructions with corresponding test specifications for the 0 120 689 5... series alternators.

T1 (RL) 28V 70/140A

Note: Alternator 0 120 689 543 was utilized in preparing these instructions.



2 Safety Precautions

2.1 Special Tool Usage



The use of incorrect or unsuitable tools and test equipment can lead to personal injury and may damage the alternator or its component parts. Only use tools that are specified in this instruction or meet the specification of the recommended tools.

2.2 Fire Risk



To provide radio interference suppression, the alternator is equipped with capacitors with a long storage time. Cleaning of alternator components may cause an electrical discharge when they are immersed in cleaning fluid. This discharge may cause combustible liquids to ignite.

2.3 Skin Protection



To avoid skin irritation when handling oils and greases, apply protective gloves or creams before starting work and wash off hands with soap and water when servicing has been completed.

2.4 Compressed Air



Only use compressed air regulated to a maximum of 4 Bar (60 PSI), and a clean cloth for cleaning of the armature, excitation windings and alternator plates.

2.5 Explosion Risk



Avoid exposure to fire, open flame and sparks. Thoroughly dry all cleaned parts as gases could form from the cleaning process and may cause an explosion.



3 Specifications

3.1 Electrical Test Specifications

Interference suppression capacitor	1.8 ... 2.6 μ F (microfarad)
Load current less than/equal to 10A	27.6 ... 28.4 V (volts, regulated)
Damping Resistance	3.1 ... 3.5 k Ω (kilohms)
Stator Resistance	0.036 Ω (-0/+10%) T1 (RL) 28V70/140A
Rotor Resistance	7.5 Ω (-0/+10%) T1 (RL) 28V70/140A

Power Output Test

Alternator	Speed (RPM)	Load Current - Inductive (A)	Test Duration (Min)
T1 (RL) 28V70/140 A	1500	76	30
	6000	136	10

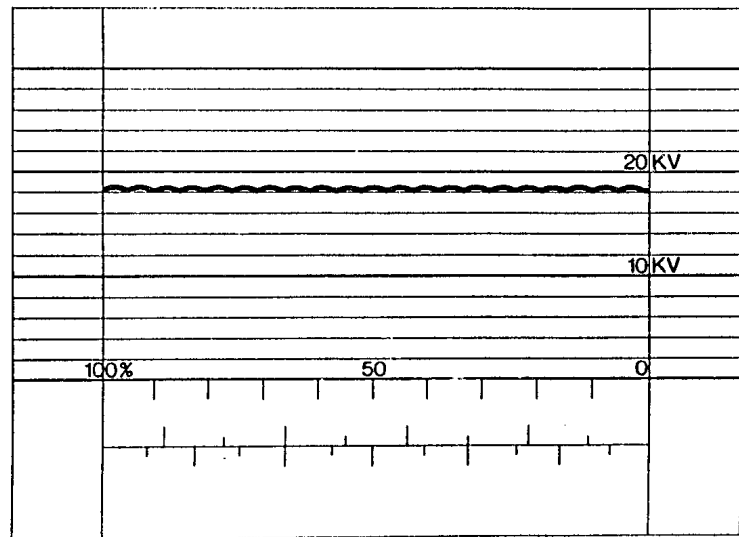
Following completion of the output test, allow alternator to run at 7000 rpm for one minute.

Oscilloscope Pattern

This image represents a properly functioning alternator. The D.C. voltage produced has a small harmonic wave.

Small spikes may be superimposed on the oscilloscope screen if the voltage regulator is regulating. Applying a load to the alternator output terminals can turn off the regulator.

In order to be able to compare oscilloscope images, the oscilloscope so the pattern fits between two vertical 10x divisions.



KME00052

Figure 1 Normal Oscilloscope Pattern



3.2 Mechanical Test Specifications

Rotor to Stator Air Gap (Between any side of stator and rotor)		Greater than 0.3 mm (0.012 in)
Eccentricity (Rotor mounted at bearing points)	Outer Diameter Of Rotor	0.05 mm (0.002 in) maximum
	Outer Diameter Of Collector Rings	0.03 mm (0.0012 in) maximum
Collector ring diameter	New	32.5 mm (1.279 in)
	Used	31.5 mm (1.240 in) minimum
Carbon Brush Projection	New	16.0 mm (0.630 in) minimum
	Used	7.0 mm (0.275 in) minimum

3.3 Tightening Torques

Item Number	Description	Metric (Nm)	SAE
55	Air Intake Stud	3.0 ... 3.4	26.5 ... 30.1 in. lbs.
66	D+ Terminal	2.4 ... 3.2	21.2 ... 28.3 in. lbs.
29	B+ Terminal, B- Terminal	10.0 ... 13.0	88.5 ... 115 in. lbs.
37	W Terminal	4.1 ... 5.5	36.3 ... 48.7 in. lbs.
15	Voltage Regulator	1.3 ... 1.7	11.5 ... 15.0 in. lbs.
43	Capacitor Mounting Screw	4.3 ... 5.7	38.0 ... 50.4 in. lbs.
23	Rectifier Mounting Screw	1.3 ... 1.7	11.5 ... 15.0 in. lbs.
21	Drive End Shield to Collector Ring Shield	7.2 ... 9.7	63.7 ... 85.9 in. lbs.
5	Drive End Shield Bearing Cover Plate	4.1 ... 5.5	36.3 ... 48.7 in. lbs.
52	Pulley Retaining Nut	135 ... 170	99.5 ... 125.4 ft. lbs.

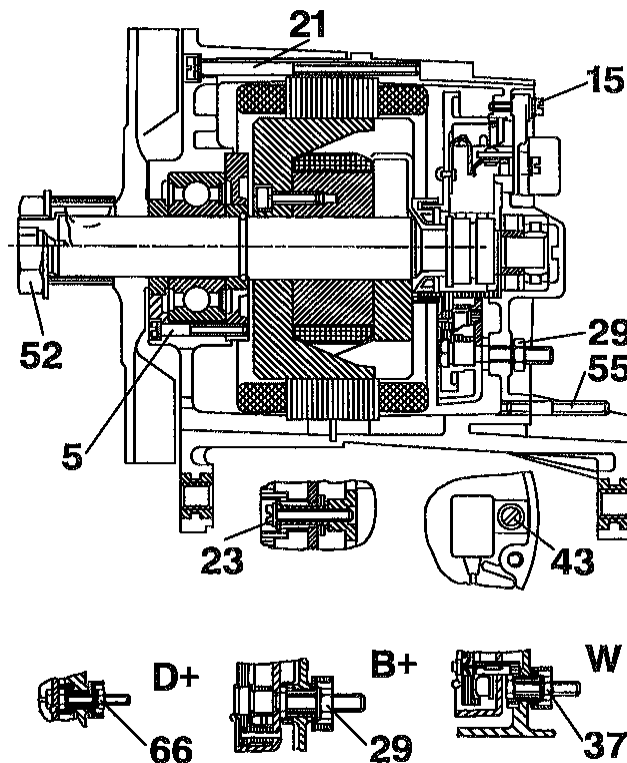
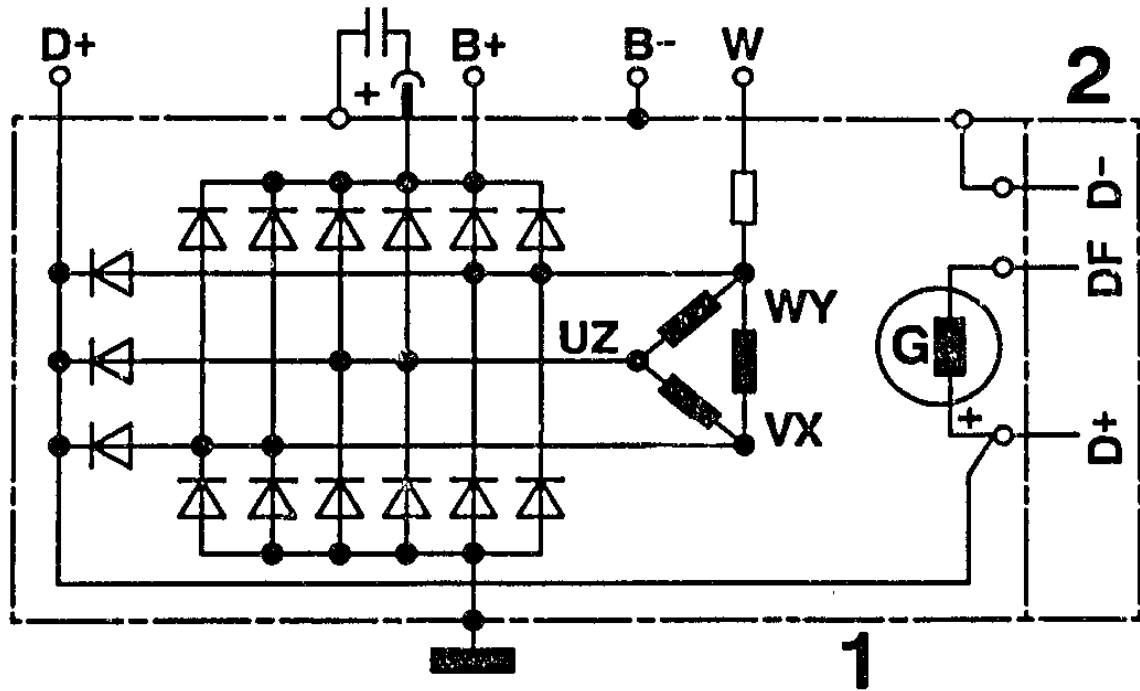


Figure 2 Fastener Torque Chart



4 Alternator Schematic



KME 00050

Figure 3 Alternator/Voltage Regulator Schematic

1 Alternator

- B+ Battery Positive
- B- Battery Negative
- D+ Dynamo + (Warning Lamp Output)
- W Tachometer Output

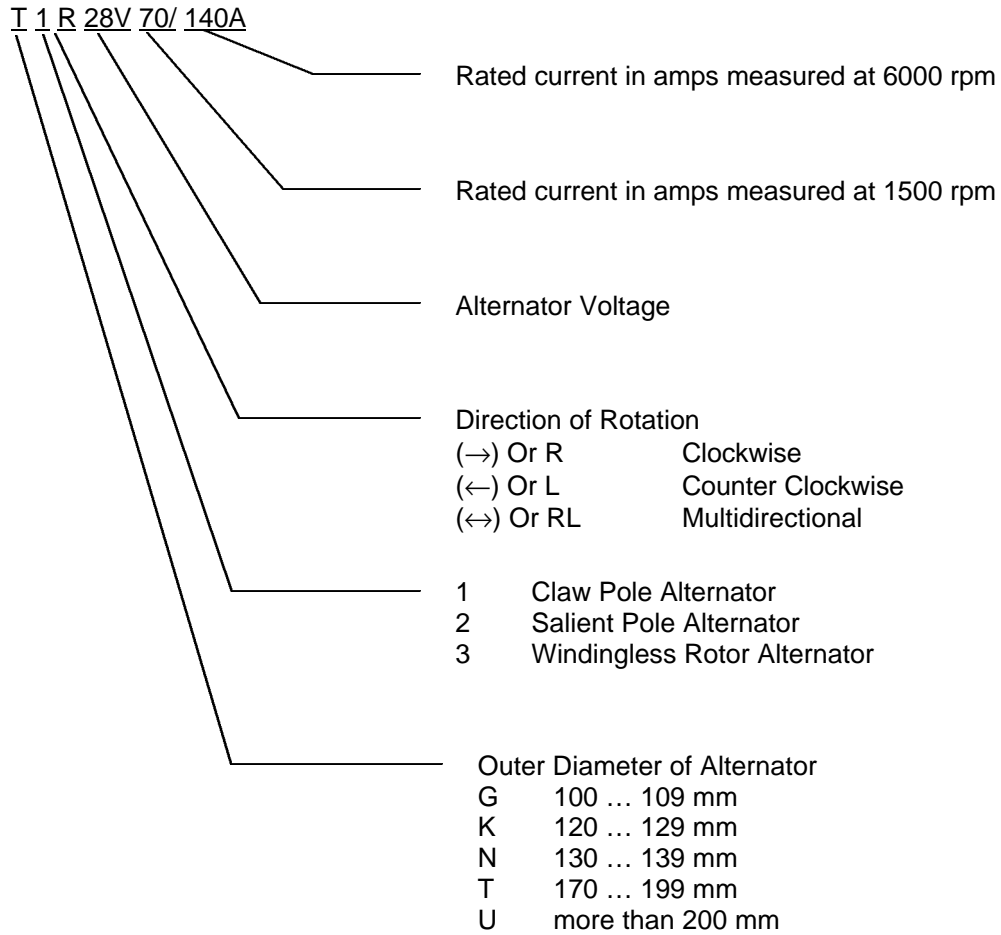
2 Voltage Regulator

- D+ Dynamo + (Alternator Output)
- DF Dynamo Field
- D- Dynamo -



5 Alternator Coding

T 1 R 28V 70/ 140A





6 Parts Cleaning

***Caution: Fire Risk***

To provide radio interference suppression, the alternator is equipped with capacitors with a long storage time. Cleaning of alternator components may cause an electrical discharge when they are immersed in cleaning fluid. This discharge may cause combustible liquids to ignite.

Alternator components with capacitors should only be cleaned with a non-combustible cleaner such as HAKU 1025/6.

***Caution: Compressed Air***

Only use compressed air regulated to a maximum of 4 Bar (60 PSI), and a clean cloth for cleaning of the armature, excitation windings and alternator plates.

***Caution: Explosion Risk***

Avoid exposure to fire, open flame and sparks. Thoroughly dry all cleaned parts as gases could form from the cleaning process and may cause an explosion.



7 Tools, Test Equipment Lubricants and Adhesives

7.1 Test Equipment

Description	Bosch Number	
Alternator Test Bench	Commercially Available	
Internal Short-Circuit Tester (Flash Tester)	KDAW 9978	0 986 619 110
Universal Multi-Meter	MMD 302	0 684 500 302
Alternator Tester	WPG 012.00	0 684 201 200

7.2 Special Tools

Description	Bosch Number	
Arbor Press	Commercially Available	
Soldering Iron	Commercially Available	
Universal Bearing Puller	Commercially Available	
V-Block <i>Note: 2 Required</i>	Commercially Available	
14mm Hex, 1/2" Drive Socket	Commercially Available	
Clamping Support	KDAW 9999	0 986 619 362
Die Spigot for Arbor Press (Used with KDLJ 6011, KDLJ 6012, KDLJ 6015)	KDLJ 6010	0 986 618 124
Bearing Remover	KDLJ 6009	0 986 618 121
Press Tool for Roller Bearing	KDLJ 6021	0 986 618 139
Bearing and Seal Installer	KDLJ 6011	0 986 618 125
Collector Ring Installer	KDLJ 6012	0 986 618 126
Drive End Shield Support Ring for Rotor Pressing	KDLJ 6013	0 986 618 127
Press Tool - Spacer Ring, Roller Bearing Inner Race and Collector Rings	KDLJ 6018	0 986 618 134
Alignment Pin - Drive End Shield and Collector Ring End Shield	KDLJ 6014	0 986 618 128
Removal Tool - Sliding Bushing	KDLJ 6015	0 986 618 129
Holding Tool - Sliding Bushing	KDLJ 6016	0 986 618 130
Inner Bearing Race Removal Tool	KDAW 9996	0 986 619 269
Puller Receiver Cup	KDAW 9995/0/1	0 986 619 214
Threaded Pin with Cone	KDAW 9995/14	0 986 619 250
Bearing Puller Spring Collet	KDAW 9995/6	0 986 619 233
Feeler Gauge 0.15 ... 0.6 mm (.005 ... .024 in) <i>Note: 4 required</i>	KDZV 7399	0 986 618 378
Dial Indicator	EFAW 7	1 687 233 011
Magnetic Indicator Stand	T-M 1	4 851 601 124



7.3 Lubricants and Adhesives

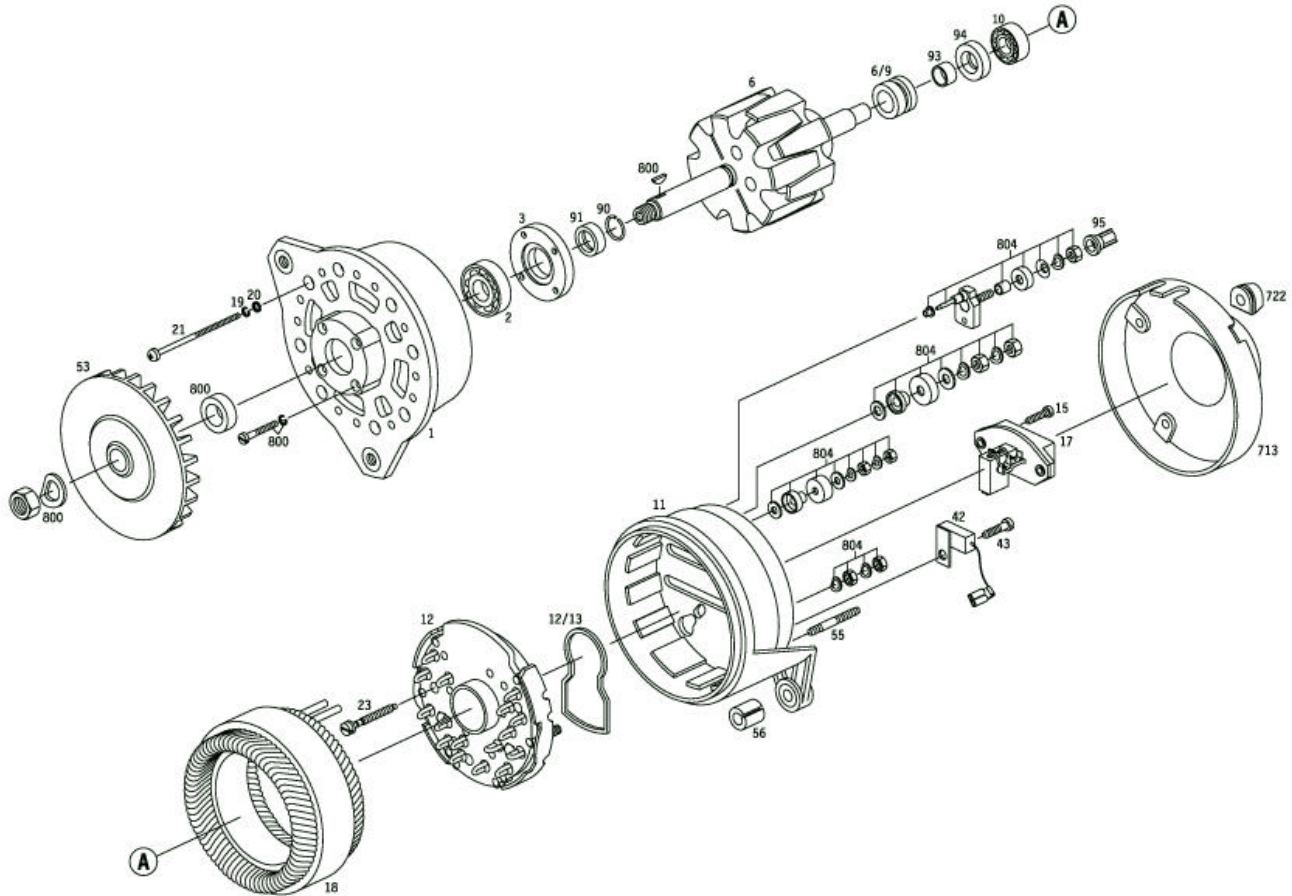
Description	Manufacturer Number	Bosch Number
Roller Bearing Grease	UNIREX N3	5 975 560 125
	Ft1 v 34	5 700 009 000
	VS 15164-Ft	5 975 560 000
Molycote Paste	Ft 70 v 1	5 700 040 000
Adhesive Dispersant	KK57v1	5 703 151 000
Silicon Paste	Ft2v4	5 700 083 005

7.3.1 Lubricant Quantities

Bottom of Roller Bearing	2 g (0.07 oz.)
Collector End Shield Radial Seal	2 g (0.07 oz.)
Roller Bearing	2...2.5 g (0.07...0.09 oz.)



8 Exploded View

**Figure 4 Alternator Exploded View**

<u>Item</u>	<u>Designation</u>	<u>Item</u>	<u>Designation</u>
1	Drive End Shield	20	Plain Washer
2	Ball Bearing	21	Oval-Head Screw
3	Cover Plate	23	Washer & Screw Assembly
6	Rotor	42	Suppression Capacitor
6/9	Collector Ring	43	Oval-Head Screw
10	Roller Bearing	53	Fan
11	Collector-Ring End Shield	55	Stud
12	Rectifier	56	Expansion Bushing
12/13	Seal	90	Retainer
15	Washer & Screw Assembly	91	Support Ring
17	Transistor Regulator	93	Spacer Ring
17/3/8	Compression Spring	94	Radial Seal
17/3/801	Carbon-Brush Set	95	Protective Cap
17/10	Gasket	713	Air-Intake Cover
18	Stator	722	Grommet
19	Spring Lock Washer		



9 Alternator Disassembly and Testing

9.1 Rear Cover Removal

1. Clamp alternator in clamping fixture KDAW 9999 (Bosch Number 0 986 619 362).
2. Remove four nuts holding on the air intake cover. (Figure 5)

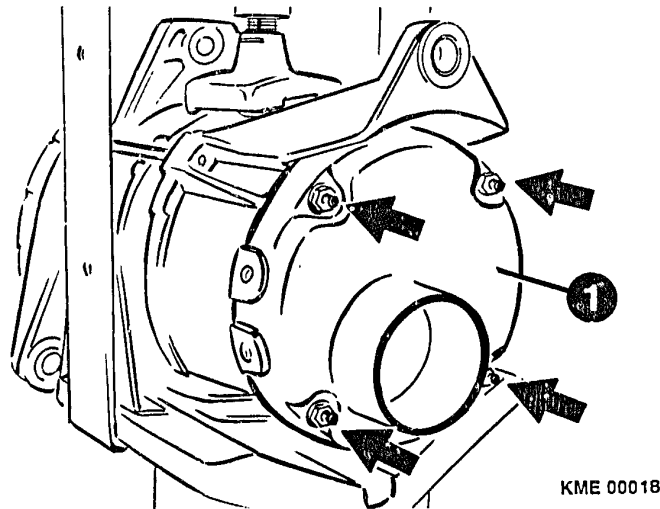


Figure 5 Air Intake Cover Removal (1)

Note: The voltage regulator must be removed before any further disassembly of the alternator takes place. The brushes of the regulator can break if the regulator is not removed before any other disassembly takes place.

9.2 Voltage Regulator Removal

1. Remove the three (3) screws that secure the regulator to the collector ring end shield. (Figure 6)
2. Carefully remove the voltage regulator from the collector ring end shield.

Note: The brushes of the regulator will break if the regulator is not removed before any other disassembly of the alternator takes place.

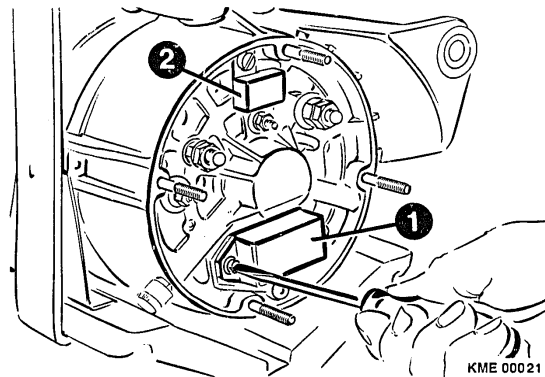


Figure 6 Voltage Regulator (1) and Suppression Capacitor (2)

9.2.1 Brush Replacement

1. The exposed length of the carbon brushes must be measured to determine if they require replacement. Measure the length of each brush. If the exposed brush length is less than 7 mm (0.276"), the brush must be replaced. (Figure 7)

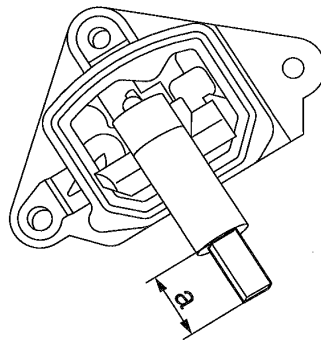


Figure 7 Brush Length Measurement

2. To replace the brushes, the brush lead must be unsoldered and the brush removed from the regulator.
3. Insert the new brush into the regulator and solder the brush lead to the regulator.

Note: Use only rosin-core solder to attached the brush lead.

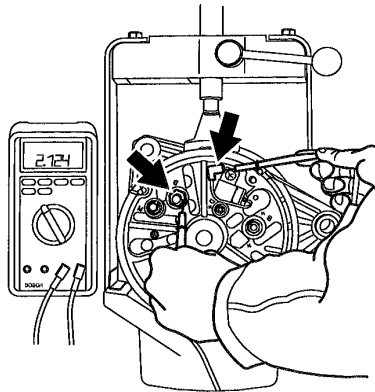
4. Check the brushes for freedom of movement after they are soldered.
5. Measure the exposed length of the new brushes. The exposed length should be 16 mm (0.630")

9.3 Noise Suppression Capacitor Testing and Removal

1. Disconnect the suppression capacitor from terminal B+.



2. Connect Multimeter MMD 302 (Bosch Number 0 684 500 302) or equivalent to the lead of the suppression capacitor and the B- terminal of the alternator. (Figure 8)

**Figure 8 Testing of Suppression Capacitor**

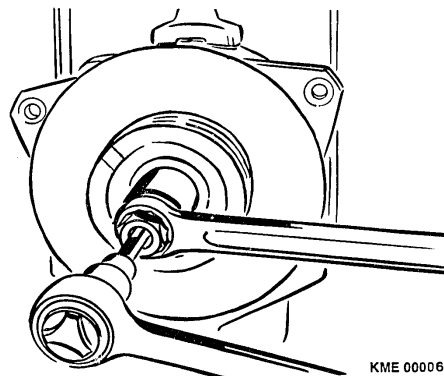
3. Measure the capacitance of the suppression capacitor. If the capacitance does not read between 1.8 and 2.6 μF (microfarad), the capacitor must be replaced.
4. Remove the screw that secures the suppression capacitor and remove capacitor.

Note: After removing the suppression capacitor from the alternator, the capacitor lead should be shorted to the capacitor-mounting strip to discharge the capacitor. Failure to do so may cause the capacitor to discharge while being cleaned.

9.4 Pulley and Fan Removal

1. Using a 14-mm hex socket to hold the rotor shaft. Loosen and remove pulley-retaining nut with a box wrench. (Figure 9)

Note: Do not use an air impact gun to remove the nut as the force of the impact may cause damage to the alternator bearings.

**Figure 9 Pulley and Fan Removal**

2. Remove the pulley and cooling fan from the alternator.

9.5 Separation of Drive Shield and Collector End Shield

Note: With a scribe, mark the relationship between the drive end shield and the collector ring end shield. This will assist in the realignment of the two shields upon reassembly.

1. Loosen and remove the four (4) outer Oval-head screws which hold the end shields together. (Figure 10)



- Slide the drive end shield and rotor out of the collector end shield.

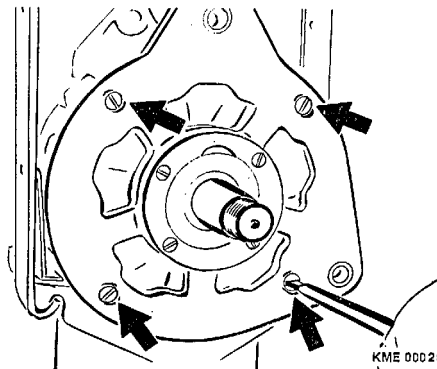


Figure 10 Drive End Shield Removal

9.6 Rectifier Assembly Testing

Note: The following testing of the rectifier is to be performed with the rectifier assembly installed and wired in to the stator.

- With the rectifier assembly still installed in the collector end shield, testing of the rectifier is to be performed.
 - Using tester WPG 012.00 (Bosch Number 0 684 201 200)** (Figure 11)
 - Connect the negative (black) lead of the tester to the collector end shield and the positive (red) lead to each of the stator connection solder joints.
 - Connect the positive (red) lead of the tester to the B+ Terminal and the negative (black) lead to each of the stator connection solder joints.
 - Connect the positive (red) lead of the tester to the D+ Terminal and the negative (black) lead to each of the stator connection solder joints.

The rectifier assembly is reusable if the tester remains in green zone. If the rectifier assembly fails any test, one or more of the diodes are defective and the whole assembly must be replaced.

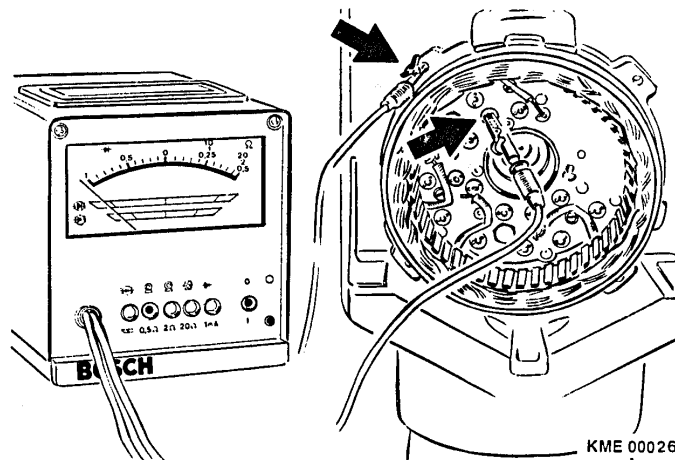


Figure 11 Testing of Rectifier Assembly

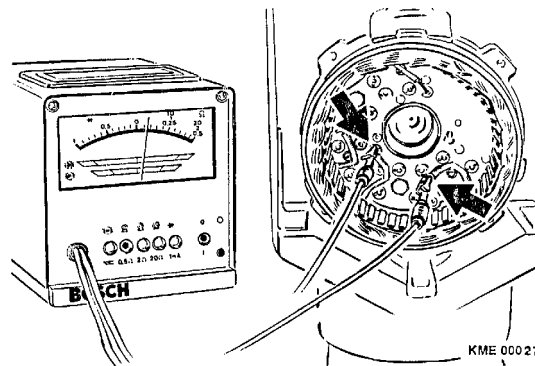
**b. Using a Diode Tester**

- i) Connect the negative (black) lead of the tester to the collector end shield and the positive (red) lead to each of the stator connection solder joints. No current should pass through the rectifier assembly.
- ii) Connect the positive (red) lead of the tester to the collector end shield and the negative (black) lead to each of the stator connection solder joints. Current should pass through the rectifier assembly.
- iii) Connect the positive (red) lead of the tester to the B+ Terminal and the negative (black) lead to each of the stator connection solder joints. No current should pass through the rectifier assembly.
- iv) Connect the negative (black) lead of the tester to the B+ Terminal and the positive (red) lead to each of the stator connection solder joints. Current should pass through the rectifier assembly.
- v) Connect the positive (red) lead of the tester to the D+ Terminal and the negative (black) lead to each of the stator connection solder joints. No current should pass through the rectifier assembly.
- vi) Connect the negative (black) lead of the tester to the D+ Terminal and the positive (red) lead to each of the stator connection solder joints. Current should pass through the rectifier assembly.

If the rectifier assembly fails any test, one or more of the diodes are defective and the whole assembly must be replaced.

9.7 Removal and Testing of Stator Assembly

1. With tester WPG 012.00 or Multimeter MMD 302 set to read 0 to 0.5 Ω , test the resistance of the stator while it is still attached to the rectifier assembly. Connect the test leads between the phase outputs of the stator. Repeat the test until all three phases of the stator has been tested. A good stator will read between 0.036 Ω and 0.040 Ω . (Figure 12)

**Figure 12 Stator Resistance Testing**

2. Unsolder the stator phase connections from the rectifier assembly with a soldering gun or iron.
3. Bend open any bent-over lead connections with a screwdriver or pliers and pull the stator leads from the rectifier eyelets.

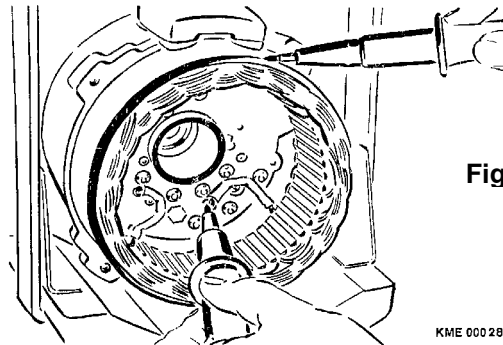


Note: The insulation tester applies a voltage of 80 VAC to the stator. Voltages of 80V can be fatal. When performing this test, observe care is used in handling the stator and any component or surface that is exposed to the stator. Use insulated gloves and do not touch the work surface until all tests are completed.



- Using insulation tester KDAW 9983 (Bosch Number 0 986 619 110) or equivalent, apply 80 VAC to each of the stator phase leads with one probe while the other probe is in contact with the exterior of the stator. (Figure 13)

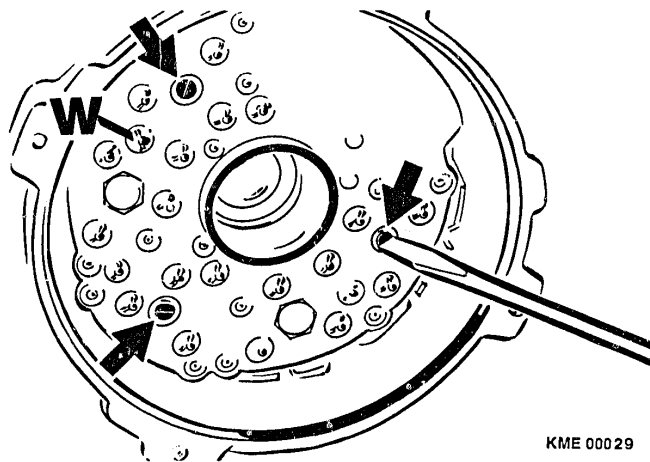
No continuity should be present. Any continuity between the stator phase leads and the exterior of the stator indicates a breakdown of the stator insulation and a short to ground. If continuity is present, the stator must be replaced.

**Figure 13 Stator Insulation Testing**

KME 000 28

9.8 Rectifier Assembly Removal

- Loosen and remove the three screws that hold the rectifier to the collector end shield. (Figure 14)
- Unsolder the W terminal from the rectifier assembly.



KME 000 29

Figure 14 Rectifier Assembly Removal

- Remove the nuts holding terminals B+, B- and D+ to the collector end shield.

Note: Do not attempt to remove the studs from the rectifier assembly. Terminals B+, B- and D+ are permanently attached to the rectifier assembly. Terminal W is attached to the collector end shield. Do not loosen Terminal W.

- Remove the rectifier assembly from the collector end shield.



9.9 Dampening Resistor Testing and Removal

1. The W Terminal incorporates a dampening resistor. Using a Multimeter MMD 302, connect one lead to the exterior portion of the W terminal and connect the other lead to the other side of the W Terminal. The Multimeter should read between 3.1 and 3.5 k (kilohm). If the resistance is above or below this range, the W terminal is to be replaced as an assembly. (Figure 15)

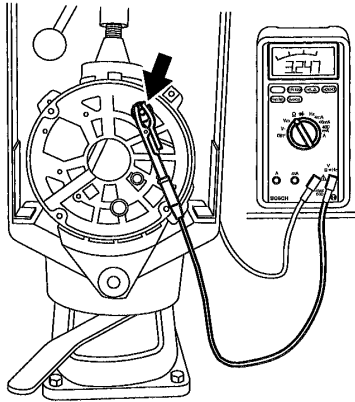
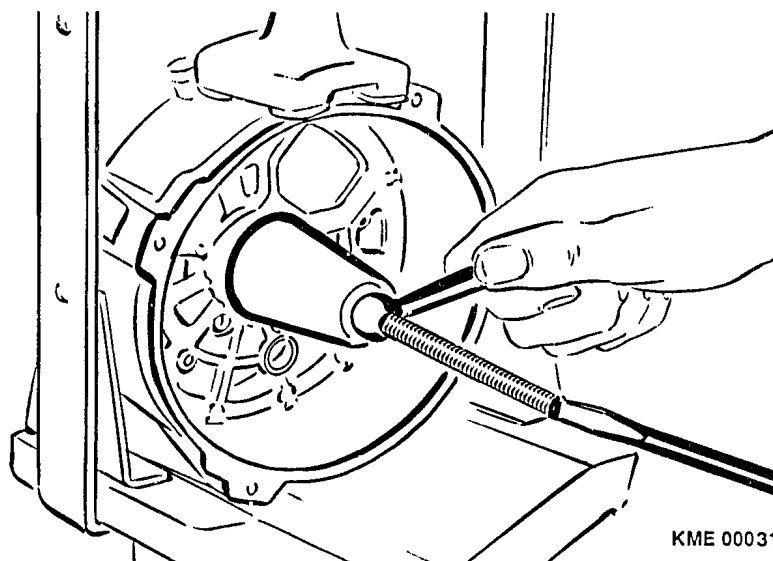


Figure 15 Testing of W Terminal Dampening Resistor

2. Loosen the nut retaining terminal W to the collector end shield.
3. Remove terminal W.

9.10 Removal of Collector End Shield Bearing and Seal

1. Insert extractor KDLJ 6009 (Bosch Number 0 986 618 121) into bearing.
2. Screw threaded rod KDAW 9995/14 (Bosch Number 0 986 618 214) into extractor KDLJ 6009.
3. Slide the receiver cup KDAW 9995/0/5 (Bosch Number 0 986 619 250) onto threaded rod.
4. Screw on the handle, rotate until the bearing, and seal come out of the collector end shield. (Figure 16)



KME 00031

Figure 16 Bearing and Seal Removal



5. If the roller bearing is stuck in end shield, proceed as follows:
 - a. Remove extractor KDLJ 6009 from the bearing.
 - b. Destroy the bearing cage with a screwdriver or similar tool.
 - c. Remove rollers from bearing.
 - d. Insert spring collet KDAW 9995/6 (Bosch Number 0 986 619 233) into bearing outer race.
 - e. Screw threaded rod KDAW 9995/14 into extractor KDAW 9995/6.
 - f. Slide the receiver cup KDAW 9995/0/5 onto threaded rod.
 - g. Screw on handle and rotate until the bearing race comes out of the collector end shield.

9.11 Removal of Sliding Bushing in Collector End Shield

1. Place collector end shield in an arbor press, support mounting/pivot boss on mandrel KDLJ 6016 (Bosch Number 0 986 618 130). (Figure 17)
2. Place bushing mandrel KDLJ 6015 (Bosch Number 0 986 618 219) on sliding bushing.
3. Press sliding bushing out of collector end shield into mandrel KDLJ 6016.

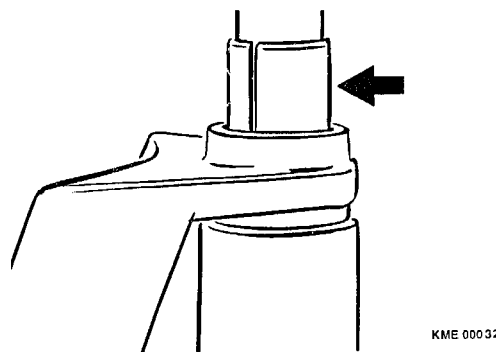


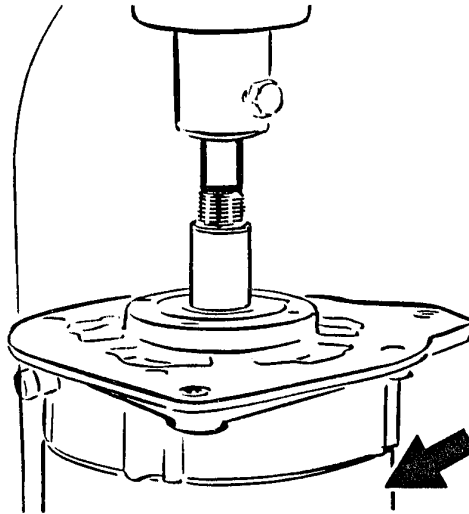
Figure 17 Sliding Bushing Removal

9.12 Removal of Rotor from Drive End Shield

1. Place drive end shield onto pressing ring KDLJ 6013 (Bosch Number 0 986 618 127).
2. Place pressing ring into an arbor press. (Figure 18)



3. Press out rotor.



KME 00033

Figure 18 Pressing out Rotor

4. Remove spacer ring from rotor shaft.

Notes: Protect the threads of the rotor from damage prior to pressing. Always replace the drive end bearing if the rotor has been pressed out. Therefore, only remove the rotor if;

- *the rotor is to be replaced*
- *the excitation winding of the rotor is to be replaced*
- *the drive end bearing/spacer ring is to be serviced*
- *the rotor collector rings are to be replaced*



9.13 Removal of Bearing and Seal from Drive End Shield

1. Loosen and remove the four (4) screws holding the bearing cover plate. (Figure 19)
2. Remove the spacer ring (Refer to arrow in Figure 19).
3. Remove the bearing from the drive end shield.

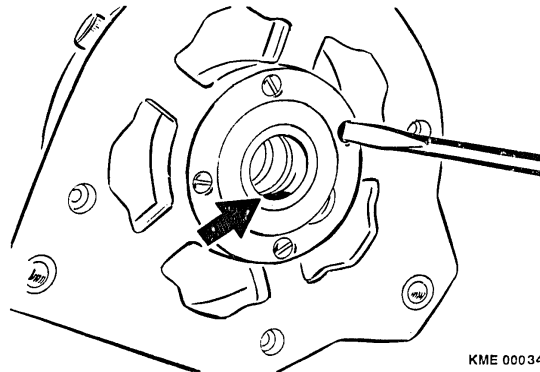


Figure 19 Drive End Bearing Removal

9.14 Removal of Collector Ring End Inner Bearing Race from Rotor

1. With a universal bearing puller, remove the inner race of the endshield bearing. (Figure 20)

Notes: Place jaws of the puller yoke behind the inner-bearing race and pull the bearing race only. Do not place the yoke behind the spacer ring. Pulling both the bearing and the spacer ring at the same time may damage the rotor. The inner bearing race must be replaced anytime the collector end shield bearing is replaced.

2. Reposition the puller and remove the spacer ring from the rotor shaft.

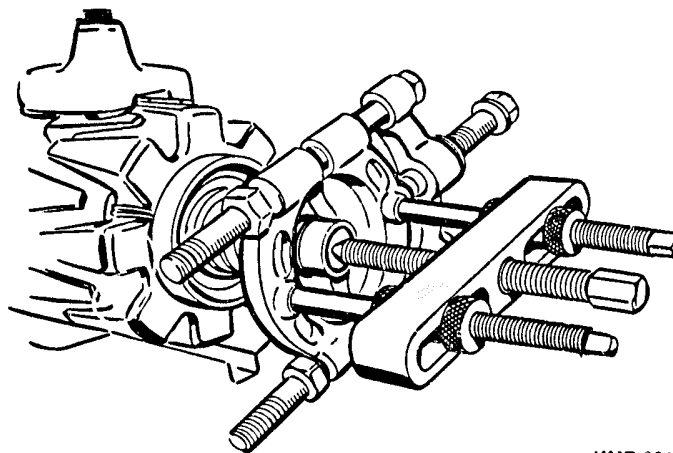


Figure 20 Inner Bearing Race Removal



9.15 Rotor Inspection

1. Using electric tester ETE 014.00 or Multimeter MMD 302, measure the resistance between the two collector rings of the rotor. The resistance measured should be between 7.5 and 8.3 Ω . (Figure 21)

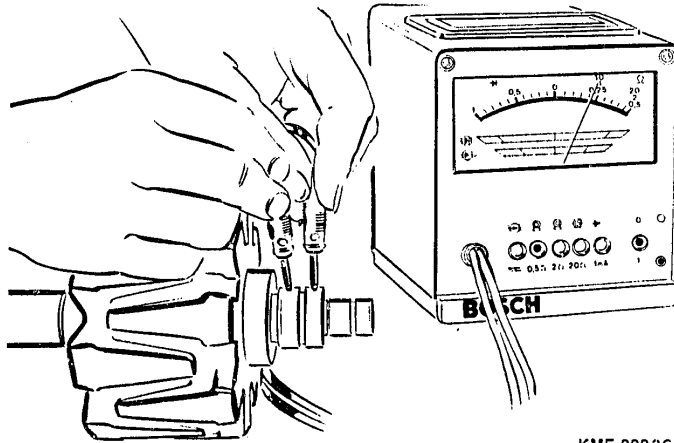


Figure 21 Rotor Resistance Testing

KME 00036

2. Using insulation tester KDAW 9983 or equivalent, apply 80 VAC to the rotor claw poles and each of the collector rings. If the insulation tester lights, there is a short to ground within the rotor. (Figure 22)

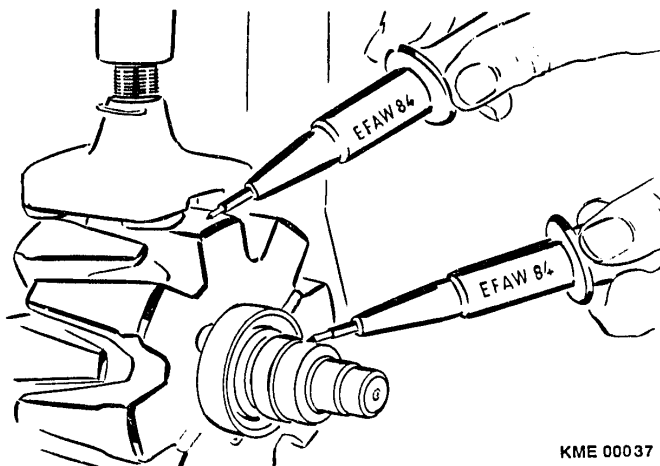


Figure 22 Rotor Insulation Testing

KME 00037

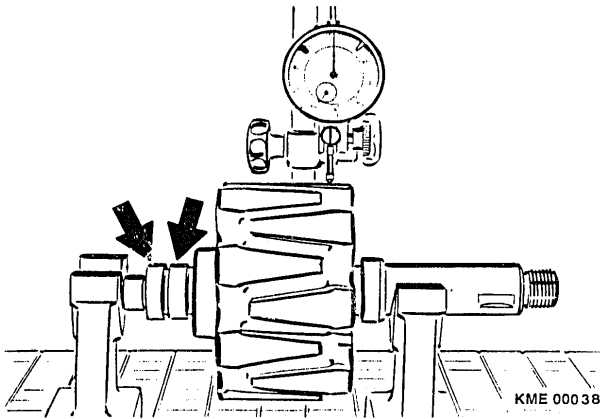


Note: The insulation tester applies a voltage of 80 VAC to the rotor. Voltages of 80V can be fatal. When performing this test, observe care is used in handling the rotor and any component or surface that is exposed to the rotor. Use insulated gloves and do not touch the work surface until all tests are completed.

3. Mount the rotor in a pair of V-Blocks at the rotor bearing points.



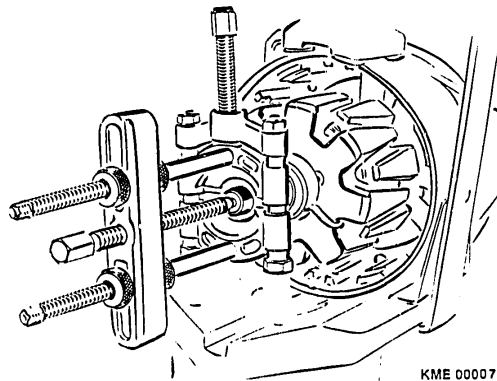
4. Position dial indicator (Magnetic Base T-M 1 (Bosch Number 4 851 601 124) and Dial Indicator EFAW 7 (Bosch Number 1 687 233 011)) to measure the concentricity of the rotor at: (Figure 23)
 - a. Outer diameter of rotor, maximum run-out 0.05 mm (0.002 in). If the run-out of the rotor exceeds the maximum, the rotor must be replaced.

**Figure 23 Rotor Concentricity Measurement**

- b. Each collector ring, maximum run-out 0.03 mm (0.0012 in). If the run-out exceeds the maximum, the collector rings can be machined down to a minimum of 31.5 mm (1.240 in) diameter. If the required machining causes the collector ring diameter to drop below the minimum dimension, the collector ring(s) must be replaced.

9.16 Collector Ring Replacement

1. Before the collector rings can be removed, the spacer ring from the end of the rotor must be removed. Refer to Section 9.14 *"Removal of Inner Bearing Race from Rotor."*
2. Unsolder the rotor leads from each collector ring.
3. With a universal bearing puller, remove each collector ring one at a time from the rotor. (Figure 24)

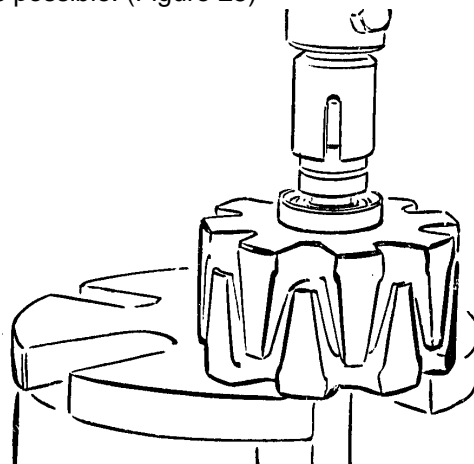
**Figure 24 Collector Ring Removal**



10 Alternator Assembly

10.1 Rotor Assembly

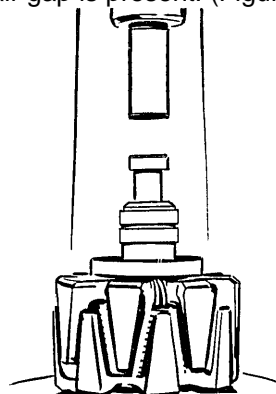
1. Position rotor in arbor press with the drive end pointing down.
2. Press the lead for the rotor winding into the slot of the rotor.
3. Slide the collector rings onto the rotor shaft as far as possible by hand. Make sure the lead for the rotor windings does not become damaged while sliding the collector rings over the lead.
4. Lining up the slot in tool KDLJ 6012 (Bosch Number 0 986 618 126) with the rotor lead, press the collector rings onto the rotor as far as possible. (Figure 25)



KME 00040

Figure 25 Pressing on Collector Rings

5. Solder each of the rotor winding leads to one of the collector rings with rosin core solder.
6. After soldering, touch up surface of collector ring to remove any excess solder from the brush contact surface.
7. Press on collector end shield bearing spacer ring with tool KDLJ 6018 (Bosch Number 0 986 618 134) until it contacts the stop on the rotor and no air gap is present. (Figure 26)



KME 00008

Figure 26 Spacer Ring



Note: Do not allow the spacer ring to twist while pressing onto the rotor.

8. Place the inner bearing race of the collector end shield bearing onto the rotor shaft.
9. Press the bearing onto the rotor shaft with tool KDLJ 6018. (Figure 26)

10.2 Drive End Shield Assembly

1. Insert sealed ball bearing into the drive end shield.
2. Align the holes of the bearing cover plate with the holes in the drive end shield.
3. Start the four screws which hold the bearing cover plate and tighten to 4.1 ... 5.5 Nm (36.3 ... 48.7 in. lbs.) (Figure 27)

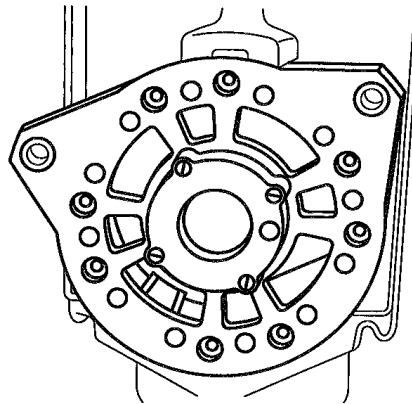
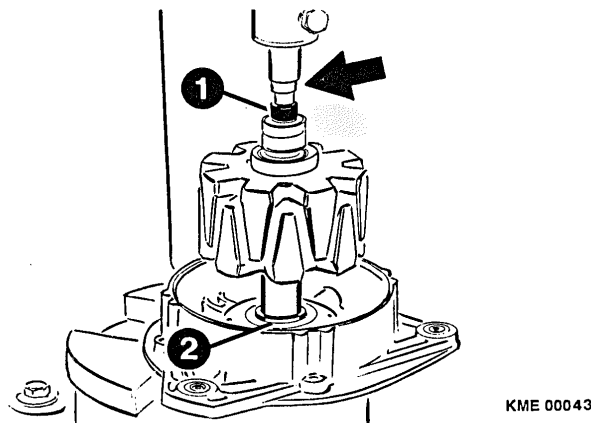


Figure 27 Drive End Bearing Retaining Screws

4. Insert bearing/fan spacer ring into the drive end shield from the fan side of the shield.
5. Place drive end shield on to an arbor press with the bearing/fan spacer ring pointed down. (Figure 28)
6. Slide support ring onto the drive end of the rotor. Make sure the under cut side of the ring faces the retaining ring on the rotor.



**Figure 28 Installing Rotor into Drive End Shield
(1) Tool KDLJ 6018 (2) Support Ring**



7. Place rotor into the drive end bearing.
8. Place tool KDLJ 6018 onto the end of the rotor and press the rotor into the drive end bearing until the bearing seats against the support ring.

10.3 Collector Ring End Shield Assembly

1. Pack the collector end roller bearing with 2 to 2.5 g (0.07 to 0.09 oz.) of UNIREX N3 grease.
2. Place the end shield on an arbor press.
3. Place tool KDLJ 6011 (Bosch Number 0 986 618 125) into bearing and press bearing into collector end shield. (Figure 29)
4. Pack the bottom of the collector end housing bearing bore with an additional 2 g (0.07 oz.) of UNIREX N3 grease.
5. Coat the sealing lip of the radial lip seal and pack the seal with 2 g (0.07 oz.) of UNIREX N3 grease.

Notes: Do not assemble the alternator with a dry radial seal as this will lead to seal failure and contamination of the brushes and collector rings.

Make sure there is no excess grease on the exterior of the seal before installation in the collector end shield. Excess grease on the exterior of the seal will cause contamination of the collector rings and brushes.

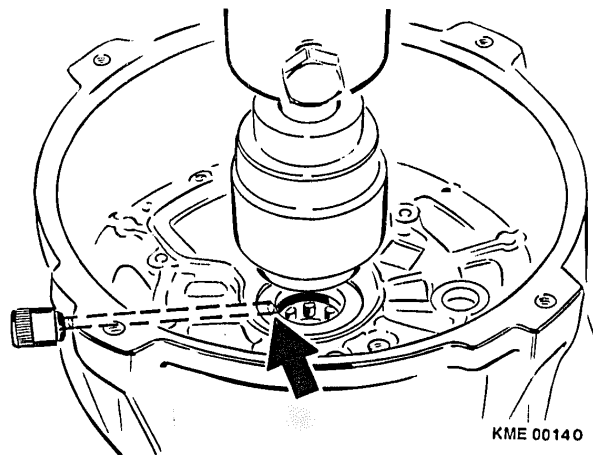
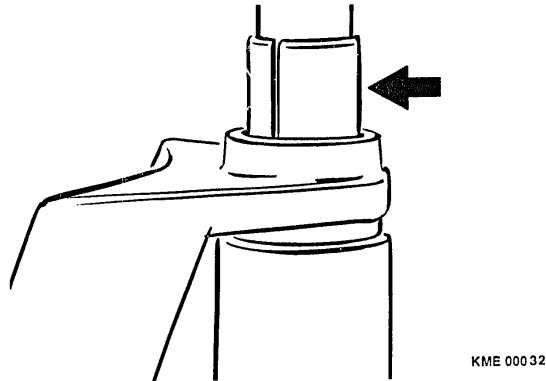


Figure 29 Installation of Bearing and Seal

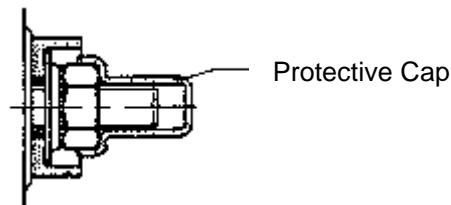
6. Place seal onto tool KDLJ 6011 and press the seal into the collector end shield. (Figure 29)
7. Place collector end shield in an arbor press, support mounting/pivot boss on tool KDLJ 6016. (Figure 30)
8. Coat the inside of the collector end shield bore with Molycote.
9. Place sliding bushing into place on collector end shield.



10. With tool KDLJ 6015, press sliding bushing into end shield until the bushing is flush with the inner surface of the mounting/pivot boss. (Figure 30)

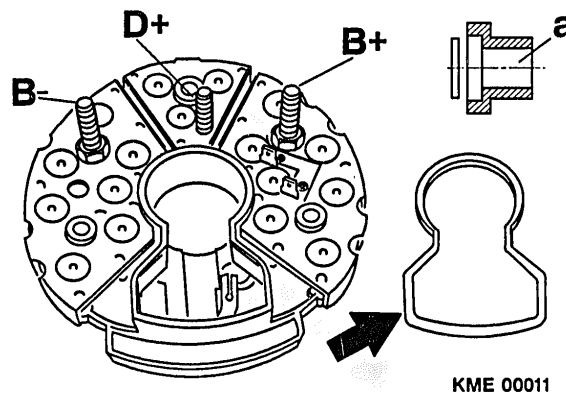
**Figure 30 Sliding Bushing Installation**

11. Insert terminal W into collector end shield in location marked W. Make sure the locating lug of the terminal assembly indexes the end shield correctly.
12. Place insulator and flat washer onto terminal W.
13. Install nut and torque to 4.1 to 5.5 Nm (36.3 to 48.7 in. lbs.)
14. Install protective cap onto terminal W. (Figure 31)

**Figure 31 Terminal W Insulator,
Washer, Nut and Cap**

10.4 Rectifier Assembly

1. Place flat washer and insulator (a) onto terminal B+ and D+ studs of the rectifier assembly. (Figure 32)

**Figure 32 Rectifier Insulators and Seal**



2. Coat the keyhole shaped surface of the rectifier with adhesive. (Figure 32)
3. Place the rectifier seal ring onto the keyhole shaped surface of the rectifier. Make sure the seal conforms to the shape of the keyhole.
4. Once the adhesive has cured, place the rectifier into the collector end shield. Make sure the solder lug of the W Terminal passes into the correct position of the rectifier assembly.
5. Install the insulating washer, flat washer and nut to terminal studs B+ and D+. (Figure 33)
6. Install flat washer and nut onto terminal stud B-. (Figure 33)
7. Check that the soldering lug of terminal W is still in the proper location of the rectifier assembly.

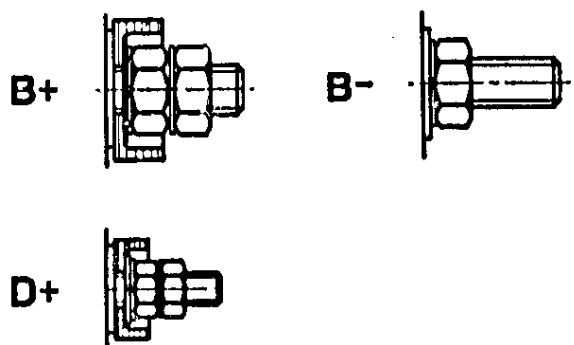


Figure 33 Terminal B+, B- and D+ Assembly

8. Torque terminal stud nuts B+, D+ and B- to:
 - a. Terminal B+ and B-..... 10 to 13 Nm (88.5 to 115 in. lbs.)
 - b. Terminal D+..... 2.4 to 3.2 Nm (21.2 to 28.3 in. lbs.)
9. Install the flat washer and second nut to terminal studs B+, D+ and B- and torque to:
 - a. Terminal B+ and B-..... 10 to 13 Nm (88.5 to 115 in. lbs.)
 - b. Terminal D+..... 2.4 to 3.2 Nm (21.2 to 28.3 in. lbs.)
10. Install the three (3) rectifier mounting screws and torque to 1.3 to 1.7 Nm (11.5 to 15 in. lbs.).
11. Solder the soldering lug of terminal W to the solder pad of the rectifier assembly with rosin core solder. (Figure 34)

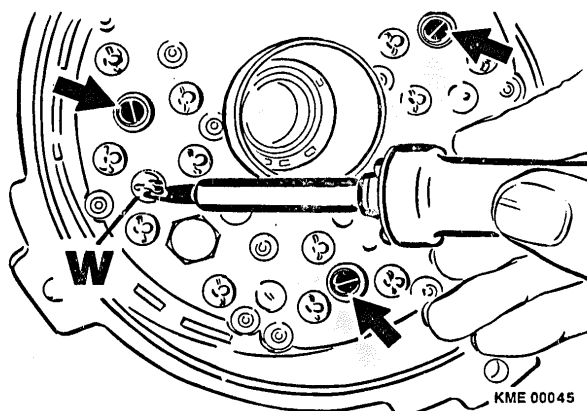


Figure 34 Rectifier Mounting and Soldering of Terminal W



10.5 Stator Assembly

1. Position the stator on the collector end shield. The side of the stator with the winding leads should be closest to the collector end shield.
2. Line up the scribed mark of the stator with the scribed mark of the collector end shield. If either the stator or collector end shield was replaced, a new mark should be scribe across the new part using the replaced component as a reference.
3. Place each of the stator leads into a corresponding soldering lug of the rectifier assembly. After the lead is through the soldering lug, bend the lead so it forms a U around the lug. (Figure 35)

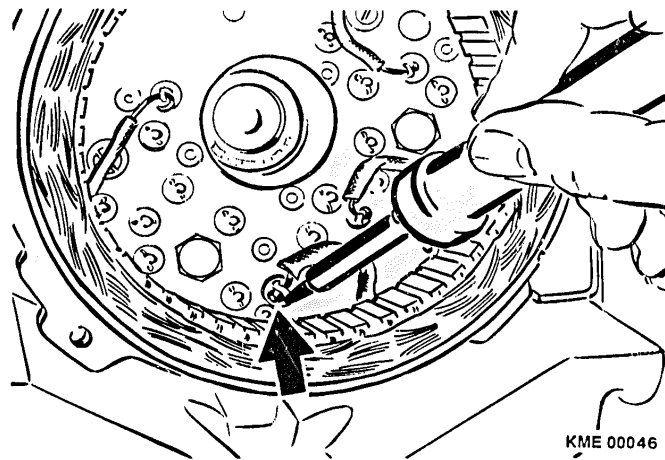


Figure 35 Soldering of Stator Leads

4. Solder each of the stator leads to the rectifier assembly with rosin core solder.

10.6 Rotor and Drive End Shield Installation

1. Place collector end shield and stator assembly on a suitable surface so the rotor and drive end shield assembly can be lowered into place
2. Guide the rotor and drive end shield assembly until the inner bearing race of the collector end bearing enters the roller bearing. Once the inner race enters the bearing, lower the assemblies completely into the collector end shield.
3. Insert guide pin KDLJ 6014 (Bosch Number 0 986 618 128) through the sliding bushing of the collector end shield and the bushing of the drive end shield. (Figure 36)
4. Start the four (4) drive end shield to collector end shield screws.
5. Place the alternator assembly into clamping fixture KDAW 9999.
6. Insert four (4) 0.3 mm (0.012 in) feeler gauges between the stator and the rotor. The feeler gauges should be place in four diametrically opposed positions. (Figure 36)
7. Torque the drive end shield to collector end shield screws to 7.2 to 9.7 NM (21.2 to 28.3 in. lbs.).



8. Remove the four feeler gauges from between the stator and rotor.
9. Turn the rotor by hand. The rotor should rotate freely by hand. If the rotor does not turn freely, loosen the drive end shield to collector end shield screws and repeat steps 6, 7, 8 and 9.
10. While rotating the rotor by hand, listen for contact between the rotor and the stator or stator leads. If any contact sound is heard, the rotor and drive end shield assembly must be removed, the cause determined and repaired before continuing. Once the problem has been corrected, start at step 1 of this section.

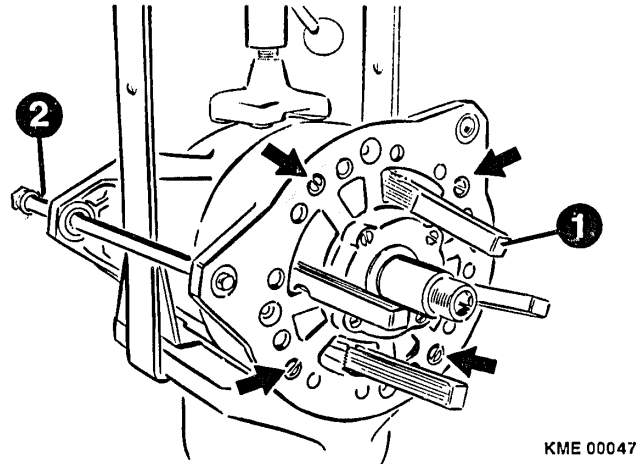


Figure 36 Drive End Shield, Stator and Collector End Shield Assembly
(1) Feeler Gauge (2) Tool KDLJ 6015

11. Remove the alignment pin KDLJ 6014 from the alternator.

10.7 Regulator and Capacitor Installation

1. Depress the carbon brush closest to the regulator into the regulator/brush holder.
2. Insert a straightened paper clip (1 to 1.3 mm dia. x 40mm) into the hole of the regulator until the pin holds the brush in place.
3. Pivot the regulator into the opening of the alternator. Once the brush holder is inside the alternator cavity, slowly remove the paper clip and allow the brushes to extend from the holder. (Figure 37)

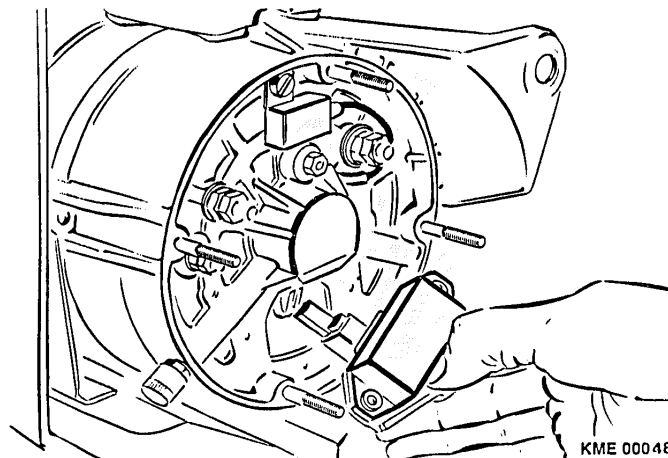


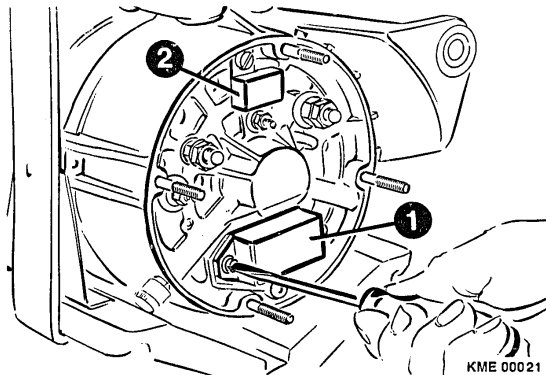
Figure 37 Regulator Installation



4. Align the mounting holes of the regulator to holes of the alternator housing.

Note: When aligning the mounting holes, pay attention to the force used as damage can occur to the brushes.

5. Install the three (3) regulator mounting screws and torque to 1.3 to 1.7 Nm (11.5 to 15 in. lbs.). (Figure 38)
6. Install capacitor on collector end shield and tighten mounting screw to 4.3 to 5.7 Nm (38.0 to 50.4 in. lbs.). (Figure 38)



**Figure 38 Capacitor Installation
(1) Voltage Regulator (2)**

7. Connect lead of capacitor to spade terminal +.
8. Install air intake cover onto alternator. Do not torque cover until it has been installed on the vehicle/engine.



11 Functional Testing

11.1 General Information

The functional testing of the alternator is broken into two categories, Power Output and Voltage Trace Evaluation. All of the tests describe here are performed with the voltage regulator installed on the alternator.

11.1.1 Power Output Tests

The power output tests verify the capability of the alternator to produce rated current and voltage at different speeds. This test requires a test bench of sufficient horsepower to turn a fully loaded alternator at a given speed. Additionally, the test bench must have the ability to inductively load the alternator to its rated amperage for an extended amount of time.

The power output test is to be performed anytime the alternator is suspected of being defective or if the alternator has been disassembled.

11.1.1.1 Test Bench Requirements

To perform the power output test of this series alternator, a test bench must meet the following minimum criteria.

Characteristic	Minimum Specification
Variable Speed Control	0 - 12,000 RPM
Drive Motor	4 kW (5.4 hp)
Load Bank Capability	170 A @ 28 V for 10 minutes 80 A @ 28 V for 30 minutes
Output Voltage Capability	28 V

11.1.2 Voltage Trace Evaluation

The voltage trace evaluation compares the output of the alternator as viewed on an oscilloscope to know oscilloscope patterns. The voltage trace evaluation is an important tool for diagnostics of an alternator that cannot meet the criteria of the power output test. Proper interpretation of the waveforms obtained can lead a technician to the defective component of a failed alternator. The voltage trace evaluation is done while the alternator is still mounted to the alternator test bench. Most any oscilloscope, which is capable of accepting the alternator voltage output, is useable for this evaluation.

11.2 Power Output Testing

11.2.1 Test Bench Mounting

1. Mount the alternator to the test bench per the operating instructions of the test bench manufacturer.
2. Connect the drive system of the test bench to the alternator as per the instructions of the test bench manufacturer.

Note: Only perform the power output tests with the fan pulley installed on the alternator. Failure to test the alternator with the correct fan installed can cause the alternator to overheat and damage the internal components of the alternator.



3. Connect the test leads of the test bench to the alternator as follows:

- a. Connect the +24 v lead of the test bench to the B+ terminal of the alternator.
- b. Connect the -24 v lead of the test bench to the B- terminal of the alternator.
- c. Connect the charging indicator lamp of the test bench to the D+ terminal of the alternator.

*Note: Refer to test bench manufacturers operating instructions for correct terminology of test leads
Refer to figure 39 for a schematic outline of alternator to test bench connections. Compare this schematic to the hook-up schematic of your test bench.*

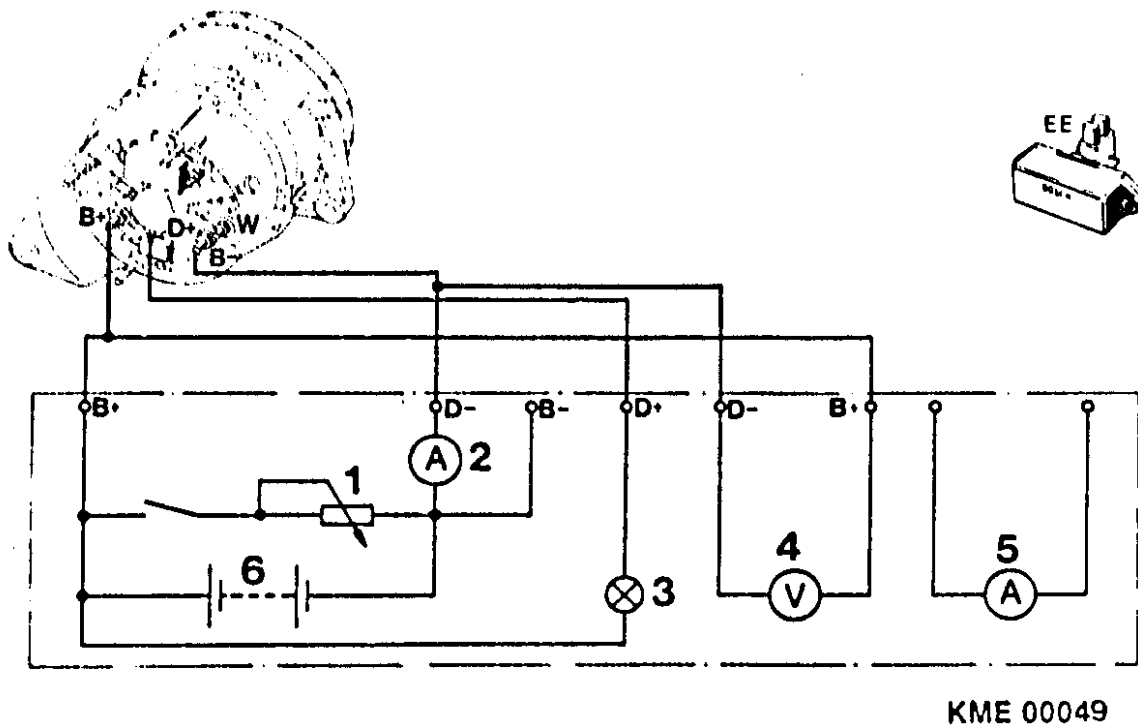


Figure 39 Alternator Test Bench Hook-up Schematic

- (1) Variable Load Resistor
- (2) Ammeter (Alternator Output)
- (3) Charging Indicator Lamp
- (4) Voltmeter (Regulated Voltage)
- (5) Ammeter
- (6) Test Bench Battery

4. Make sure the test bench is set for the correct voltage and rotation before starting tests.

11.2.2 Power Output Test

1. Start test bench and increase speed to 1500 rpm, alternator speed.
2. Increase inductive load on the alternator until 76A output is achieved. As load is increased, monitor test bench speed and correct if speed drops while applying load.



3. Hold test bench at this speed and load for 30 minutes. Monitor alternator output and speed during the test period.
4. Remove load and operate the alternator at 7000 rpm for one minute to allow the alternator to cool.
5. Refer to the test bench operating instructions and allow the load bank to cool the required amount of time before proceeding to the next test.
6. After the load bank has cooled, increase the test bench until the alternator has reached 6000 rpm.
7. Increase inductive load on the alternator until 136A alternator output is achieved. As load is increased, monitor test bench speed and correct if speed drops while applying load.
8. Hold test bench at this speed and load for 10 minutes. Monitor alternator output and speed during the test period.
9. Remove load and operate the alternator at 7000 rpm for one minute to allow the alternator to cool.
10. Refer to the test bench operating instructions and allow the load bank to cool the required amount of time before proceeding to the next test.
11. Apply a minimum load of 10A to the alternator.
12. Measure the regulated voltage of the alternator. The correct regulated voltage is between 27.6 and 28.4 volts.
13. If the alternator passes the three output tests, no further testing is required. If the alternator failed any of the three tests, proceed with the voltage trace evaluation.

11.3 Voltage Trace Evaluation

The voltage trace evaluation is a comparison of the voltage output of the alternator to know patterns. These know patterns will help identify different failed components.

11.3.1 Oscilloscope Hook-up

1. Following the manufacturer's instructions for your oscilloscope, connect the scope to the B+ and B- terminals of the alternator.
2. Adjust the oscilloscope to read 28 volts.
3. Turn on test bench and operate the alternator with a 10A load.
4. Compare oscilloscope display to the following test patterns.

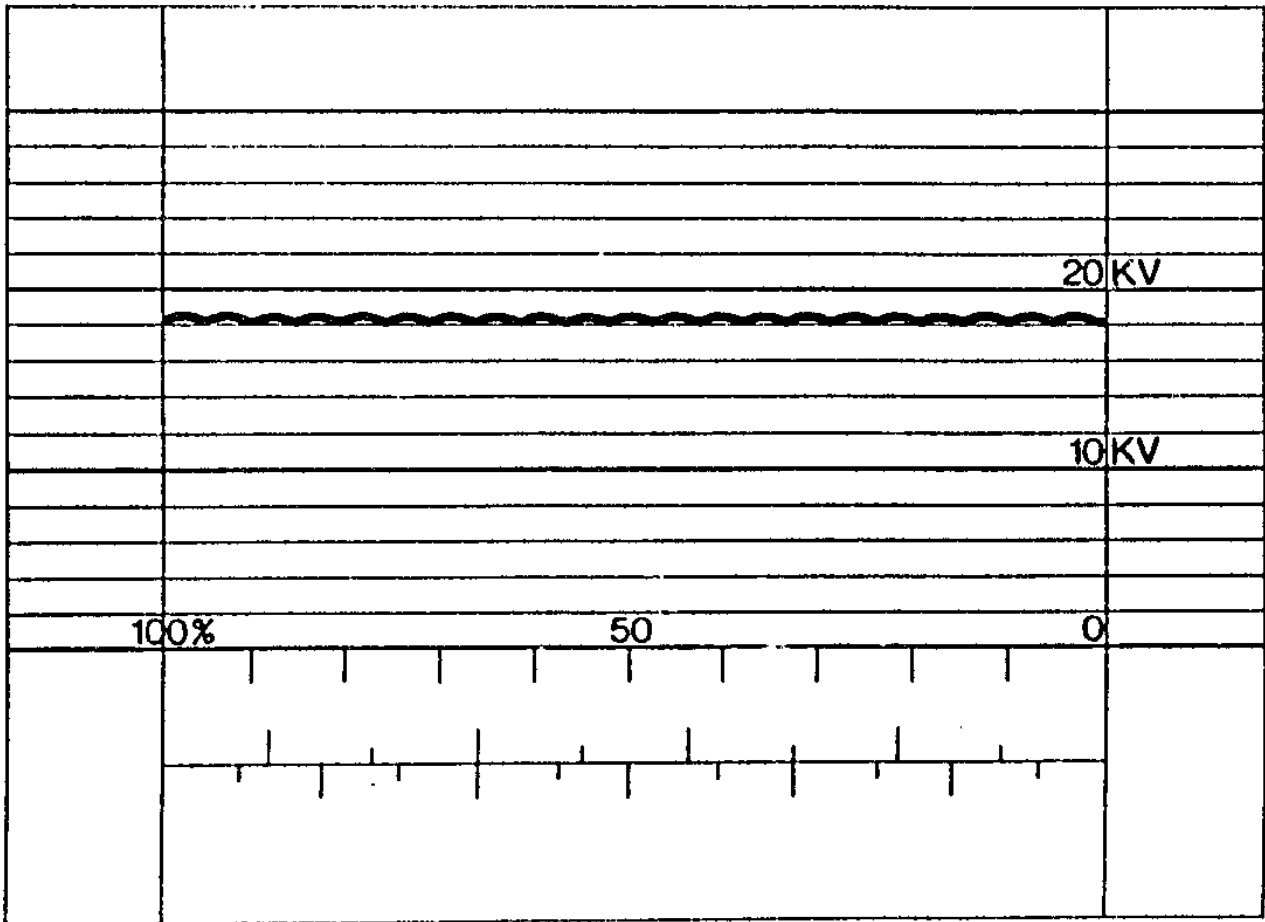


11.3.2 Normal Pattern

This image represents a properly functioning alternator. The D.C. voltage produced has a small harmonic wave.

Small spikes may be superimposed on the oscilloscope screen if the voltage regulator is regulating. Applying a load to the alternator output terminals can turn off the regulator.

In order to be able to compare oscilloscope images, the oscilloscope so the pattern fits between two vertical 10x divisions.



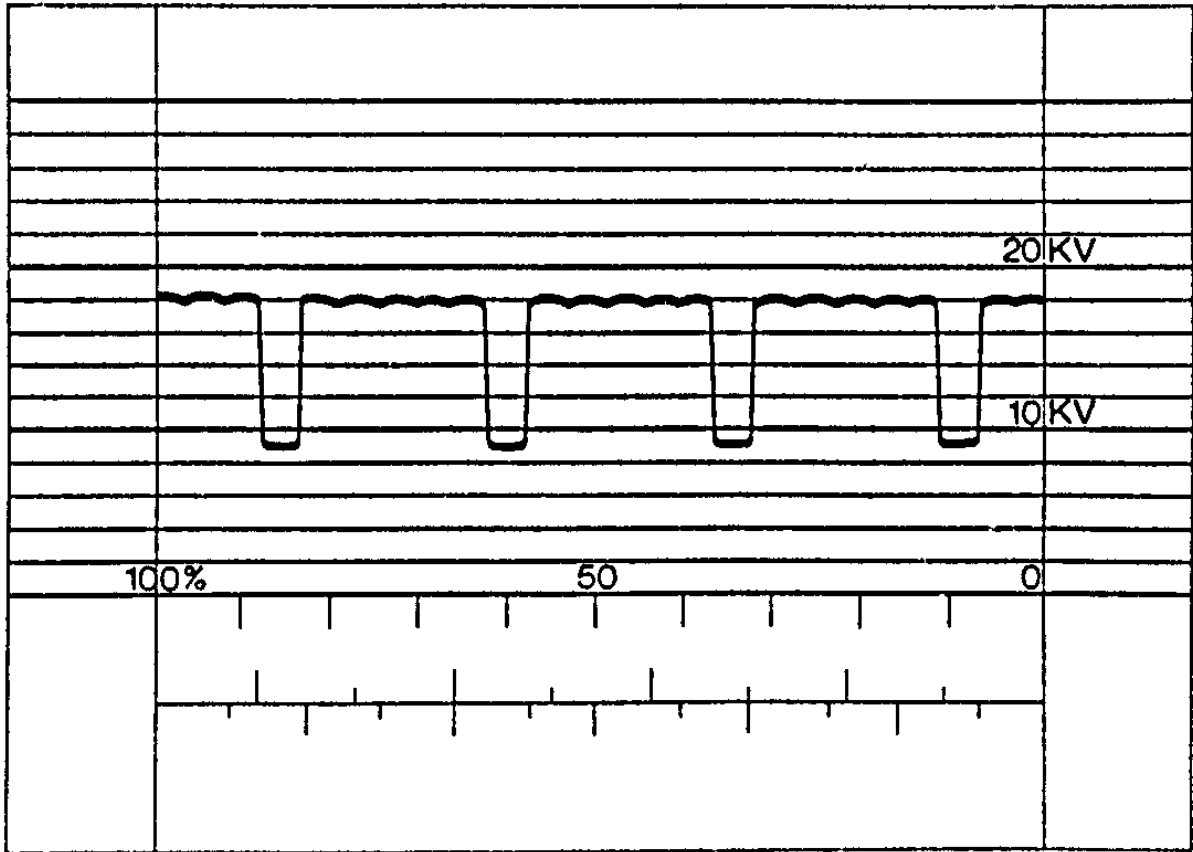
KME00052

Figure 40 Normal Pattern



11.3.3 Open Exciter Diode

This pattern displays a characteristic dip in the normally smooth wave characteristic of a defective exciter diode. This would require disassembly of the alternator and replacement of the rectifier assembly.



KME00053

Figure 41 Open Exciter Diode

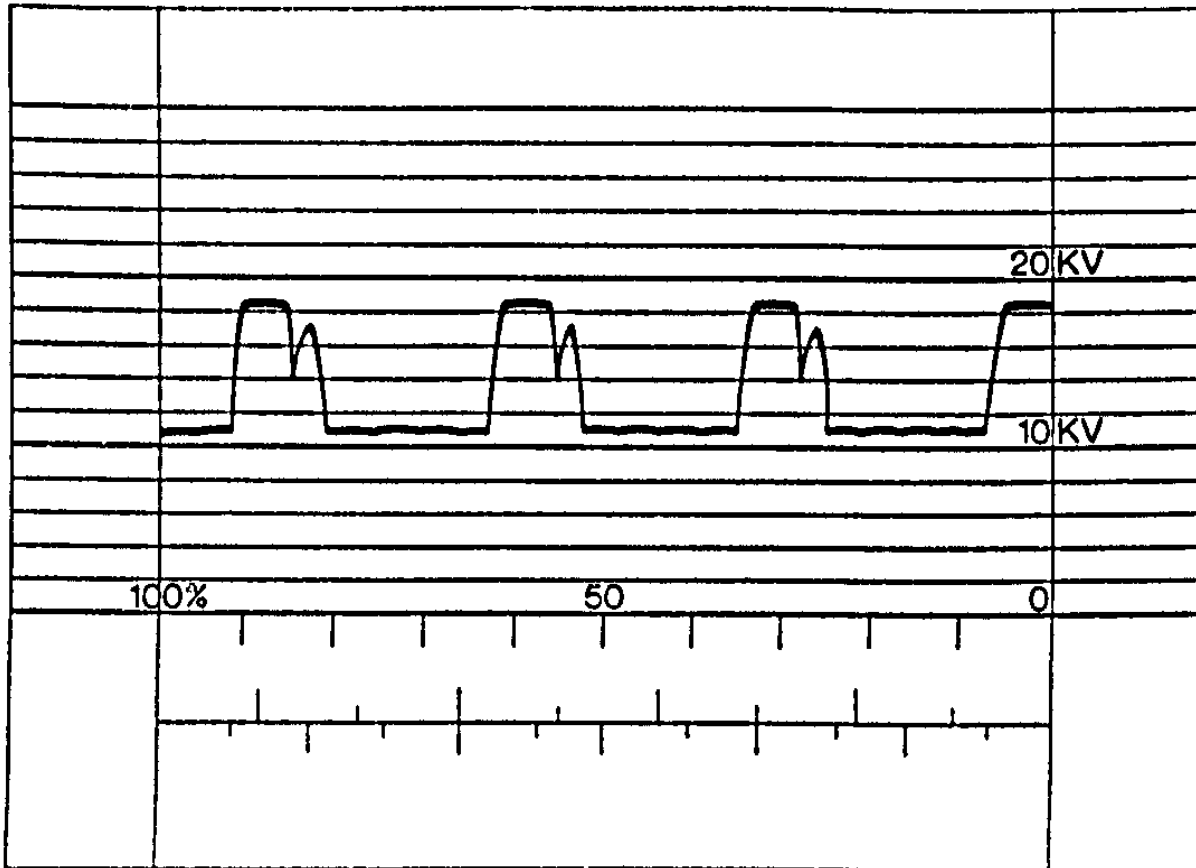


11.3.4 Open Positive Rectifier Diode

This pattern identifies an open positive rectifier diode. In the case of multiple diodes in parallel, all of the diodes on the circuit must be open. An example is:

There are two diodes in the rectifier for each phase of the stator. Both diodes must be open for this pattern to appear.

With this type of defect, the rectifier assembly must be replaced.



KME00054

Figure 42 Open Positive Rectifier Diode

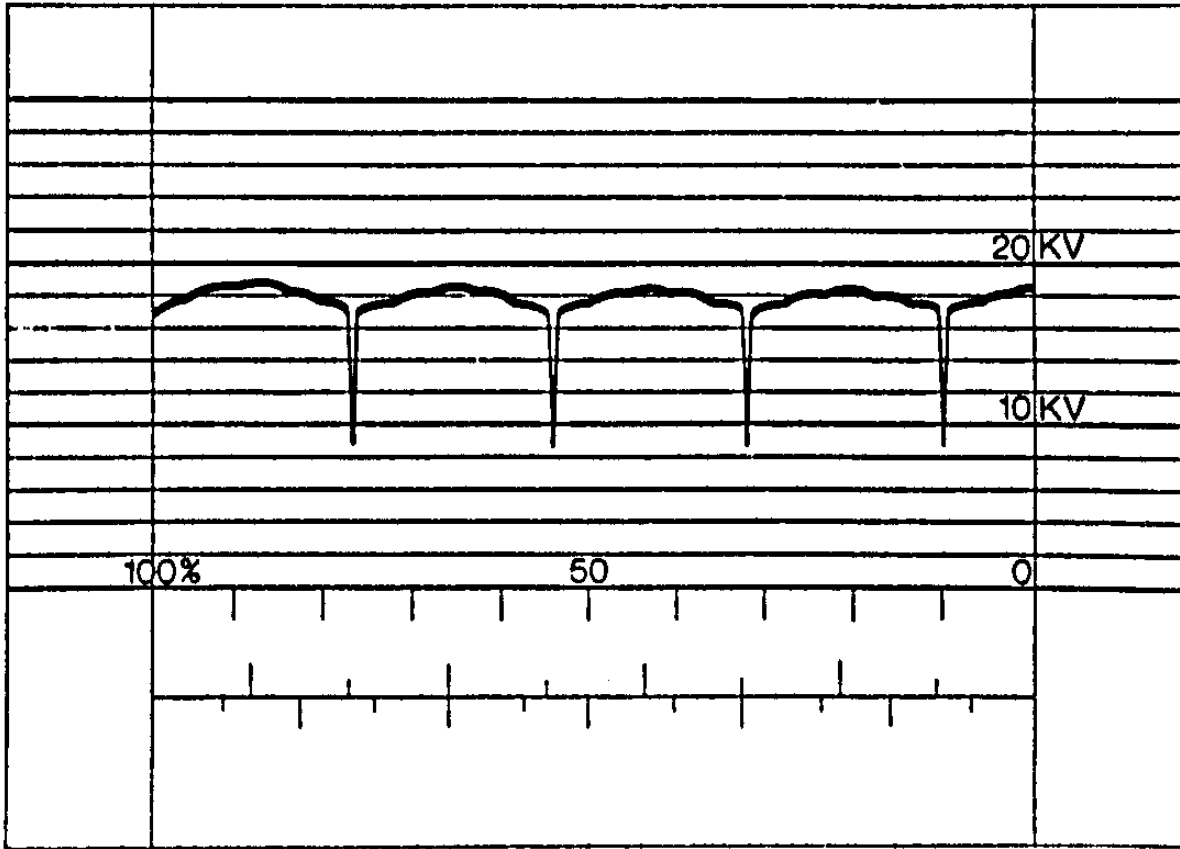


11.3.5 Open Negative Rectifier Diode

This pattern identifies an open negative rectifier diode. In the case of multiple diodes in parallel, all of the diodes on the circuit must be open. An example is:

There are two diodes in the rectifier for each phase of the stator. Both diodes must be open for this pattern to appear.

With this type of defect, the rectifier assembly must be replaced.



KME00055

Figure 43 Open Negative Rectifier Diode



11.3.6 Shorted Exciter Diode

This pattern identifies a shorted exciter diode. This would require disassembly of the alternator and replacement of the rectifier assembly.

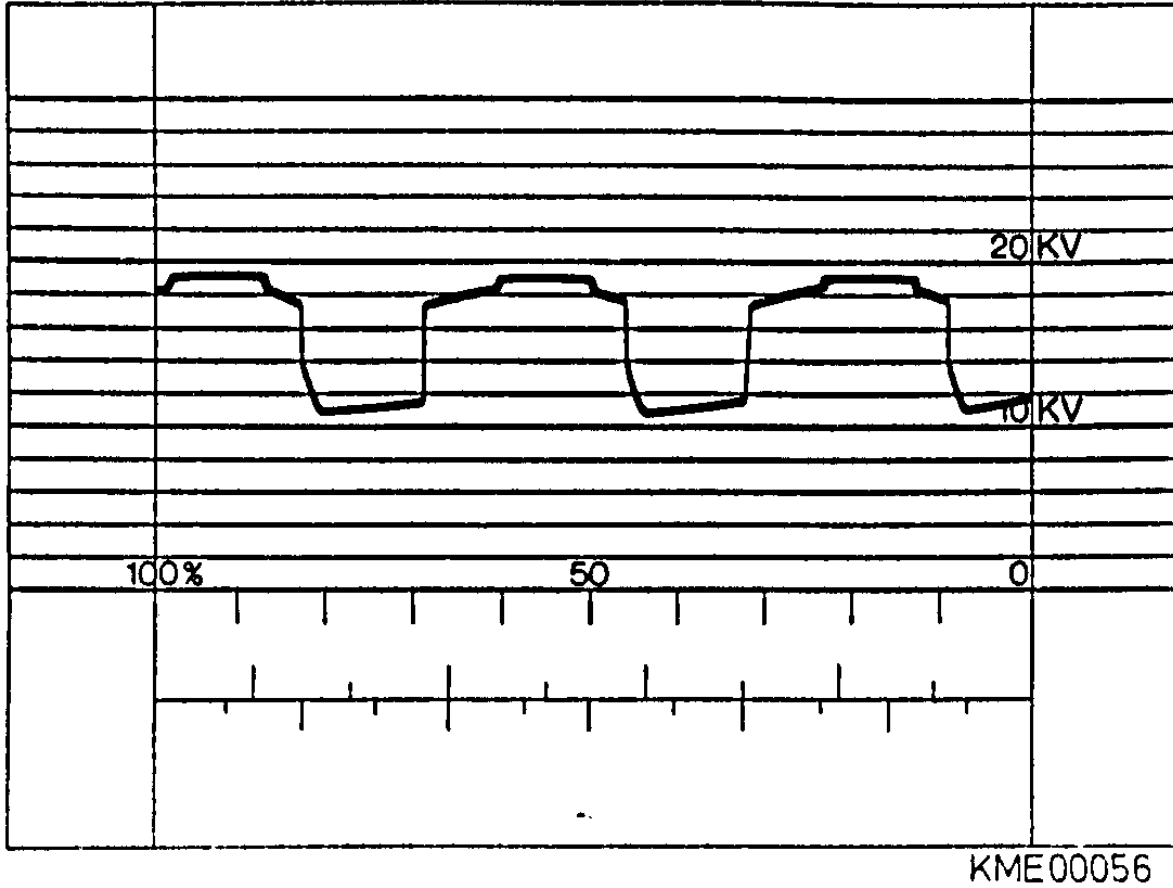


Figure 44 Shorted Exciter Diode



11.3.7 Shorted Positive Rectifier Diode

This pattern identifies a positive rectifier diode that is shorted. This defect requires replacement of the rectifier assembly.

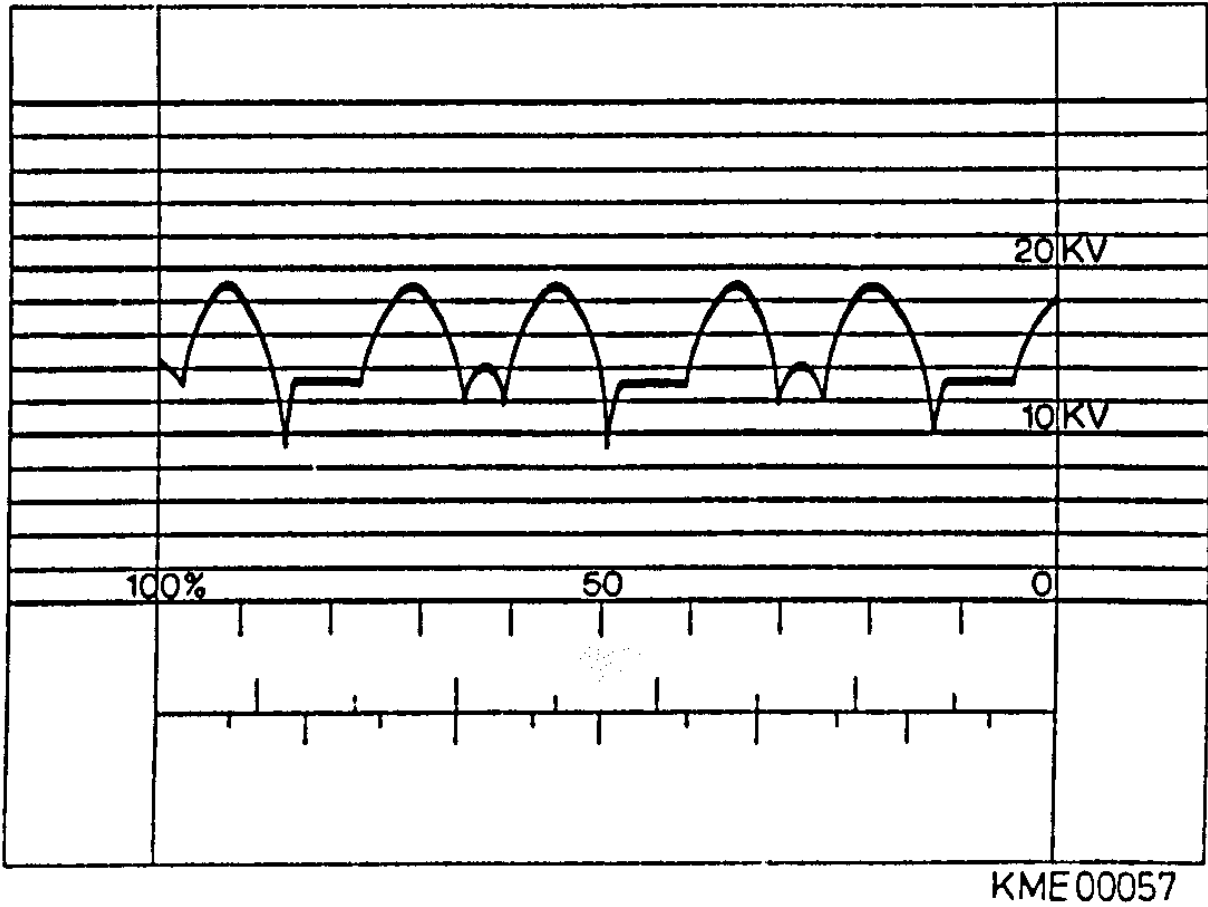
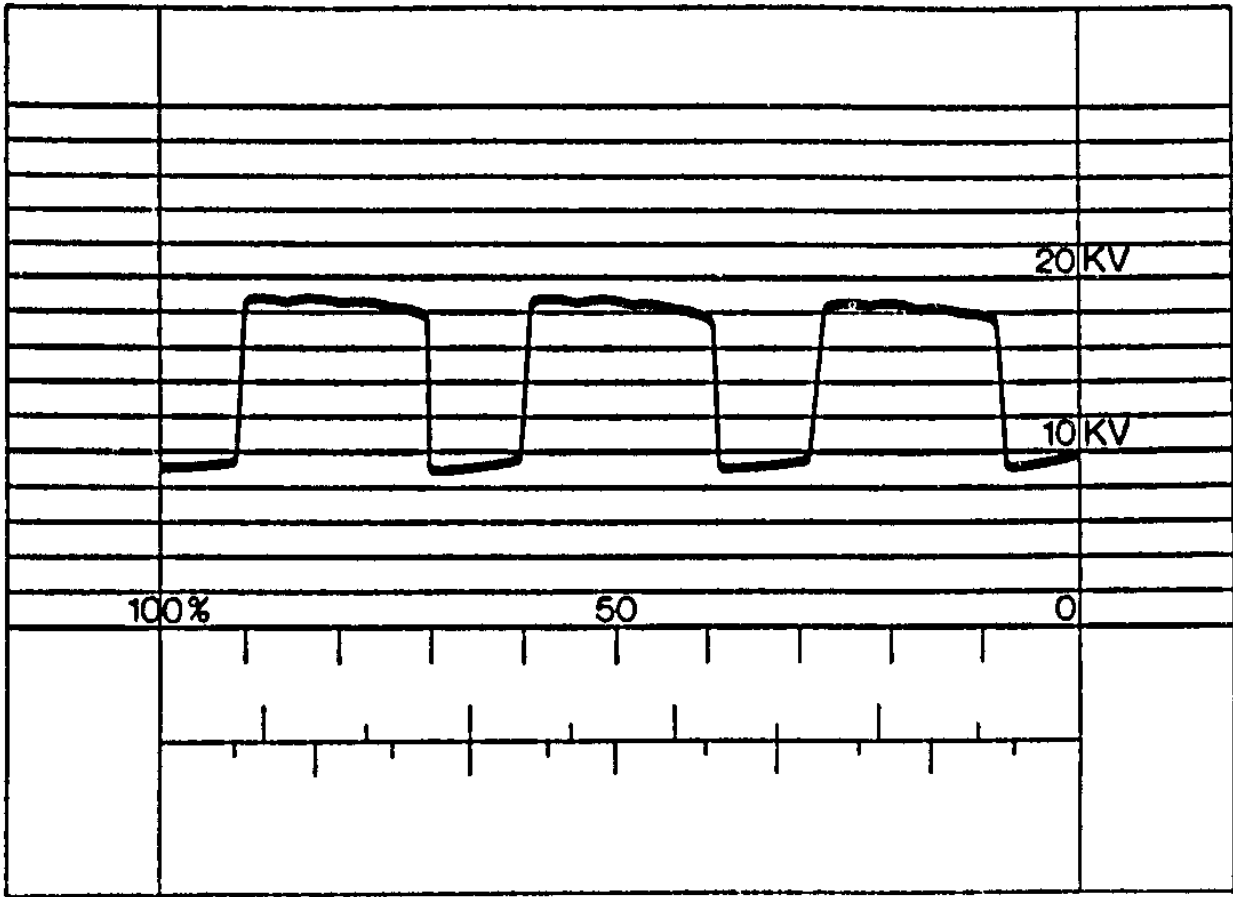


Figure 45 Shorted Positive Rectifier Diode



11.3.8 Shorted Negative Rectifier Diode

This pattern identifies a negative rectifier diode that is shorted. This defect requires replacement of the rectifier assembly.



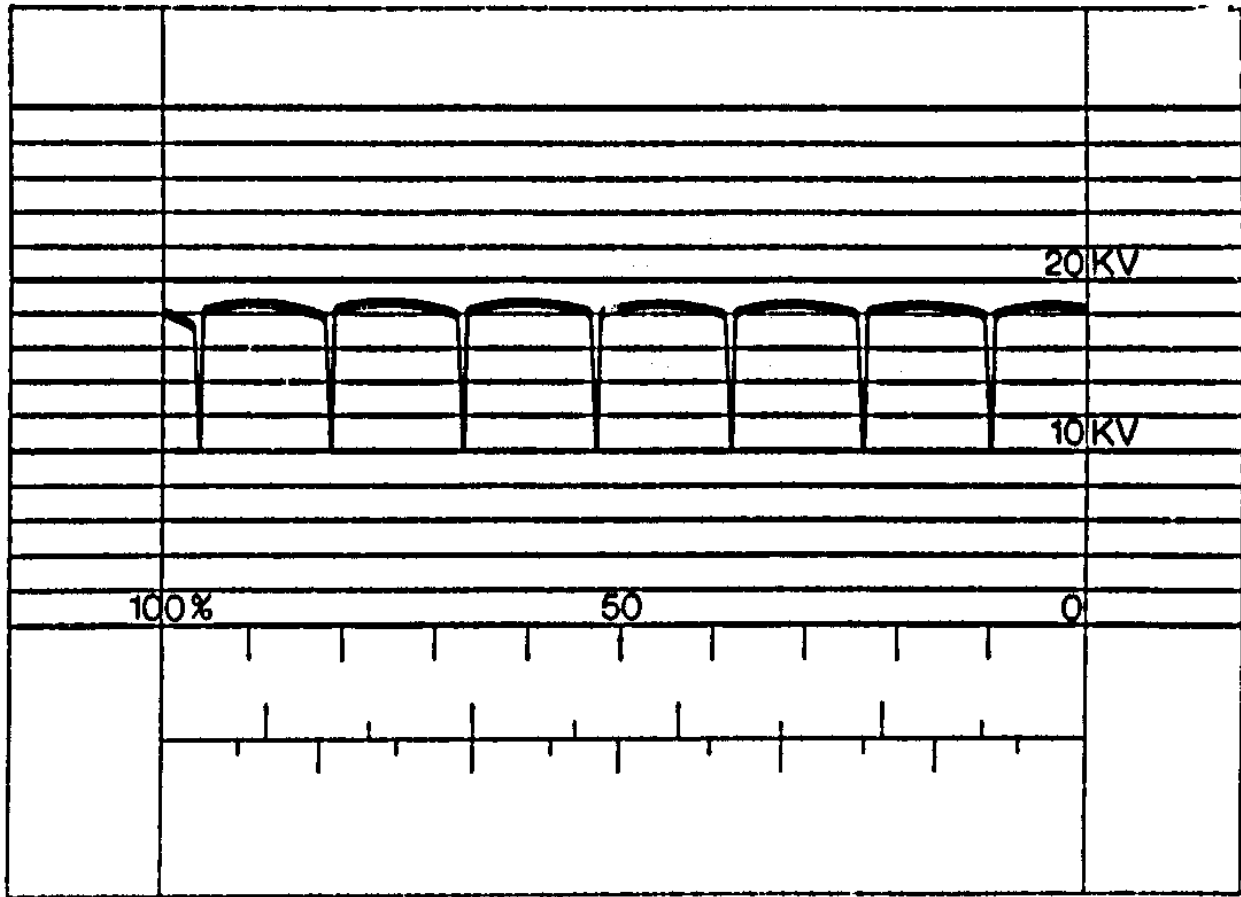
KME00058

Figure 46 Shorted Negative Rectifier Diode



11.3.9 Open Phase of Stator

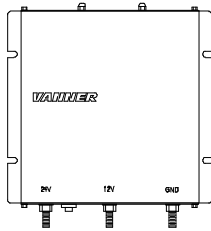
This pattern illustrates a stator with an open phase winding. This type of defect would require replacement of the stator.



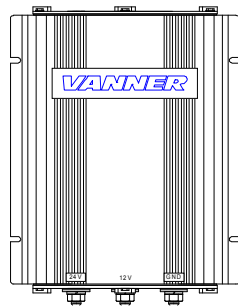
KME00059

Figure 47 Open Stator Phase

VoltMaster Battery Equalizer



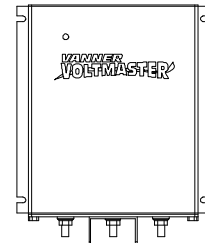
Family 1
 60-10B
 60-20A
 60-50A
 60-50E
 60-50M



Family 2
 60-100C
 60-100D
 60-100E



Family 3
 60-60
 60-60M
 60-80
 60-100



<u>Family 4</u>	<u>Family 5</u>
65-60	66-60
65-60M	66-80
65-80	66-100
65-100	

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Introduction

Thank you for purchasing a Vanner *VoltMaster* Battery Equalizer. We are confident that you will be very pleased with its performance because our Battery Equalizers are designed and manufactured by skilled professionals using the highest standards in workmanship. With minimum maintenance and care, you can be assured of many years of trouble free service.

General Description

The Vanner *VoltMaster* Battery Equalizer is an efficient and highly reliable method of obtaining a 12 volt DC power source from a 24 volt DC electrical system. The equalizer makes the batteries look like they are in series and parallel at the same time. In addition to providing regulated 12 volt power, the system ensures that battery voltages remain equal which significantly extends battery life. Ideally suited for vehicle and alternate energy applications, the *VoltMaster* Battery Equalizer is designed to save your batteries and the money you would spend replacing them. Users of the Vanner *VoltMaster* Battery Equalizer know that it is the most cost effective and dependable solution for dual voltage systems.

A typical system would include a 24VDC power source, such as an alternator or solar array, two 12 volt battery banks in series, and the *VoltMaster* Battery Equalizer. The Battery Equalizer connects to the 24 volt, 12 volt and ground terminals of the battery system. When the 12 volt loads require power, the Battery Equalizer ensures that the current is taken equally from both batteries, and that the voltages of the two batteries are kept equal. This equalization ensures extended battery life and provides a stable 12 volt supply for operating accessories.

Parallel Equalizers: Models are available which provide 10, 20, 60, 80 and 100 amps of 12 volt DC power. *VoltMaster* Battery Equalizers may also be operated in parallel to provide more power. For example, two 60 amp units can be installed to provide 120 amps of 12 volt DC power. Family 1, Family 3, Family 4, and Family 5 models may be paralleled in any combination. Family 2 models may be paralleled only with other Family 2 models.

NOTE: The Vanner *VoltMaster* Battery Equalizer is an extremely reliable device and, when installed according to the instructions, will provide reliable operation for an indefinite period of time. However, if a system abnormality should develop that would cause a Battery Equalizer malfunction, damage to the battery system could result if 12 volt loads are present. If your system application is critical you may consider installing a Vanner **Model EM-70 Electrical System Monitor**. This module monitors the battery system's voltages and balance, and provides fault signals that can be wired to warning lights, buzzers or other control/warning devices. Models 60-50M , 60-60M and 65-60M have the EM-70 built in. Call Vanner for more details.

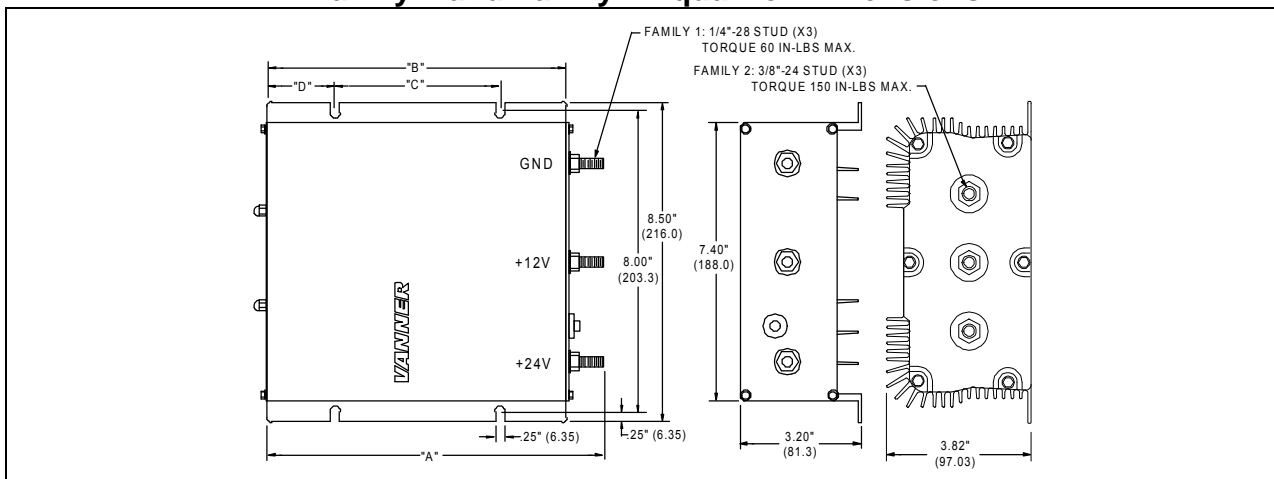
Specifications

	Family 1			Family 2*	Family 3* / Family 4			Family 5		
Model Number	60-10B	60-20A	60-50A*	60-100E*	60-60*	60-80*	60-100*	66-60	66-80	66-100
					65-60	65-80	65-100			
Input Voltage 24v	20 to 35v			18 to 36v	18 to 32v			18 to 32 v		
Efficiency (Peak)	>91%	>92%	>92%	>94%	>97.5%	>97.5%	>97.5%	>97%	>97%	>97%
Max 24v Input Amps	6	12	28	55	32	43	53	32	43	53
Output Voltage	(Input Voltage/2) ±2% - 50mv									
Output Amps (12v)	0-10	0-20	0-50	0-100	0-60	0-80	0-100	0-60	0-80	0-100
Standby Current	17 milliamps nominal at 28.4V									
Operating Temp.	-40° C to +71° C (-40° F to 160° F)				-40° C to +75° C (-40° F to 167° F)					
Storage Temp.	-54° C to +85° C (-65° F to 185° F)				-54° C to +95° C (-65° F to 203° F)					
Serviceable	Yes	Yes	Yes	Yes	No	No	No	No	No	No
Environmental Considerations	Anodized aluminum enclosure provides protection against salt, fungus, dust, water, fuel vapors and all fluids associated with commercial and off-highway vehicle operations. Continuous exposure to splashes and spills should be avoided.									
Mounting Location	Mount on a flat surface close to the batteries to allow short cable runs. Vertical mounting with terminals down is recommended. Location should be protected from battery acid and gases.									
Weights	2.3 lbs	5.0 lbs	7.0 lbs	9.5 lbs	6.0 lbs	6.6 lbs	6.6 lbs	6.0 lbs	6.3 lbs	6.3 lbs
					7.0 lbs	7.6 lbs	7.6 lbs			

Unlisted models: Model 60-60M and 65-60M have built-in EM-70 Electrical System Voltage Monitor. Model 60-50M is a 60-50A with built-in EM-70. Model 60-50E is a 60-50A with weather resistant gasket. Model 60-100C is an early 60-100E. Model 60-100D is a 60-100C with circuit breakers instead of internal fuses. Older models not listed in the above table should be tested as Family 1 and should be considered non-repairable.

*Obsolete.

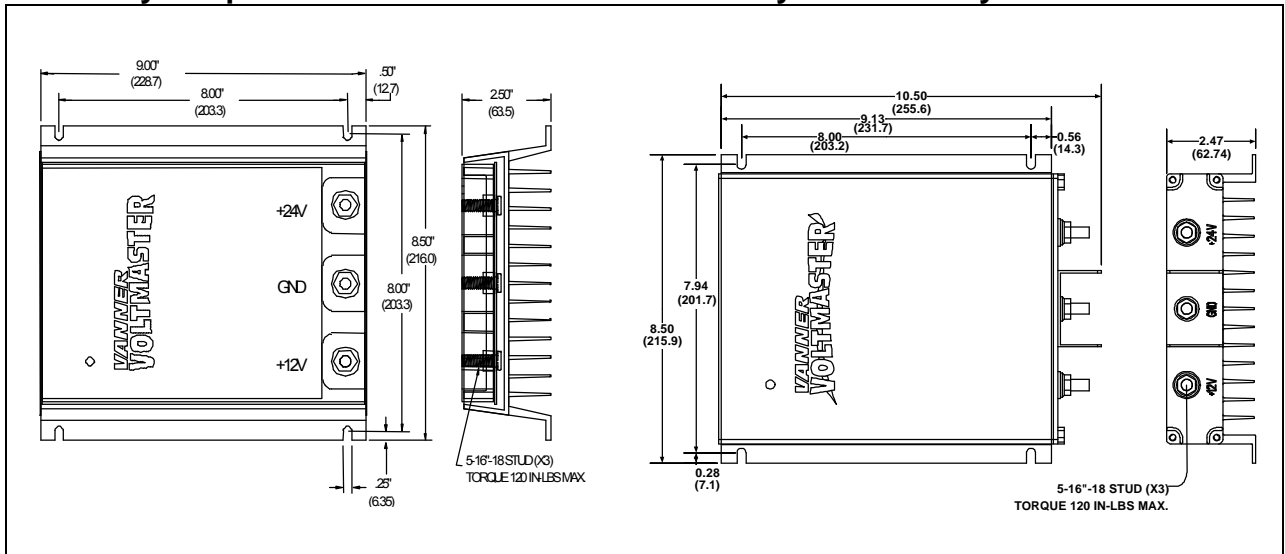
Family 1 and Family 2 Equalizer Dimensions



Model	"A"	"B"	"C"	"D"
60-10B	4.25 (107.9)	3.00 (76.3)	2.00 (50.80)	0.50 (12.7)
60-20A	9.38 (238.2)	8.00 (203.2)	4.50 (114.3)	1.75 (44.4)
60-50A	13.38 (339.8)	12.00 (304.8)	8.00 (203.2)	2.00 (50.8)
60-100C	13.46 (341.88)	12.00 (304.8)	8.00 (203.2)	2.00 (50.8)

Family 3 Equalizer Dimensions

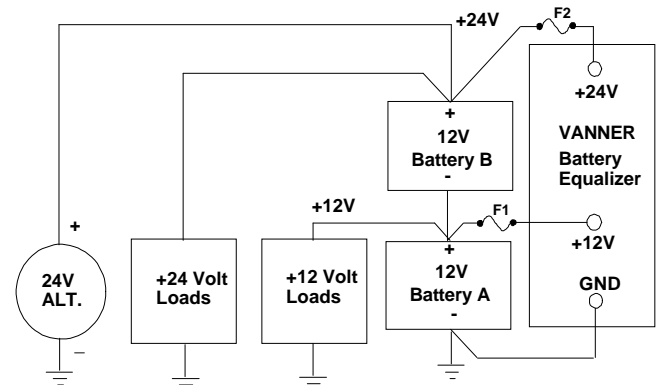
Family 4 and Family 5 Dimensions



Theory of Operation

In many 24 volt electrical systems it is desirable to tap into the battery system to obtain power for 12 volt loads. This method, while seemingly simple, causes a charge imbalance resulting in Battery B (see diagram) being overcharged, and possibly boiling, while Battery A discharges.

To solve this application problem the Vanner *VoltMaster* Battery Equalizer is connected to the battery system at the +24 volt, +12 volt, and ground points. The Battery Equalizer makes the batteries look like they are in series and in parallel at the same time. The Battery Equalizer maintains the voltage balance and therefore the charge acceptance rate of each battery. Family 3 and Family 4 Equalizers hold Battery A and B voltages to within 0.05 volts under light loads and to within 0.1 volts at full rated load. Family 1 and Family 2 models hold Battery A and B voltages to within 0.10 volts under light loads and to within 0.50 volts under full rated load.



Note-Battery Banks A and B should have the same amp-hour capacity.

When the voltage of Battery A is higher than or equal to Battery B the Battery Equalizer is in the standby mode, i.e., it is not transferring power from its 24 volt input to its 12 volt output. When a 12 volt load is present, and Battery A's voltage decreases to just below the voltage of Battery B, the Battery Equalizer activates and transfers sufficient current from Battery B to Battery A to satisfy the load and maintain an equal voltage and charge in both batteries.

A key advantage of a system containing a Vanner *VoltMaster* Battery Equalizer, compared to a DC to DC converter, is that if the 12 volt load requires a momentary surge current which exceeds the rated capacity

of the Battery Equalizer, Battery A will supply the extra current to the load. The Battery Equalizer will then replenish the energy to Battery A after the surge has passed.

The *VoltMaster* Battery Equalizer is a completely automatic device that requires no human intervention when installed according to the recommended procedures. Family 1 Equalizers and some Family 2 Equalizers have a manually resettable circuit breaker. If the circuit breaker trips, due to a system overload or abnormality, it can be reset by pushing the white button. Note that on some units the white circuit breaker button may protrude slightly in its normal (non-tripped) position. A blown fuse on Family 2 Equalizers requires factory repair. There are no user operational devices on Family 3, Family 4 or Family 5 models.

The following scenarios describe the *VoltMaster* Battery Equalizer's system operation.

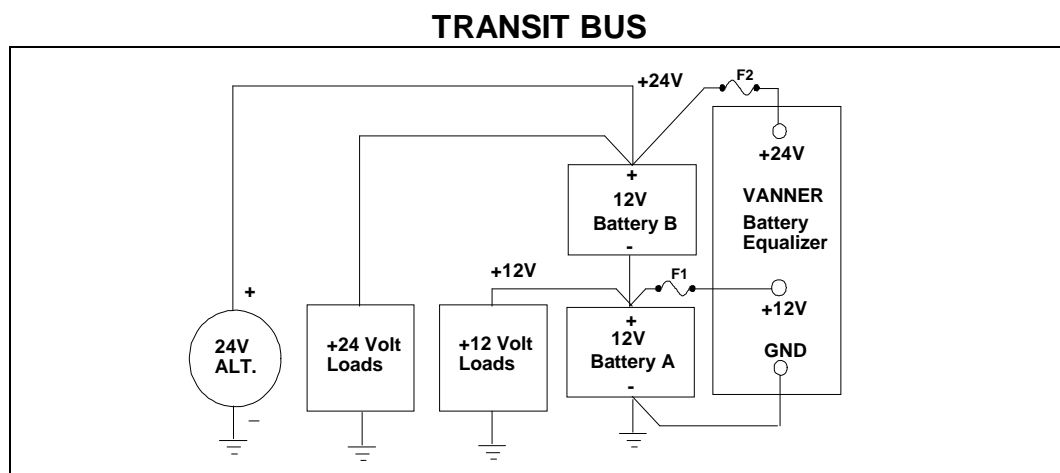
Scenario #1 - 24 volt load present, no 12 volt load present. The system operates as a system would without the Battery Equalizer whether the alternator is ON or OFF. The Battery Equalizer is in the standby mode except for making small adjustments to keep the batteries in balance.

Scenario #2 - Both 24 volt and 12 volt loads present, alternator is OFF. The Battery Equalizer will insure that both batteries will discharge at the same rate even if different loads are present.

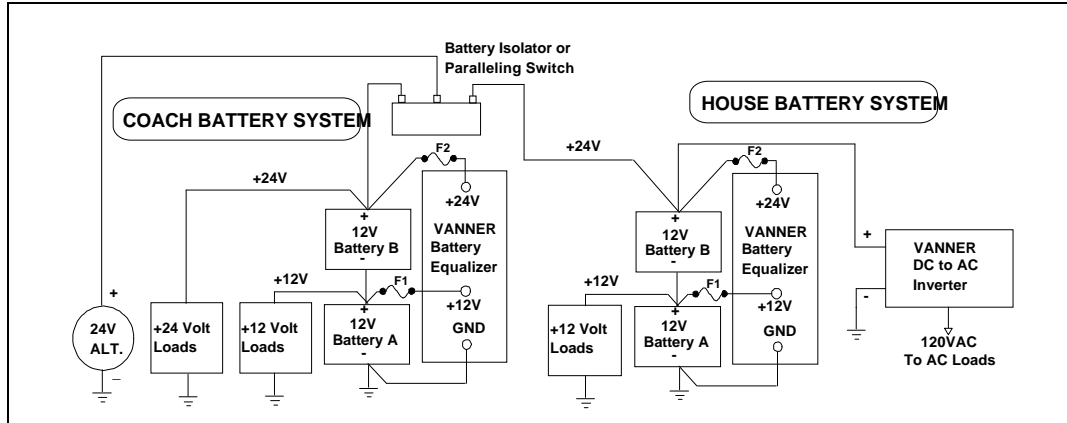
Scenario #3 - Both 24 volt and 12 volt loads present, alternator is ON. The alternator provides 24 volt power to the battery system and to the 24 volt loads. The Battery Equalizer transfers power from the 24 volt source to the 12 volt load by converting 24 volt power to 12 volts. It will supply sufficient 12 volt power to satisfy the 12 volt load and to maintain battery voltage balance.

Typical Applications

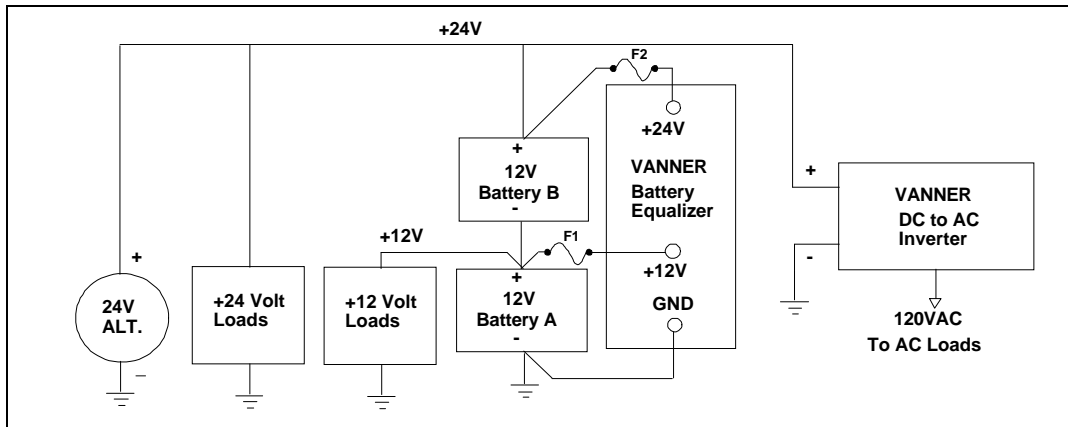
Vanner *VoltMaster* Battery Equalizer are used in many types of applications including transit and tour buses, private coaches, heavy trucks and off highway equipment, yachts, and alternative energy systems such as solar powered homes. In addition to Battery Equalizers, Vanner manufactures a wide range of complementary products such as DC to DC converters, DC to AC inverters, battery charger/conditioners, and battery isolators. The following system diagrams illustrate how these products are used in various applications.



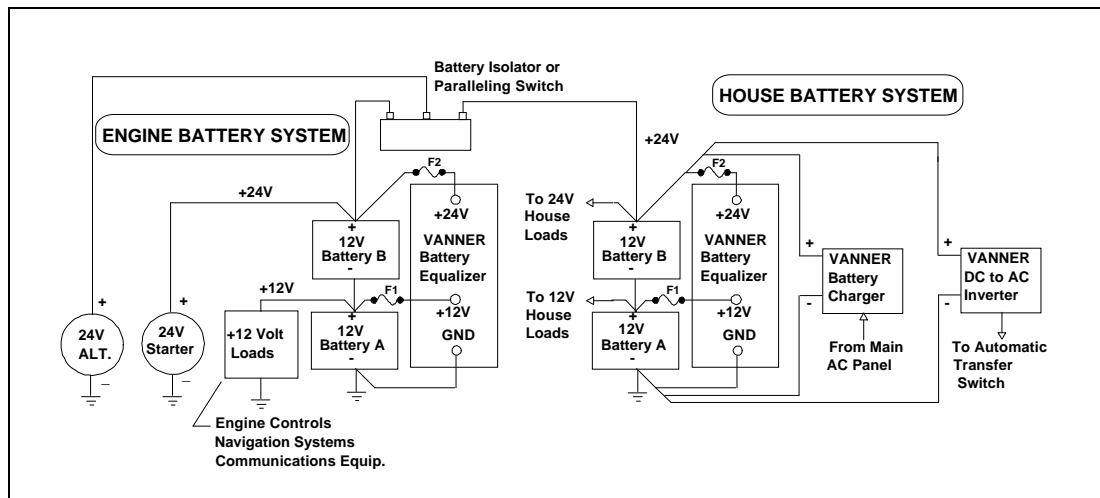
PRIVATE COACH



TOUR/CHARTER COACH



MARINE



Installation Instructions

When connecting wires or cables to the available post (+24, GND, +12) when installing Vanner Equalizer Models 60-60, 60-80, 60-100, do not exceed the specified torque of 120 in-lbs. This information is printed on the Product Label just above the connection post. Torque values higher than specified may damage the product, reducing performance or creating hazardous conditions. Products damaged by improper torque may not be covered by warranty.

Do not connect more than one conductor per available post on any model of Vanner Equalizer. Multiple wires and cables may overstress internal components, resulting in poor performance or creating hazardous conditions. Products damaged by the installation of multiple conductors per post may not be covered by warranty.

Fault protection devices must be installed between the Equalizer and the power source (battery). A fault protection device would be any fuse or circuit breaker properly rated for the maximum DC current obtainable. This advisory is in accordance with SAE, NEC and UL, for mobile power applications. Install per applicable codes or within 18" of the battery. See Wire and Fuse Sizing Chart on page 9 of this manual or contact Vanner at 1-800-227-6937 or pwrsales@vanner.com if assistance is needed in sizing fault protection devices.

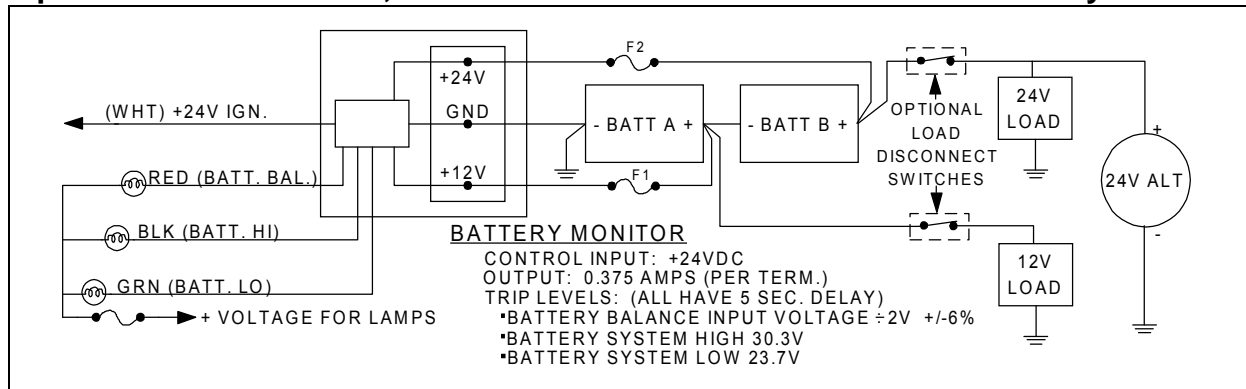
Caution: This equipment employs components that tend to produce arcs and sparks. To prevent fire or explosion, do not install in compartments containing batteries or flammable materials. Safety goggles should always be worn when working near batteries

Mounting Location –The Equalizer may be mounted in any orientation, however, the recommended orientation for optimum heat dissipation is vertical. It is recommended that the wiring terminals be down to prevent the possibility of a falling metal object shorting the terminals. Do not mount in zero-clearance compartment that may result in the Equalizer overheating. Locate so that contact by people is unlikely.

Environmental Protection – Do not expose to rain or moisture. The unit should be located in an area that will protect it from direct exposure to moisture such as high pressure washing, rain, etc.

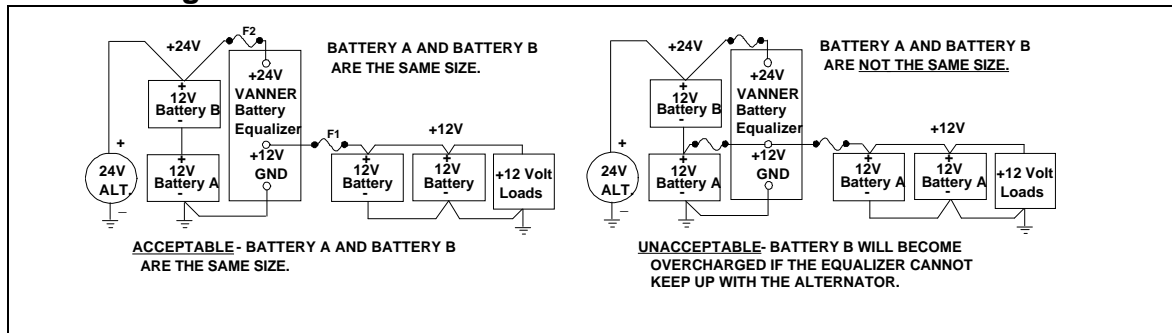
Wiring Sequence– To prevent reverse polarity damage on Family 1 and Family 2 models when connecting/disconnecting battery terminals: ALWAYS 1) Remove Equalizer ground terminal first, and 2) Replace Equalizer ground terminal last. The wiring sequence is not an issue with Family 3 or 4 models.

Equalizer Models 60-50M, 60-60M and 65-60M with built-in EM-70 Battery Monitor



The EM-70 Battery Monitor provides the following ground signals: Battery HI when +24 rises above 30.3V, Battery LO when +24 falls below 23.7V, Battery BALANCE when +12 is not within 6% of (+24 \div 2). Each ground signal is rated 0.375 amps and should be protected by a 1 amp fuse.

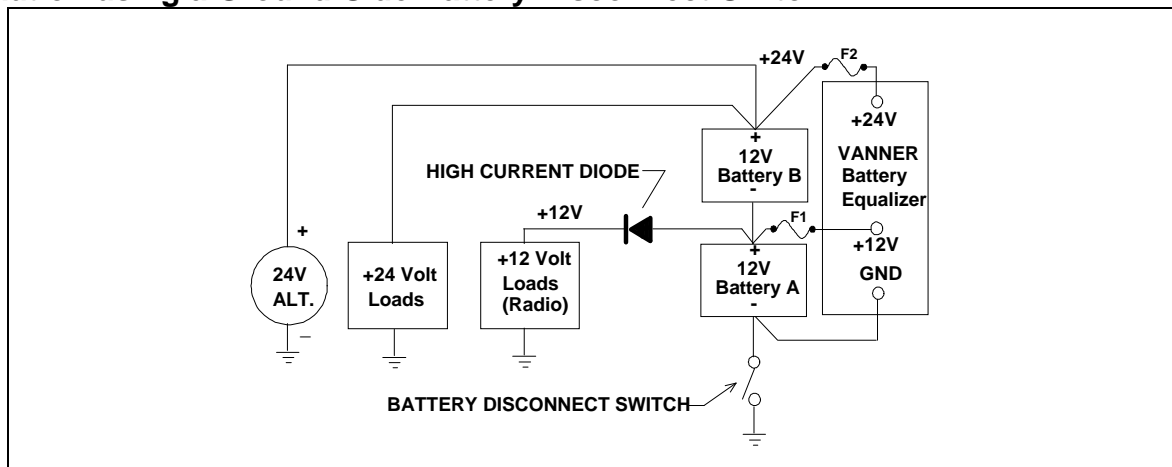
Caution adding 12volt batteries



In certain applications, such as private coach or alternate energy applications, it may be desirable to have additional 12 volt “House Batteries” to operate heavy 12 volt (inverter) loads. Use the Equalizer to charge the additional batteries.

Connect the Equalizer 12V terminal to the additional batteries only. Do not connect the Equalizer 12V terminal to both battery banks as this would make Battery A larger than Battery B. **Damage to Battery B may occur during charging** due to overcharging, if the equalizer cannot keep up with the charging system.

Caution using a Ground-Side Battery Disconnect Switch



The system must be wired as shown to prevent Reverse Polarity Damage to polarity sensitive 12 volt loads and Family 1 and Family 2 Equalizers while the ground-side disconnect switch is open. The equalizer's GND terminal must be wired to the battery side of the ground-side disconnect switch circuit for the equalizer to work properly.

Install the external High Current Diode, such as Vanner Model 52-75 (45 amp continuous rating) to protect polarity sensitive 12 volt loads if these loads do not already contain input diode protection. This prevents a reverse polarity on the 12 volt equipment when the battery switch is open. The reverse polarity does not come from the Equalizer but from any 24 volt equipment that may be turned ON.

Wire Size and temperature rating

Cables connecting the Battery Equalizer to the batteries must be sufficiently large to prevent unwanted voltage drops. These voltage drops (loss) must be less than 0.05 VDC between the Equalizer's +24 volt terminal and the battery +24 volt terminal (Battery B positive terminal), less than 0.10 VDC between the Equalizer's +12 volt terminal and the battery +12 volt terminal (the jumper between Battery A and Battery

B), and less than 0.05 VDC between the Equalizer' s GND terminal and the battery ground terminal (Battery A negative terminal that is connected to chassis ground). In most installations, the Battery Equalizer' s terminals are wired directly to the battery terminals to prevent voltage loss that could occur in switch contacts, connections, and long wire runs. Since the equalizer can be operated in temperatures up to 71° or 75° C, use wire rated at least 90° C. See Wire and Fuse Size Chart.

Wire and Fuse Size Chart

Wire Size AWG	Ring Terminal Molex or UL recognized equal	Max wire length, in feet, between Equalizer and battery to keep voltage drop under 0.1 volt. The chart assumes wire carries no other load and wire temperature is below 80° C.						
		60-10	60-20	60-50	60-60	60-80	60-100	2 x 60-100
					65-60	65-80	65-100	2 X 65-100
					66-60	66-80	66-100	2 X 66-100
#14	191930072	3.2	XXX	XXX	XXX	XXX	XXX	XXX
#12	191930134	5.0	2.5	XXX	XXX	XXX	XXX	XXX
#10	191930134	7.7	3.8	XXX	XXX	XXX	XXX	XXX
#8	191930157	12.8	6.4	2.6	2.1	XXX	XXX	XXX
#6	191930251	19.4	9.7	3.9	3.2	2.4	XXX	XXX
#4	191930278	35.2	17.6	7.0	5.9	4.4	3.5	XXX
#2	191930309	51.9	26.0	10.4	8.7	6.5	5.2	2.6
#1	191930333	65.4	32.7	13.1	10.9	8.2	6.5	3.3
#1/0	191930333	82.9	41.4	16.6	13.8	10.4	8.3	4.1
#2/0	191930346	105.5	52.7	21.1	17.6	13.2	10.5	5.3
Fuse F1		20 amp	30 amp	80 amp	80 amp	100 amp	125 amp	250 amp
Fuse F2		10 amp	15 amp	35 amp	40 amp	50 amp	80 amp	150 amp

Crimp the ring terminals using *Molex* tool 192840002 (14ga), 192840001 (10 -12ga), 192840035 (2 - 8ga) (phone 813-521-2700) and *AC Terminal* tool model 0280 (6 ga and larger) (phone 614-868-9828).

Testing and Troubleshooting

All Vanner equalizers fall into one of three distinct families. The three families operate differently and must be tested differently. The following three test procedures apply **only** to the equalizer family listed.

CAUTION

Servicing of electrical systems should only be performed by trained and qualified technical personnel.

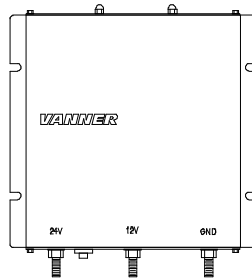
Equipment Required

- VoltMeter having 0.01 volt resolution. (Fluke Model 87 Multimeter recommended).
- Clamp-on amp meter (Fluke Model 36 Clamp-on Meter recommended).

Vanner Repair Service

Vanner offers a quick turn around factory repair service for Family 1 and Family 2 models. (Family 3, 4 and 5 models are non-repairable.) Send the unit to the address below with a note instructing us to repair it. Include your name, phone number, shipping address (not a P.O. Box Number), and your purchase order number.

Test Procedure for Family 1 Battery Equalizers



Models 60-10B, 60-20A, 60-50A

CAUTION

To avoid Reverse Polarity Damage to Family 1 and Family 2 Equalizers when servicing the electrical system or when performing any work which involves making battery connections always:

1. Remove Equalizer Ground terminal first.
2. Replace Equalizer Ground terminal last.

Family 1 Battery Equalizer Test Procedure:

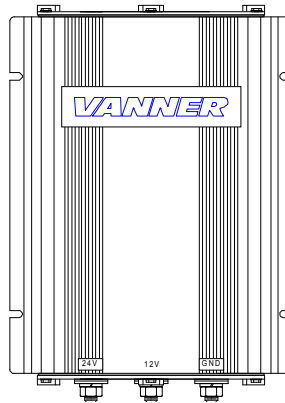
1. Carefully remove the ground (GND) cable from the Equalizer. Do not allow this cable to touch any other connection on the Equalizer because the other terminals are connected to the batteries.
2. Make sure there is approximately 12 volts between the +24 and +12 terminals of the Equalizer by momentarily connecting the two terminals of a 12 volt light (headlight, marker light, etc.) to the +24 and +12 terminals of the Equalizer. The light should light and stay lit.
3. Next, connect that same 12 volt lamp between the +12 and GND terminals of the Equalizer. The lamp should light and stay lit. If the lamp does not light, the light then goes out, or the light dims, the Equalizer requires repair.
4. Further verification may be made by measuring the voltages on the Equalizer terminals. Be certain that the lamp used earlier is connected between the +12 and GND terminals.
5. Measure the voltage between +24 and +12 terminals. Note this reading.
6. Measure the voltage from the +12 terminal to GND. Note this reading.
7. Compare the two readings by subtracting the +12 to GND reading from the +24 to +12 reading. A properly functioning Equalizer is one where the difference is between -0.5 and +0.13 volts. For example, the +24 to +12 reading might be 12.85 volts. The +12 to GND voltage might read 12.75 volts. This Equalizer would be functioning properly with a 0.10 difference (12.85 minus 12.75 volts) which is within specs.

Common Questions for Family 1 Battery Equalizers

- Q) Will operating loads which exceed the output rating of the Battery Equalizer cause the circuit breaker (white button near the wiring terminals on Family 1 or Family 2 equalizers) to trip?

- A) No, the Battery Equalizer electronically limits the output current to a value less than the amount required to trip the circuit breaker. (Extreme conditions, such as 28 VDC input with 8 VDC output at very high ambient temperatures, may cause the circuit breaker to trip.)
- Q) Why is the Battery Equalizer' s circuit breaker value lower than its output current rating (35 amp circuit breaker in model 60-50A)?
- A) The circuit breaker is in the ground circuit. Due to the equalizer's two to one (24/12 VDC) voltage conversion, the model 60-50A requires 25 amps at 24VDC input to produce about 50 amps output at 12 VDC. Therefore, a 35 amp circuit breaker in the GND circuit will properly protect for the maximum 25 amp rating.
- Q) What causes the circuit breaker to trip on a Battery Equalizer?
- A1) The Battery Equalizer' s circuit breakers designed to trip when the +12 volt to GND terminals are exposed to reverse polarity.
- A2) With the Battery Equalizer' s GND terminal connected to chassis and the battery negative terminal disconnected, a short between a +24 volt circuit and chassis will pull the chassis up to +24 volts, causing a reverse polarity on the +12 volt to GND circuits. The circuit breaker trips to protect the Battery Equalizer.
- A3) With the Battery Equalizer' s GND terminal connected to chassis and the battery negative cable disconnected, 24 volt loads (e.g., starter motor) will pull the chassis up to +24 volt causing a reverse polarity on the Battery Equalizer' s +12 Volt to GND circuits. The circuit breaker will trip to protect the Battery Equalizer.
- A4) Since the above reverse polarity conditions may occur during bus maintenance it is recommended that the service personnel verify the circuit breaker is IN before releasing the bus for service and the tour bus operator do the same in his "walk around".
- Q) What are some known conditions that could cause Battery Equalizer problems?
- A1) Corrosive liquids or water forced into the Battery Equalizer' s case from high pressure spray cleaning could shorten the normal life expectancy.
- A2) Drilling into the case (except for the mounting flanges) can shorten the life or prevent the unit from operating. The installer may not realize the Battery Equalizer is not operating correctly unless a 12 volt load is applied to the system and the Battery Equalizer 12 volt current is measured.
- A3) Too small of wire or bad connections will allow the Battery balance to be less than optimum. Voltage loss in wire from the battery' s +24 volt terminal to the Battery Equalizer' s +24 volt terminal should be 0.05 VDC maximum; from the battery' s +12 volt terminal to the Battery Equalizer' s +12 volt terminal should be 0.10 VDC maximum, and from the battery ground terminal to the Battery Equalizer' s GND terminal should be 0.05 VDC maximum, when the +12 volt load is causing the Battery Equalizer to operate at 100% capacity.
- A4) Installing the Battery Equalizer in a location where it will be exposed to battery fumes will shorten its normal life. Acid fumes are heavier than air. Installation of Battery Equalizers on the battery mounting surface near the bottom of the batteries have caused severe corrosion to the Battery Equalizers. However, installation of Battery Equalizers 3 or more inches above the top of the batteries have not caused problems.
- Q) Can different models of equalizers be paralleled?
- A) Yes, any combination of models from Family 1, Family 3 and Family 4 may be paralleled. Family 2 models may only be paralleled with other Family 2 models.

Test Procedure for Family 2 Battery Equalizers



Models 60-100C, 60-100D and 60-100E

General: Family 2 Equalizers were designed to be more energy conservative during low power requirements compared to Family 1 models. This along with unique protection circuitry require Family 2 models to be tested differently than Family 1, or Family 3, 4 and 5 models.

CAUTION

To avoid Reverse Polarity Damage to Family 1 and Family 2 Equalizers when servicing the electrical system or when performing any work which involves making battery connections always:

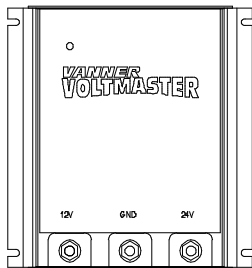
1. Remove Equalizer Ground terminal first.
2. Replace Equalizer Ground terminal last.

Family 2 Battery Equalizer Test Procedure:

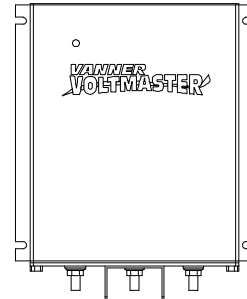
1. With the coach engine and vehicle loads OFF measure the voltage of Battery A. Replace or recharge Battery A if less than 11.5 volts.
2. Start the engine and turn ON a 12 volt load such as headlights.
3. Measure the input voltage between the +24 and GND posts of the equalizer. This voltage should be between 25.5 volts and 29.0 volts. If it isn't then check the alternator and 24 volt voltage regulator circuits.
4. Zero the DC Clamp-on ammeter as needed.
5. Put the jaws of the clamp-on ammeter around all wires connected to the equalizer +12 volt terminal stud.
6. Observe the DC amperage out of the equalizer with the clamp-on ammeter. If there are 3 amps or more showing on the ammeter, the equalizer is functioning and no further tests are needed.
7. Continue with the following steps ONLY if the ammeter shows less than 3 amps.
8. Measure the voltage between the +24 terminal (meter positive lead) and the +12 terminal (meter negative lead) of the equalizer. Record this voltage.
9. Subtract 0.60 volts from the number recorded in Step 8.
10. Measure the voltage between the equalizer +12 terminal (meter pos) and the GND terminal (meter neg).
11. Wait for this voltage to drop below the voltage calculated in Step 9 or the clamp-on ammeter reading jumps from approximately 0 to more than 3 amps. More than 3 amps means the equalizer is functioning.

12. If the voltage drops below the calculated value from Step 9 and the clamp-on ammeter has not jumper from approximately 0 to more than 3 amps of current wait for an additional 30 seconds.
13. If the equalizer does not turn ON after 30 seconds the unit is defective and should be sent in for repair.

Test Procedure for Family 3, 4 & 5 Battery Equalizers



Models 60-60, 60-80 and 60-100



Models 65-60, 65-80, 65-100
Models 66-60-66-80, 66-100

General: Family 3, Family 4 and Family 5 Equalizers contain an indicator light. If the indicator light is ON the equalizer is working.

The Equalizer is working properly if:

1. The Indicator Light is ON and;
2. The 12 volt DC loads are being operated continuously and are within the rated capacity of the equalizer and;
3. Battery A voltage is lower than Battery B by no more than 0.05 to 0.10 volts (measured at the equalizer +24, +12 and GND terminals).

Family 3, 4 and 5 Battery Equalizers are electronically protected against reverse polarity damage therefore the DC connection sequence is not an issue.

Family 3, 4 and 5 Equalizers will not function properly unless all three battery connections are made. Battery A and Battery B voltages both must be above 8 volts for the unit to turn ON.

Any combination of Family 1, Family 3, Family 4 and Family 5 models may be operated in parallel.

Please note that the 24V, 12V and GND stud position and orientation are different on Family 3, 4 and 5 models than on Family 1 or Family 2 models.

Family 3, Family 4 and Family 5 Battery Equalizer Test Procedure:

1. Field test the equalizer while fully connected to the vehicle batteries. For bench testing, two 12 volt batteries, or two 12 volt power supplies are required. Family 3, 4 and 5 Equalizers must be connected to the batteries at GND, 12V and 24V to function properly.
2. If battery voltage is below 24 volts start the vehicle or apply a 24 volt battery charger to the batteries.
3. Turn ON 12 volt DC loads up to the equalizer rated capacity. Measure DC amps on the equalizer +12 cable to verify load amperages.
4. **At the equalizer** measure and record:
 - a. Battery A voltage (voltage between the equalizer +12 and GND terminals)
 - b. Battery B voltage (voltage between the equalizer +24 and +12 terminals)
 - c. Equalizer Indicator Light status (ON or OFF)

5. Subtract Battery A voltage from Battery B voltage and compare readings.

Voltage Comparison		Indicator Light	Equalizer Status	
a.	Battery A is lower than Battery B but within 0.05 volt.	OFF	OFF	Stand-by Mode. The equalizer will not turn ON until Battery A is lower than Battery B by more than 0.05 volts.
b.	Battery A is lower than Battery B by 0.05 to 0.10 volts.	ON	ON	Normal Operating Mode
c.	Battery A is lower than Battery B by more than 0.10 volts	ON	ON	Self-Protection Mode due to Overload Condition. See below.
d.	Battery A is lower than Battery B by more than 0.10 volts	OFF	OFF	The Equalizer is not functioning properly.
e.	Battery A is <u>higher</u> than Battery B	Abnormal condition. Suspect Battery B is defective or a 12 volt load is connected to Battery B.		

Overload Condition on Family 3, Family 4 and Family 5 Equalizers

An overload condition exists when the 12 volt loads exceed the equalizer's rated capacity. The overload condition will not damage the equalizer but may cause damage to the batteries.

During the overload, the equalizer output is limited by internal protection circuits to its Rated Output Amps. The 12 volt amps exceeding the equalizer output are drawn from Battery A which will begin to draw the batteries out of balance. The equalizer full Rated Output Amps are maintained as long as Battery A and Battery B remain balanced within 0.10 volt. The internal protection circuits will reduce equalizer output as the batteries become further out-of-balance. If Battery A voltage falls below approximately 8 volts the equalizer will shut itself OFF.

To correct the overload condition the 12 volt load must be reduced or the equalizer capacity must be increased.

Trouble Shooting an Engine No-Start Situation

Situation:

A coach has dead batteries and won't start while jump starting. The coach is equipped with a 24 volt starting and charging system, a 12 volt electronic diesel engine control, a Family 3, 4 or 5 Equalizer, and a moderate 12 volt load which cannot be turned OFF. The coach sits for several days and the batteries run completely dead. During jump starting the engine cranks but does not start due to low voltage on the 12 volt supply. Electrical testing reveals there is no 12 volt output from the equalizer while jump starting even though the equalizer separately tests OK.

Cause:

The 12 volt load which could not be turned OFF first ran both batteries down until the equalizer shut itself OFF due to low voltage. (Family 3, 4 and 5 Equalizers will shut OFF if system voltage falls below 16 volts or if voltage on either battery falls below 8 volts.) Then Battery A alone was drained to near zero volts. As the bus is being jumped, 12 volt loads hold Battery A voltage too low for the equalizer to turn ON and Battery A is too weak to support the 12 volt electronic engine control.

Solution:

Turn OFF all 12 volt loads (turning the battery disconnect switch OFF may accomplish this). Connect the jumper cables but do not crank the engine for two or three minutes or until the equalizer indicator light has turned ON which means the equalizer is ON. (Both batteries must rise above 8 volts.) The battery disconnect switch can then be turned ON and the bus should have adequate 12 volt power to start.

NORTH AMERICAN LIMITED WARRANTY

Vanner Inc., doing business as The Vanner Power Group, referred to herein as Vanner, warrants that this product is free from defects in materials and workmanship for a period of two (2) years from date of installation or two and one half (2 1/2) years from date of manufacture, whichever is less if and only if the following requirements are complied with:

1. The product is installed and checked out properly according to all guidelines, instructions, and checkout procedures set forth in the product Installation and Operating Manual.
2. The installer records all checkout data required and completes, signs, and returns the warranty registration card to Vanner within ten (10) days after installation.
3. The product was purchased after January 1, 2000.

Vanner does not warrant its products against any and all defects when: defect is a result of material or workmanship not provided by Vanner; normal wear and tear, or defects caused by misuse or use in contrary to instructions supplied, neglect, accident, reversed polarity, unauthorized repairs and/or replacements.

All warranties of merchantability and fitness for a particular purpose: written or oral, expressed or implied, shall extend only for a period of two (2) years from date of installation or two and one half (2 1/2) years from date of manufacture, whichever is first. There are no other warranties that extend beyond those described on the face of this warranty. Some states do not allow limitation on how long an implied warranty lasts, so the above limitations may not apply to you.

Vanner does not undertake responsibility to any purchaser of its product for any undertaking, representation, or warranty made by any dealers or distributors selling its products beyond those herein expressed unless expressed in writing by an officer of Vanner.

Vanner does not assume responsibility for incidental or consequential damages, including, but not limited to, responsibility for loss of use of this product, removal or replacement labor, loss of time, inconvenience, expense for telephone calls, shipping expense, loss or damage to property, or loss of revenue. Some states do not allow the exclusion or limitation of incidental or consequential damages, so these limitations may not apply to you.

Vanner reserves the right to repair, replace, or allow credit for any material returned under this warranty. Any damage caused by the customer will be charged or deducted from the allowance.

All warranty work will be performed at Vanner's factory, or authorized repair facility utilizing a valid Warranty Authorization Number (WAN) prior to repair. Products shall be delivered to Vanner's facility, freight prepaid and fully insured. Products repaired under warranty, or replacement parts or products will be returned to North American location prepaid via same transportation means and level of service as received, unless directed otherwise. Prepaid freight policy does not apply to locations outside North America.

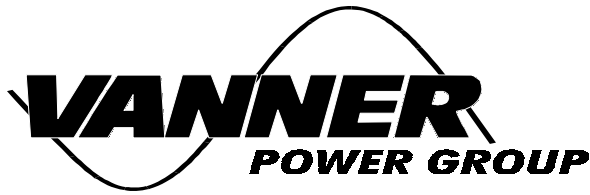
VANNER Incorporated **BATTERY EQUALIZER OWNER'S MANUAL**

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GENERAL

The EM-70D Electronic Monitor is a device designed to monitor several critical functions in the electrical system of a vehicle that operates on a 24 volt system. It will also monitor the 12 volt service when using a Vanner VoltMaster Battery Equalizer which supplies 12 volt service from a 24 volt source.

CHARACTERISTICS

The EM-70D can function in a variety of ways:

1. The monitor functions as an alternator monitor when the battery balance lamp output and +12 volt monitor input terminals are not in use.
2. The monitor functions as a device to control a field current relay, shutting down the field current if the voltage regulator fails in the full field mode. This function is accomplished by connecting the EM-70D as normal and installing a latching field current relay to the battery high lamp output terminal.

In all cases the lamp outputs in the EM-70D are designed to provide the ground connection for the lamps (or buzzers, beepers, relays) under a fault condition. The lamp outputs have also been designed so they may be paralleled should the installer wish to have fewer than three (3) indicator lamps in service. If this is done, the output current remains at 0.375 (375 milliamps). It is possible to install momentary light test switches (or just one (1) light test switch provided three (3) isolating diodes are installed) so as to enable the operator to check the lamps to determine if they are functioning.

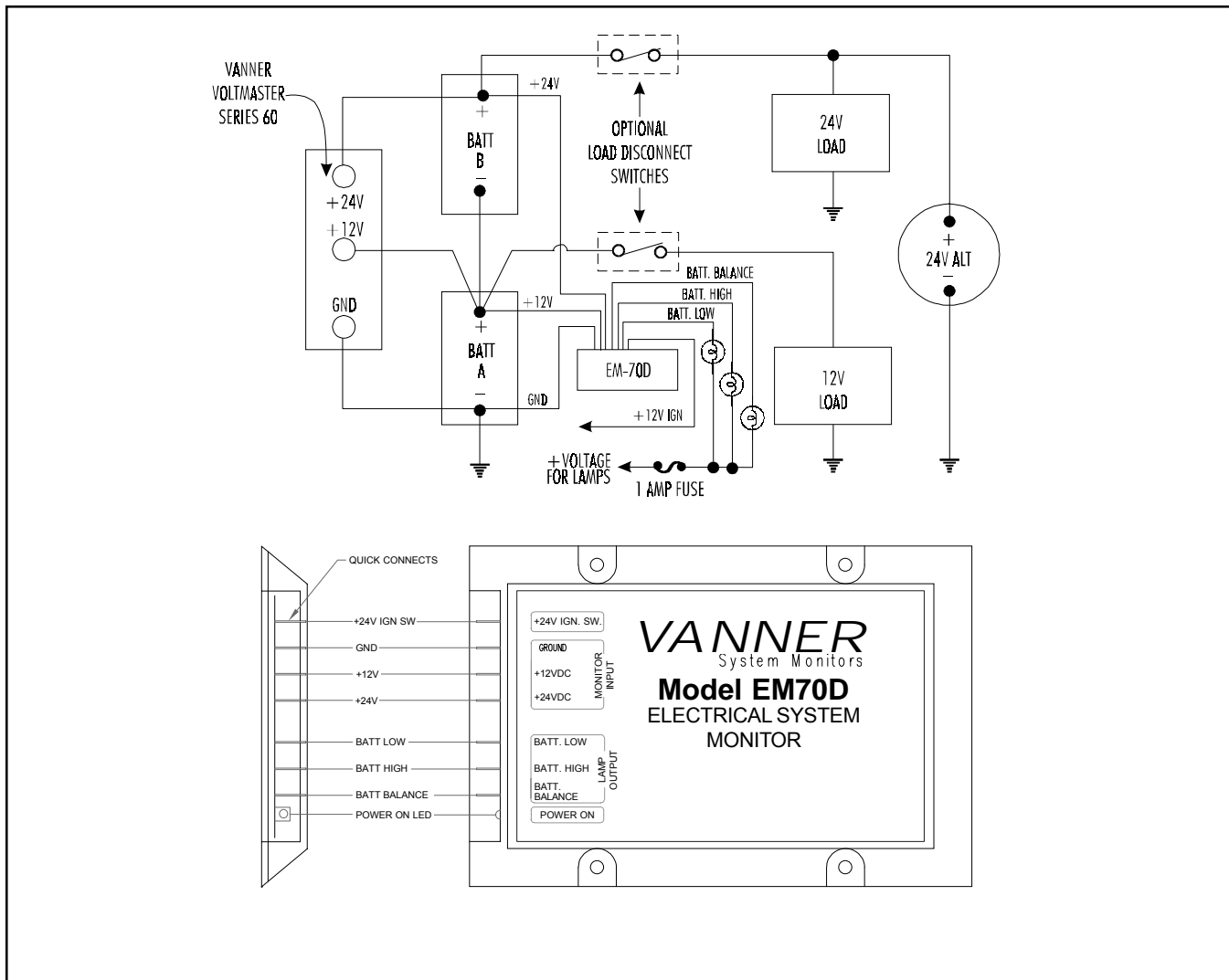
INSTALLATION

When installing the EM-70D, locate a dry, flat surface that will accommodate the four mounting holes. Even though the unit is potted and completely sealed, it is preferable to locate the monitor in as clean a location as possible. Since the current levels are in the milliamp range, it is permissible to use 18 gauge wire at all seven spade terminals. When connecting the three (3) monitor input leads to the system, it is important to note that the connections should be made to the wiring system as close to the battery terminals as possible. This will allow the EM-70D to monitor the condition of the wiring and terminals in the system and alert the operator if a problem develops. Should these three (3) wires be connected to the three terminals on the equalizer, the EM-70D will only monitor the equalizer voltages and will not respond to wiring or termination problems.

SPECIFICATIONS

IGNITION SYSTEM INPUT:	24 VDC (Minimum 18 VDC, Maximum 35 VDC)
WARNING LAMP TRIP LEVELS:	Battery System High - greater than 30 VDC Battery System Low - less than 24 VDC Battery Balance - greater than $\frac{INPUT}{2} + 6\%$ OR less than $\frac{INPUT}{2} - 6\%$
WARNING LAMP* OUTPUT:	Open collector style, 0.375 amps (375 milliamps) maximum *Also applies to buzzers, beepers, relays, etc.

INSTALLATION SCHEMATIC



WARNING LAMP DEFINITIONS—LAMPS WILL GLOW UNDER FOLLOWING CONDITIONS:

BATTERY LOW

- Battery voltage drops below 24 VDC
 - Check alternator output
 - Check alternator regulator
 - Check battery connections
 - Check battery cells
 - Check Battery Equalizer connections

BATTERY HIGH

- Battery voltage exceeds 30 VDC
 - Check alternator output
 - Check alternator regulator
 - Check battery connections

BATTERY BALANCE

- Batteries out of balance (greater than 1.5 volt difference between the two batteries)
 - Check circuit breaker on Battery Equalizer (if applicable)
 - Check Battery Equalizer connections
 - Check Equalizer cables for proper gauge
 - Check battery connections
- Demand for 12 volt power exceeding rated amperage output of Battery Equalizer; causing batteries to go out of balance
 - Reduce 12 volt loads
 - Install larger or additional Battery Equalizer
- Equalizer not functioning properly
 - Perform on-vehicle tests from troubleshooting guide (see Equalizer Owner's Manual).
 - If inoperable, replace Battery Equalizer and return inoperable unit to Vanner for repairs.



800- AC POWER

Corporate Office: 4282 Reynolds Drive • Hilliard, Ohio 43026 • Tel (614) 771-2718 • Fax (614) 771-4904 • www.vanner.com
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Part #A94319

FAULT CODE MANUAL

B7L, B7TL, B12

Preface

The content of this manual has been based upon information from design department at Volvo Bus, Volvo Trucks and external suppliers. Due to problems with retrieving updated documents, new signal specifications etc. we cannot guarantee that the information is 100% correct. Therefore we are very grateful to retrieve any notification about occurrence of incorrect information. We will however, update the manual as soon as we get new information and distribute revised versions to all parties concerned.

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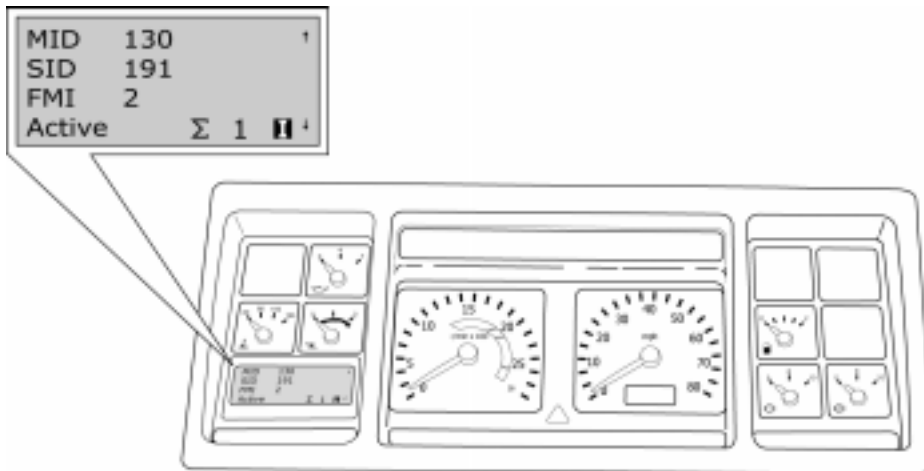
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1. Bus Instrument Cluster (BIC)

The bus instrument cluster contains a number of indicators and lamps that shows the status of different parts of the bus. It can also be used to display faultcodes from the different control units by using the windscreen wiper handle. Normally this procedure is done by using a computer with related software but this manual offers an alternative to that as well as a complete list of all fault codes for each ECU.

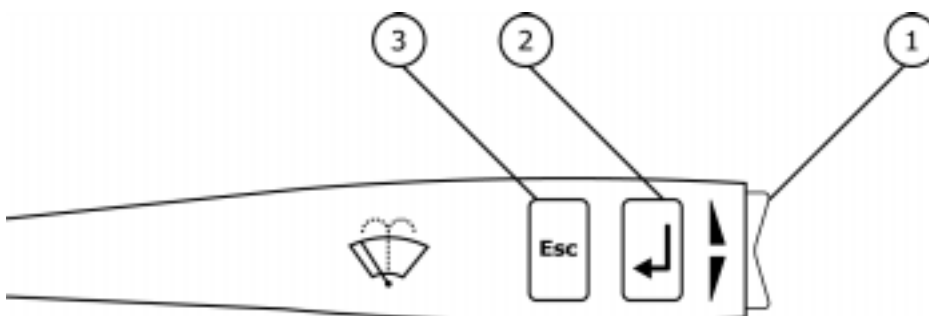
2. The instrument display

At the lower left corner of the instrument cluster there is a small display that can show various information about the bus. From this display it is possible to read the fault codes that may have been set in one or more of the different control units.



3. The windscreen wiper handle

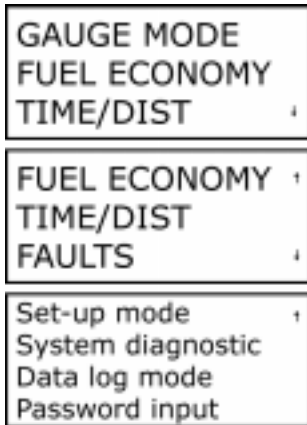
Using the the windscreen wiper handle at the right of the steeringwheel makes it possible to display the error at the lower left corner of the BIC. The errors can be displayed in numerical form and with help of the fault code table in this manual you can draw conclusions of what may have caused the errors.



1. Up/Down buttons, used to browse up or down through the menus.
2. "Return" button, confirms selected choice.
3. "Esc" button, regrets selected choice or moves one step up in the hierarchy.

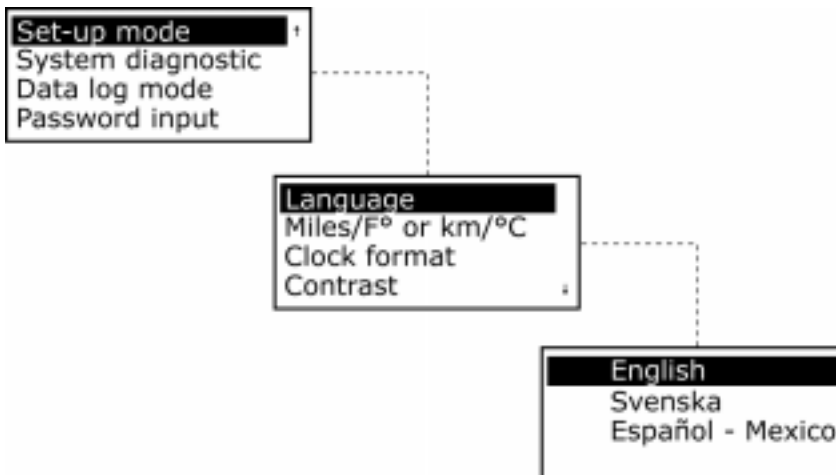
4. Display menus

The image below displays the main menus in the display window. The window can only display three items at once, therefore the up/down button on the windscreen wiper handle must be used to browse through the menus. Simply press the “Return” button on the windscreen wiper handle to enter a desired menu. If you wish to return to the level above just press the “Esc” button on the windscreen wiper handle.



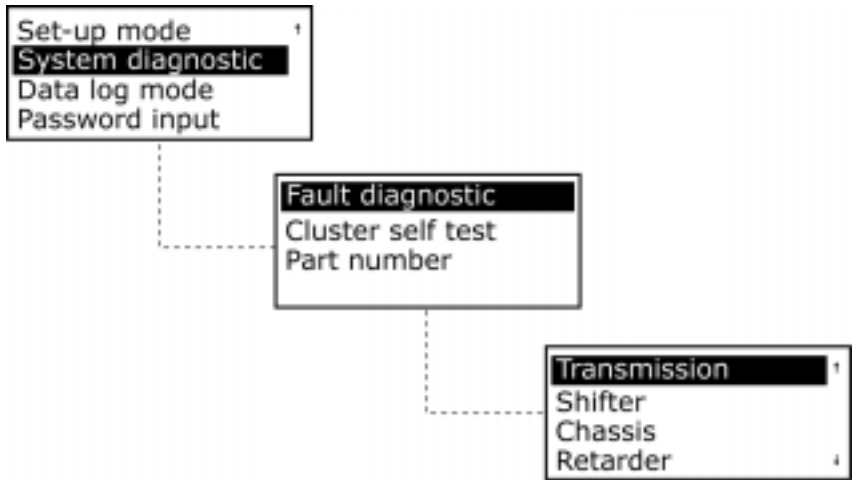
5. Setting the display language

Turn on the ignition on the bus. The display at the lower left corner of the instrument can display an icon of some sort depending on the bus status. If this is the case then press “Esc” on the windscreen wiper handle to go to the main menu. If the language of the display is not English we recommend that you change the language settings of the display. This is done by entering the set-up mode in the display menu. Simply use the up/down button on the windscreen wiper handle and press the “Return” button when the text “Set-up mode” is highlighted. The display now changes to display the submenus to the “Set-up mode” menu. Klick the up/down button to highlight the text “Language” if it is not already highlighted. Press the “Return” button again to enter the choices of languages, select “English” and press the “Return” button once more.



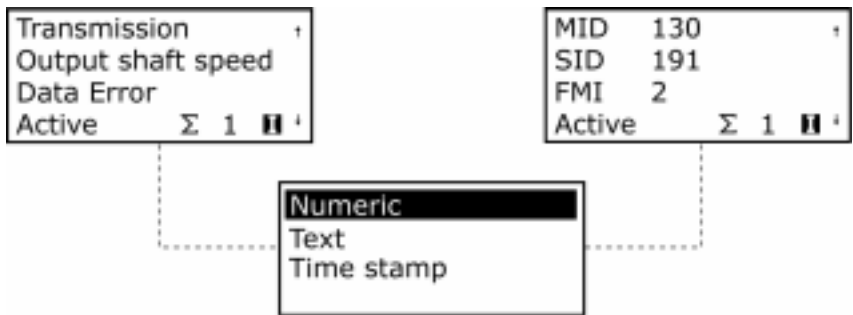
6. Read fault codes from ECU

From the main menu, use the up/down button on the windscreen wiper handle to move down to the “System diagnostic” menu and press the “Return” key.



The line “Fault diagnostic” should now be highlighted, if it’s not you can simply use the up/down button on the windscreen wiper handle to move to that line. Press the “Return” button again and the fault code set in the transmission ECU will now be displayed on the screen.

The fault codes can be displayed in both numeric and text mode. Since the text mode is default you have to change it to numeric manually. This is done by pressing the “Return” button when the display shows the fault code in text mode. A menu with three choices is now shown on the display. Press the “Return” button while the choice “Numeric” is highlighted (it should be highlighted by default).



As in the example above, you can see that the fault code is set in MID 130, the SID number is 191 and the FMI number is 2. By looking at the fault code table for MID 130 (which represents the TECU) you can see that SID number 191 means “Output speed level error” as well as the displaytext shown if your display would have been set to show faults in text mode.

9	130	PID 177	3	Transmission temperature sensor above	Transm. oil temp.
0	130	PID 177	4	Transmission temperature sensor below	Transm. oil temp.
1	130	PID 191	2	Output speed level error	Output shaft speed
2	130	PID 191	11	Output speed measuring overflow	Output shaft speed
3	130	SID 1	3	Solenoid valve B shorted high	Solenoid valve #1
4	130	SID 1	4	Solenoid valve B shorted ground	Solenoid valve #1
5	130	SID 1	5	Solenoid valve B circuit break	Solenoid valve #1

The information about the PID number (or SID, PPID or PSID) together with the explanation of the FMI number associated with the fault might help you to draw a conclusion of what may have caused the error. The image below shows the FMI table which tells what type of fault the FMI number represents.

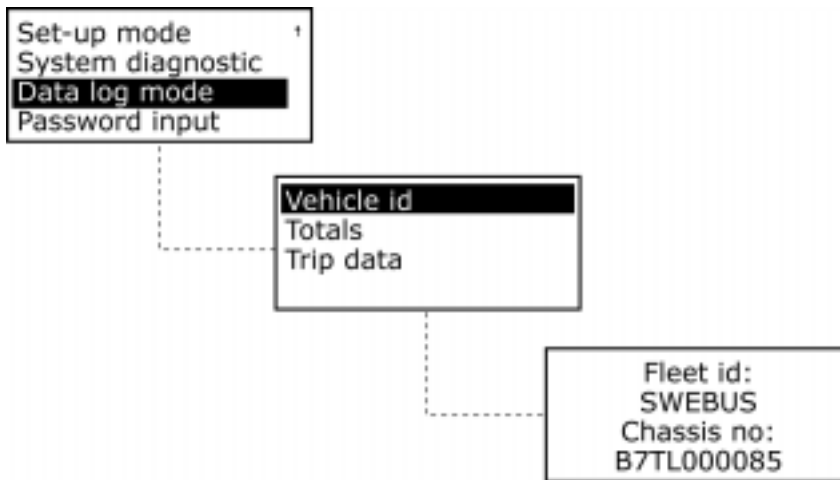
SAE-standard	
FMI	SAE-text
0	Data valid, but above normal operating range.
1	Data valid, but under normal operating range.
2	Intermittent or incorrect data.
3	Abnormally high voltage or short circuit to higher voltage.
4	Abnormally low voltage or short circuit to lower voltage.
5	Abnormally low current or break.
6	Abnormally high current or short circuit to earth.
7	Incorrect response from mechanical system.
8	Abnormal frequency
9	Abnormal update rate
10	Abnormally large variations.
11	Unknown fault.
12	Component fault
13	Out of calibration
14	Special instructions
15	Reserved for future use.

In this case the information MID 130, PID 191, FMI 2 means that the output shaft speed has retrieved intermittent or incorrect data, this gives an initial position to start the fault tracing from. Future revisions of this manual will contain more clearly instructions of how to fix the errors.

7. Comparing chassis number with the VIC

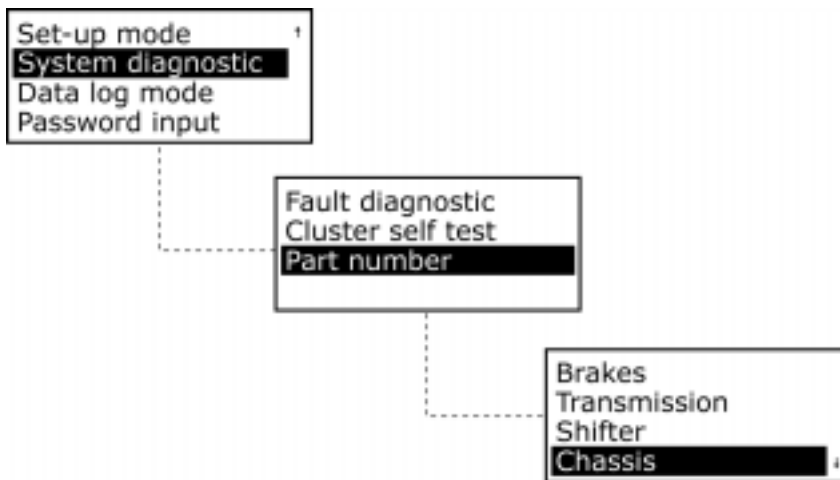
The VIC (Vehicle Identification Card) is a card that comes with every new bus that identifies the chassis number for the bus and the HW/SW id for each control unit.

To check chassis number, select “Data log mode” from the displays main menu and press the “Return” button on the windscreen wiper handle. You now move down one step in the hierarchy and three new choices are presented on the display, select “Vehicle id” and press the “Return” button on the windscreen wiper handle. The fleet id and the chassis number should occur on the display.



8. Comparing HW/SW id with the VIC

Just as with the chassis number the VIC can be used to verify HW/SW id for each ECU in the bus. To read the HW/SW id from a control unit you first select “System diagnostic” from the main menu of the display and press the “Return” button on the windscreen wiper handle. Then select “Part number” from the menu and press the “Return” button on the windscreen wiper handle once again. The menu now displays the different control units in the bus, in this case we want to see the HW/SW id for the chassis control unit (CECM) and therefore we select “Chassis” and press the “Return” button again.



The image below shows the HW/SW id for the CECM, the display cannot display both SW id and HW id at the same time, therefore you have to use the up/down buttons on the windscreen wiper handle to show SW id instead of HW id.

MID	164	SW ID
70301493P01*70301452		
P01*70301453P01*		

MID	164	HW ID :
VOLVO*00000000P01*00		
000000:		

9. Fault codes, ABS (MID 136)

MID	(P)PID/SID	FMI	Seriousness	Component/Function	Display text
136	SID 1	1		Air gap	Sensor wheel sp LF
136	SID 1	2		Incorrect tyre	Sensor wheel sp LF
136	SID 1	3		Shorted to UBATT	Sensor wheel sp LF
136	SID 1	4		Shorted to ground	Sensor wheel sp LF
136	SID 1	5		Open circuit	Sensor wheel sp LF
136	SID 1	6		Short circuit	Sensor wheel sp LF
136	SID 1	7		Incorrect pole wheel	Sensor wheel sp LF
136	SID 1	8		Slip	Sensor wheel sp LF
136	SID 1	9		Wires mismatched	Sensor wheel sp LF
136	SID 1	10		Speed drop-out	Sensor wheel sp LF
136	SID 1	11		Abnormal speed (chatter)	Sensor wheel sp LF
136	SID 1	12		Frequency too high	Sensor wheel sp LF
136	SID 2	1		Air gap	Sensor wheel sp RF
136	SID 2	2		Incorrect tyre	Sensor wheel sp RF
136	SID 2	3		Shorted to UBATT	Sensor wheel sp RF
136	SID 2	4		Shorted to ground	Sensor wheel sp RF
136	SID 2	5		Open circuit	Sensor wheel sp RF
136	SID 2	6		Short circuit	Sensor wheel sp RF
136	SID 2	7		Incorrect pole wheel	Sensor wheel sp RF
136	SID 2	8		Slip	Sensor wheel sp RF
136	SID 2	9		Wires mismatched	Sensor wheel sp RF
136	SID 2	10		Speed drop-out	Sensor wheel sp RF
136	SID 2	11		Abnormal speed	Sensor wheel sp RF
136	SID 2	12		Frequency too high	Sensor wheel sp RF
136	SID 3	1		Air gap	Sensor wheel sp L1R
136	SID 3	2		Incorrect tyre	Sensor wheel sp L1R
136	SID 3	3		Shorted to UBATT	Sensor wheel sp L1R
136	SID 3	4		Shorted to ground	Sensor wheel sp L1R
136	SID 3	5		Open circuit	Sensor wheel sp L1R
136	SID 3	6		Short circuit	Sensor wheel sp L1R
136	SID 3	7		Incorrect pole wheel	Sensor wheel sp L1R
136	SID 3	8		Slip	Sensor wheel sp L1R
136	SID 3	9		Wires mismatched	Sensor wheel sp L1R
136	SID 3	10		Speed drop-out	Sensor wheel sp L1R
136	SID 3	11		Abnormal speed	Sensor wheel sp L1R
136	SID 3	12		Frequency too high	Sensor wheel sp L1R
136	SID 4	1		Air gap	Sensor wheel sp R1R
136	SID 4	2		Incorrect tyre	Sensor wheel sp R1R
136	SID 4	3		Shorted to UBATT	Sensor wheel sp R1R
136	SID 4	4		Shorted to ground	Sensor wheel sp R1R
136	SID 4	5		Open circuit	Sensor wheel sp R1R
136	SID 4	6		Short circuit	Sensor wheel sp R1R
136	SID 4	7		Incorrect pole wheel	Sensor wheel sp R1R
136	SID 4	8		Slip	Sensor wheel sp R1R
136	SID 4	9		Wires mismatched	Sensor wheel sp R1R
136	SID 4	10		Speed drop-out	Sensor wheel sp R1R
136	SID 4	11		Abnormal speed	Sensor wheel sp R1R
136	SID 4	12		Frequency too high	Sensor wheel sp R1R

MID	(P)PID/SID	FMI	Seriousness	Component/Function	Display text
136	SID 5	1		Air gap	-
136	SID 5	2		Incorrect tyre	-
136	SID 5	3		Shorted to UBATT	-
136	SID 5	4		Shorted to ground	-
136	SID 5	5		Open circuit	-
136	SID 5	6		Short circuit	-
136	SID 5	7		Incorrect pole wheel	-
136	SID 5	8		Slip	-
136	SID 5	9		Wires mismatched	-
136	SID 5	10		Speed drop-out	-
136	SID 5	11		Abnormal speed	-
136	SID 5	12		Frequency too high	-
136	SID 6	1		Air gap	-
136	SID 6	2		Incorrect tyre	-
136	SID 6	3		Shorted to UBATT	-
136	SID 6	4		Shorted to ground	-
136	SID 6	5		Open circuit	-
136	SID 6	6		Short circuit	-
136	SID 6	7		Incorrect pole wheel	-
136	SID 6	8		Slip	-
136	SID 6	9		Wires mismatched	-
136	SID 6	10		Speed drop-out	-
136	SID 6	11		Abnormal speed	-
136	SID 6	12		Frequency too high	-
136	SID 7	1		Open circuit in- and outlet	Modulator valve LF
136	SID 7	3		Shorted to UBATT	Modulator valve LF
136	SID 7	5		Open circuit	Modulator valve LF
136	SID 7	6		Shorted to ground	Modulator valve LF
136	SID 8	1		Open circuit in- and outlet	Modulator valve RF
136	SID 8	3		Shorted to UBATT	Modulator valve RF
136	SID 8	5		Open circuit	Modulator valve RF
136	SID 8	6		Shorted to ground	Modulator valve RF
136	SID 9	1		Open circuit in- and outlet	Modulator valve L1R
136	SID 9	3		Shorted to UBATT	Modulator valve L1R
136	SID 9	5		Open circuit	Modulator valve L1R
136	SID 9	6		Shorted to ground	Modulator valve L1R
136	SID 10	1		Open circuit in- and outlet	Modulator valve R1R
136	SID 10	3		Shorted to UBATT	Modulator valve R1R
136	SID 10	5		Open circuit	Modulator valve R1R
136	SID 10	6		Shorted to ground	Modulator valve R1R
136	SID 11	1		Open circuit in- and outlet	-
136	SID 11	3		Shorted to UBATT	-
136	SID 11	5		Open circuit	-
136	SID 11	6		Shorted to ground	-
136	SID 12	1		Open circuit in- and outlet	-
136	SID 12	3		Shorted to UBATT	-
136	SID 12	5		Open circuit	-
136	SID 12	6		Shorted to ground	-
136	SID 13	3		Shorted to UBATT	Retard contr relay
136	SID 13	5		Open circuit	Retard contr relay
136	SID 13	6		Shorted to ground	Retard contr relay
136	SID 14	3		Ground diagonal, shorted to UBATT	Valve relay

MID	(P)PID/SID	FMI	Seriousness	Component/Function	Display text
136	SID 14	4		Diag. 1 Voltage, low voltage/open circuit	Valve relay
136	SID 14	5		Ground diagonal, open circuit	Valve relay
136	SID 14	5		ECU-Ground or WL-Ground	Valve relay
136	SID 14	6		Ground diagonal 1, shorted to low	Valve relay
136	SID 14	7		Voltage feeding solenoid valve ABS	Valve relay
136	SID 15	3		Voltage feeding solenoid valve ABS	Valve relay
136	SID 15	4		Voltage feeding solenoid valve ABS	Valve relay
136	SID 15	5		Voltage feeding solenoid valve ABS	Valve relay
136	SID 15	6		Voltage feeding solenoid valve ABS	Valve relay
136	SID 15	7		Valve relay diagonal 2	Valve relay
136	SID 18	3		Diff. Brake Valve, shorted to UBATT	ATC valve L
136	SID 18	5		Diff. Brake Valve, open circuit	ATC valve L
136	SID 18	6		Diff. Brake Valve, shorted to ground	ATC valve L
136	SID 19	3		Diff, lock shorted to UBATT	ATC valve R
136	SID 19	5		Diff, lock open circuit	ATC valve R
136	SID 19	6		Diff, lock shorted to ground	ATC valve R
136	SID 23	5		Warning lamp ABS	Warning light bulb
136	SID 231	5		SAE J1939 Control link	SAE J1939 data link
136	SID 231	6		SAE J1939 Control link	SAE J1939 data link
136	SID 231	9		SAE J1939 Control link	SAE J1939 data link
136	SID 231	12		SAE J1939 Control link	SAE J1939 data link
136	SID 248	2		CAN plausibility	-
136	SID 248	5		CAN open circuit	-
136	SID 248	6		CAN grounded circuit	-
136	SID 248	9		CAN time-out	-
136	SID 248	12		CAN, internal error	-
136	SID 249	5		SAE-J1922 datalink open circuit	-
136	SID 249	6		SAE-J1922 datalink grounded circuit	-
136	SID 249	10		SAE-J1922 bus not free	-
136	SID 251	3		Overvoltage Diag. 1 or 2	Power supply
136	SID 253	1		ASR Configuration	Calibration memory
136	SID 253	2		ABS Configuration	Calibration memory
136	SID 253	2		EEPROM Wheel parameter incorrect	Calibration memory
136	SID 253	12		EEPROM Checksum	Calibration memory
136	SID 254	2		Internal Error	Controller #1
136	SID 254	5		ABS (ASR) ELECTRONIC no loads	Controller #1
136	SID 254	8		Excessive slip / dynotester	Controller #1
136	SID 254	9		Modulator-Valve activation-time	Controller #1
136	SID 254	12		Internal Error	Controller #1

10. Fault codes, BIC (MID 140 & 234)

MID	(P)PID/SID	FMI	Seriousness	Component/function	Display text
140	PID 84	9		Speed	Road speed
140	PID 190	9		Number of revolutions	Engine speed
140&234	SID 240	13		Program memory	Program memory
140&234	SID 253	12		EEPROM	Calibration memory
140&234	SID 253	13		EEPROM	Calibration memory
140&234	SID 254	12		Control unit	Controller #1
140&234	SID 254	13		Control unit	Controller #1
140&234	SID 254	14		Control unit	Controller #1
234	PID 117	9		Brake pressure #1	Brake pressure #1
234	PID 118	9		Brake pressure #2	Brake pressure #2
234	PID 120	9		ZF/Allison oiltemp	Hyd retard oil temp
234	PID 158	0	Yellow lamp	Control unit battery potential	Battery potential
234	PID 175	9		Engine oil temp.	Engine oil temp.
234	PID 177	9		Voith oil temp	Transm. oil temp.
234	PPID 91	9		Brake pressure circuit 3	Brake pressure #3
234	SID 250	2		SAE J1708 data link	SAE J1708 data link
234	SID 250	9	Yellow lamp	SAE J1708 data link	SAE J1708 data link
234	SID 250	12	Yellow lamp	SAE J1708 data link	SAE J1708 data link
234	PSID 1	6		Fuel indication, low level	Output LX:13
234	PSID 2	6	Yellow lamp	Alarm clock, activating	Alarm clock activ.
234	PSID 3	6		Buzzer, danger	Buzzer, alarm
234	PSID 4	6		Buzzer, warning	Buzzer, caution

11. Fault codes, CECM (MID 164)

MID	(P)PID/SID	FMI	Seriousness	Component/Function	Display text
164	PID 43	4			Starting sw. status
164	PID 43	5			Starting sw. status
164	PID 70	3			Park brake switch
164	PID 117	3			Brake pressure #1
164	PID 117	4			Brake pressure #1
164	PID 118	3			Brake pressure #2
164	PID 118	4			Brake pressure #2
164	PPID 191	3			Buzzer
164	PPID 191	4			Buzzer
164	PPID 191	5			Buzzer
164	PSID 20	3			Chassis data link
164	PSID 20	4			Chassis data link
164	PSID 23	3			D data link
164	PSID 23	4			D data link
164	PSID 31	3			Output CECM
164	PSID 31	4			Output CECM
164	PSID 31	5			Output CECM
164	PSID 32	5			Panel switch
164	PSID 33	3			Warning lamp output
164	PSID 34	3			Engine run signal
164	PSID 34	4			Engine run signal
164	PSID 35	3			Ignition output
164	PSID 35	4			Ignition output
164	PSID 35	5			Ignition output
164	PSID 36	3			Steer wheel adjust
164	PSID 36	4			Steer wheel adjust
164	PSID 36	5			Steer wheel adjust
164	PSID 37	3			Fuel shutoff valve
164	PSID 37	4			Fuel shutoff valve
164	SID 231	3			SAE J1939 kontrlänk
164	SID 231	4			SAE J1939 kontrlänk
164	SID 250	3			SAE J1708 infolänk
164	SID 250	4			SAE J1708 infolänk

12. Fault codes, CIM (MID 164)

MID	(P)PID/SID	FMI	Seriousness	Component/function	Display text
164	PSID 31	3			Short-circuit to battery
164	PSID 31	4			Short-circuit to ground
164	PSID 3	4			Alternator not charging
164	PSID 4	4			Alternator not charging
164	PSID 45	4			Alternator not charging
164	PSID 46	4			Alternator not charging

13. Fault codes, EECU (MID 128)

MID	(P)PID/SID	FMI	Seriousness	Component/function	Display text
128	PID 45	3	Yellow lamp	Starting heater status relay	Inlet air heat stat
128	PID 45	4	Yellow lamp	Starting heater status relay	Inlet air heat stat
128	PID 45	5	Yellow lamp	Starting heater status relay	Inlet air heat stat
128	PID 84	9	Yellow lamp	Vehicle speed	Road speed
128	PID 84	11	Yellow lamp	Vehicle speed	Road speed
128	PID 85	9	Yellow lamp	Cruise control, status switch	Cruise control stat
128	PID 91	9	Yellow lamp	Accelerator pedal percentage position	Acc. Pedal pos, %
128	PID 91	11	Yellow lamp	Accelerator pedal percentage position	Acc. Pedal pos, %
128	PID 94	1	Yellow lamp	Feed pressure, fuel	Fuel delivery pres.
128	PID 94	3	Yellow lamp	Feed pressure, fuel	Fuel delivery pres.
128	PID 94	4	Yellow lamp	Feed pressure, fuel	Fuel delivery pres.
128	PID 94	7	Yellow lamp	Feed pressure, fuel	Fuel delivery pres.
128	PID 98	1	Yellow lamp	Oil level sensor engine	Engine Oil Level
128	PID 98	3	Yellow lamp	Oil level sensor engine	Engine Oil Level
128	PID 98	4	Yellow lamp	Oil level sensor engine	Engine Oil Level
128	PID 100	1	Red lamp	Oil pressure sensor engine	Engine Oil Pressure
128	PID 100	3	Yellow lamp	Oil pressure sensor engine	Engine Oil Pressure
128	PID 100	4	Yellow lamp	Oil pressure sensor engine	Engine Oil Pressure
128	PID 102	3	Yellow lamp	Boost pressure sensor	Boost pressure
128	PID 102	4	Yellow lamp	Boost pressure sensor	Boost pressure
128	PID 105	3	Yellow lamp	Boost air temperature sensor	Intake manif temp
128	PID 105	4	Yellow lamp	Boost air temperature sensor	Intake manif temp
128	PID 107	0	Yellow lamp	Drop in pressure air filter	Air filt press drop
128	PID 107	3	Yellow lamp	Drop in pressure air filter	Air filt press drop
128	PID 107	4	Yellow lamp	Drop in pressure air filter	Air filt press drop
128	PID 107	5	Yellow lamp	Drop in pressure air filter	Air filt press drop
128	PID 108	3	Yellow lamp	Atmospheric pressure sensor	Barometric press
128	PID 108	4	Yellow lamp	Atmospheric pressure sensor	Barometric press
128	PID 110	0		Coolant temperature sensor	Eng coolant temp
128	PID 110	3		Coolant temperature sensor	Eng coolant temp
128	PID 110	4		Coolant temperature sensor	Eng coolant temp
128	PID 111	1	Red lamp	Coolant level sensor	Coolant level
128	PID 158	3	Yellow lamp	Battery voltage	Battery voltage
128	PID 172	3	Yellow lamp	Air temperature, inlet	Air inlet temp.
128	PID 172	4	Yellow lamp	Air temperature, inlet	Air inlet temp.
128	PID 174	3	Yellow lamp	Fuel temperature sensor	Fuel temperature
128	PID 174	4	Yellow lamp	Fuel temperature sensor	Fuel temperature
128	PID 175	0	Red lamp	Oil temperature	Engine oil temp
128	PID 175	3	Yellow lamp	Oil temperature	Engine oil temp
128	PID 175	4	Yellow lamp	Oil temperature	Engine oil temp
128	PID 224	2	Yellow lamp	Electronic immobilizer	Vehicle sec. Code
128	PID 224	12	Yellow lamp	Electronic immobilizer	Vehicle sec. Code
128	PID 228	11	Yellow lamp	Calibration Factor (K)	Calibration number

MID	(P)PID/SID	FMI	Seriousness	Component/function	Display text
128	PPID 100	3	Yellow lamp	Outer actuator	Ext. timing act.
128	PPID 100	4	Yellow lamp	Outer actuator	Ext. timing act.
128	PPID 100	5	Yellow lamp	Outer actuator	Ext. timing act.
128	PPID 109	3	Yellow lamp	Exhaust pressure governor EPG3	EPG # 3
128	PPID 109	4	Yellow lamp	Exhaust pressure governor EPG3	EPG # 3
128	PPID 109	5	Yellow lamp	Exhaust pressure governor EPG3	EPG # 3
128	PPID 122	3	Yellow lamp	Compression brake VCB	VCB Compr. Brake st.
128	PPID 122	4	Yellow lamp	Compression brake VCB	VCB Compr. Brake st.
128	PPID 122	5	Yellow lamp	Compression brake VCB	VCB Compr. Brake st.
128	PPID 123	3	Yellow lamp	Exhaust pressure governor EPG2	EPG2 Start/warmhold
128	PPID 123	4	Yellow lamp	Exhaust pressure governor EPG2	EPG2 Start/warmhold
128	PPID 123	5	Yellow lamp	Exhaust pressure governor EPG2	EPG2 Start/warmhold
128	PPID 124	3	Yellow lamp	Exhaust pressure governor EPG1	EPG # 1
128	PPID 124	4	Yellow lamp	Exhaust pressure governor EPG1	EPG # 1
128	PPID 124	5	Yellow lamp	Exhaust pressure governor EPG1	EPG # 1
128	SID 1-6	2	Yellow lamp	Injector	Injector Cylinder (SID#)
128	SID 1-6	3	Yellow lamp	Injector	Injector Cylinder (SID#)
128	SID 1-6	4	Yellow lamp	Injector	Injector Cylinder (SID#)
128	SID 1-6	5	Yellow lamp	Injector	Injector Cylinder (SID#)
128	SID 1-6	7	Yellow lamp	Injector	Injector Cylinder (SID#)
128	SID 1-6	11	Yellow lamp	Injector	Injector Cylinder (SID#)
128	SID 17	3		Fuel shut-off valve	Fuel Valve
128	SID 17	4		Fuel shut-off valve	Fuel Valve
128	SID 17	5		Fuel shut-off valve	Fuel Valve
128	SID 20	2	Yellow lamp	Actuator, injection angle	Timing actuator
128	SID 20	3	Red lamp	Actuator, injection angle	Timing actuator
128	SID 20	4	Red lamp	Actuator, injection angle	Timing actuator
128	SID 20	5	Red lamp	Actuator, injection angle	Timing actuator
128	SID 20	6	Red lamp	Actuator, injection angle	Timing actuator
128	SID 20	7	Red lamp	Actuator, injection angle	Timing actuator
128	SID 20	8	Red lamp	Actuator, injection angle	Timing actuator
128	SID 20	11	Red lamp	Actuator, injection angle	Timing actuator
128	SID 21	2	Yellow lamp	Neelde lifting sensor	Engine position
128	SID 21	3	Yellow lamp	Neelde lifting sensor	Engine position
128	SID 21	8	Yellow lamp	Neelde lifting sensor	Engine position
128	SID 22	2	Yellow lamp	Speed sensor, flywheel	Timing sens crank
128	SID 22	3	Yellow lamp	Speed sensor, flywheel	Timing sens crank
128	SID 22	8	Yellow lamp	Speed sensor, flywheel	Timing sens crank
128	SID 23	2	Yellow lamp	Control rod, actuator	Rack actuator
128	SID 23	3	Red lamp	Control rod, actuator	Rack actuator
128	SID 23	4	Red lamp	Control rod, actuator	Rack actuator
128	SID 23	5	Red lamp	Control rod, actuator	Rack actuator
128	SID 23	6	Red lamp	Control rod, actuator	Rack actuator
128	SID 23	7	Red lamp	Control rod, actuator	Rack actuator
128	SID 23	8	Red lamp	Control rod, actuator	Rack actuator
128	SID 23	11	Red lamp	Control rod, actuator	Rack actuator

MID	(P)PID/SID	FMI	Seriousness	Component/Function	Display text
128	SID 24	2	Red lamp	Control rod position	Rack positoin sens.
128	SID 24	13	Red lamp	Control rod position	Rack positoin sens.
128	SID 64	3	Yellow lamp	Engine speed pump	Tim. Sens inj. Pump
128	SID 64	8	Yellow lamp	Engine speed pump	Tim. Sens inj. Pump
128	SID 70	3	Yellow lamp	Starting heater 1	Air inlet heater 1
128	SID 70	4	Yellow lamp	Starting heater 1	Air inlet heater 1
128	SID 70	5	Yellow lamp	Starting heater 1	Air inlet heater 1
128	SID 230	3	Yellow lamp	Idle switch	Idle valid switch
128	SID 230	4	Yellow lamp	Idle switch	Idle valid switch
128	SID 231	2	Yellow lamp	SAE J1939 Control link	SAE J1939 data link
128	SID 231	9	Yellow lamp	SAE J1939 Control link	SAE J1939 data link
128	SID 231	11	Yellow lamp	SAE J1939 Control link	SAE J1939 data link
128	SID 231	12	Yellow lamp	SAE J1939 Control link	SAE J1939 data link
128	SID 232	3	Yellow lamp	5 V supply to sensor	5 V supply
128	SID 232	4	Yellow lamp	5 V supply to sensor	5 V supply
128	SID 240	2	Red lamp	Programme memory (Flash)	Program memory
128	SID 240	12		Programme memory (Flash)	Program memory
128	SID 250	12	Yellow lamp	SAE J1708 Information link	SAE J1708 data link
128	SID 253	2	Red lamp	Data set memory EEPROM	Calibration memory
128	SID 253	12	Red lamp	Data set memory EEPROM	Calibration memory
128	SID 254	2	Red lamp	Engine control unit (EECU)	Controller #1
128	SID 254	8	Red lamp	Engine control unit (EECU)	Controller #1
128	SID 254	9	Red lamp	Engine control unit (EECU)	Controller #1
128	SID 254	11	Red lamp	Engine control unit (EECU)	Controller #1
128	SID 254	12	Red lamp	Engine control unit (EECU)	Controller #1
128	SID 254	13		Engine control unit (EECU)	Controller #1

14. Fault codes, TECU Voith 863,3 retarders and transmission (MID 130)

MID	(P)PID/SID	FMI	Seriousness	Component/function	Display text
130	PID 40	2	-	Hand brake sensor	Retarder switches
130	PID 65	2	-	Foot brake sensor	Brake pedal switch
130	PID 92	2	-	Software	Engine load, %
130	PID 93	2	-	CAN	Engine torque
130	PID 93	14	-	CAN	Engine torque
130	PID 124	1	-	Low oil level	Transm. oil level
130	PID 152	14	-	ECU-Reset	No. of ECU resets
130	PID 158	1	-	Power supply	Battery potential
130	PID 162	2	-	Gear selector switch	Gear selected
130	PID 177	0	-	Temperature sensor	Transm. oil temp.
130	PID 177	5	-	Temperature sensor	Transm. oil temp.
130	PID 177	6	-	Temperature sensor	Transm. oil temp.
130	PID 177	13	-	Temperature sensor	Transm. oil temp.
130	PID 177	14	-	Temperature sensor	Transm. oil temp.
130	PID 190	11	-	Engine speed	Engine speed
130	PID 191	11	-	Output speed	Output shaft speed
130	PID 234	14	-	Frequency output	Software no.
130	SID 1	12	-	Control solenoid valve turbine brake	Solenoid valve #1
130	SID 4	12	-	Control solenoid valve 4 speed clutch	Solenoid valve #4
130	SID 6	12	-	Solenoid valve converter brake	Solenoid valve #6
130	SID 7	12	-	Control solenoid valve pump brake	Lockup sol. valve
130	SID 8	12	-	Control solenoid valve input clutch	Forward sol. valve
130	SID 17	11	-	Turbine speed	Turbine speed
130	SID 52	13	-	Pressure rise fault	Hydraulic system
130	SID 153	14	-	-	-
130	SID 153	14	-	-	-
130	SID 153	14	-	-	-
130	SID 153	14	-	-	-
130	SID 153	14	-	-	-
130	SID 221	14	-	Power supply for brake sensors	Int sensor supply
130	SID 231	9	-	CAN	SAE J1939 data link
130	SID 233	2	-	Message from safety computer	Controller #2
130	SID 238	14	-	Pushbutton switch lightning	Diagnostic lamp RED
130	SID 239	14	-	Central warning light	Diag. lamp AMBER
130	SID 240	14	-	Software	Program memory

15. Fault codes, ZF HP 502 retarder (MID 222) and transmission (MID 130)

MID	(P)PID/SID	FMI	Seriousness	Component/function	Display text
130	PID 1	0		Transmission slip	Invalid data
130	PID 155	3		Not used dig. Out shorted high	Aux. input/output 1
130	PID 155	12		Internal I/O safety switch error	Aux. input/output 1
130	PID 161	2		Turbine speed level error	Input shaft speed
130	PID 161	11		Turbine speed measuring overflow	Input shaft speed
130	PID 177	0		Transmission oil temperature high	Transm. oil temp.
130	PID 177	3		Transmission temperature sensor above	Transm. oil temp.
130	PID 177	4		Transmission temperature sensor below	Transm. oil temp.
130	PID 191	2		Output speed level error	Output shaft speed
130	PID 191	11		Output speed measuring overflow	Output shaft speed
130	SID 1	3		Solenoid valve B shorted high	Solenoid valve #1
130	SID 1	4		Solenoid valve B shorted ground	Solenoid valve #1
130	SID 1	5		Solenoid valve B circuit break	Solenoid valve #1
130	SID 2	3		Solenoid valve C shorted hig	Solenoid valve #2
130	SID 2	4		Solenoid valve C shorted ground	Solenoid valve #2
130	SID 2	5		Solenoid valve C circuit break	Solenoid valve #2
130	SID 225	3		Operating lamp shorted high	Green lamp
130	SID 225	4		Operating lamp shorted ground	Green lamp
130	SID 253	2		Operating time counter checktime error	Calibration memory
130	SID 253	11		Statistik memory checksum error	Calibration memory
130	SID 253	12		Error read error memory	Calibration memory
130	SID 254	11		Internal system error	Controller #1
130	SID 3	3		Solenoid valve D shorted high	Solenoid valve #3
130	SID 3	4		Solenoid valve D shorted ground	Solenoid valve #3
130	SID 3	5		Solenoid valve D circuit break	Solenoid valve #3
130	SID 4	3		Solenoid valve E shorted high	Solenoid valve #4
130	SID 4	4		Solenoid valve E shorted ground	Solenoid valve #4
130	SID 4	5		Solenoid valve E circuit break	Solenoid valve #4
130	SID 5	3		Solenoid valve F shorted high	Solenoid valve #5
130	SID 5	4		Solenoid valve F shorted ground	Solenoid valve #5
130	SID 5	5		Solenoid valve F circuit break	Solenoid valve #5
130	SID 55	2		D1 current resistor	Clutch actuator
130	SID 55	3		D1 current shorted high	Clutch actuator
130	SID 55	4		D1 current shorted ground	Clutch actuator
130	SID 55	5		D1 current circuit break	Clutch actuator
130	SID 6	3		Solenoid valve G shorted high	Solenoid valve #6
130	SID 6	4		Solenoid valve G shorted ground	Solenoid valve #6
130	SID 6	5		Solenoid valve G circuit break	Solenoid valve #6
130	SID 7	3		Torque converter clutch shorted high	Lockup sol.valve
130	SID 7	4		Torque converter clutch shorted ground	Lockup sol.valve
130	SID 7	5		Torque converter clutch circuit break	Lockup sol.valve
130	SID 8	3		Solenoid valve A shorted high	Forward sol. valve
130	SID 8	4		Solenoid valve A shorted ground	Forward sol. valve
130	SID 8	5		Solenoid valve A circuit break	Forward sol. valve
222	PID 1	3		U_Ret shorted high	Invalid data
222	PID 1	4		U_Ret shorted ground	Invalid data
222	PID 62	14		Reduction of retarder function active	Retard inhibit stat
222	PID 120	0		Retarder oil temperature high	Hyd retard oil temp
222	PID 120	3		Retarder temperature sensor above	Hyd retard oil temp
222	PID 120	4		Retarder temperature sensor below	Hyd retard oil temp
222	SID 10	3		Ret_On Valve shorted high	?

MID	(P)PID/SID	FMI	Seriousness	Component/function	Display text
222	SID 10	4		Ret_On Valve shorted ground	?
222	SID 10	5		Ret_On Valve current circuit break	?
222	SID 11	2		Retarder current resistor	?
222	SID 11	3		Retarder current shorted high	?
222	SID 11	4		Retarder current shorted ground	?
222	SID 11	5		Retarder current circuit break	?
222	SID 12	3		Retarder accumulator shorted high	?
222	SID 12	4		Retarder accumulator shorted ground	?
222	SID 12	5		Retarder accumulator circuit break	?
223	PID 163	2		Shifter encoding error	Gear attained
130, 222, 223	SID 231	2		CAN error	SAE J1939 data link
130, 222, 223	SID 250	2		J1708 busoff	SAE J1708 data link
130, 222, 223	SID 250	9		J1708 error warning	SAE J1708 data link

16. Fault codes, Voith 115v retarder (MID 222)

MID	(P)PID/SID	FMI	Seriousness	Component/function	Display text
222	PID 110	0		Eng. coolant temp.	Eng. coolant temp.
222	PID 110	4		Eng. coolant temp.	Eng. coolant temp.
222	PID 110	5		Eng. coolant temp.	Eng. coolant temp.
222	PID 110	13		Eng. coolant temp.	Eng. coolant temp.
222	PID 120	0		Hyd retard oil temp	Hyd retard oil temp
222	PID 120	4		Hyd retard oil temp	Hyd retard oil temp
222	PID 120	5		Hyd retard oil temp	Hyd retard oil temp
222	PID 120	13		Hyd retard oil temp	Hyd retard oil temp
222	PID 158	0		Control unit, battery potential	Battery potential
222	PID 158	1		Control unit, battery potential	Battery potential
222	PPID 30	13		Retarder current, PWM-valve	Retarder current
222	PPID 31	0		Retarder air press.	Retarder air press.
222	PPID 31	3		Retarder air press.	Retarder air press.
222	PPID 31	5		Retarder air press.	Retarder air press.
222	PPID 34	0		ECU, 12V Output	ECU, 12V Output
222	PPID 34	1		ECU, 12V Output	ECU, 12V Output
222	PPID 54	0		ECU +5V output	ECU +5V output
222	PPID 54	1		ECU +5V output	ECU +5V output
222	PPID 55	0		ECU temperature	ECU temperature
222	SID 2	3		Retard modul. Valve	Retard modul. valve
222	SID 2	4		Retard modul. Valve	Retard modul. valve
222	SID 2	5		Retard modul. Valve	Retard modul. valve
222	SID 2	6		Retard modul. Valve	Retard modul. valve
222	SID 231	2		SAE J1939 data link	SAE J1939 data link
222	SID 231	12		SAE J1939 data link	SAE J1939 data link
222	SID 240	2		Program memory	Program memory
222	SID 250	2		SAE J1708 data link	SAE J1708 data link
222	SID 250	4		SAE J1708 data link	SAE J1708 data link
222	SID 253	2		Calibration memory	Calibration memory
222	PSID 1	3		Power supply relay	Power supply relay
222	PSID 1	6		Power supply relay	Power supply relay
222	PSID 254	3		Controller #1	Controller #1

17. Fault codes, retarder 133

To the right of the bus instrument cluster there is a green checklamp (5022) for the retarder function and fault indications. At every voltage inflow the lamp will normally be lit for five seconds, if the lamp doesn't go out after five seconds have passed, a fault code is set in the retarder. The fault codes set in the retarder can be read via blink codes on the checklamp (5022) which can blink with two different intervals, long blink (2 seconds) to represent multiples of ten and short blink (0,5 seconds) to represent singular. For instance a combination of two long and two short blinks represents the number 22. A short look at the table below shows that 22 means "ABS signal internal control unit error".

The fault codes set in the retarder can be show by first turning the ignition on and off and then on again. Then press the lever to the position 1 and immediately back to position 0. The first fault code will now be displayed as an icon on the control lamp. Repeated movement of the lever between position 1 and position 0 will display the next fault code in line, if the same fault code is shown two times in a row there are no more fault codes set in the retarder.

Code	Description
1	Stop light relay short to ground
2	LS1 short to battery
3	HS 1 short to ground
4	HS 2 short to ground
5	Terminal 15 undervoltage
6	Terminal 15 overvoltage
7	Pilot valve short to ground
8	Tw sensor interruption or short to battery
9	Tw sensor short to ground
10	
11	To sensor interruption or short to battery
12	To sensor short to ground
13	RSS undefined switch condition (closing sequence)
14	RSS short to battery
15	RSS short to ground
16	Tachograph signal interruption
17	Pilot valve interruption or short to battery
18	Tachograph signal short to battery or undefined sign.
19	ABS short to ground
20	
21	ABS undefined level
22	ABS signal internal control unit error
23	Prop valve fault No. 1
24	Prop valve fault No. 2
25	Prop valve fault No. 3
26	Prop valve fault No. 4
27	Prop valve fault No. 5
28	Terminal 30 undervoltage
29	Internal fault conc. Safety component
30	
31	Data record/parameter: faulty coding
32	RKL interruption or short to ground
33	RKL short to battery
34	Missing engine speed signal

Code	Description
35	Internal fault concerning: ROM (CRC check). EEPROM (data record)
36	2/2-way valve fault
37	Non-plausibility of brake pedal operation
38	Pressure sensor fault
41	Time-out > 500ms press signal (VECU)
42	Time-out > 500ms ABS-signal (J1939)
43	J 1939 link "bus off".

18. Fault codes, VECU (MID 144)

MID	(P)PID/SID	FMI	Seriousness	Component/Function	Display text
144	PID 29	3	Yellow lamp	Extra throttle, percentage mode	Second throttle
144	PID 29	4	Yellow lamp	Extra throttle, percentage mode	Second throttle
144	PID 46	1		Wet tank air pressure	Wet tank air press
144	PID 46	3	Yellow lamp	Wet tank air pressure	Wet tank air press
144	PID 46	4	Yellow lamp	Wet tank air pressure	Wet tank air press
144	PID 84	2	Yellow lamp	Road speed	Road speed
144	PID 84	5		Road speed	Road speed
144	PID 84	6		Road speed	Road speed
144	PID 84	8	Yellow lamp	Road speed	Road speed
144	PID 84	12	Yellow lamp	Road speed	Road speed
144	PID 84	13	Yellow lamp	Road speed	Road speed
144	PID 91	3	Yellow lamp	Accelerator pedal position, percentage mode	Acc. pedal pos., %
144	PID 91	4	Yellow lamp	Accelerator pedal position, percentage mode	Acc. pedal pos., %
144	PID 152	12		Control unit, number of resets	No. of ECU resets
144	PPID 69	4	Yellow lamp	Buffered idle switch	Buff. idle val. sw.
144	PPID 70	4	Yellow lamp	Pedal contact, feeding	Output supply #3
144	PPID 71	4	Yellow lamp	Constant speed keeper and retarder, feeding switch	Output supply #4
144	PPID 72	3	Yellow lamp	Accelerator pedal and retarder, feeding sensor	Output supply #1
144	PPID 72	4	Yellow lamp	Accelerator pedal and retarder, feeding sensor	Output supply #1
144	PPID 73	3	Yellow lamp	Extra throttle and wet tank, feeding sensor	Output supply #2
144	PPID 73	4	Yellow lamp	Extra throttle and wet tank, feeding sensor	Output supply #2
144	PPID 75	3	Yellow lamp	Range inhibitor	Range inhibitor
144	PPID 75	4	Yellow lamp	Range inhibitor	Range inhibitor
144	PPID 76	3	Yellow lamp	Brake light status relay	Brakelight output
144	PPID 77	3	Yellow lamp	Compressor, status solenoid valve	Compressor control
144	PPID 77	4	Yellow lamp	Compressor, status solenoid valve	Compressor control
144	PPID 79	3	Yellow lamp	Fault gear shift lock 3/1, status relay	Area inh. sol valve
144	PPID 79	4	Yellow lamp	Fault gear shift lock 3/1, status relay	Area inh. sol valve
144	SID 230	7	Yellow lamp	Idle switch 1	Idle valid switch
144	SID 231	2	Yellow lamp	Control link, SAE J1939	SAE J1939 data link
144	SID 231	12	Yellow lamp	Control link, SAE J1939	SAE J1939 data link
144	SID 240	2	Yellow lamp	Program memory	Program memory
144	SID 243	7	Yellow lamp	Constant speed keeper, set switch (SET+/SET-)	CC Set switch
144	SID 250	2	Yellow lamp	Information link SAE J1708	SAE J1708 data link
144	SID 253	2	Red lamp	Calibration memory	Calibration memory
144	SID 253	13	Red lamp	Calibration memory	Calibration memory
144	PSID 1	7	Yellow lamp	Retarder, set switch	Retard contr SET sw
144	PSID 2	7	Yellow lamp	Idle valid switch 2	Idle valid switch 2
144	PSID 3	7	Yellow lamp	Idle valid switch 3	Idle valid switch 3
144	PSID 4	3	Yellow lamp	Retarder, switch	Retard contr lever

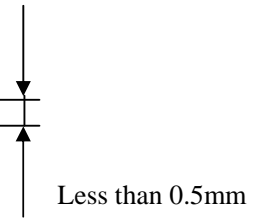
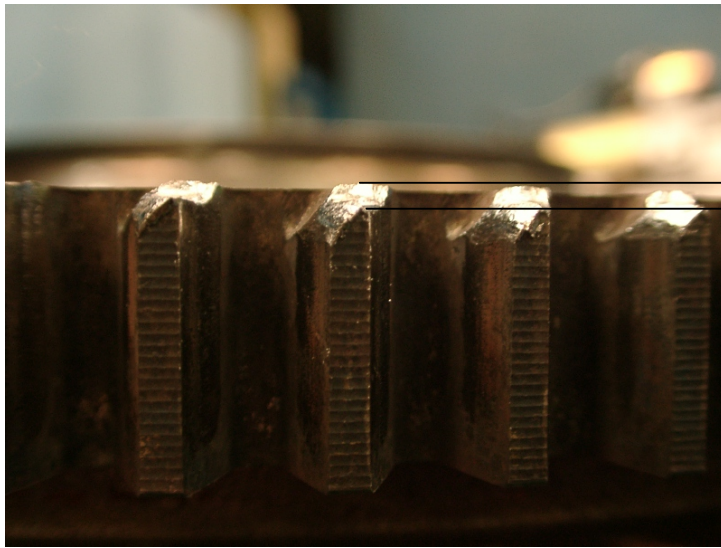
Service Bulletin A1-M1N-1729EN - Flywheel Ring Gear Wear / Damage

(Sample of Maximum Ring Gear Wear / Damaged)

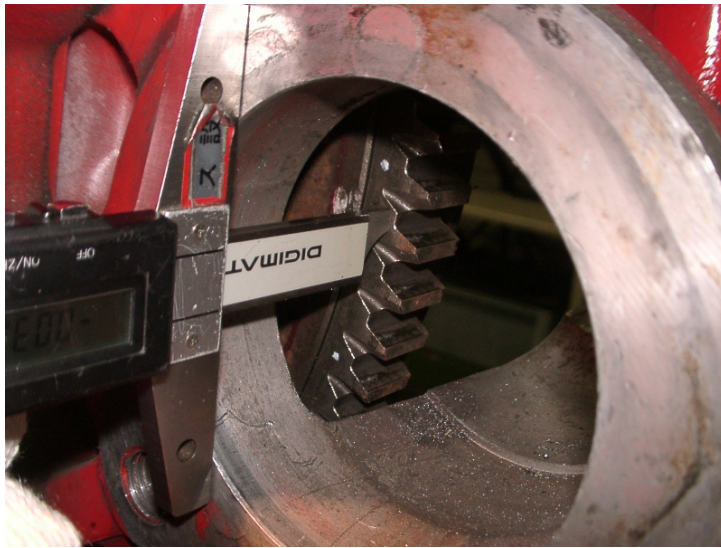


Please refer to the above photos and please replace the ring gear which has similar level of damage as these. See the next page for the method to measure the depth of the damage.

(Depth of wear / damage on ring gear)



(Measurement method)



Dimension between the mounting surface and the end surface of ring gear



Dimension between the mounting surface and the damage depth portion of ring gear

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1. DESCRIPTION

X3 Series coaches may be provided with either an Allison automatic transmission or a ZF-AsTronic transmission.

NOTE

Volvo D13 engines may only be provided with an Allison automatic transmission

1.1 ALLISON AUTOMATIC TRANSMISSION

The B500 and B500R (with retarder) Allison Transmissions have 6 speeds with two top range (fifth and sixth) overdrives. Total coverage is determined by dividing the highest gear ratio by the lowest gear ratio. Total coverage expresses the transmission gear ratio versatility. Transmissions with larger total coverage number have a wider variety of available ratios.

An electronic control allows the transmission to shift at exactly the right point on the engine's fuel consumption curve for best economy. Early lockup maintains the highest possible mechanical efficiency through the closely-spaced gear steps, culminating in two overdrive ratios. This combination allows progressive shifting techniques, where engine speeds are reduced for higher efficiency and lower fuel consumption.

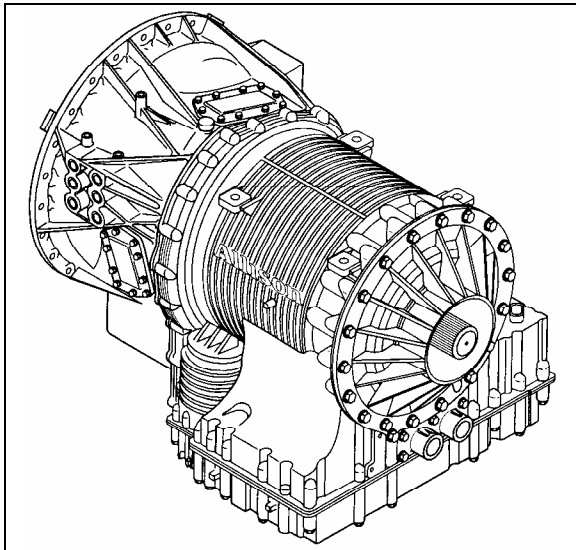


FIGURE 1: ALLISON TRANSMISSION

07136

Gear selection and torque converter modes are controlled by a microcomputer-based electronic transmission management system. It is fed information regarding throttle position, operator range selection, engine speed, turbine speed, transmission output speed and various system pressures from special electronic sensors. With

this information, it computes shift points and clutch pressures to meet immediate needs. Using closed loop adaptive logic; the electronic control looks at a number of parameters during the shift, and makes minute adjustments to match the shift to desired profile stored in its memory. It then looks at these adjustments and resets the parameters, which allow the transmission to quickly compensate for variations in load, terrain or environment and to adjust for clutch wear and engine power changes. A Diagnostic Data Reader can be connected to the electronic control unit to provide a self-check of all systems in the transmission. Five-digit trouble codes greatly reduce the time it takes to pinpoint potential problems. (Refer to paragraph "10. TROUBLESHOOTING" in this section).

1.1.1 Retarder (if applicable)

This optional auxiliary braking device for the automatic transmission is integrated into the basic envelope of the transmission and transmits its braking force directly to the propeller shaft. It requires no additional length and adds only 75 pounds (34 kg) of weight. Operation of the retarder is controlled electronically by the driver's use of the brake and/or by hand control lever.

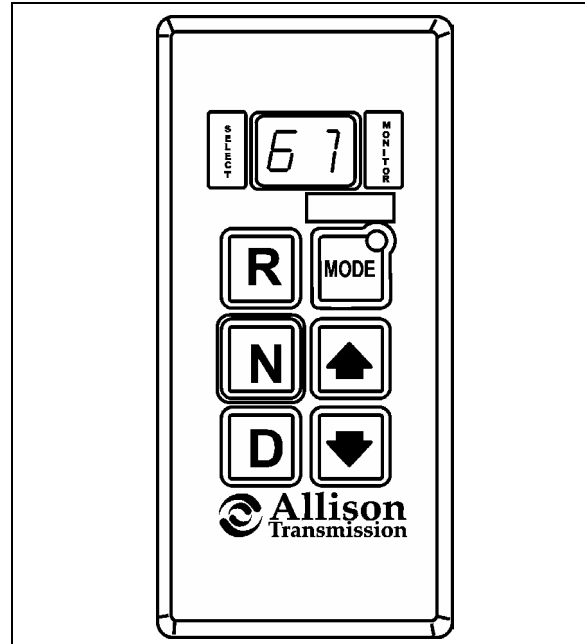


FIGURE 2: ALLISON TRANSMISSION CONTROL PAD 07025

When activated, fluid enters a cavity and provides resistance to the turning of rotor blades revolving with the output shaft. This effectively slows the vehicle to the point where the service brakes are needed only for final stopping. The retarder is fully modulated and is compatible with ABS.

Section 07: TRANSMISSION

1.2 ZF-ASTRONIC TRANSMISSION

The AS TRONIC gear shift system is a combination of an electro-pneumatically shifted constant-mesh gearbox and an automated dry clutch.

If the AS TRONIC transmission system is to be used, the vehicle must have an electronic engine control unit as well as CAN communication. Since the clutch is automated (clutch pedal no longer fitted), the driver no longer has to activate the clutch.

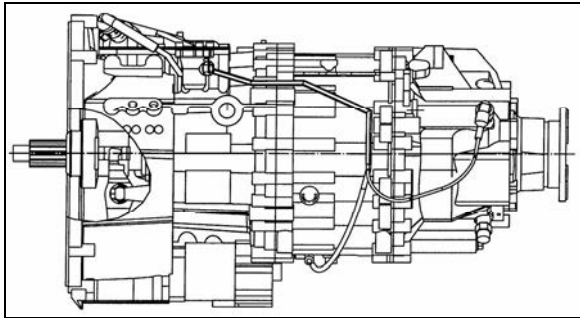


FIGURE 3: ZF-ASTRONIC TRANSMISSION 07078

The actual shift procedure is performed by the electronic transmission control unit. The driver has the option of driving the vehicle in both semi-automatic mode as well as fully automatically. When in semi-automatic mode, manual shifting with the range selector is made easier.

When in fully automatic mode, gears are selected and shifts made by the electronic control unit. The driver can still intervene if he wishes to. All system functions required are shown on the display, e.g. neutral, gear change, clutch overload and diagnosis information.

2. WELDING PROCEDURES

These procedures are intended only for vehicles equipped with transmission electronic controls. When frame or other welding is required on the vehicle, precautions are to be taken to protect the electronic control components. Refer to section 00: GENERAL INFORMATION, paragraph 3: "Precautions to be observed before welding" for complete procedure.

3. MAINTENANCE

3.1 ALLISON TRANSMISSION

To gain access to the dipstick, open the engine compartment rear doors; dipstick is located on the radiator side of the engine (Fig. 4).

3.1.1 Manual Fluid level Check

DANGER

When checking the oil level, be sure that the parking brake and/or emergency brakes are set and properly engaged, and the wheels are chocked. Unexpected and possible sudden vehicle movement may occur if these precautions are not taken.

- Special care must be taken not to touch the engine coolant tubing and/or exhaust pipe, since this could cause severe burns.
- Do not wear loose clothing and, stay away from rotating parts during procedure; personal injury could occur.

Clean all dirt from around the end of the oil filler tube before removing the dipstick. Dirt or foreign matter must not be permitted to enter the oil system since it will cause valves to stick, undue wear of transmission parts, and clogged passages. Check the oil level using the procedures in Cold Check and Hot Check. Record any abnormal level on your "Maintenance Records".

Always check the oil level reading at least twice when the engine is running. Consistency is important in maintaining the accuracy of the reading. If inconsistent readings persist, check the transmission breather to ensure it is clean and free of debris.

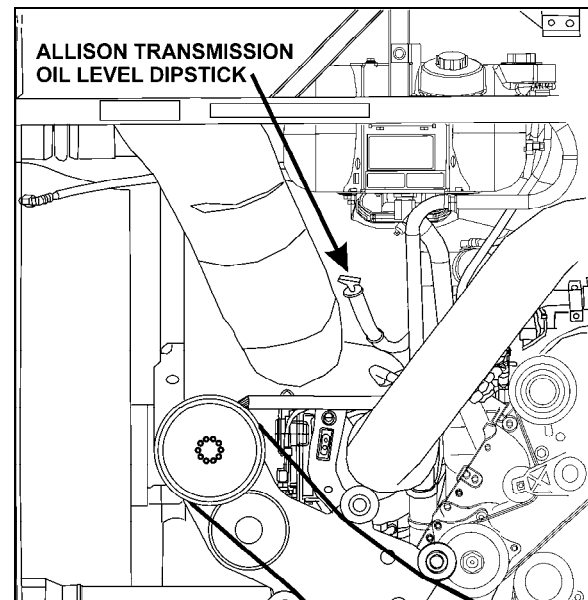


FIGURE 4: OIL LEVEL DIPSTICK (AUTO. TRANS.) 07113

3.1.2 Cold Check

The purpose of the **Cold Check** is to determine if the transmission has enough fluid to be operated safely until a **Hot Check** can be made.

1. If the engine has been shut down for an extended period of time, park the vehicle on a level surface and apply the parking brake.

CAUTION

The oil level rises as sump temperature increases. **DO NOT** fill above the "Cold Run" band if the transmission oil is below normal operating temperature. During operation, an overfull transmission can become overheated, leading to transmission damage.

2. Run the engine at idle in «N» (Neutral) for about one minute.
3. Shift to Drive (D) and operate the engine for 30 seconds at 1000-1500 rpm; then shift to Reverse (R) to clear the hydraulic system of air.
4. Move the vehicle to a level surface, put transmission in «N» (Neutral), and set the parking brake.
5. Finally shift to Neutral (N) and allow the engine to idle (500 - 800 rpm).
6. While the engine is running, remove the dipstick from the tube and wipe it clean (Figs. 4 & 5). Insert the dipstick into the fill tube, pushing down until it stops.

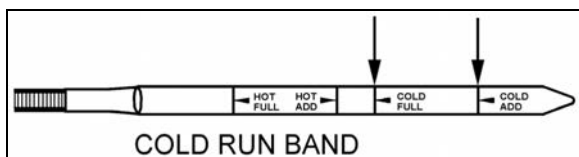


FIGURE 5: COLD CHECK

07050

7. Remove the dipstick and observe the fluid level. Repeat the check procedure to verify the reading. If the fluid on the dipstick is within the COLD CHECK band, the level is satisfactory for operating the transmission until the oil is hot enough to perform a **Hot Check**. If the fluid level is **not** within this band, add or drain fluid as necessary to bring the level within the COLD CHECK band.
8. Perform a **Hot Check** at the first opportunity after the normal operating temperature of 160°F (71°C) to 200°F (93°C) is attained.

**CAUTION**

DO NOT operate the transmission for extended periods of time until a **Hot Check** has verified proper fluid level. Transmission damage can result from extended operation at improper fluid level conditions.

**CAUTION**

Obtain an accurate fluid level by imposing the following conditions:

- Engine is idling (500-800 rpm) in «N» (Neutral).
- Transmission fluid is at normal operating temperature.
- The vehicle is on a level surface.

3.1.3 Hot Check

**CAUTION**

The oil **must be hot** to ensure an accurate check for this procedure. The oil level rises as temperature increases.

To perform a **Hot Check**, do the following:

1. The **Hot Check** can be performed when the transmission oil reaches the normal operating temperature (160°F to 200°F / 71°C to 93°C). The transmission oil temperature can be checked with the dashboard message center display (MCD) when selecting the Gauge Mode (refer to the "Operator's Manual" for added information).
2. Park the vehicle on a level surface and shift to Neutral (N). Apply the parking brake and allow the engine to idle (500 - 800 rpm).
3. Remove the dipstick from the tube and wipe it clean. Insert the dipstick into the fill tube, pushing down until it stops.
4. Remove the dipstick and observe the fluid level. The safe operating level is anywhere within the HOT RUN band on the dipstick. Repeat the check procedure to verify the reading.
5. If the level is **not** within this band, add or drain fluid as necessary to bring the level within the HOT RUN band. (Fig. 6).

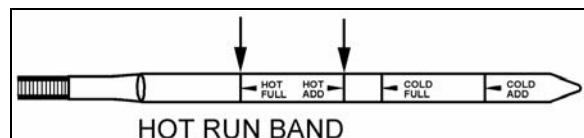


FIGURE 6: HOT CHECK

07049

Section 07: TRANSMISSION

6. Be sure fluid level checks are consistent. Check level more than once and if readings are not consistent, check to be sure the transmission breather is clean and not clogged. If readings are still not consistent, contact your nearest Allison dealer or distributor.

NOTE

The Cold Check is more appropriate for verifying the oil level after the first fill-up. In case of conflict, the Hot Check has priority over the Cold Check; the fluid level check using the pushbutton shift selector has priority over the Hot Check.

3.1.4 Fluid Level Check Using the Pushbutton Shift Selector

Oil level codes are obtained as follows:

1. Park vehicle on a level surface, select «N» (neutral) on the pushbutton shift selector and apply parking brake.
2. Press simultaneously the ▲ (Up) and ▼ (Down) arrow buttons once.
3. Oil level codes are displayed in 2 minutes (e.g. display will flash and 8, 7, 6, 5, ...; countdown will occur during the 2 minutes) once the following parameters are met:
 - **Waiting time, vehicle must be stationary for at least 2 minutes to allow the oil to settle;**
 - **Engine at idle;**
 - **Oil at normal operating temperature, between 140°F (60°C) and 220°F (104°C);**
 - **Transmission in «N» (Neutral);**
 - **Transmission output shaft stopped;**
 - **Oil level sensor present and working.**

After 2 minutes, the display will flash one of the codes shown below:

CODE	CAUSE OF CODE
OL...OK	Oil level is correct
OL...LO...01	One quart low
OL...LO...02	Two quarts low
OL...HI...01	One quart high
OL...HI...02	Two quarts high

NOTE

Failure to meet one of the above parameters will stop the two minute countdown. One of the codes shown hereafter will indicate the cause of the countdown interruption. Once all parameters are met, the countdown will continue from where it left off.

CODE	CAUSE OF CODE
OL...OX	Waiting time too short
OL...50	Engine speed (rpm) too low
OL...59	Engine speed (rpm) too high
OL...65	Neutral must be selected
OL...70	Sump oil temperature too low
OL...79	Sump oil temperature too high
OL...89	Output shaft rotation
OL...95	Sensor failure

To exit the Oil Level Display Mode, press any range button: «R», «N» or «D».

3.1.5 Importance of Proper Fluid Level

It is important that the proper fluid level be maintained at all times because the transmission fluid cools, lubricates, and transmits hydraulic power. If the fluid level is too low, the converter and clutches do not receive an adequate supply of fluid. If fluid level is too high, the fluid can aerate, causing the transmission to shift erratically or overheat.

3.1.6 Keeping Oil Clean

Oil must be handled in clean containers, fillers, etc., to prevent foreign material from entering the transmission. Place the dipstick on a clean surface area while filling the transmission.



CAUTION

Containers or fillers that have been used to handle antifreeze or engine coolant must NEVER be used for handling transmission fluid. Antifreeze and coolant solutions contain ethylene glycol that, if introduced into the transmission, can cause the clutch plates to fail.

3.1.7 Recommended Automatic Transmission Fluid

Hydraulic fluids used in the transmission are important influences on transmission performance, reliability and durability. **Castrol TranSynd™ Synthetic Fluid, DEXRON-III®** and **DEXRON-VI®** fluids are recommended for on-highway applications.

- **TranSynd™** is a full synthetic transmission fluid developed by Allison Transmission and Castrol Ltd. This fluid meets Allison specifications for Severe Duty and Extended Drain Intervals. TranSynd™ is fully qualified to the Allison TES295 specifications and is available through Prevost Parts
- To be sure a fluid is qualified for use in Allison transmission, check for the **DEXRON-III®** or **DEXRON-VI®** license numbers on the container or consult the lubricant manufacturer. Consult your Allison Transmission dealer or distributor before using other fluid types.

Customers may use TranSynd™/TES 295 equivalent and extend drain intervals. Equivalent TranSynd™ fluid must meet or exceed TES 295 requirements. Customers may choose from a wide variety of approved Dexron-III® fluids.

Customers may choose from a wide variety of approved non-TES 295 like Dexron-III®, Dexron-VI® or approved Schedule 1 TES-389 fluids.

The Transmission Fluid Operating Temperature Requirements table lists the minimum fluid temperatures at which the transmission may be safely operated without preheating. Preheat with auxiliary heating equipment or by running the equipment or vehicle with the transmission in «N» (Neutral) for a minimum of 20 minutes before attempting range operation.

Transmission Fluid Operating Temperature Requirements

Fluid type	Minimum operating temperature	
	Celsius	Fahrenheit
TranSynd™	-30	-22
DEXRON-VI®	-25	-13



CAUTION

Disregarding minimum fluid temperature limits can result in transmission malfunction or reduced transmission life.

NOTE

The use of an arctic preheat kit is recommended at temperatures below -25°F (-32°C). If a preheat kit is not available, the TCM will restrict full operation until the sump temperature is increased.

3.1.8 Oil Contamination

At each oil change, examine the drained oil for evidence of dirt or water. A nominal amount of condensation will emulsify during operation of the transmission. However, if there is evidence of water; check the cooler (heat exchanger) for other signs of leakage. This, however, may also indicate leakage from the engine oil system.

3.1.9 Metal Particles

Metal particles in the oil (except for minute particles normally trapped in the oil filter) indicate damage has occurred in the transmission. When these particles are found in the sump, the transmission must be disassembled and closely inspected to find the source. Metal contamination will require complete disassembly of the transmission and cleaning of all internal and external circuits, coolers, and all other areas where the particles could lodge.



CAUTION

If excessive metal contamination has occurred, replacement of the oil cooler and replacement of all bearings within the transmission is recommended.

3.1.10 Coolant Leakage

If engine coolant leaks into the transmission oil system, immediate action must be taken to prevent malfunction and possible serious damage. The transmission must be completely disassembled, inspected, and cleaned. All traces of the coolant contamination must be removed. Friction clutch plates contaminated with ethylene glycol must be replaced.

TABLE 1

Recommended Fluid and Filter Change Intervals Using Dexron-III/ Dexron-VI/ Non-TranSynd™/Non-TES 295/Mixture							
Severe ³ Coaches equipped with retarder				General ⁴ Coaches without retarder			
Fluid	Filters			Fluid	Filters		
	Main	Internal	Lube/ Auxiliary		Main	Internal	Lube/ Auxiliary
12,000 Miles (20 000 km) 6 Months	12,000 Miles (20 000 km) 6 Months	Overhaul	12,000 Miles (20 000 km) 6 Months	25,000 Miles 40 000 km 12 Months	25,000 Miles 40 000 km 12 Months	Overhaul	25,000 Miles (40 000 km) 12 Months

2 inch Control Module (1.75 approximately) – Requires High-Capacity Filter kit Allison P/N 571709

TABLE 2

Recommended Fluid and Filter Change Intervals ¹ Using 100% TranSynd™/TES 295 Approved Fluid ²							
Severe ³ Coaches equipped with retarder				General ⁴ Coaches without retarder			
Fluid	Filters			Fluid	Filters		
	Main	Internal	Lube/ Auxiliary		Main	Internal	Lube/ Auxiliary
150,000 Miles (240 000 km) 48 Months	75,000 Miles (120 000 km) 36 Months	Overhaul	75,000 Miles (120 000 km) 36 Months	300,000 Miles 480 000 km 48 Months	75,000 Miles (120 000 km) 36 Months	Overhaul	75,000 Miles (120 000 km) 36 Months

TABLE 3

Recommended Fluid and Filter Change Intervals Using 100% TranSynd™/TES 295 Approved Fluid And Gold Series Filters							
Coaches equipped with retarder				Coaches without retarder			
Fluid	Filters			Fluid	Filters		
	Main	Internal	Lube/ Auxiliary		Main	Internal	Lube/ Auxiliary
	Initial Break-in				Initial Break-in		
50,000 Miles (80 000 km) 24 Months	50,000 Miles (80 000 km) 24 Months	Overhaul	50,000 Miles (80 000 km) 24 Months	150,000 Miles 240 000 km 48 Months	50,000 Miles 80 000 km 24 Months	Overhaul	50,000 Miles (80 000 km) 24 Months

¹ Extended TrandSynd™/TES 295 fluid and filter change intervals are only allowed with Allison High-Capacity filters.

² Less than 100% concentration of TranSynd™/TES 295 approved fluid is considered a mixture and should utilize non-TES 295 change intervals. If the customer replaces non-TranSynd™/non-TES 295 fluid with TranSynd™/TES 295 equivalent, the change interval recommendations of non-TranSynd™/non-TES 295/mixture must be followed. Upon the next oil change, if the customer reinstall TranSynd™/TES 295 equivalent, the fluid & filter change recommendation outlined in 100% TES 295 approved fluids must be followed.

³ Severe vocation= All retarder, On/Off highway, transit and intercity coach with duty cycle greater than one (1) stop per mile.

⁴ General vocation= intercity coach with duty cycle less than or equal to one (1) stop per mile and all other vocations not listed in severe vocation.

3.1.11 Oil and Filter Change

Allison transmissions are factory fill with **Castrol TranSynd™** fluid. Oil change must be performed with the vehicle on a flat and level surface and with parking brake applied. Oil and oil filter change frequency is determined by the severity of service and operating conditions of the transmission and by the filter equipment installed. See "TABLE 1, TABLE 2 or TABLE 3" for oil and filter change intervals. More frequent changes may be required when operations are subject to high levels of contamination or overheating. Filters must be changed at or before recommended intervals.

IMPORTANT NOTE

Allison Transmission recommends that customers use fluid analysis as the primary method for determining fluid change intervals. Many customers have a systematical annual transmission fluid change while, in many cases, fluid analysis could demonstrate that the transmission fluid is still in good condition and a fluid change is not required. In the absence of a fluid analysis program, the fluid change interval listed in TABLE 1, TABLE 2 & TABLE 3 should be used.

IMPORTANT NOTE

Your transmission is equipped with **High Capacity filters**. High Capacity filters allow for increased fluid and filter change intervals in transmissions utilizing TES 295 approved fluid/TranSynd™. High Capacity filters eliminate the requirement of the initial 5000 miles (8000km) main filter change.

Former Gold Series filter kits are completely cancelled and serviced with current High Capacity filter kits. However, if you are using stocked Gold Series filter kits with TES 295 approved fluid/TranSynd™, use TABLE 3 for oil and filter change intervals.

The procedure for changing the transmission oil and oil filters is as follows:

Drain

1. The transmission should be at an operating temperature of 160°F (71°C) to 200°F (93°C) when the oil is drained. This will ensure quicker and more complete fluid drainage.

NOTE

Remove transmission protective panel located underneath transmission for easier access.

2. Remove the drain plug from under the transmission (Fig. 7) and allow the oil to drain into a suitable container. Check the condition of the oil as described previously.
 3. To replace the integral filters, remove twelve bolts (6 on each cover), two filter covers, two O-rings, two square cut seals and the two filters from the bottom of the control module (Fig. 7).
 4. To install filters, pre-lube and install the two O-rings, the two square cut seals followed by the filters (lube the O-ring in filter cartridge only) into the filter compartment. Index each filter/cover assembly to holes in channel plate/sump. Push the cover assembly in by hand to seat the seals.
- CAUTION**
- Do not use bolts to draw the cover to sump. This can damage the cover, seal, or sump.
5. Install twelve bolts and both covers, and then tighten to 38-45 lbf-ft (51-61 Nm).
 6. Inspect the drain plug and O-ring. Replace if necessary. Reinstall the drain plug and tighten to 18-24 lbf-ft (25-32 Nm).
 7. Reinstall transmission protective panel

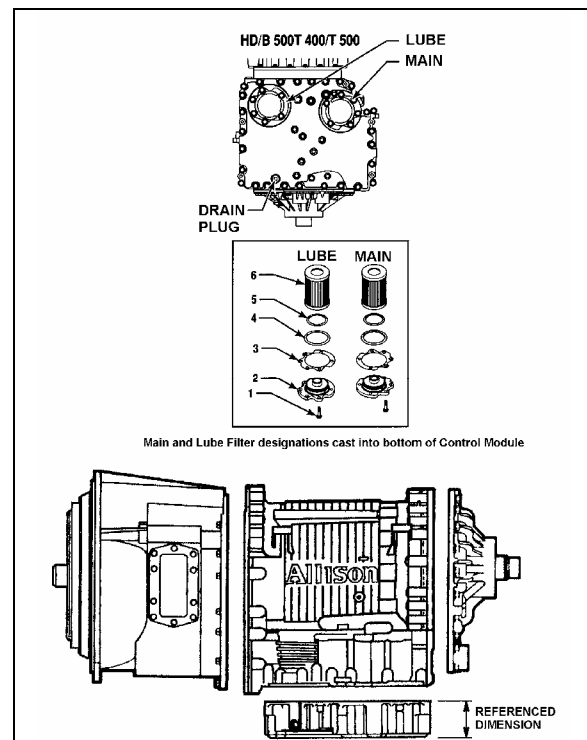


FIGURE 7: DRAIN PLUG AND FILTERS

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Fluid loss with filter change only

When changing main and lube filters at recommended intervals, approximate fluid loss for each filter as follows:

Main filter = 2 quarts (1.9 liters)

Lube filter = 8 quarts (7.6 liters)

Refilling Transmission

The amount of refill fluid is less than the amount used for the initial fill. Fluid remains in the external circuits and transmission cavities after draining the transmission.

NOTE

<i>Quantities listed above are approximations and do not include external oil cooler lines.</i>

Using the oil level dipstick filler tube, refill with 24 US qts (23 liters) [28 US qts (26.5 liters) if equipped with retarder] and check the oil level using the **Fluid Level Check Using Pushbutton Shift Selector** procedure in this section.

3.2 ZF AS-TRONIC TRANSMISSION

All information needed for the removal /installation or maintenance of the ZF transmission is included in the documents annexed at the end of this section.

3.2.1 Oil Change

Approximately 11 liters is needed for a complete oil change.

3.2.2 ZF AS-TRONIC / SACHS Clutch Installation Procedure

Important Note:

The clutch hub splines, input shaft, release bearing, clutch fork, and clutch push rod ends all come pre-lubed from the factory.

- Clean the flywheel, clutch disc, and pressure plate surfaces, removing any grease prior to assembly.
- Slide the clutch disk onto the transmission input shaft to check for smooth engagement. Remove clutch disk.

- Apply a very thin coating of Optimol Olista Longtime synthetic grease to the transmission input shaft. Slide the clutch disk along the full length of the input shaft to transfer grease to the clutch hub splines. Remove clutch disc, and remove any excess grease from the exterior of the clutch disc hub. **It is very important that no excess grease is left on the exterior of the clutch hub or clutch disk!**
- Install two temporary pilot studs (7/16-14, 3" long), placing them on the same diameter, 180° apart. These are used to aid in the alignment of the clutch pressure plate.
- Verify that the pilot bearing is seated properly in the flywheel. Insert a clutch alignment tool (SAE 2" DIA, 10 Spline) through the clutch disc and into the pilot bearing. PLEASE NOTE: the direction matters – the large side of the hub should face the clutch pressure plate. The clutch disc hub should be marked "flywheel side" – this side should face the flywheel.
- Use the clutch alignment tool to keep the clutch disc in the proper position and align the clutch cover with the two studs. Push the cover in place in the direction of the flywheel and start installing the clutch bolts. Use Lock-Tite for each bolt. Install, but do not torque, the 10 bolts. Remove the two pilot studs and in their place install the remaining 2 bolts.
- When the bolts are hand tight, be sure that the clutch cover fits into the flywheel centering ring. Tighten each bolt a little at a time, in a crisscross pattern, until the pressure plate cover contacts the flywheel face. Once the cover has touched the face of the flywheel, torque the clutch bolts to 55 ft-lbs, again in a crisscross fashion.
- Remove the clutch alignment tool. If the installation was successful, it should slide out smoothly.
- Ensure that the release bearing retaining clip (located on the "fingers" of the pressure plate) is closed. Refer to figure 8.
- Remove the Clutch Inspection Cover from the bottom of the transmission.

- The transmission should have been shipped in gear. This will allow the installer to rotate the output shaft in order to align the input shaft with the clutch disc hub. If the transmission is in neutral, a “strap wrench” (with a rubber or leather strap) can be used to align the input shaft. Do not use a wrench of the “chain” variety, as damage to the input shaft may result. When aligned, push the transmission towards the engine. Be sure that the bell housing contacts the flywheel housing.

Warning!

- Insure that the transmission moves in a straight line. It can very easily go off center relative to the clutch disc and pilot bearing.
- Insure that the bell housing interfaces evenly with the flywheel housing. Even surface contact should be attained before tightening bolts.
- Do not try to correct relative position of the bell housing and flywheel housing by pulling the transmission into place with the bell housing bolts. The transmission bell housing should seat into the flywheel housing freely.
- When the bell housing and flywheel housing surfaces and bolt holes are aligned, install the transmission bolts. Only hardened steel flat washers should be used, **SERRATED LOCK WASHERS ARE NOT ALLOWED.** Torque the transmission bolts to 55 ft-lbs. in a crisscross fashion.
- From underneath, push the clutch release bearing forward (in the direction of flywheel) using the release fork. Use force to snap the bearing into the retaining clip located on the “fingers” of the pressure plate. The installer should be able to both hear and feel the bearing seat into place. Refer to figure 8.

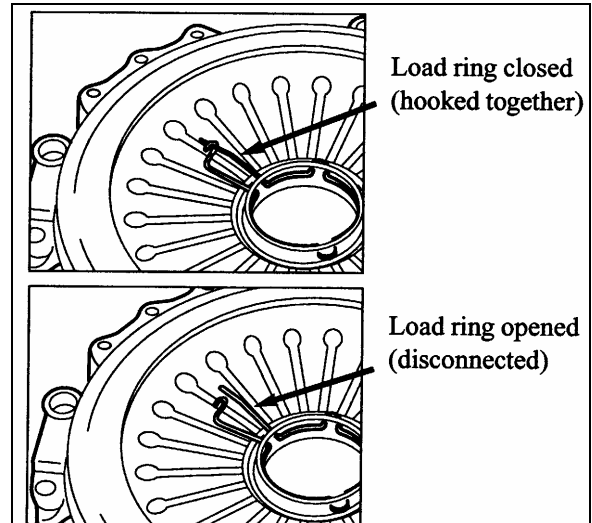


FIGURE 8: RELEASE BEARING RETAINING CLIP 07112

- Install the Clutch Actuator inspection cover.
- The clutch/transmission installation is now complete.

4. INSTALLATION OF ZF OR ALLISON TRANSMISSION BRACKETS ON VEHICLES EQUIPPED WITH DETROIT DIESEL ENGINE ONLY

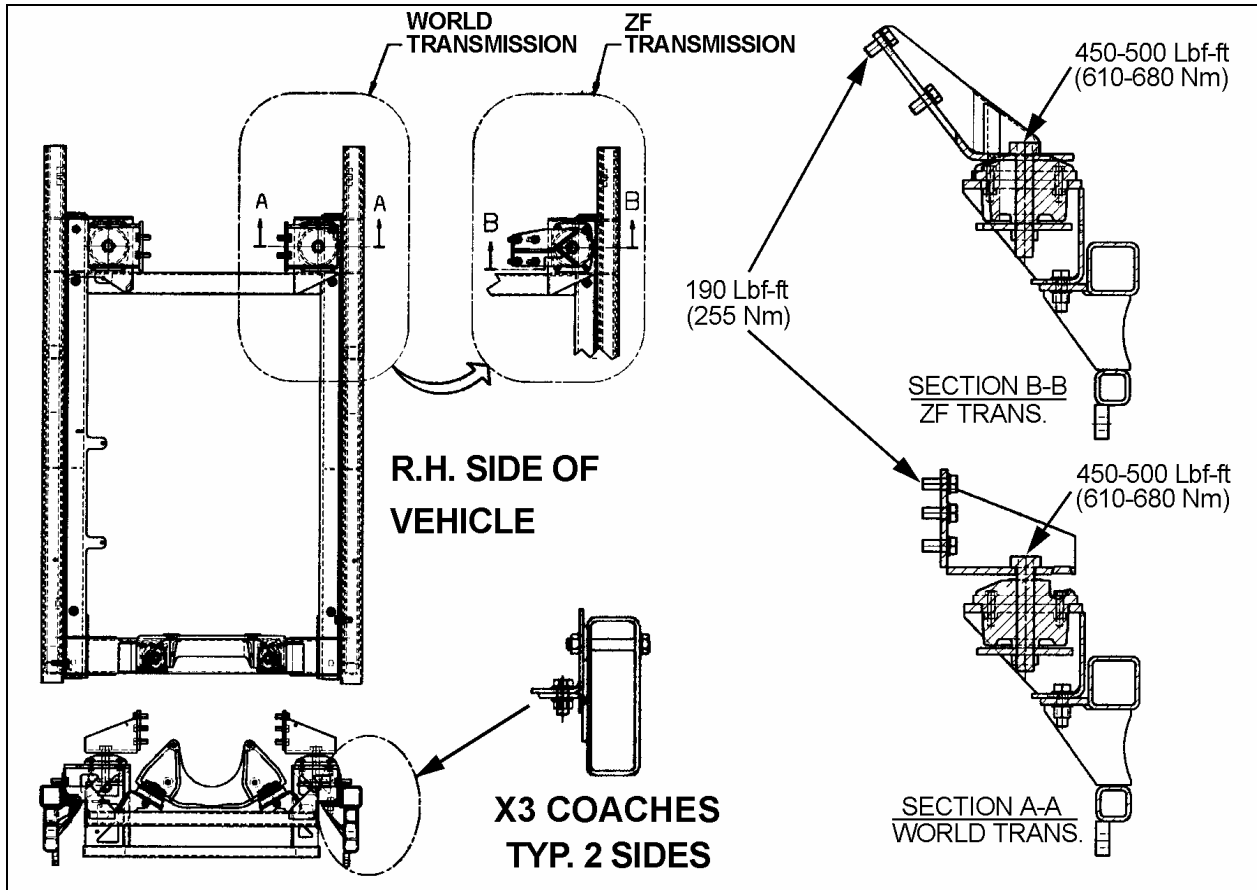


FIGURE 9: ZF OR ALLISON TRANSMISSION BRACKETS

07131

5. ALLISON TRANSMISSION REMOVAL

The following procedure deals with the removal of the Allison transmission without removing the power plant cradle from vehicle. The methods used to support the transmission and engine depend upon conditions and available equipment.

1. Select transmission's "NEUTRAL" position, apply parking brake, then set battery master switch to the "OFF" position.
2. Jack up vehicle, then place safety supports underneath body.



CAUTION

Only the recommended jacking points must be used as outlined in Section 18, "BODY".

NOTE

For more clearance between the tag axle and transmission, the tag axle may be unloaded and jacked up or retracted (if applicable).

3. Remove engine splash guards and protective panels surrounding transmission.
4. Remove cross member from under transmission.
5. Remove the transmission drain plug and allow oil to drain. Inspect the drain plug washer and replace it if necessary. Reinstall the drain plug and tighten to 33-41 lbf-ft (45-56 Nm) (see "3.1.11 Oil and Filter Change" in this section.



WARNING

It is better to drain oil when it is still warm. Avoid contact with oil since it can be very hot and cause personal injury.

6. Remove transmission dipstick and filler tube.
7. Disconnect propeller shaft from transmission and remove its safety guard. Refer to Section 09, "PROPELLER SHAFT".
8. Disconnect the two oil cooler hoses from transmission. Cover hose ends and fittings to prevent fluid contamination.

**WARNING**

A significant amount of oil may drain from oil lines when they are disconnected.

9. Disconnect all sensors on L.H. side of the transmission.
10. Disconnect main wiring harness.
11. Disconnect the air supply line (steel-braided hose) from retarder control valve (if applicable).
12. Remove any locking tie, clamp and bracket that may interfere with the removal of transmission.
13. Support transmission using a suitable transmission jack.

- **Detroit Diesel Series 60 Engine Only**

Remove the access plug from the flywheel housing on the R.H. side below starter. From access plug, remove the 12 converter-to-flexible plate attaching screws. Cranking the engine to gain access to the attaching screws may be done by turning the crankshaft pulley using a suitable adapter (fig. 10).

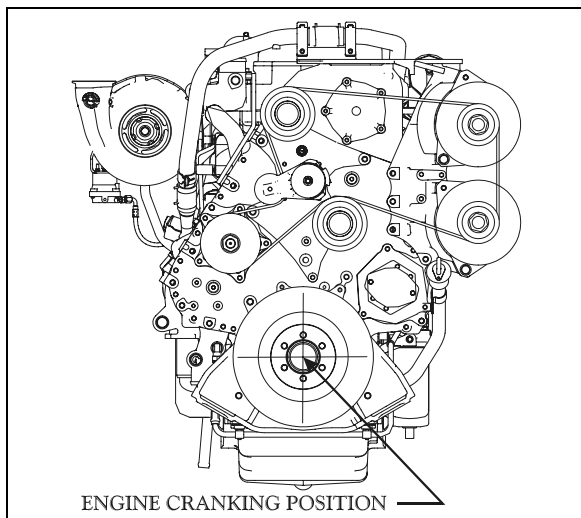


FIGURE 10: ENGINE CRANKING POSITION

01153

- **Volvo D13 Engine Only**

Remove starter motor located on engine L.H. side. Removing the starter motor will allow access to unfasten the 12 converter-to-flexible plate attaching screws. Remove the plug located below starter motor and install cranking tool (88800014). Cranking the engine to gain access to the attaching screws may be done by turning the cranking tool using a suitable adapter (fig. 11).

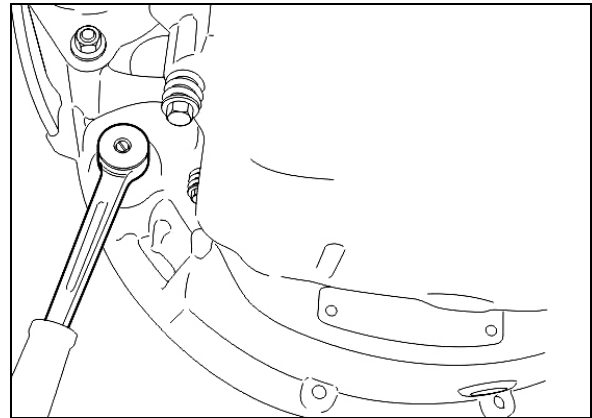


FIGURE 11: VOLVO ENGINE CRANKING POSITION

**CAUTION**

Do not rotate alternator shaft clockwise to avoid removing tension on belt.

14. Remove the 12 screws retaining the torque converter housing to the flywheel housing.

**CAUTION**

Make sure transmission-to-engine alignment is maintained when removing screws to avoid damaging torque converter housing.

15. Slowly pull transmission straight out to clear the engine.
16. Remove the transmission.

6. TRANSMISSION OIL COOLER REMOVAL

6.1 TRANSMISSION WITHOUT RETARDER

6.1.1 Detroit Diesel Series 60 Engine

Stop engine and allow engine to cool. Close both heater line shutoff valves (refer to Section 05 "Cooling").

To drain the cooling system, proceed as per Section 05 "Cooling", paragraph 5: Draining. If the cooling system is contaminated, flush

Section 07: TRANSMISSION

system as per Section 05 "Cooling", paragraph 7: Flushing.

1. Disconnect and remove the engine air intake duct mounted between the air cleaner housing and the turbocharger inlet.



CAUTION

To avoid damage to turbocharger, cover the turbocharger inlet opening to prevent foreign material from entering.

2. Disconnect the two transmission hoses from oil cooler. Cover hose ends and fittings to prevent fluid contamination (Refer to fig.12).



WARNING

A significant amount of oil may drain from oil lines when they are disconnected.

3. Unfasten the constant-torque hose clamps and remove the two hoses.

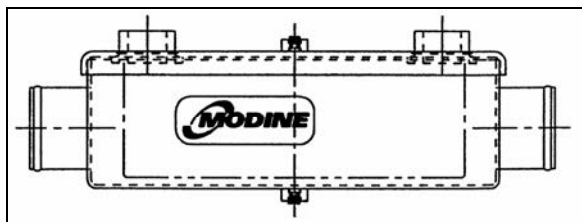


FIGURE 12: MODINE OIL COOLER

07072

4. Unscrew the four holding nuts and remove the U-bolts, remove the oil cooler from engine compartment.
5. Reinstall transmission oil cooler by using reverse procedure.

6.1.2 Volvo D13 engine

Stop engine and allow engine to cool. Close both heater line shutoff valves (refer to Section 05 "Cooling").

To drain the cooling system, proceed as per Section 05 "Cooling", paragraph 5: Draining. If the cooling system is contaminated, flush system as per Section 05 "Cooling", paragraph 7: Flushing.

1. Remove the rear L.H. side tag axle wheel, then remove the rear L.H. side fender panel.
2. Disconnect the two transmission hoses from oil cooler. Cover hose ends and fittings to prevent fluid contamination (Refer to fig.12).



WARNING

A significant amount of oil may drain from oil lines when they are disconnected.

3. Unfasten the constant-torque hose clamps and remove the two hoses.
4. Unscrew the four holding nuts and remove the U-bolts, remove the oil cooler from engine compartment.
5. Reinstall transmission oil cooler by using reverse procedure.

6.2 TRANSMISSION WITH RETARDER

6.2.1 Detroit Diesel Series 60 Engine

Stop engine and allow engine to cool. Close both heater line shutoff valves (refer to Section 05 "Cooling").

1. To drain the cooling system, proceed as per Section 05 "Cooling", paragraph 5: Draining. If the cooling system is contaminated, flush system as per Section 05 "Cooling", paragraph 7: Flushing.
2. Disconnect and remove the engine air intake duct mounted between the air cleaner housing and the turbocharger inlet.



CAUTION

To avoid damage to turbocharger, cover the turbocharger inlet opening to prevent foreign material from entering.

3. Disconnect the transmission hoses from oil cooler. Cover hose ends and fittings to prevent fluid contamination.



WARNING

A significant amount of oil may drain from oil lines when they are disconnected.

4. Unfasten the constant-torque hose clamps and remove the two hoses.
5. Unscrew the holding bolts and nuts and remove the oil cooler from engine compartment.
6. Reinstall transmission oil cooler by using reverse procedure.

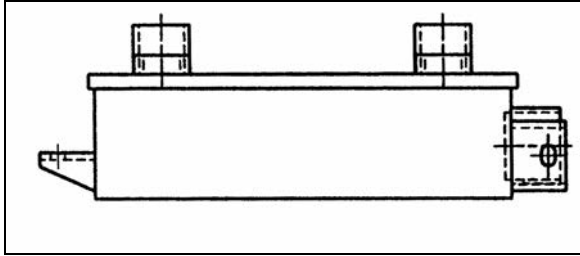


FIGURE 13: COOLER WITH RETARDER

07073

6.2.2 Volvo D13 Engine

Stop engine and allow engine to cool. Close both heater line shutoff valves (refer to Section 05 "Cooling").

1. To drain the cooling system, proceed as per Section 05 "Cooling", paragraph 5: Draining. If the cooling system is contaminated, flush system as per Section 05 "Cooling", paragraph 7: Flushing.
2. Remove the rear L.H. side tag axle wheel, then remove the rear L.H. side fender panel.
3. Disconnect the transmission hoses from oil cooler. Cover hose ends and fittings to prevent fluid contamination.

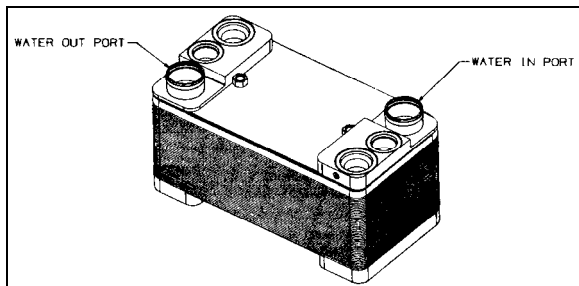


FIGURE 14: ALLISON OIL COOLER



WARNING

A significant amount of oil may drain from oil lines when they are disconnected.

4. Unfasten the constant-torque hose clamps and remove the two hoses.
5. Unscrew the holding bolts and nuts and remove the oil cooler from engine compartment.

7. CLEANING AND INSPECTION OF ALLISON AUTOMATIC TRANSMISSION

The exterior of the transmission should be cleaned and inspected at regular intervals. The length of service and severity of operating

conditions will determine the frequency of such inspections. Inspect the transmission for:

1. Loose bolts (transmission and mounting components);
2. Oil leaks (correct immediately);
3. Loose, dirty, or improperly adjusted throttle sensor linkage;
4. Damaged or loose oil lines;
5. Worn or frayed electrical harnesses, improper routing;
6. Worn or out of phase drive line U-joint and slip fittings.



CAUTION

DO NOT pressure wash the transmission electrical connectors. Water and detergent will cause the contacts to corrode or become faulty.

7.1 BREATHER

The breather is located on the engine, flywheel side near the valve cover. It serves to prevent pressure build-up within the transmission and must be cleaned to keep the passage opened. The prevalence of dust and dirt will determine the frequency at which the breather requires cleaning. Use care when cleaning the engine. Spraying steam, water or cleaning solution directly at the breather can force the water or solution into the transmission. Always use care when removing the hose connector from transmission to prevent the entry of foreign matter.

8. ALLISON TRANSMISSION INSTALLATION

NOTE

For more clearance between the tag axle and transmission, the tag axle may be unloaded and jacked up, or retracted (if applicable).

▪ Detroit Diesel Series 60 Engine Only

With the access plug removed, align one of the 12 attaching screw holes in the flexible plate with the access opening (starter side).

▪ Volvo D13 Engine Only

With the starter motor removed, align one of the 12 attaching screw holes in the flexible plate with the access opening.

Section 07: TRANSMISSION

1. Place the transmission on a transmission jack.
2. Install a headless guide bolt into one of the 12 threaded holes for flexible plate attaching screws in the flywheel.
3. Lubricate the flywheel center pilot boss with molybdenum disulfide grease (Molycote G, or equivalent).
4. Raise transmission and position the flywheel pilot boss into the flexible plate adapter. Align the guide bolt previously installed in the flywheel with the flexible plate hole facing the access opening in the flywheel housing.



DANGER

Severe damages and/or personal injury can occur if transmission is not adequately supported.

5. Seat the transmission against the engine flywheel housing. **NO FORCE IS REQUIRED.** If interference is encountered, move the transmission away from engine, then investigate the cause.



CAUTION

The torque converter housing must be seated against the flywheel housing prior to tightening any screws. **DO NOT USE SCREWS TO SEAT THE HOUSING.**

6. Start all torque converter housing screws, and then tighten four of them gradually and in a criss-cross sequence around the housing. Tighten the 12 remaining screws. Recommended torque is between 42-50 lbf-ft (57-68 Nm).
7. Remove the guide bolt through the access opening in the flywheel housing. Replace it with a self-locking screw, finger-tighten then start the remaining screws; tighten to 17-21 lbf-ft (23-28 Nm).

▪ Detroit Diesel Series 60 Engine Only

Place a wrench on the crankshaft pulley attaching screw to turn the converter to gain access to the threaded holes.

Reinstall the access plug.

▪ Volvo D13 Engine Only

Remove the plug located below starter motor and install cranking tool (88800014). Crank the engine to gain access to the threaded holes by turning the cranking tool using a suitable adapter (Refer to fig. 11).

Reinstall starter motor and connect cables.

Reinstall access plug below starter motor.

8. Remove jack from under transmission.
9. Connect all sensors.
10. Connect the main wiring harness.
11. Connect the air supply line (steel-braided hose) to the retarder control valve (if applicable).
12. Connect the two transmission oil cooler hoses as they were previously.
13. Reinstall clamps and brackets, and replace locking ties previously removed during removal procedure.
14. Install propeller shaft and its safety guard. Refer to Section 09, "PROPELLER SHAFT".
15. Install transmission dipstick and filler tube.
16. Install cross member under transmission.
17. Install engine splash guards.
18. Adjust the retarder pressure to 80 ± 3 psi with the air pressure regulator. For more information refer to Section 12, "BRAKE AND AIR SYSTEM", under heading "AIR PRESSURE REGULATOR". The air pressure regulator is located near the Webasto in engine compartment, on R.H. side (Fig. 13).
19. Make sure that the drain plug is in place, and then remove the transmission dipstick and pour approximately 24 US quarts (23 L) of automatic transmission fluid through the filler tube. Check and adjust oil level.



CAUTION

Do not overfill the transmission. Overfilling can cause oil aeration (milky appearance) and overheating. If overfilling occurs, drain oil as required to bring it to the proper level.

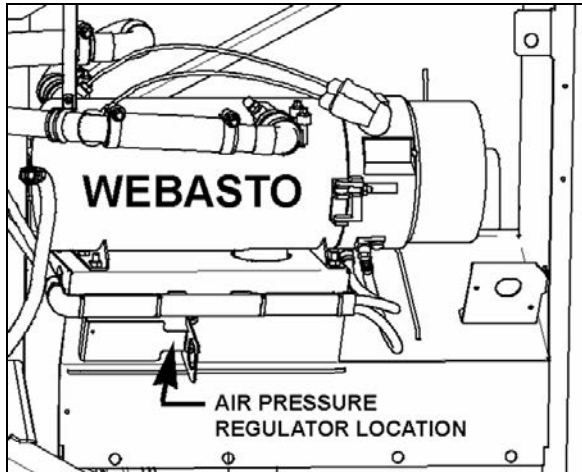


FIGURE 15: AIR PRESSURE REGULATOR (TYPICAL) 07130

9. ALLISON AUTOMATIC TRANSMISSION TROUBLESHOOTING

For complete information about Allison transmission troubleshooting, refer to "Allison 4th Generation Controls – Troubleshooting Manual: 3000 and 4000 Product families (TS3989)".

9.1 4TH GENERATION TRANSMISSION CONTROL MODULE

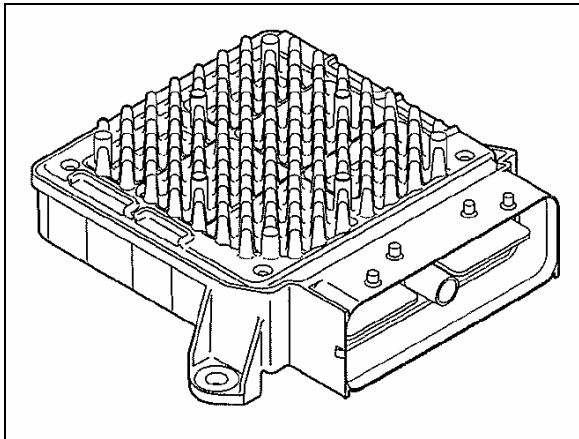


FIGURE 16: TRANSMISSION CONTROL MODULE 07140

The Allison transmission has a new Transmission Control Module (TCM) which involves specific diagnostic incident codes. The TCM unit is located in the coach rear electrical compartment.

TCM Replacement

The TCM is a non-serviceable electronic device. When it fails, it must be replaced using the following procedure:

- Open the coach rear baggage compartment then remove the rear electrical compartment door in order to get access to the TCM;

- Remove the electrical cable connectors;
- Unscrew the TCM unit;
- Replace by reversing the procedure.



CAUTION

Place the battery master switch to the "OFF" position.

9.2 DIAGNOSTIC TROUBLESHOOTING CODES (DTC) — ALLISON 4TH GENERATION CONTROLS

Diagnostic codes (DTC) are numerical indications relating to a malfunction in transmission operation. These codes are logged in a list in the TCM memory with the most severe or most recent code listed first. A maximum of five codes (numbered d1 to d5) may be listed in memory at one time. As codes are added, the oldest inactive code is dropped from the list. If all codes are active, the code with the lowest priority that is not included on the severity list is dropped from the list.

Diagnostic codes (DTC) and code information may be accessed through the pushbutton shift selector or using an Allison DOC™ diagnostic tool.

The TCM separately stores the active and inactive codes. An active code is any code that is current in the TCM decision-making process. Inactive codes are codes that are retained in the TCM memory and will not necessary affect the TCM decision-making process. Inactive codes are useful in determining if a problem is:

- Isolated ;
- Intermittent ;
- Result from a previous malfunction.



The TCM may automatically delete a code from memory if it has not recurred. If the MODE INDICATOR (LED) is not illuminated, the displayed code is not active. An illuminated MODE INDICATOR (LED) during normal operation signifies secondary shift mode operation.

Section 07: TRANSMISSION

9.3 DIAGNOSTIC CODES – ALLISON 4TH GENERATION CONTROLS

When the diagnostic mode is entered, the first code (position d1) is displayed as follows:

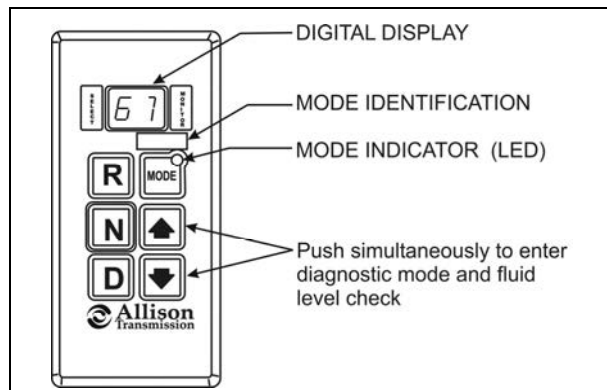
Example: Code P0722

Displayed as: **d1...P...07...22**

The code list position is the first item displayed, followed by the DTC. Each item is displayed for about one second. The display cycles continuously until the next code list position is accessed by pressing the **MODE** button. The following example shows how DTC P0722 is displayed on the pushbutton shift selector.

SELECT	d	1	MONITOR
		P	
	0	7	
	2	2	

- d1 (code list position) – The position which a code occupies in the list. Positions are displayed as « d1 » through « d5 » (code list position 1 through code list position 5).
- P0722 (DTC) – The diagnostic troubleshooting code number referring to the general condition or area of fault detected by the TCM.



9.4 DIAGNOSTIC CODE DISPLAY AND CLEARING PROCEDURE – ALLISON 4TH GENERATION CONTROLS

Diagnostic codes can be read and cleared by two methods:

- Using an Allison DOCTM diagnostic tool. For specific instructions on how to use an Allison DOCTM diagnostic tool, refer to the User Guide.
- Using the pushbutton shift selector.

To begin the diagnostic process:

1. Bring the vehicle to a stop at a safe location.
2. Apply the parking brake.

To display stored codes:

1. Simultaneously press the ▲ (Up) and ▼ (Down) arrow buttons twice to access the Diagnostic Display Mode.

NOTE

To access the Oil Level Display Mode, simultaneously press the ▲ (Up) and ▼ (Down) arrow buttons once. Consult paragraph: « ALLISON TRANSMISSION OIL LEVEL CHECK USING THE PUSHBUTTON SHIFT SELECTOR » at the end of this section.

2. Observe the digital display for code (d1).
3. Press the MODE button to see the next code (d2) – repeat for subsequent codes (d3, d4 & d5).

NOTE

Be sure to record all codes displayed before they are cleared. This is essential for troubleshooting.

NOTE

The Diagnostic Display Mode can be entered for viewing codes at any speed. Codes can only be cleared when the output speed = 0 and no output speed sensor failure is active

Active indicators (MODE INDICATOR LED) and inactive codes can be cleared manually, while in the diagnostic display mode, after the condition causing the code is identified.

To clear active indicators and inactive codes:

1. While in Diagnostic Display Mode, press and hold the MODE button for 10 seconds to clear both active indicators and inactive codes.
2. Begin operating as normal. Have the transmission checked at the earliest opportunity by an Allison Transmission distributor or dealer.

NOTE

All active indicators are cleared at TCM power down.

Some codes will clear their active indicator when the condition causing the code is no longer detected by the TCM.

The Diagnostic Display Mode can be exited by any of the following methods:

- Press simultaneously the ▲ (Up) and ▼ (Down) arrow buttons at the same time on the pushbutton shift selector.
- Press any range button «D», «N» or «R» on the pushbutton shift selector (the shift will be commanded if it is not inhibited by an active code).
- Wait until the calibrated time (approximately 10 minutes) has passed. The system will automatically return to the normal operating mode.
- Turn off power to the TCM (shut off the engine using the ignition key).

NOTE

If clearing a code while locked in a «D» (Drive) or «R» (Reverse) position (fail-to-range), the transmission will still be in «D» (Drive) or «R» (Reverse) when the clearing procedure is completed. «N» (Neutral) must be manually selected.

9.5 DIAGNOSTIC CODE RESPONSE

The following responses are used in the "Diagnostic Troubleshooting Code List and Inhibited Operation Description" table to command safe operation when diagnostic codes are sent.

DNS - Do Not Shift Response

Release lock up clutch and inhibit lock up operation.

Inhibit all shifts.

Turn ON the CHECK TRANS light.

Display the range attained.

Ignore any range selection inputs from the shift selector.

DNA - Do Not Adapt Response

The TCM stops adaptive shift control while the code is active.

SOL OFF - SOLenoid OFF Response

All solenoids are commanded OFF (turning solenoids "A" and "B" off electrically cause them to be on hydraulically).

RPR - Return to Previous Range Response

When the speed sensor ratio or C3 pressure switch test associated with a shift not successful, the TCM commands the same range as commanded before the shift.

NNC - Neutral No Clutches Response

When certain speed sensor ratio or C3 pressure switch tests are not successful, the TCM commands a neutral condition with no clutches applied.

Section 07: TRANSMISSION

9.6 DIAGNOSTIC TROUBLESHOOTING CODES (DTC) LIST - ALLISON 4TH GENERATION CONTROLS

DTC	Description	CHECK TRANS Light	Inhibited Operation Description
C1312	Retarder Request Sensor Failed Low	No	May inhibit retarder operation if not using J1939 datalink
C1313	Retarder Request Sensor Failed High	No	May inhibit retarder operation if not using J1939 datalink
P0122	Pedal Position Sensor Low Voltage	No	Use default throttle values. Freezes shift adapts.
P0123	Pedal Position Sensor High Voltage	No	Use default throttle values. Freezes shift adapts.
P0218	Transmission Fluid Over Temperature	No	Use hot mode shift schedule. Holds fourth range. TCC is inhibited. Freezes shift adapts.
P0602	TCM Not Programmed	Yes	Lock in Neutral
P0610	TCM Vehicle Options (Trans ID) Error	Yes	Use TID A calibration
P0613	TCM Processor	No	All solenoids off
P0614	Torque Control Data Mismatch - ECM/TCM	Yes	Allows operation only in reverse and second range.
P0634	TCM Internal Temperature Too High	Yes	SOL OFF (hydraulic default)
P063E	Auto Configuration Throttle Input Not Present	Yes	Use default throttle values
P063F	Auto Configuration Engine Coolant Temp Input Not Present	No	None
P0658	Actuator Supply Voltage 1 (HSD1) Low	Yes	DNS, SOL OFF (hydraulic default)
P0659	Actuator Supply Voltage 1 (HSD1) High	Yes	DNS, SOL OFF (hydraulic default)
P0702	Transmission Control System Electrical (TransID)	Yes	Use TID A calibration
P0703	Brake Switch Circuit Malfunction	No	No Neutral to Drive shifts for refuse packer. TCM inhibits retarder operation if a TPS code is also active.
P0708	Transmission Range Sensor Circuit High Input	Yes	Ignore defective strip selector inputs
P070C	Transmission Fluid Level Sensor Circuit – Low Input	No	None
P070D	Transmission Fluid Level Sensor Circuit – High Input	No	None
P0711	Transmission Fluid Temperature Sensor Circuit Performance	Yes	Use default sump temp
P0712	Transmission Fluid Temperature Sensor Circuit Low Input	Yes	Use default sump temp
P0713	Transmission Fluid Temperature Sensor Circuit High Input	Yes	Use default sump temp
P0716	Turbine Speed Sensor Circuit Performance	Yes	DNS, Lock in current range
P0717	Turbine Speed Sensor Circuit No Signal	Yes	DNS, Lock in current range
P0719	Brake Switch ABS Input Low	No	TCM assumes ABS is OFF
P071A	RELS Input Failed On	Yes	Inhibit RELS operation
P071D	General Purpose Input Fault	Yes	None
P0721	Output Speed Sensor Circuit Performance	Yes	DNS, Lock in current range
P0722	Output Speed Sensor Circuit No Signal	Yes	DNS, Lock in current range
P0726	Engine Speed Sensor Circuit Performance	No	Default to turbine speed
P0727	Engine Speed Sensor Circuit No Signal	No	Default to turbine speed
P0729	Incorrect 6 th Gear Ratio	Yes	DNS, Attempt 5 th , then 3 rd
P0731	Incorrect 1 st Gear ratio	Yes	DNS, Attempt 2 nd , then 5 th

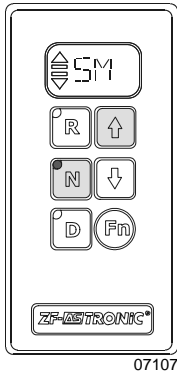
DTC	Description	CHECK TRANS Light	Inhibited Operation Description
P0732	Incorrect 2 nd Gear ratio	Yes	DNS, Attempt 3 rd , then 5 th
P0733	Incorrect 3 rd Gear ratio	Yes	DNS, Attempt 4 th , then 6 th
P0734	Incorrect 4 th Gear ratio	Yes	DNS, Attempt 5 th , then 3 rd
P0735	Incorrect 5 th Gear ratio	Yes	DNS, Attempt 6 th , then 3 rd , then 2 nd
P0736	Incorrect Reverse Gear ratio	Yes	DNS, Lock in Neutral
P0741	Torque Converter Clutch System Stuck Off	Yes	None
P0776	Pressure Control Solenoid 2 Stuck Off	Yes	DNS, RPR
P0777	Pressure Control Solenoid 2 Stuck On	Yes	DNS, RPR
P0796	Pressure Control Solenoid 3 Stuck Off	Yes	DNS, RPR
P0797	Pressure Control Solenoid 3 Stuck On	Yes	DNS, RPR
P0842	Transmission Pressure Switch 1 Circuit Low	Yes	DNS, Lock in current range
P0843	Transmission Pressure Switch 1 Circuit High	Yes	DNS, Lock in current range
P0880	TCM Power Input Signal	No	None
P0881	TCM Power Input Signal Performance	No	None
P0882	TCM Power Input Signal Low	Yes	DNS, SOL OFF (hydraulic default)
P0883	TCM Power Input Signal High	No	None
P0894	Transmission Component Slipping	Yes	DNS, Lock in first
P0960	Pressure Control Solenoid Main Mod Control Circuit Open	Yes	None
P0962	Pressure Control Solenoid Main Mod Control Circuit Low	Yes	DNS, SOL OFF (hydraulic default)
P0963	Pressure Control Solenoid Main Mod Control Circuit High	Yes	None
P0964	Pressure Control Solenoid 2 (PCS2) Control Circuit Open	Yes	DNS, SOL OFF (hydraulic default)
P0966	Pressure Control Solenoid 2 (PCS2) Control Circuit Low	Yes	DNS, SOL OFF (hydraulic default)
P0967	Pressure Control Solenoid 2 (PCS2) Control Circuit High	Yes	DNS, SOL OFF (hydraulic default)
P0968	Pressure Control Solenoid 3 (PCS3) Control Circuit Open	Yes	DNS, SOL OFF (hydraulic default)
P0970	Pressure Control Solenoid 3 (PCS3) Control Circuit Low	Yes	DNS, SOL OFF (hydraulic default)
P0971	Pressure Control Solenoid 3 (PCS3) Control Circuit High	Yes	DNS, SOL OFF (hydraulic default)
P0973	Shift Solenoid 1 (SS1) Control Circuit Low	Yes	DNS, SOL OFF (hydraulic default)
P0974	Shift Solenoid 1 (SS1) Control Circuit High	Yes	DNS, SOL OFF (hydraulic default)
P0975	Shift Solenoid 2 (SS2) Control Circuit Open	Yes	7-speed: Allow 2 through 6, N, R
P0976	Shift Solenoid 2 (SS2) Control Circuit Low	Yes	7-speed: Allow 2 through 6, N, R Inhibit TCC operation
P0977	Shift Solenoid 2 (SS2) Control Circuit High	Yes	7-speed: Allow 2 through 6, N, R
P0989	Retarder Pressure Sensor Failed Low	No	None
P0990	Retarder Pressure Sensor Failed High	No	None
P1739	Incorrect Low Gear Ratio	Yes	Command 2 nd and allow shifts 2 through 6, N, R
P1891	Throttle Position Sensor PWM Signal Low Input	No	Use default throttle values
P1892	Throttle Position Sensor PWM Signal High Input	No	Use default throttle values
P2184	Engine Coolant Temperature Sensor Circuit Low Input	No	Use default engine coolant values
P2185	Engine Coolant Temperature Sensor Circuit High Input	No	Use default engine coolant values
P2637	Torque Management Feedback Signal (SEM)	Yes	Inhibit SEM
P2641	Torque Management Feedback Signal (LRTP)	Yes	Inhibit LRTP
P2670	Actuator Supply Voltage 2 (HSD2) Low	Yes	DNS, SOL OFF (hydraulic default)

Section 07: TRANSMISSION

DTC	Description	CHECK TRANS Light	Inhibited Operation Description
P2671	Actuator Supply Voltage 2 (HSD2) High	Yes	DNS, SOL OFF (hydraulic default)
P2685	Actuator Supply Voltage 3 (HSD3) Low	Yes	DNS, SOL OFF (hydraulic default)
P2686	Actuator Supply Voltage 3 (HSD3) High	Yes	DNS, SOL OFF (hydraulic default)
P2714	Pressure Control Solenoid 4 (PCS4) Stuck Off	Yes	DNS, RPR
P2715	Pressure Control Solenoid 4 (PCS4) Stuck On	Yes	DNS, SOL OFF (hydraulic default)
P2718	Pressure Control Solenoid 4 (PCS4) Control Circuit Open	Yes	DNS, SOL OFF (hydraulic default)
P2720	Pressure Control Solenoid 4 (PCS4) Control Circuit Low	Yes	DNS, SOL OFF (hydraulic default)
P2721	Pressure Control Solenoid 4 (PCS4) Control Circuit High	Yes	DNS, SOL OFF (hydraulic default)
P2723	Pressure Control Solenoid 1 (PCS1) Stuck Off	Yes	DNS, RPR
P2724	Pressure Control Solenoid 1 (PCS1) Stuck On	Yes	DNS, RPR
P2727	Pressure Control Solenoid 1 (PCS1) Control Circuit Open	Yes	DNS, SOL OFF (hydraulic default)
P2729	Pressure Control Solenoid 1 (PCS1) Control Circuit Low	Yes	DNS, SOL OFF (hydraulic default)
P2730	Pressure Control Solenoid 1 (PCS1) Control Circuit High	Yes	DNS, SOL OFF (hydraulic default)
P2736	Pressure Control Solenoid 5 (PCS5) Control Circuit Open	Yes	Inhibit retarder operation
P2738	Pressure Control Solenoid 5 (PCS5) Control Circuit Low	Yes	Allow 2 through 6, N, R. Inhibit retarder and TCC operation
P2739	Pressure Control Solenoid 5 (PCS5) Control Circuit High	Yes	Inhibit retarder operation
P2740	Retarder Oil Temperature Hot	No	None
P2742	Retarder Oil Temperature Sensor Circuit – Low Input	No	Use default retarder temp values
P2743	Retarder Oil Temperature Sensor Circuit – High Input	No	Use default retarder temp values
P2761	TCC PCS Control Circuit Open	Yes	Inhibit TCC operation
P2763	TCC PCS Control Circuit High	Yes	Inhibit TCC operation
P2764	TCC PCS Control Circuit Low	Yes	7-speed: Allow 2 through 6, N, R. Inhibit TCC operation
P278A	Kickdown Input Failed ON	No	Inhibit kickdown operation
P2793	Gear Shift Direction Circuit	Yes	Ignores PWM input from shift selector
P2808	Pressure Control Solenoid 6 (PCS6) Stuck Off	Yes	DNS, RPR
P2809	Pressure Control Solenoid 6 (PCS6) Stuck On	Yes	DNS, RPR
P2812	Pressure Control Solenoid 6 (PCS6) Control Circuit Open	Yes	DNS, SOL OFF (hydraulic default)
P2814	Pressure Control Solenoid 6 (PCS6) Control Circuit Low	Yes	DNS, SOL OFF (hydraulic default)
P2815	Pressure Control Solenoid 6 (PCS6) Control Circuit High	Yes	DNS, SOL OFF (hydraulic default)
U0001	Hi Speed CAN Bus Reset Counter Overrun (IESCAN)	No	Use default values, inhibit SEM
U0010	CAN BUS Reset Counter Overrun	No	Use default values, inhibit SEM
U0100	Lost Communications with ECM/PCM (J1587)	Yes	Use default values
U0103	Lost Communication with Gear Shift Module (Shift Selector) 1	Yes	Maintain range selected, observe gear shift direction circuit
U0115	Lost Communication with ECM	Yes	Use default values
U0291	Lost Communication with Gear Shift Module (Shift Selector) 2	Yes	Maintain range selected, observe gear shift direction circuit
U0304	Incompatible Gear Shift Module 1 (Shift Selector) ID	Yes	Ignore shift selector inputs
U0333	Incompatible Gear Shift Module 2 (Shift Selector) ID	Yes	Ignore shift selector inputs
U0404	Invalid Data Received From Gear Shift Module (Shift Selector) 1	Yes	Maintain range selected, observe gear shift direction circuit
U0592	Invalid Data Received From Gear Shift Module (Shift Selector) 2	Yes	Maintain range selected, observe gear shift direction circuit

10. ZF-ASTRONIC TRANSMISSION SYSTEM FAULTS AND ERROR MESSAGES

10.1 SYSTEM FAULTS (ERROR MESSAGES)



If the “SM” symbol appears in the display, a system error has occurred.

- Stop the vehicle
- Vehicle may no longer be driven

Error messages and the reactions resulting from these errors can be deleted with the vehicle at a standstill and the “Ignition OFF”. (Wait until the display goes out). If the display does not go out once the ignition has been turned “OFF”, set the battery master switch to the **OFF** position. Switch the ignition back on. If the error message is still in place, the transmission has to be repaired. The transmission is inoperative. The vehicle will have to be taken to a service point. The error number(s) must be specified when the service point is contacted.

ERROR CODES

Remark to titles in table:

ZF fault number: defined by ZF.

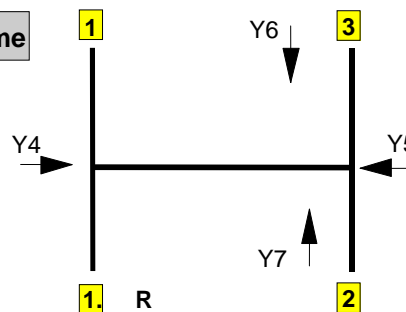
Display SM-Symbol : (0=NO, 1=YES) Display shows “SM”(severe failure)

Warning lamp : (0=NO, 1=YES) Telltale panel warning lamp “check trans“(less severe failure)

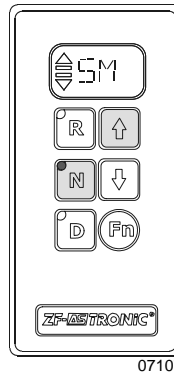
Shift schemes of transmissions:

- Y2 Splitter K2
- Y3 Splitter K1
- Y8 Range (GP) low
- Y9 Range (GP)

10/12-Gear Scheme

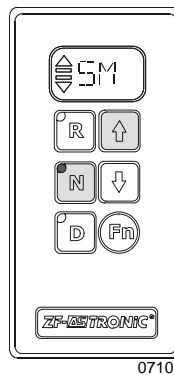


Calling up error numbers



- Switch on ignition
- Depress “N” key
- Hold down “↑” key
- * One or more error numbers appear on the display. These correspond to the errors presently active in the system.

Calling up error numbers from the error memory:



- Switch on ignition
- Press “N” key and at the same time depress the foot-operated brake
- Hold down the foot-operated brake and depress and hold down “↑” key
- * The errors stored in the transmission ECU are shown on the display one after another.

Section 07: TRANSMISSION

ON MESSAGES CENTER DISPLAY (MCD) SAE-J1587 Codes	ON SHIFT SELECTOR DISPLAY	ISO CODES WITH TESTMAN TOOL	DESCRIPTION
8, 7	8	161	Easy Start, Brake doesn't open completely
8, 14	8	162	Easy Start, Not Available
20,6	14	22	Short circuit to ground at output ACC (wakeup control signal for ZMTEC, keep alive signal for voltage doubler, and power signal for speed sensor #2)
20,5	14	54	Interruption at output ACC (wakeup control signal for ZMTEC, keep alive signal for voltage doubler, and power signal for speed sensor #2)
20,3	14	86	Short circuit to positive at output ACC (wakeup control signal for ZMTEC, keep alive signal for voltage doubler, and power signal for speed sensor #2)
21,2	15	127	Error on ECU temperature sensor signal
21,0	15	193	ECU temperature too high
31,3	1F	137	No range change group (GP) sensor signal (Short circuit to positive)
31,6	1F	138	No range change group (GP) sensor signal (Short circuit to ground)
31,5	1F	139	No range change group (GP) sensor signal (Interruption)
31,13	1F	140	Self adjustment error of range change group sensor in position fast
31,7	1F	159	Range-change group sensor signal leaves engaged position during driving
32,3	20	141	No splitter group (GV) sensor signal (Short circuit to positive)
32,6	20	142	No splitter group (GV) sensor signal (Short circuit to ground)
32,5	20	143	No splitter group (GV) sensor signal (Interruption)
32,13	20	144	Splitter group (GV) sensor self adjustment error
32,7	20	160	Splitter sensor signal leaves engaged position during driving
33,14	21	107	Stabilised voltage supply at output AU (clutch sensor supply) too high or too low
33,13	21	117	Error in clutch self-adjustment process
33,2	21	124	Error on clutch travel signal
34,7	22	120	Mechanical failure of small clutch disengagement valve
34,7	22	121	Mechanical failure of large clutch disengagement valve
34,7	22	122	Mechanical failure of small clutch engagement valve
34,7	22	123	Mechanical failure of large clutch engagement valve
34,6	22	18	Short circuit to ground at output stage to small disengagement clutch valve
34,6	22	19	Short circuit to ground at output stage to small engagement clutch valve
34,6	22	20	Short circuit to ground at output stage to large disengagement clutch valve
34,6	22	21	Short circuit to ground at output stage to large engagement clutch valve
34,5	22	50	Interruption at output stage to small disengagement clutch valve
34,5	22	51	Interruption at output stage to small engagement clutch valve
34,5	22	52	Interruption at output stage to large disengagement clutch valve
34,5	22	53	Interruption at output stage to large engagement clutch valve

ON MESSAGES CENTER DISPLAY (MCD) SAE-J1587 Codes	ON SHIFT SELECTOR DISPLAY	ISO CODES WITH TESTMAN TOOL	DESCRIPTION
34,3	22	82	Short circuit to positive at output stage to small disengagement clutch valve
34,3	22	83	Short circuit to positive at output stage to small engagement clutch valve
34,3	22	84	Short circuit to positive at output stage to large disengagement clutch valve
34,3	22	85	Short circuit to positive at output stage to large engagement clutch valve
35,5	23	41	Interruption at output stage to Y9 (Valve Range)
35,3	23	73	Short circuit to positive at output stage to Y9 (Valve range)
35,6	23	9	Short circuit to ground at output stage to Y9 (Valve Range)
36,5	24	40	Interruption at output stage to Y8 (Valve Range)
36,3	24	72	Short circuit to positive at output stage to Y8 (Valve range)
36,6	24	8	Short circuit to ground at output stage to Y8 (Valve Range)
37,6	25	2	Short circuit to ground at output stage to Y2 (Valve Splitter)
37,5	25	34	Interruption at output stage to Y2 (Valve Splitter)
37,3	25	66	Short circuit to positive at output stage to Y2 (Valve Splitter)
38,6	26	3	Short circuit to ground at output stage to Y3 (Valve Splitter)
38,5	26	35	Interruption at output stage to Y3 (Valve Splitter)
38,3	26	67	Short circuit to positive at output stage to Y3 (Valve Splitter)
39,5	27	36	Interruption at output stage to Y4 (Valve Select)
39,6	27	4	Short circuit to ground at output stage to Y4 (Valve Select)
39,3	27	68	Short circuit to positive at output stage to Y4 (Valve Select)
40,5	28	38	Interruption at output stage to Y6 (Valve Shift)
40,6	28	6	Short circuit to ground at output stage to Y6 (Valve Shift)
40,3	28	70	Short circuit to positive at output stage to Y6 (Valve Shift)
43,2	2B	175	Error on "Ignition lock" signal (terminal 15)
48,3	30	129	No shift sensor signal (Short circuit to positive)
48,6	30	130	No shift sensor signal (Short circuit to ground)
48,5	30	131	No shift sensor signal (Interruption)
48,13	30	132	Self adjustment error of shift sensor
48,7	30	157	Selector sensor signal leaves position during driving
48,7	30	158	Engage sensor signal leaves engaged position during driving
50,5	32	37	Interruption at output stage to Y5 (Valve Select)
50,6	32	5	Short circuit to ground at output stage to Y5 (Valve Select)
50,3	32	69	Short circuit to positive at output stage to Y5 (Valve Select)
51,5	33	39	Interruption at output stage to Y7 (Valve Shift)
51,6	33	7	Short circuit to ground at output stage to Y7 (Valve Shift)

Section 07: TRANSMISSION

ON MESSAGES CENTER DISPLAY (MCD) SAE-J1587 Codes	ON SHIFT SELECTOR DISPLAY	ISO CODES WITH TESTMAN TOOL	DESCRIPTION
51,3	33	71	Short circuit to positive at output stage to Y7 (Valve Shift)
54,6	36	17	Short circuit to ground at output stage to Y1 (inertia brake valve)
54,5	36	49	Interruption at output stage to Y1 (inertia brake valve)
54,3	36	81	Short circuit to positive at output stage to Y1 (inertia brake valve)
55,7	37	114	Clutch engaged unintentionally at standstill, gear engaged
55,7	37	118	Clutch does not disengage
55,7	37	119	Clutch does not engage / does not transmit engine torque
56,7	38	145	Range change group (GP) disengagement error
56,7	38	146	Changeover error during range change group (GP) shifting
56,7	38	147	Range change group (GP) does not engage
57,2	39	108	Error in shift lever
57,14	39	110	ZF CAN timeout (can also means shift lever error through ZMP06400.hex)
58,7	3A	154	Main transmission gear does not disengage
58,7	3A	155	Main transmission gear does not engage
58,7	3A	156	Wrong gear shifting
59,7	3B	151	Selector cylinder does not disengage
59,7	3B	152	Change over error during gate selection procedure
59,7	3B	153	Selector cylinder does not engage
60,3	3C	133	No gate select sensor signal (Short circuit to positive)
60,6	3C	134	No gate select sensor signal (Short circuit to ground)
60,5	3C	135	No gate select sensor signal (Interruption)
60,13	3C	136	Gate select sensor self adjustment error
61,7	3D	148	Splitter (GV) does not disengage
61,7	3D	149	Change over error during splitter shifting
61,7	3D	150	Splitter (GV) does not engage
63,14	3F	100	Error on output speed signal 2
106,0	6A	125	Error on pressure reduction valve
106,14	6A	126	Error on pressure sensor signal
150,14	96	59	Acknowledge fault of PTO 1
150,14	96	60	Acknowledge fault of PTO 2
150,7	96	61	Disengagement fault of PTO 1
150,7	96	62	Disengagement fault of PTO 2
150,7	96	63	Engagement fault of PTO1
150,7	96	64	Engagement fault of PTO2

ON MESSAGES CENTER DISPLAY (MCD) SAE-J1587 Codes	ON SHIFT SELECTOR DISPLAY	ISO CODES WITH TESTMAN TOOL	DESCRIPTION
151,14	97	102	Plausibility error between transmission input speed and output speed
152,6	98	10	Short circuit to ground at output stage to Y10 (Main valve)
152,5	98	42	Interruption at output stage to Y10 (Main valve)
152,3	98	74	Short circuit to positive at output stage to Y10 (Main valve)
153,14	99	-	Error on ISO 14320 communications line
154,14	9A	101	Error on both output speed signals
161,14	A1	98	Error on transmission input speed signal
177,2	B1	128	Error on oil temperature sensor signal
191,14	BF	194	Both sources of vehicle speed are faulty
191,14	BF	99	Error on output speed signal 1
230,14	E6	166	Permanent idle signal
230,14	E6	168	No idle signal or error on "idle signal switch" signal (EEC2)
230,14	E7	103	Error on "Wheel-based vehicle speed" signal (CCV)
231,7	E7	163	Engine does not react on torque intervention
231,14	E7	164	Error on "Drivers demand engine percent torque" (EEC1)
231,14	E7	165	Error on "Accelerator pedal position" (EEC2)
231,14	E7	167	Error on "Percent load at current speed" signal (EEC2)
231,14	E7	171	Error on "Actual engine percent torque" signal (EEC1)
231,14	E7	172	Permanent engine brake request signal
231,14	E7	173	Error on "Brake switch" signal (CCVS)
231,14	E7	177	System-CAN Busoff error
231,11	E7	178	CAN error frames
231,11	E7	179	CAN queue overrun
231,14	E7	180	CAN EEC1 timeout
231,14	E7	181	CAN EEC2 timeout
231,14	E7	182	CAN CCVS timeout
231,14	E7	183	CAN ERC1_ER timeout
231,14	E7	197	Error on "Front axle speed" (WSI)
231,14	E7	198	Error on "Relative wheel speeds" (WSI)
231,14	E7	199	CAN WSI timeout
231,14	E7	26	CAN engine configuration timeout
231,14	E7	27	Error on "engine configuration message" (engine configuration)
231,14	E7	31	Error on "Actual engine retarder - percent torque" signal (ERC1_ER)
231,14	E7	32	Error on "Engine retarder configuration message" (Engine retarder configuration)

Section 07: TRANSMISSION

ON MESSAGES CENTER DISPLAY (MCD) SAE-J1587 Codes	ON SHIFT SELECTOR DISPLAY	ISO CODES WITH TESTMAN TOOL	DESCRIPTION
231,14	E7	33	CAN "Engine retarder configuration" timeout
231,14	E7	91	CAN EBC1 timeout
231,14	E7	92	Error on "ABS active" signal (EBC1)
231,14	E7	93	Error on "ASR engine control active" signal (EBC1)
231,14	E7	94	Error on "ASR brake control active" signal (EBC1)
231,14	E7	95	Error on "Cruise control active" signal (CCVS)
231,14	E7	96	Error on "Cruise control set speed" (CCVS)
231,14	E7	97	Error on "Engine speed" signal (EEC1)
-	EE	-	Communication error between GS3 and ZMTEC on display line
248,6	F8	25	Short circuit to ground at output SD to display
248,3	F8	89	Short circuit to positive at output SD to display

11. SPECIFICATIONS**ALLISON AUTOMATIC TRANSMISSION WITH OR WITHOUT RETARDER**X3 Coaches

Gross input power (maximum).....	500 HP (373 kW)
Gross input torque (maximum)	1525 Lbf-ft- (2068 Nm)
Rated input speed (minimum-maximum)	1600-2300 rpm

Mounting:

Engine.....SAE #1 flywheel housing, flex disk drive

Torque converter:

Type..... One stage, three element, polyphase
 Stall torque ratio

TC 551-1.8

Lockup clutch with torsional damper

Integral/standard

Gearing:

Type..... Patented, constant mesh, helical, planetary

Ratio:

First.....	3.51:1
Second.....	1.91:1
Third.....	1.43:1
Fourth.....	1.00:1
Fifth.....	0.74:1
Sixth.....	0.64:1
Reverse	4.80:1

Ratio coverage:

6 speed.....5.48:1

*** Gear ratios do not include torque converter multiplication.**

Oil System:

Oil type.....TRANSYND, DEXRON-III, DEXRON-VI
 Capacity (excluding external circuits).....Initial fill 47 US qts (45 liters)
 Oil change..... 24 US qts (23 liters)
 Oil change (with retarder)..... 27.6 US qts (26 liters)

Oil Filters:

Make..... Allison Transmission
 Type..... Disposable cartridge
 Prevost Part Number (2-filter replacement kit).....571709

SECTION 09: PROPELLER SHAFT

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Section 09: PROPELLER SHAFT

1. PROPELLER SHAFT

1.1 DESCRIPTION

The propeller shaft transmits power from the transmission to the differential (Fig. 1). Refer to paragraph "6. SPECIFICATIONS" at the end of this section for propeller shaft length. The propeller shaft is "Dana 1810" type with tubular shafts. It is provided with two heavy-duty universal joints (Fig. 1).

The propeller shaft has a full round end yoke at one end and a half round end yoke at the other end. The tube yoke is connected to the differential by a full round end yoke with four needle bearings.

The other extremity (slip yoke assembly) is connected to the transmission by a half round end yoke with two needle bearings.

Furthermore, a slip joint on the propeller shaft compensates for variations in distance between the transmission and the differential, or between the output retarder (optional on the automatic transmission) and differential.

The rise and fall of the drive axle bring about these variations as the vehicle passes over uneven surfaces. The slip joint also eases removal of the transmission or the drive axle.

2. REMOVAL, DISASSEMBLY, REASSEMBLY AND INSTALLATION

Refer to "SPICER UNIVERSAL JOINTS AND DRIVESHAFTS" annexed to this section, under headings "Heavy Duty - removal, disassembly, reassembly and installation".

Where applicable:

- Remove or install propeller shaft safety guard.
- Screw bolts to the specified torque (Fig. 1).

NOTE

Disregard the procedure on "Lock straps" mentioned in the "Spicer Universal Joints and Driveshafts Manual".

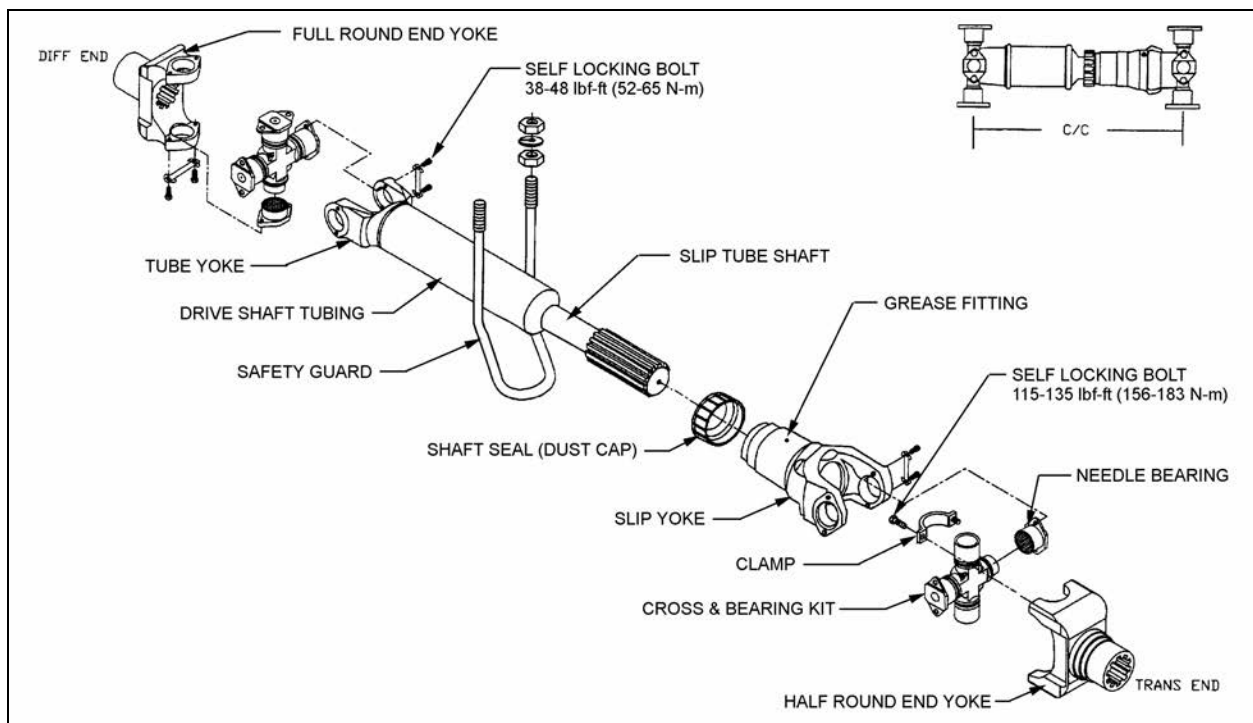


FIGURE 1: PROPELLER SHAFT ASSEMBLY

09002

3. CLEANING, INSPECTION AND LUBRICATION

3.1 CLEANING AND INSPECTION

Thoroughly clean grease from bearings, journal, lubricating grease fittings and other parts. Needle bearing assemblies may be soaked in a cleaning solution to soften hard grease particles. It is extremely important that bearing assemblies be absolutely clean and blown out with compressed air, since small particles of dirt or grit can cause rapid bearing wear. Do not attempt to disassemble needle bearings.

Bearing journal areas should be inspected for roughness or grooving. If light honing does not remove roughness, the entire bearing assembly should be replaced. Excessive wear of the needle bearing is indicated if the needles drop out of the retainer, or if marks are present on the journal bearing surface. In such case, replace bearing assembly. Finally, inspect yokes for cracks, wear or distortion.

NOTE

Repair kits are available for overhaul of the propeller shaft assembly. Refer to the paragraph "6. Specifications" of this section.

3.2 LUBRICATION

Lubricate propeller shaft universal joints and slip yoke periodically, every 6,250 miles (10 000 km) or twice a year, whichever comes first. Apply grease gun pressure to the lube fitting. Use a good quality lithium-base grease such as: NLGI No.2 (suitable for most temperatures) or NLGI No.1 (suitable for extremely low temperatures). Refer to "Spicer Universal Joints and Driveshafts, Service Manual", under heading, "Inspection and Lubrication". See lubrication procedures for U-joints and lubrication for slip splines.

NOTE

Do not assume that bearing cavities have been filled with new grease unless it has expelled around all seals.

4. EXPLANATION OF COMMON DAMAGES

1. Cracks: Stress lines due to metal fatigue. Severe and numerous cracks will weaken the metal until it breaks.

2. Galling: Scraping off of metal or metal displacement due to friction between surfaces. This is commonly found on trunnion ends.

3. Spalling (surface fatigue): Breaking off of chips, scales, or flakes of metal due to fatigue rather than wear. It is usually found on splines and U-joint bearings.

4. Pitting: Small pits or craters in metal surfaces due to corrosion. If excessive, pitting can lead to surface wear and eventual failure.

5. Brinelling: Surface wear failure due to the wearing of grooves in metal. It is often caused by improper installation procedures. Do not confuse the polishing of a surface (false brinelling), where no structural damage occurs, with actual brinelling.

6. Structural Overloading: Failure caused by a load greater than the component can stand. A structural overload may cause propeller shaft tubing to twist under strain or it may cause cracks or breaks in U-joints and spline plugs.

5. TROUBLESHOOTING

Refer to "Spicer Service Manual - Universal Joints and Driveshafts" under heading "Troubleshooting".

6. SPECIFICATIONS

PROPELLER SHAFT

X3-45 COACHES EQUIPPED WITH ALLISON WORLD TRANSMISSION

Make Hayes-Dana Inc.
Series..... 1810
Supplier number 819299-1
Prevost number580075

X3-45 COACHES EQUIPPED WITH ZF TRANSMISSION

Make Hayes-Dana Inc.
Series..... 1810
Supplier number (Traction) 17937CCF
Prevost number580083

Repair kits

Make Hayes-Dana Inc.
U-joint kit (tube yoke), Supplier number 5-281X
U-joint kit (tube yoke), Prevost number580043
U-joint kit (slip yoke), Supplier number 5-510X
U-joint kit (slip yoke), Prevost number580062
Cap and bolt kit, bolt torque 115-135 lbf•ft (156-183 N•m), Supplier number6.5-70-18X
Cap and bolt kit, bolt torque 115-135 lbf•ft (156-183 N•m), Prevost number580063
Bolts kit, bolt torque 38-48 lbf•ft (52-65 N•m), Supplier number 6-73-209
Bolts kit, bolt torque 38-48 lbf•ft (52-65 N•m), Prevost number580071

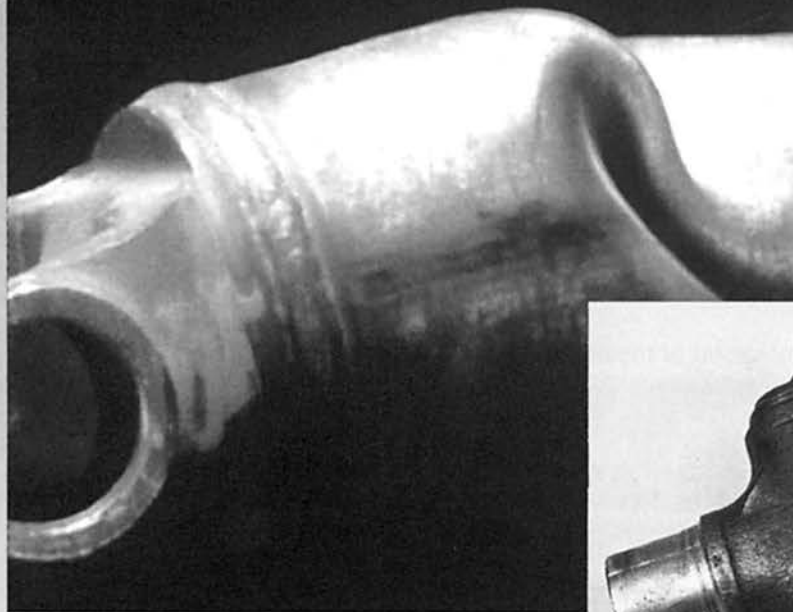
Half Round End Yoke

Make Covington Detroit Diesel
Supplier number29511516

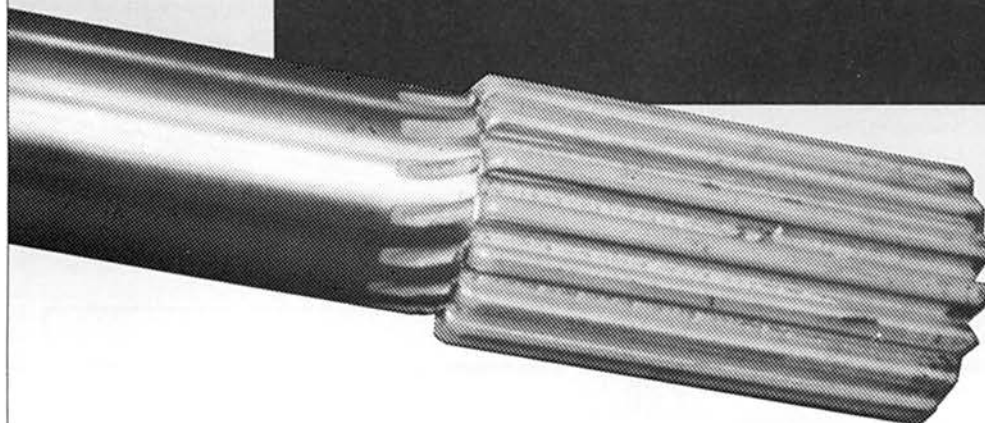
<p><i>NOTE</i></p> <p><i>U-joint kits will come equipped with the serrated bolt and lock patch and will no longer contain a lock strap.</i></p>
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SPICER DRIVELINE COMPONENTS

TROUBLESHOOTING GUIDELINES



Causes and Solutions
To Field Problems



SPICER®
DANA

SAFETY PRECAUTIONS

GENERAL SAFETY INFORMATION

To prevent injury to yourself and/or damage to the equipment:

- Read carefully all owners manuals, service manuals, and/or other instructions.
- Always follow proper procedures and use proper tools and safety equipment.
- Be sure to receive proper training.
- Never work alone while under a vehicle or while repairing or maintaining equipment.
- Always use proper components in applications for which they are approved.
- Be sure to assemble components properly.
- Never use worn-out or damaged components.
- Always block any raised or moving device that may injure a person working on or under a vehicle.
- Never operate the controls of the power take-off or other driven equipment from any position that could result in getting caught in the moving machinery.



WARNING: ROTATING DRIVESHAFTS

- Rotating auxiliary driveshafts are dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death.
- Do not go under the vehicle when the engine is running.
- Do not work on or near an exposed shaft when engine is running.
- Shut off engine before working on power take-off or driven equipment.
- Exposed rotating driveshafts must be guarded.

WARNING: GUARDING AUXILIARY DRIVESHAFTS

We strongly recommend that a power take-off and a directly mounted pump be used to eliminate the auxiliary driveshaft whenever possible. If an auxiliary driveshaft is used and remains exposed after installation, it is the responsibility of the vehicle designer and PTO installer to install a guard.

WARNING: USING SET SCREWS

Auxiliary driveshafts may be installed with either recessed or protruding set screws. If you choose a square head set screw, you should be aware that it will protrude above the hub of the yoke and may be a point where clothes, skin, hair, hands, etc. could be snagged. A socket head set screw, which may not protrude above the hub of the yoke, does not permit the same amount of torquing as does a square head set screw. Also, a square head set screw, if used with a lock wire, will prevent loosening of the screw caused by vibration. Regardless of the choice made with respect to a set screw, an exposed rotating auxiliary driveshaft must be guarded.



THIS SYMBOL WARNS OF POSSIBLE PERSONAL INJURY.

INTRODUCTION

Universal joint failures, as a rule, are of a progressive nature, which, when they occur, generally accelerate rapidly resulting in a mass of melted trunnions and bearings.

Some recognizable signs of universal joint deterioration are:

- 1) Vibrations - Driver should report to maintenance.
- 2) U-joint Looseness - End play across bearings.
- 3) U-joint discoloration due to excessive heat build-up.
- 4) Inability to purge all four trunnion seals when relubing U-joint.

Items 2) thru 4) should be checked at re-lube cycle and if detected, reported to the maintenance supervisor for investigation.

Experience with universal joint failures has shown that a significant majority are related to lubricating film breakdown. This may be

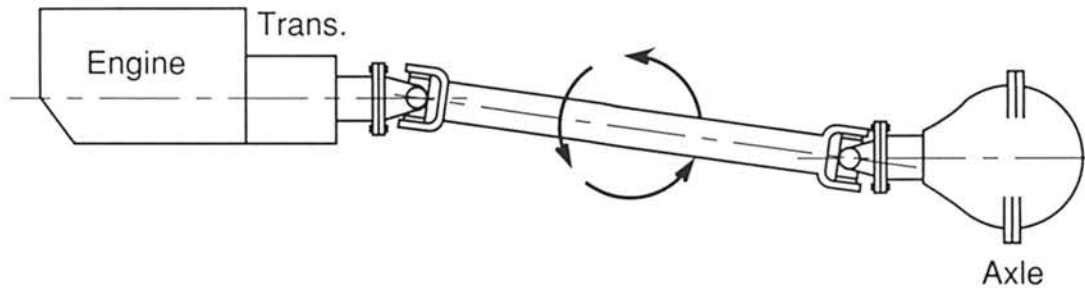
caused by a lack of lubricant, inadequate lube quality for the application, inadequate initial lubrication or failure to lubricate properly and often enough.

Failures which are not the result of lubrication film breakdown are associated with the installation, angles and speeds and manufacturing discrepancies.

Driveshaft failures through torque, fatigue and bending are associated with overload, excessively high U-joint angles and drive shaft lengths excessive for operating speeds.

The trouble shooting chart in this bulletin is intended to provide service people with an aid to enable them to associate complaints with some of the **probable causes** and **probable corrections**. Through normal vehicle maintenance and recognition of discrepancies, this may enable them to make necessary corrections to ward off a serious breakdown.

DRIVESHAFT TORQUE



Twisted driveshaft tube?
Broken yoke shaft?
Broken journal cross?

Usually a result of torque overload— How much torque can be generated in your application?

Here is how to figure torque:

$$\text{L.G.T.} = \text{N.E.T.} \times \text{Trans L.G.R.} \times .85 \text{ (efficiency factor)}$$

$$\text{D.L.T. (to Slip Wheels)} = \frac{W_R \times \text{C.O.F.} \times \text{R.R.}}{12 \times \text{A.R.}}$$

A.R. = Axle ratio

C.O.F. = Coefficient of friction (.7)

D.L.T. = Drive line torque

L.G.R. = Low gear ratio

L.G.T. = Low gear torque

N.E.T. = Net engine torque

R.R. = Tire loaded rolling radius

W_R = Weight on drive axle

Relate the lesser of above to Spicer U-joint ratings. If your torque exceeds the Spicer rating for the U-joint used in your application, switch to a size with a rating compatible to your calculation.

U-JOINT OPERATING ANGLES

U-joint operating angles are a primary source of problems contributing to:

- Vibrations
- Reduced U-joint life
- Problems with other drivetrain components that may include:
 - Transmission gear failures
 - Synchronizer failures
 - Differential problems
 - Premature seal failures in axles, transmissions, pumps or blowers
 - Premature failure of gears, seals and shafts in Power Take-Offs

Every U-joint that operates at an angle will vibrate.

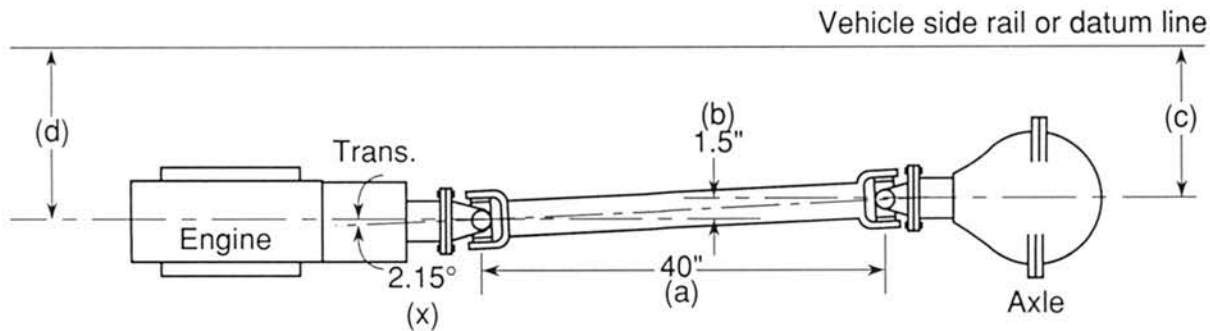
U-joint operating angles are probably the most common causes of driveline vibrations in vehicles that have been re-worked or in vehicles that have had auxiliary equipment installed.

To correct or eliminate these causes of driveline vibrations from your vehicle or new installation, you must determine the TRUE OPERATING ANGLE of each U-joint in your system.

The TRUE OPERATING ANGLE of a U-joint is a combination of the angle that occurs in the top view and the angle that occurs in the side view.

To determine the TRUE OPERATING ANGLE of a U-joint you must follow the instructions outlined in the following sections, numbered I and II, and calculate the TRUE OPERATING ANGLE using the information detailed in Section III.

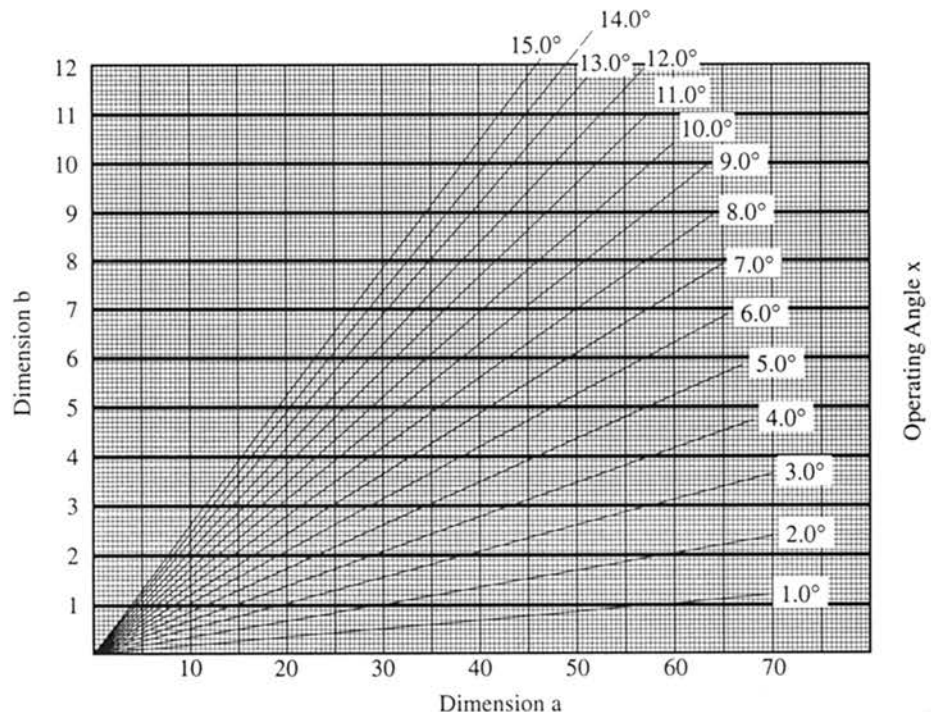
I. TO DETERMINE OPERATING ANGLES IN TOP VIEW



1. From side rail or convenient datum, measure offset dimensions c & d.
2. Calculate dimension $b = d - c$
3. Measure dimension a
4. Using dimensions a & b, determined through measurement, calculate U-joint angle x by using the chart provided.

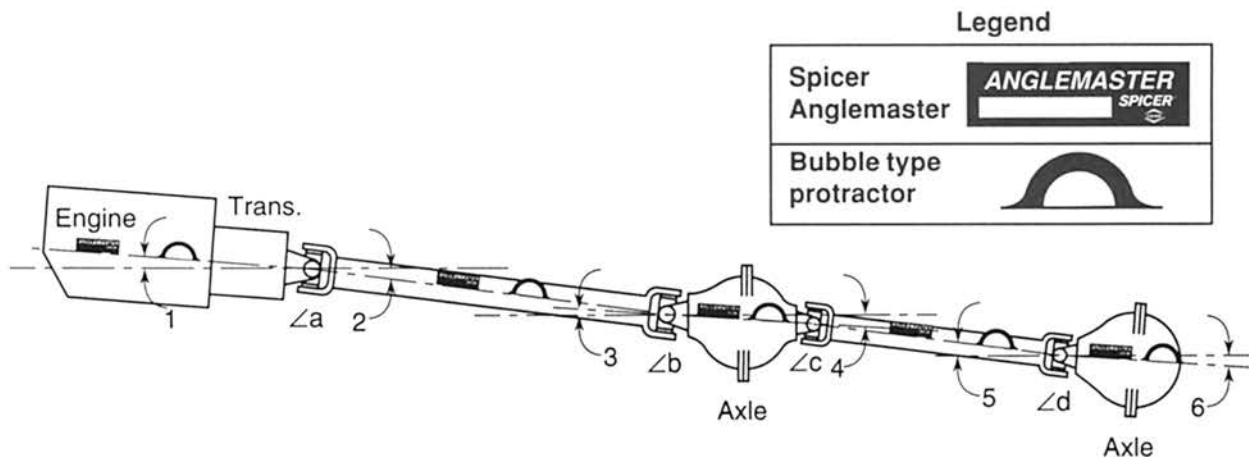
Example:

Where $a = 40.0''$
 $b = 1.5''$
 $X = 2.15^\circ$ operating angle

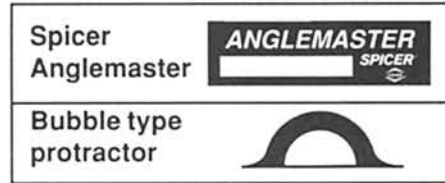


U-JOINT OPERATING ANGLES

II. TO DETERMINE OPERATING ANGLES IN SIDE VIEW



Legend



The most convenient way to determine U-joint angles in the side view is through use of a Spicer Anglemaster™ or a bubble type protractor. Procedure is as follows:

Step I. Using an Anglemaster or a bubble protractor, record inclination angles of drivetrain components. Set Anglemaster or protractor on machined surfaces of engine, transmission, axle or on machined lugs of transmission output and axle input yokes.

Note: U-joint angles can change significantly in a loaded situation. Therefore, check vehicle loaded and unloaded to achieve the accepted angle cancellation. (See Step IV.)

Example:

Eng-Trans Output	4°30' Down (1)
Main Drive Shaft	7°00' Down (2)
Input 1st Rear Axle	4°00' Up (Input Shaft Nose Up) (3)
Output 1st Rear Axle	4°00' Down (4)
Inter-axle Shaft	7°00' Down (5)
Input 2nd Rear Axle	4°15' Up (Pinion Shaft Nose Up) (6)

Note: If inclination of driveshaft is opposite connecting component, add angles to obtain the U-joint operating angle.

$$\begin{aligned}\angle a &= (2) - (1) = 7^{\circ}00' - 4^{\circ}30' = 2^{\circ}30' (2.50^{\circ}) \\ \angle b &= (2) - (3) = 7^{\circ}00' - 4^{\circ}00' = 3^{\circ}00' (3.00^{\circ}) \\ \angle c &= (5) - (4) = 7^{\circ}00' - 4^{\circ}00' = 3^{\circ}00' (3.00^{\circ}) \\ \angle d &= (5) - (6) = 7^{\circ}00' - 4^{\circ}15' = 2^{\circ}45' (2.75^{\circ})\end{aligned}$$

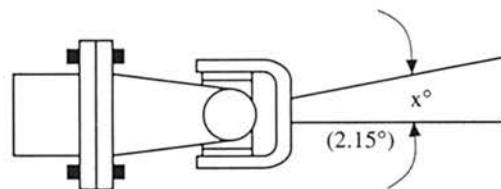
III. CALCULATING THE TRUE U-JOINT OPERATING ANGLE

The true U-joint operating angle is the sum of the U-joint angles in both the top view and the side view. The true U-joint operating angle is calculated in the following manner:

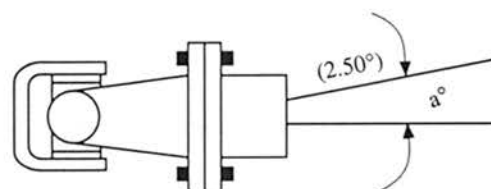
True operating angle = $\sqrt{x^2 + a^2}$
Where $x = 2.15^{\circ}$ as determined by use of chart in Section I.

$a = 2.5^{\circ}$ as determined in Section II.

$$\begin{aligned}\text{True operating angle} &= \sqrt{2.15^2 + 2.5^2} \\ &= 3.297^{\circ} \text{ or } 3^{\circ}18'\end{aligned}$$



ANGLE IN TOP VIEW (FROM CHART)



ANGLE IN SIDE VIEW (MEASURED)

IV. U-JOINT ANGLE CANCELLATION

After calculating the TRUE OPERATING ANGLE of each U-joint in your driveline:

- Make sure the inboard yoke ears of each driveshaft are in line within each other.
- Compare the TRUE OPERATING ANGLE of each U-joint on each end of each shaft. They must be within one degree of each other or they will be a potential source of vibration.

If adjustments must be made to the system:

- Install shims between the axle housing and springs to rotate the axle input yoke to change operating angles.
- Change operating angle on torque arm type suspensions by lengthening or shortening torque arms.
- Raise, lower, or shift side to side a pump, blower or other piece of auxiliary equipment to change operating angles.

IMPORTANT TO REMEMBER: Keep the centerlines of two components that are connected by a driveshaft parallel in both the top and side views, so the operating angles will ALWAYS be equal.

V. MAXIMUM TRUE OPERATING ANGLES*

For Two Joint Shafts with Equal or Intersecting Angles

When you settle on a true operating angle that is correct, make sure it doesn't exceed the angles shown in this chart for the driveshaft RPM.

R.P.M. is the main factor in determining maximum allowable operating angles. As a guide to maximum normal operating angles, refer to the chart below.

Driveshaft RPM	Max. Normal Operating Angles	Driveshaft RPM	Max. Normal Operating Angles
5000	3.2°	3000	5.8°
4500	3.7°	2500	7.0°
4000	4.2°	2000	8.7°
3500	5.0°	1500	11.5°

*Based on application experience (1000 rad/sec acceleration).

UNIVERSAL JOINTS TROUBLE SHOOTING CHART

Complaints


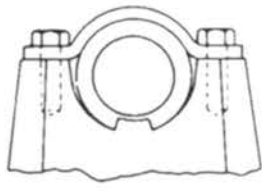

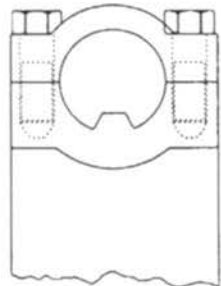


Probable Causes

Complaint	Lack of Lubrication	Inadequate Initial Lubrication	Inadequate Grease Quality for Application	Inadequate Relube Cycles for Application Environment	Failure to Lubricate Properly	Defective or Worn Seals	Yoke Distortion Due to Initial Failure	Continuous Operation at High Angle — High Speed	Excessive Continuous Running Load	End Galling of Cross Trunnion and Bearing Cup	Contamination (Abrasion)	Lubricating Film Breakdown	Excessive Thrust Fit	Yoke Cross Hole Alignment	No U-Joint Operating Angle	Long Shaft with Loose U-Joint Thrust Fit and Unbalance	Roller Lock	Roller Skewing	Fretting Corrosion Due to Yoke Working Under Load	Galling (Adhesive Wear)	Slip Member Working In Extreme Extended	Excessive Loose O.D. Fit	Male Spline Head	Excess
Low Mileage U-Joint Failure	1	1	1	1	2	4	5	14																
Repeat U-Joint Failure	1	1	1	1	2	4	5	14																
End Galling of Cross Trunnion and Bearing Cup										1	1	7	7	7										
Fretting (Also: False Brinelling, Wear Oxidation, Friction Oxidation, and Chaffing Fatigue)										1	1	7	7	7										
Bearing Race O.D. Seizure in Yoke Cross Holes																								
Slip Spline Seizures	1	1	1	1	1					8	1										1	5	15	5
Slip Spline Galling										8	1													
Slip Spline O.D. Wear at Extremities and at 180°																								
Slip Spline Shaft or Tube Broken in Torsion																								
Shaft Broken in Bending																								
Tube Split in Longitudinal Seam Weld																								
Tube Circle Weld Failure																								
Yoke Broken in Hub																								
Yoke Broke at Ear Tip																								
Broken Cross or Cups																								
Needle Rollers Brinelled into Cups and Cross Trunnion																								
Shaft Support Brg. Failure	11	11			11			11																
Shaft Support Rubber Insulator Failure	32							32																
Transmission Extension Bell Housing and Clutch Housing Failures																								
Vibrations																								
Low Gear Shudder																								
Vibrations in Short Speed Ranges Under Full Drive or Full Coast																								

1. See Spicer Universal Joint Lube specs #3306.
2. If new kit...Replace seals. If used...Replace complete kit.
3. Replace yoke if distorted.
4. Reduce U-Joint's continuous running angles.
5. Replace with higher capacity U-joint and driveshaft.
6. Use Hi-Temp grease.
7. Check U-joint flex effort. If sticks, binds or grabs...Replace U-Joint kit. If still sticks, binds or grabs...Check yokes for span, lug squareness, cross hole alignment, etc. Replace as needed.

8. Check components. If serviceable...Clean and relubricate per lube specs. If not serviceable...Replace.
9. No immediate fix. Anti-seize lubricant on bearing O.D. will initially help.
10. Re-align for a minimum 1° running angle.
11. Replace.
12. Replace roller lock assembly.
13. Yoke deflections under load...Use larger joint.
14. Use Spicer "Glidecote" on slip spline.
15. Increase driveshaft assembly length. Position slip spline head towards U-joint.
16. Check for male slip member with longer spline.
17. Design is inadequate for application.

SPICER UNIVERSAL JOINT KIT ATTACHING HARDWARE & TORQUE SPECIFICATIONS CHART

U-BOLT				
Series	Spicer Kit No.	U-Bolt Ass'ys.	Recommended Nut Torque	
				
1280	5-200X	2-94-28X	14-17 Lb. Ft.	
1310	5-153X	2-94-28X	14-17 Lb. Ft.	
1330	5-213X	2-94-28X	14-17 Lb. Ft.	
1350	5-178X	3-94-18X	20-24 Lb. Ft.	
1410	5-160X	3-94-18X	20-24 Lb. Ft.	
1480	5-188X	3-94-28X	32-37 Lb. Ft.	
1550	5-155X	3-94-28X	32-37 Lb. Ft.	
BEARING STRAP				
Series	Spicer Kit No.	Strap Kit Ass'ys.	Recommended Bolt Torque	
				
SPL90	SPL90X	90-70-28X	45-60 Lb. Ft.	
1210	5-443X	2-70-18X	13-18 Lb. Ft.	
1280	5-200X	2-70-18X	13-18 Lb. Ft.	
1310	5-153X	2-70-18X	13-18 Lb. Ft.	
1330	5-213X	2-70-18X	13-18 Lb. Ft.	
1350	5-178X	3-70-28X	30-35 Lb. Ft.	
1410	5-160X	3-70-28X	30-35 Lb. Ft.	
1480	5-188X	3-70-38X	55-60 Lb. Ft.	
1550	5-155X	3-70-38X	55-60 Lb. Ft.	
1610	5-438X	5-70-28X	55-60 Lb. Ft.	
1710	5-515X	6.5-70-18X	130-135 Lb. Ft.	
1760	5-469X	6.5-70-18X	130-135 Lb. Ft.	
1810	5-510X	6.5-70-18X	130-135 Lb. Ft.	
	WARNING: Bearing Strap Retaining Bolts Should NOT Be Reused.			
CAP & BOLT				
Series	Spicer Kit No.	Cap & Bolt Ass'ys.	Recommended Bolt Torque	
				
1650	5-165X	5-70-18X	77-103 Lb. Ft.	
1850	5-185X	8-70-18X	110-147 Lb. Ft.	
1850	5-227X	8-70-18X	110-147 Lb. Ft.	
1910	5-316X	N.S.S.	110-147 Lb. Ft.	
1950	5-339X	9-70-18X	271-362 Lb. Ft.	
2010	5-371X	N.S.S.	102-118 Lb. Ft.	
2050	5-340X	9-70-28X	744-844 Lb. Ft.	
2110	5-372X	N.S.S.	171-197 Lb. Ft.	
2150	5-298X	9-70-38X	744-844 Lb. Ft.	
2210	5-373X	N.S.S.	260-298 Lb. Ft.	
BEARING PLATE				
Series	Spicer Kit No.	Bolt Part No.	Lockstrap Part No.	Recommended Bolt Torque
				
1610	*5-279X	5-73-709	N.A.	26-35 Lb. Ft.
1710	*5-280X	6-73-209	N.A.	38-48 Lb. Ft.
1760	*5-407X	6-73-209	N.A.	38-48 Lb. Ft.
1810	*5-281X	6-73-209	N.A.	38-48 Lb. Ft.
1880	*5-308X	7-73-315	N.A.	60-70 Lb. Ft.
New part nos. for kits with lockstraps available after Spring, 1994				
1610	5-654X	5-73-109	98-1741	17-24 Lb. Ft.
1710	5-656X	6-73-109	230323	32-42 Lb. Ft.
1760	5-658X	6-73-109	230323	32-42 Lb. Ft.
1810	5-660X	6-73-109	230323	32-42 Lb. Ft.
1880	5-668X	7-73-115	231009	50-66 Lb. Ft.
	WARNING: Self Locking Bolts Should NOT Be Reused			

* THESE U-JOINT KITS WILL USE SELF-LOCKING BOLTS WITH LOCK PATCH™ AFTER SPRING, 1994. A LOCKSTRAP WILL NO LONGER BE NEEDED.

SPICER FLANGE BOLT INFORMATION

Series	Part Numbers			Diameter, Thread, & Length Under Head	Recommended Torque
	Bolt	Washer	Nut		
1000/1100	5-73-414	500357-10	231421-2	.312" - 24 x 0.875"	22-26 Lb. Ft.
1350/1410/1550	5-73-2216	"	"	- 24 x 1.000"	"
1550 *	5-73-1125	"	"	- 24 x 1.562"	"
1280/1310	6-73-316	500357-11	231421-3	.375" - 24 x 1.000"	40-48 Lb. Ft.
SPL90/1610	6-73-1219	"	"	- 24 x 1.188"	"
1710	6-73-220	"	"	- 24 x 1.250"	"
SPL90/1610 *	6-73-325	"	"	- 24 x 1.562"	"
1710 *	6-73-1227	"	"	- 24 x 1.688"	"
1350/1410	7-73-219	500357-12	231421-4	.438" - 20 x 1.188"	63-75 Lb. Ft.
1810	7-73-122	"	"	- 20 x 1.375"	"
1350/1410 *	7-73-126	"	"	- 20 x 1.625"	"
1760/1810 *	7-73-228	"	"	- 20 x 1.750"	"
1480/1550	8-73-122	500357-13	231421-5	.500" - 20 x 1.375"	97-116 Lb. Ft.
1650	8-73-123	(Bearing Race Cap)		- 20 x 1.438"	"
1480/1550 *	8-73-228	500357-13	231421-5	- 20 x 1.750"	"
1880/1910	10-73-131	500358-15	231421-7	.625" - 18 x 1.938"	194-232 Lb. Ft.
1950	12-73-140	500358-17	231421-8	.750" - 16 x 2.500"	341-409 Lb. Ft.
2010	9.55-73-11	—	231483	18mm x 75mm	277-319 Lb. Ft.
2050	14-73-264	500358-19	231421-9	.875" - 9 x 3.500"	543-652 Lb. Ft.
2110	9.60-73-11	—	231482	20mm x 80mm	397-457 Lb. Ft.
2150	16-73-164	500358-21	231421-10	1.000" - 12 x 4.000"	810-976 Lb. Ft.
2210	9.65-73-11	—	231481	22mm x 90mm	534-575 Lb. Ft.

* - Tru Stop Brake Applications

Spicer Flange Bolts are **Special, Heat Treated, Grade 8 Bolts.**

Do not substitute inferior grade bolts.

Dana Corporation
Drivetrain Service Division
P.O. Box 321
Toledo, Ohio 43697-0321

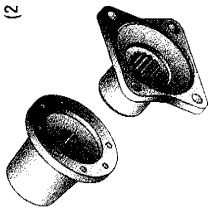
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SPICER®



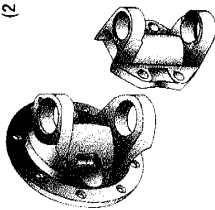
COMPANION FLANGE (1)

(2 STYLES)

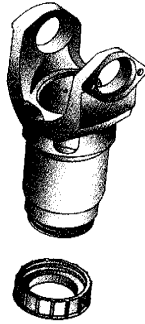


FLANGE YOKE (2)

(2 STYLES)



SLIP YOKE ASSEMBLY (3)

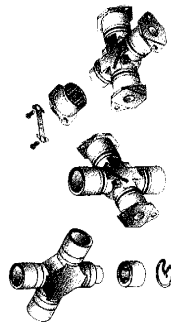


END YOKE (4)

(3 STYLES)

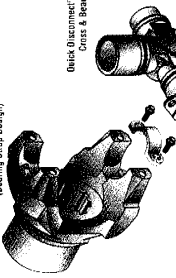


JOURNAL & BEARING KIT

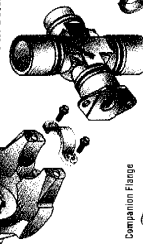


SPICER LIFE™ DRIVELINE COMPONENTS

Quick Disconnect™ Half Round End Yoke (Bearing Style Design)



Quick Disconnect™ Half Round Cross & Bearing Kit



Companion Flange



Flange Yoke



Cross & Bearing Kit



Midship Tube Shaft



Driveshaft Tubing



3 JOINT ASSEMBLY DRIVESHAFT



Slip Tube Shaft



Slip Yoke Assembly



Cross & Bearing Kit



Tube Yoke



Driveshaft Tubing



U-Bolt Assembly



Socket Yoke



Strap or Cap & Bolt Assembly



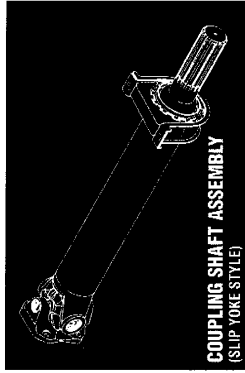
Dust Cap & Washer Kit



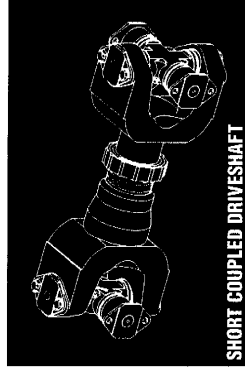
U-Bolt Design End Yoke



U-Bolt Design End Yoke

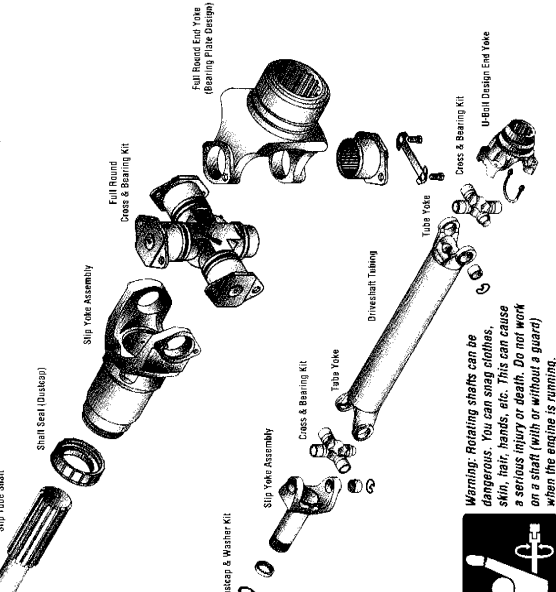


COUPLING SHAFT ASSEMBLY (SLIP YOKE STYLE)



SHORT COUPLED DRIVESHAFT

2 JOINT ASSEMBLY DRIVESHAFT



Slip Tube Shaft

Slip Seal (Optional)

Slip Yoke Assembly

Full Round Cross & Bearing Kit

U-Bolt Design End Yoke (Bearing Plate Design)

U-Bolt Design End Yoke

U-Bolt Design End Yoke

U-Bolt Design End Yoke

U-Bolt Design End Yoke

U-Bolt Design End Yoke

U-Bolt Design End Yoke

U-Bolt Design End Yoke

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U-Bolt Design End Yoke

U-Bolt Design End Yoke

U-Bolt Design End Yoke

U-Bolt Design End Yoke

U-Bolt Design End Yoke

Warning: Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc. This can cause a serious injury or death. Do not work on a shaft (with or without a guard) when the engine is running.



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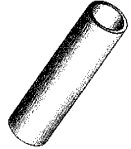
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Spicer Universal Joint Division
P.O. Box 955
Toledo, Ohio 43697-0955

SPICER



Serial: 0221-2

TUBING (30 or 32)



TUBE SHAFT (40-42)



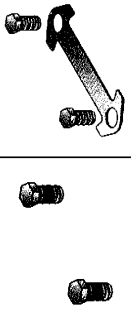
MIDSHIP TUBE SHAFT (53-57)



(SLIP STYLE)

(END YOKE STYLE)

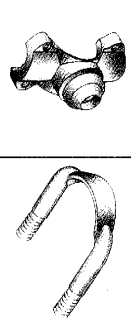
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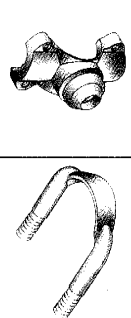
After Spring 94

Pre-Spring 94

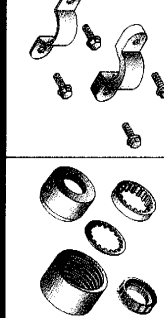
U-BOLT ASSEMBLY (94)



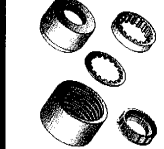
SOCKET YOKE (63)



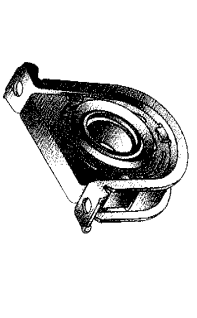
STRAP OR CAP & BOLT ASSEMBLY (70)



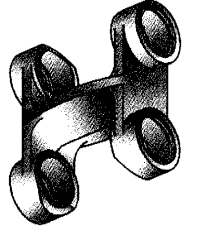
DUST CAP & WASHER KIT (VARIOUS PART NOS.)



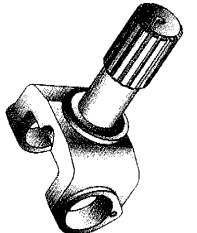
SHAFT SUPPORT BEARING ASSEMBLY



CENTER YOKE (26)

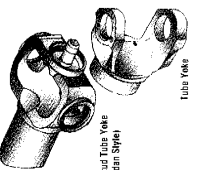


YOKE SHAFT (82)



TUBE YOKE (28)

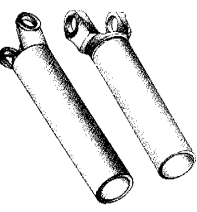
(2 STYLES)



Double Cross Style

Tube Yoke

TUBE YOKE w/TUBE (27)



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Section 10: FRONT AXLE

1. FRONT AXLE

1.1 DESCRIPTION

This front axle is of the "Reverse Elliot" type manufactured by Dana Spicer Europe. The front axle consists of a girder section axle bed or beam with stub axles. Each stub axle is carried on a taper kingpin, with a plain phosphor bronze bushing at the top and at the bottom. The unitized hub bearings used on the NDS range of axles, are non-serviceable items. Bearings are pre-adjusted, lubricated and have seals fitted as part of the manufacturing process. The bearings are greased for life and there is no need or facility for re-lubrication. Brakes are manufactured by KNORR-BREMSE. Steering ball joints with hardened balls and rubbing pads incorporate compression springs which automatically take up any wear.

The tie rod simplifies toe-in adjustment. The maximum turning angle is set through stop screws installed on the inner side of the knuckle.

Steering stabilizer (damper) and steering drag link which are mounted on the front axle are described in Section 14; "Steering" of this manual.

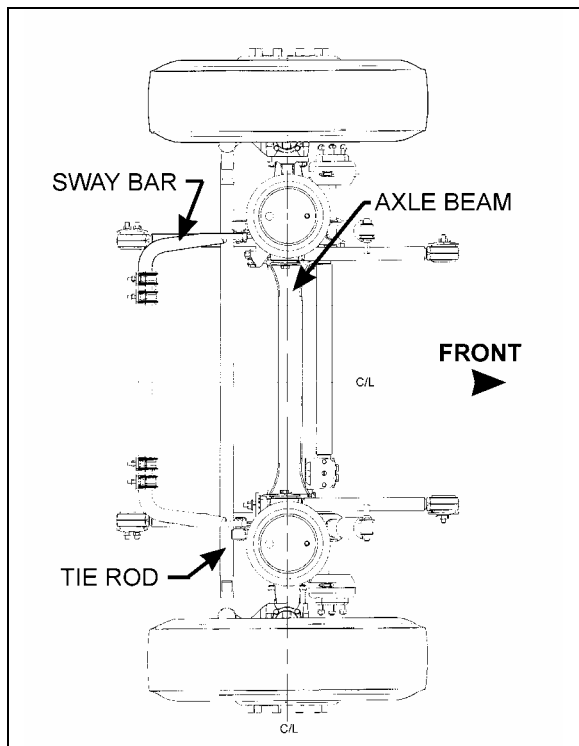


FIGURE 1: FRONT AXLE ASSEMBLY

10026

2. LUBRICATION

Pressure lubricate axle every 6 months or 30,000 miles (48 000 km) whichever comes first (Fig. 2). Tie rod ends and knuckle pins are provided with grease fittings for pressure lubrication. These grease fittings should be serviced every 6,250 miles (10 000 km) or twice a year whichever comes first. Good quality lithium-base roller bearing grease NLGI No.1 and 2 are recommended.

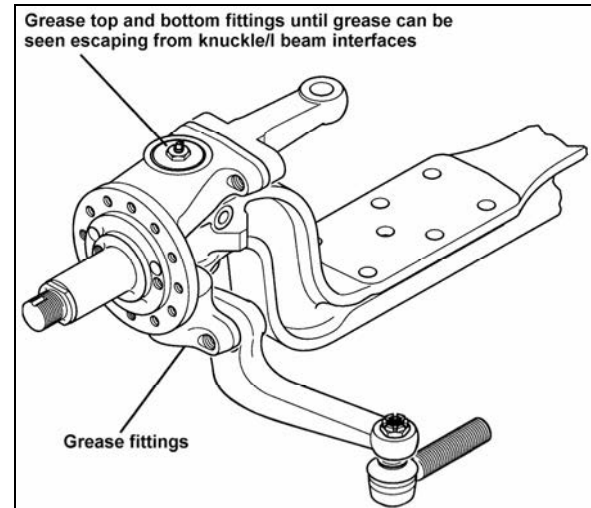


FIGURE 2: FRONT AXLE GREASING POINTS

10031

3. MAINTENANCE

A periodic inspection of the front axle assembly should be made to check that all bolts are tight, and that no damage and distortion have taken place. Suspension support stud nuts, U-bolt nuts, tie rod arms, steering arm nuts and stop screws should be checked and tightened, as required, to the torque specifications given at the end of this section. Also check the condition of the steering knuckle pins and bushings. In case of excessive looseness, the bushings and pins should be replaced.

Any looseness in the steering linkage, under normal steering loads, is sufficient cause to immediately check all pivot points for wear, regardless of accumulated mileage. Steering linkage pivot points should be checked each time the front axle assembly is lubricated. Any looseness can be visually detected while rotating the steering wheel in both directions.

Steering knuckles, knuckle pins and bushings can be overhauled or replaced without removing the axle from the vehicle. However, if extensive

overhaul work is necessary, the axle assembly should be removed.



CAUTION

Should removal of a locking device be required when undergoing repairs, disassembly or adjustments, always replace with a new one.

3.1 TIE ROD END PLAY ADJUSTMENT

If end play exceeds 0.047" (1.2 mm), readjustment is necessary.

Remove protective cap, using a suitable tool ie: a 1" x 1/8" x 9" long flat bar, tighten adjuster piece fully home (SOLID) locating thrust cup onto ball pin.

Still with tool located on adjuster piece, back off carefully (LEAST AMOUNT) until adjuster piece cotter pin is allowed to pass through body, then remove tool.

Reinstall protective cap.

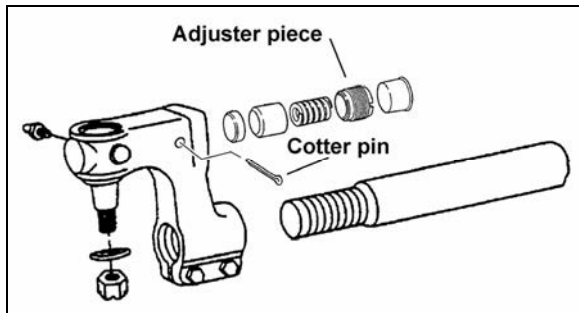


FIGURE 3: TIE ROD END PLAY ADJUSTMENT 10029

4. REMOVAL AND REPLACEMENT

The following procedure deals with the removal of the front axle assembly. The method used to support the axle assembly and suspension components during removal and disassembly depends upon local conditions and available equipment.

4.1 REMOVAL

1. Raise the vehicle by its jacking points on the body (see Section 18, "Body" under heading 16; Vehicle Jacking Points) until vehicle body is approximately 30 inches (760 mm) from the floor. Place jack stands under frame. Remove the wheels (if required, refer to Section 13, "Wheels, Hubs and Tires").



CAUTION

Use only the recommended jacking points as outlined in section 18 "Body".

2. Exhaust compressed air from the air supply system by opening the drain valve of each reservoir.
3. Install jacks under axle jacking points to support the axle weight.



DANGER

To help prevent injury caused by the axle rolling off the jacks, these should be equipped with U-adapters, or similar precautions must be taken

4. Disconnect the steering drag link from the steering arm.
5. Remove the ABS sensors from their location in hubs (if applicable).
6. Disconnect the height control valve link from its support on the axle.
7. Disconnect air lines from front brake chambers, and cover line ends and fittings to prevent the entry of foreign matter.



CAUTION

Position the air lines and electric wires so they will not be damaged while removing the front axle assembly.

8. Proceed with steps a, b and c, while referring to Section 16: "Suspension".
 - a) Disconnect sway bar links from axle brackets.
 - b) Remove shock absorbers.
 - c) Disconnect five radius rods: one transversal and two longitudinal from subframe, and two upper rods from axle.
9. Remove the bolts and nuts fixing the axle to the left-hand and right-hand side air bellows mounting supports.
10. Using the jacks, slowly lower the axle assembly, and carefully pull away from underneath vehicle.

Section 10: FRONT AXLE

4.2 REPLACEMENT

Reverse front axle "Removal" procedure. Ensure cleanliness of air bellows support mounting plates.

NOTE

Refer to Section 16, "Suspension", Section 14, "Steering" and to paragraph 8 "Specifications" at the end of this section for applicable checks and recommended tightening torques.

5. SERVICE INSTRUCTIONS FOR STEER AXLE

5.1 HUB BEARING INSPECTION

An inspection should be made at intervals of 30,000 miles (48 000 km).

- Apply parking brake, raise wheels off the ground and support axle on stands. When the wheels are raised, they should revolve quite freely without roughness.
- Place magnetic base of a dial indicator on brake caliper and position dial indicator stem against a convenient marked spot on face of hub flange.
- With dial indicator in position pull hard but steadily on hub flange and oscillate at same time until a steady reading is achieved.
- Without releasing the pressure, turn bearing so that dial indicator stem contacts marked spot and note reading on indicator.
- Push bearing flange hard and oscillate as before until a steady reading is achieved.
- Without releasing the pressure, turn bearing so that indicator stem again contacts the marked spot and note new reading on indicator.
- The difference between readings is the amount of mounted end play in bearing unit.
- The mounted end play figure should not exceed **0.050 mm (0.002")** for a new bearing and **0.20 mm (0.008")** for a bearing which has been in service.

NOTE

If original bearing unit is re-fitted, and end-float is measured at 1 mm, with hub not fully tightened to correct torque, then the retaining clip within the unit is damaged and a new unit must be fitted.

5.2 KING PIN INSPECTION

An inspection should be made at intervals of 30,000 miles (48 000 km).

Aspects to be considered are: Lateral slackness and Vertical slackness.

NOTE

Before commencing checks, apply parking brake, raise wheels off ground and support axle on stands.

5.2.1 Checking Lateral Slackness

- While this is being carried out the brake must be applied.
- Place a set-square with its stock on ground and its blade against tire wall.
- Place a mark on ground to indicate position of stock end.
- Insert a lever through bottom cut-out of wheel and lever it upwards thus moving set-square outwards.
- Mark changed position of stock end.
- Maximum allowable stock displacement is given as follows: **for 22.5" wheels = 8mm (5/16")**.
- If displacement exceeds stated allowance then need for bush / bearing attention and possible renewal, is in evidence.

5.2.2 Checking Vertical Slackness

- This is measured by a dial indicator anchored to axle beam and having its pointer placed vertical against swivel top.
- Place a jack against underside of swivel and, while applying a lifting force, observe any movement on indicator dial.
- **If vertical movement is evident and it exceeds 0.040" (1.02mm)** then readjustment of swivel is required by adjusting thickness of bearing adjusting washers.

Refer to "DANA SPICER Maintenance Manual Model NDS and Maintenance Manual NDS Axles" annexed at the end of this section.

6. FRONT WHEEL ALIGNMENT

Correct front wheel alignment must be maintained for steering comfort and satisfactory tire life. Road shocks and vibrations, as well as normal stress and strains on the front-end system can, under normal operating conditions, result in loss of front wheel alignment.

Check the front wheel alignment when the following occurs:

1. Every 200,000 miles (320 000 km) or 24 months (normal maintenance);
2. When the vehicle does not steer correctly; or
3. To correct a tire wear condition.

There are two types of front wheel alignment: **minor alignment** and **major alignment**.

6.1 MINOR FRONT WHEEL ALIGNMENT

Perform a minor front wheel alignment for all normal maintenance conditions.

Perform the minor front wheel alignment in the following sequence :

1. Inspect all the systems that affect the wheel alignment. See paragraph 6.3, "*Inspection Before Alignment*" in this section.
2. Check the hub bearings. See section 13, "*Wheels, hubs and Tires*" under heading 8: Front and Tag Axle Wheel Hubs.
3. Check and adjust the toe-in.

6.2 MAJOR FRONT WHEEL ALIGNMENT

Perform a major front wheel alignment to correct steering and tire wear conditions.

Perform the major front wheel alignment in the following sequence:

1. Inspect all systems affecting the wheel alignment. See paragraph 6.3, "*Inspection Before Alignment*" in this section.
2. Check the hub bearings. See section 13, "*Wheels, hubs and Tires*" under heading 8: Front and Tag Axle Wheel Hubs.

NOTE

If steering angle stoppers are changed, a special procedure is required for readjusting gearbox steering limiter. See paragraph 6.5 "Hydraulic Stop" in this section.

3. Check and adjust the turning angle adjustment.
4. Check the camber angle.
5. Check and adjust the caster angle.
6. Check and adjust the toe-in.

6.3 INSPECTION BEFORE ALIGNMENT

Check the following before doing a front wheel alignment:

1. Ensure that the vehicle is at normal riding height. See Section 16, "*Suspension*" under heading 7: "*Suspension Height Adjustment*".
2. Ensure that front wheels are not the cause of the problem. See Section 13, "*Wheels, Hubs and Tires*". Inspect the tires for wear patterns indicating suspension damage or misalignment.
 - a. Make sure the tires are inflated to the specified pressure.
 - b. Make sure the front tires are the same size and type.
 - c. Make sure the wheels are balanced.
 - d. Check wheel installation and straightness.
3. Check the wheel bearing adjustment.
4. Check steering linkage for bending and pivot points for looseness.
5. Check knuckle pins for evidence of excessive wear.
6. Check radius rods for bending and rubber bushings for evidence of excessive wear.
7. Make sure all fasteners are tightened to the specified torque. Use a torque wrench for verification. As soon as the fastener starts to move, record the torque. Correct if necessary. Replace any worn or damaged fasteners.

6.4 TURNING ANGLE ADJUSTMENT

The maximum turning angle is set through the two steering stop screws installed on the axle center. The turning angle is factory adjusted to accommodate the chassis design, and therefore, does not require adjustment on new vehicles. However, it should be checked and

Section 10: FRONT AXLE

adjusted any time any component of the steering system is repaired, disassembled or adjusted.

Check if front tires rub against the frame or if the steering gear has been serviced.

Proceed with the following method to check the steering maximum turning angle :

6.4.1 R.H. Turn Adjustment



CAUTION

To prevent the steering damper from interfering with the adjustment of turning angles, make sure its fixing bracket is at the correct location on the axle center (refer to section 14 "Steering").

1. Turn steering wheel to the right until the boss on the axle center touches the right stop screw.
2. Verify the nearest point of contact of the ball socket body with the air bellows support assembly. Measure the distance between those two points.
3. The distance between these two points should be approximately 1/8 inch (3 mm). If not, the steering stop screws must be readjusted.
4. Verify the nearest point of contact of the drag link with the tire. Measure the distance between those two points.
5. The distance should be 1 inch (25 mm) or more. If not, the steering stop screws must be readjusted.
6. This must be done for a full right turn.
7. If readjustment is required:
 - a. Remove the swivel stop screw.
 - b. Add to the stop screw the required number of washers to obtain the proper measure, tighten the stop screw afterwards. Two washers of different thickness are available: 1/16 inch and 3/16 inch.

6.4.2 L.H. Turn Adjustment

1. Turn steering wheel to the left until the boss on the axle center touches the left stop screw.

2. Verify the nearest point of contact of the ball socket body with the air bellows support assembly. Measure the distance between those two points.
3. The distance between these two points should be approximately 1/8 inch (3 mm). If not, the steering stop screws must be readjusted.
4. Check the stroke of the steering stabilizer cylinder (damper). It should not exceed 12.59 inches (320 mm).
5. This must be done for a full left turn.
6. If readjustment is required:
 - a. Remove the swivel stop screw.
 - b. Add to the stop screw the required number of washers to obtain the proper measure, tighten the stop screw afterwards. Two washers of different thickness are available: 1/16 inch and 3/16 inch.

NOTE

If steering angle stoppers are changed, a special procedure is required for readjusting gearbox steering limiter. See paragraph 6.5 "Hydraulic Stop" in this section.

6.5 HYDRAULIC STOP

NOTE

Before steering limiter readjustment, verify vehicle wheel alignment and ensure that oil level is checked and that air bleeding is done.

Refer to "ZF-Servocom Repair Manual" annexed at the end of Section 14 "Steering" under heading "Setting and Functional Test."

6.6 FRONT WHEEL CAMBER

Wheel camber is the number of degrees the top of the wheel tilts outward (positive) or inward (negative) from a vertical angle (Fig. 4).

The camber angle is not adjustable. Camber variations may be caused by wear at the wheel bearings, steering knuckle pins or by a bent knuckle or sagging axle center. Steering effort is affected by improper camber, and uneven tire wear will result. Excessive positive camber causes an irregular wear of tire at the outer shoulder and excessive negative camber causes wear at the inner shoulder.

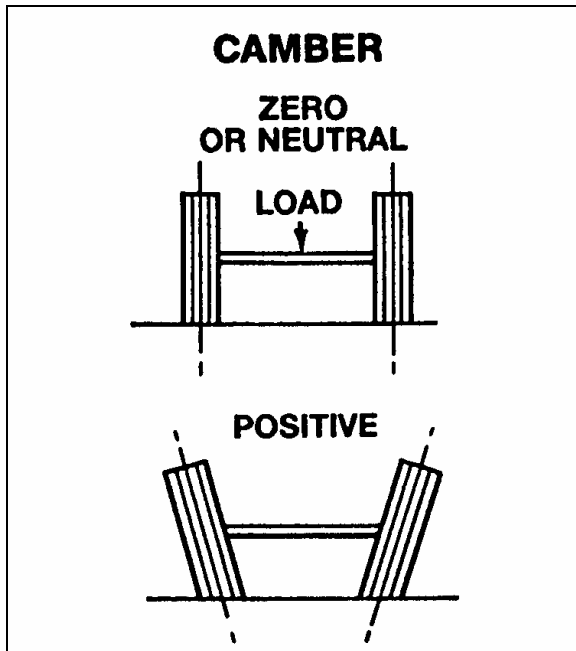


FIGURE 4: CAMBER

10006

6.6.1 Camber Check

For camber specifications, refer to paragraph 8: "Specifications" in this section

1. Use an alignment machine to check the camber angle.
2. If camber reading is not in the specifications, check the wheel bearings and repeat the check. If the reading is still not within specifications, verify the steering knuckle pins and axle center.

See instructions in "DANA SPICER Maintenance Manual Model NDS and Maintenance Manual NDS Axles" annexed at the end of this section.

3. Check the wheel lateral distortion as instructed in Section 13, "Wheels, Hubs and Tires" under heading, "Checking for Distorted Wheel on Vehicle". If distortion is excessive, straighten or replace wheel(s).

6.7 FRONT AXLE CASTER

For caster specifications, refer to paragraph 8: "Specifications" in this section.

Positive caster is the rearward tilt from the vertical axis of the knuckle pin. Negative caster is the forward tilt from the vertical axis of the knuckle pin (Fig. 5). This vehicle is designed with a positive caster. The purpose of the caster angle is to give

a trailing effect. This results in stabilized steering and a tendency for the wheels to return to the straight-ahead position after taking a turn.

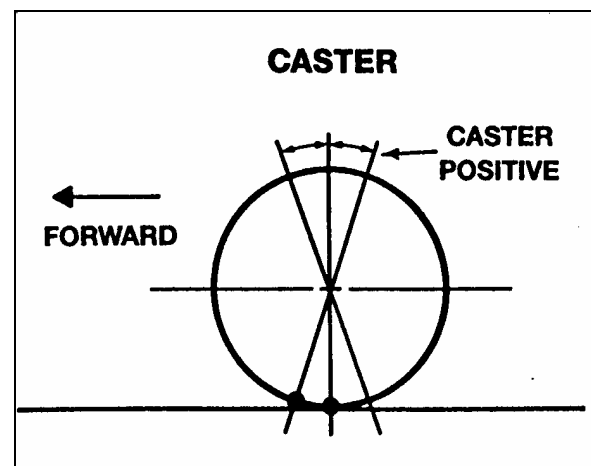


FIGURE 5: CASTER

10007

Excessive caster results in hard steering around corners. A shimmy may also develop when returning to the straight ahead position (pulling out of curves).

Insufficient caster will cause wandering and steering instability. Caster variations may be caused by a bent axle, tilting or distortion of the side suspension supports, damaged radius rod bushings, or unequal tightening of the front and rear suspension support bolts. Incorrect caster must be corrected by replacing the damaged suspension parts. A precision instrument should be used to measure the caster.

NOTE

The caster of this vehicle is factory set and is not adjustable. However, if after replacing damaged parts or in case of improper caster due to irregular setting, the front axle caster needs adjustment; it can be adjusted by means of shims (Prévost #110663) on the left-hand side upper radius rod support in order to obtain minor adjustment.

6.8 FRONT WHEEL TOE-IN

Wheel toe-in is the degree (usually expressed in fractions of an inch) to which the forward part of the vehicle front wheels are closer together than the rear part, measured at wheel centerline height with the wheels in the normal "straight-ahead" position of the steering gear.

Incorrect toe-in results in excessive tire wear caused by side slippage and also steering instability with a tendency to wander. Toe-in may

Section 10: FRONT AXLE

be measured from the center of tire tread or from the inside of the tires. Take measurements at both front and rear of axle (see "A and "B" in fig. 6).

When setting toe-in adjustment, the front suspension must be neutralized; that is, all component parts must be in the same relative position when marking the adjustment as they will be when in operation.

To neutralize the suspension, the vehicle must be rolled forward, approximately ten feet.

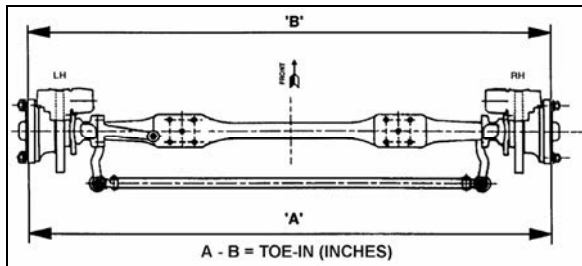


FIGURE 6: TOE-IN MEASUREMENTS

10032

For toe-in specifications, refer to paragraph 8 "Specifications" in this section.

By rolling the vehicle forward, all tolerances in the front suspension are taken up and the suspension is then in its normal operating position. Neutralizing the front suspension is extremely important, especially if the vehicle has been jacked up in order to mark the tires. Otherwise, the front wheels will not return to their normal operating position due to the tires gripping the floor surface when the vehicle jack is lowered.

NOTE

"Toe-in" measurements must be taken at the horizontal axis of the wheel centerline.

6.8.1 Inspection and Adjustment

Before checking front wheel toe-in, first check the camber angles and make the necessary corrections.

1. Measure the toe-in.
2. If the toe-in measurement is not within the specified tolerance, carry out the following procedure :
 - a. Loosen the pinch bolt nuts and bolts on each tie rod end.
 - b. Turn the tie rod until the specified toe-in measurement is obtained.
 - c. Tighten the pinch bolt nuts alternately and progressively to 65-75 lbf-ft (88-102 Nm), thus securing all tie rod joints.

7. TROUBLESHOOTING

CONDITION	CAUSE	CORRECTION
Tires wear out quickly or have uneven tire tread wear.	<ol style="list-style-type: none"> 1. Tires have incorrect air pressure. 2. Tires out-of-balance. 3. Incorrect tag axle alignment. 4. Incorrect toe-in setting. 5. Incorrect steering arm geometry. 	<ol style="list-style-type: none"> 1. Put specified air pressure in tires. 2. Balance or replace tires. 3. Align tag axle. 4. Adjust toe-in specified setting. 5. Service steering system as necessary.
Vehicle is hard to steer.	<ol style="list-style-type: none"> 1. Low pressure in the power steering system. 2. Steering gear not assembled correctly. 3. Steering linkage needs lubrication. 4. King pins binding. 5. Incorrect steering arm geometry. 6. Caster improperly adjusted. 7. Tie rod ends hard to move. 8. Worn thrust bearing. 	<ol style="list-style-type: none"> 1. Repair power steering system. 2. Assemble steering gear correctly. 3. Lubricate steering linkage. 4. Replace king pins. 5. Service steering system as necessary. 6. Adjust caster as necessary. 7. Replace tie rod ends. 8. Replace thrust bearing.
Bent or broken steering arm, steering top lever or tie rod assembly.	<ol style="list-style-type: none"> 1. Too much pressure in the power steering system. 2. Cut-off pressure of the power steering system improperly adjusted. 3. Vehicle not powered on correctly. 4. Power steering system not installed correctly. 	<ol style="list-style-type: none"> 1. Replace damaged part(s), adjust power steering system to specified pressure. 2. Make sure vehicle is powered on correctly. 3. Correctly install the power steering system. 4. Correctly install the power steering system.
Worn or broken steering ball stud.	<ol style="list-style-type: none"> 1. Drag link fasteners tightened past specified torque. 2. Lack of lubrication or incorrect lubricant. 3. Power steering stops improperly adjusted. 	<ol style="list-style-type: none"> 1. Replace damaged part(s), tighten drag link fasteners to specified torque. 2. Lubricate linkage with specified lubricant. 3. Adjust stops to specified dimension.
Worn king pins and knuckle bushings.	<ol style="list-style-type: none"> 1. Worn or missing seals and gaskets. 2. Incorrect lubricant. 3. Axle not lubricated at scheduled frequency. 4. Incorrect lubrication procedures. 5. Lubrication schedule does not match operating conditions. 	<ol style="list-style-type: none"> 1. Replace damaged part(s), replace seals and gaskets. 2. Lubricate axle with specified lubricant. 3. Lubricate axle at scheduled frequency. 4. Use correct lubrication schedule to match operating conditions. 5. Change lubrication schedule to match operating conditions.
Vibration or shimmy of front axle during operation.	<ol style="list-style-type: none"> 1. Caster not adjusted properly. 2. Wheels and/or tires out-of balance. 3. Worn steering stabilizer cylinder. 	<ol style="list-style-type: none"> 1. Adjust caster. 2. Balance or replace wheels and/or tires. 3. Replace steering stabilizer cylinder.

Section 10: FRONT AXLE

8. SPECIFICATIONS

Front Axle

Make DANA SPICER EUROPE

Model NDS

Front Track 84.4 inches (2 145 mm)

Rated load capacity 16,500 lbs (7 500 kg)

Torque specifications

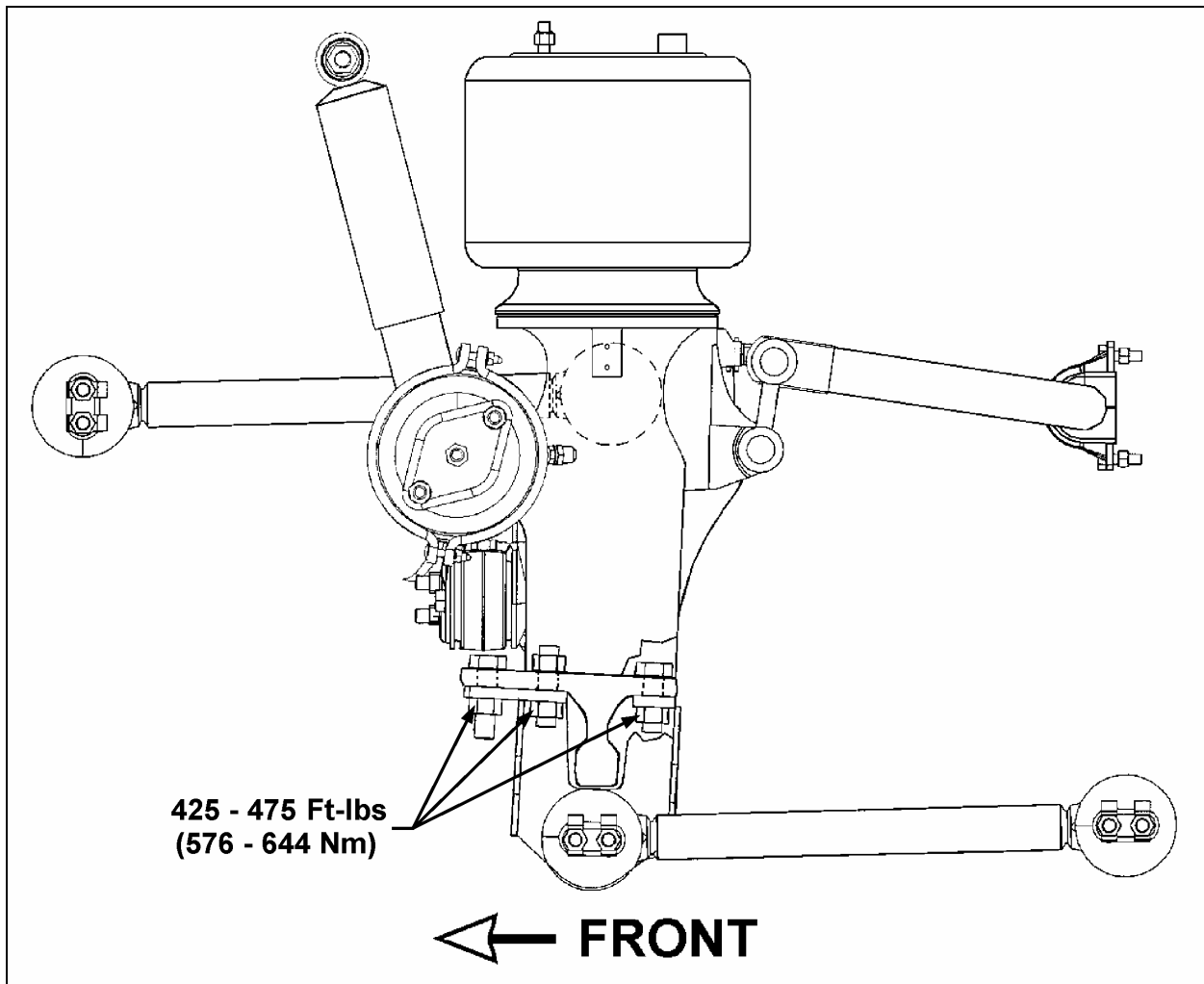


FIGURE 7: AIR BELLOWS MOUNTING SUPPORT AND AXLE

10030

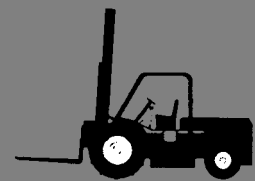
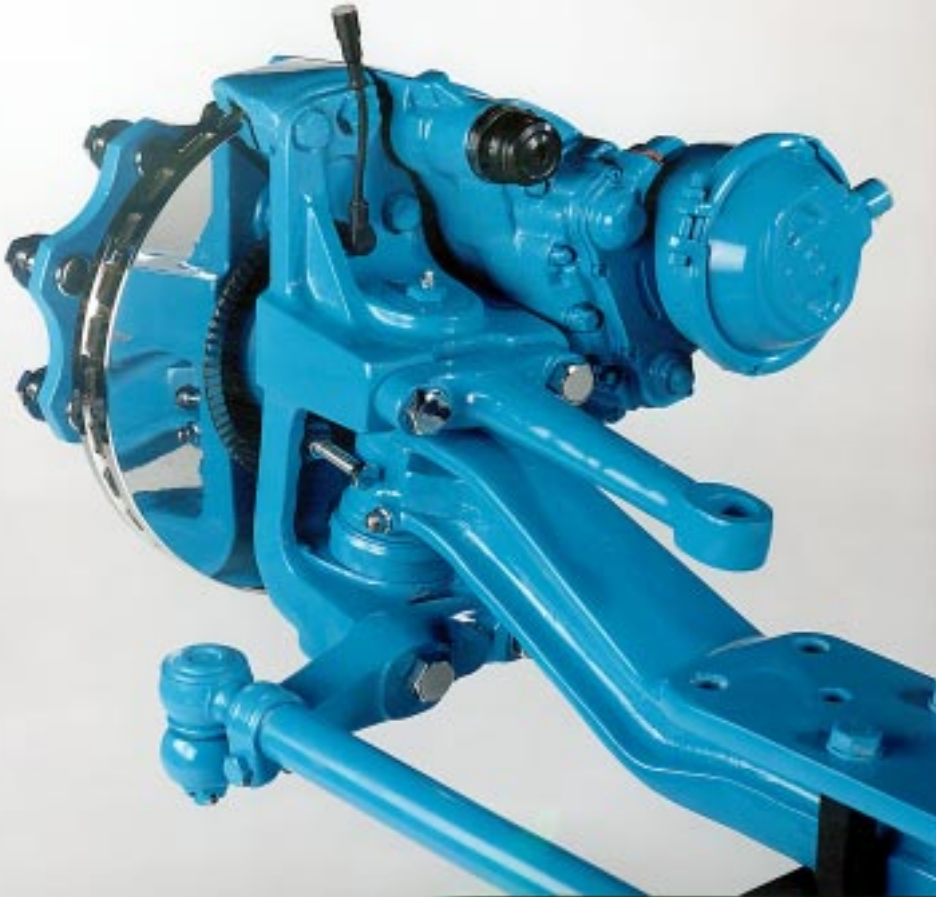
For more torque specifications, see 'Dana Spicer Maintenance Manual NDS Axles and Maintenance Manual Model NDS' annexed at the end of this section.

FRONT WHEEL ALIGNMENT SPECIFICATIONS			
Front Wheel Alignment	Minimal	Nominal	Maximal
Camber, (degrees) R.H. and L.H. *	-0.250	0.125	0.375
Caster, (degrees) R.H. and L.H.	2	2.75	3.5
Toe-in (A minus B), (degrees)	0.06	0.08	0.10

NOTE

Camber angle changes with loading. The given numbers are for an empty vehicle.

SERVICE MANUAL
GENERAL INFORMATION
NDS Axle range



SPICER SPECIALITY AXLE DIVISION



INFORMATION ABOUT THIS MANUAL.**THIS MANUAL IS DIVIDED INTO THE FOLLOWING GENERAL SECTIONS:-**

- 1) GENERAL INFORMATION (this section)
- 2) LUBRICATION AND MAINTENANCE
- 3) REMOVAL AND REFITTING OF THE SWIVEL (KNUCKLE) ASSEMBLY
- 4) REMOVAL AND REFITTING OF THE BRAKE ASSEMBLY
- 5) PARTS IDENTIFICATION

The description, testing procedures, and specifications contained in this parts / service publication were current at time of printing. This manual will not be updated. If in doubt about any aspect of maintenance or servicing of the axle please contact the vehicle builder or our service department direct.

Spicer Speciality Axle Division products are subject to continual development and we reserve the right to modify procedures and to make changes in specifications at any time without prior notice and without incurring obligation.

The recommendations of the vehicle manufacturer should be considered as the primary source of service information regarding this **SPICER**® product. This manual is intended to be used as a supplement to such information.

Any references to brand names in this publication is made simply as an example of the types of tools and materials recommended for use and, as such, should not be considered as an endorsement.

Spicer Speciality Axle division recommends following all manufacturers recommendations for the proper handling and disposal of lubricants and solvents. For further information please contact the supplier of lubricants and solvents.

IMPORTANT NOTICE

THIS SYMBOL IS USED THROUGHOUT THIS MANUAL, TO CALL ATTENTION TO PROCEDURES WHERE CARELESSNESS OR FAILURE TO FOLLOW SPECIFIC INSTRUCTIONS MAY RESULT IN PERSONAL INJURY OR COMPONENT DAMAGE. DEPARTURE FROM THE INSTRUCTIONS, CHOICE OF TOOLS, MATERIALS AND RECOMMENDED PARTS MENTIONED IN THIS PUBLICATION MAY JEOPARDISE THE PERSONAL SAFETY OF THE SERVICE TECHNICIAN OR VEHICLE OPERATOR.

SPICER SPECIALITY AXLE DIVISION URGES CAUTION WHEN PERFORMING ANY SERVICE OR MAINTENANCE PROCEDURE



WARNING: FAILURE TO FOLLOW INDICATED PROCEDURES CREATES A HIGH RISK OF PERSONAL INJURY TO THE SERVICE TECHNICIAN.



NOTE: FAILURE TO FOLLOW INDICATED PROCEDURES MAY CAUSE COMPONENT DAMAGE OR MALFUNCTION

FOR EASE OF ASSEMBLY / DISASSEMBLY:

HELPFUL REMOVAL / INSTALLATION PROCEDURES TO AID IN THE SERVICE OF YOUR NDS AXLE

EVERY EFFORT HAS BEEN MADE TO ENSURE THE ACCURACY OF THE INFORMATION CONTAINED WITHIN THIS MANUAL.

HOWEVER, SPICER SPECIALITY AXLE DIVISION MAKES NO EXPRESSED OR IMPLIED WARRANTY OR REPRESENTATION BASED ON THE ENCLOSED INFORMATION.

ANY ERRORS OR OMISSIONS MAY BE REPORTED TO :

THE TECHNICAL PUBLICATIONS DEPARTMENT
SPICER SPECIALITY AXLE DIVISION
ABBAY ROAD
KIRKSTALL
LEEDS
LS5 3NF
TEL: 0044-113-2584611
FAX: 0044-113-2091115

**WARNINGS!****NON ASBESTOS FIBRES!**

ALTHOUGH NON OF THE BRAKE LININGS USED ON THE NDS RANGE OF AXLES CONTAIN ASBESTOS.

IT SHOULD BE NOTED THAT NON ASBESTOS BRAKE LININGS CAN STILL CONTAIN INGREDIENTS WHICH CAN PRESENT HEALTH RISKS IF INHALED.

ACCORDINGLY CARE SHOULD BE TAKEN TO AVOID THE CREATION AND INHALATION OF DUST WHEN BRAKES ARE SERVICED.

FURTHER DETAILS SHOULD BE OBTAINED FROM YOUR EMPLOYER OR THE BRAKE MANUFACTURER!

**PERSONAL INJURY!**

TO PREVENT PERSONAL INJURY, ALWAYS WEAR APPROPRIATE PERSONAL PROTECTION EQUIPMENT (P.P.E) WHEN PERFORMING ANY MAINTENANCE WORK.

**SOLVENT CLEANERS!**

IF SOLVENT BASED CLEANERS ARE TO BE USED, THE MANUFACTURERS INSTRUCTIONS SHOULD BE CAREFULLY FOLLOWED AS WELL AS TAKING THE FOLLOWING BASIC PRECAUTIONS:-

- 1) WEAR EYE PROTECTION!
- 2) WEAR PROTECTIVE CLOTHING!
- 3) WORK IN A WELL VENTILATED AREA!
- 4) DO NOT USE PETROLIUM (GASOLINE) BASED PRODUCTS DUE TO THE RISK OF FIRE AND / OR EXPLOSION!

ON NO ACCOUNT SHOULD SOLVENT CLEANERS BE USED ON ANY OF THE BEARING COMPONENTS CONTAINED IN YOUR NDS RANGE AXLE

**NOTE:**

WELDING , MACHINING OR MODIFICATION OF ANY AXLE COMPONENT IS PROHIBITED UNLESS NOTED IN THIS MANUAL, OR OTHER SPICER SPECIALITY AXLE DIVISION SERVICE LITERATURE.

GLOSSARY OF TERMS

Due to the international nature of Spicer Speciality Axle Division products certain terms and words require clarification; hence the following list:-

ENGLISH

SWIVEL
COTTER PIN
AXLE BED
STEERING LEVER
HUB NUT
SWIVEL STOP SCREW
TOP / BOTTOM CAP
BUSHES
LUBRICATOR

U.S.A

KNUCKLE
DRAW KEY
I BEAM
TIE ROD ARM
SPINDLE NUT
STOP BOLT
KING PIN CAP
BUSHINGS
ZIRC

GENUINE SPICER SERVICE PARTS

Should an axle assembly require replacement component parts, it is recommended that Spicer Speciality Axle Division service parts be used. Spicer Speciality Axle Division service parts are manufactured under the same rigid specification as are the original equipment axle components. This assures the customer who uses genuine Spicer Speciality Axle Division service parts, maximum reliability for a Spicer Speciality Axle Division assembly. Spicer Speciality Axle Division service parts are available through either your vehicle manufacturer or through Spicer Speciality Axle Division spares department. The use of non Spicer service parts may cause premature component failure and void the warranty.

The items included in the spare parts section of this manual are currently available as service spare parts at the time of printing.

The part numbers and illustrations are provided specifically as a guide only.

ORDERING SPARE PARTS

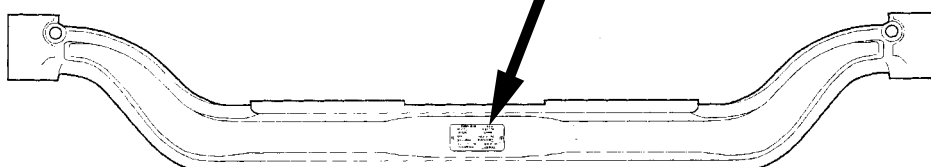
In order to assist our spares department when ordering spare parts for your NDS range axle, please have the following information to hand.

1. Axle type
2. Axle list number
3. serial number

These can be found on the axle nameplate situated on the front of the axle bed as shown below:-



typical example
of nameplate



ALWAYS USE GENUINE *SPICER*[®] SPARE PARTS!

APPLICATION POLICY

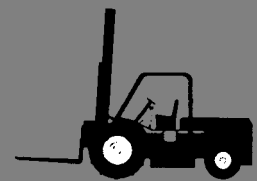
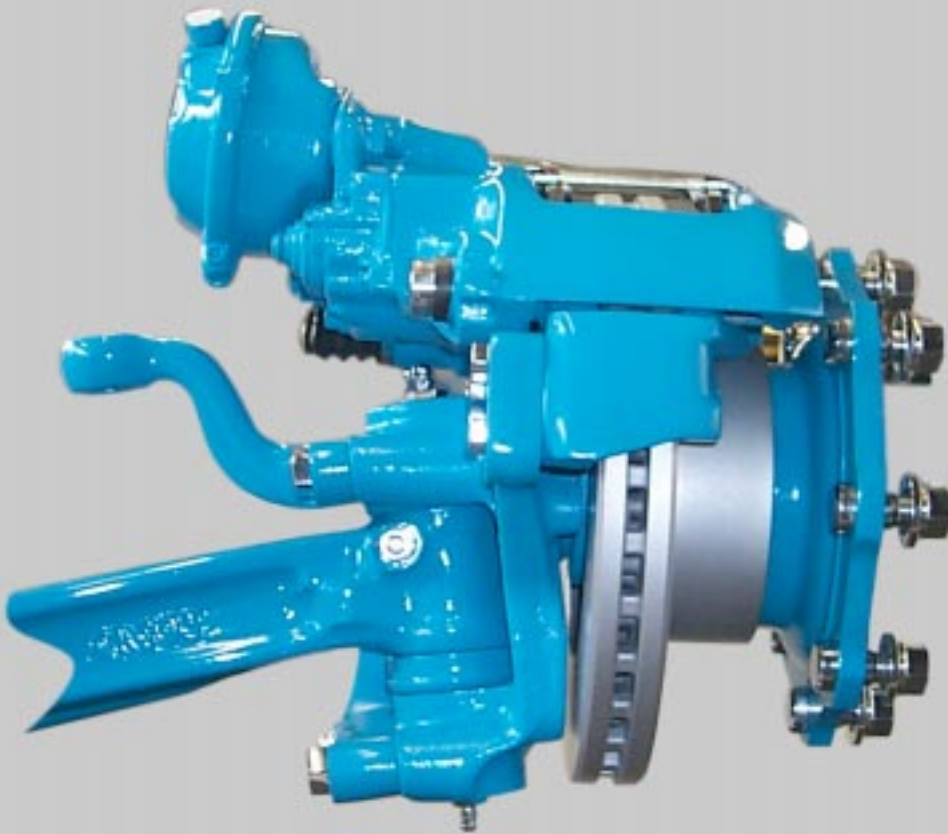
Capability ratings, features and specifications vary depending upon the model type of service. Applications approvals must be obtained from Spicer Speciality axle division. We reserve the right to change or modify our product specifications, configurations, or dimensions at any time without notice.



**SPICER SPECIALITY AXLE DIVISION
ABBAY ROAD
LEEDS LS5 3NF
ENGLAND**

TEL (+44-113) 2584611 FAX (+44-113) 2586097

Maintenance Manual
NDS axles
Lubrication and Maintenance
NDS Axle range
Issue D



SPICER SPECIALITY AXLE DIVISION





MANUAL ISSUE SHEET

Page No.	Issue	Description / Alteration	Reason	Date
All	A	New Manual		Nov. 99
5	B	Mileage interval altered	Updated spec.	Mar.2000
9	B	Mileage interval altered	Updated spec.	Mar.2000
13	B	Tie rod torques added	New tie rod	Mar.2000
14	B	Tie rod torques added	New tie rod	Mar.2000
15	B	Air cylinder torques added	New spec	Mar.2000
18	B	Air cylinder torques added	New spec	Mar.2000
4	B	Lockstop setting info added	Clarification see SB1258	Sep.2000
3	B	Greasing period altered	Standardisation	Jan.2001
4	C	End float checking period added	Standardisation	Jan.2001

SECTION 1 LUBRICATION

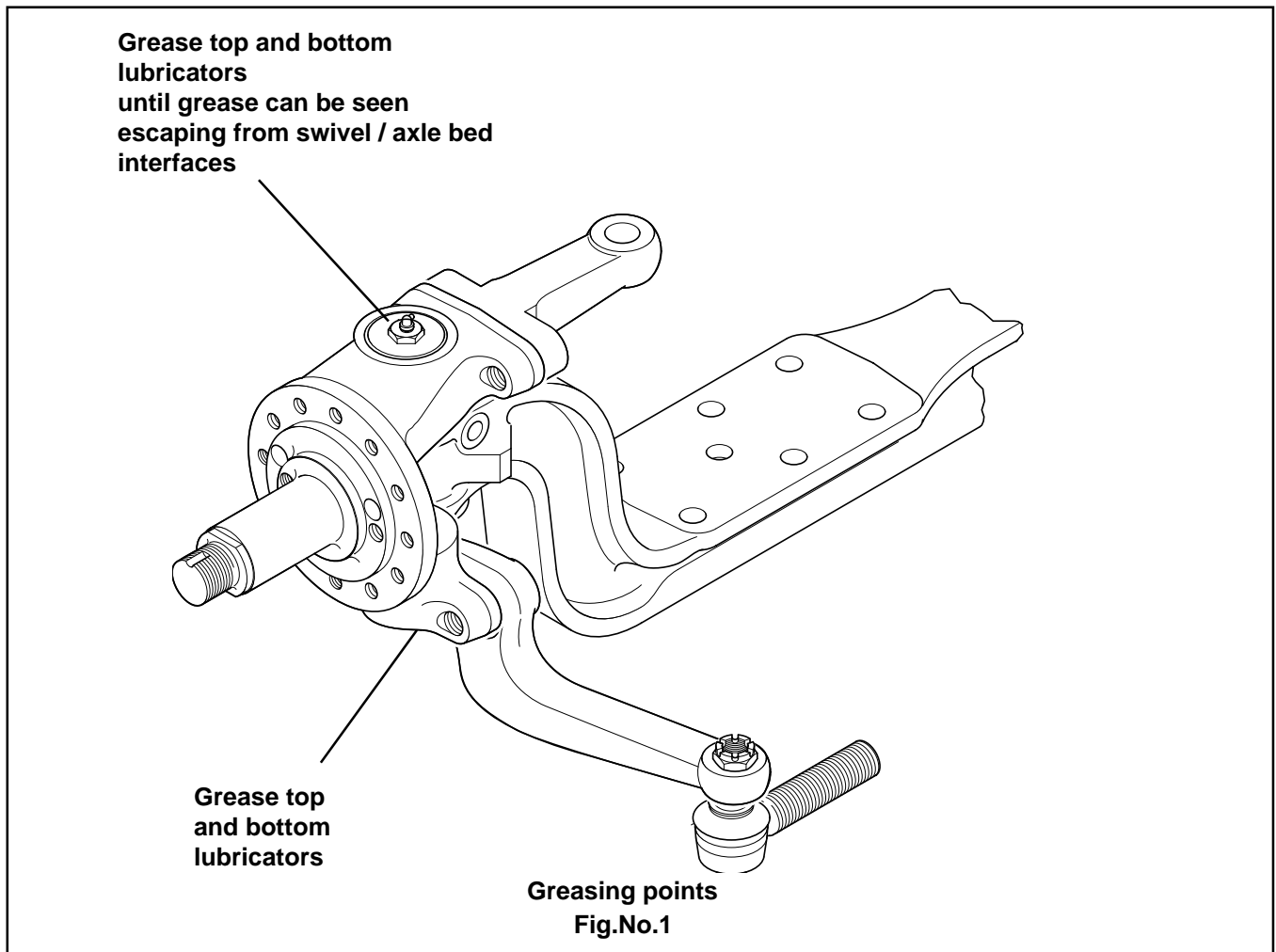
1.1 GREASING PERIODS

1.1.1 ON HIGHWAY APPLICATIONS

Pressure lubricate every 6 months or 30000 miles (48000 km)

A more frequent lubrication cycle is required for axles used in on/off highway, refuse, or other severe service applications.

1.1.2 Grease points as shown in fig.no.1.



NOTE :- ALL OTHER COMPONENTS IN THE NDS RANGE OF AXLES ARE GREASED FOR LIFE AND REQUIRE NO FURTHER LUBRICATION DURING THE LIFE OF THE COMPONENT.

Recommended lubrication - LITHIUM BASE ROLLER BEARING GREASE NLGI NUMBER 2

1.2 Recommended Greases

Use greases to grade "F" in lubrication manual

SECTION 2 ROUTINE MAINTENANCE

- 2.1 Hub bearing check should be carried out every 30000 miles (48000 km)
- a) Before commencing checks, apply parking brake, raise wheels off ground and support axle on stands. and remove brake drum (if fitted) .



WARNING!
NEVER WORK UNDER A VEHICLE SUPPORTED ONLY BY JACKS!
ALWAYS USE SUITABLE AXSLE STANDS!

- b) Place magnetic base of a dial indicator on brake shoe / caliper and position dial indicator stem against a convenient marked spot on face of Hub flange
- c) With dial indicator in position pull hard but steadily on Hub flange and oscillate at same time until a steady reading is achieved.
- d) Without releasing the pressure, turn bearing so that dial indicator stem contacts marked spot and note reading on indicator.
- e) Push bearing flange hard and oscillate as before until a steady reading is achieved.
- f) Without releasing the pressure, turn bearing so that indicator stem again contacts the marked spot and note new reading on indicator.
- g) The difference between readings is amount of mounted end play in bearing unit .
- h) The mounted end play figure should not exceed 0.050mm for a new bearing.

NOTE:-
IF ORIGINAL BEARING UNIT IS RE-FITTED, AND END FLOAT IS MEASURED AT 1MM, WITH HUB NUT FULLY TIGHTENED TO CORRECT TORQUE, THEN THE RETAINING CLIP WITHIN THE UNIT IS DAMAGED / DISPLACED AND A NEW UNIT MUST BE FITTED.



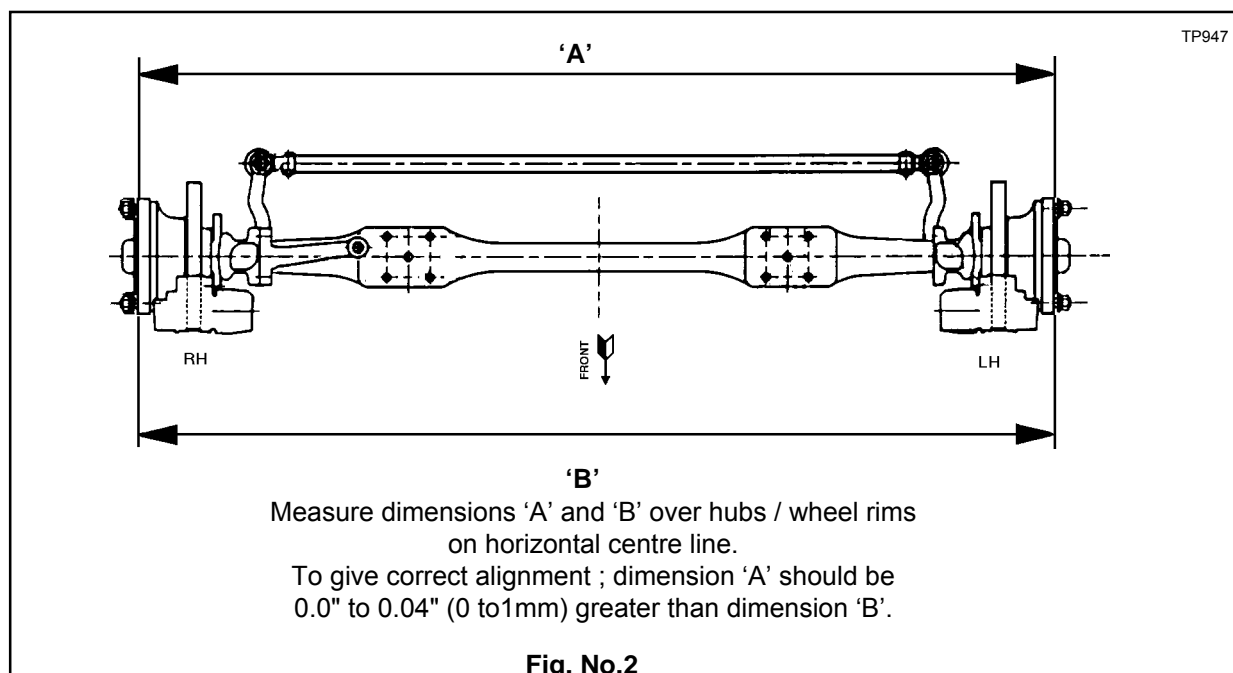
To check front wheel ' Toe In '

- a) To preserve correct steering and avoid excessive tyre wear, tracking (or alignment) of front wheels should be checked periodically, as follows :-
 Set front wheels in straight ahead position and at points level with wheel centre, measure distance over hubs / wheel rims, both in front and behind axle centre.
 For correct 'Toe In' front measurement 'B' should be 0" to 0.04" (0 to1mm) smaller than rear measurement 'A' .
- b) To allow for inaccuracies in wheels, same check should be made with vehicle moved an equivalent to half of a wheel revolution (180°). Any adjustment required can be effected by backing off clamp bolts in ball sockets and rotating tie (track) rod tube.
 After adjustment, tighten clamp bolts to specified torque.

All steer axles supplied by Spicer Speciality Axle Division have their lockstops set to customer requirements.

It is important that when the power assisted steering is fitted, the steering gear is adjusted so that the hydraulic assistance cuts out just before the lockstops come into contact with the axle beam, to avoid excessive loads being transmitted through the steering linkages.

Incorrectly adjusted steering could lead to premature failure or shortened life of all steering components.



- 2.3 Check condition of brake pads as described in relevant brake manufacturers service manual.

SECTION 2 ROUTINE MAINTENANCE Cont.

2.4 Check permissible slackness in swivel (king) pins every 30000 miles (48000 km) as follows :-

Aspects to be considered are :-

- a) Lateral slackness.
- b) Vertical slackness.

Before commencing checks, apply parking brake, raise wheels off ground and support axle on stands.

a) Checking lateral slackness

Whilst this is being carried out the brake must be applied.
 Place a set -square with its stock on ground and its blade against tyre wall.
 Place a mark on ground to indicate position of stock end.
 Insert a lever through bottom cut-out of wheel and lever it upwards thus moving set-square outboard.
 Mark changed position of stock end.
 Maximum allowable stock displacement is given as follows:-

for 17.5" wheels	=	6mm.
for 19.5" wheels	=	7mm.
for 22.5" wheels	=	8mm.
for 24.0" wheels	=	9mm.

If displacement exceeds stated allowance then need for bush / bearing attention and possible renewal, is in evidence.

b) Checking vertical slackness

This is measured by a dial indicator anchored to axle beam and having its pointer placed vertical against swivel top.
 Place a jack against underside of swivel and, whilst applying a lifting force, observe any movement on indicator dial.
 If vertical movement is evident and it exceeds 0.040" (1.02mm) then re-adjustment of swivel is required by adjusting thickness of bearing adjusting washers.

2.5 Every 6 months, check for movement in ball joints as follows :-



NOTE :-
THIS TEST IS TO BE CARRIED OUT WITH VEHICLE IN LOADED CONDITION,
DO NOT JACK UP VEHICLE

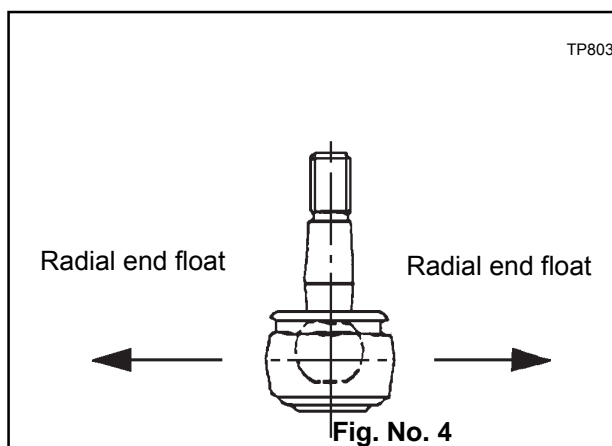
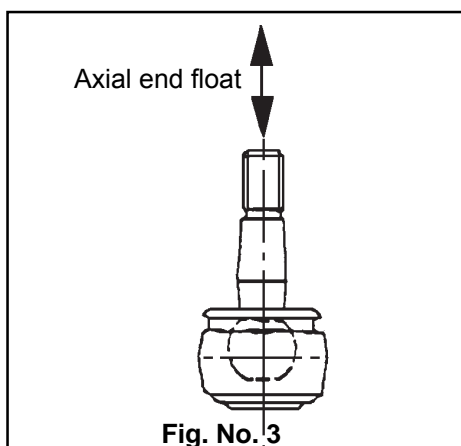
a) Axial end float (axial travel)

End float in direction of axis of ball pin, as shown in fig. no.3 should be within limits of 0.4mm to 2.0mm max. using a test force of 850N.

b) Radial end float (radial travel)

Radial end float at right angles to axis of ball pin as shown in fig. no. 4 should be within limits of 0.4mm to 0.8mm max. using a test force of 6000N.

Replace ball joints if outside limits given in a) and / or b).



SECTION 2 ROUTINE MAINTENANCE Cont.

2.6 Every 6 months inspect ball joints for corrosion as follows :-

**NOTE:-**

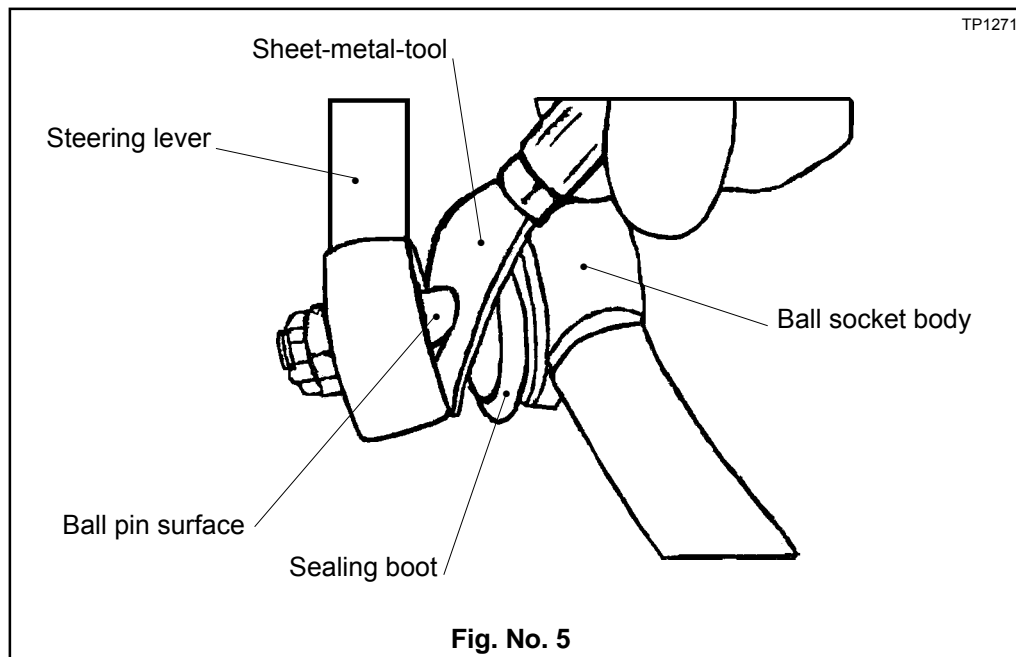
INSPECTION OF BALL JOINTS IS IMPORTANT, ESPECIALLY THOSE IN OLDER VEHICLES. DAMAGED SEALING BOOTS, SALT ON ROADS IN WINTER AND CLIMATIC CONDITIONS CAN CAUSE LOSS OF THE CORROSION PROTECTION COATING APPLIED DURING MANUFACTURE.

Inspection instructions:-

Ensure that ball joint is in an easy access-position.

Carefully clean the sealing boot contact area, to ensure that pollutants cannot get under the sealing boot during the following inspection procedure.

Use an appropriate inspection sheet-metal-tool, eg. spatula with cut out, (fig. no.5) to push up the sealing boot (without damaging it) until ball pin surface is visible. Degrease the ball pin surface.



If there is corrosion of the ball pin or the sealing boot has deteriorated through ageing or is damaged, replace the ball joint in question, or the complete tie rod or drag link as appropriate.

If there is corrosion of the steering lever area which is in contact with the sealing boot, clean and eliminate all surface irregularities.

If there is no corrosion or damage to the sealing boot, smear the steering lever surface with Lithium grease and push the sealing boot back into its properly seated position.

When dismantling tie rods, drag links or drop arms ensure that no damage is caused to the sealing boots or ball joint housings.

SECTION 3 CARE OF WHEELS AND FIXING FACES (ALL AXLES WITH SPIGOT FIXING)

At approximately 100 miles after fitting wheels, wheel nut torque should be checked with wheel ends in " cold " condition (ie not after prolonged braking.).

If any relaxation of original torque (**see specification**) has occurred, re-tighten.

Relaxation of initial torque may occur because of " **Bedding Down**" of hub and wheel surfaces.

**NOTE:-**

TIGHTENING SHOULD NOT BE DONE IMMEDIATELY AFTER PROLONGED BRAKING I.E. WHEN WHEEL ENDS ARE HOT. A RELAXATION OF WHEEL NUT TORQUE DOES OCCUR WHEN WHEEL END IS HOT BUT SHOULD REVERT BACK TO THE ORIGINAL SETTING AS THE WHEEL END COOLS DOWN. RE- TIGHTENING WHEN HOT WILL PRODUCE A HIGHER TORQUE READING WHEN COLD!

Although this single re-tightening after first 100 miles should be sufficient to ensure wheels stay tight, extra checks are recommended within at least the first 1000 miles to check that wheel assembly is stable and that no further relaxation is occurring.

see graphic on following page for correct tightening sequence of wheel nuts

3.1 Care of wheels :-

Check for **CRACKS** in wheels, especially around the fixing holes, and in studs, nuts and washers. If in doubt **RENEW** .

DO NOT simply re-tighten very loose wheel fixings or wheels which are continually becoming loose. Find out why they are loose and whether any damage has been caused.

Use **TRAINED** personnel and keep **RECORDS** of all attention to wheels and fixings, including which parts were renewed and when.

**NOTE :-**

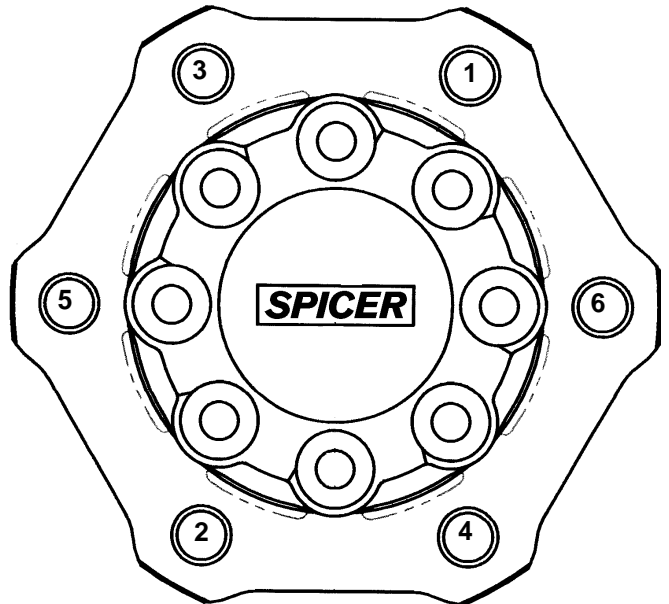
FURTHER DETAILS ARE GIVEN IN BRITISH STANDARD CODE OF PRACTICE FOR THE SELECTION AND CARE OF TYRES AND WHEELS FOR COMMERCIAL VEHICLES:- BSAU50 : PART 2 : SECTION 7A : 1995

3.2 PROTECTION OF SPIGOT WHEEL FIXING DIAMETERS AND PRESSURE SURFACES.

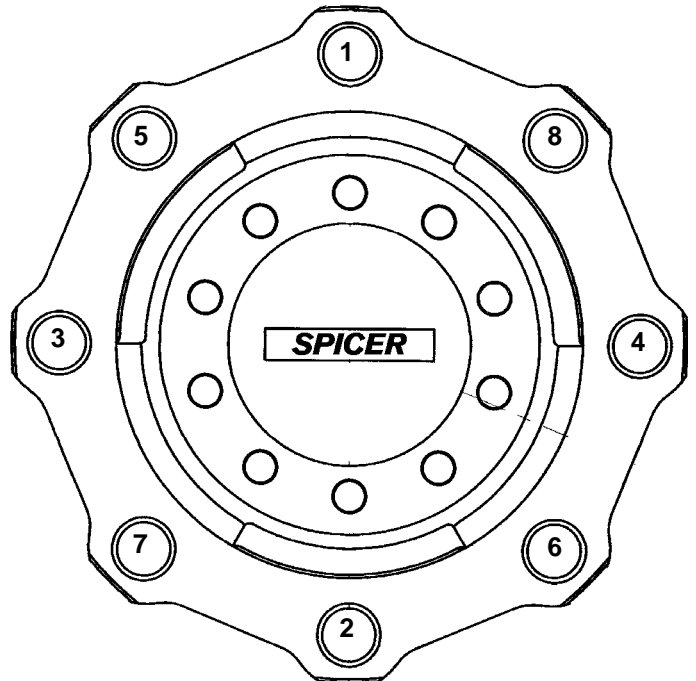
Although **Spicer Speciality Axles Division** apply an initial surface coating to wheel rim mating faces on spigot to stop rusting and facilitate easy removal of wheels. The application of P.B.C. grease such as 'Rocol Tufgear' or equivalent to wheel register is recommended.

The above P.B.C. grease is available from Rocol Ltd., Rocol House, Wakefield Road, Swillington, Leeds, UK. Phone: 44 (113) 2322600. Fax: 44 (113) 2322740.

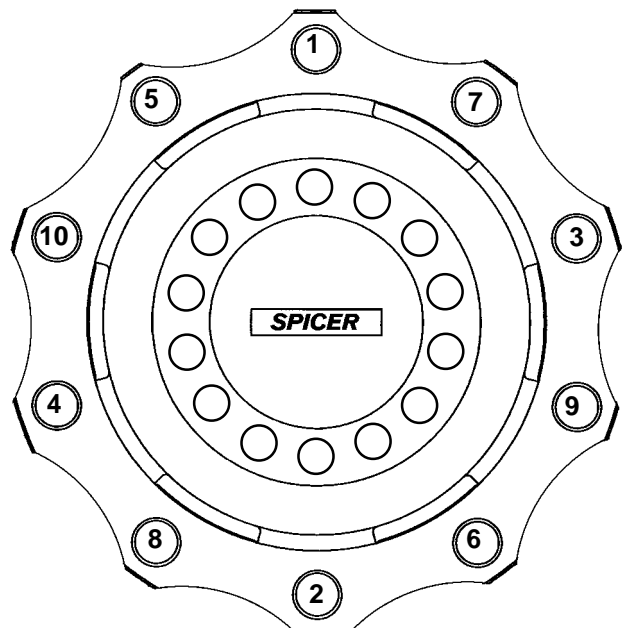
**WHEELNUT TIGHTENING
TORQUE SEQUENCE
6 - STUD FIXING**



**WHEELNUT TIGHTENING
TORQUE SEQUENCE
8 - STUD FIXING**



**WHEELNUT TIGHTENING
TORQUE SEQUENCE
10 - STUD FIXING**



SECTION 4 **Guidance standards for acceptable brake drum crazing (if fitted).**

Every 30000 miles (48000 km) or whenever brake drums are removed for axle maintenance purposes they should be checked for crazing.

Brake drums with crazing in excess of that shown in fig.6 below, and which are of Spicer Speciality axle division manufacture should not be re introduced into service.

Figs.7 & 8 show examples of unacceptable crazing.



fig.6



fig.7



fig.8

EVALUATION OF BRAKE DISC SURFACE

TP1627

Upon removal of brake disc Fig. 9. It's surface should be checked for defects. Inspection should cover both sides of the braking surface as well as the outer diameter of the disc.

Brake disc thickness should be checked in accordance with manufacturers dimensional recommendations.

You should inspect for the following:-

- Heat checking
- Cracks
- Grooves - scoring
- Blue marks - Banding
- Polished discs

Heat checking can be light or heavy,

If **light heat checking** type cracks (fine and light) are found as shown in Fig.10 the disc can continue to be used.

If **heavy heat checking** type cracks (deep and wide) are found the disc **must be replaced.**



Fig. 9



Fig. 10

Cracks can be of 2 types **Radial or Through.**

If any **radial** cracks are found in the brake disc surface as shown in fig. 11. then the disc **must be replaced.**



Fig. 11

If any **Through** cracks are found in the brake disc as shown in fig. 12. then the disc **must be replaced.**



Fig. 12

EVALUATION OF BRAKE DISC SURFACE CONTINUED

Grooving - Scoring can be light or heavy,

If **light** grooving is found as shown in Fig. 13 then the disc can continue to be used.

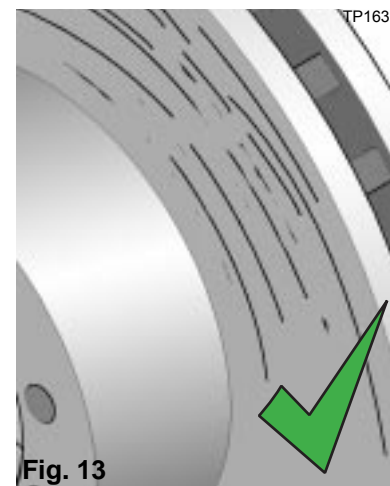


Fig. 13

If **Heavy** grooving is found as shown in Fig. 14 then the disc must be replaced.



Fig. 14

Blue marks - banding indicates that the disc has been exposed to very high temperatures.

If **Blue marks - banding** are found, the reason for the high temperatures must be investigated and corrected.

Refer to the Brake manufacturer for details.

if left uncorrected the formation of heavy heat checking / cracks will occur.



Fig. 15

Polished discs indicate the use of improper lining material or that the disc has been re-machined to too fine a surface finish.

The **Gloss / polish** should be removed using (80) grit Emery cloth and the brake manufacturer should be contacted for an alternate liner material.

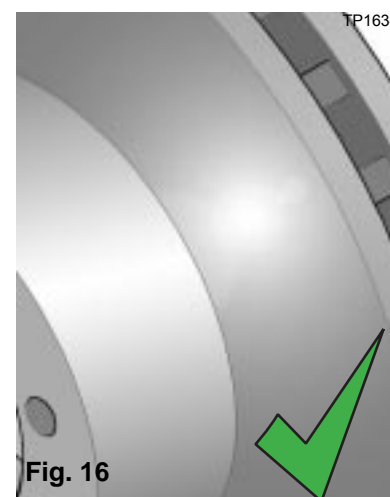


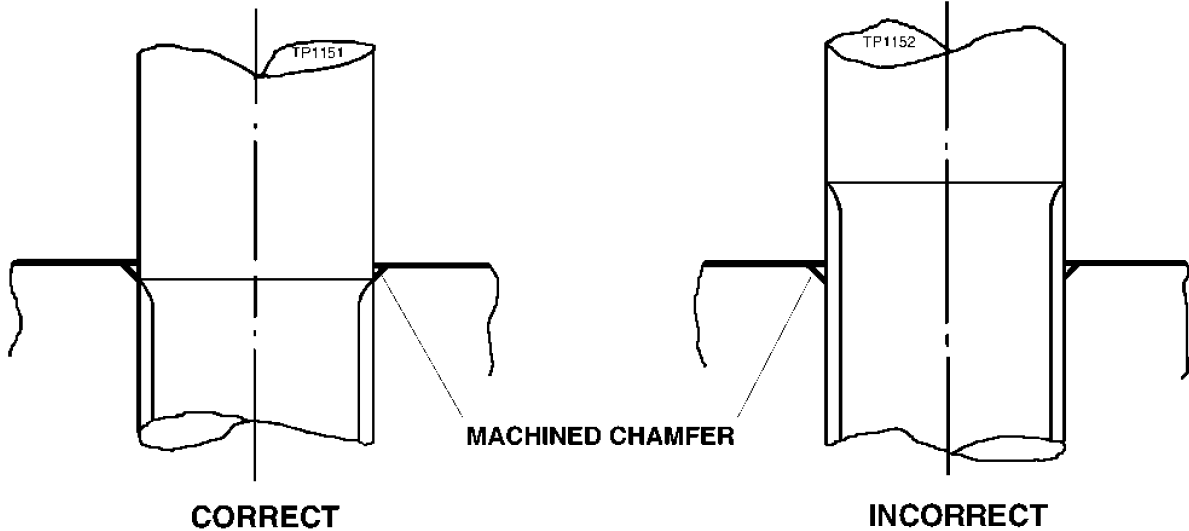
Fig. 16



SPICER SPECIALITY AXLE DIVISION

STANDARD STUDS - FITTED INTO MACHINED CHAMFERED HOLES

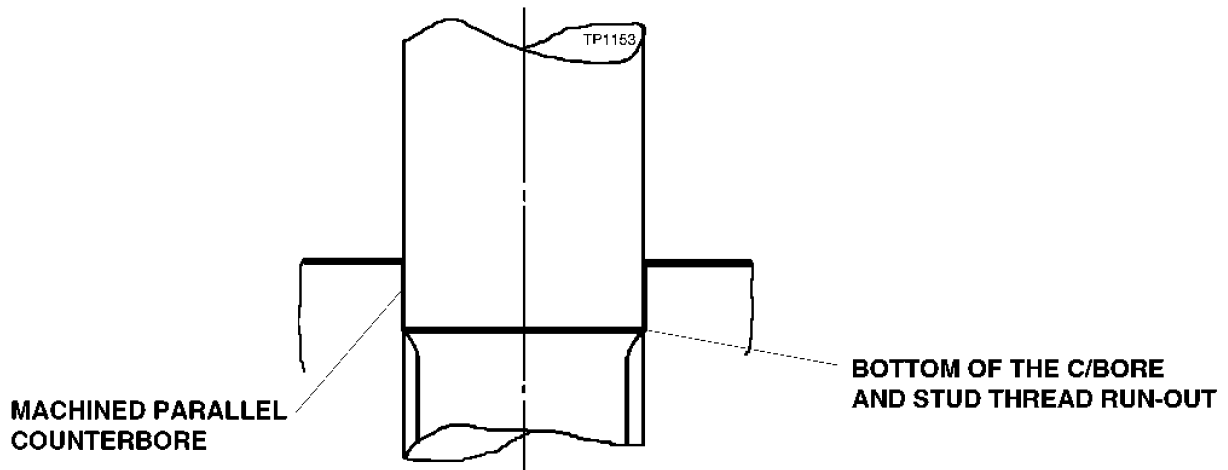
STUDS TO BE INSERTED UNTIL THREAD RUN-OUT LOCKS INTO PARENT METAL



IMPORTANT :- THIS STUD FITTING PROCEDURE IS TO BE USED IN LIEU OF STATED TORQUE VALUES ON EXISTING ARRANGEMENTS. NEW ARRANGEMENTS WILL SPECIFY TD183/1 FROM THE DATE OF ISSUE.

SPECIAL STUDS - FITTED INTO MACHINED PARALLEL COUNTERBORE

STUDS TO BE INSERTED UNTIL CORRECT TORQUE VALUE IS OBTAINED - AS SHOWN ON RELEVANT ARRANGEMENT DRAWING



THIS SPECIFICATION IS FOR STUD FITTING ONLY ; NUTS & SETSCREWS MUST BE TORQUED TO VALUE SPECIFIED

Alteration Numbers

ISSUE A									
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<p>DISTRIBUTION Front Axle B.U. Drive Axle B. U. Production</p>	<p>STUD FITTING PROCEDURES</p>	<p>TD183/1 SHT 1 OF 1</p>
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SWIVEL / AXLE BED TIGHTENING TORQUES

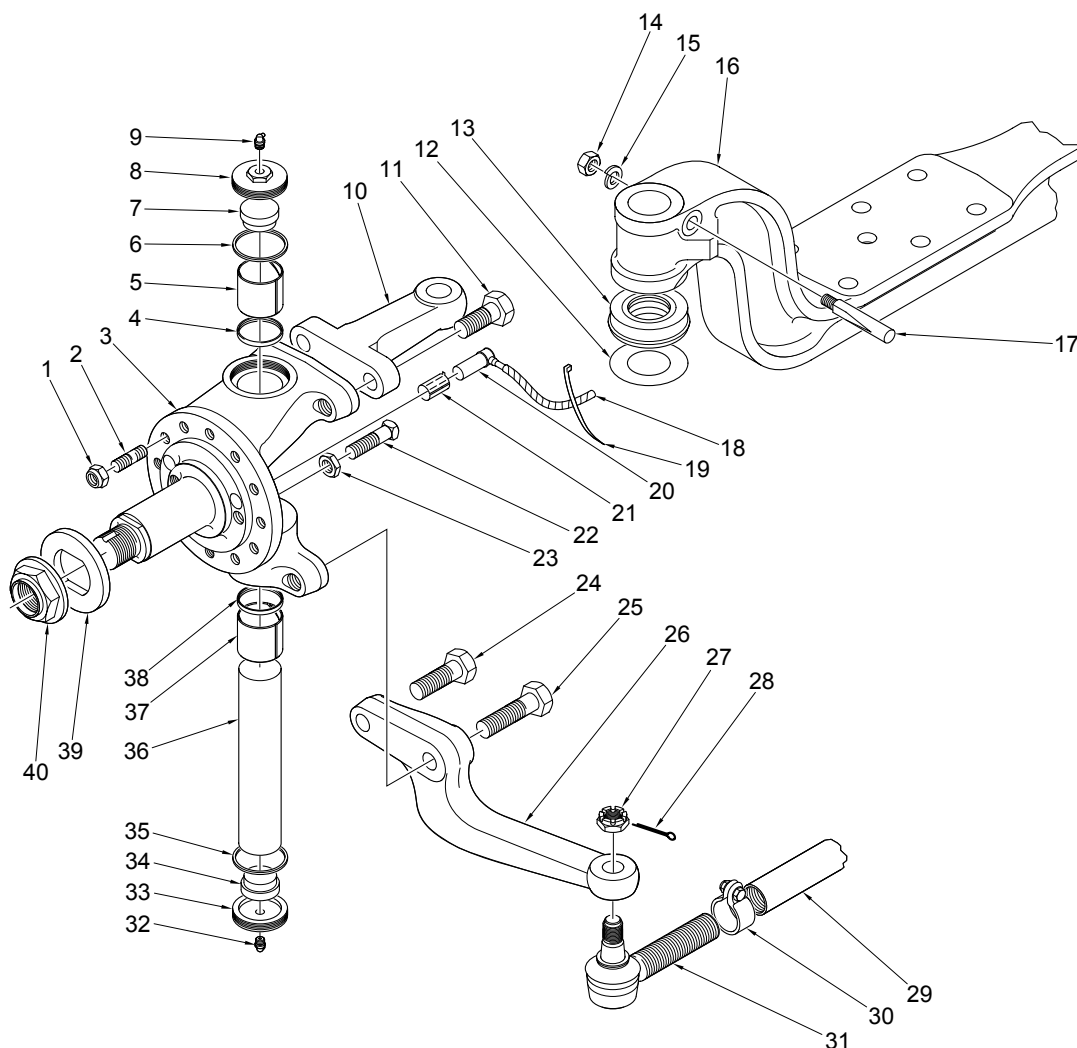


Fig.No.17

PART N° --- DESCRIPTION ----- TIGHTENING TORQUE

1	Brake backplate nut 1/2" UNF	85 - 103 lbs.ft	115 - 140 NM	(All axles)
2	Brake backplate stud 1/2" UNF	See TD 183/1		(All axles)
8	Swivel top cap	25 - 75 lbs.ft	34 - 102 NM	(All axles)
9	Swivel top cap lubricator	10 - 15 lbs.ft	14 - 20 NM	(All axles)
11	Top lever bolts M20 x 2.5 grade 10.9	433 - 479 lbs.ft	587 - 649 NM	(NDS 35/41/56)
	Top lever bolts M20 x 2.5 grade 12.9	520 - 575 lbs.ft	705 - 780NM	(NDS 56)
	Top lever bolts M24 x 3 grade 10.9	751 - 830 lbs.ft	1018 - 1125 NM	(NDS 80)
14	Cotter pin nut 1/2" UNF	51 - 61 lbs.ft	69 - 82 NM	(All axles)
23	Lockstop nut	90 - 120 lbs.ft	122 - 162 NM	(All axles)
24 & 25	Bottom lever bolts M20 x 2.5 grade 10.9	433 - 479 lbs.ft	587 - 649 NM	(NDS 35/41/56)
	Bottom lever bolts M20 x 2.5 grade 12.9	520 - 575 lbs.ft	705 - 780NM	(NDS 80)
	Bottom lever bolts M24 x 3 grade 10.9	751 - 830 lbs.ft	1018 - 1125 NM	(NDS 80)
27	Ball pin nut (F4845T assembly)	155 - 170 lbs.ft	210 - 230 NM	(All axles)
	Ball pin nut (F4109T assembly)	184 - 206 lbs.ft	249 - 279 NM	(All axles)
	Ball pin nut (F4779S assembly)	100 - 170 lbs.ft	135 - 230 NM	(All axles)
	Ball pin nut (F4897S assembly)	190 - 220 lbs.ft	257 - 298 NM	(All axles)
30	Socket pinch bolt (F4845T assembly)	33 - 37 lbs.ft	45 - 50 NM	(All axles)
	Socket pinch bolt (F4109T assembly)	52 - 59 lbs.ft	70 - 80 NM	(All axles)
	Socket pinch bolt (F4779S assembly)	65 - 75 lbs.ft	88 - 102 NM	(All axles)
	Socket pinch bolt (F4897S assembly)	118 - 155 lbs.ft	160 - 210 NM	(All axles)
33	Swivel bottom cap lubricator	10 - 15 lbs.ft	14 - 20 NM	(All axles)
34	Swivel bottom cap	25 - 75 lbs.ft	34 - 102 NM	(All axles)
41	Hub nut	350 - 400 lbs.ft	475 - 542 NM	(NDS 35/41/56)
	Hub nut	575 - 626 lbs.ft	778 - 849 NM	(NDS 80)

SWIVEL / AXLE BED TIGHTENING TORQUES

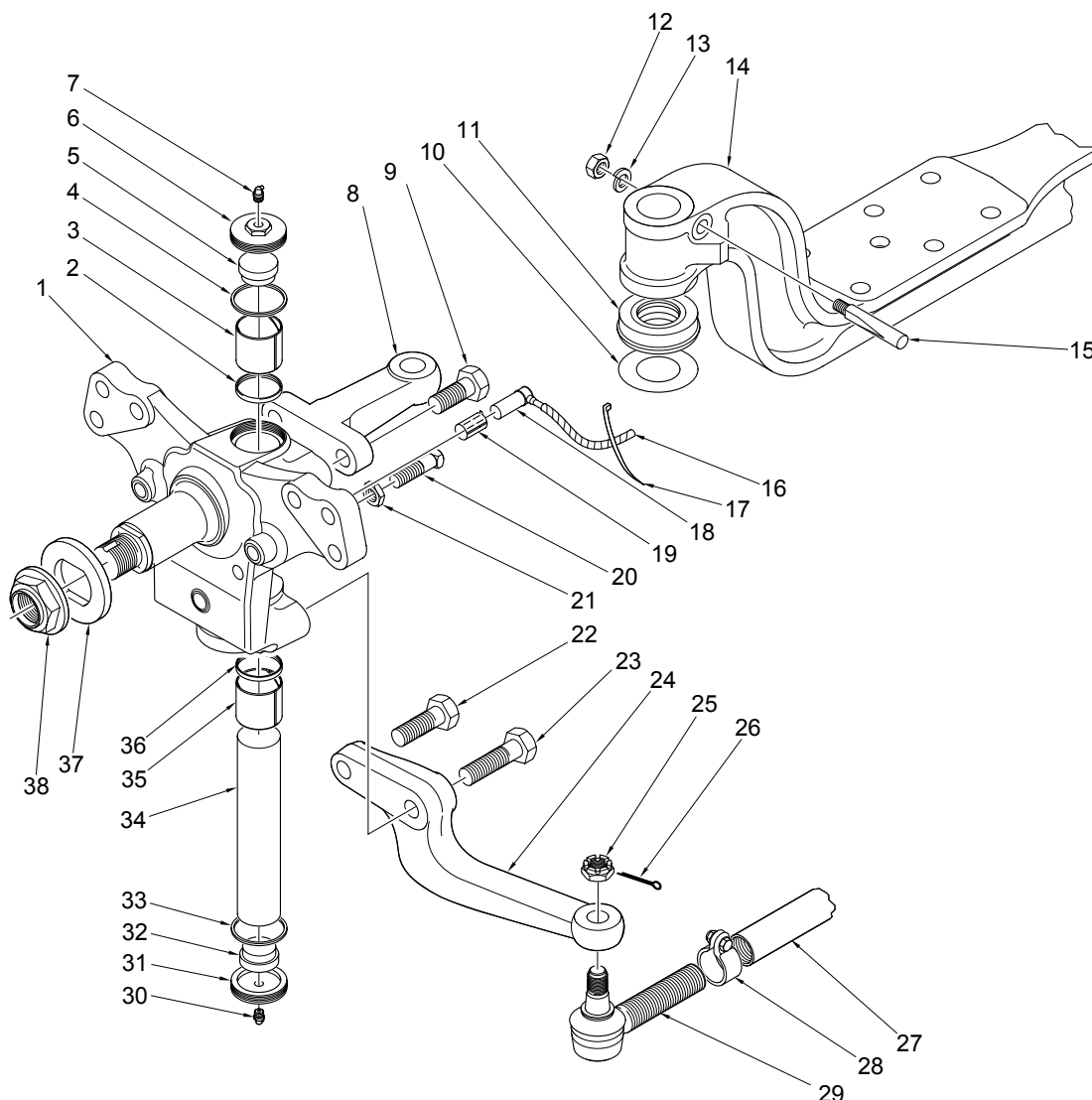


Fig.No.18

PART N° --- DESCRIPTION ----- TIGHTENING TORQUE

6	Swivel top cap	25 - 75 lbs.ft	34 - 102 NM	(All axles)
7	Swivel top cap lubricator	10 - 15 lbs.ft	14 - 20 NM	(All axles)
9	Top lever bolts M20 x 2.5 grade 10.9	433 - 479 lbs.ft	587 - 649 NM	(NDS 35/41/56)
	Top lever bolts M20 x 2.5 grade 12.9	520 - 575 lbs.ft	705 - 780NM	(NDS 56)
	Top lever bolts M24 x 3 grade 10.9	751 - 830 lbs.ft	1018 - 1125 NM	(NDS 80)
12	Cotter pin nut 1/2" UNF	51 - 61 lbs.ft	69 - 82 NM	(All axles)
21	Lockstop nut	90 - 120 lbs.ft	122 - 162 NM	(All axles)
22 & 23	Bottom lever bolts M20 x 2.5 grade 10.9	433 - 479 lbs.ft	587 - 649 NM	(NDS 35/41/56)
	Bottom lever bolts M20 x 2.5 grade 12.9	520 - 575 lbs.ft	705 - 780NM	(NDS 80)
	Bottom lever bolts M24 x 3 grade 10.9	751 - 830 lbs.ft	1018 - 1125 NM	(NDS 80)
25	Ball pin nut (F4845T assembly)	155 - 170 lbs.ft	210 - 230 NM	(All axles)
	Ball pin nut (F4109T assembly)	184 - 206 lbs.ft	249 - 279 NM	(All axles)
	Ball pin nut (F4779S assembly)	100 - 170 lbs.ft	135 - 230 NM	(All axles)
	Ball pin nut (F4897S assembly)	190 - 220 lbs.ft	257 - 298 NM	(All axles)
28	Socket pinch bolt (F4845T assembly)	33 - 37 lbs.ft	45 - 50 NM	(All axles)
	Socket pinch bolt (F4109T assembly)	52 - 59 lbs.ft	70 - 80 NM	(All axles)
	Socket pinch bolt (F4779S assembly)	65 - 75 lbs.ft	88 - 102 NM	(All axles)
	Socket pinch bolt (F4897S assembly)	118 - 155 lbs.ft	160 - 210 NM	(All axles)
30	Swivel bottom cap lubricator	10 - 15 lbs.ft	14 - 20 NM	(All axles)
31	Swivel bottom cap	25 - 75 lbs.ft	34 - 102 NM	(All axles)
38	Hub nut	350 - 400 lbs.ft	475 - 542 NM	(NDS 35/41/56)
	Hub nut	575 - 626 lbs.ft	778 - 849 NM	(NDS 80)

SWIVEL / HUB END TIGHTENING TORQUES

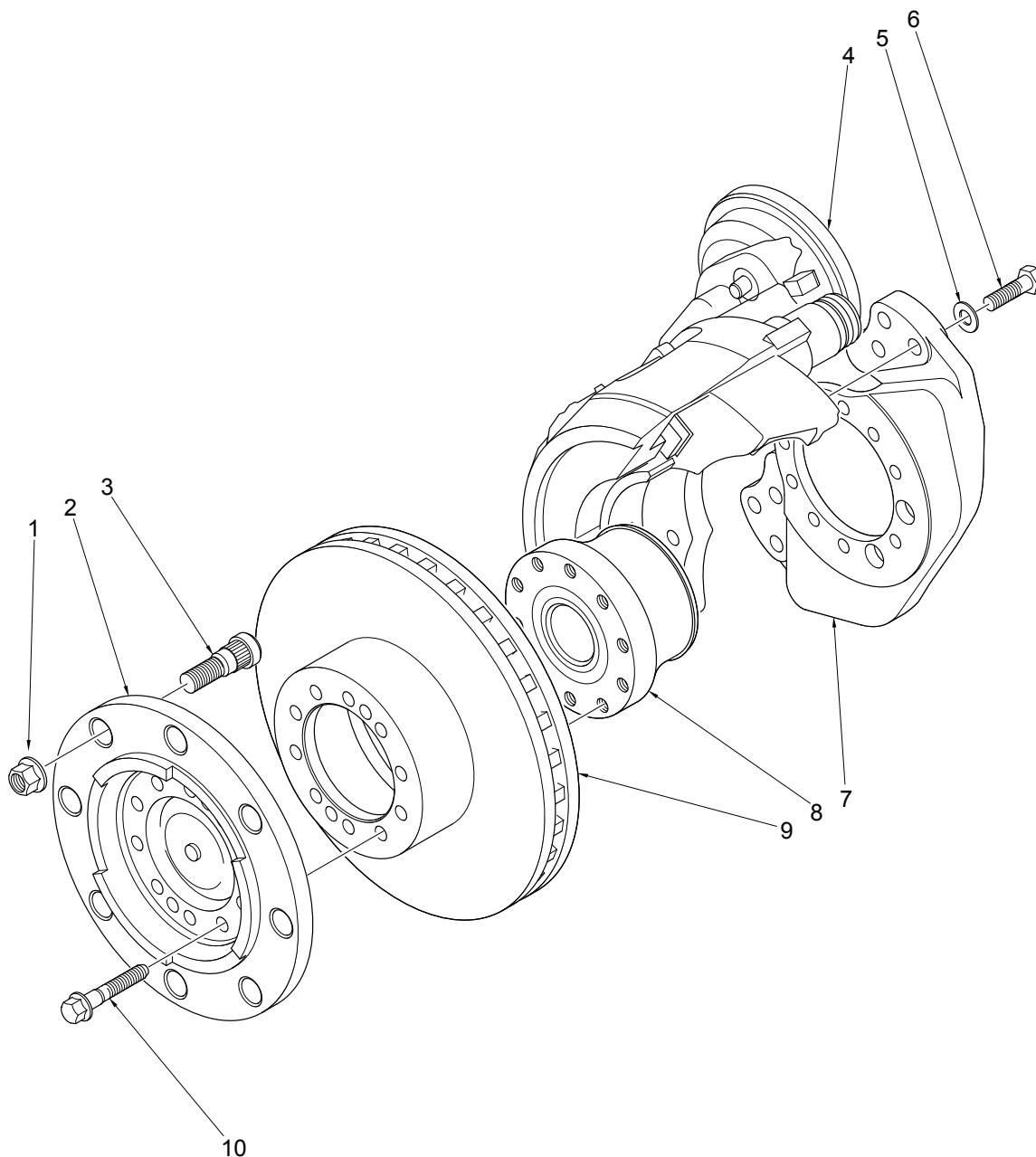


Fig.No.19

PART N°	DESCRIPTION	TIGHTENING TORQUE	
1	Wheel nut M18 x 1.5 -----	235 - 260 lbs.ft	318 - 352NM
	Wheel nut M20 x 1.5 -----	285 - 315 lbs.ft	386 - 427NM
	Wheel nut M22 x 1.5 -----	475 - 525 lbs.ft	644 - 712NM
6	Brake Caliper Mounting Bolt M14 x 1.5 -----	174 - 192 lbs.ft	236 - 260NM
	Brake Caliper Mounting Bolt M16 x 1.5 -----	266 - 294 lbs.ft	360 - 399NM
	Brake Caliper Mounting Bolt M18 x 1.5 -----	372 - 412 lbs.ft	504 - 559NM
	Brake Caliper Mounting Bolt M20 x 1.5 -----	520 - 574 lbs.ft	705 - 778NM
4	Brake air cylinder retaining nuts M16 X 1.5 -----	133 - 155 lbs.ft	180 - 210NM
10	Hub flange retaining bolt M14 x 1.5 -----	174 - 192 lbs.ft	236 - 260NM

SWIVEL / HUB END TIGHTENING TORQUES

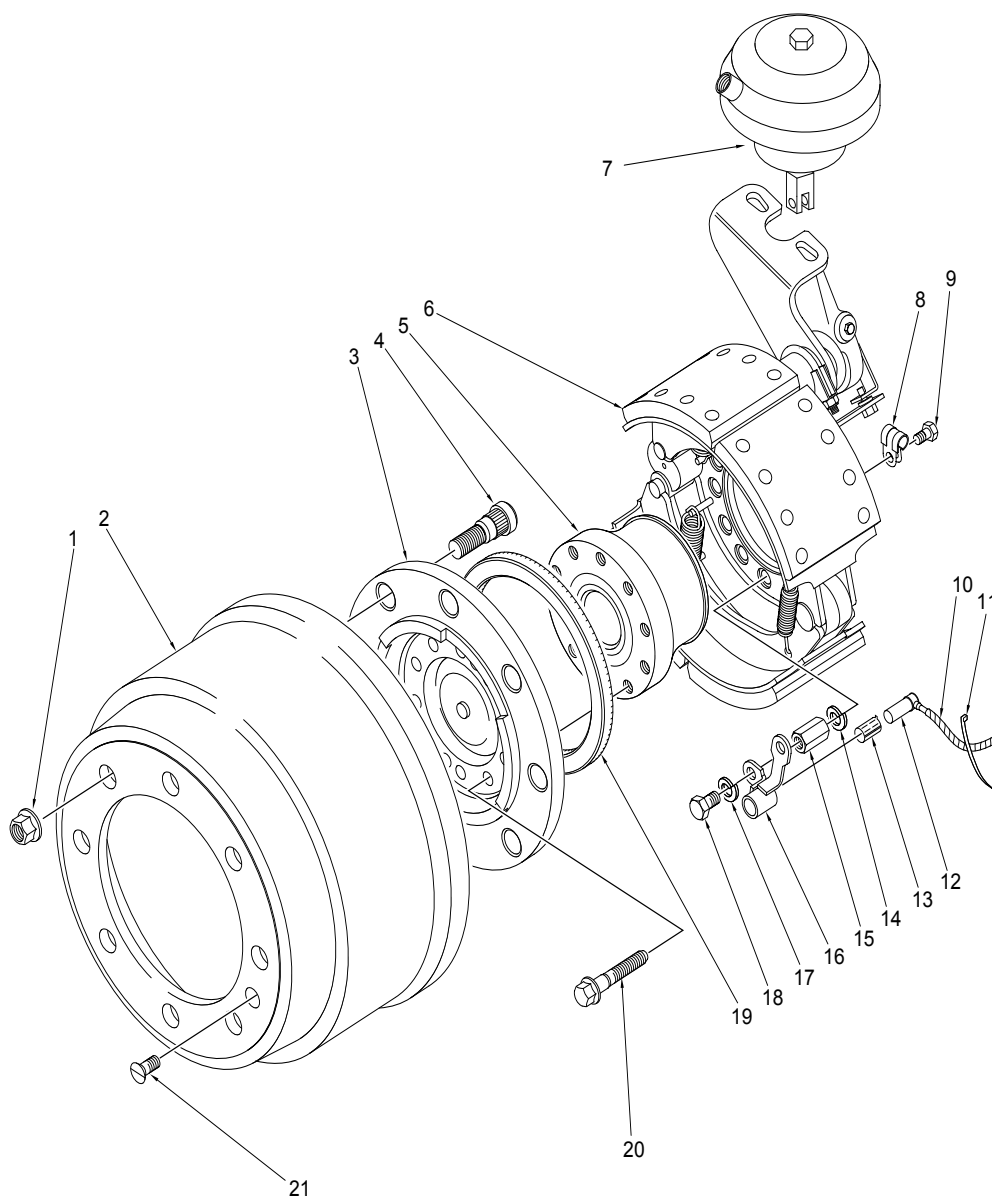


Fig.No.20

PART N°	DESCRIPTION	TIGHTENING TORQUE	
1	Wheel nut M18 x 1.5 -----	235 - 260 lbs.ft	318 - 352NM
	Wheel nut M20 x 1.5 -----	285 - 315 lbs.ft	386 - 427NM
	Wheel nut M22 x 1.5 -----	475 - 525 lbs.ft	644 - 712NM
8	Hub flange retaining bolt M14 x 1.5-----	174 - 192 lbs.ft	236 - 260NM
9	Brake drum retaining screw -----	26 - 32 lbs.ft	35 - 43NM

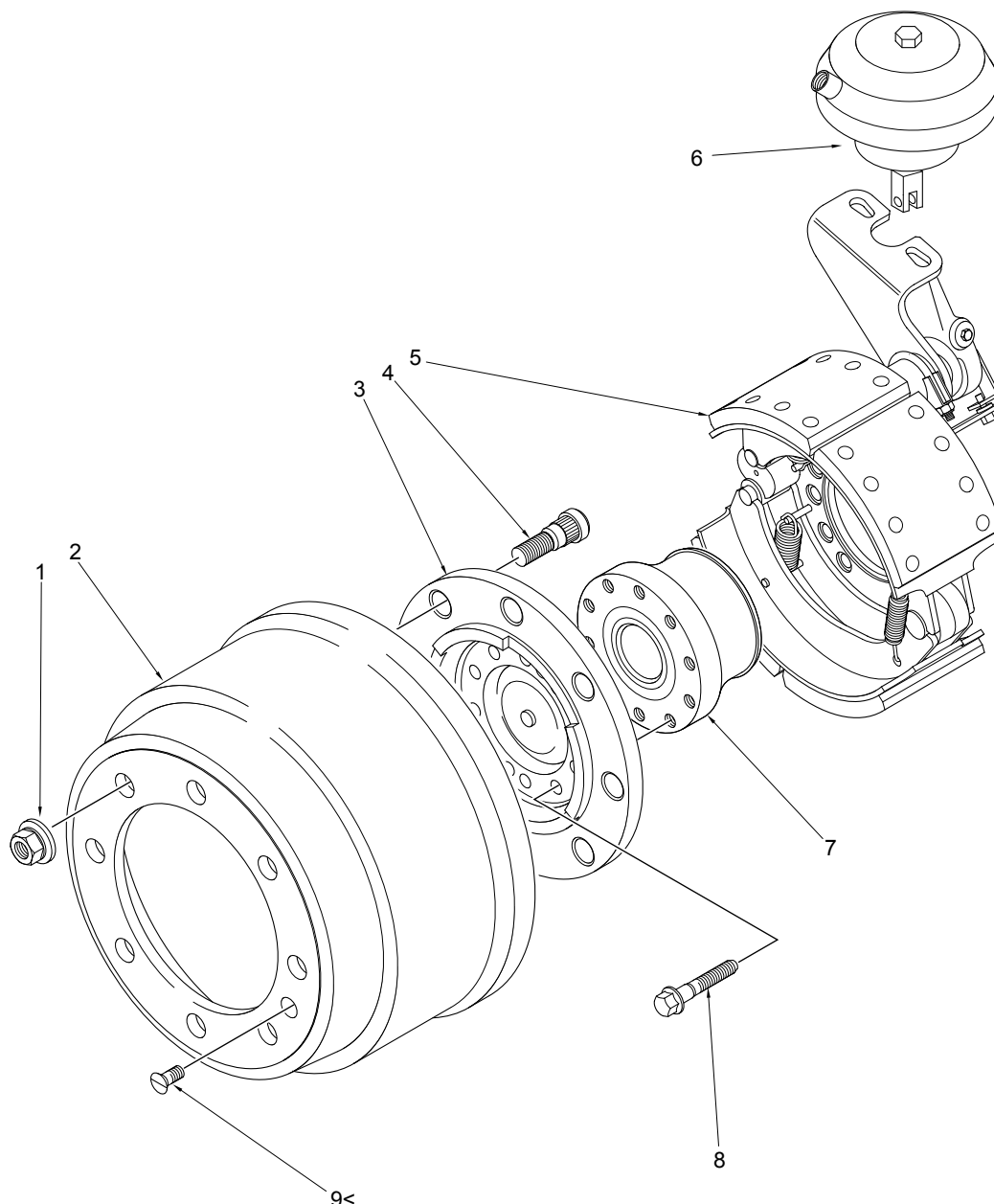


Fig.No.21

PART N°	DESCRIPTION	TIGHTENING TORQUE	
1	Wheel nut M18 x 1.5 -----	235 - 260 lbs.ft	318 - 352NM
	Wheel nut M20 x 1.5 -----	285 - 315 lbs.ft	386 - 427NM
	Wheel nut M22 x 1.5 -----	475 - 525 lbs.ft	644 - 712NM
20	Hub flange retaining bolt M14 x 1.5 -----	174 - 192 lbs.ft	236 - 260NM
21	Brake drum retaining screw -----	26 - 32 lbs.ft	35 - 43NM

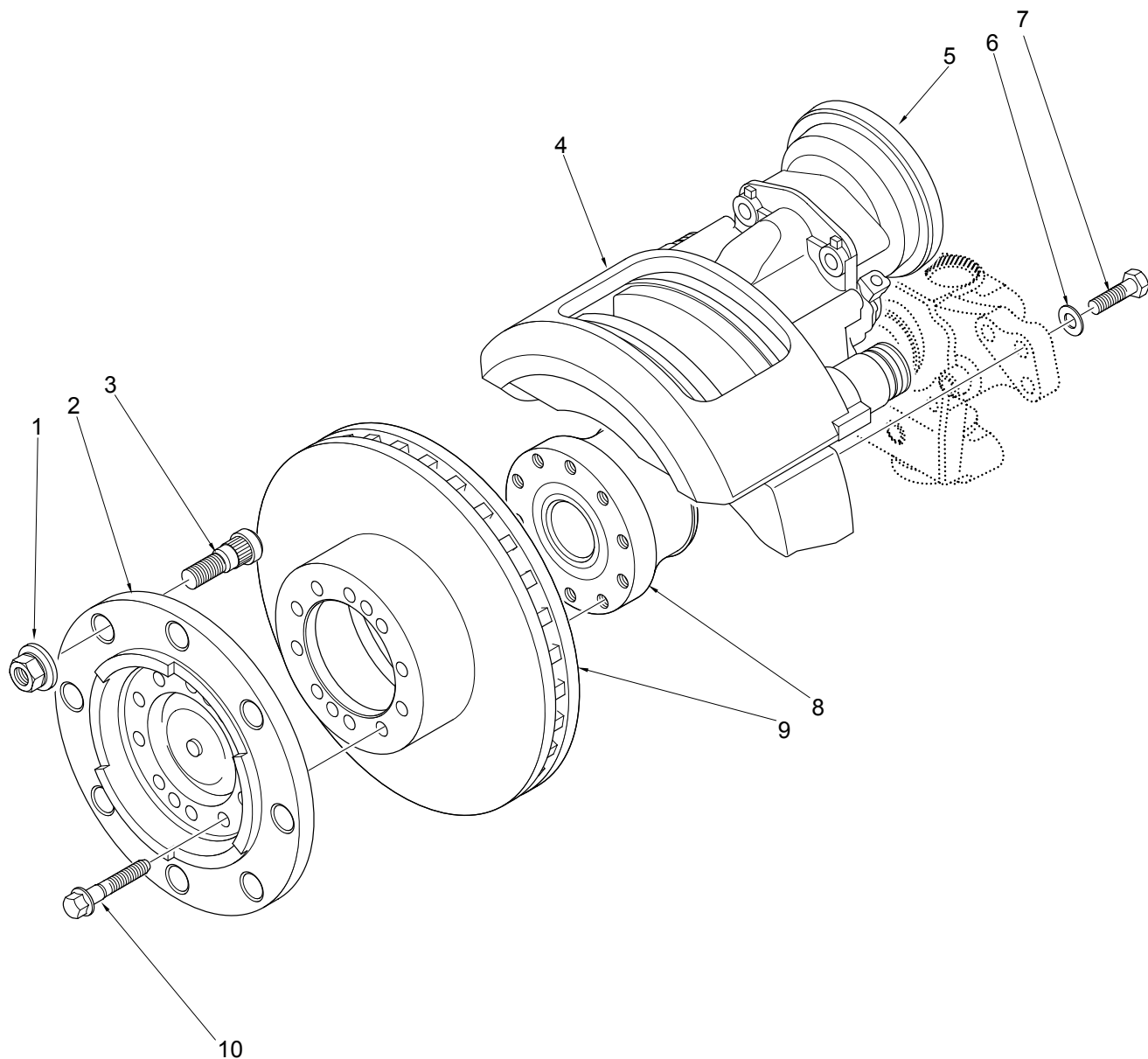


Fig.No.22

PART N ^o	DESCRIPTION	TIGHTENING TORQUE	
1	Wheel nut M18 x 1.5-----	235 - 260 lbs.ft	318 - 352NM
	Wheel nut M20 x 1.5-----	285 - 315 lbs.ft	386 - 427NM
	Wheel nut M22 x 1.5-----	475 - 525 lbs.ft	644 - 712NM
5	Brake air cylinder retaining nuts M16 X 1.5-----	133 - 155 lbs.ft	180 - 210NM
6	Brake Caliper Mounting Bolt M14 x 1.5-----	174 - 192 lbs.ft	236 - 260NM
	Brake Caliper Mounting Bolt M16 x 1.5-----	266 - 294 lbs.ft	360 - 399NM
	Brake Caliper Mounting Bolt M18 x 1.5-----	372 - 412 lbs.ft	504 - 559NM
	Brake Caliper Mounting Bolt M20 x 1.5-----	520 - 574 lbs.ft	705 - 778NM
10	Hub flange retaining bolt M14 x 1.5-----	174 - 192 lbs.ft	236 - 260NM

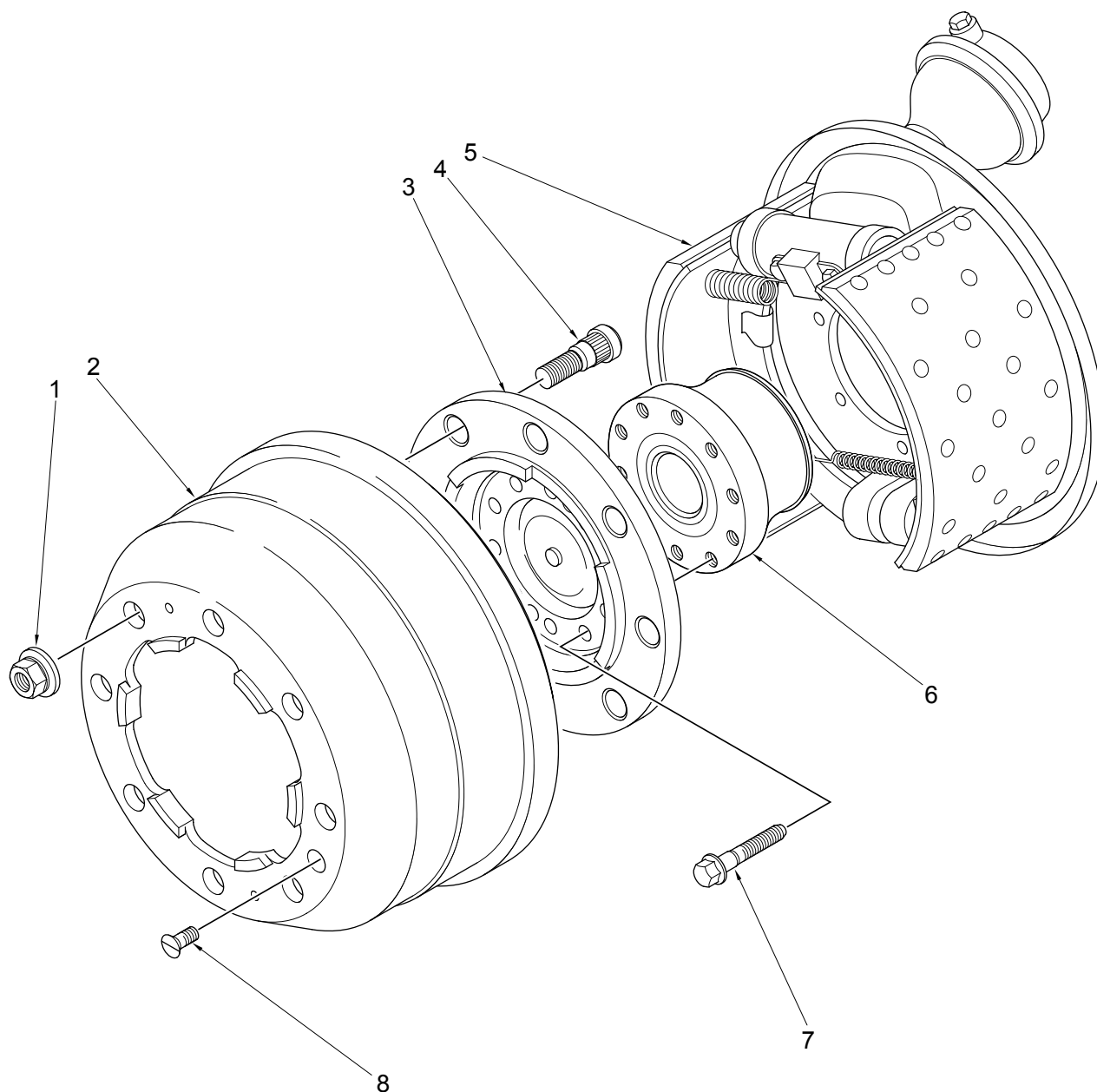


Fig.No.23

PART N°	DESCRIPTION	TIGHTENING TORQUE	
1	Wheel nut M18 x 1.5-----	235 - 260 lbs.ft	318 - 352NM
	Wheel nut M20 x 1.5-----	285 - 315 lbs.ft	386 - 427NM
	Wheel nut M22 x 1.5-----	475 - 525 lbs.ft	644 - 712NM
7	Hub flange retaining bolt M14 x 1.5-----	174 - 192 lbs.ft	236 - 260NM
8	Brake drum retaining screw-----	26 - 32 lbs.ft	35 - 43NM

APPLICATION POLICY

Capability ratings, features and specifications vary depending upon the model type of service. Applications approvals must be obtained from Spicer Speciality Axle Division. We reserve the right to change or modify our product specifications, configurations, or dimensions at any time without notice.



SPICER SPECIALITY AXLE DIVISION

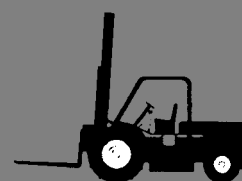
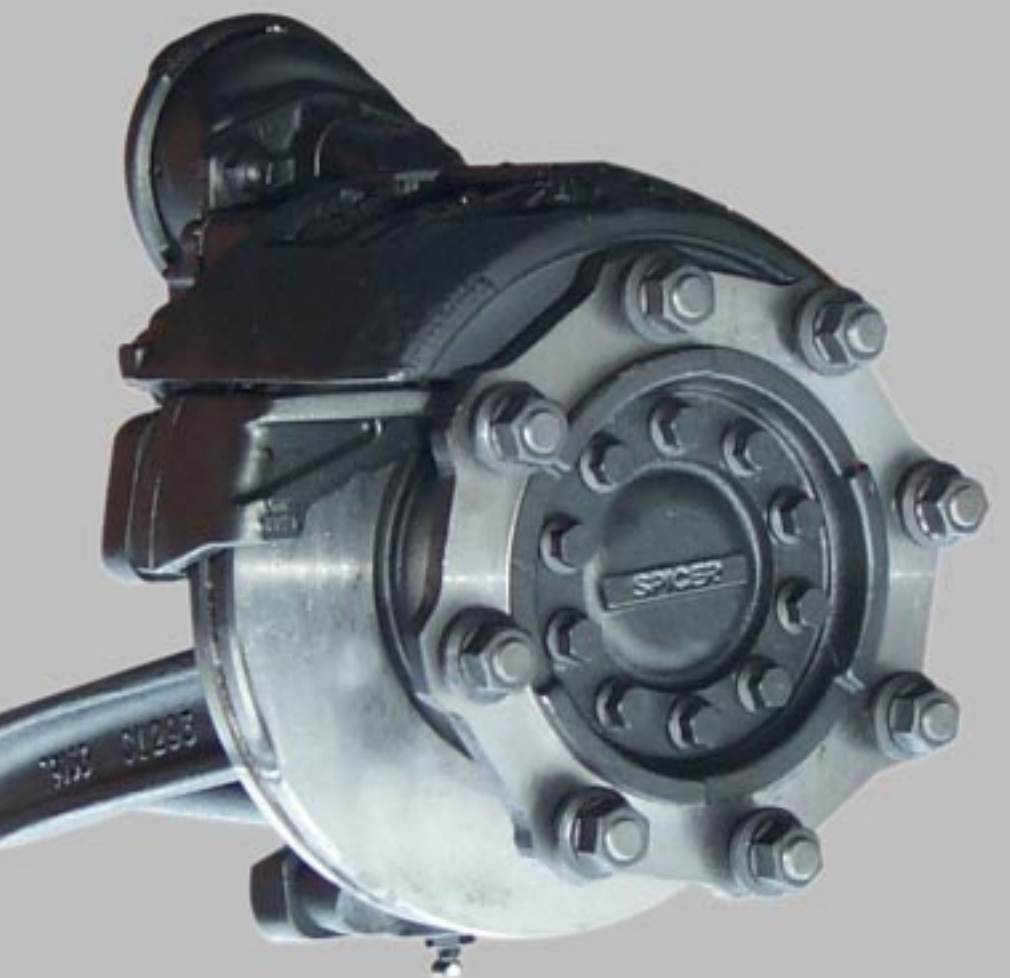
Abbey Road, Kirkstall

Leeds LS5 3NF

England

Tel: (113) 2584611 Fax: (113) 2586097

Maintenance manual
Model NDS
Hub and brake assembly
With Knorr Bremse
Disc brake
Fitted to offset barrel swivel



SPICER SPECIALITY AXLE DIVISION



MANUAL ISSUE SHEET

Page No.	Issue	Description / Alteration	Reason	Date
All 11 7	A B C	New Manual Page added all subsequent pages re numbered Optimol Paste Added	Brake disc checking added To prevent fretting ECN 8695	Mar.2000 Oct.2000 Aug.2002

OVERHAUL PROCEDURES

PREPARATION

Prepare for axle overhaul as follows:

1. Set parking brake and block drive wheels to prevent vehicle movement.
2. Raise vehicle until tyres are off the ground. support raised vehicle with safety stands.



WARNING!

NEVER WORK UNDER A VEHICLE SUPPORTED ONLY BY A JACK. ALWAYS USE SAFETY STANDS.

HUB END DISASSEMBLY

1. Disconnect brake connections and ABS sensor from vehicle. Fit plugs to connections to prevent dirt ingress.
2. Loosen but do not remove, brake caliper retaining bolts
3. Using suitable lifting equipment, support the brake caliper.
4. Remove brake caliper retaining bolts and remove brake caliper from axle.



WARNING!

BRAKE CALIPER IS HEAVY ENSURE WEIGHT IS FULLY SUPPORTED BEFORE REMOVING RETAINING BOLTS. TAKE CARE TO AVOID CALIPER SWINGING AND TRAPPING FINGERS.

NOTE:-

BRAKE CALIPERS ARE HANDED! SPICER SPECIALITY AXLE DIVISION RECOMMENDS MARKING CALIPERS WITH PAINT OR MARKER PEN TO FACILITATE CORRECT REFITTING

BRAKE AIR CYLINDERS SHOULD ONLY BE REMOVED IF REPLACEMENT OR REPAIR IS REQUIRED.

REFER TO THE BRAKE MANUFACTURERS MANUAL FOR DETAILS OF CALIPER OR AIR CYLINDER SERVICE.



OVERHAUL PROCEDURES

HUB END DISASSEMBLY

5. Loosen but do not remove hub flange bolts.
6. Remove 2 diametrically opposed hub flange bolts.
7. Replace 2 diametrically opposed hub flange bolts with 2 studs (loosely fitted).



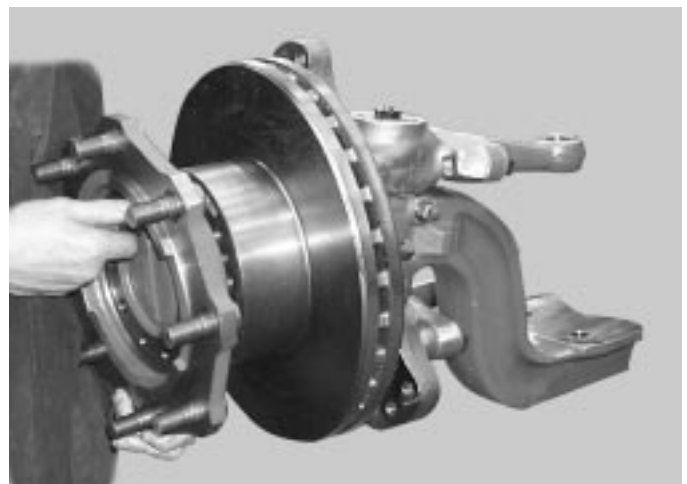
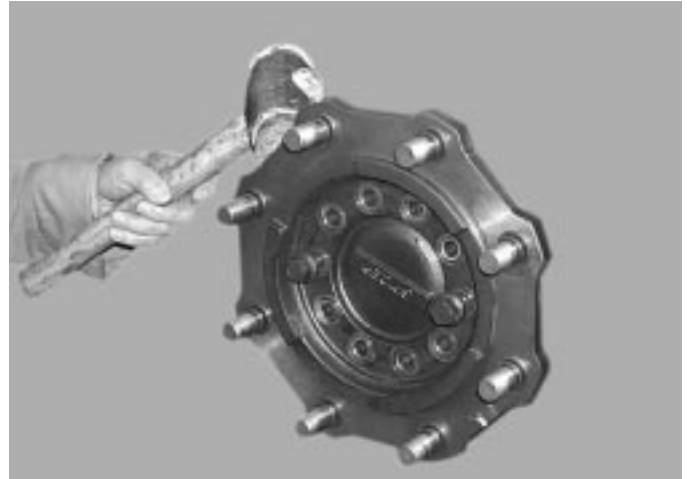
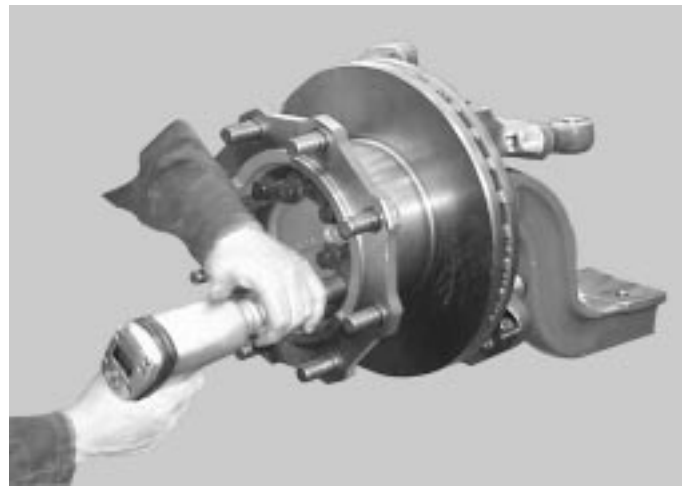
NOTE!
REPLACEMENT STUDS SHOULD PROTRUDE BEYOND FRONT FACE OF HUB FLANGE TO AID REMOVAL

8. Gently tap hub flange outwards using a hide faced hammer.
9. Support weight of hub flange and remove hub flange retaining bolts.
10. Remove hub flange and place on a suitable workbench.



WARNING!
COMPONENT IS HEAVY ENSURE WEIGHT IS FULLY SUPPORTED BEFORE REMOVING RETAINING BOLTS.

11. Inspect wheel studs and remove for replacement, any that are found to be defective.



OVERHAUL PROCEDURES

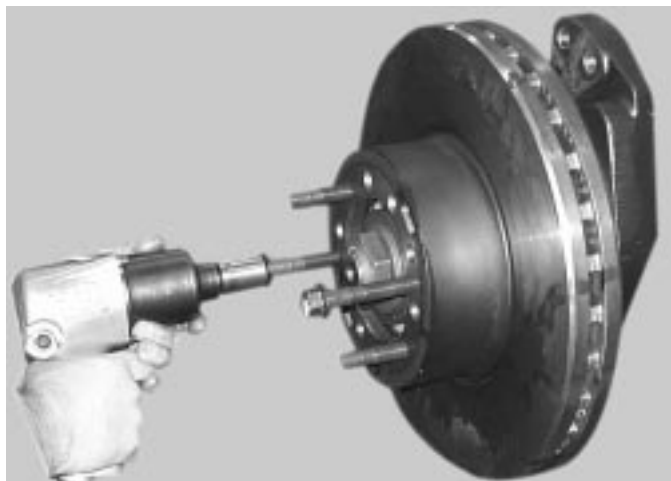
HUB END DISASSEMBLY

- 12. Once hub flange has been removed, insert two bolts into brake disc extraction holes
- 13. Tighten to free brake disc from hub bearing.
- 14. Support weight of brake disc and carefully slide along dummy studs to remove.

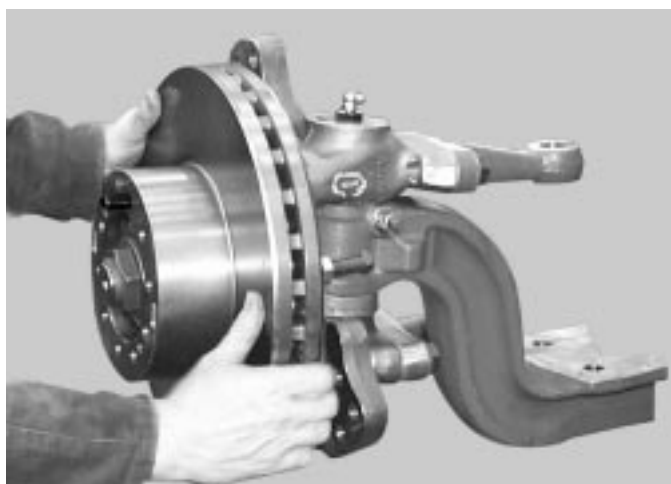


WARNING!
COMPONENT IS HEAVY
ENSURE WEIGHT IS FULLY SUPPORTED
BEFORE REMOVING .

- 15. Place brake disc on a suitable work bench and inspect for cracks and defects, Replace if necessary.
 (See Lubrication and maintenance section for details of typical defects and acceptability)
 Check brake disc thickness is within manufacturers specifications.
 Refer to table below for Acceptable dimensions:



WARNING!
DO NOT ALLOW BRAKE DISC TO WEAR
BELOW MINIMUM THICKNESS!



Brake disc type	Original thickness	Minimum thickness
SB5000	34MM	28MM
SB6000	45MM	37MM
SB7000	45MM	37MM

OVERHAUL PROCEDURES

HUB END DISASSEMBLY

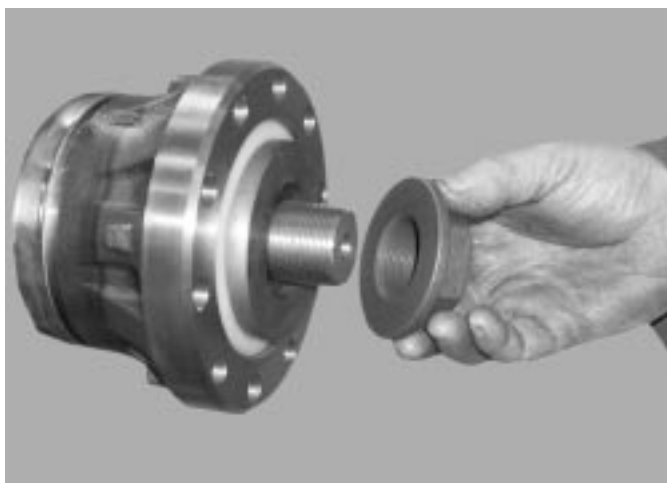
16. Using a small ended chisel, pry off the "staking" on the hub nut.
17. Remove hub nut and discard.
18. Remove bearing thrust washer.
19. Fit bearing guide sleeve onto swivel thread. (See chart at front of swivel assembly)
20. Carefully pull unitised hub bearing assembly towards end of swivel stub and remove.
21. Place on a suitable workbench and inspect for wear / damage, taking care not to damage the ABS exciter ring in the process.



NOTE:-
THE UNITISED BEARINGS USED ON THE NDS RANGE OF AXLES, ARE NON SERVICABLE ITEMS. BEARINGS ARE PRE ADJUSTED, LUBRICATED AND HAVE SEALS FITTED AS PART OF THE MANUFACTURING PROCESS. THE BEARINGS ARE GREASED FOR LIFE AND THERE IS NO NEED OR FACILITY FOR RE-LUBRICATION.

22. Remove ABS sensor and sensor bush inspect for wear / damage and replace if necessary.

 Stripdown remainder of axle as described in swivel assembly removal and refitting instructions.



Place bearing this way up on bench to avoid damaging pole wheel.

OVERHAUL PROCEDURES

HUB END REASSEMBLY

1. Follow instructions contained in swivel / axle bed reassembly section, before attempting to reassemble hub end.
2. Fit Unitised hub bearing guide sleeve onto swivel stub .
(see chart at front of swivel section)
3. Lightly smear the axle stub bearing journal with a thin layer of anti-fretting assembly paste, white i.e Optimol Paste White T (Castrol) or equivalent.
4. Offer new unitised bearing onto swivel stub.



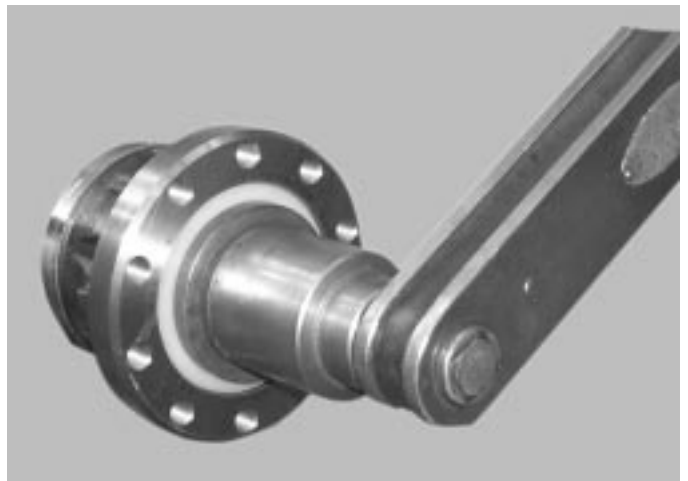
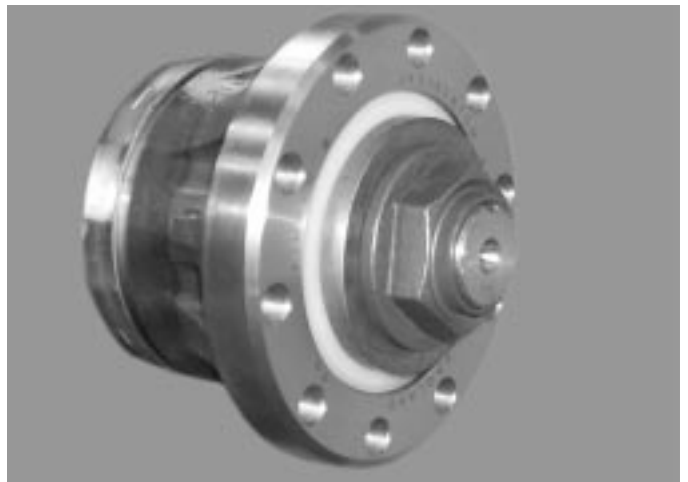
OVERHAUL PROCEDURES

HUB END REASSEMBLY CONTINUED

- 5. Place unitised hub bearing thrust washer onto axle stub.
- 6. Fit hub nut.
- 7. Tighten to specified torque.



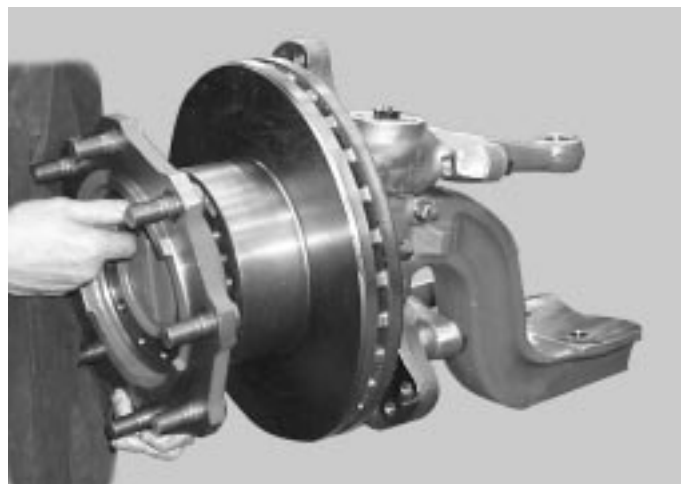
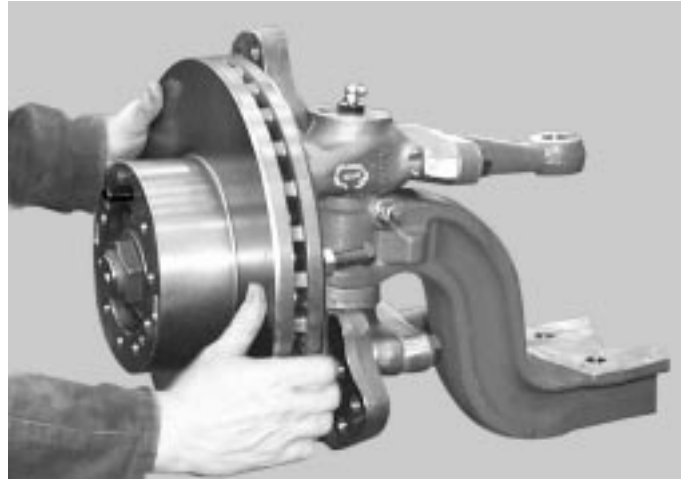
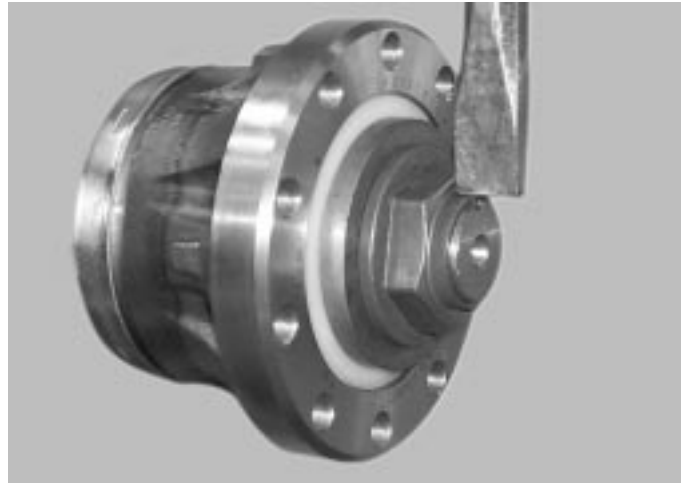
**NOTE:-
ROTATE UNITISED HUB BEARING
WHILST TIGHTENING.**



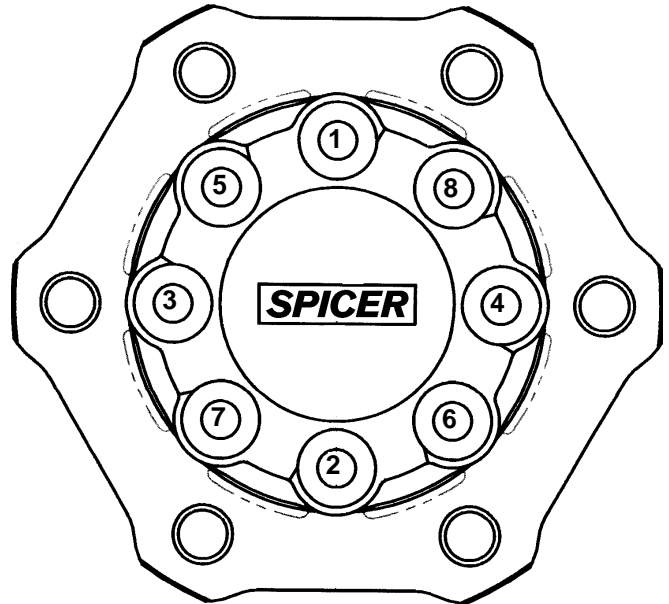
OVERHAUL PROCEDURES

HUB END REASSEMBLY CONTINUED

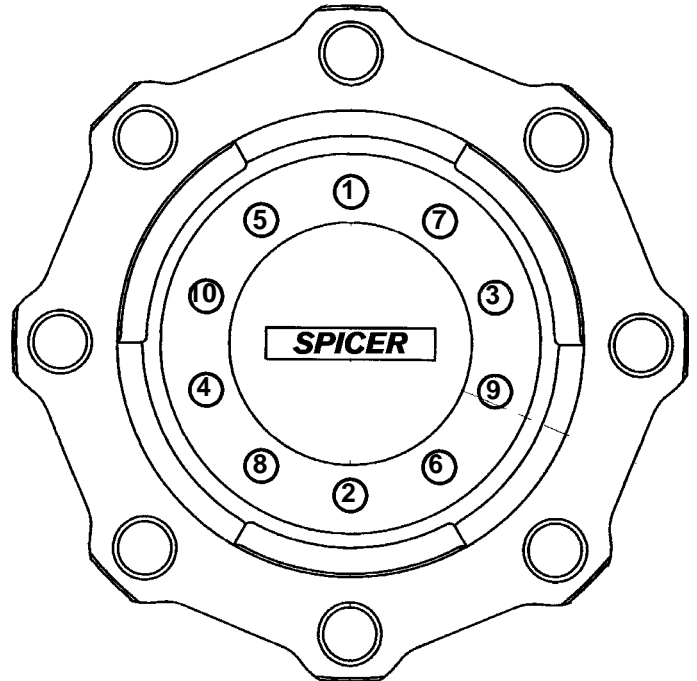
8. Stake the hub nut by deforming with a round nosed chisel.
9. Using a modified hub flange bolt as a guide, carefully position brake disc onto unitised hub bearing.
10. Tap securely home (using a hide faced hammer to avoid damaging the brake disc itself.)
11. Remove the modified hub flange bolt at this point.
12. Carefully offer hub flange up to brake disc / unitised hub bearing assembly and hold in position by inserting 1 - off hub flange bolt and tightening hand tight.
13. Insert remainder of hub flange bolts.
14. Tighten to correct torque using selection procedure as shown on following page.



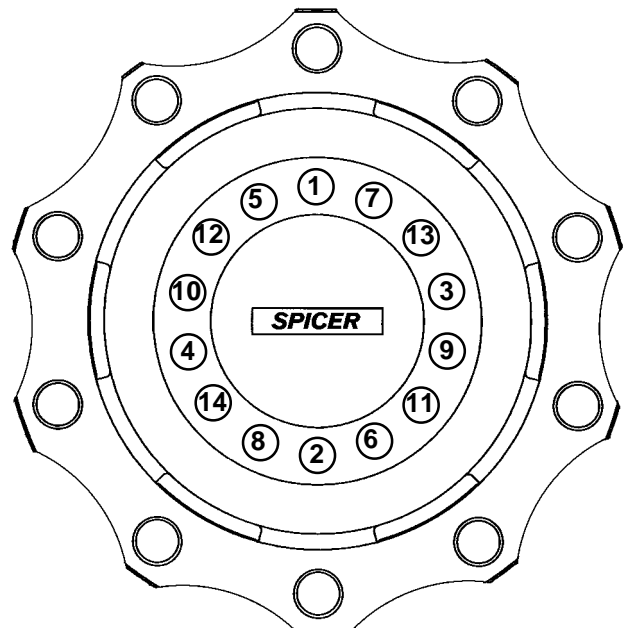
**HUB FLANGE BOLT
TIGHTENING TORQUE SEQUENCE
FOR 8 BOLT FIXING**



**HUB FLANGE BOLT
TIGHTENING TORQUE SEQUENCE
FOR 10 BOLT FIXING**



**HUB FLANGE BOLT
TIGHTENING TORQUE SEQUENCE
FOR 14 BOLT FIXING**



OVERHAUL PROCEDURES**HUB END REASSEMBLY CONTINUED**

15. Once the hub flange has been correctly fitted; it is necessary to check the axial run out of the brake disc.
16. Position a metric dial test indicator onto axle in a suitable position as shown.



**NOTE:-
POSITION MAY VARY DEPENDENT ON
AXLE SPECIFICATION**

17. Position stylus of dial test indicator onto brake disc as shown.
18. Rotate the hub through 360° and note any movement of the dial test indicator.

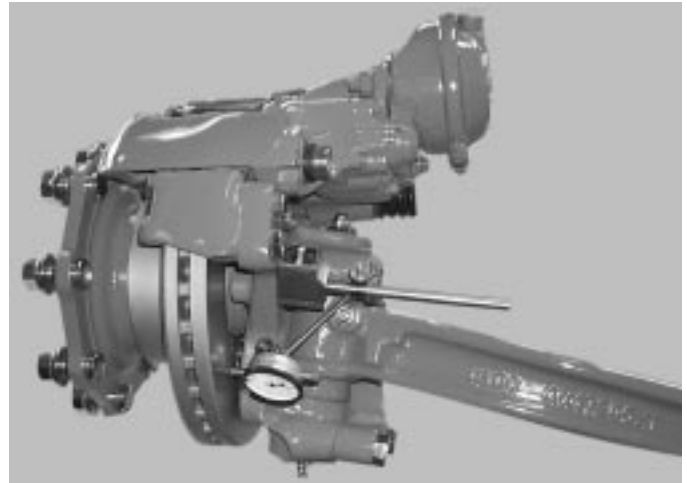


**NOTE:-
MAXIMUM AXIAL RUNOUT IS 0.1mm**

19. Should axial runout exceed 0.1mm. the brake disc is out of specification .
20. Remove and check out of specification disc to ensure no damage has occurred to the mounting faces, or that no dirt is present.
21. Remove any dirt found on the mounting faces and refit and re check disc.

**NOTE:-
DAMAGED DISCS SHOULD BE
REPLACED AS A MATTER OF
COURSE!**

22. Should it be found that a cleaned and refitted disc is still out of specification; it must be replaced.



OVERHAUL PROCEDURES

HUB END REASSEMBLY CONTINUED

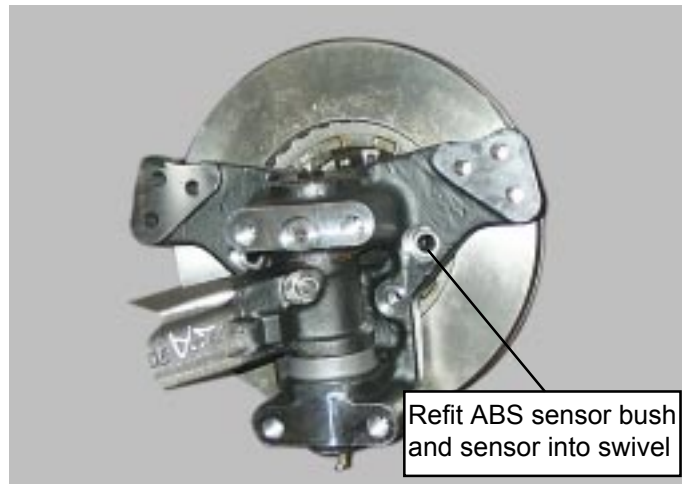
23. Refit ABS sensor bush and sensor into swivel



**NOTE:-
A NEW SENSOR BUSH SHOULD BE
FITTED WHENEVER A NEW SENSOR IS
FITTED.
IF FITTING A NEW SENSOR AND BUSH
INTO AN ABS READY AXLE. SENSOR
AND BUSH SHOULD BE SUPPLIED
FROM THE SAME MANUFACTURER.**

24. Push sensor through bush until it comes into contact with polewheel on hub assembly.
25. Rotate hub bearing assembly through at least one revolution.

**THIS SERVES TO SET THE CORRECT
GAP BETWEEN SENSOR AND
POLEWHEEL.**



OVERHAUL PROCEDURES

HUB END REASSEMBLY CONTINUED

26. Check A.B.S. sensor performance as follows :-

Before commencement of this check It is important that the number of teeth be checked and found to be the correct, on both LH and RH hubs.

- a) Insert the probes from a volt-meter into the two plugs in the sensor connector.
- b) set the voltmeter to read mili-volts AC.
- c) Rotate the hub in any direction at a constant speed of 60Hz (7Kph).
To determine this speed use the following calculation ;

$$\text{RPM} = \frac{60\text{Hz}}{z} \times 60 \text{ secs}$$

where z = the number of teeth on the pole wheel.

Note :- The reading may not be steady due to the possibility of pole wheel run out and the inconsistent speed of the wheel.

- d) The maximum reading (Vmax) must not be more than 80% greater than the minimum reading (Vmin). ie.

$$\frac{V_{\max}}{V_{\min}} \leq 1.8$$

If the following is true then it is likely that there is excessive pole wheel runout. The pole wheel installation will therefore need to be inspected and remounted or replaced.

$$\frac{V_{\max}}{V_{\min}} > 1.8$$

- e) The minimum reading must be greater than the voltage threshold (Vt) ie.

$$V_{\min.} > V_t$$

$$V_t = 60\text{mV}$$

If this is not the case, then the sensor gap is too large or there may be excessive pole wheel runout. The pole wheel will therefore need to be inspected and remounted or replaced.

- f) If sections d) and e) are satisfied, then the installation can be considered as satisfactory.

Note :- The above test procedure is as recommended by A.B.S. manufacturers.

OVERHAUL PROCEDURES

HUB END REASSEMBLY CONTINUED

27. Using suitable lifting equipment, support the brake caliper.



WARNING!
BRAKE CALIPER IS HEAVY.

28. Offer brake caliper up to brake bracket.
(Ensure correct hand of brake caliper is selected)
29. Insert brake caliper retaining bolts and tighten hand tight.
30. Tighten brake caliper bolts to secure assembly.
31. Remove caliper lifting equipment



WARNING!
BRAKE CALIPER IS HEAVY
ENSURE WEIGHT IS FULLY SUPPORTED
BY RETAINING BOLTS BEFORE
REMOVING LIFTING EQUIPMENT.

32. Tighten brake caliper bolts to correct torque.
33. If the brake caliper air chamber has been removed; Refit to caliper and tighten nuts to correct torque.

NOTE!
TAKE CARE NOT TO DAMAGE PAD
WEAR SENSOR CABLE DURING
REASSEMBLY OF CHAMBER TO
CALIPER.



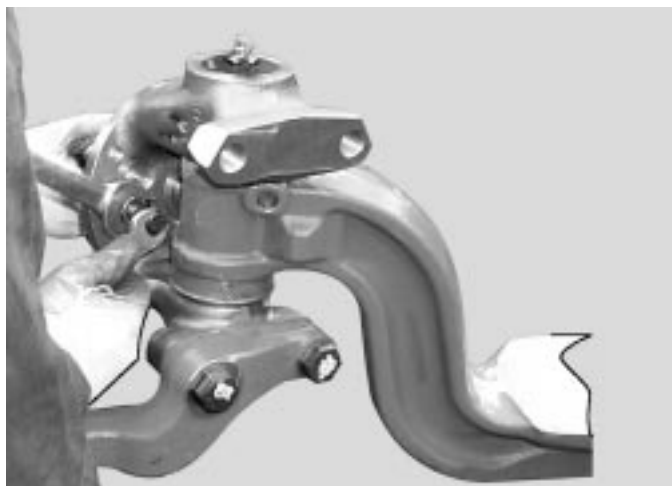
OVERHAUL PROCEDURES

HUB END REASSEMBLY CONTINUED

- 34. Refit lockstop screws and adjusting nuts
- 35. Reset lockstop screws to achieve correct lock angles as shown on installation drawing or vehicle manufacturers specifications.

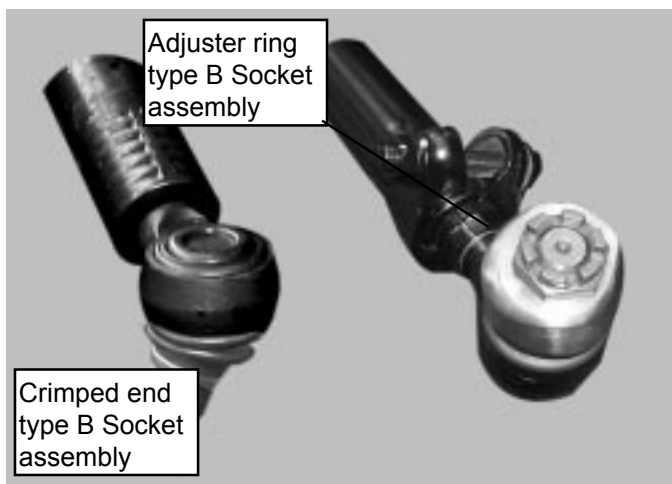
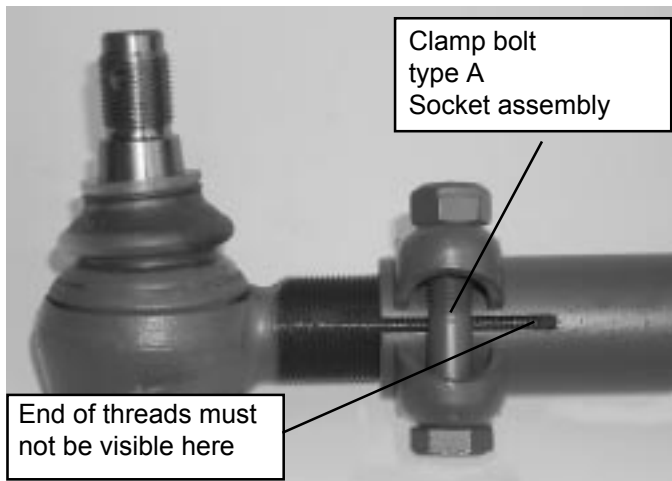


**NOTE:-
DO NOT ALLOW LOCKSTOP THREADS
TO PROTRUDE THROUGH FRONT FACE
OF SWIVEL.**

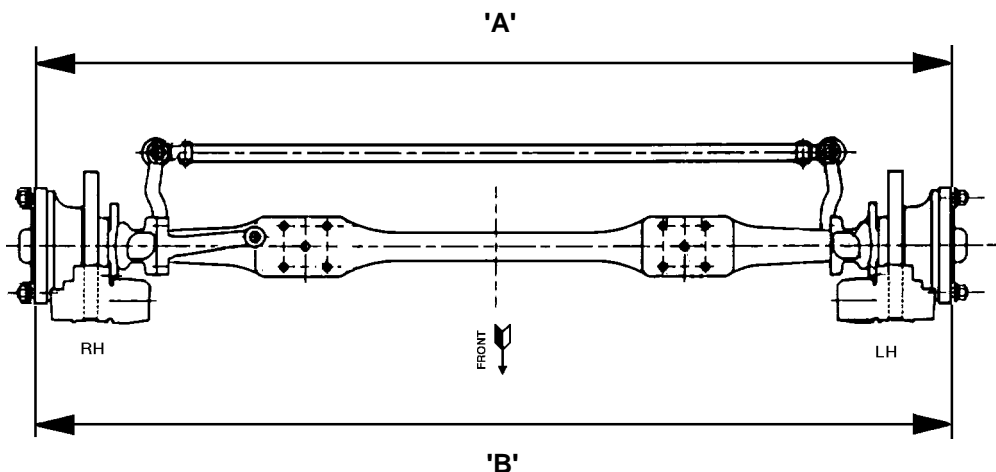


36. Check wheel alignment as follows :-

- a) Set axle in straight ahead position.
- b) At a point level with wheel centre, measure distance over hubs / wheel rims, both in front and behind axle centre.
- c) Front measurement 'B' should be 0.0" to 0.04" (0.0 to 1mm) **LESS** than rear measurement 'A'.
- d) Any adjustment on type A socket and tie rod assemblies can be effected by slackening clamp bolts in ball sockets and rotating track rod tube. For type B socket and tie rod assemblies, slacken the clamped end of the assembly and use the adjuster ring.
- e) After adjustment, tighten clamp bolts to specified torque.



**NOTE:-
WHEN ADJUSTING TYPE A TIE RODS,
ENSURE SOCKET THREADS ARE
EQUALLY POSITIONED IN EACH END OF
THE TIE ROD AND THAT THE END OF
THE SOCKET THREAD IS NOT VISIBLE
THROUGH THE SAWCUT**



OVERHAUL PROCEDURES

HUB END REASSEMBLY CONTINUED

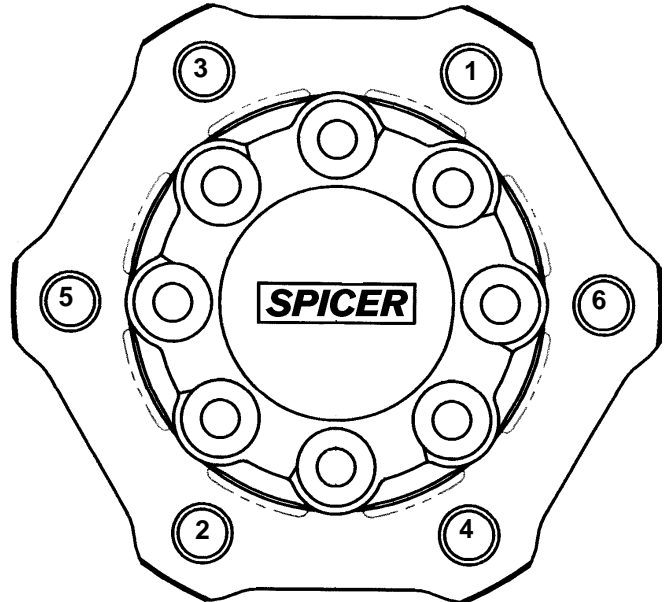
37. Re-connect brake to vehicle hydraulic system as recommended in brake manufacturer's manual.
38. Clean interfaces of wheelnuts, wheel rim & hub then re-fit road wheels securing with wheel nuts and tighten in correct sequence (as shown on following page) to specified torque.



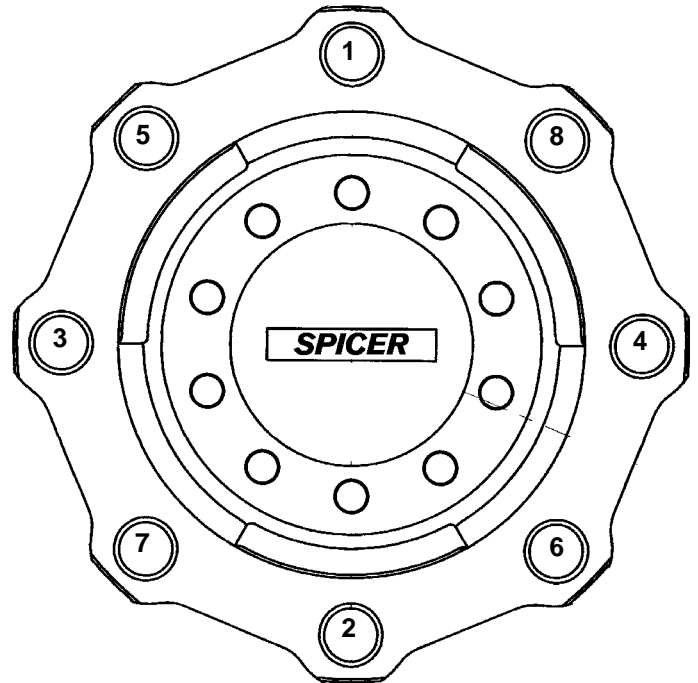
**NOTE:-
INTERFACES MUST BE FREE FROM
DIRT, INCLUDING BRAKE LINER
MATERIAL DEBRIS, RUST AND PAINT.
FAILURE TO KEEP INTERFACES
CLEAN CAN AND WILL CAUSE WHEEL
RIM TO DISTORT UPON TIGHTENING
OF WHEEL NUTS
FOR FURTHER DETAILS SEE
BS AU50 : part 2 : section 7A : 1995**

39. Remove axle supports and lower vehicle to ground.

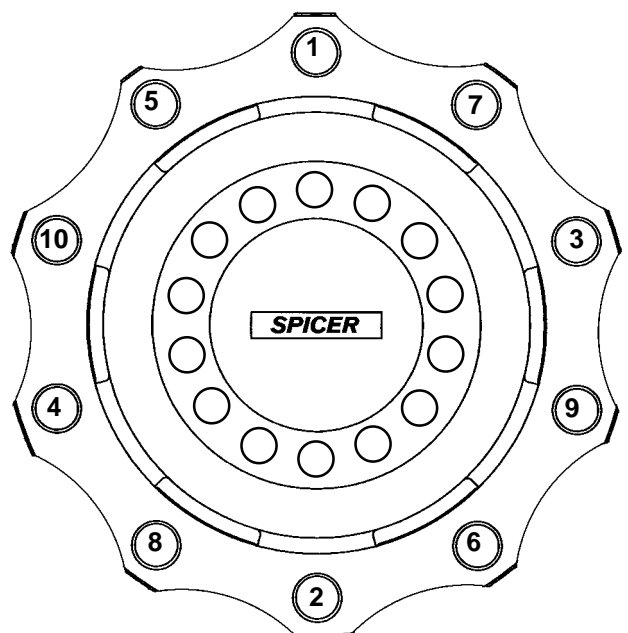
**WHEELNUT TIGHTENING
TORQUE SEQUENCE
FOR 6 STUD FIXING**



**WHEELNUT TIGHTENING
TORQUE SEQUENCE
FOR 8 STUD FIXING**



**WHEELNUT TIGHTENING
TORQUE SEQUENCE
FOR 10 STUD FIXING**



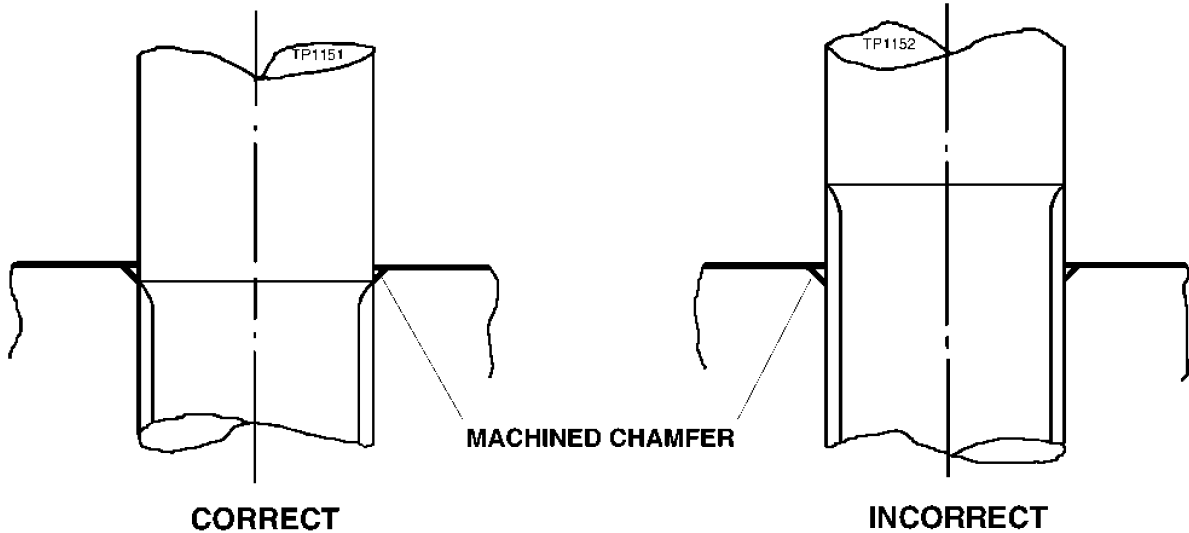


SPICER SPECIALITY AXLE DIVISION

TP1193

STANDARD STUDS - FITTED INTO MACHINED CHAMFERED HOLES

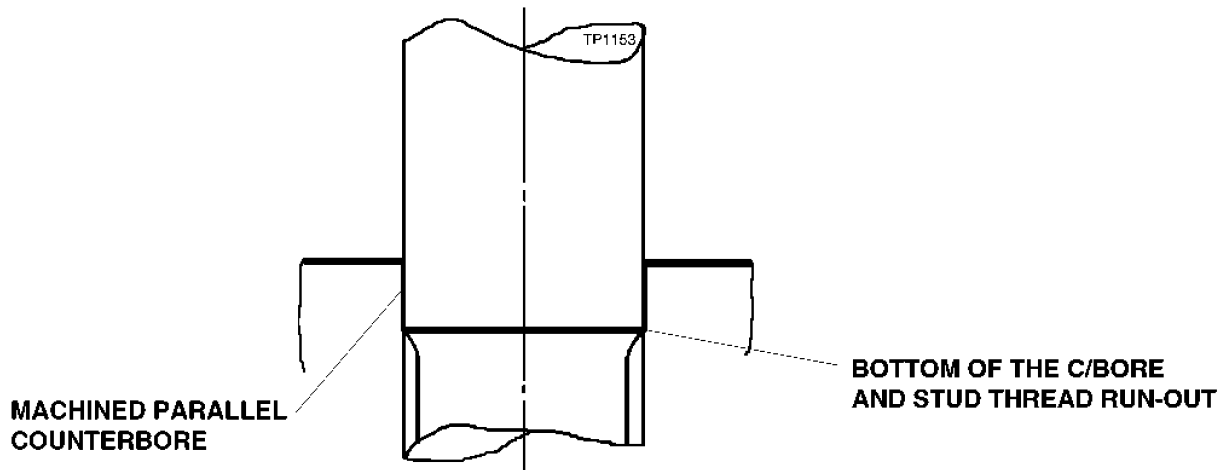
STUDS TO BE INSERTED UNTIL THREAD RUN-OUT LOCKS INTO PARENT METAL



IMPORTANT :- THIS STUD FITTING PROCEDURE IS TO BE USED IN LIEU OF STATED TORQUE VALUES ON EXISTING ARRANGEMENTS. NEW ARRANGEMENTS WILL SPECIFY TD183/1 FROM THE DATE OF ISSUE.

SPECIAL STUDS - FITTED INTO MACHINED PARALLEL COUNTERBORE

STUDS TO BE INSERTED UNTIL CORRECT TORQUE VALUE IS OBTAINED - AS SHOWN ON RELEVANT ARRANGEMENT DRAWING



THIS SPECIFICATION IS FOR STUD FITTING ONLY ; NUTS & SETSCREWS MUST BE TORQUED TO VALUE SPECIFIED

Alteration Numbers

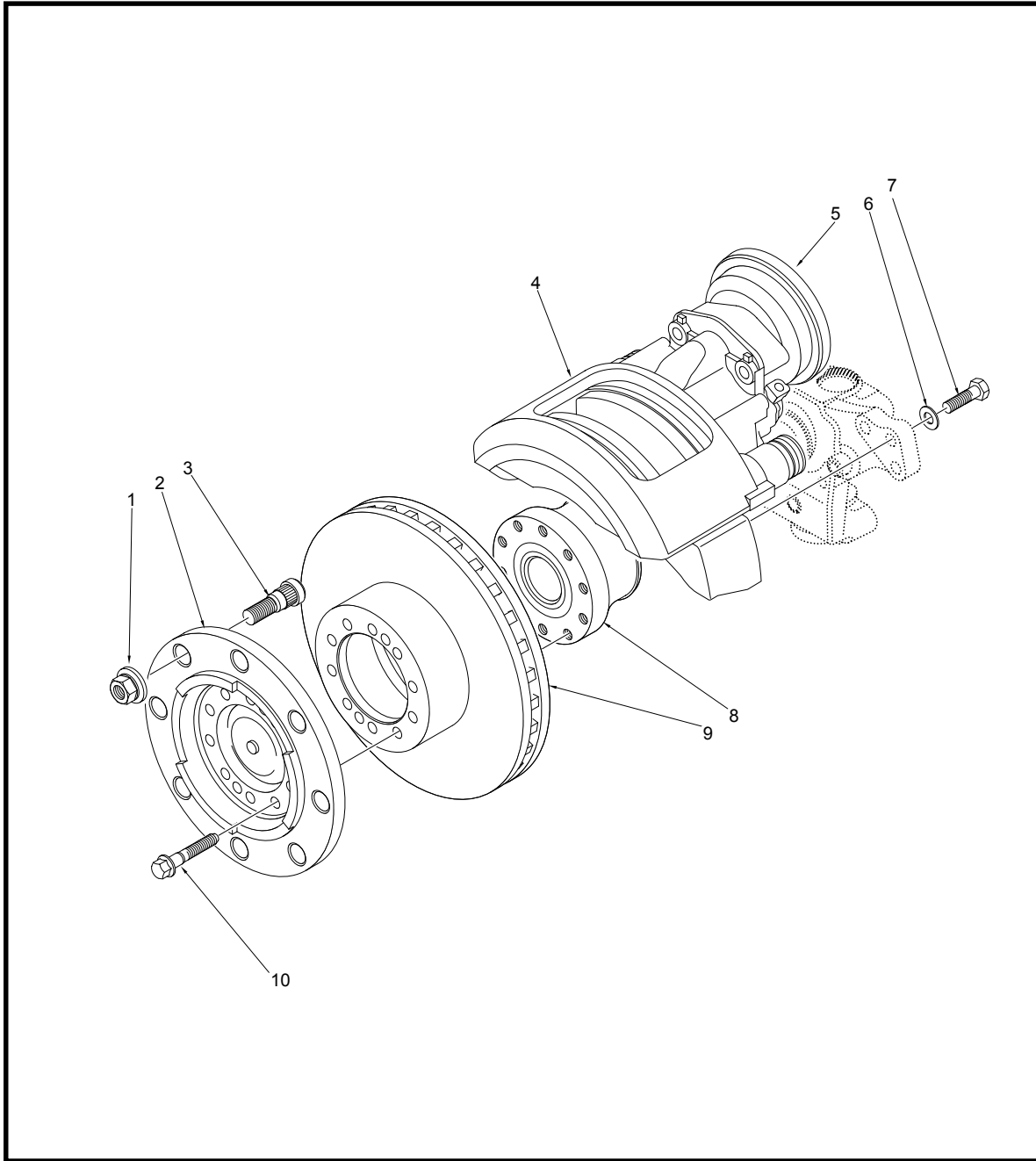
ISSUE A									
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DISTRIBUTION
Front Axle B.U.
Drive Axle B. U.
Production

STUD FITTING PROCEDURES

TD183/1
SHT 1 OF 1

ILLUSTRATION OF NDS HUB END WITH SEPARATE BRAKE BRACKET



PART NUMBER

DESCRIPTION

- 1 Wheel nut (Not Supplied By Spicer Speciality Axles)
- 2 Hub flange
- 3 Wheel stud
- 4 Brake Caliper
- 5 Air chamber
- 6 Brake Caliper Mounting Washer
- 7 Brake Caliper Mounting Bolt
- 8 Unitised Hub Bearing
- 9 Brake Disc
- 10 Hub Flange Retaining Bolt

APPLICATION POLICY

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**SPICER SPECIALITY AXLE DIVISION
ABBAY ROAD
LEEDS LS5 3NF
ENGLAND
TEL (+44-113) 2584611 FAX (+44-113) 2586097**

SECTION 11: REAR AXLES

CONTENTS

1. DRIVE AXLE	2
1.1 DESCRIPTION.....	2
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Section 11: REAR AXLES

1. DRIVE AXLE

1.1 DESCRIPTION

The Meritor drive axle is equipped with a single reduction standard carrier mounted in front of the axle housing. The carrier consists of a hypoid drive pinion, a ring gear set and gears in the differential assembly.

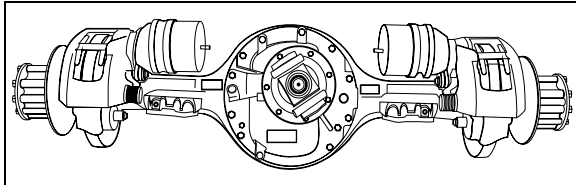


FIGURE 1: DRIVE AXLE

11019

A straight roller bearing (spigot) is mounted on the head of the drive pinion. All other bearings in the carrier are tapered roller bearings. When the carrier operates, there is a normal differential action between the wheels all the time.

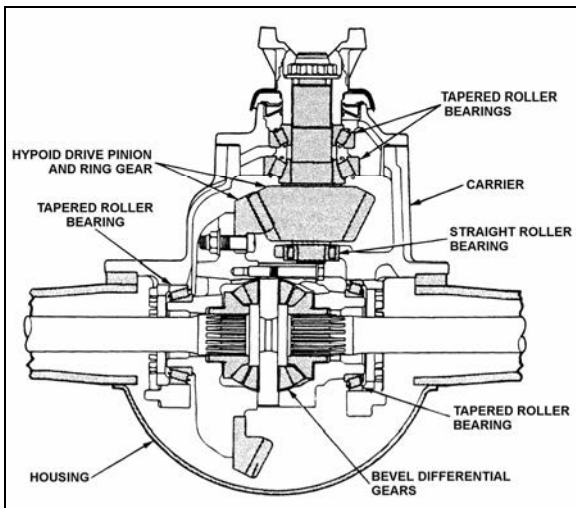


FIGURE 2: DIFFERENTIAL ASSEMBLY

11024

Several speed ratios are available for the drive axle. These ratios depend upon the motor and transmission. Also, special applications may suggest slightly different gear ratios.

1.2 DCDL (DRIVER-CONTROLLED MAIN DIFFERENTIAL LOCK)

Meritor Single-reduction carriers with driver-controlled main differential lock (DCDL) have the same type of gears and bearings as the standard-type carriers. The differential lock is operated by an air actuated shift assembly that is mounted on the carrier.

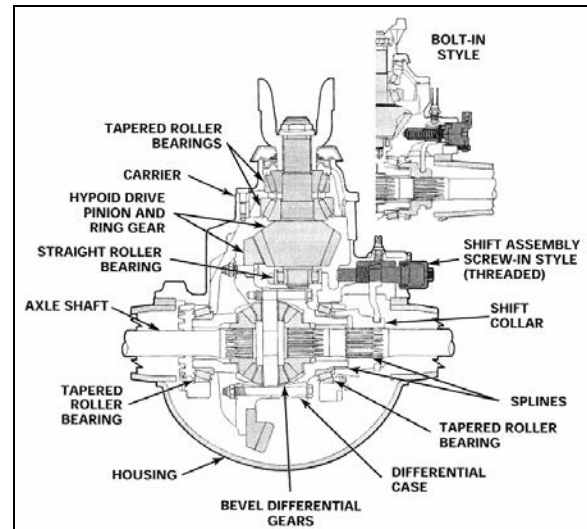


FIGURE 3: DRIVER-CONTROLLED DIFFERENTIAL LOCK

11028

1.3 DRIVE AXLE LUBRICATION

Additional lubrication information is covered in the Meritor Technical Bulletin TP-9539: "Approved Rear Drive Axle Lubricants" annexed to this section. During initial stage of normal operation, tiny metal particles originating from moving parts can be found on mating surfaces. These particles are carried by the lubricant through the assembly and act as lapping compound, which accelerates wear of all parts. To ensure maximum life of the differential and prevent premature failure, the original "factory fill" lubricant should be drained. Change break-in oil before 3,000 miles (4 800 km) of initial operation (drain the unit while it is still warm from operation), in accordance with the lubrication and servicing schedule.

Change differential oil and clean the breathers, magnetic fill and drain plugs, every 100,000 miles (160 000 km) or once every two years, whichever comes first.

Use Multigrade gear oil MIL-L-2105-D. Use the 75W90-gear oil for northern climates and the 80W140 for southern climates. In extreme conditions, or for better performance, fill with synthetic gear oil. Check oil level and add (if necessary) every 6,250 miles (10 000 km) or twice a year, whichever comes first (Fig. 4).

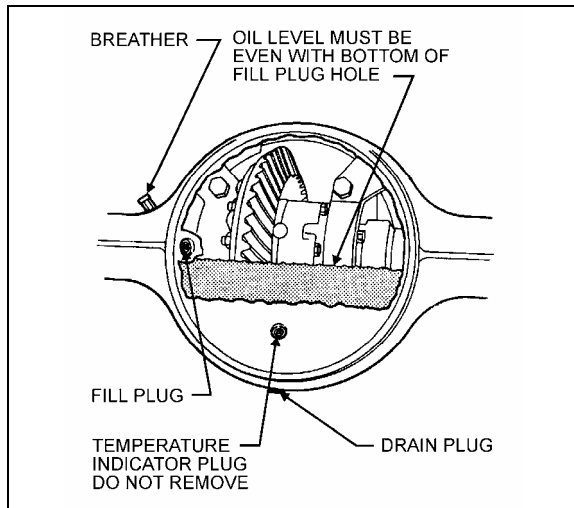


FIGURE 4: DIFFERENTIAL HOUSING BOWL 11007

1.4 MAINTENANCE

Proper vehicle operation begins with preventive maintenance, such as good differential use. The most common types of drive axle carrier failures are spinout, shock, fatigue, overheating and lubrication. Avoid neglecting these points since they would be the first steps to improper maintenance, expensive repairs, and excessive downtime.

Inspect the pinion oil seal, axle shaft flange and carrier housing gaskets for evidence of lubricant leakage. Tighten the bolts and nuts, or replace the gaskets and seals to correct leaks. Maintenance of the axle mountings consists primarily in a regular and systematic inspection of the air suspension units and radius rods, as directed in Section 16, "Suspension".

1.4.1 Checking and Adjusting the Oil Level

DANGER

Before servicing, park safely over a repair pit, apply parking brake, stop engine and set battery master switch to the "OFF" position.

1. Make sure the vehicle is parked on a level surface.

WARNING

Check the oil level when the axle is at room temperature. When hot, the oil temperature may be 190°F (88°C) or more and can cause burns. Also, a correct reading is not obtained when the axle is warm or hot.

2. Make sure the axle is "cold" or at room temperature.
3. Clean the area around the fill plug. Remove the fill plug from the differential axle housing bowl (Fig. 4).
4. The oil level must be even with the bottom of the hole of the fill plug.
 - a. If oil flows from the hole when the plug is loosened, the oil level is high. Drain the oil to the correct level.
 - b. If the oil level is below the bottom of the hole of the fill plug, add the specified oil.
5. Install and tighten the fill plug to 35-50 lbf-ft (48-67 Nm).

1.4.2 Draining and Replacing the Oil

DANGER

Before servicing, park safely over a repair pit, apply parking brake, stop engine and set battery master switch to the "OFF" position.

1. Make sure the vehicle is parked on a level surface. Put a large container under the axle's drain plug.

NOTE

Drain the oil when the axle is warm.

2. Remove the drain plug from the bottom of the axle. Drain and discard the oil in an environment friendly manner.
3. Install and tighten the drain plug to 35-50 lbf-ft (48-67 Nm).
4. Clean the area around the fill plug. Remove the fill plug from the differential housing bowl.
5. Add the specified oil until the oil level is even with the bottom of the hole of the fill plug. Allow the oil to flow through the axle and check the oil level again (lube capacity 41 pints [13,3 liters]).

CAUTION

The differential overheats when the oil temperature rises above 250°F (120°C).

6. Install and tighten the fill plug to 35-50 lbf-ft (48-67 Nm).

Section 11: REAR AXLES

1.4.3 Speed Sensors (Anti-Lock Brake system, ABS)

For removing and installing the drive axle speed sensors (for anti-lock brake systems, ABS), refer to Section 12: "Brake and Air System" and to Rockwell WABCO Maintenance Manual: "Anti-Lock Brake Systems For Trucks, Tractors and Buses", annexed at the end of section 12.

1.5 REMOVAL AND REINSTALLATION

The following procedure deals with the removal of the drive axle assembly and its attachments as a unit. The method used to support the axle during removal and disassembly depends upon local conditions and available equipment.

1. Raise vehicle by its jacking points on the body (fig. 5 or see Section 18, "Body" under heading "Vehicle Jacking Points"). Place jack stands under frame. Remove drive axle wheels (if required, refer to Section 13, "Wheels, Hubs And Tires".

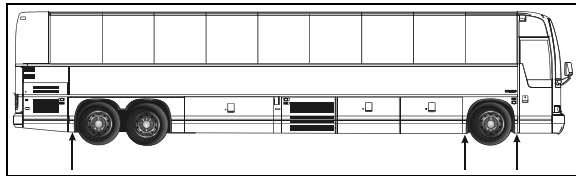


FIGURE 5: JACKING POINTS ON FRAME 18618

2. Exhaust compressed air from the air supply system by opening the drain cock on each air reservoir.
3. Disconnect the propeller shaft as directed in Section 9, "Propeller Shaft", in this manual.
4. On both sides of the vehicle, unscrew fasteners retaining front wheel housing plastic guards, and remove them from vehicle.
5. Disconnect both height control valve links from air spring mounting plate brackets then move the arm down to exhaust air suspension.
6. Remove cable ties securing the ABS cables (if vehicle is so equipped) to service brake chamber hoses. Disconnect the ABS cable plugs from the drive axle wheel hubs.

NOTE

When removing drive axle, if unfastening cable ties is necessary for ease of operation, remember to replace them afterwards.

7. Disconnect the brake chamber hoses.

NOTE

Position the hoses so they will not be damaged when removing the axle.

8. Install jacks under the axle jacking points to support the axle weight (refer to figure 6).

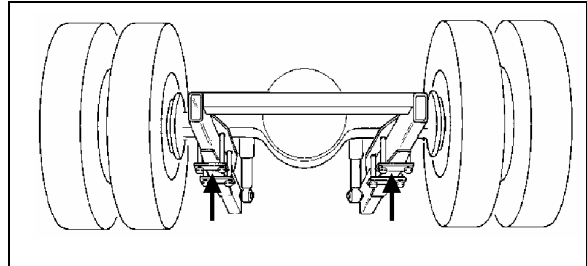


FIGURE 6: JACKING POINTS ON DRIVE AXLE 11005

9. Remove the four shock absorbers as outlined in Section 16, "Suspension" under heading "Shock Absorber Removal".
10. Remove the sway bar.
11. Remove the lower and upper longitudinal radius rod supports from vehicle sub-frame as outlined in Section 16, "Suspension", under heading "Radius Rod Removal".
12. Remove the transversal radius rod support from the vehicle sub-frame.
13. Remove the two retaining nuts from each of the four air bellows lower mounting supports.
14. Use the jacks to lower axle. Carefully pull away the jacks axle assembly from underneath vehicle.
15. Reverse removal procedure to reinstall drive axle.

NOTE

Refer to Section 16, "Suspension" for suspension components' proper tightening torques.

NOTE

Refer to section 13 "Wheels, Hubs And Tires" for correct wheel bearing adjustment procedure.

1.6 DISASSEMBLY AND REASSEMBLY

Disassembly and re-assembly procedures are covered under applicable headings in Meritor's "MAINTENANCE MANUAL, NO. 5", annexed to this section.

1.7 GEAR SET IDENTIFICATION

Gear set identification is covered under applicable heading in Meritor's "MAINTENANCE MANUAL NO. 5", annexed to this section.

1.8 ADJUSTMENTS

Adjustments are covered under applicable headings in Meritor's "MAINTENANCE MANUAL NO. 5", annexed to this section.

1.9 FASTENER TORQUE CHART

A differential fastener torque chart is provided in Meritor's "MAINTENANCE MANUAL NO. 5", annexed to this section.

1.10 TIRE MATCHING

Drive axle tire matching is covered under the applicable heading in Section 13, "Wheels, Hubs And Tires" in this manual.

1.11 DRIVE AXLE ALIGNMENT

NOTE
For drive axle alignment specifications, refer to paragraph 3: "Specifications" in this section.

The drive axle alignment consists in aligning the axle according to the frame. The axle must be perpendicular to the frame. The alignment is achieved with the use of shims inserted between the lower longitudinal radius rod supports and the frame.

Drive axle alignment is factory set and is not subject to any change, except if the vehicle has been damaged by an accident or if there are requirements for replacement.

DRIVE AXLE ALIGNMENT

- With the system installed as in figure 7, adjust drive axle according to specifications' chart below.

DRIVE AXLE ALL VEHICLES			
Alignment / value	Minimum value	Nominal value	Maximum value
Thrust angle (deg.)	-0.04	0	0.04
Total Toe (deg.)	0.18 Toe-in	0	0.18 Toe-out

TAG AXLE ALIGNMENT

- Remove and reinstall all wheel mount sensors on the drive and tag axles (fig. 8);

If the axle has been removed for repairs or servicing and if all the parts are reinstalled exactly in the same place, the axle alignment is not necessary. However, if the suspension supports have been replaced or altered, proceed with the following instructions to verify or adjust the drive axle alignment.

NOTE
When drive axle alignment is modified, tag axle alignment must be re-verified.

1.11.1 Procedure

- Park vehicle on a level surface, then chock front vehicle wheels.
- Using two jacking points (which are at least 30 inches [76 cm] apart) on drive axle, raise the vehicle sufficiently so that wheels can turn freely at about 1/2 inch from ground. Secure in this position with safety stands, and release parking brake.
- Install wheel mount sensors on front end and drive axle wheels (fig. 7).

NOTE
See reference numbers on wheel mount sensors (fig.7).

NOTE
Select axle specifications in the appropriate chart

Section 11: REAR AXLES

NOTE

For an accurate alignment, the tag axle must be aligned with the drive axle.

NOTE

Reinstall wheel mount sensors as shown in figure 8.

- Adjust tag axle according to specifications' chart below in reference with drive axle.

TAG AXLE ALL VEHICLES			
Alignment / value	Minimum value	Nominal value	Maximum value
Parallelism (deg.)	-0.02	0	0.02
Total Toe (deg.)	0.18 Toe-in	0	0.18 Toe-out

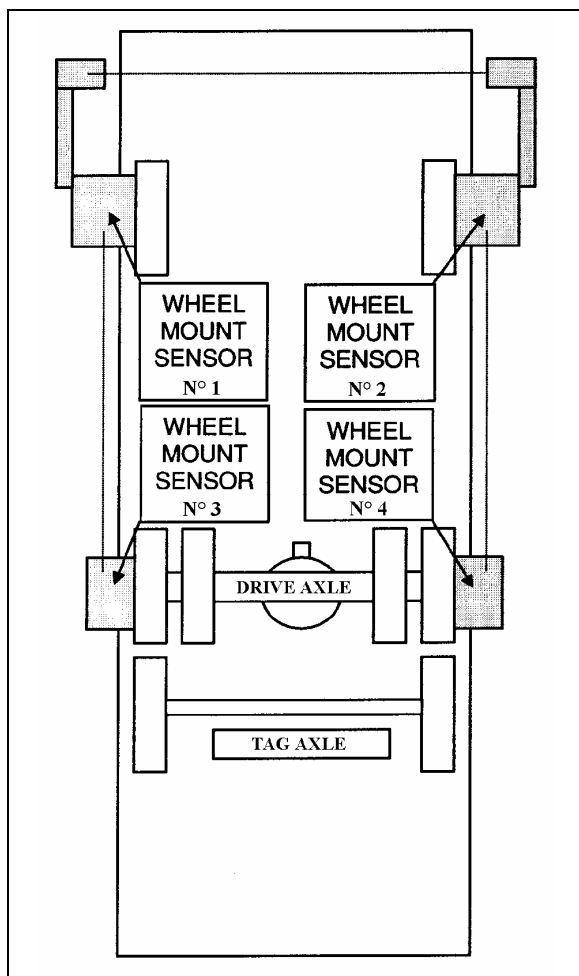


FIGURE 7: FRONT & DRIVE AXLE ALIGNMENT 11025

NOTE

Refer to Section 16, "Suspension", for proper torque tightening of the longitudinal radius rod support nuts.

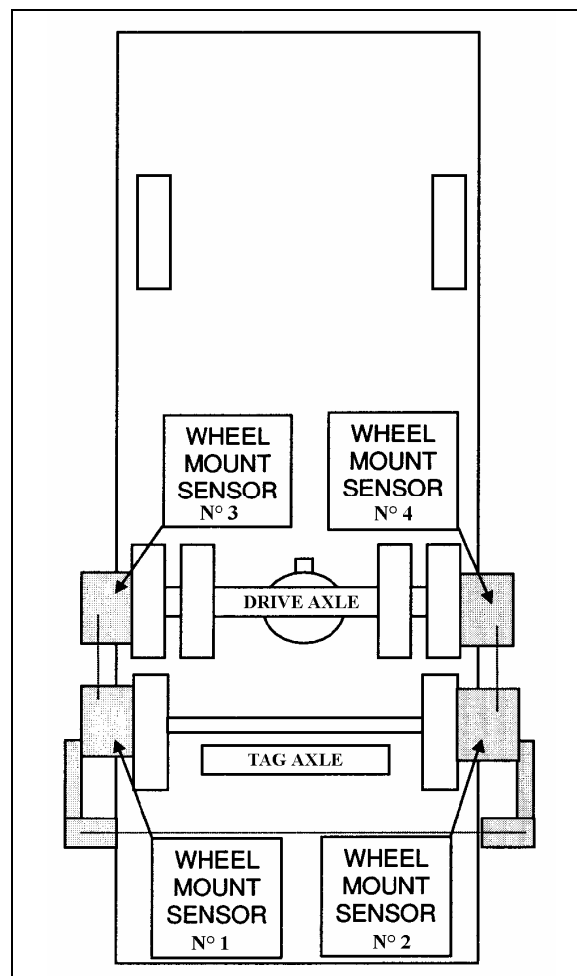


FIGURE 8: TAG AXLE ALIGNMENT 11026

NOTE

When the drive alignment is changed, the tag alignment must also be adjusted.

1.12 AXLE SHAFT SEALING METHOD

The following method is to be used to ensure that axle shaft installation is fluid-tight:

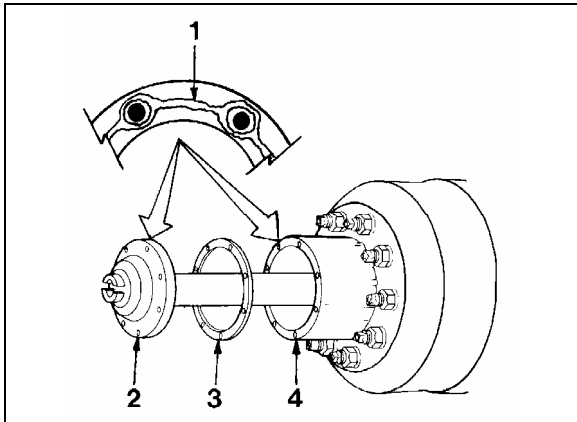


FIGURE 9: AXLE SHAFT INSTALLATION 11003

- 1..... Silicone sealant*
- 2..... Axle shaft
- 3..... Gasket
- 4..... Wheel hub

1. Clean the mounting surfaces of both the axle shaft flange and wheel hub where silicone sealant will be applied. Remove all old silicone sealant, oil, grease, dirt and moisture. Dry both surfaces.
2. Apply a continuous thin bead of silicone sealant* (Prévost P/N 680053) on the mounting surfaces and around the edge of all fastener holes of both the axle shaft flange and wheel hub.

* GENERAL ELECTRIC Silicone Rubber Adhesive Sealant RTV 103 Black.

WARNING

Carefully read cautions and instructions on the tube of silicone sealant and its packing.

3. Assemble components immediately to permit the silicone sealant to compress evenly between parts.
 - a. Place a new gasket and then install the axle shaft into the wheel hub and differential carrier. The gasket and flange of the axle shaft must fit flat against the wheel hub.
 - b. Install the tapered dowels at each stud and into the flange of the axle shaft. Use a punch or drift and hammer if needed.

- c. Install the lock washers and nuts on the studs. Tighten nuts to the correct torque value.

NOTE
Torque values are for fasteners that have a light application of oil on the threads (refer to Meritor Maintenance Manual).

9/16-18 plain nut: 110 - 165 lbf-ft (149 -224 Nm)

5/8-18 plain nut: 150 - 230 lbf-ft (203 - 312 Nm)

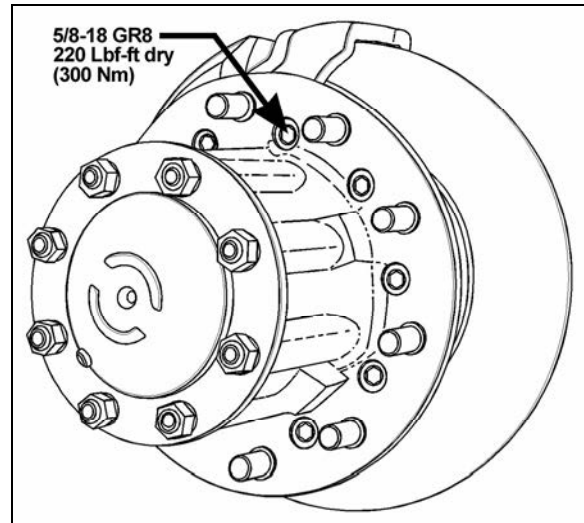


FIGURE 10: TORQUE SPECIFICATION

2. TAG AXLE

The tag axle is located behind the drive axle. It carries a single wheel and tire on each side.

2.1 UNLOADING TAG AXLE

To reduce the turning radius, the air springs pressure will be automatically reduced by 75% when the coach is moving at speed lower than 5 mph (8 km/h) and with more than 1½ turn from the steering.

2.2 RETRACTING TAG AXLE

The standard tag axle retraction system is controlled by a valve located on the right lateral console and enables unloading and raising the tag axle (refer to the "OPERATOR'S MANUAL" for location of controls). This system has been designed for the following purposes:

1. Shortening of wheelbase, thus allowing tighter turning in tight maneuvering areas such as parking lots or when making a sharp turn.

Section 11: REAR AXLES

2. Transferring extra weight and additional traction to the drive wheels on slippery surfaces.

The tag axle service brakes operate only when the axle is in normal driving (loaded) position.



CAUTION

Do not use tag axle in raised position for an extended period. Raising tag axle increases load on the drive axle, suspension and tires.

Do not drive vehicle with tag axle raised when speed is exceeding 9mph (15 km/h).

In order to prevent damage to the suspension, always raise the tag axle before lifting the coach.

2.3 RETRACTING TAG AXLE FOR REPAIR PURPOSES

- Connect an external air pressure line to the emergency fill valve in the engine compartment.
- Lift the axle by pushing the lever forward.



WARNING

Install a protective cover to prevent unfortunate lever operation while work is being carried out under the vehicle.

- Raise the vehicle using the lifts.



WARNING

Lift manufacturers recommend lowering the vehicle to the ground or installing some safety stands before activating the suspension to prevent the lifts from becoming unstable.

- For added safety, install nylon slings over tag axle shock absorbers.

2.4 GREASE LUBRICATED WHEEL BEARINGS

The unitized hub bearings used on the NDS range of axles, are non-serviceable items. Bearings are pre-adjusted, lubricated and have seals fitted as part of the manufacturing process. The bearings are greased for life and there is no need or facility for re-lubrication

Front and tag axle hub bearings need to be checked every 30,000 miles (48 000 km).

NOTE

For more information on front and tag axle wheel hub, refer to "DANA SPICER Maintenance Manual Model NDS and Maintenance Manual NDS Axles" annexed at the end of this Section.

2.5 REMOVAL AND INSTALLATION

2.5.1 Removing Tag Axle Only

The following procedure deals with the removal of the tag axle while keeping the air springs installed. The method used to support the axle and suspension components during removal and disassembly depends upon local conditions and available equipment.

- Connect an external air pressure line to the emergency fill valve in the engine compartment.
- Lift the axle by pushing the lever forward.



WARNING

Install a protective cover to prevent unfortunate lever operation while work is being carried out under the vehicle.

- Disconnect tag axle air springs pneumatic hoses and install valves or plugs.
- Raise the vehicle using the lifts.
- Dismount tag axle components.
- Before reinstalling air spring hoses, make sure there is no pressure left inside by opening the valves or unloading tag axle.

2.5.2 Removing Tag Axle Along With Suspension Components

The following procedure deals with the removal of the tag axle assembly along with the suspension components. The method used to support the axle and suspension components during removal and disassembly depends upon local conditions and available equipment.

1. Raise vehicle by its jacking points on the body (fig. 5 or see Section 18, "Body" under heading: "Vehicle Jacking Points"). Place jack under frame. Remove drive axle wheels (if

required, refer to Section 13, "Wheels, Hubs And Tires").

2. Exhaust compressed air from the air supply system by opening the drain cock on each air reservoir and deplete air bags by moving leveling valve arm down.
3. Install jacks under tag axle jacking points to support the axle weight (refer to figure 11).

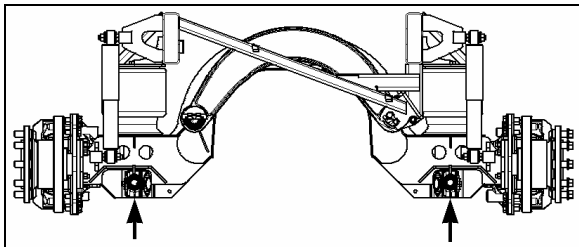


FIGURE 11: JACKING POINTS ON TAG AXLE 11029

4. Disconnect tag axle lifting chain collars from lower longitudinal radius rods.
5. Remove the propeller shaft as directed in Section 9, "Propeller Shaft", in this manual.
6. Disconnect the tag axle brake chamber hoses.



CAUTION

Position the hoses so they will not be damaged when removing axle.

7. Disconnect hose from the air spring upper mounting plate.
8. Remove the two shock absorbers as outlined in Section 16, "Suspension", under "Shock Absorber Removal".
9. Disconnect the lower longitudinal radius rods as outlined in Section 16, "Suspension", under "Radius Rod Removal".
10. Disconnect the transversal radius rod.
11. Disconnect the upper longitudinal radius rod.
12. Remove the air bellows retaining nuts from each of the two upper mounting plates.
13. Use the jacks to move the axle forward to clear the axle off the transmission. Lower the axle.



CAUTION

On vehicles equipped with an automatic transmission (with or without the output retarder), move tag assembly very carefully. Pay special attention to the U-shaped section, as the transmission end components may be easily damaged through a false maneuver.

14. Reverse removal procedure to reinstall tag axle.

NOTE

Refer to Section 16, "Suspension", for proper torque tightening of suspension components.

NOTE

Refer to section 13 "Wheels, Hubs And Tires" for correct wheel bearing adjustment procedure.

2.6 TAG AXLE ALIGNMENT

The tag axle alignment consists in aligning the tag axle parallel to the drive axle position. Before aligning the tag axle, proceed with the drive axle alignment (paragraph 1.11). Tag axle alignment is achieved with the use of shims inserted between the lower longitudinal radius rod supports and axle. Tag axle alignment is factory set and is not subject to any change, except if vehicle has been damaged by an accident or if there are requirements for parts replacement.



CAUTION

If this setting is altered significantly, it will cause excessive tire wear.

NOTE

It may be necessary to adjust the axle TOE as well as its alignment. In this case, insert shims (7 min. - P/N 121203 or 15 min. - P/N 121240) in between mounting plate and spindle, as required.

If axle has been removed for repair or servicing and if all parts are reinstalled exactly in their previous locations, axle alignment is not necessary. However, if the suspension supports have been replaced or have changed position, proceed with the following instructions to verify or adjust the tag axle alignment.

Section 11: REAR AXLES

3. SPECIFICATIONS

Drive Axle

MakeMeritor
Drive track..... 76.7 inches (1 949 mm)
Gear typeHypoid
Axle type Full floating
Lube capacity 41 pints (19,3 liters)

Drive axle ratio

World Transmission

4.30:1 Standard
4.10:1 Optional
4.56:1 Optional
4.88:1 Optional

ZF Transmission

3.73:1 Standard
3.42:1 Optional
3.58:1 Optional

NOTE

The drive axle alignment consists in aligning the axle with reference to the frame. The axle must be perpendicular to the frame.

Tag Axle

MakePrévost
Rear track 83.6 inches (2 124 mm)
Axle type Dana Spicer Europe TS8U Hub Unit

NOTE

The tag axle alignment consists in aligning the tag axle parallel to the drive axle.

MERITOR®

Technical Bulletin

Approved Rear Drive Axle Lubricants

 **CAUTION**

You must fill Meritor axles with Meritor-specified lubricants only. Do not fill an axle with non-approved lubricants, which will void Meritor’s warranty. Damage to axle components also can result.

To avoid axle component damage, fill Meritor axles with approved lubricants only. Using non-approved lubricants also will void Meritor’s warranty.

For complete lubrication information, refer to Maintenance Manual 1, Preventive Maintenance and Lubrication. To obtain this publication, call ArvinMeritor’s Customer Service Center at 800-535-5560, or visit Literature on Demand on our website at meritorhvs.com.

Table A: Oil Change Intervals and Specifications for All Rear Drive Axles

Vocation or Vehicle Operation	Linehaul	Intercity Coach	City Delivery, School Bus, Fire Truck, Motorhome	Construction, Transit Bus, Refuse, Yard Tractor, Logging, Heavy Haul, Mining, Oil Field, Rescue
Initial Oil Change	Not required			
Check Oil Level Add the correct type and amount of oil as required.	Every 25,000 miles (40 000 km), or the fleet maintenance interval, whichever comes first		Every 10,000 miles (16 000 km), once a month, or the fleet maintenance interval, whichever comes first	Every 5,000 miles (8000 km), once a month, or the fleet maintenance interval, whichever comes first ①
Petroleum-Based Oil Change on Axle with or without Pump and Filter System ②	Every 100,000 miles (160 000 km), or annually, whichever comes first		Every 50,000 miles (80 000 km), or annually, whichever comes first	Every 25,000 miles (40 000 km), or annually, whichever comes first
Synthetic Oil Change on Axle with or without Pump and Filter System ③	Every 500,000 miles (800 000 km), or every 4 years, whichever comes first	Every 250,000 miles (400 000 km), or every 4 years, whichever comes first	Every 250,000 miles (400 000 km), or every 3 years, whichever comes first	Every 100,000 miles (160 000 km), or every 2 years, whichever comes first ④
Filter Change on Axle with Pump and Filter System	Every 100,000 miles (160 000 km)			

- ① For continuous heavy-duty operation, check the oil level every 1,000 miles (1600 km).
- ② All ArvinMeritor GL5 approved gear lubricants have been SAE J2360 tested and approved. A current list of approved oils is available at www.pri.sae.org/PRI/IMprograms/Lubricant.
- ③ These intervals apply to approved semi-synthetic and full synthetic oils only. For a list of approved extended-drain axle oils, refer to **Table C** or **Table D**.
- ④ The change interval for transit buses can be increased to **150,000 miles** or **3 years**, whichever comes first, contingent upon:
 - 1) documented 10% fleet oil sampling with results below ArvinMeritor guidelines per Maintenance Manual 1,
 - 2) minimum of six magnets in housing (61163/ 71163 drive axles come standard with six magnets in housing), and
 - 3) use of approved extended-drain interval lubricants per **Table B**. (Drive axles excluded are: RC-26-633/634 and RC-26/27-720.)

Table B: Axle Oil Specifications

	Gear Oil Type	A.P.I. Specification	SAE Viscosity Grade	ArvinMeritor Specification	SAE Specification	Outside Temperature
Standard Drain Lubricants	Petroleum with EP additives	GL-5	85W/140	O76-A	SAE J2360 Tested and Approved	Above +10°F (-12°C)
			80W/140	O76-B		Above -15°F (-26°C)
			80W/90	O76-D		Above -15°F (-26°C)
			75W/90	O76-E		Above -40°F (-40°C)
			75W	O76-J		From -40°F (-40°C) to +35°F (+2°C)
			75W/140	O76-L		Above -40°F (-40°C)
Extended-Drain Lubricants	Petroleum with Extended-Drain Base Oils and EP additives	GL-5	75W/90, 80W/90, 80W/140 or 75W/140	O76-Q, O76-R	SAE J2360 Tested and Approved	Depends on viscosity. Refer to the viscosity grades listed above.
	Petroleum with Semi-Synthetic Base Oils and EP additives		80W/90	O76-P		Above -15°F (-26°C)
	Fully Synthetic Base Oil and EP additives		75W/140	O76-M		Above -40°F (-40°C)
	Fully Synthetic Base Oil and EP additives		75W/90	O76-N		Above -40°F (-40°C)

Table C: Extended-Drain-Approved Synthetic Axle Oil Suppliers – United States Distributors

Name of Lubricant	Viscosity	Manufacturer
Allied Mag Synthetic EP	75W/90, 80W/140	Allied Oil and Supply Incorporated
Altra Syntec GT-7	75W/90, 80W/140	Allegheny Petroleum Products
Amalie Synthetic Gear Lubricant	75W/90, 80W/140	Amalie Refining Company
Amoco Ultimate Multipurpose Gear Lube	75W/90, 80W/140	Amoco Oil Company
Archer Synthetic	75W/90, 80W/140	McCollister & Co.
Brad Penn Full Syn. Hypoid Gear Lube	75W/90, 80W/140	American Refining Group
Bulldog Syn Gear Lube	75W/90, 80W/140	Mack Truck Company
Chevron Delo Synthetic Gear Lubricant	75W/90	Chevron Global Lubricants
Chevron RPM Synthetic Gear Lubricant	75W/90, 80W/140	Chevron Global Lubricants
Citgo Synthetic Gear Lube	75W/90, 80W/140	Citgo Petroleum Corporation
Coastal HD	75W/90, 80W/140	Coastal Unilube Inc.
Dyna-Plex 21C Synzol	75W/90, 80W/140	Universal Lubricants
Dyno-Tech HD	75W/90, 80W/140	Chemtool Inc.
Emgard EP	75W/90, 80W/140	Cognis Corporation
Emgard FE Fuel Efficient Synthetic Gear Lubricant	75W/90	Cognis Corporation
Emgard Synthetic Gear Lubricant	75W/90, 80W/140	Cognis Corporation
Emgard 2986	75W/90	Cognis Corporation
Fleerite Synthetic	75W/90, 80W/140	International Truck & Engine Group
FS Synthetic	75W/90, 80W/140	Growmark
Gear Plus Super EW	75W/90, 80W/140	Pennzoil-Quaker State

Table C: Extended-Drain-Approved Synthetic Axle Oil Suppliers – United States Distributors

Name of Lubricant	Viscosity	Manufacturer
Gibraltar Syn-Gear	75W/90, 80W/140	David Weber Oil Company
Gulf Syngear	75W/90, 80W/140	Gulf Oil
Hi-Tek Synthetic	75W/90, 80W/140	Industrial Oils Limited
Imperial SGO	75W/90, 80W/140	IPAC
Lubemaster Syn EP	75W/90, 80W/140	Lubemaster (A Division of Certified Labs)
Maxtron GL	75W/90, 80W/140	Country Energy LLC
Mobil Delvac Synthetic Gear Oil	75W/90, 80W/140	ExxonMobil Corporation
Mobilube SHC	75W/90, 80W/140	ExxonMobil Corporation
Monarch Syngear Plus	75W/90, 80W/140	Royal Manufacturing Co. Inc.
Mystik Synguard SX-7000	75W/90, 80W/140	Cato Oil and Grease Company
NEO	75W/90, 80W/140	Neo Lubricants
Pennzoil Long-Life EW	75W/90, 80W/140	Shell Oil U.S.
Quaker State FCI Synthetic	75W/90, 80W/140	Shell Oil U.S.
Raloy Transintex Plus EP	75W/90, 80W/140	Raloy Lubricantes S. A. de C.V.
Roadranger FE Fuel Efficient Synthetic Gear Lubricant	75W/90	Eaton Corporation
Roadranger Synthetic Gear Lubricant	75W/90, 80W/140	Eaton Corporation
Schaeffer Synthetic EP	75W/90, 80W/140	Schaeffer Manufacturing Company
SHP Gear Lube	75W/90, 80W/140	Kendall Lubricants
Spirax S	75W/90, 80W/140	Shell Lubricants
SYN HD Gear Oil	75W/90, 80W/140	Lyondell Lubricants
Syn. Axle Lubricant 12345841	75W/90, 80W/140	General Motors Service Parts
Syncon HP Synthetic Gear Oil	75W/90, 80W/140	Conoco Lubricants
SYN-EP Gear Lubricant	75W/90, 80W/140	Black Bear Company Incorporated
Synergy Syn. Gear Lube EP	75W/90, 80W/140	Northland Products Company
Syn-Gear	75W/90, 80W/140	Castrol Heavy Duty Lubricants, Inc.
Syngear EP	75W/90, 80W/140	American AGIP
Synolec	75W/90, 80W/140	Lubrication Engineers Incorporated
Synpro	75W/90, 80W/140	Fina Oil and Chemical Company
Syn-Star GL	75W/90, 80W/140	Texaco Lubricants Company
Synsure Synthetic Lubricant	75W/90, 80W/140	D-A Lubricant Company Incorporated
Syn-Tech EP	75W/90, 80W/140	Benz Oil
Syntex 2700	75W/90, 80W/140	Texas Refinery Corporation
Texaco Syn-Star GL	75W/90, 80W/140	Chevron Global Lubricants
Traxon E Synthetic	75W/90, 80W/140	Petro-Canada Lubricants Centre
Triton Syn Lube EP	75W/90, 80W/140	76 Lubricants
United Syn	75W/90, 80W/140	McCollister & Co.
Valvoline HD Synthetic Gear Oil EP	75W/90, 80W/140	Valvoline Incorporated

Table D: Additional Extended-Drain-Approved Axle Oil Suppliers

CANADA:

Name of Lubricant	Viscosity	Manufacturer
HDH Synthetic	75W/90, 80W/140	Irving Oil Limited
NEMCO Syngear	75W/90, 80W/140	NemCo Resources Limited
Sonic MP Gear Oil	75W/90, 80W/140	Federated Cooperatives Limited
Titan Syndrive	75W/90, 80W/140	Fuchs Lubricants Canada Limited

MEXICO:

Name of Lubricant	Viscosity	Manufacturer
Akron Axle Synthetic	75W/90, 80W/140	Mexicano de Lubricantes, S.A. de C.V.
Q.S. Synquest Gear	80W/140	Commercial Importada, S.A. de C.V.
Sun Gear Gold Syn	75W/90, 80W/140	Aceites Y Parafinas Industriales
Syn-Star GL	75W/90, 80W/140	Productos Texaco, S.A. de C.V.
Transintex Plus EP	75W/90, 80W/140	Raloy Lubricantes, S.A. de C.V.

AUSTRALIA/NEW ZEALAND:

Name of Lubricant	Viscosity	Manufacturer
Synstar GL	75W/90, 80W/140	Caltex Oil Pty. Limited
Syntrax E	75W/90, 80W/140	Castrol Australia PTY Limited
TransGear S	80W/140	BP Oil Company
Tutela Truck FE Axle	80W/140	Fiat Lubrificanti

Other Approved Extended-Drain Gear Oils

Name of Lubricant	Viscosity	Manufacturer
Delo Gear Lubricant ESI	80W/90, 85W/140	Chevron Global Lubricants
PED 6449	75W/90	Chevron Global Lubricants
Pennzoil Long-Life EW	75W/90, 80W/140	Shell Lubricants
SAF-AM	80W/90	Castrol Heavy Duty Lubricants
Shell Spirax EW	75W/90, 80W/140	Shell Lubricants
Synergyn Blended Synthetic	80W/90	Synergyn Racing Products
Texaco Star Gear Lubricant	80W/90, 85W/140	Chevron Global Lubricants
Triton Syn Lube LDO	75W/90, 80W/140	76 Lubricants
Super Three Star	75W/90, 80W/140	Kendall

For Meritor R-170 Axles Equipped With Traction Equalizer®

Meritor's R-170 axles with Traction Equalizer normally operate with either standard petroleum, semi-synthetic or full-synthetic oils.

When to Use "Limited Slip Friction Modifiers"

Occasionally the Traction Equalizer will "slip" or "stick." When this happens, you will hear intervals of shrill noises when the vehicle operates at low speed or when the vehicle makes sharp turns. You can correct this condition by adding "limited slip friction modifiers."

NOTE: "Limited slip friction modifiers" usually deteriorate more quickly than extreme pressure (EP) additives. Shorten the lubricant change schedule if you add a friction modifier.

- **At the initial lubricant change interval for an R-170 equipped with Traction Equalizer:** Replace the factory-installed lubricant with an approved lubricant and one of the additives specified in the following table.
- **After the initial change interval:** Change the lubricant and the additive at or before 50,000 miles (80 000 km).

Specifications

For all GL-5 oils (petroleum oil or synthetic), add one of the following modifiers specified in the following table.

Manufacturer	Specification
DSL-178	Guardsman Products
Equa-Torque #2411 and #2414	Sta-Lube Corporation
Lubrizol #6178	Lubrizol Corporation

Quantities for R-170 Axles With and Without Traction Equalizer

WITH Traction Equalizer	WITHOUT Traction Equalizer
40 pints oil (18.9 liters) + 3 pints additive (1.4 liters)	43 pints oil (20.3 liters)

Lubrication Analysis Recommendations

Meritor recommends using a lubricant analysis program. Perform lubricant analysis at regularly-scheduled preventive maintenance intervals. Refer to Maintenance Manual 1, Preventive Maintenance and Lubrication, for drive axle differential oil analysis guidelines.

ArvinMeritorTM

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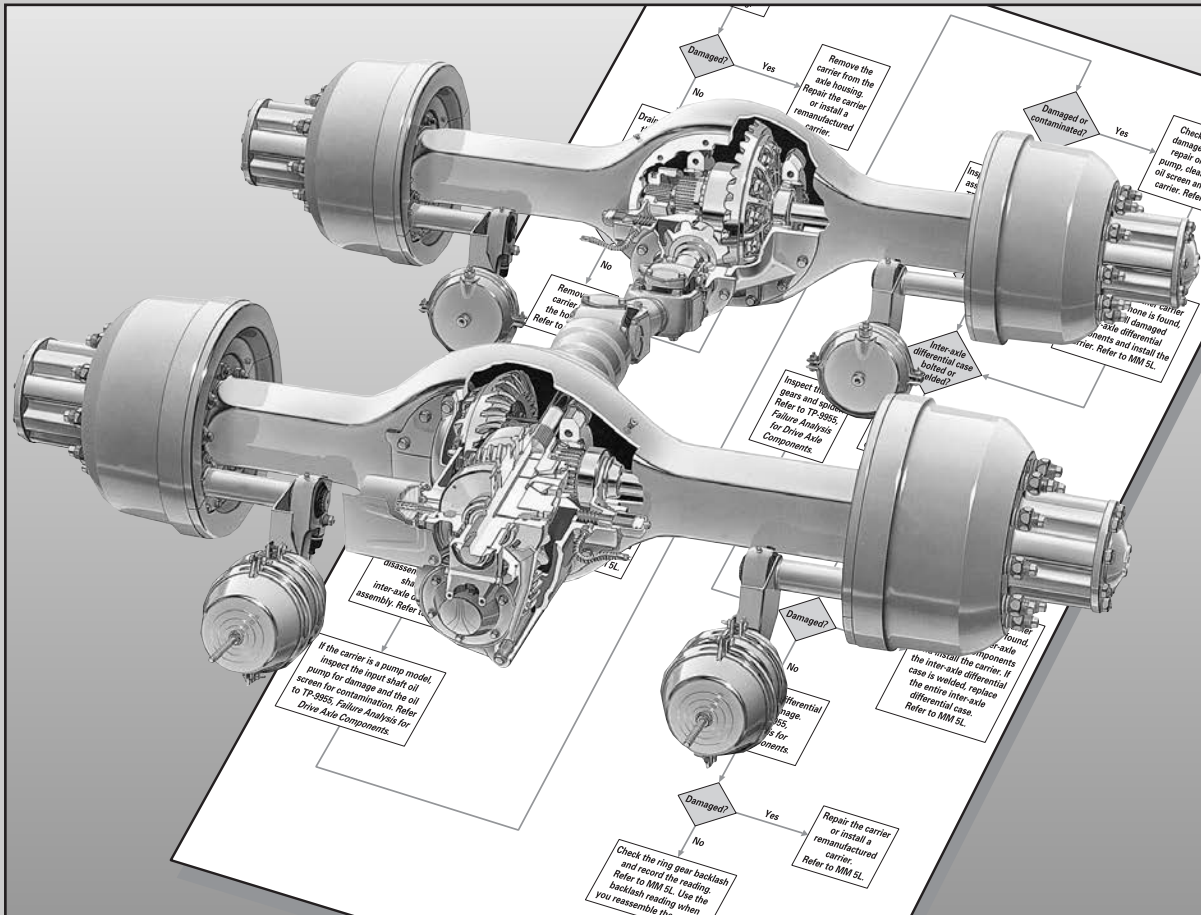
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Revised 06-07
16579/22882



TECHNICAL BULLETIN

Forward and Rear Axle Carrier Diagnostic Flowcharts



Introduction

How to Use This Publication

Refer to the following diagnostic flowcharts to help you determine the source of axle differential carrier complaints.

Before you use the flowcharts, investigate the axle carrier complaint and confirm that the problem involves the carrier.

To locate the correct flowchart, refer to the following tables.

Forward Tandem Carrier

Flowchart	Page
Vehicle Will Not Move	2
Differential Making Noise	4
Oil Leak	6

Rear Tandem or Single Carrier

Flowchart	Page
Vehicle Will Not Move	7
Differential Making Noise	8
Oil Leak	9

All Rear Axles

Flowchart	Page
Contaminated Lubricant Found During Preventive Maintenance	10

Performing the Diagnostic Procedures in This Bulletin

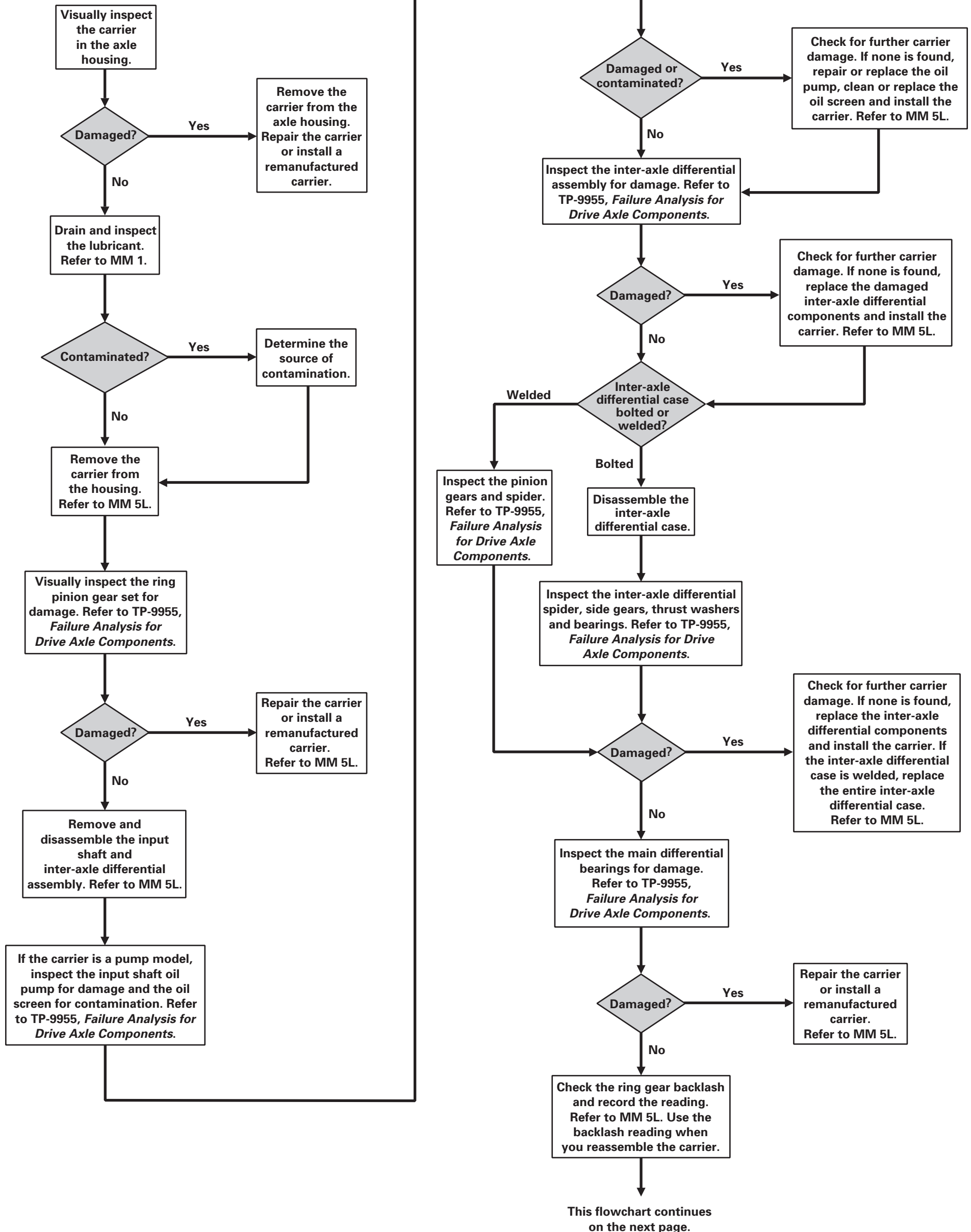
Refer to the following publications when you perform the diagnostic procedures in this bulletin.

- *Lubrication*
Maintenance Manual No. 1
- *Single Reduction Differential Carriers*
Maintenance Manual No. 5
- *Single Reduction Rear Differential Carriers*
Maintenance Manual No. 5A
- *Tandem Axle Forward Carriers and Single Axle Carriers* — Maintenance Manual No. 5E
- *Single Reduction Forward Differential Carriers on Tandem Axles* — Maintenance Manual No. 5L
- *Failure Analysis for Drive Axle Components*
Manual No. TP-9955

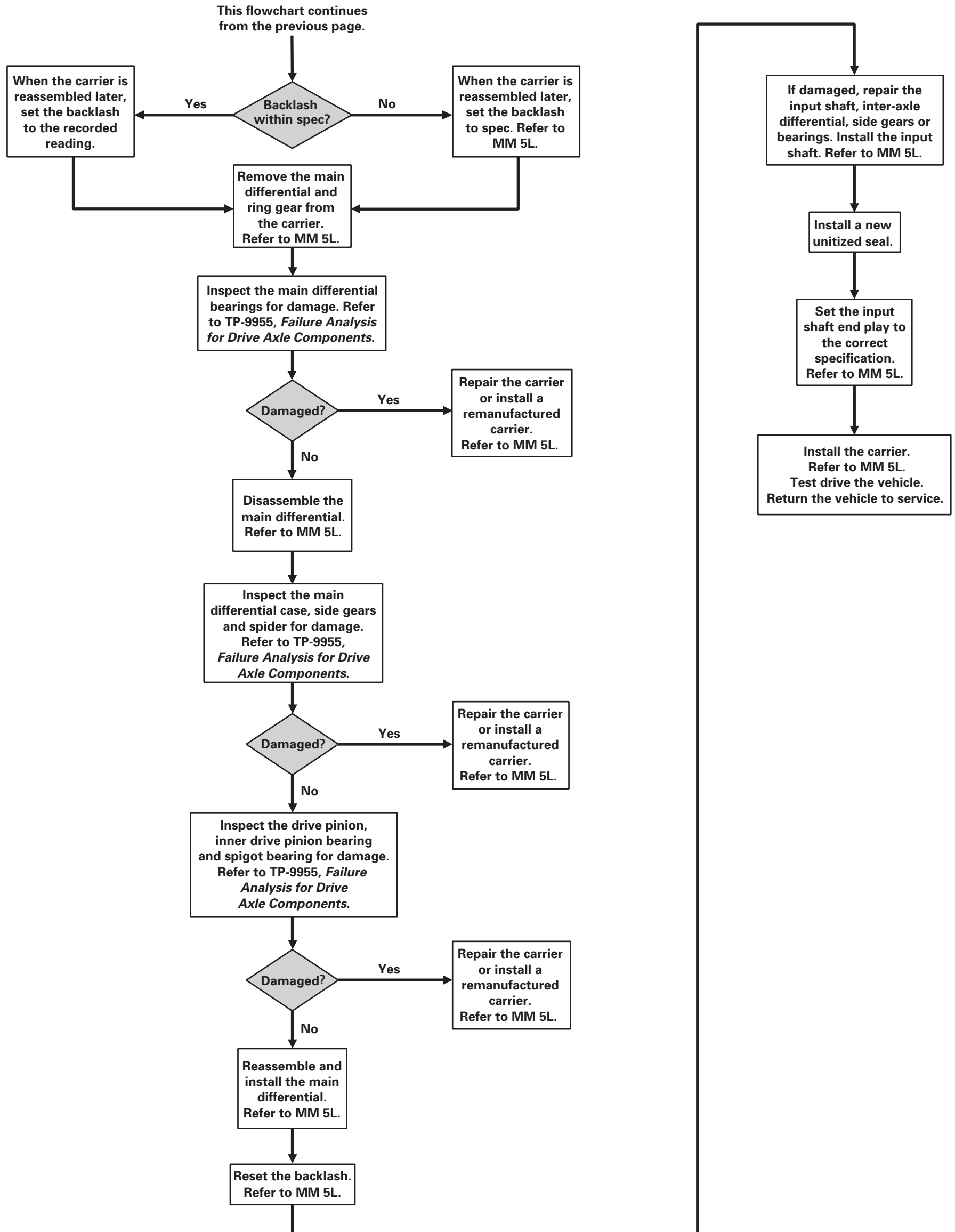
To order copies of these publications or a CD version of the diagnostic flowcharts (TP-99113), call Meritor's Customer Service Center at 800-535-5560.

Forward Tandem Carrier

Vehicle Will Not Move

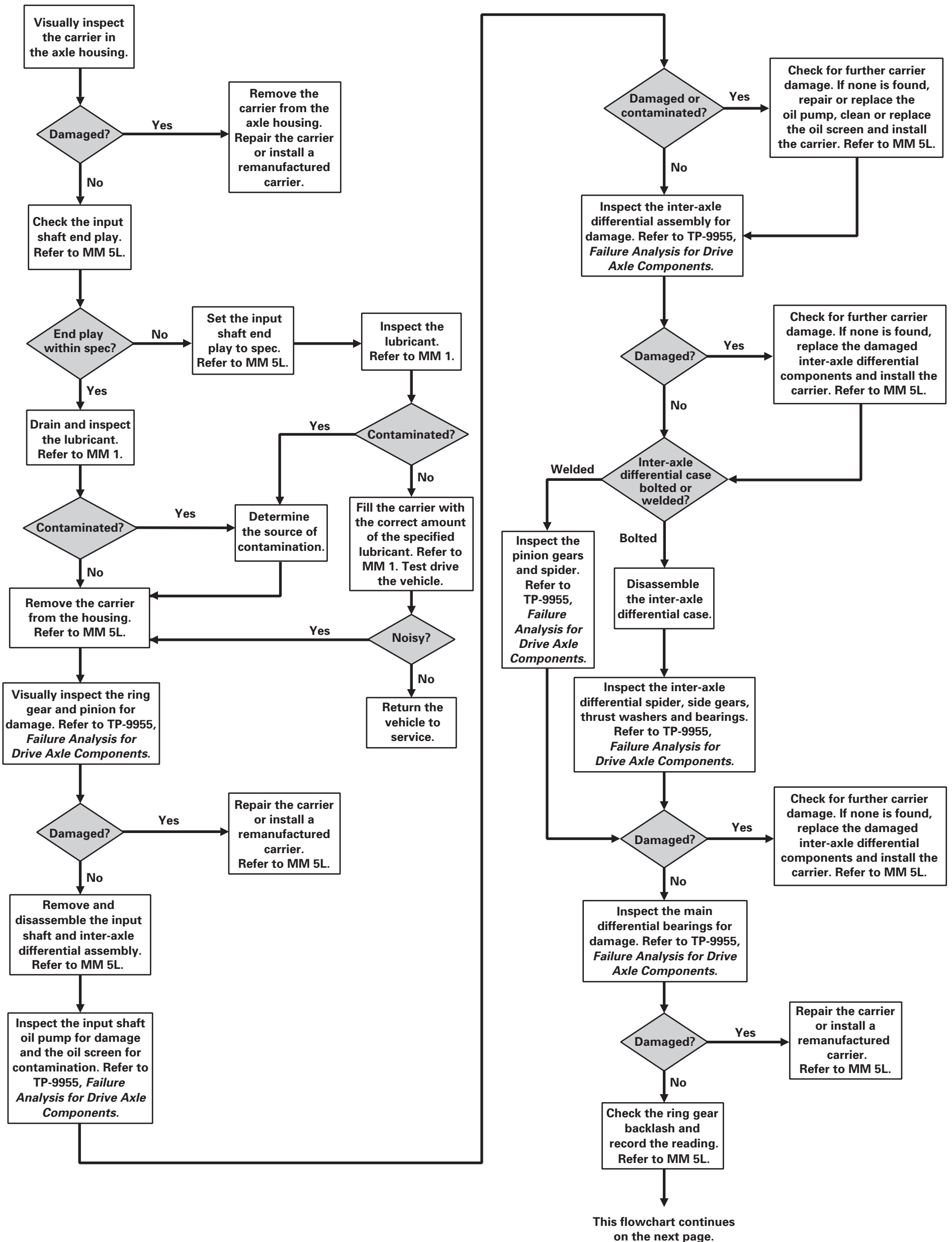


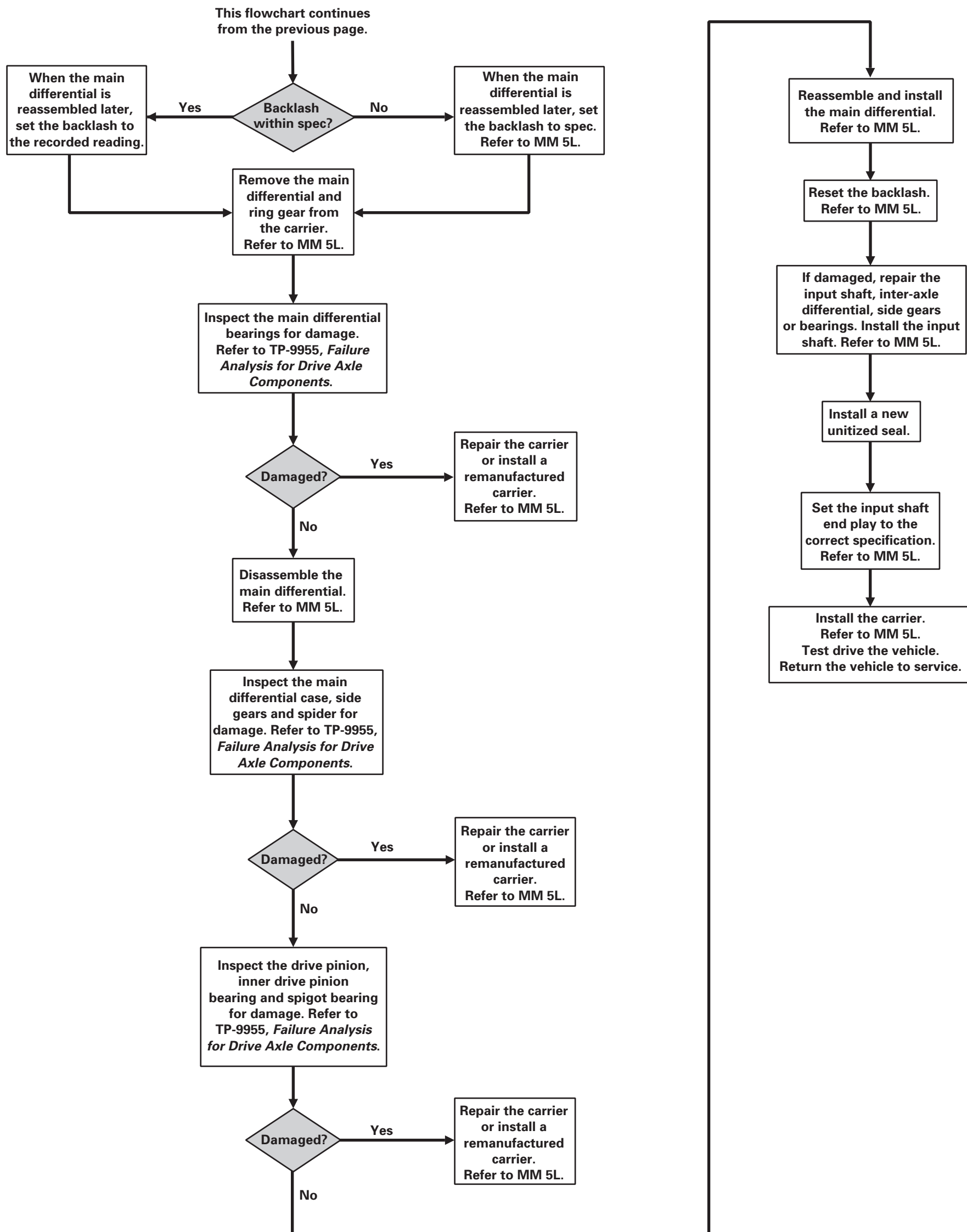
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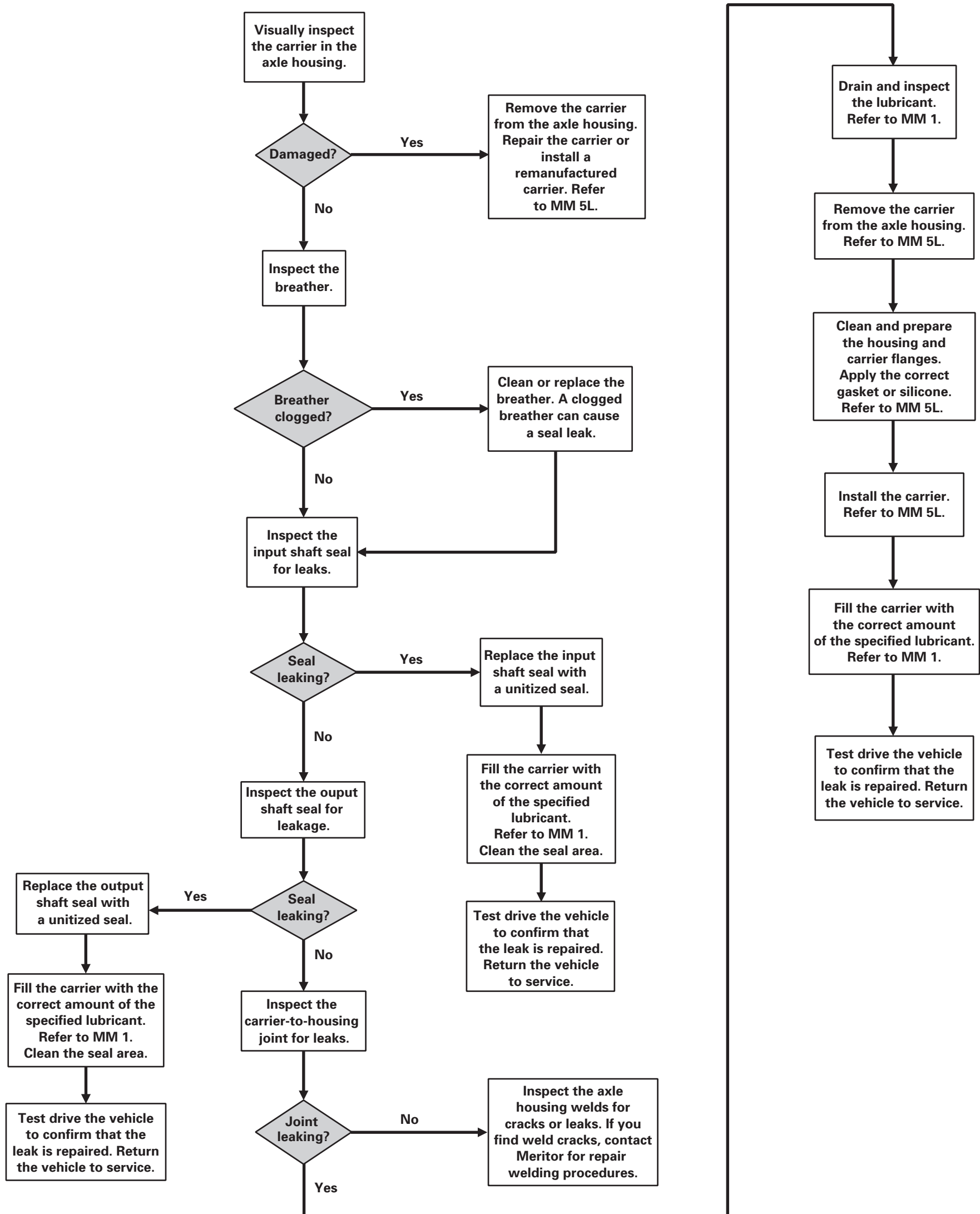
Forward Tandem Carrier

Differential Making Noise

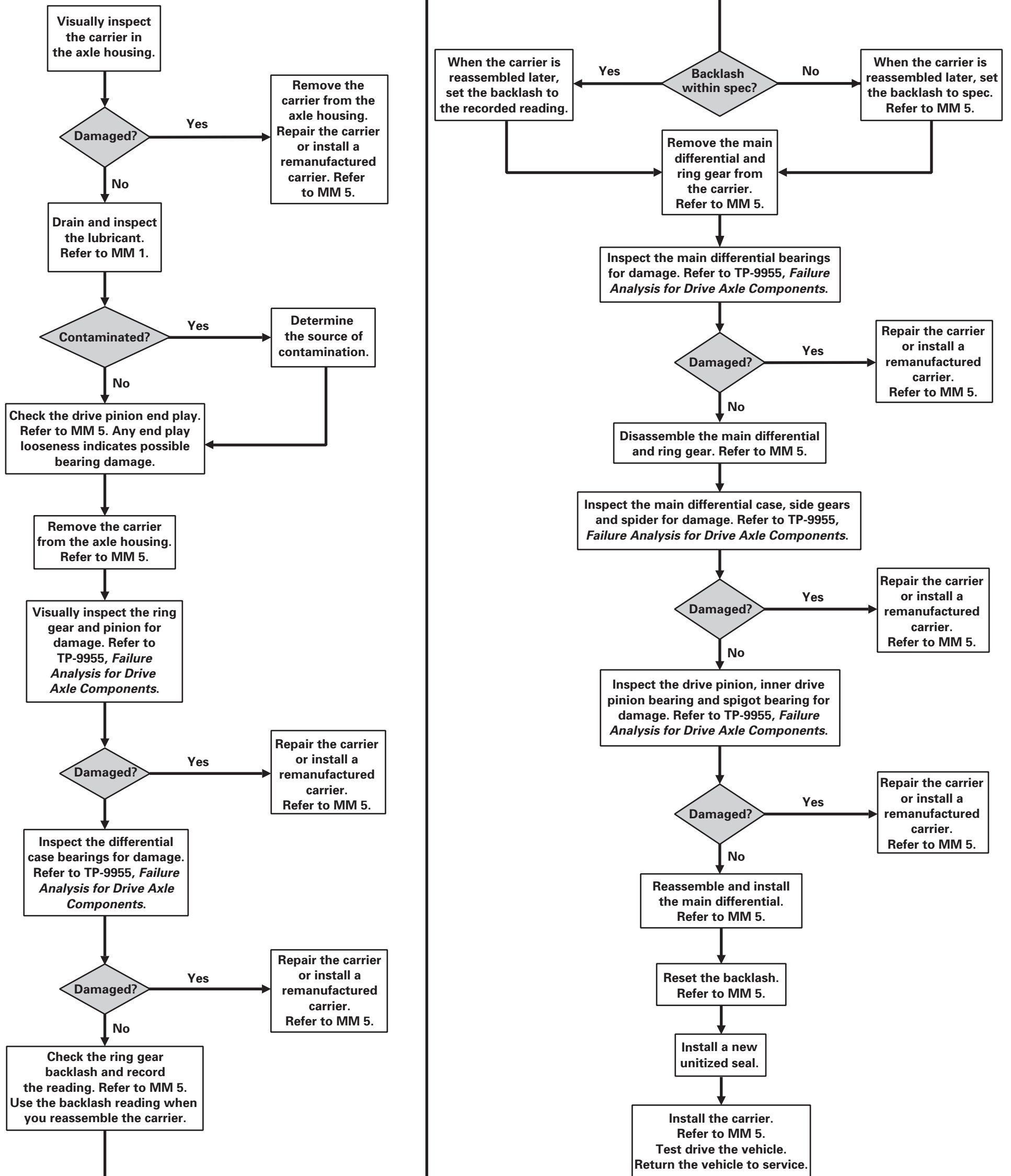




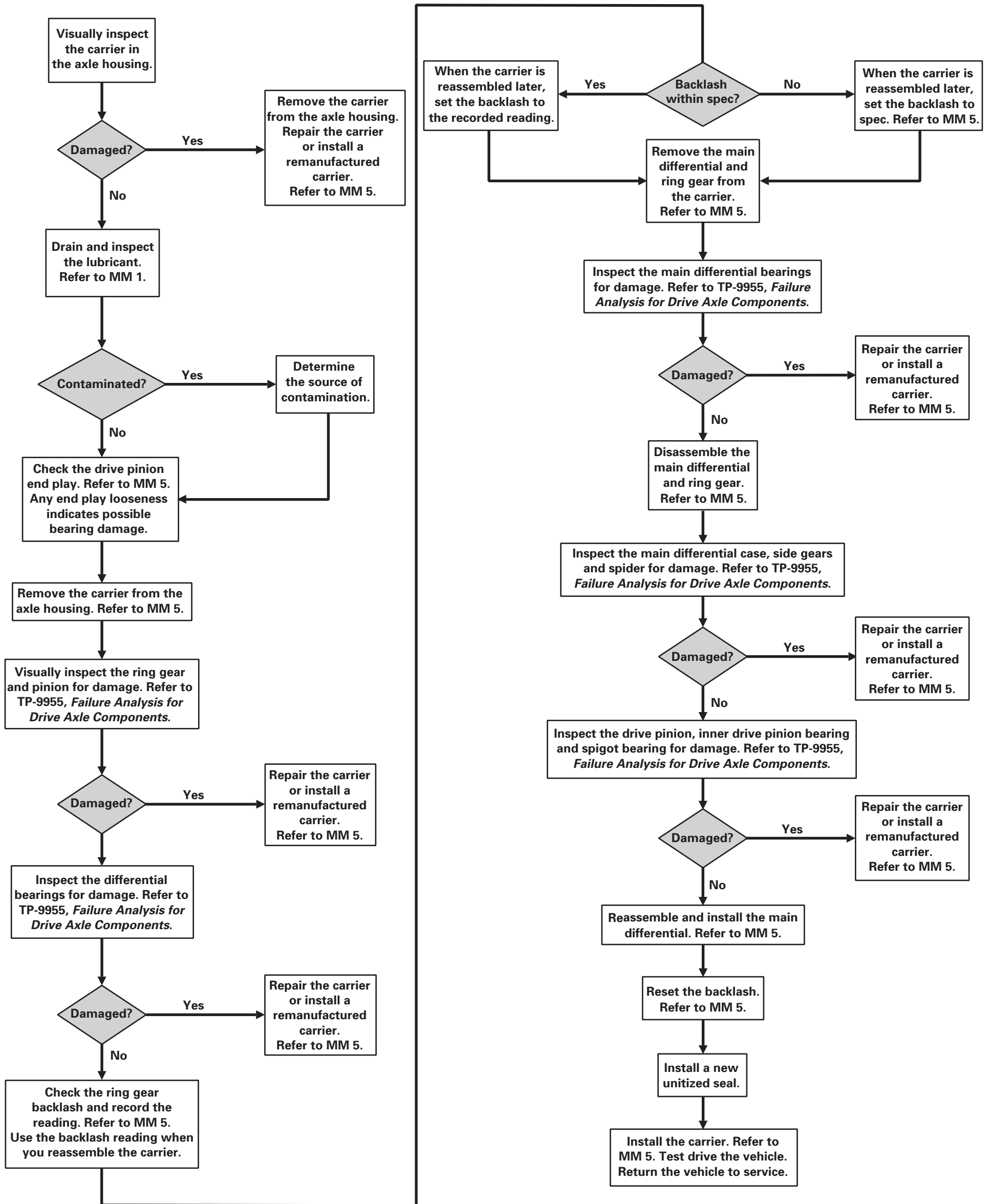
Forward Tandem Carrier Oil Leak



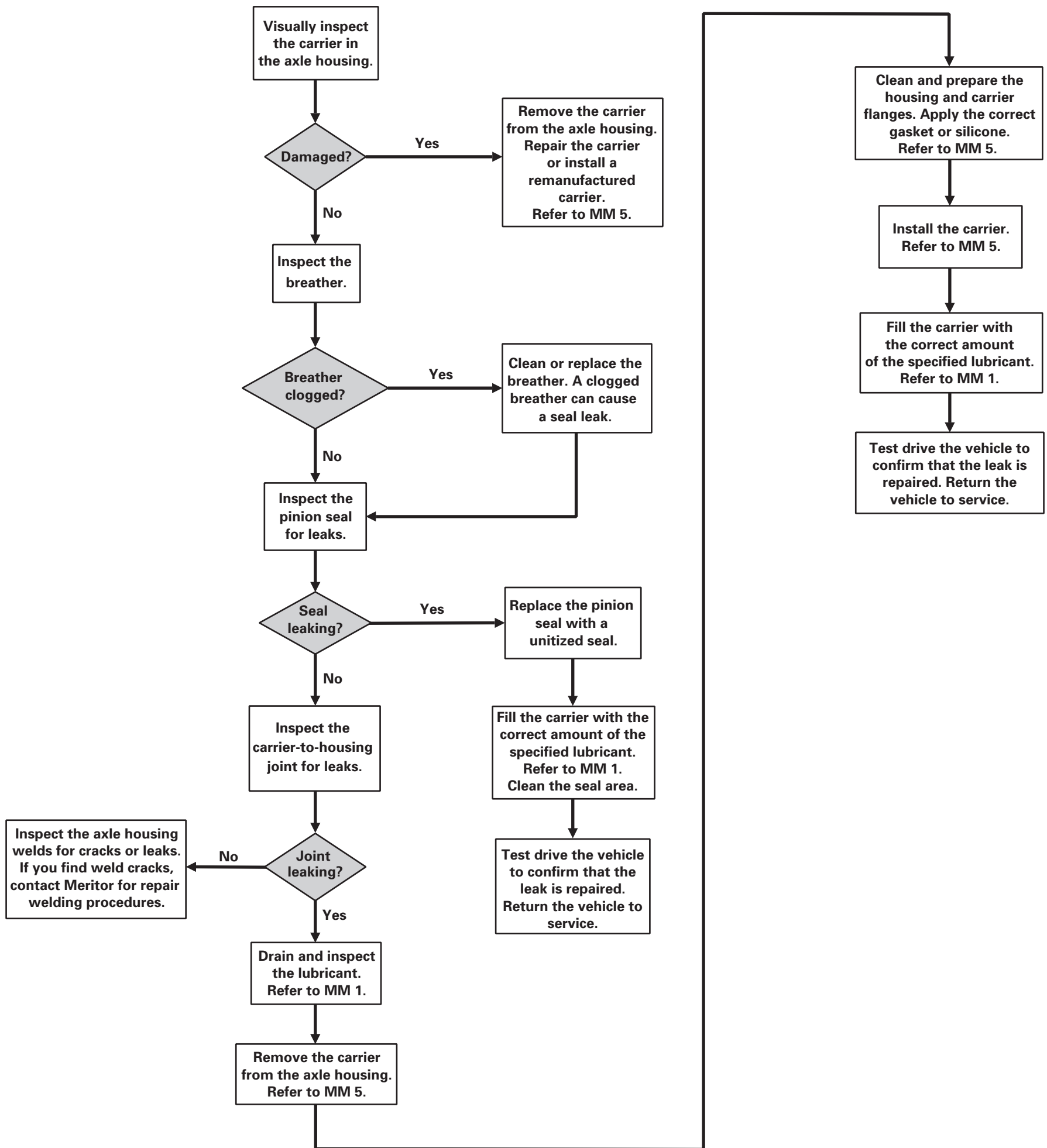
Rear Tandem or Single Carrier Vehicle Will Not Move



Rear Tandem or Single Carrier Differential Making Noise

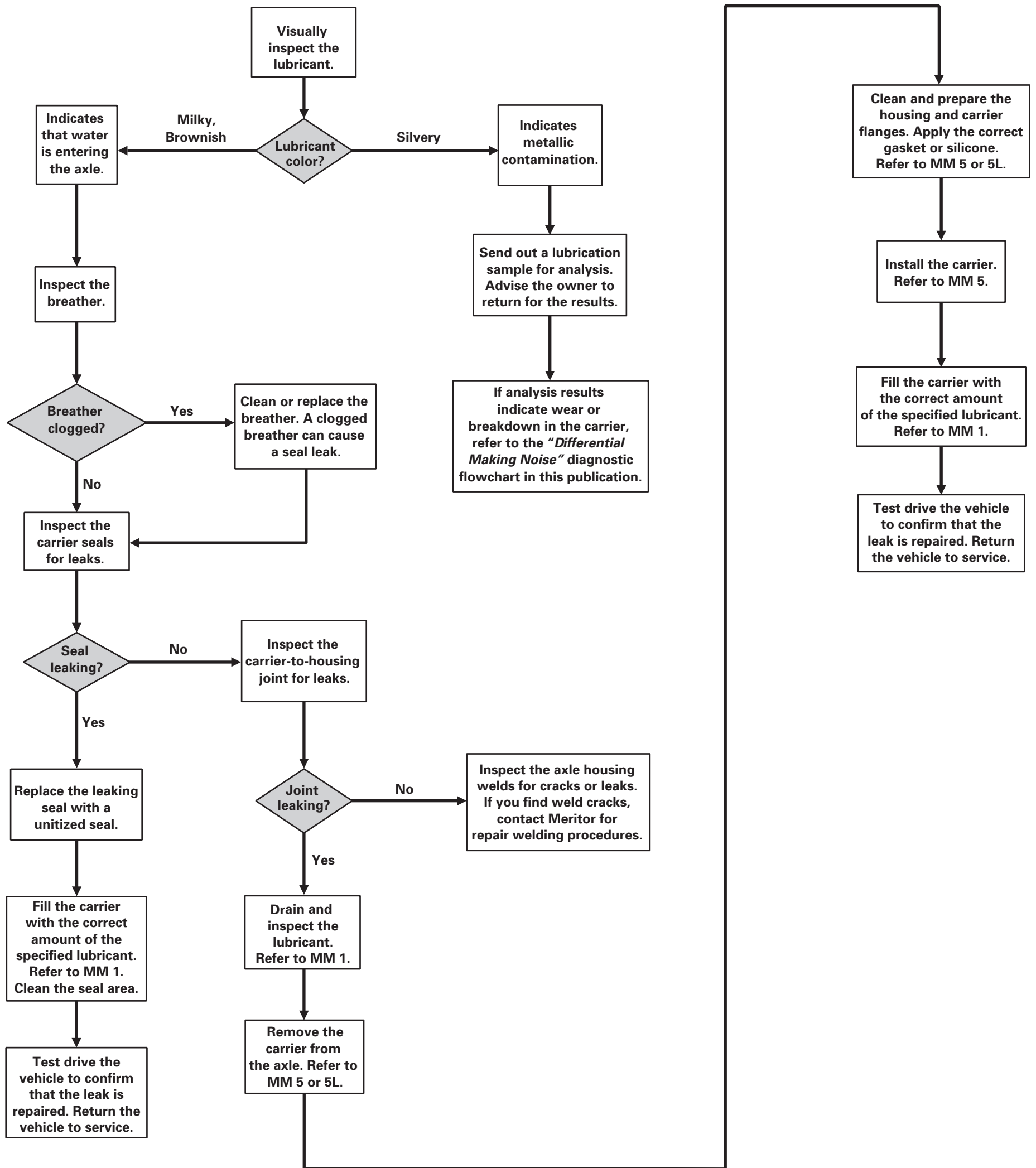


Rear Tandem or Single Carrier Oil Leak



All Rear Axles

Contaminated Lubricant Found During Preventive Maintenance





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1. AIR SYSTEM

The basic air system consists of an air compressor, reservoirs, valves, filters and interconnecting lines and hoses. It provides a means for braking; operating controls and accessories, and suspension (refer to Section 16, "Suspension", for complete information on suspension description and maintenance). An air system schematic diagram is annexed in the technical publications box provided with the vehicle for better understanding of the system.

2. BRAKES

This vehicle uses both the service brake and emergency/parking brake. The service brake air system is divided into two independent circuits to isolate front brakes from rear brakes, thus providing safe braking in the event that one circuit fails. Front axle brakes operate from the secondary air system, while brakes on both the drive axle and tag axle operate from the primary air system.

NOTE
The tag axle service brake operates only when the axle is in normal ride position (loaded and down).

Furthermore, the brake application or release, which is speed up by a pneumatic relay valve (R-12), will start with the rear axles and will be followed by the front axle, thus providing uniform braking on a slippery road. The vehicle is also equipped with an Anti-Lock Braking System (ABS), which is detailed later in this section.

The drive axle is provided with spring-loaded emergency/parking brakes, which are applied automatically whenever the control valve supply pressure drops below 40 psi (275 kPa).

3. AIR RESERVOIRS

The air coming from the air dryer is first forwarded to the wet air tank, then to the primary (for the primary brake system), secondary (for the secondary brake system), and accessory (for the pneumatic accessories) air tanks (Fig. 1 & 2).

Two additional air reservoirs may be installed on the vehicle: the kneeling air tank and ZF transmission air tank.

3.1 MAINTENANCE

Ensure that the wet (main) air tank is purged during pre-starting inspection. In addition, it is good practice to purge this reservoir at the end of every working day. The remaining reservoirs must be purged at every 12,500 miles (or 20 000 km) or once every year, whichever comes first.

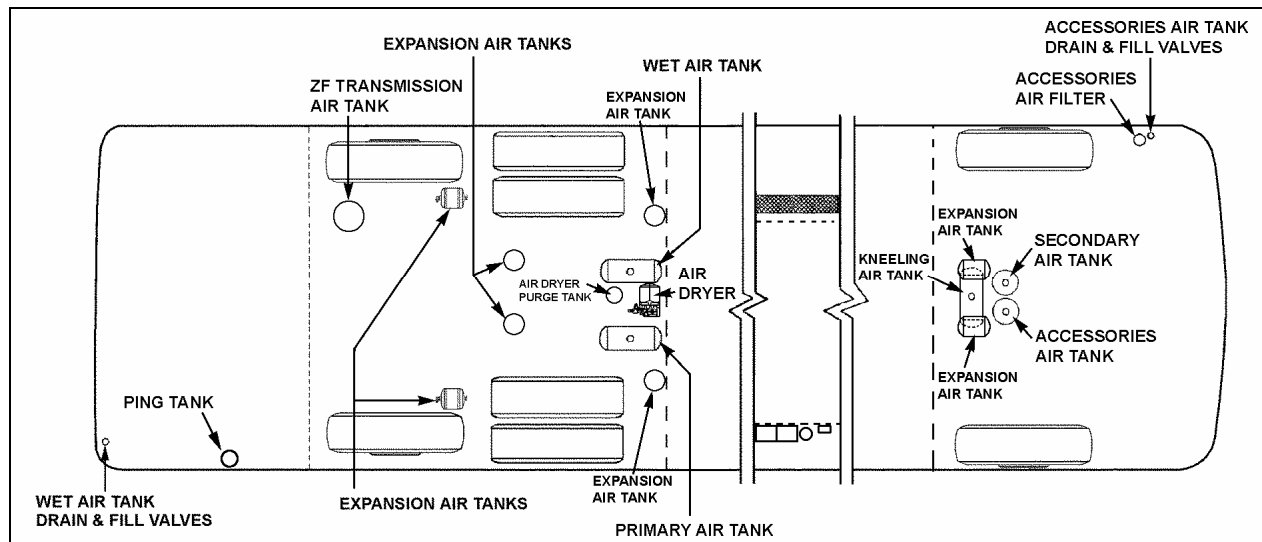


FIGURE 1: IFS AIR RESERVOIRS LOCATION

12212

Section 12: BRAKE AND AIR SYSTEM

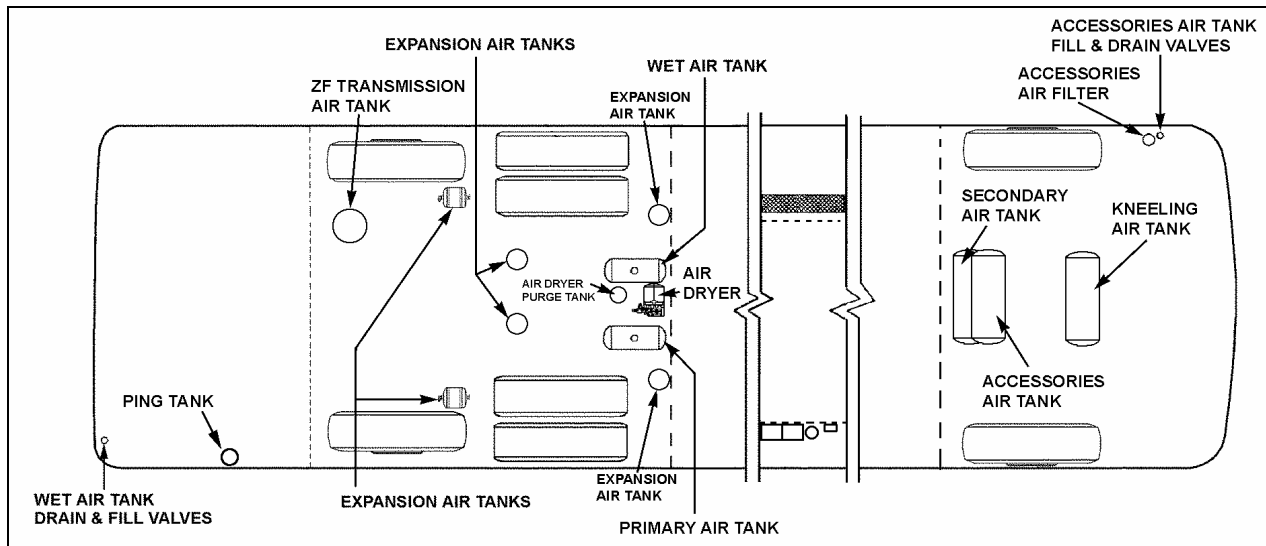


FIGURE 2: I-BEAM FRONT SUSPENSION AIR RESERVOIRS LOCATION

12213

3.1.1 Wet (Main) Air Tank

This reservoir, located above the L.H. wheel of drive axle in the rear wheelhousing, is provided with a bottom drain valve. A recommended purge using the bottom drain valve should be done every 12,500 miles (20 000 km), or once a year, whichever comes first.

3.1.2 Primary Air Tank

This reservoir is located above the R.H. wheel of the drive axle and is provided with a bottom drain valve (Fig. 1 & 2). It is recommended to purge the primary air tank every 12,500 miles (20 000 km) or once a year, whichever comes first.

3.1.3 Accessory Air Tank

The accessory air tank is installed close to the front axle and is provided with a bottom drain valve (Fig. 1 & 2).

Purge the reservoir by it's drain valve every 12,500 miles (20 000 km) or once a year, whichever comes first.

3.1.4 ZF transmission Air Tank

Installed on vehicles equipped with this option, this reservoir is located in the rear wheelhousing, beside the transmission on the L.H. side of the vehicle (Fig. 1 & 2). It is provided with a bottom drain valve.

Purge this reservoir every 12,500 miles (20 000 km) or once a year, whichever comes first.

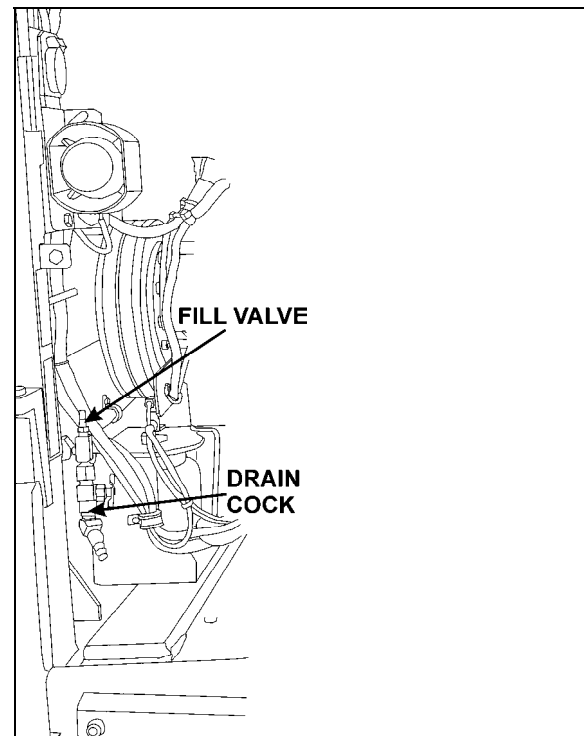


FIGURE 3: REAR VALVE LOCATION (TYPICAL)

12211

3.1.5 Secondary Air Tank

This tank is located in the front wheelhousing, behind the steering axle (Fig. 1 & 2). It is provided with a bottom drain valve.

Purge this reservoir every 12,500 miles (20 000 km) or once a year, whichever comes first.

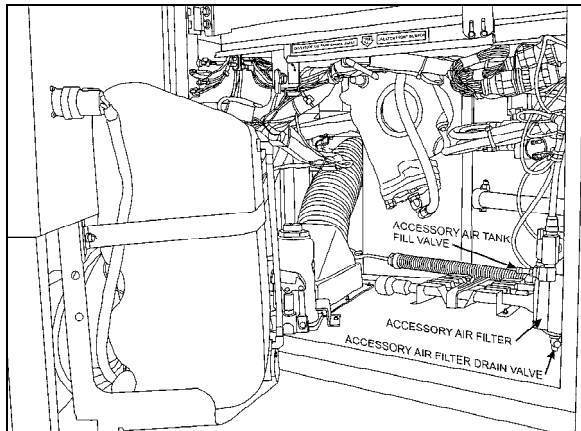


FIGURE 4: FRONT SERVICE COMPARTMENT 12210

3.1.6 Kneeling Air Tank

The kneeling air tank is installed on vehicles equipped with the Kneeling or Hi/Low-Buoy options. It is located in the front wheelhousing (Fig. 1 & 2), and is provided with a bottom drain valve.

3.2 PING TANK

The ping tank may be located behind the tag axle or in the engine compartment; in this case, it is accessible through the engine compartment R.H. side door. It is used to dissipate heat and to reduce noise produced by the air compressor cycling on and off.

4. AIR SYSTEM EMERGENCY FILL VALVES

All vehicles come equipped with two emergency fill valves that enable system pressurization by an external source such as an air compressor. The rear valve is located in the engine compartment and is accessible from engine R.H. side door (Fig 3). It is positioned close to the door opening.



CAUTION

Maximum allowable air pressure is 125 psi (860 kPa). Air filled through these two points will pass through the standard air filtering system provided by Prevost. Do not fill system by any point on the system.

The front valve is located in the front service compartment close to R.H. side of door frame (Fig. 4).

These two air system emergency fill valves are fitted with the same valve stems as standard

tires, and can be filled by any standard external air supply line.

The rear air system emergency fill valve will supply air for all systems (brakes, suspension and accessories) while the front fill valve will supply air for accessories only.

5. ACCESSORY AIR FILTER

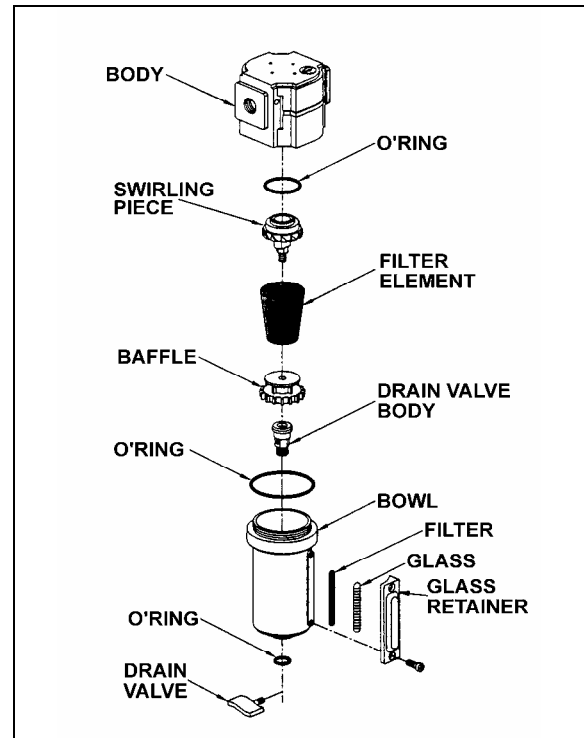


FIGURE 5: ACCESSORY AIR FILTER 12088

This filter is located inside the front service compartment (Fig. 4). Its main function consists in filtering the air supplied to the accessory air system, when connected to an external supply line. Ensure filter is purged whenever supplying the system with an external air line and at least every 12,500 miles (20 000 km). To purge, open drain valve (Fig. 4), let the moisture come out, then close the drain valve.

5.1 FILTER ELEMENT REPLACEMENT

Replace filter element whichever of the following occurs first: every 100,000 miles (160 000 km), every two years, or whenever differential pressure exceeds 15 psi (105 kPa) between filter inlet and outlet ports. Check condition of all three O'rings for damage. Replace when necessary (Fig. 5).

5.2 CLEANING

Clean filter body and bowl with a warm water and soap solution. Rinse thoroughly with clean

Section 12: BRAKE AND AIR SYSTEM

water. Blow dry with compressed air making sure the air stream is moisture free and clean. Pay particular attention to the internal passages. Inspect all parts for damage and replace if necessary.

6. AIR GAUGES (PRIMARY, SECONDARY AND ACCESSORY)

The air pressure gauges, located on the dashboard (see *"Operator's Manual"*), are connected to the DC-4 double check valve, located on the pneumatic accessory panel in the front service compartment.

The latter is connected to the air lines running from the primary and secondary air tanks, as shown on the pneumatic system diagram provided in the technical publications box. The accessory air gauge is connected to the accessory air tank using the drain valve connector. The vehicle should never be set in motion until the buzzer alarm and warning lights turn off, i.e. when air pressure registers at least 66 psi (455 kPa). Moreover, if pressure drops below 66 psi (455 kPa), the *"Low air pressure"* warning lights will turn on, and the *"Low air pressure"* buzzer will sound. Stop the vehicle immediately, determine and correct the cause(s) of pressure loss. Check the gauges regularly with an accurate test gauge. Replace the gauge with a new unit if there is a difference of 4 psi (27 kPa) or more in the reading.

7. AIR FILTER/DRYER

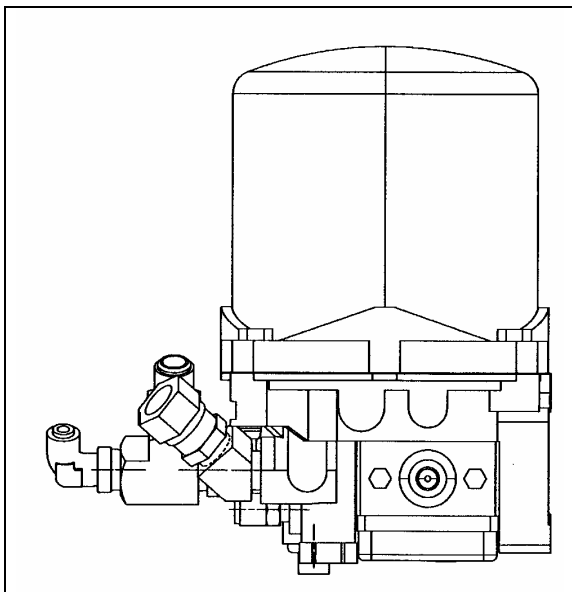


FIGURE 6: HALDEX AIR FILTER DRYER

12194

The air filter/dryer is located in front of rear wheelhousing above drive axle (Fig. 1, 2 & 6). Its purpose is to remove moisture that could damage the air system before the air enters the system reservoir. The air filter/dryer also filters the air to remove dirt, compressor oil, and other contaminants that can damage the system. Change cartridge every 100,000 miles (160 000 km) or once every two years, whichever comes first. The air dryer may be purged for maintenance purposes using the remote drain valve located in the engine compartment and accessible through the engine compartment R.H. side door. The valve is positioned close to the L.H. side of door opening (Fig. 3). The air filter/dryer has a built-in governor to maintain the system between 108 psig and 123 psig.

Maintenance and repair information is supplied in the maintenance information annexed to this section.

7.1 AIR FILTER/DRYER PURGE TANK

A tank is supplied to purge the air filter/dryer to remove moisture and contaminants.

8. AIR LINES

Copper piping, nylon-reinforced tubing, and flexible hoses are used to connect the units in the pneumatic system, including air brake system, suspension system and accessory systems such as the entrance door, fresh air damper cylinder, air horns, etc. Furthermore, the nylon tubing is color coded to ease identification. Refer to the following table for the complete color identification code. Service instructions for each type of air line are also provided under the applicable headings.

Color	Circuit
Red	Secondary
Green	Primary and Delivery
Yellow	Parking Brake
Blue	Suspension
Black	Accessory
Brown	Trailer Brake

8.1 COPPER PIPING

A heat dissipation copper piping assembly is used to dissipate the heat coming from the compressor before it enters the air filter/dryer. Connections should be checked for leakage at least every 6,250 miles (10 000 km) or twice a

year, whichever comes first. Tighten or replace when necessary. When replacing copper piping, the parts must be free of burrs, copper cuttings, and dirt. Blow out piping with compressed air. Any such particles will destroy sealing seats in air control units. Also, new piping must be the same size as the old one.

8.2 FLEXIBLE HOSES


A flexible hose is used normally where it is impractical to use copper or nylon tubing due to constant flexing during operation, such as brake chamber hoses. Hose connections should be tested for leakage at least every 6,250 miles (10 000 km) or twice a year, whichever comes first and tightened or replaced if necessary. Any hose which is chafed, worn or kinked should be replaced.

Teflon-braided stainless steel hoses used in the engine compartment must be replaced only with similar hoses.

8.3 NYLON TUBING

Nylon tubing is used for air lines in areas where usage of this material is suitable. Nylon tubing is flexible, durable, and weather resistant. When replacing an air line, use nylon tubing only where it has been used previously.

Nylon air lines must never be routed in areas where temperature could exceed 200°F (93°C).

	<p>CAUTION</p>
<p>Nylon air lines should be used to replace existing nylon lines only, and must comply with the color identification code to ease pneumatic system troubleshooting.</p>	

8.4 AIR LINE OPERATING TEST

If any trouble symptom such as slow brake application or slow brake release indicates a restricted or clogged air line, disconnect the suspected tube or hose at both ends and blow through it to clear the passage.

Inspect tubing and hose for partial restriction that may be caused by dents or kinks. If such a condition is found, the tubing or hose should be replaced.

8.5 AIR LINE LEAKAGE TEST

With air system fully charged and the brakes applied, coat all tubing and hose connections

with a soapy solution to check for air leakage. No leakage is permitted. Leakage can sometimes be corrected by tightening the connection. If this fails to correct the leakage, new fittings, nylon tubing, copper tubing, teflon-braided stainless steel and flexible hoses must be installed as applicable.

8.6 MAINTENANCE

Inspect all lines for cuts, swelling, kinks or other damage or deterioration. Check for lines being pinched by other components. Retaining clips and ties must be in place.

Any support or bracket should be in good condition and mounted firmly in position. Hose spring guards should be in usable condition and not distorted. Particular attention should be given to long lines. Any supporting component (clips, ties, grommets, etc.) must be secured to prevent against unnecessary vibration and eventual loosening of connection. Any detected leak should be repaired. Be sure nylon lines are not near areas of intense heat. Check for any missing grommets or loose material where chafing or cutting may occur. Replace with new material as required. In general, lines should be securely located in position and free from any binding condition which would hinder air flow.

9. PRESSURE REGULATING VALVES

There is one pressure regulator for the belt tensioners, and an optional one installed on vehicles equipped with the World transmission output retarder.

The belt tensioner pressure regulating valve is located in the engine compartment above the doors and is used to limit the air pressure in belt tensioners to 50 ± 2 psi (345 ± 15 kPa) (Fig. 7).

The optional regulator is located near the Webasto in the engine compartment (accessible through the engine R.H. side door). It is used for transmission retarder and should be adjusted to 80 ± 3 psi (550 ± 20 kPa).

	Air Pressure (psi)	Air Pressure (kPa)
Belt Tensioner	Series 60 50	Series 60 345
Retarder	80 ± 3	550 ± 20

Section 12: BRAKE AND AIR SYSTEM

9.1 MAINTENANCE

Every 100,000 miles (160 000 km) or once every two years, whichever comes first, disassemble the regulating valve and wash all metal parts in a cleaning solvent (Fig. 7). Examine the diaphragm; if cracked, worn or damaged, replace with a new one. If the valve is excessively grooved or pitted, it should be replaced. Replace any other part that appears worn or damaged. After reassembly, adjust to the specified pressure setting and check for air leakage.

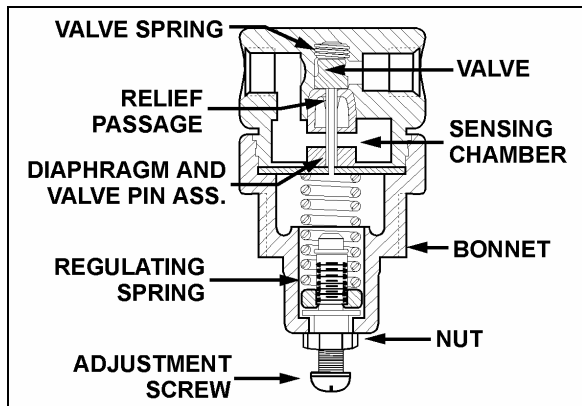


FIGURE 7: AIR PRESSURE REGULATING VALVE 12141B

9.2 PRESSURE SETTING PROCEDURE

Remove the dust cap from the pressure check valve (Fig. 8). Attach a pressure gauge at this port and check the pressure reading. If the pressure reading is incorrect, adjust as follows:

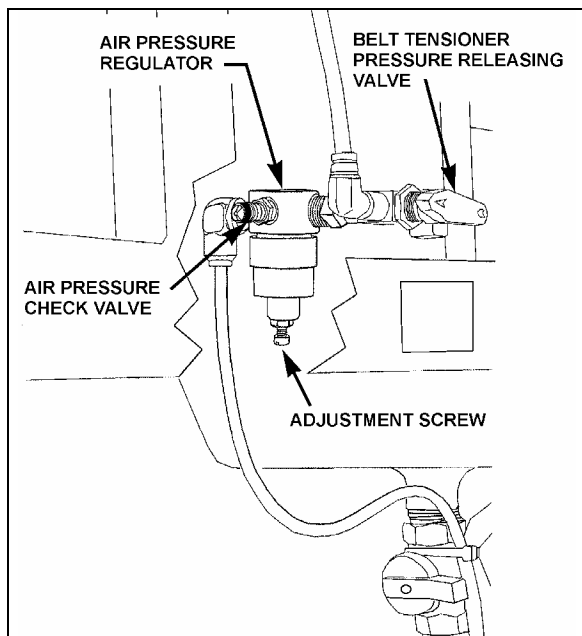


FIGURE 8: AIR PRESSURE REGULATOR 12200

1. Loosen the locking nut, turn the adjustment screw counterclockwise to decrease pressure by approximately 10 psi (70 kPa) below the required pressure.
2. Turn the adjustment screw clockwise to increase the pressure slowly until the required pressure setting is reached. Tighten the locking nut.
3. Remove pressure gauge and replace dust cap on the air pressure check valve.

10. AIR COMPRESSOR

10.1 WITH DETROIT DIESEL SERIES 60 ENGINE

The BA-921 Bendix air compressor is located on starter side of the engine, on the rear of the engine gear case (Fig. 9). Its function is to provide and maintain air under pressure to operate devices in brake and air systems.

This air compressor also drives the engine fuel pump which is bolted to the rear end of the compressor. The compressor crankshaft is designed to accept a drive coupling which is placed between the compressor and fuel pump.

The compressor is driven by the bull gear, and is water cooled. Engine coolant is fed to the compressor through a flexible hose tapped into the block water jacket and connected to the rear of the compressor. Coolant returns from the top of the compressor (governor side) through a flexible hose to the engine pump.

The air is taken from the air intake manifold and entered in the top of the compressor. The compressed air is pushed into the discharge line located on side of the compressor, which sends air to the air dryer. Lubricating oil is supplied to the compressor by a line from the cylinder block oil gallery connected to the air compressor. Lubricating oil returns to the engine crankcase through the air compressor drive assembly.

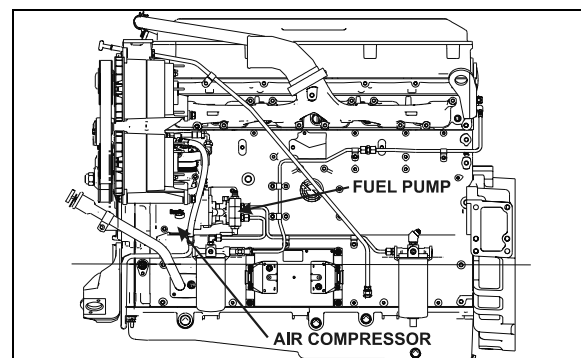


FIGURE 9: AIR COMPRESSOR LOCATION 03061

Maintenance and repair information on the Bendix BA-921 air compressor is supplied in the applicable booklet annexed to this section under reference number SD-01-676.

10.1.1 Compressor Removal and Installation

1. Exhaust compressed air from air system by opening the drain valve of each air tank.
2. Drain the engine cooling system. See Section 5: "Cooling System".
3. Identify and disconnect all air, coolant and oil lines from the compressor assembly.
4. Access the compressor by the engine R.H. side compartment. Remove the four compressor mounting bolts and the two fuel pump support bracket bolts.
5. Slide air compressor rearward to disengage the hub from coupling. Remove the air compressor.

Reverse removal procedure for installation.

10.2 WITH VOLVO D13 ENGINE

The Wabco System Saver 636 Twin Cylinder air compressor is located on the alternator side of the engine, at the flywheel end (Fig. 10). Its function is to provide and maintain air under pressure to operate devices in brake and air systems.

The compressor is driven by the ring gear, and is water cooled. Engine coolant is fed to the compressor through a flexible hose tapped into the block water jacket and connected to the rear of the compressor. Coolant returns from the top of the compressor (governor side) through a flexible hose to the engine pump.

The air is taken from the air intake manifold and entered in the top of the compressor. The compressed air is pushed into the discharge line located on side of the compressor, which sends air to the air dryer. Lubricating oil is supplied to the compressor by a line from the cylinder block oil gallery connected to the air compressor. Lubricating oil returns to the engine crankcase through the air compressor drive assembly.

Maintenance and repair information on the Wabco 636 Twin Cylinder air compressor is supplied in the applicable booklet annexed at the end of this section.

Item	Description	Notes
1	Air Compressor	Wabco 636

2	O'Ring	
3	Stud (3)	M12
4	Flange Nut (3)	Torque to 15lb-ft (20 Nm)
5	Nipple (2)	
6	Hose Assembly	

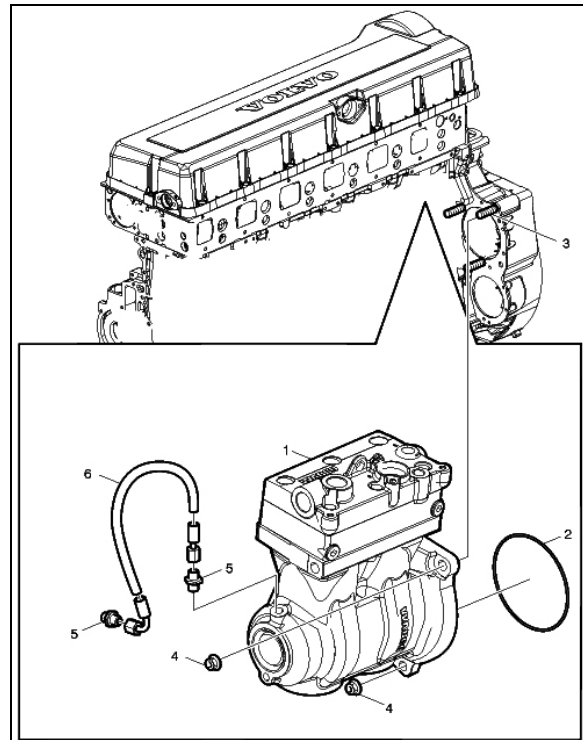


FIGURE 10: AIR COMPRESSOR LOCATION 03061

10.2.1 Compressor Removal and Installation

1. Exhaust compressed air from air system by opening the drain valve of each air tank.
2. Drain the engine cooling system. See Section 5: "Cooling System".
3. Access the compressor by the engine R.H. side compartment. Identify and disconnect all air, coolant and oil lines from the compressor assembly.
4. Remove the three compressor flange mounting nuts.
5. Slide air compressor rearward to disengage the hub from coupling. Remove the air compressor.

Remove and retain the oil supply tube that runs between the compressor and the engine

Reverse removal procedure for installation.

Section 12: BRAKE AND AIR SYSTEM

11. EMERGENCY/PARKING BRAKE CONTROL VALVE (PP-1)

A push-pull control valve mounted on the L.H. lateral console is provided for parking brake application or release. The spring brakes are self-actuated whenever the control valve supply pressure drops below 40 psi (275 kPa). In the UP position, brakes are ON. In the DOWN position, brakes are RELEASED. A protective case around the knob prevents accidentally releasing the brakes.

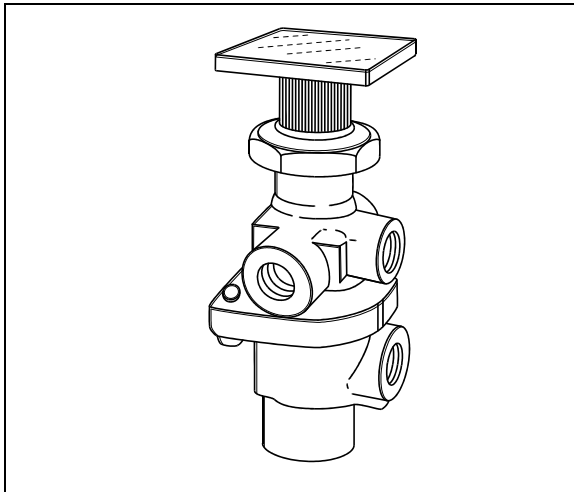


FIGURE 11: PP-1

12142

Maintenance and repair information on this valve is supplied in the applicable booklet annexed to this section under reference number SD-03-3611.

Remove the valve the following way:

1. Drain the air system.
2. Access this valve by tearing out the finishing panel, which holds the controls in place (Fig. 11).
3. Disconnect the air tubes.
4. Remove the retaining screws.
5. Service or replace the valve.
6. Installation is the reverse of removal.

12. EMERGENCY / PARKING BRAKE OVERRULE CONTROL VALVE (RD-3)

A RD-3 control valve is used with the optional parking brake overrule system. In the case of self-application of spring brakes due to a pressure drop, the brakes can be released by holding down this control valve. Maintenance and repair information on this valve is supplied

in the applicable booklet annexed to this section under reference number SD-03-3611.

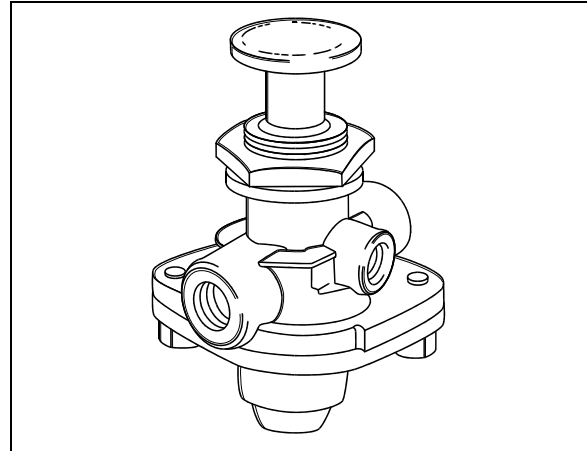


FIGURE 12: RD-3

12136

13. FLIP-FLOP CONTROL VALVE (TW-1)

A flip-flop control valve mounted on the L.H. lateral console is provided to unload tag axle air springs (and to lift tag axle if vehicle is so equipped). Another one controls the low-buoy system (coaches only). It is a manually operated "on-off" valve. Maintenance and repair information on this valve is supplied in the applicable booklet annexed to this section under reference number SD-03-3602.

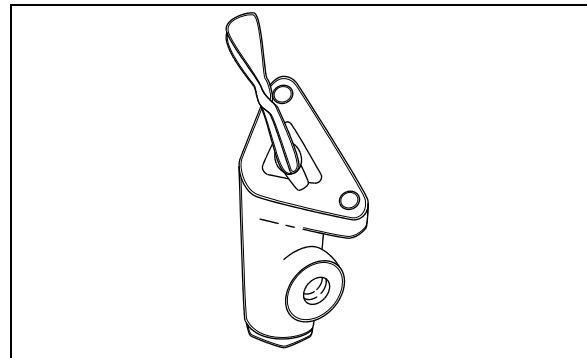


FIGURE 13: TW-1

12138

14. DUAL BRAKE APPLICATION VALVE (E-10P)

The E-10P dual brake valve is a floor mounted, foot-operated type brake valve with two separate supply and delivery circuits. This valve is located in the front service compartment (Fig. 14).

14.1 BRAKE PEDAL ADJUSTMENT

After brake pedal replacement or repair, adjust the pedal to its proper position according to the following procedure:

1. Replace the linkage, loosen threaded rod lock nuts and screw or unscrew the threaded adjustment rod in order to obtain a 45° brake pedal inclination (Fig. 14).
2. Tighten threaded rod lock nuts.

14.1.1 Maintenance

Maintenance and repair information on the E-10P dual brake application valve is supplied in the applicable booklet annexed to this section under reference number SD-03-830.

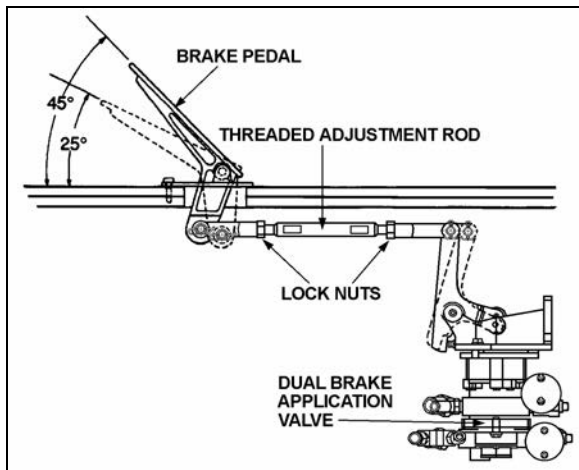


FIGURE 14: BRAKE PEDAL ADJUSTMENT 12208

15. STOPLIGHT SWITCHES

Two electro-pneumatic stoplight switches are mounted on the dual brake application valve (E-12). The upper one is used for the primary air circuit while the lower one is used for the secondary air circuit. Both switches are connected in parallel and have the same purpose, i.e. completing the electrical circuit and lighting the stoplights when a brake application is made. The upper switch (AC Delco) is designed to close its contact between 2 psi and 4 psi (14 kPa to 28 kPa) (Fig. 15), while the lower one (Bendix, SL-5) closes its contact at 4 psi (28 kPa) (Fig. 16). The switches are not serviceable items; if found defective, the complete unit must be replaced.

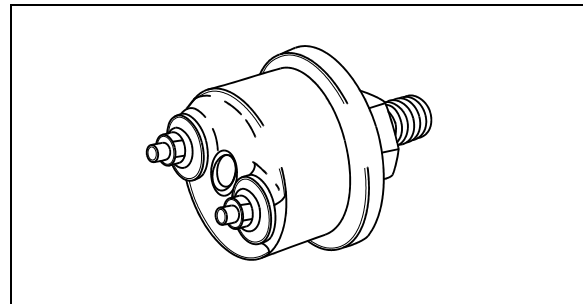


FIGURE 15: DELCO SWITCH 12139

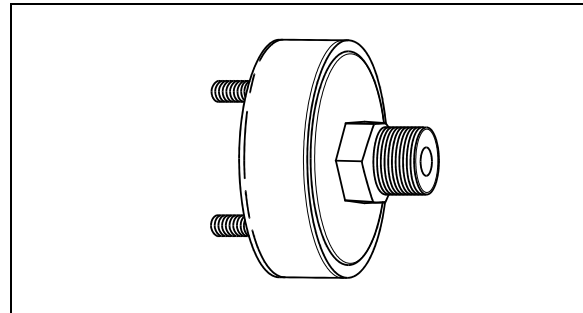


FIGURE 16: BENDIX SWITCH 12140

16. PARKING BRAKE ALARM SWITCH

Refer to the appropriate annexed booklet (Bendix, SL-5 Stop Light Switch; reference no. SD-06-2501).

The parking brake alarm uses the same switch as the stoplights. It is mounted on the spring brake valve and operates in conjunction with a NC relay to sound a warning alarm by completing the electrical circuit when the ignition key is turned OFF with parking brake released.

17. BRAKE RELAY VALVE (R-12 & R-14)

The primary air system includes three brake relay valves being supplied by the dual brake valve, and which function is to speed up the application and release of the service brakes.

One Wabco R-14 valve located in the rear underframe supplies the drive axle service brake air line, while the other two R-12 valves supply independently both the tag axle right and left service brake air line and act as interlock valves. These valves are accessible from under the vehicle at the level of the tag axle. Maintenance and repair information on these valves is supplied in the applicable booklet annexed to this section under reference number SD-03-1064.

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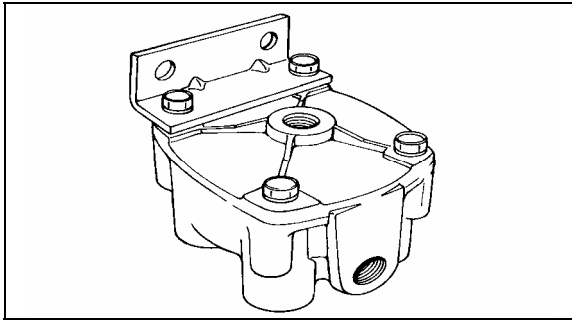


FIGURE 17: R-12

12074

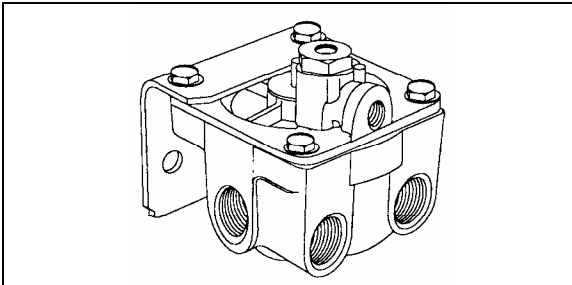


FIGURE 18: R-14

12207

18. QUICK RELEASE VALVES (QR-1)

The quick release valve is located on the front axle service brakes air line and permit rapid exhaust of air pressure from brakes, thus decreasing the brake release time.

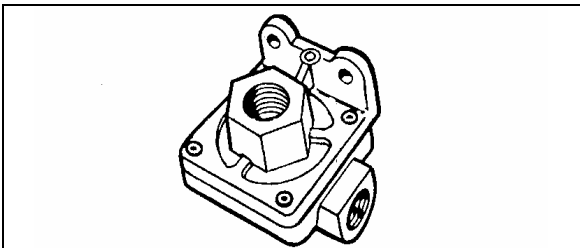


FIGURE 19: QR-1

12075

Maintenance and repair information on this valve is supplied in the applicable booklet annexed to this section under reference number SD-03-901.

19. SPRING BRAKE VALVE (SR-7)

The spring brake valve is located in the rear underframe. The SR-7 Modulating Valve is used in conjunction with a dual air brake system and spring brake actuator and performs the following functions:

- Provides a rapid application of the spring brake actuator when parking.
- Modulates the spring brake actuator application using the dual brake valve

should a primary failure occur in the service brake system.

- Prevents compounding of service and spring forces.

Maintenance and repair information on the spring brake valve is supplied in the applicable booklet annexed to this section under reference number SD-03-9043.

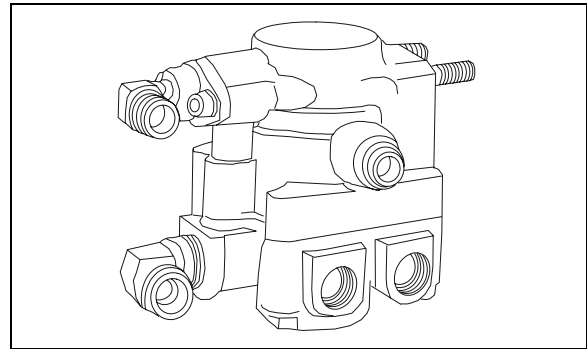


FIGURE 20: SR-7

12206

20. PRESSURE PROTECTION VALVE (PR-4)

Maintenance and repair information on the pressure protection valve is supplied in the applicable booklet annexed to this section under reference number SD-03-2010.

The air system includes two pressure protection valves (Fig. 21). One valve is installed on the manifold block, and insures at all times a minimum pressure of 70 psi (482 kPa) in the suspension air system in the event that a pressure drop occurs in either the suspension air system or accessory air system. This valve is located in the front service compartment beside the air filter.

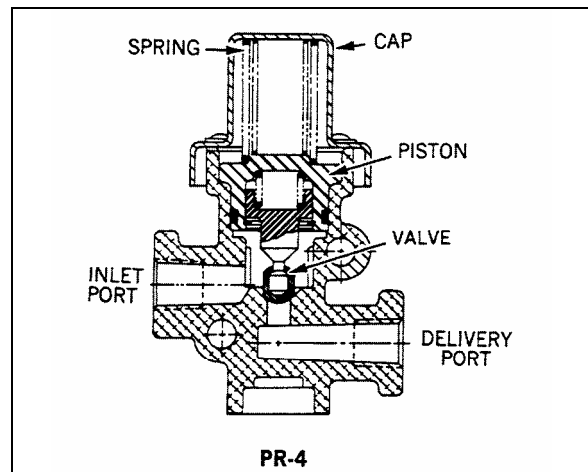


FIGURE 21: PR-4

12174

The other valve is installed on the accessory air tank, and insures a minimum pressure of 70 psi (482 kPa) in the accessory air system in the event that a pressure drop occurs in either the suspension air system or braking air system (refer to Fig. 1 & 2 for accessory air tank location).

21. LOW PRESSURE INDICATOR (LP-3)

Maintenance and repair information on the low pressure indicators is supplied in the applicable booklet annexed to this section under reference number SD-06-1600.

The air system includes two low pressure switches (Fig. 22), both located on the pneumatic accessory panel in the front service compartment. One serves for the parking brake signal, its pressure setting is 66 ± 6 psi (455 ± 40 kPa). The remaining pressure switch monitors the parking brake telltale panel indicator; its pressure setting is 30 psi (205 kPa).

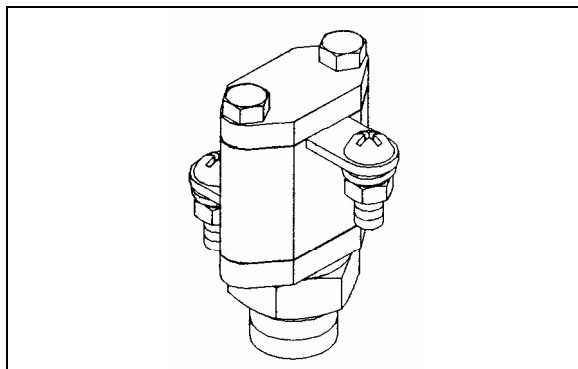


FIGURE 22: LP-3 12214

22. SHUTTLE-TYPE DOUBLE CHECK VALVE (DC-4)

Maintenance and repair information on the shuttle-type double check valve is supplied in the applicable booklet annexed to this section under reference number SD-03-2202.

The double check valve is located on the pneumatic accessory panel in the front service compartment. In the event of a pressure drop in either the primary or secondary system, this unit will protect the emergency /parking brake control valve and the intact portion of the air system from pressure loss.

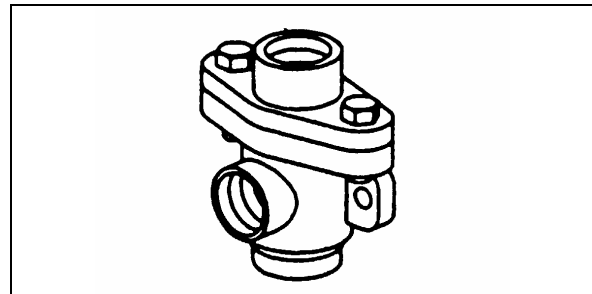


FIGURE 23: DC-4 12134

23. EMERGENCY DOOR OPENING VALVES

Two emergency door opening three-way valves are installed on coaches. One is in the front service compartment, readily accessible. The other one is on the R.H. side lateral console, close to the entrance door. When used, the valve releases pressure in the door locking cylinder, thus allowing the door to be manually opened.

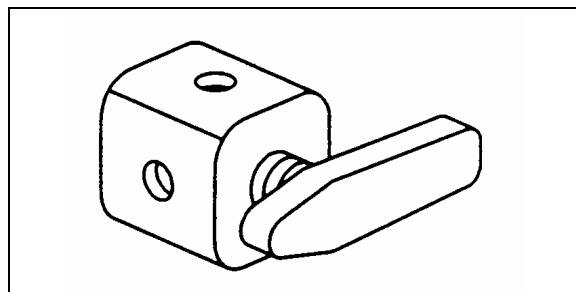


FIGURE 24: THREE-WAY VALVE 12186

24. AIR HORN VALVE

The air horn valve is located in the L.H. front service compartment. The air horn button is on the center of the steering wheel. Refer to section 23 "ACCESSORIES" for more information.

25. AIR SYSTEM TROUBLESHOOTING

The following list has been designed to help in troubleshooting some of the most common problems in the air system and main causes. For air brakes troubleshooting, refer to "Air Brakes Troubleshooting" in this section. For more troubleshooting information, refer to the manufacturer's brochures annexed to this section.

Air pressure doesn't rise to, or doesn't maintain, a normal setting:

- Defective air gauge (registering incorrectly).
- Excessive leaking in air system.

Section 12: BRAKE AND AIR SYSTEM

- Reservoir drain cock open.
- Governor poorly adjusted or defective.
- Defective compressor.
- Worn compressor or excessive wear on piston and/or ring.
- Air pressure rises to normal setting too slowly.

Excessive leaking in air system:

- Clogged engine air cleaner.
- Worn compressor or excessive wear on piston and/or ring.
- Engine speed too low.

Air pressure rises above a normal setting:

- Defective air gauge (registering incorrectly).
- Governor poorly adjusted or defective.
- Restriction in line between governor and compressor unloading mechanism.

Air pressure drops quickly when engine is stopped:

- Leaks in compressor discharge valve.
- Leaks in governor.
- Leaks in air lines.
- Leaks in air system valves.

26. BRAKE OPERATION

The vehicle braking system uses both service and parking air-operated brakes. The air system is divided into two independent circuits to isolate the front axle brakes and the rear axle brakes (drive and tag), thus providing safe brake operation in the event that one circuit of the system fails. The primary circuit is connected to the drive and tag axle brakes, while the secondary circuit is connected to the front axle brakes. The tag axle service brakes operate only when the axle is in the normal driving (loaded) position. The spring-type emergency brakes are mounted on the drive axle, and will apply automatically if primary system pressure falls below 40 psi (276 kPa).

Furthermore, brake application or release, which is speed up by a pneumatic relay valve (R-12), will start with the rear axles and be followed by the front axle, thus providing uniform braking on

a slippery surface. The vehicle is also equipped with an Anti-lock Brake System (ABS), detailed later in this section.

Brake and air system maintenance consists of periodic inspections. Check all parts for damage and brake adjustment (refer to subsequent headings in this section for more details). Ensure all fasteners are tight (refer to "Specifications" for recommended tightening torques).

27. AIR BRAKES

27.1 DISC BRAKES

Knorr-Bremse SN7000 disc brakes are used on all axles. The front and drive axle discs are actuated by 24 square inch effective area air brake chambers, while on tag axle, the brake chambers have a 14 or 16 square inch effective area for service. The *Knorr-Bremse SN7000* brakes are supplied with automatic clearance (slack) adjusters as standard equipment for easier adjustment. For more information on disc brake components and maintenance, refer to the manufacturer's brochure at the end of this section.

27.1.1 Disc Brake Pads

Brake pads have to be checked on a regular basis depending on the vehicle operation. The remaining thickness of the pads should never be less than 3/32 in (2 mm). To check pad condition without removing the wheel, verify the position of guide bushing (6) relatively to guide sleeve (4) (see Fig. 25). When guide sleeve is in alignment with guide bushing, brake pad thickness has to be checked more precisely with the wheel removed. When replacing brake pads, all four pads on an axle have to be changed at the same time. There is no inner or outer pad, since all pads are the same. Once removed, worn pads should be replaced in their original position.

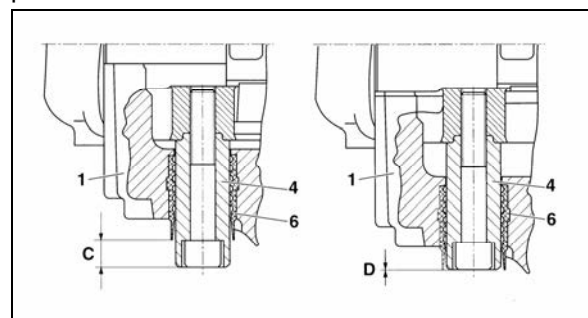


FIGURE 25: BRAKE PAD CHECK

12117

27.1.2 Caliper Maintenance

Use the following procedure for brake calipers servicing. The procedure must be followed in proper sequence to ensure that only needed repairs or replacements are performed on calipers. Problems such as hot brakes or cracked rotors may be effects of sticking calipers, too-small clearance between rotor and pad or possible trapped air pressure in the brake chamber. If any of these symptoms occur, perform this procedure before replacing the rotor to ensure the cause of the problem is properly solved.

1. Check for presence of residual pressure:

To check if there is any residual air pressure in the brake chamber, make four or five brake applications, then try to turn the wheel manually, if the wheel does not turn, use a wrench to crack the air line and listen for trapped air in the brake chamber then try to turn the wheel manually again. If you find trapped air in the brake booster, ensure that all pneumatic components in the braking system are functioning properly.

NOTE

A residual pressure of 2-3 PSI in the system is sufficient to prevent the brakes from releasing. Also the stop light switch can operate with as little as 1 PSI, therefore an illuminated brake light does not mean brakes are dragging.

2. Pad to rotor clearance inspection:

Remove clip and washer (26 & 45, Fig. 26), push down retainer bar (11), pull out pin (44) and remove retainer bar. Push caliper toward actuator (center of vehicle) for maximum clearance.

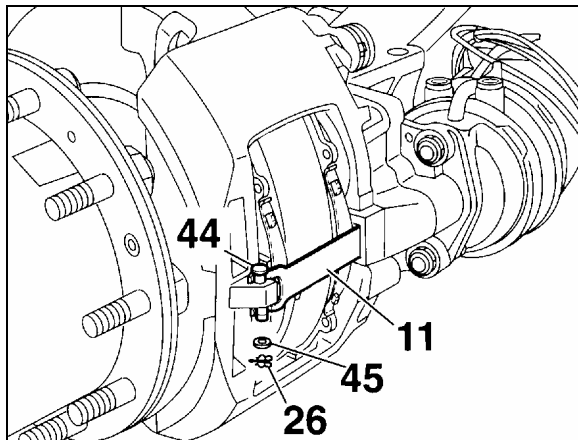


FIGURE 26: CLEARANCE INSPECTION 12119

3. Measure pad to rotor clearance:

Place a long feeler gauge (long enough to measure across entire tappet surface) between the tappet and the backing plate of the pad, measure clearance at both tappets. Clearance should range between 0.020 and 0.035 inch (0.5 mm and 0.9 mm), with a maximum difference between tappet measurements on same brake of 0.008 inch (0.2 mm).

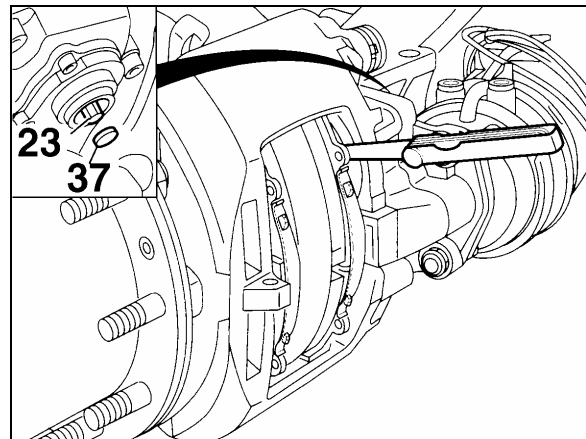


FIGURE 27: RUNNING CLEARANCE 12116

4. Checking the adjuster



CAUTION

Use only a standard box wrench on the adjuster hexagonal pinion. Do not overtorque the pinion as overtorquing will damage the pinion.

- a) Remove cap (37, Fig. 27).
- b) Using a box wrench (8 mm), turn the adjuster pinion (23, Fig. 28) counterclockwise about 2 - 3 clicks to increase running clearance. By operating the braking system about 5 - 10 times (30 PSI or 2 bar), the wrench should turn clockwise in small increments if the adjuster is functioning correctly (Figs. 28 and 29).

NOTE

With increasing number of applications, the incremental adjustment will decrease.

- c) In case of malfunction, i. e. the pinion or box wrench:
 - i) Does not turn.
 - ii) Turns only with the first application.

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- iii) Turns forwards then backwards with every application.

In any of the above cases, the automatic adjuster has failed and the caliper must be replaced. In such cases the brakes can be adjusted manually to run a short distance.

- d) Take the box wrench off. Replace the cap and check for proper sealing.

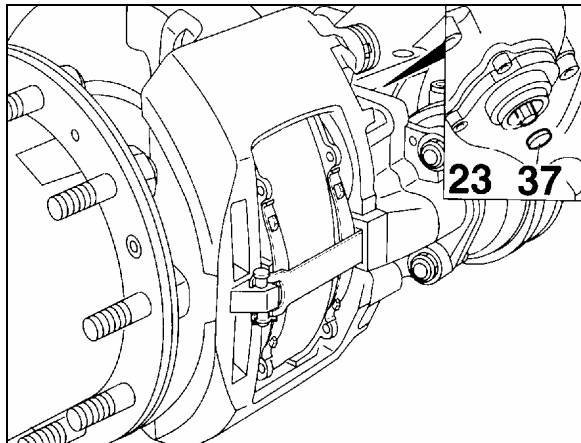


FIGURE 28: ADJUSTER PINION 12120

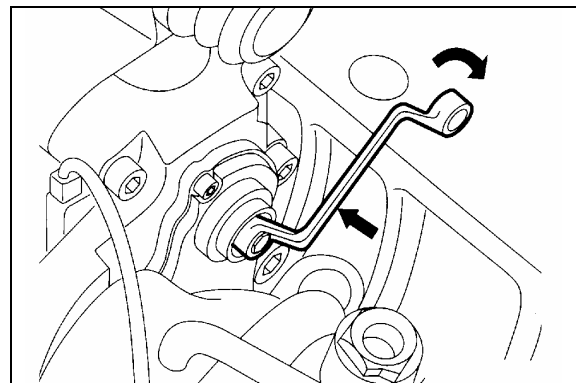


FIGURE 29: BOX WRENCH ON ADJUSTER PINION 12118

27.1.3 Roadside Inspection for Knorr/Bendix Air Disc Brakes

The coach is equipped with air disc brakes and therefore, cannot be inspected using the requirements for chamber stroke or visible lining clearance or lining thickness as specified for drum brakes. The roadside inspector should use the following instructions to determine that the air disc brakes are within proper adjustment and have sufficient pad wear thickness.

The Knorr/Bendix air disc brake is designed to move freely, with minimal force, in the axial direction on the two sliding pins as identified in figure 30. The movement in the axial direction should not exceed 2 mm (5/64").

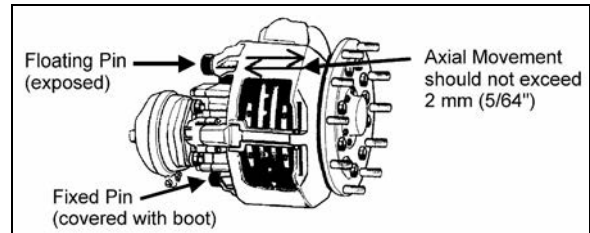


FIGURE 30: CALIPER AXIAL MOVEMENT 12132

The pad thickness can be seen but would require removal of the tire and rim. An indicator of the pad wear condition is available by inspecting the floating pin location in relation to the rubber bushing as shown in figure 31. When pads are in new thickness condition, the pin will be exposed (C) 19 mm (3/4"). When the pads are worn to replacement conditions, the pin will be nearly flush to the bushing (D) or within 1 mm (3/64") of the edge of the rubber bushing.

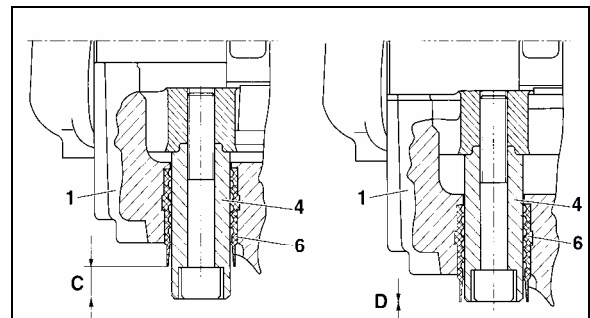


FIGURE 31: BRAKE PAD CHECK 12117

27.1.4 Pad Removal

Turn adjuster pinion (23) counterclockwise to increase pad to rotor clearance (a clicking noise will be heard). Push caliper toward actuator and remove pads (12).



CAUTION

Do not apply brakes while pads are removed as this could cause over stroke damage to the adjusting mechanism.

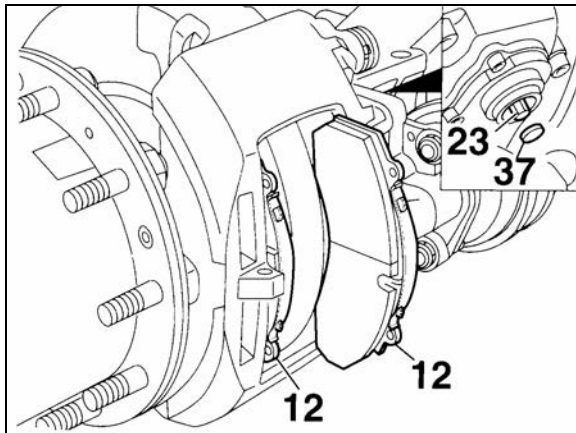


FIGURE 32: PAD REMOVAL 12111

27.1.5 Checking Pad Wear

Minimum friction material thickness is 2 mm (A, Fig. 33)

New friction material has a thickness of 21 mm (B, Fig. 33)

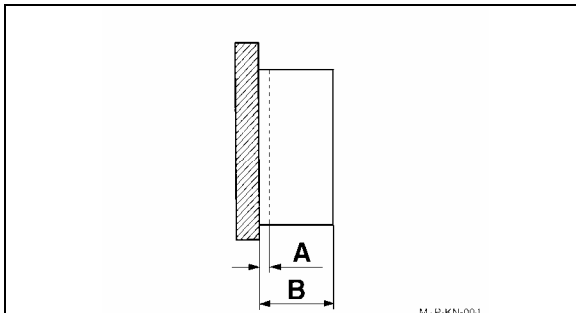


FIGURE 33: PAD WEAR 12112

27.1.6 Important Pad and Rotor Measurements

- A = Rotor thickness (new): 45 mm;
- B = Rotor thickness (worn): 37 mm, requires replacement;
- C = Overall thickness of pad (new): 30 mm;
- D = Backplate: 9 mm;
- E = Minimum thickness of pad material: 2 mm;
- F = Minimum allowed thickness of overall backplate and friction material: 11 mm.
Replacement necessary.

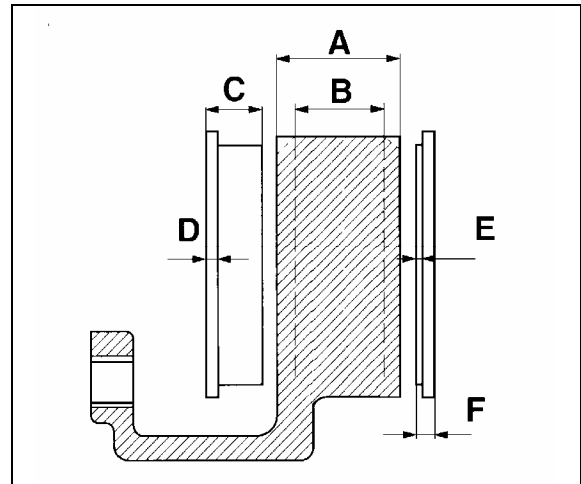


FIGURE 34: ROTOR AND PAD WEAR LIMITS 12113

27.1.7 Checking Caliper Guidance and Seal Condition

Perform sliding test. You must be able to slide the caliper easily at any time. Sliding test should be performed at least every three months or more often depending on the type of operation.

Sliding Test (Refer to Fig. 35):

- a) Using hand pressure only, the caliper (1) must slide freely with its guide pin arrangements (4-7) across a distance of 1 3/16 inch (30 mm) when the pads are removed. The sleeve (5) is sealed using the boot (9) and the cap (10).
- b) The rubber components (9 and 10) should show no damage. The positioning must be checked. If necessary the caliper has to be repaired using the guide kit (part #611168) or with the seal and guide kit (part #611199). When repairing a caliper with the above kits, make sure all parts in the kit are used. Use special green grease (Prévost #683344) to reassemble the slide pin into the bushing, white or yellow grease (Prévost #683345) may be used for all other lubrication needs.
- c) Depending on caliper manufacturing date, black paint may be present on the unsealed pin (short pin). Paint on the slide pin can prevent the caliper from sliding properly especially when the pad starts to wear. If paint is present on the pin, separate the pin from the bushing, clean and reinstall the pin according to procedure.

NOTE

Do not attempt to use thinner or alcohol to clean the pin without removing it as it may damage the rubber bushing.

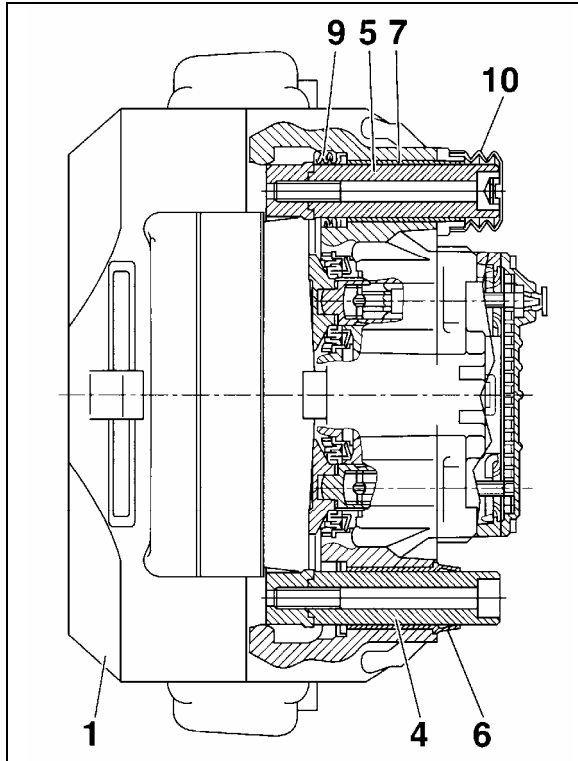


FIGURE 35: CALIPER GUIDANCE 12114

27.1.8 Checking the Tappet Boots

- a) The rubber boots (13, Fig. 36) should show no damage, check the attachment.

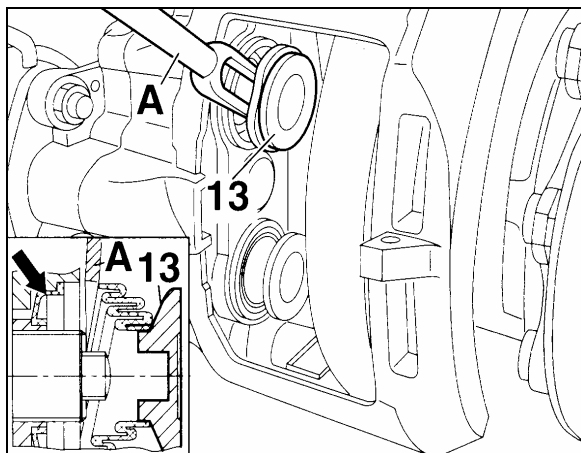


FIGURE 36: RUBBER BOOTS 12115



CAUTION

Any ingress of water and dirt will lead to corrosion and may affect the function of the actuation mechanism and adjuster unit.

- b) If boots are damaged but show no corrosion, the boots and tappets should be replaced (Prévost #611177).

27.1.9 Pad Installation

Turn adjuster pinion (23, Fig. 37) counterclockwise until tappets are fully retracted and clean pad seat area. Slide caliper to full outboard position and install outside pad. Slide caliper to full inboard position and install inside pad.



WARNING

It is recommended to change all pads on an axle at the same time.

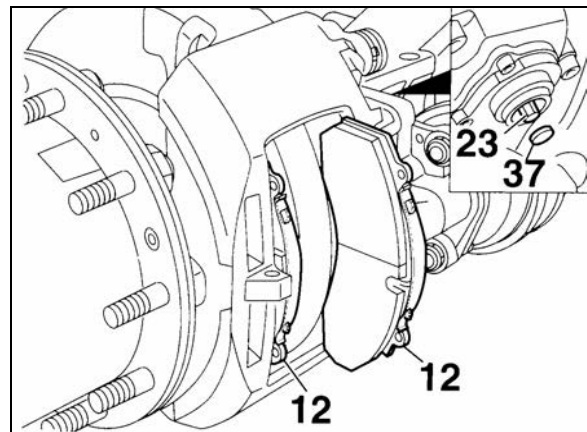


FIGURE 37: PAD INSTALLATION 12111

27.1.10 Adjusting the Running Clearance

- a) Insert a feeler gauge 0.028 inch (0.7 mm thickness) between tappet and pad backplate (Fig. 38). Turn adjuster pinion clockwise until 0.028 inch (0.7 mm) clearance is achieved. Replace cap (37) (Prévost # 641313).
- b) To ensure a constant running clearance between the rotor and pads, the brake is equipped with an automatic adjuster unit. When the pads and rotor wear, the running clearance between the pads and rotor increases. The adjuster (23, Fig. 38) and turning device turn the threaded tubes by the amount necessary to compensate the wear.

Total running clearance should be between 0.020 and 0.035 inch (0.5 and 0.9 mm). Smaller clearances may lead to overheating problems.

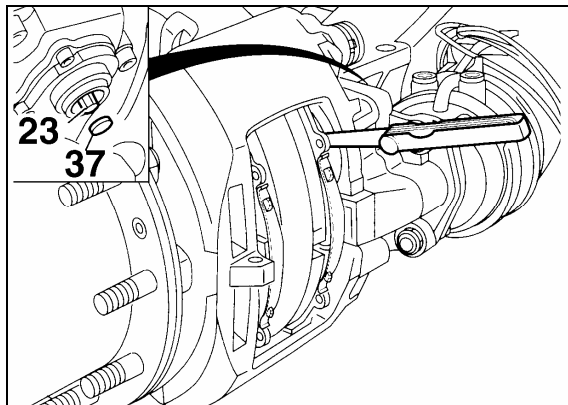


FIGURE 38: RUNNING CLEARANCE 12116

27.1.11 Brake Tools

Four brake tools are available from Prévost to facilitate disc brake maintenance:

- a) #641321, Tappet with boot (item 13).
- b) #641322, Caliper inner boot (item 9).
- c) #641323, Caliper bushing (item 7).
- d) #641435, Fork for boot tappet (item 13).

Maintenance tip

Using the following procedure, pad wear can be determined without removing the wheel.

27.1.12 Checking Brake Pads

Brake pads have to be checked on a regular basis depending on the vehicle operation. The remaining thickness of the pads should never be less than 3/32 inch (2 mm). To check pad condition without removing the wheel, verify the position of guide bushing (6) relatively to guide sleeve (4) (Fig. 39). When guide sleeve is in alignment with guide bushing, brake pad thickness must be checked more precisely with wheel removed. When replacing the brake pads, all four pads on an axle have to be changed at the same time. There is no inner or outer pad, since all pads are the same. Worn pads should be replaced in the same position.

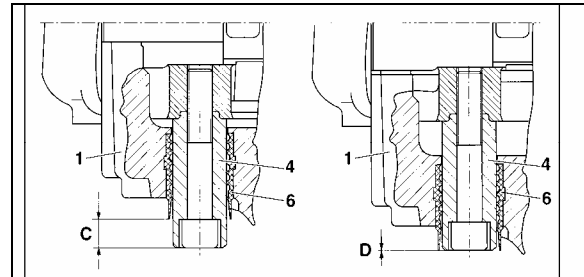


FIGURE 39: BRAKE PAD CHECK 12117

27.1.13 Torque specifications

For proper caliper maintenance, refer to the following figures.

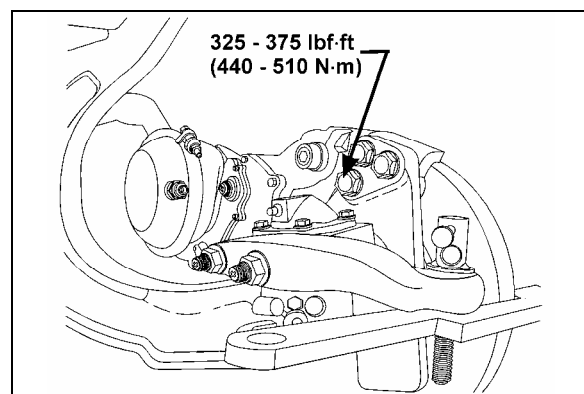


FIGURE 40: TORQUE SPECIFICATION 12145

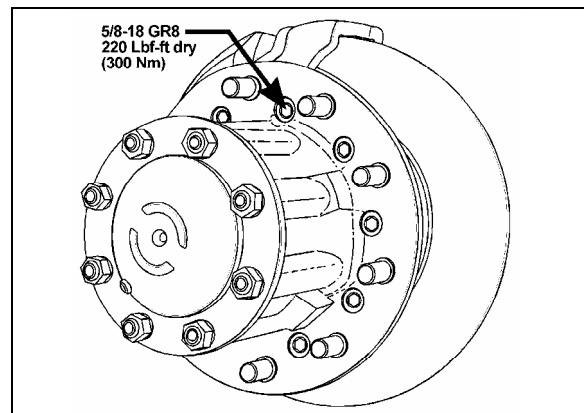


FIGURE 41: TORQUE SPECIFICATION 11030

28. SAFE SERVICE PROCEDURES

Most recently manufactured brake linings no longer contain asbestos fibers. Instead of asbestos, these linings contain a variety of ingredients, including glass fibers, mineral wool, aramid fibers, ceramic fibers, and carbon fibers. At present, OSHA (Occupational Safety and Health Administration) does not specifically regulate these non-asbestos fibers, except as nuisance dust. Medical experts do not agree about the potential long-term risks from working

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with and inhaling non-asbestos fibers. Nonetheless some experts think that long-term exposure to some non-asbestos fibers could cause diseases of the lung, including pneumoconiosis, fibrosis, and cancer. Therefore, lining suppliers recommend that workers use caution to avoid creating and breathing dust when working on brakes that contain non-asbestos fibers.



WARNING

Whenever possible, work on brakes in a separate area away from other operations.

Always wear a respirator approved by NIOSH (National Institute of Occupational Safety and Health) or MSHA (Mine Safety and Health Administration) during all brake service procedures. Wear the respirator from removal of the wheels through assembly.

NEVER use compressed air or dry brushing to clean brake parts or assemblies. OSHA recommends that you use cylinders that enclose the brake. These cylinders have vacuums with high efficiency (HEPA (Health and Environment Protection Agency)) filters and workmans' arm sleeves. But, if such equipment is not available, carefully clean parts and assemblies in the open air.

Clean brake parts and assemblies in the open air. During disassembly, carefully place all parts on the floor to avoid getting dust into the air. Use an industrial vacuum cleaner with a HEPA filter system to clean dust from the brake drums, backing plates and other brake parts. After using the vacuum, remove any remaining dust with a rag soaked in water and wrung until nearly dry.

If you must grind or machine brake linings, take additional precautions because contact with fiber dust is higher during these operations. In addition to wearing an approved respirator, do such work in an area with exhaust ventilation.

When cleaning the work area, NEVER use compressed air or dry sweeping to clean the work area. Use an industrial vacuum with a HEPA filter and rags soaked in water and wrung until nearly dry. Dispose of used rags with care to avoid getting dust into the air. Use an approved respirator when emptying vacuum cleaners and handling used rags.

Wash your hands before eating, drinking or

smoking. Do not wear your work clothes home. Vacuum your work clothes after use and then launder them separately, without shaking, to prevent fiber dust from getting into the air.

Material safety data sheets on this product, as required by OSHA, are available from Rockwell and Knorr-Bremse.

29. AIR BRAKE TROUBLESHOOTING

The following tests and check lists have been designed to identify the cause(s) of a sluggish performance and/or leaks in the system. These tests require very little time to perform, and give you a general idea of the system condition. Each test is provided with a corresponding check list which will guide you to the most common causes of problems.

Before performing any test, check all air lines for kinks or dents, and hoses for signs of wear, drying out or overheating.



WARNING

When working on or around brake system and its related components, the following precautions should be observed:

Always block vehicle wheels. Stop engine when working under a vehicle. Keep hands away from chamber push rods and slack adjusters as they may apply when system pressure drops.

Never connect or disconnect a hose or line containing air pressure. It may whip as air escapes. Never remove a component or pipe plug unless you are sure all system pressure has been depleted.

Never exceed recommended air pressure and always wear safety glasses when working with air pressure. Never look into air jets or direct them at anyone.

Never attempt to disassemble a component until you have read and understood the recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to the use of those tools.

Always clean connecting piping and/or fittings, and coat pipe threads with Teflon pipe sealant before installing any air brake system component.

Pressure Build-Up / Low Pressure Warning / Cutoff Point / Air Filter/Dryer Built-in Governor Cutout

CONDITION: Vehicle leveled, parking brake applied.

1. Completely drain wet, primary and secondary air reservoirs only.
2. Start engine and run at fast idle. Low pressure warning lights should be "On".
3. Start checking pressure at 50 psi (344 kPa).
4. Low pressure warning lights and buzzer should go off at or above 60 psi (415 kPa).
5. At 85 psi (586 kPa), run engine at full rpm, then check that build up time to 100 psi (690 kPa) is 30 seconds or less.
6. Air filter/dryer built-in governor cut-out. Cuts out at the correct pressure of 123 psi \pm 3 (847 \pm 21 kPa).
7. Air filter/dryer built-in governor cut-in. Cuts in around 110 psi (758 kPa).

For common corrections, refer to the following check list:

High or Low Warning Cutoff Point

- Perform a telltale light and gauge test. Replace entire cluster if found defective.

High or Low Air Filter/Dryer Built-in Governor Cutout Point

- Perform a telltale light and gauge test. Replace entire cluster if found defective.

OR

- Repair or replace air filter/dryer as necessary after checking that compressor unloader mechanism operates correctly.

More than 30 seconds to build-up pressure from 85 to 100 psi (585 - 690 kPa) at full engine RPM

- Perform a telltale light and gauge test. Replace entire cluster if found defective.
- Check compressor strainer or inlet line. If restricted, clean or replace element or faulty line.
- Check compressor head or discharge line for carbonization or restriction. Clean or replace as necessary.

- If discharge valves leak, pull head and correct or replace cylinder head.
- If drive is slipping, replace gear.
- If inlet valves are stuck, open or leaking severely, replace unloader kit, inlet valves and/or seats as necessary.
- If drain cock is found open, close it.
- Listen for air leaks and repair.
- Redo list to check all items repaired or replaced.

Air Supply Reservoir Leakage

CONDITION: Full pressure, engine stopped, parking brake applied

1. Allow at least 1 minute for pressure to stabilize.
2. Stop engine, then check air pressure gauge for 2 minutes. Note any pressure drop.
3. Pressure should not drop by more than 3 psi (20 kPa) per minute.

For common corrections, refer to the following check list:

Excessive air loss:

- With the primary air system at normal operating pressure (95 - 125 psi (655 - 860 kPa)), coat all air line connections and pneumatic components with a water and soap solution. Bubbles will indicate an air leak, and none should be permissible. Repair or replace defective parts.
- Listen for leaks and correct as required.
- Redo test to check all items repaired or replaced.

Brake System Air Leakage

CONDITION: Full pressure, engine stopped, parking brake released.

1. Apply service (foot) brakes, allow at least 1 minute for pressure to stabilize.
2. Hold down foot valve for 2 minutes while observing air pressure gauge on the dashboard.
3. Pressure drop should not be more than 4 psi (27 kPa) per minute.

For common corrections, refer to the following check list.

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Excessive leakage on brake service side:

- With the primary air system at normal operating pressure (95 - 125 psi (655 - 860 kPa)) and foot brake applied, coat all air line connections and brake pneumatic components with a water and soap solution. Bubbles will indicate an air leak, and none should be permissible. Repair or replace defective parts.
- Listen for leaks and correct as required.
- Redo test to check all items repaired or replaced.

IMPORTANT NOTE

To maintain your vehicle's air disc brakes at their original performance standard, we strongly recommend use of only genuine, approved service replacement parts on Bendix and Knorr-Bremse air disc brake systems. If non-approved friction materials or replacement components are used, neither Prévost Car nor Bendix Spicer Foundation Brake LLC will accept any air disc brake-related warranty returns or claims.

For more information on this policy, refer to Bendix-Prévost product notification annexed at the end of Section 12 of Maintenance Manual.

30. BRAKE AIR CHAMBER

If this vehicle is equipped with *Knorr-Bremse SN7000* disc brakes on all axles, it also uses "Knorr-Bremse" brake chambers. The drive axle chambers consist of two separate air chambers, each having its own diaphragm and push rod. They are used as a service brake chamber, an emergency brake in case of air pressure loss and a spring-applied parking brake. Refer to figures 42 and 43.

The front and tag axle brake air chambers are used only for service brake duty (Fig. 42).

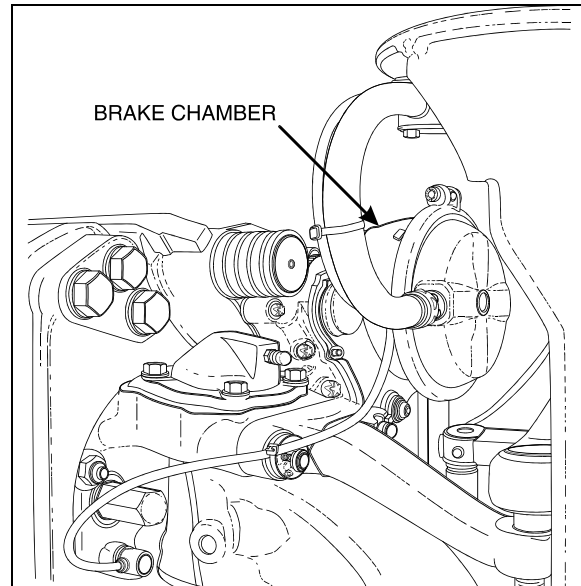


FIGURE 42: FRONT AXLE BRAKE AIR CHAMBER 12158

30.1 MAINTENANCE

Every 6,250 Miles (10 000 km) or twice a year, whichever comes first depending on type of operation:

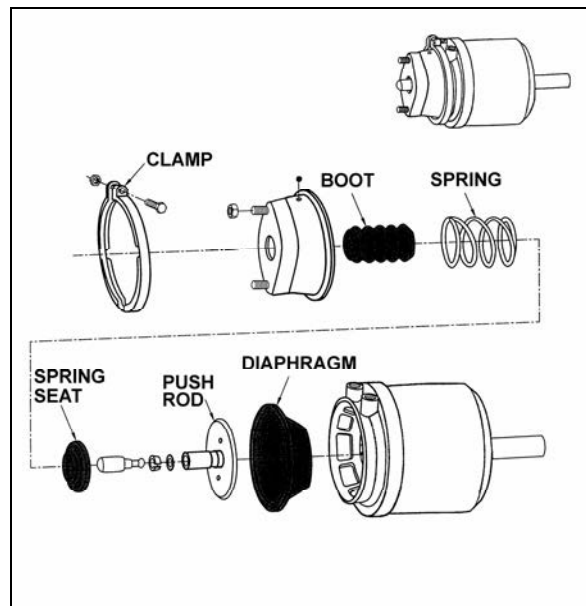


FIGURE 43: DRIVE AXLE BRAKE AIR CHAMBER 12126

Check all hoses and lines. They should be secure and in good condition.

Every 100,000 Miles (160 000 km) or once a year, whichever comes first depending on type of operation:

1. Disassemble and clean all parts.

2. Install new diaphragm or any other part if worn or deteriorated.

NOTE

When the diaphragm, spring, or both are replaced, they should be replaced in the corresponding chamber on the same axle.

3. Perform an airtightness test:
 - a) Make and hold a full brake application.
 - b) Coat clamping ring(s) with a soapy solution. If leakage is detected, tighten clamping ring only enough to stop leakage. **Do not overtighten** as this can distort sealing surface or clamping ring. Coat area around push rod hole (loosen boot if necessary). No leakage is permitted. If leakage is detected, the diaphragm must be replaced.

30.2 EMERGENCY/PARKING BRAKE MANUAL RELEASE



DANGER

Never stand in the axis line of the spring brake chambers, especially when caging the spring.

Drive Axle

1. Block the wheels to prevent the vehicle from moving.
2. Remove the release stud tool from its storage place on drive axle brake air chamber.
3. Remove the access plug from the end of the spring chamber and then insert the release stud through the opening. Turn the release stud ¼ turn (clockwise) to anchor it into the spring plate. Install the flat washer and nut, then turn the nut clockwise to cage the spring. Repeat on the opposite side.



DANGER

Make sure the release stud is properly anchored in spring plate receptacle prior to caging the spring.

4. To manually reset the emergency/parking brake, turn the nut counterclockwise. Reinstall access plugs on the spring chambers, and release stud tools in their storage places.

30.3 BRAKE CHAMBER REMOVAL



WARNING

To prevent personal injuries, brakes should be inoperative prior to working on any of their components.

To prevent personal injuries, brake chambers should be made inoperative by releasing spring tension prior to disposal.

1. Block the wheels to prevent the vehicle from moving.
2. Safely support vehicle at the recommended body jacking points.
3. To gain access to a given brake air chamber, the corresponding wheel can be removed (refer to Section 13: "Wheels, Hubs and Tires").
4. Exhaust compressed air from system by opening the drain valve of each reservoir.
5. For the drive axle brake chambers, manually release spring brakes (refer to "Emergency/Parking Brake, Manual Release" procedure in this section).
6. Disconnect air line(s) from brake chamber.
7. Remove the cotter pin connecting brake chamber and slack adjuster (drive axle).
8. Unbolt and remove the brake chamber from vehicle.

30.4 BRAKE CHAMBER INSTALLATION

Reverse removal procedure and then check brake adjustment.



CAUTION

Always clean air lines and fittings, and coat pipe threads with teflon pipe sealant before reconnecting air lines.

30.5 BRAKE CHAMBER DISASSEMBLY



DANGER

Spring brake chambers, on drive and tag axles contain an extremely high compressive force spring, which can possibly cause serious injury if special precautions are not taken when working around this area.

To avoid such injury, the following recommendations must be applied:

- Prévost recommends the installation of a new spring brake chamber if it is found to be defective.
- Spring brake chamber maintenance and/or repair must be performed by trained and qualified personnel only.
- Before manually releasing spring brakes, visually check spring brake for cracks and/or corrosion.
- On “MGM” brake chambers (drive axle), make sure the release stud is properly anchored in spring plate receptacle prior to caging the spring.
- Never stand in the axis line of the spring brake chambers, especially when caging the spring.



WARNING

To prevent personal injuries, brakes should be inoperative prior to working on any of their components.

1. Block the wheels to prevent the vehicle from moving.
2. Safely support vehicle at the recommended body jacking points.

NOTE

To gain access to a given brake air chamber, the corresponding wheel can be removed (refer to Section 13: "Wheels, Hubs and Tires").

3. Exhaust compressed air from air system by opening the drain valve of each reservoir.
4. For the drive axle brake chambers, manually release spring brakes (refer to “Emergency/Parking Brake Manual Release” procedure in this section).
5. Remove clamp ring, remove and discard the existing diaphragm. Install the new diaphragm squarely on body.
6. Reverse the procedure for assembly. Tap clamp ring to ensure proper seating. Check for proper operation before placing vehicle in service.

31. ANTI-LOCK BRAKING SYSTEM (ABS)

This device has been designed to ensure stability and permit steering control of vehicle during hard braking, and to minimize its stopping distance whatever the road conditions are. On slippery roads and generally in emergency situations, over-braking frequently induces wheel lock. The anti-lock braking system provides maximum braking performance while maintaining adequate steering control on slippery roads.

The ABS continuously monitors wheel behavior during braking. Sensors on each wheel of front and drive axles (tag axle is slave to drive axle) transmit data to a four channel electronic processor which senses when any wheel is about to lock. Modulator valves quickly adjust the brake pressure (up to 5 times per second) to prevent wheel locking. Each wheel is therefore controlled according to the grip available between its tire and the road.

With this device, the vehicle is brought to a halt in the shortest possible time, while remaining stable and under the driver's control.

Since the braking system has dual circuits, the ABS is also provided with a secondary system should a fault develop in the ABS. Anti-lock systems are a parallel system which does not hinder brake functioning in case of failure. Braking system functions in normal, non anti-lock controlled operation during ABS system failure.

The ABS system consists of two diagonally related circuits, only the half of the system which has sustained damage or other fault is switched off (i.e. wheels return to normal non-ABS braking). The other diagonal half remains under full ABS control.

NOTE

ABS is active on service brake, transmission retarder, Jake brake, but is inactive on emergency/parking brake.

NOTE

The ABS system is inoperative at speeds under 4 mph (6 Km/h). Illumination of ABS telltale indicator at these speeds is normal.

CAUTION

Disconnect the ECU or pull the ABS fuse before towing vehicle.

31.1 TROUBLESHOOTING AND TESTING

For troubleshooting and testing of the vehicle's anti-lock braking system, refer to Meritor Wabco Maintenance Manual MM-0112: "Anti-Lock Braking System (ABS) for Trucks, Tractors and Buses", at the end of this section. Use dashboard Message Center Display (MCD) Diagnostic Mode for troubleshooting and repair.

31.2 AUTOMATIC TRACTION CONTROL (ATC) – ELECTRONIC STABILITY PROGRAM (ESP)

In addition to the ABS function, vehicle may be equipped with an advanced model of Bendix EC-60 controller to provide an **Automatic Traction Control (ATC)** feature. Bendix ATC can improve vehicle traction during acceleration, and lateral stability while accelerating through curves. ATC utilizes **Engine Torque Limiting (ETL)** where the ECU communicates with the engine's controller and/or **Differential Braking (DB)** where individual wheel brake applications are used to improve vehicle traction.

The EC-60 advanced model controller also provides ABS-based stability features referred to as **ESP® Electronic Stability Program**.

NOTE

Vehicles equipped with the ATC/ESP system have one more modulator valve and two additional sensors located on the tag axle wheels (6S/5M). Basic ABS consists of 4 sensors and 4 modulator valves (4S/4M).

CAUTION

Even with ESP-equipped vehicles, the driver remains responsible for ensuring vehicle stability during operation.

DANGER

ESP may reduce the vehicle speed automatically.

DANGER

ESP can make the vehicle **decelerate automatically**. ESP can slow the vehicle with or **without the operator applying the brake**, and **even when the throttle is being applied**.

31.3 ABS COMPONENTS

The main components of the ABS system are listed hereafter. Refer to each component for its specific function in the system and for proper maintenance.

31.3.1 Electronic Control Unit (ECU)

This control unit is located in the front electrical compartment, (refer to figure 44 for location). According to the data transmitted by the sensors (number of pulses/sec is proportional to the speed of each wheel), the electronic control unit determines which wheel is accelerating or decelerating. It then establishes a reference speed (average speed) from each wheel data, and compares the speed of each wheel with this reference speed to determine which wheel is accelerating or decelerating.

As soon as wheel deceleration or wheel slip threshold values are exceeded, the electronic control unit signals a solenoid control valve to limit the excessive brake pressure produced by the driver in the appropriate brake chamber.

Maintenance

No specific maintenance is required. The ECU is not serviceable. When found to be defective, replace.

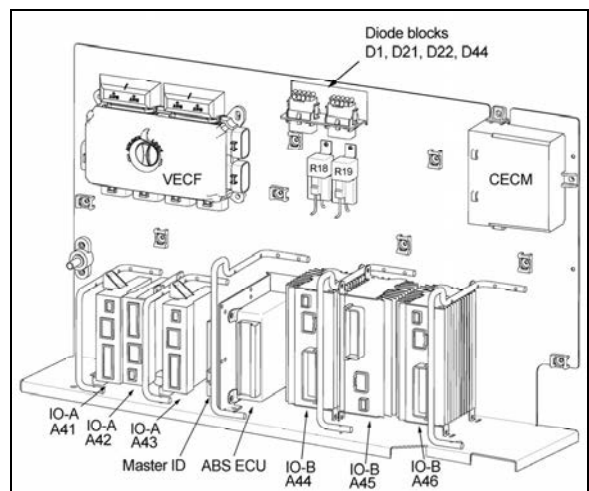


FIGURE 44: ABS ECU LOCATION

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CAUTION

In order to protect the ABS electronic control unit from voltage surges, always disconnect before performing any welding procedure on vehicle.

31.3.2 ABS Modulator Valve

This ABS system is equipped with four or five modulator valves, located between the brake chamber and the relay valve or quick release valve (Fig. 45). Note that on the basic ABS system, there is only one solenoid valve controlling the drive and tag axle wheels on the same side (tag axle is slave to drive axle).

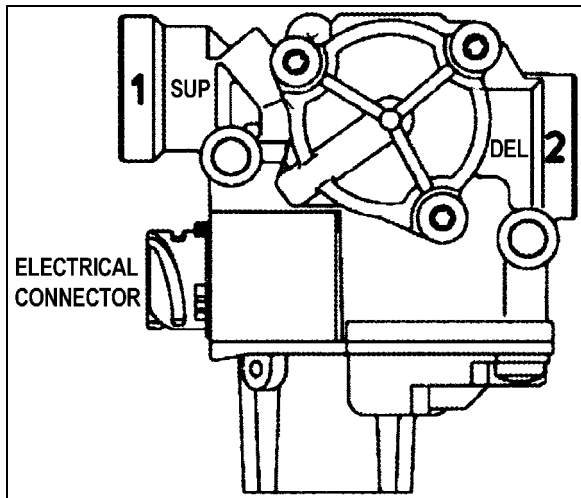


FIGURE 45: ABS MODULATOR VALVE 12221

This is an "On/Off" type valve, i.e., at brake application, the valve exhausts air from the brake chamber when the electronic unit senses that the corresponding wheel speed is decreasing in relation to the other wheels.

Maintenance

Refer to Bendix Service Data sheet SD-13-4870 located at the end of this section..

31.3.3 Sensors

The sensors are mounted on the front, drive and tag axle (if applicable) wheel hubs (Fig. 46). The inductive sensors consist essentially of a permanent magnet with a round pole pin and a coil. The rotation of the toothed wheel alters the magnetic flux picked up by the coil, producing an alternating voltage, the frequency of which is proportional to wheel speed. When wheel speed decreases, magnetic flux decreases proportion-

ately. Consequently, the electronic control unit will command the solenoid control valve to decrease the pressure at the corresponding brake chamber.

Maintenance

No specific maintenance is required for sensors, except if the sensors have to be removed for axle servicing. In such a case, sensors should be lubricated with special grease (Prévost #680460) before reinstallation. Refer to paragraph "Sensor Installation" for details.

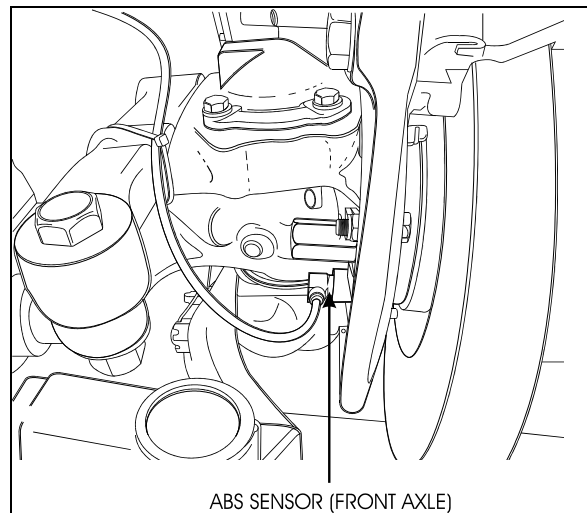


FIGURE 46: ABS SENSOR LOCATION 12153

NOTE

The resistance value, when sensors are checked as a unit, must be equal to 1,75 k ohms. To check the sensors for proper output voltage after the sensors and toothed wheels have been assembled to the axle, connect a suitable AC voltmeter across the output terminals. With the hubs rotating at 30 rpm, the output voltages should read from 50 to 1999 mV to be acceptable.

Sensor Installation

The following procedure deals with sensor installation on the axle wheel hubs. Read procedure carefully before reinstalling a sensor, as its installation must comply with operational tolerances and specifications.

1. Apply recommended lubricant (Prévost #680460) to spring clip and sensor.



CAUTION

Use only this type of grease on the sensors.

2. Insert spring clip in the holder on hub. Make sure the spring clip tabs are on the inboard side of the vehicle. Push in until the clip stops.
3. Push the sensor completely inside the spring clip until it is in contact with the tooth wheel. Ensure mounting is rigid, as it is an important criterion for adequate sensor operation.

NOTE

This installation should be of the "press fit" type.

31.3.4 Spring clip

The spring clip retains the sensor in its mounting bracket close to the toothed pulse wheel. The gap between the sensor end and teeth is set automatically by pushing the sensor in the clip hard up against the tooth wheel, and the latter knocks back the sensor to its adjusted position (Fig. 47).

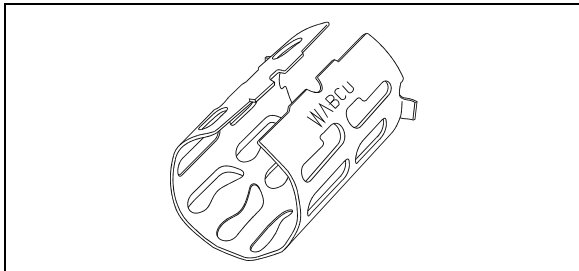


FIGURE 47: SPRING CLIP

12161

Maintenance

The spring clip requires no specific maintenance.

32. FITTING TIGHTENING TORQUES

45° Flare and Inverted Flare: Tighten assembly with a wrench until a solid feeling is encountered. From that point, tighten 1/6 turn (Fig. 48).

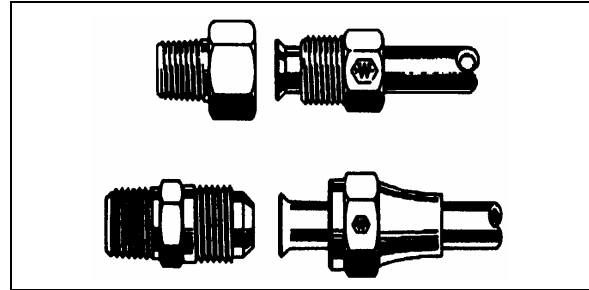


FIGURE 48: HOSE FITTINGS¹²⁰⁵³

Compression: Tighten nut by hand (Fig. 49). From that point, tighten using a wrench the number of turns indicated in the chart hereafter.

Fitting size	Pipe diameter (inches)	Number of additional turns required following hand tightening
2	1/8	1 ¼
3	3/16	1 ¼
4	1/4	1 ¼
5	5/16	1 ¾
6	3/8	2 ¼
8	1/2	2 ¼
10	5/8	2 ¼
12	3/4	2 ¼
16	1	2 ¼

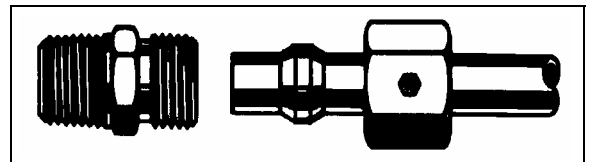


FIGURE 49: HOSE FITTING

12054

NTA-Type Plastic Tubing: Hand tighten nut (Fig. 50). From that point, tighten using a wrench the number of turns indicated in the following chart.

Tubing diameter (inches)	Number of additional turns required following hand tightening
1/4	3
3/8 to 1/2	4
5/8 to 3/4	3 ½

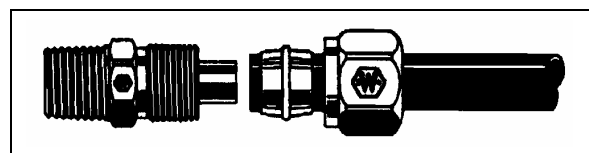


FIGURE 50: HOSE FITTING

12055

Section 12: BRAKE AND AIR SYSTEM

AB-Type Copper Piping: Hand tighten nut (Fig. 51). From that point, tighten with a wrench the number of turns indicated in the following chart.

Piping diameter (inches)	Number of additional turns required following hand tightening
1/4, 3/8, 1/2	2
5/8, 3/4	3

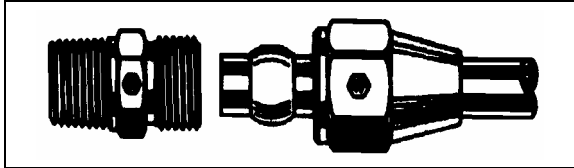


FIGURE 51: HOSE FITTING

12056

Pipe Tightening: All connections must be hand tightened. From that point, tighten a minimum of 2 ½ additional turns.

NOTE

Use Loctite (Prévost number 680098) pipe sealant to seal pipe thread.

33. SPECIFICATIONS

Air Compressor (with Detroit Diesel Series 60 Engine)

Make..... Bendix Westinghouse
 Model..... BA-921
 Capacity (at 1250 rpm) 15.7 cfm (0,445 m³/min.)
 Prévost number..... 641990

BA-921 Service Kits

ST-4 Safety Valve
 Prévost number..... 641989
 Series 60 Seal Kit
 Prévost number..... 641988
 Compressor Seal Kit
 Prévost number..... 641987
 Cylinder Head Gasket Kit
 Prévost number..... 641986

Air Compressor (with Volvo D13 Engine)

Make..... Meritor Wabco
 Model..... SS636
 Capacity (at 1250 rpm) 37.4 cfm (1,059 m³/min.)
 Prévost number.....

Air Dryer

Make..... Haldex
 Model..... AT-87192
 Prévost number..... 70303498
 Desiccant cartridge Prévost number..... 3097369

Flip-Flop Control Valve

Make..... Bendix Westinghouse
 Model..... TW-1
 Type On-Off
 Prévost number..... 640136

Emergency/Parking Brake Control Valve

Make..... Bendix Westinghouse
 Model..... PP-1
 Automatic release pressure 40 psi (275 kPa) nominal
 Prévost number..... 641128

Dual Brake Application Valve

Make..... Bendix Westinghouse
 Model..... E-10P
 Prévost number..... 641856

Stoplight Switches

Make..... Bendix Westinghouse
 Model..... SL-5
 Contact close (ascending pressure) 4 psi and more (28 kPa)
 Prévost number..... 641462

Brake Relay Valves

Make..... Bendix Westinghouse

Section 12: BRAKE AND AIR SYSTEM

Model..... R-12
Supplier number.....
Prévost number.....

Brake Relay Valve

Make..... Meritor Wabco
Model..... R-14
Prévost number.....

Quick Release Valve

Make..... Bendix Westinghouse
Model..... QR-1
Prévost number..... 641429

Spring Brake Valve

Make..... Bendix Westinghouse
Model..... SR-7
Prévost number.....

Pressure Protection Valve

Make..... Bendix Westinghouse
Model..... PR-4
Nominal closing pressure..... 70 psi (482 kPa)
Prévost number..... 641137

Shuttle-Type Double Check Valve

Make..... Bendix Westinghouse
Model..... DC-4
Prévost number..... 641015

Low Pressure Indicators

Make..... Bendix Westinghouse
Model..... LP-3
Contact close 66 psi (455 kPa)
Prévost number..... 640975

Air Pressure Regulator

Make..... Norgren
Adjustable output range 0-80/85 psi (0-552/586 kPa)
Recommended pressure setting 75 psi (517 kPa)
Prévost number..... 641472

Air Filter Element

Make..... Norgren
Type With manual drain
Prévost number..... 641338

Front Axle Brake Chambers

Make..... Knorr-Bremse
Type 24
Prévost number (R.H.) 641414
Prévost number (L.H.) 641413

Drive Axle Brake Chambers

Make..... Knorr-Bremse
Type 24 as service -24 as emergency
Prévost number..... 641432

Piggy Back (On Drive Brakes)

Make.....Knorr-Bremse
Type 24 as emergency
Prévost number..... 641433

Tag Axle Brake Chambers

Make.....Knorr-Bremse
Type 14
Prévost number..... 642087

Tag Axle Brake Chambers

Make.....Knorr-Bremse
Type 16
Prévost number..... 642086

Brake Lining (All Axles)

Make.....Knorr-Bremse
Prévost number..... 611049
Prévost number..... 641226

ABS ANTILOCK BRAKING SYSTEM

ABS MODULATOR VALVE

Make..... Bendix
Voltage 12 V
Prévost number..... 642077

Sensor

Prévost number..... 642085

Sensor (90°)

Prévost number..... 642084



Effective Date: 12/02/05

Subject: Bendix Air Disc Brake Pad Replacement on Prevost Car Vehicles

Prevost Car and Bendix Spicer Foundation Brake LLC are issuing this product notification about the potential brake performance degradation associated with use of non-approved, aftermarket replacement friction materials on Bendix® and Knorr-Bremse air disc brakes.

A compatible combination of disc pads and rotor material is essential for the safe and reliable performance of air disc brakes and also helps to extend the useful life of both parts.

Prevost Car and Bendix Spicer Foundation Brake worked together to optimize the disc pad and rotor material combination (“the friction couple”) for use with Bendix® air disc brakes. Prevost Car and Bendix offer service replacement parts that maintain the same quality and compatibility as the original equipment pads and rotors.

Recent benchmarking tests by Bendix Spicer Foundation Brake with two different non-approved aftermarket brake pad brands indicate that there is a significant risk of brake performance degradation when non-approved friction materials are used with Bendix or Knorr-Bremse air disc brakes. The aftermarket pads tested demonstrated the following shortcomings:

- At high operating temperatures the non-approved pads had approximately 20% lower friction level than the original equipment friction material.
- During fade testing, brake torque was 50% to 60% of original material levels.
- Significant brake torque reduction was experienced at increased temperatures.
- Tests to replicate stops on mountain roads and other severe service conditions showed significant performance reductions.
- Insufficient pad strength caused cracking across the friction material.

- Shear testing of the friction material adhesion resulted in the friction material completely separating from the backing plate in many instances.
- Pad wear was accelerated.
- Early rotor cracking symptoms were observed much earlier than for typical genuine parts.

Based on our tests, Prevost Car and Bendix Spicer Foundation Brake LLC strongly recommend against the use of non-approved aftermarket brake pads and service parts on Bendix and Knorr-Bremse air disc brakes. Brake performance, reliability and service life can be seriously degraded if non-approved aftermarket replacement parts are used in Bendix and Knorr-Bremse air disc brake systems.

To maintain your vehicle’s air disc brakes at their original performance standard, we strongly recommend use of only genuine, approved service replacement parts on Bendix and Knorr-Bremse air disc brake systems. If non-approved friction materials or replacement components are used, neither Prevost Car nor Bendix Spicer Foundation Brake LLC will accept any air disc brake-related warranty returns or claims.

**BRAKE DUST WARNING:
AVOID CREATING DUST WHEN WORKING WITH
BRAKE PADS DUE TO POSSIBLE CANCER AND
LUNG DISEASE HAZARD.**

While Bendix Spicer Foundation Brake LLC does not offer asbestos-containing brake linings or disc pads, the long-term effects of certain non-asbestos fibers have not been determined. Current OSHA Regulations cover exposure levels to some, but not all, components of non-asbestos linings and pads. The following precautions should be used when handling these materials:

- Avoid creating dust. Compressed air or dry brushing must never be used to clean brake assemblies or the work area.

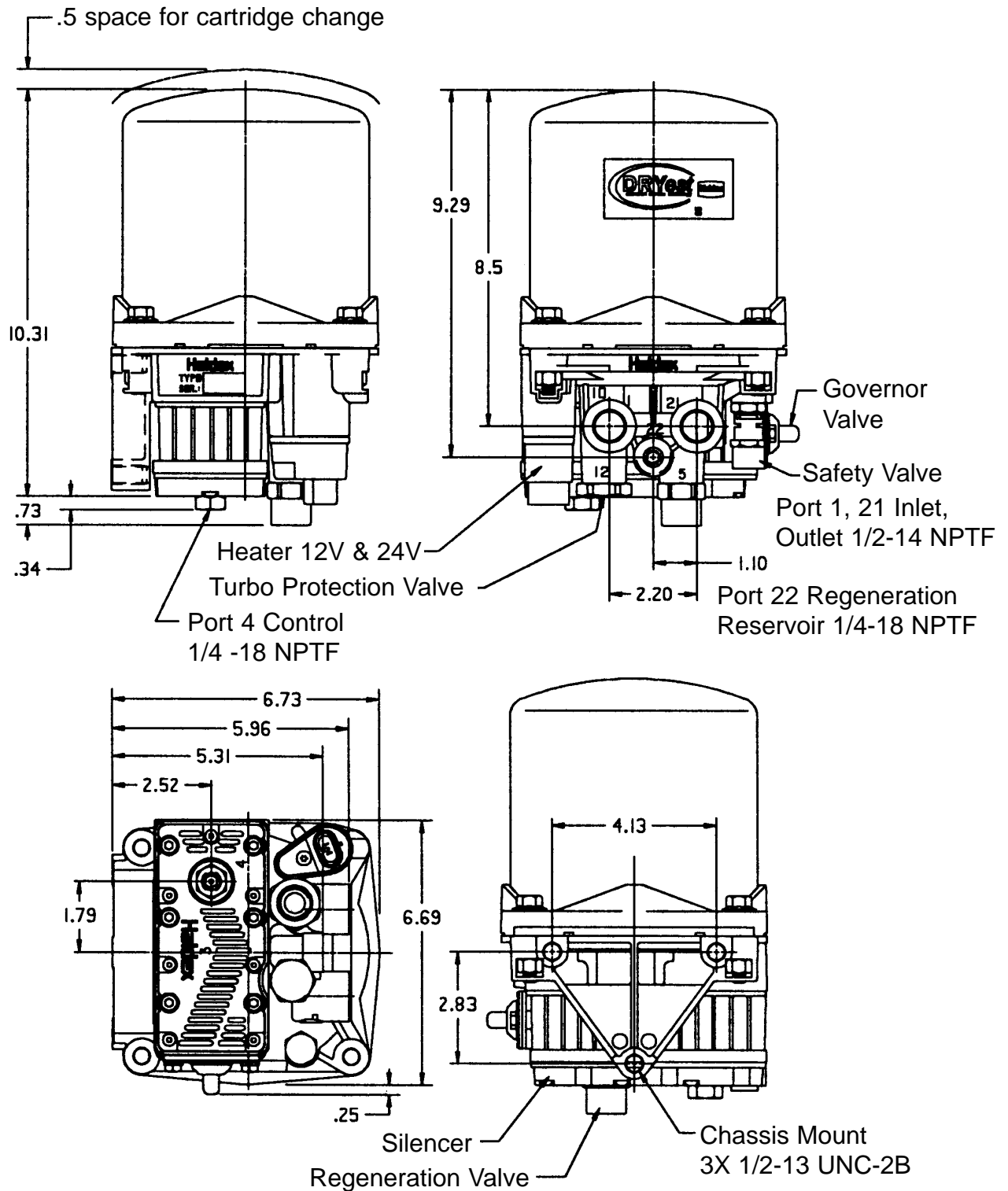
(Continued over)

- Brake workers must take steps to minimize their exposure to airborne brake lining particles. Procedures to reduce exposure include: working in a well-ventilated area, segregating areas where brake work is performed, using local filtered ventilation systems or enclosed cells with filtered vacuums for all brake work. Respirators approved by the Mine Safety and Health Administration (MSHA) or National Institute for Occupational Safety and Health (NIOSH) should be worn at all times during brake servicing.
- Workers must wash before eating or drinking, should not use tobacco products in any form, shower after working, and not wear work clothes home. Work clothes should be vacuumed using a high efficiency particulate filter (HEPA) vacuum and laundered separately without shaking.
- OSHA Regulations regarding testing, disposal of waste and methods of reducing exposure for asbestos are set forth in 29 Code of Federal Regulations §1910.001. These Regulations provide valuable information which can be utilized to reduce exposure to airborne particles.
- Material Safety Data Sheets on Bendix® air disc brake pads, as required by OSHA, are available from Bendix Spicer Foundation Brake LLC.





DRYest Air Dryer Installation and Maintenance



The Haldex DRYest is a desiccant type dryer that effectively removes moisture, oil and contaminants from the compressed air system. This reduces the risk of freezing or corrosion of the components in the air system. When compressor cut-out is reached, dry air is allowed to flow back to regenerate the desiccant bed. The SIX (6) different applications available for the DRYest are illustrated on the next page.

Application Schematics

FIG. 2.A. Standard System Regeneration with Integrated Governor

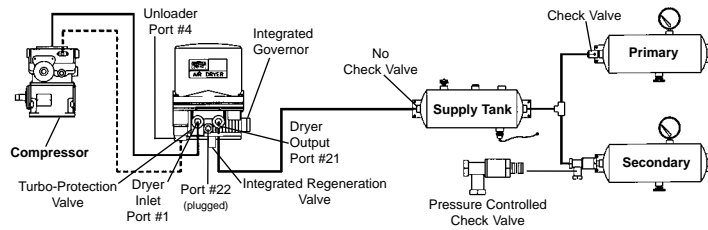


FIG. 2.B System Regeneration with External Governor

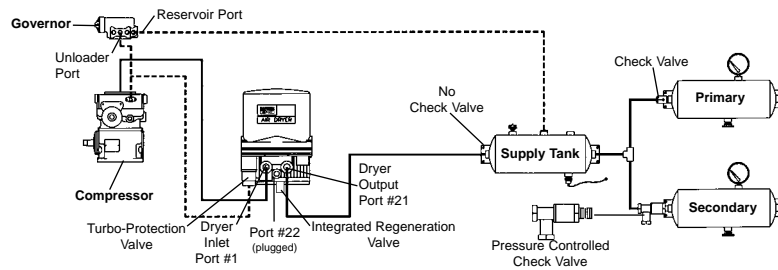


FIG. 2.C External Purge Tank Regeneration with Integrated Governor

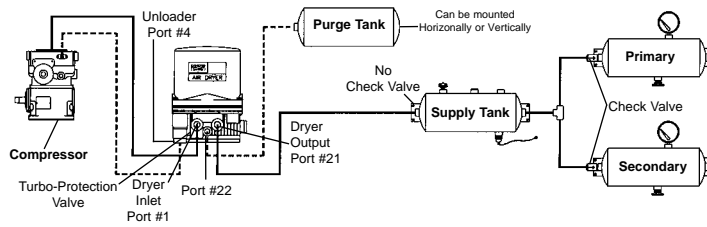


FIG. 2.D External Purge Tank Regeneration with External Governor

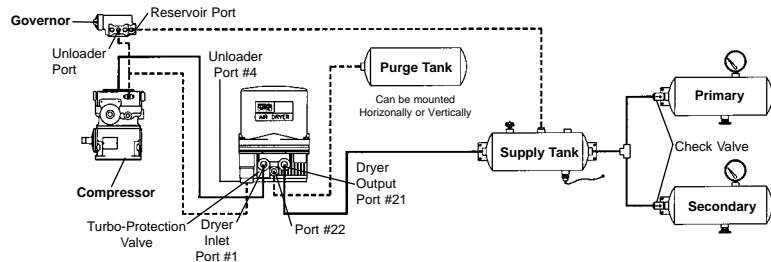


FIG. 2.E Blow Thru: External Purge Tank with Integrated Governor

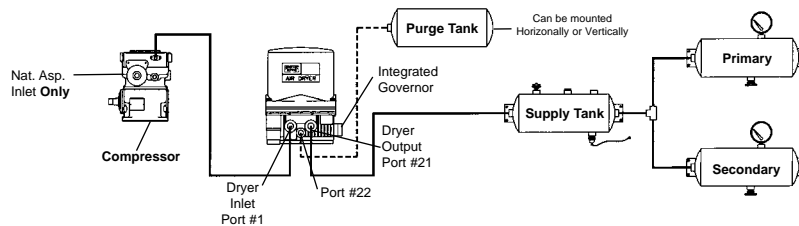
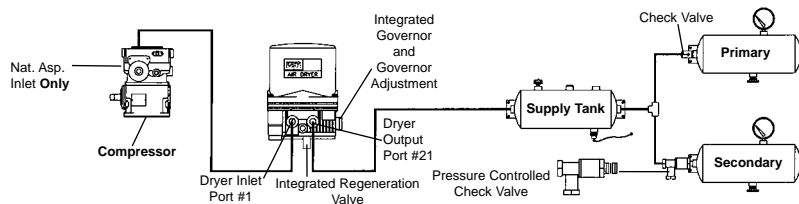


FIG. 2.F Blow Thru: System Regeneration with Integrated Governor



Installing the DRYest

IMPORTANT CAUTION

1. Park the vehicle on a level surface, apply the parking brakes and always block the wheels.
2. Stop the engine when working around the vehicle.
3. Make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle.
4. Following the vehicle manufacturer's recommended procedures; deactivate the electrical system in a manner that removes all electrical power from the vehicle.
5. When working in the engine compartment, the engine should be shut off. Where circumstances require that the engine be in operation, extreme caution should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated or electrically charged components.
6. Never connect or disconnect a hose or line containing pressure. Never remove a component plug unless you are certain all system pressure has been depleted.
7. Never exceed recommended pressures and always wear safety glasses.
8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to the use of those tools.
9. Use only genuine Haldex replacement parts, components and kits. Replacement hardware, tubing, fitting, etc should be of equivalent size, type and strength as original equipment and be designed specifically for such applications and systems.
10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.
11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

General

The vehicle installation guidelines presented in the Application Schematic apply to all DRYest Air Dryer installations. Determine your system configuration and plumb accordingly. Vehicles with the Holset Type-E or QE compressor require the following additional instructions.

Haldex "isolation valve" must be mounted before the DRYest. Consult Cummins for additional plumbing requirements.

Mounting on Vehicle

1. Locate with sufficient space to facilitate service & visual access.
2. Mount away from direct tire splash.
3. Brackets, Fittings and Lines to be mounted in a protected area.
4. Exhaust port downward.
5. Mount in area to avoid excessive heat.
6. Rigid mount to avoid excess vibration.
7. Line from compressor to DRYest should have continuous downward slope and no dips.
8. 90° Fittings should be avoided.
9. Not to exceed 15° inclination.
10. Maintain a minimum of ½" above the dryer for access to the desiccant cartridge.
11. The dryer is equipped with an integrated mounting bracket. The enclosed template is to be used to drill three (3) 9/16" holes. If the dryer is to be bolted directly to the frame or support member, check vehicle manufacturer's recommendations.
12. A mounting bracket can be used if necessary.
13. Install the dryer using the enclosed ½" bolts. Tighten to 45-55 ft-lb.

Heater Connection

1. Locate a circuit with the correct voltage that is "hot" when the ignition is "ON". The current draw is 8 amp@12V; 4amp@24V. A 10-15amp fuse is recommended in this line. Connect one heater lead to this wire.
2. Connect other lead to a good ground on vehicle chassis or electrical junction box.
3. For upgrade heater and connector information see " Service Information".

Installing the DRYest (con'd)

Compressor Discharge Line

General

While minimum diameters are specified, larger line diameters generally improve performance and life and reduce temperatures, particularly in severe applications.

1. The compressor discharge line material should be wire braided "Teflon" hose, copper tubing or a combination of both.
2. Compressor discharge line lengths and inside diameter requirements are dependent on the vehicle application.
3. The dryer inlet temperature must be less than 170°F. This can normally be accomplished with 12' to 15' of air compressor discharge line length.
4. Excessive line length should also be avoided to prevent freeze-up. The dryer inlet temperature must be greater than 40°F. If the discharge line exceeds 15', the line can be insulated as needed to prevent freeze-up.

Air Connections

1. Connect a suitable line from the compressor to the ½" NPT Inlet Port #1.
2. From the ½" NPT dryer outlet, Port #21, use a suitable line and connect to the supply tank.
3. Connect a ¼" nylon line or equivalent for control line(s).

Exhaust Line

1. If it is necessary to direct DRYest Air Dryer discharge contaminates away from vehicle components, it will be necessary to purchase an air dryer with special hose fitting option.

Testing the DRYest

Before placing the vehicle in service, perform the following tests.

1. Close all reservoir drain cocks.
2. Build up system air pressure to governor cut-out and note that the air dryer purges with an audible exhaust of air. If system 2.E or 2.F is used, the purge will be followed by a steady pulsating flow of air indicating that the system is "unloaded" and is venting to atmosphere.
3. Actuate the service brakes to reduce system air pressure to governor cut-in. Note that the system once again builds to full pressure and is followed by a purge.
4. It is recommended that the vehicle be tested for leakage using the following procedure to assure that the air dryer will not cycle excessively:
 - A. Apply the parking brakes, build system pressure to governor cut-out and allow pressure to stabilize for at least 1 min.
 - B. Observe the dash gauge pressures for 2 min. and note any pressure drop. Pressure drop should not exceed 4 psi with brake released and 6 psi with brakes applied. Any noticeable leakage must be repaired to avoid excessive cycling.
 - C. On vehicles using "system regeneration": At cut-out pressure, system air is allowed to backflow from the secondary reservoir for desiccant regeneration. The vehicle secondary air gauge pressure will drop approximately 6 psi after the dryer purges.
5. Charge Cycle Time: During normal, daily operation the compressor should recover from governor cut-in to governor cut-out in 90 seconds or less at engine RPM's depending on vehicle vocation.
6. Purge Cycle Time: During normal vehicle operation, the air compressor must remain unloaded for a minimum of 30 seconds between charge cycles. This minimum purge time is required to insure complete regeneration of the desiccant.

Troubleshooting

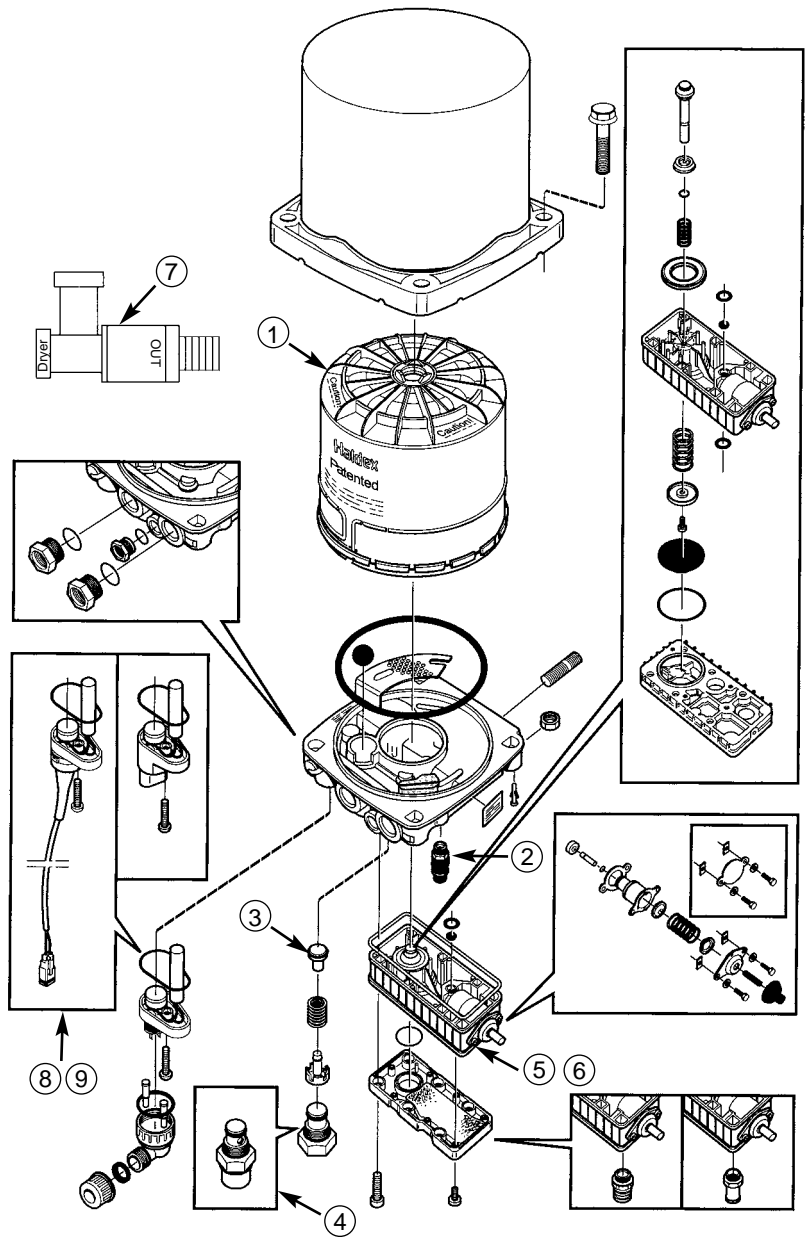
Problem	Cause	Repair
Water in air system	<ol style="list-style-type: none"> 1. Contaminants in desiccant. 2. Leaks in air system. 	<ol style="list-style-type: none"> 1. Change desiccant cartridge. Check compressor for excessive oil passage. 2. Tighten air connections, soap connection and recheck for leaks per Testing the <i>DRYest</i> section.
Constant exhaust of air at air dryer and not Blow-Thru Type	<ol style="list-style-type: none"> 1. Defective dryer outlet check valve. 2. Dryer unloading valve not closing. 	<ol style="list-style-type: none"> 1. Clean valve seat and replace check valve. 2. At compressor cut-out there must be a slight blow of regenerated air from the purge tank for approximately 30 seconds. If air flow continues, replace valve pack.
Excessive compressor cycling	<ol style="list-style-type: none"> 1. Excessive leaks in air system. 2. Defective dryer outlet check valve. 3. Undersize compressor, duty cycle of compressor should not exceed 25%. 	<ol style="list-style-type: none"> 1. Tighten air connections, soap connection and recheck for leaks. 2. Clean valve seat and replace check valve. 3. Reduce air demand or use greater output compressor.
Safety valve is open	<ol style="list-style-type: none"> 1. Desiccant cartridge is plugged. 2. Ice block in dryer. 3. Excessive system pressure. 	<ol style="list-style-type: none"> 1. Excessive oil passage from compressor. Check for worn compressor. Replace desiccant cartridge. 2. Check heater function. 3. Repair or replace governor.
Short life of dryer or desiccant cartridge	<ol style="list-style-type: none"> 1. Air at inlet of dryer exceeds 170°F. 2. Duty cycle of compressor does not allow for sufficient time for desiccant regeneration. 	<ol style="list-style-type: none"> 1. Extend length of compressor discharge line; see Installing the <i>DRYest</i> section. The 170°F dryer inlet temperature can usually be accomplished with 12' to 15' of compressor discharge line. 2. During normal operation the compressor must remain unloaded for a minimum of 30 seconds to allow for sufficient purge. Lengthy loading times must be avoided. Air dryer must be "by-passed" in applications with high air use such as bulk unloading.
Poor drying efficiency	<ol style="list-style-type: none"> 1. Air at inlet of dryer exceeds 170°F. 	<ol style="list-style-type: none"> 1. Extend length of compressor discharge line; see Installing the <i>DRYest</i> section. The 170°F dryer inlet temperature can usually be accomplished with 12' to 15' of compressor discharge line.

Service Parts

General Instructions

The following parts are available for maintenance and repair. Each service kit comes with specific repair instructions.

1. Desiccant Cartridge: 47178964
2. Safety Valve: 47178275
3. Check Valve: 47177433
4. Regeneration Valve: 47177434
5. Valve Pack with Integrated Governor: 47177343
6. Valve Pack w/o Integrated Governor: 47177442
7. Pressure Controlled Check Valve: 47110007
8. 12 V Heater: 47110020
9. 24 V Heater: 47110021
10. Integrated Turbo Protection Valve: 47189189 (Not Shown)



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9/02 1M ART L31166

MERITOR WABCO

**System Saver 636 Twin
Cylinder Air Compressor
for Mack E-Tech™ Engines**




**Maintenance Manual MM-0204
Issued 08-02**

Before You Begin

This manual provides service and repair procedures for the Meritor WABCO System Saver 636 twin cylinder air compressor for Mack E-Tech™ engines. Before you begin procedures:

1. Read and understand all instructions and procedures before you begin to service components.
2. Read and observe all Caution and Warning safety alerts that precede instructions or procedures you will perform. These alerts help to avoid damage to components, serious personal injury, or both.
3. Follow your company's maintenance and service, installation, and diagnostics guidelines.
4. Use special tools when required to help avoid serious personal injury and damage to components.

Safety Alerts, Torque Symbol and Notes

 WARNING	A Warning alerts you to an instruction or procedure that you must follow exactly to avoid serious personal injury.
 CAUTION	A Caution alerts you to an instruction or procedure that you must follow exactly to avoid damage to components.
	A torque symbol alerts you to tighten fasteners to a specified torque value.
NOTE	A Note provides information or suggestions that help you correctly service a component.

Access Product and Service Information on Our Website

Enter meritorwabco.com in your browser's address box for quick access to our website. At our home page, click on literature to access our publications.

meritorwabco.com

To Order Information by Phone

Call ArvinMeritor's Customer Service Center at 800-535-5560 to order the following item.

- Drivetrain Plus™ by ArvinMeritor Technical Electronic Library on CD. Features product and service information on most Meritor, ZF Meritor and Meritor WABCO products. \$20. Order TP-9853.

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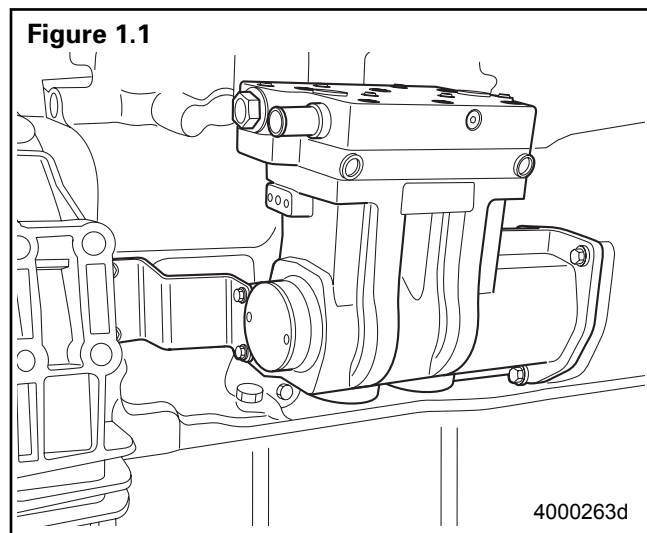
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Application

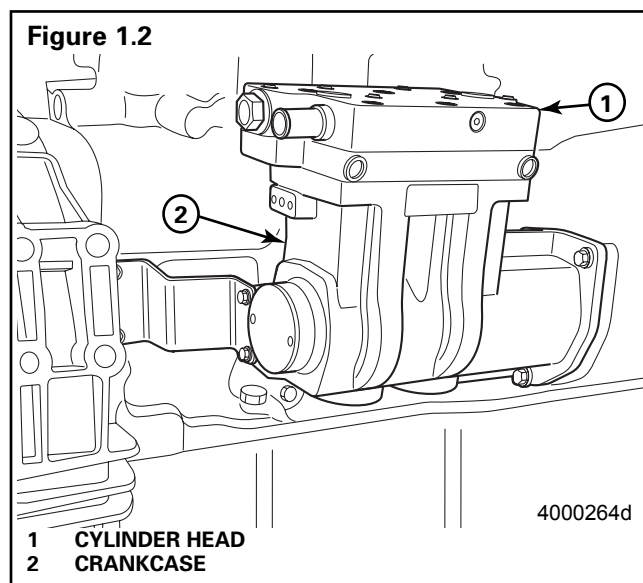
- Used on Mack engines. **Figure 1.1.**
- Swept volume displacement: 37.4 cubic feet per minute.
- Flange mounted to the engine.
 - Coupling driven through the auxiliary shaft.
 - Inlet air, oil lubrication and coolant supplied from the engine.
- Pneumatic pressure signal from the governor controls compression:
 - Integrated pressure relief valve protects the compressor and engine if discharge or governor lines become blocked, or if compressor cannot unload. The valve prevents the compressor from pumping more than 250 psi in the event of a blocked discharge line or other malfunction.

NOTE: This compressor has NO through drive capabilities for hydraulic power steering pumps.



Description

The Meritor WABCO System Saver 636 twin cylinder air compressor provides and maintains air under pressure to operate devices in the air brake and auxiliary air systems of a vehicle. It consists of two major subassemblies: Cylinder head and crankcase. **Figure 1.2.**



The **cylinder head** contains the inlet, discharge and unloader valving, as well as an integral relief valve. There are two water ports, marked Port 9, an air discharge port, marked Port 2, and an inlet port, marked Port 0, cast into the cylinder head to accommodate a hose connection. The cylinder head is mounted on the crankcase.

The **crankcase** contains the cylinder bores, pistons, bearings, crankshaft, governor port and connecting rods.

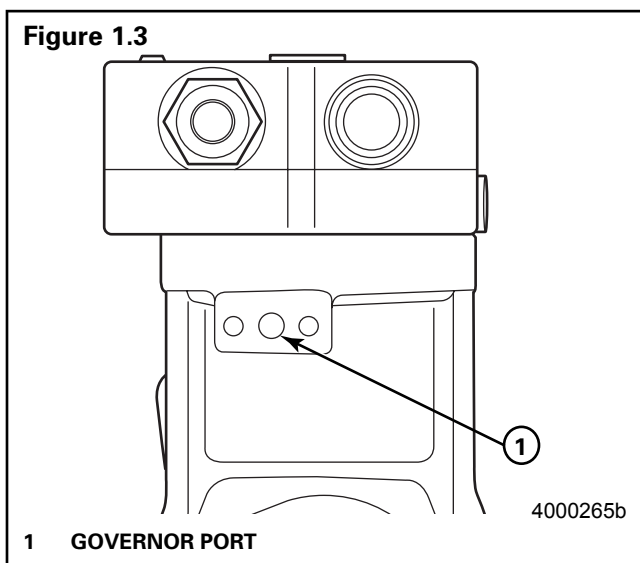
Section 1 Introduction

MERITOR WABCO

Operation

The compressor is driven by the engine. The compressor's crankshaft turns continuously while the engine is running. Compression of air is controlled by the **governor** and by the **compressor's unloading mechanisms**.

The **governor** maintains the brake system air pressure at preset maximum and minimum levels. The governor is mounted apart from the compressor, either horizontally or vertically. The governor port is located on the crankcase of the compressor. **Figure 1.3**.

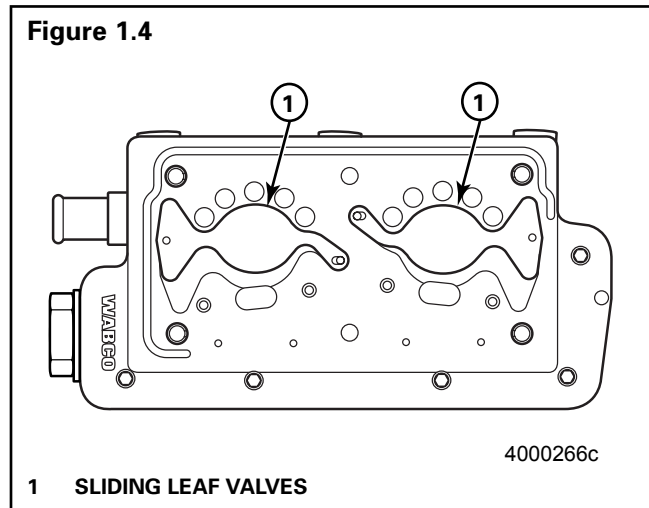


The **unloader mechanisms** control the air compression cycle; an air compression cycle has three phases:

1. **Induction:** Air flows from the engine to the compressor, opening the inlet valves in the cylinder head of the compressor.
2. **Compression:** Air pressure is increased, causing the compressor's discharge valves to open.
3. **Unloading:** Air passes from the cylinders to the inlet chambers of the cylinder head via a port controlled by sliding leaf valves.

When system cut-in pressure is reached, air is exhausted from the unloader ports.

4. After unloading, the unloader pistons return the sliding leaf valves to the loaded position. This seals the unloader ports and compression resumes. **Figure 1.4**.



Maintenance Intervals

The Meritor WABCO System Saver 636 twin cylinder air compressor receives inlet air, oil and coolant from the engine, so it is important to follow the engine manufacturer's recommendations and maintenance schedules regarding fluid levels, air filter and recommended change intervals.

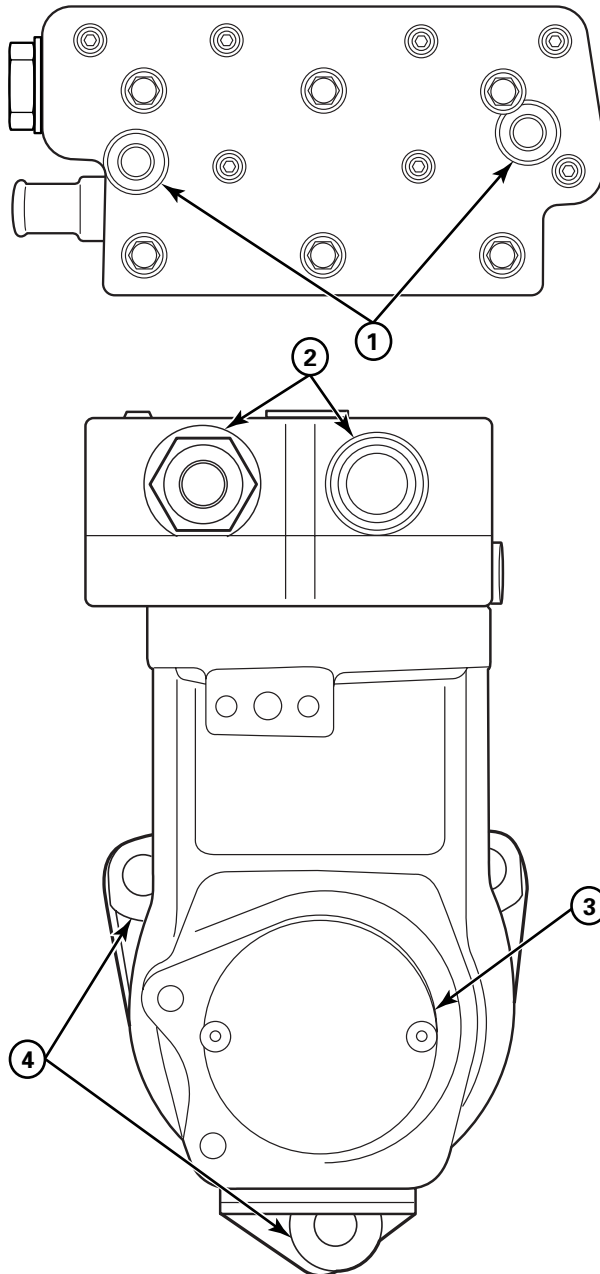
Cylinder Head

Remove carbon deposits from the discharge cavity and rust and scale from the cooling passages of the cylinder head.

Clean carbon and dirt from the inlet and unloader passages.

Visual Inspection

A visual check of the compressor can detect minor problems (see legend for examples of these problems). This check should be part of the vehicle preventive maintenance program. **Figure 1.5.**

Figure 1.5

- 1 Check water ports for leakage.
- 2 Check air inlet and discharge ports for leakage.
- 3 Check around end cover for oil leakage.
- 4 Check flanges for cracks or breaks.

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Use the following chart to troubleshoot the Meritor WABCO System Saver 636 twin cylinder air compressor.

NOTE: If you have any questions or need additional information, please contact the Meritor WABCO Customer Service Center at 866-668-7221.

Table A: Compressor Troubleshooting Guide

Condition	Possible Cause	Solution
Compressor passes excessive oil (for example, the presence of oil at exhaust air brake system valves, oil in air dryer dessicant, etc.)	Blocked or restricted oil return	Clean oil drain passages in the compressor and on the engine surface. Verify proper passage alignment.
	Contaminated inlet air or oil	Replace damaged, defective or dirty engine air filter. Repair any leaking, damaged or defective compressor air intake components. Change engine lubricating oil. NOTE: To avoid this condition, make sure vehicle manufacturer's oil and filter maintenance schedules are followed.
	Restricted air inlet or excessive vacuum present at compressor inlet	Verify engine air cleaner is functioning properly. Replace if necessary. Repair compressor air inlet kinks or excessive bends. Check vehicle specifications to ensure air and coolant lines meet all requirements.
	Excessive engine crankcase pressure	Verify engine crankcase venting is to manufacturer's specification.
	Compressor duty cycle too high	Check system for leaks. Make necessary repairs.
	None of the above, but condition persists	Replace the compressor.
Compressor leaks oil	Physical damage or internal problems with compressor	Replace the compressor.
Compressor continuously cycles	Compressor unloader piston leaking	With compressor unloaded check for air leakage. If leaking, replace the cylinder head.
	Governor air leak	Refer to the manufacturer's manual for governor maintenance and troubleshooting procedures.
	Dryer purge valve air leakage	Check for air dryer malfunction. Refer to air dryer manufacturer's service instructions.
	Air leak at governor-compressor attachment.	Inspect connection for physical damage. Inspect and repair connection.
	Air leak at alcohol injector	Clear line of any obstructions. Inspect and repair connection.
	Excessive reservoir contamination	Drain reservoirs.
	None of the above, but condition persists	Replace the compressor.

Section 2 Troubleshooting

Table A: Compressor Troubleshooting Guide (Continued)

Condition	Possible Cause	Solution
No air delivery Low air delivery Low air pressure	Discharge line blockage	Check for freeze up in the discharge line. Check low spots and eliminate any traps in the discharge line. Inspect and repair compressor discharge port and clear any line restrictions. Replace damaged lines as necessary. Check for carbon build-up. If carbon has built up, make sure cooling lines are not kinked or restricted. If carbon has built up in the discharge line, replace the line.
	Inlet line kinked or restricted	Inspect the compressor air induction line for kinks and restrictions. Repair or replace as necessary.
	Governor malfunction or misadjustment	Check for proper loader/unloader cycles of compressor. Refer to vehicle manufacturer's manual for governor maintenance and troubleshooting procedures.
	External contamination	Replace broken, defective or dirty air filters. Clean contaminants from surface of compressor.
	Air dryer purge valve stuck open or leaking	Check for air dryer malfunction. Refer to air dryer manufacturer's service instructions.
	Chafed or worn discharge line	Replace faulty sections of discharge line.
	Loose or leaking air line connections	Verify all connections are secure. Tighten to vehicle specifications where necessary. Inspect port threads for damage. If damage is extensive, replace cylinder head.
	Damage to compressor valves and/or valve seats	Replace the cylinder head.
	Leaking or malfunctioning internal pressure relief valve	Replace the cylinder head.
Noisy air compressor	Loose drive hub Loose accessory drive coupling	Check fit of drive coupling. Ensure hub is completely seated and crankshaft nut is tight. Inspect crankshaft for damage — replace compressor if crankshaft is damaged.
	None of the above, but condition persists	Replace the compressor.
	Broken connecting rod or crankshaft	Oil starvation to crank pin or front main bearing	Check oil pressure. Verify oil passage is free of obstructions. Make necessary repairs.
Failed power steering pump		Verify power steering pump is in proper operating order. Refer to the component manufacturer's service instructions.
All of the above		Replace compressor.

Table A: Compressor Troubleshooting Guide (Continued)

Condition	Possible Cause	Solution
Compressor leaks engine coolant	Loose fitting	Check fittings at compressor and engine for leaks and verify fittings are properly torqued.
	Cracked coolant port	Replace cylinder head.
	Porosity in cylinder head	Replace cylinder head.
	Leaking of gasket internal to the cylinder head	Verify cylinder head bolts are properly torqued. Make necessary adjustments. Inspect gasket for cracks or signs of wear. Replace if necessary. Replace cylinder head.
	None of the above, but condition persists	Replace compressor.
Compressor pressurizes coolant system or coolant leakage to compressor inlet	Leaking of gasket internal to the cylinder head	Inspect gasket. Replace if necessary.
	Cavitation or corrosion in cylinder head	Replace cylinder head.
	Porosity in cylinder head or cylinder head cracked	Replace cylinder head.
	None of above, but condition persists	Replace the compressor.
Unloader leakage	Possible internal damage, including worn or damaged unloader piston O-ring, porosity in unloader piston bore, loose or leaking seal at unloader piston bore	Replace compressor cylinder head assembly.
Compressor head gasket failure	Discharge line blocked due to freezing or carbon build-up	Check for trap (low spots) in lines. Make necessary repairs. Clear discharge line. Replace line if necessary. Check for carbon build-up. If carbon build-up is present, replace the discharge line.
	Frozen or blocked line to governor	Clear blocked line. Replace line if necessary. Check for air dryer malfunction. Repair or replace as required. Refer to the air dryer manufacturer's maintenance manual for service information.
	Governor malfunction	Repair or replace the governor. Refer to governor manufacturer's maintenance manual for service information.
	Improper cylinder head bolt torque, machining defect on cylinder head or block, defective cylinder head gasket	Inspect gasket. Replace if necessary. Verify all bolts are properly torqued. If problem persists, replace cylinder head.
	None of the above, but condition persists	Replace compressor cylinder head assembly.

The cylinder head portion of the compressor is replaceable. The crankcase is not replaceable. If the crankcase is damaged or malfunctioning, replace the complete compressor.

 **WARNING**

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Remove all pressure from the air system before you disconnect any component. Pressurized air can cause serious personal injury.

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

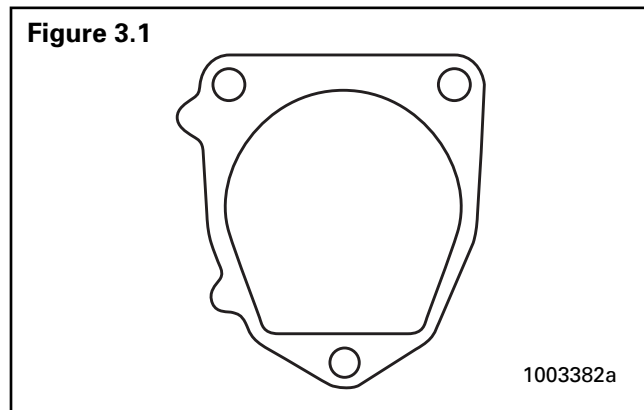
Compressor Replacement Information

 **CAUTION**

The removal instructions given in this manual are general. Depending on the type of vehicle involved, additional steps may be required. Refer to the vehicle manufacturer's manual for additional information.

The front of the Meritor WABCO System Saver 636 air compressor is mounted to the engine.

Before you remove the compressor, make sure you have a replacement gasket to install with the new compressor (Mack Part Number 590GB2159). Figure 3.1.



Compressor Removal

1. Set the spring (parking) brakes and block the wheels of the vehicle.
2. Drain the air pressure from the air system.
3. Drain the engine cooling system and the cylinder head of the compressor.
4. Disconnect all air and water lines leading to the compressor.
5. Remove the discharge and coolant fittings. Note fitting locations to aid in reassembly.

NOTE: The discharge fitting consists of a fitting and a bushing. The bushing should remain in the cylinder head.

6. Loosen and remove the four bracket mounting bolts: Two bolts that hold the rear support bracket to the back of the compressor and two bolts that hold the bracket to the engine block. Retain the bolts for re-assembly.

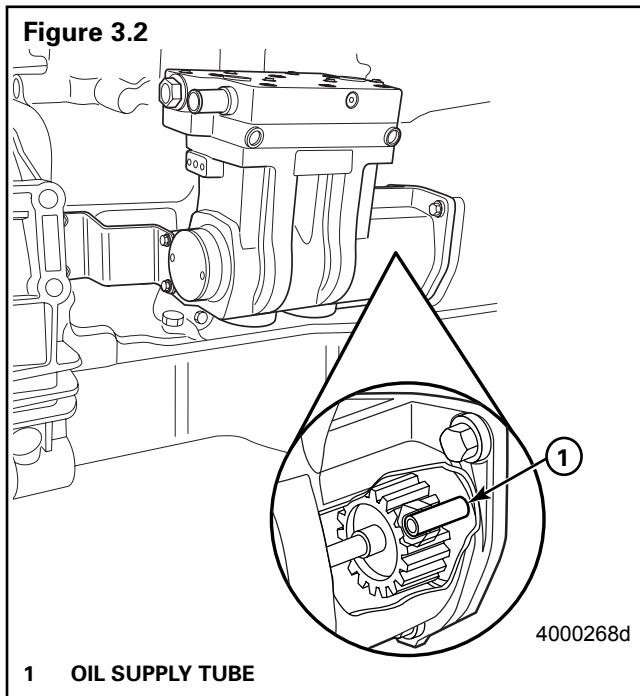
NOTE: This bracket supports the weight of the compressor.

7. Loosen the three flange mounting bolts that hold the compressor to the engine.
8. Remove the compressor from the engine.




Remove and retain the oil supply tube that runs between the compressor and the engine. Figure 3.2.

Section 3 Compressor Replacement

MERITOR WABCO



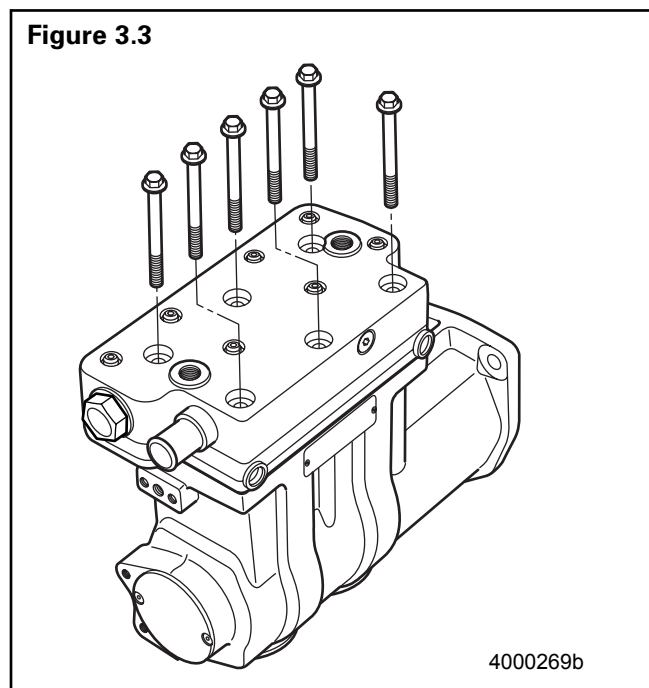
Compressor Installation

1. Reinstall the oil supply tube.
 2. Install a new compressor gasket.
 3. Position the compressor on the engine.
 4. Install the three flange mounting bolts. Tighten to 15 lb-ft (20 N•m) +90° rotation. 
 5. Install the two bolts that hold the bracket to the compressor and the two bolts that hold the bracket to the engine block. Run the bolts down finger tight at both ends of the bracket (engine and compressor). The bracket should be in contact with both surfaces; engine block and compressor rear support face. Tighten bolts to 18 lb-ft (25 N•m) maximum at compressor side. Tighten bolts at engine side per Mack specification. 
 6. Attach the discharge and coolant fittings. Finger-tighten fittings and rotate 2 to 3 turns to position fitting. 
 7. Connect all air and water lines leading to the compressor. Tighten per Mack specifications.
 8. Add engine coolant to the cooling system. Use the coolant recommended by the engine manufacturer. Visually inspect the engine and compressor for leaks.
9. Start the engine and allow air system to build to governor cutout. Stop the engine. Use a soap and water solution at connection points to check for air leaks. Make any necessary repairs.
 10. Remove the wheel blocks and release the spring (parking) brakes.

Cylinder Head Replacement

Removal

1. Follow the steps listed in Compressor Removal to remove the compressor from the engine. Take care not to damage the crankcase, since it will not be replaced.
2. Use a cleaning solvent to remove road dirt and grease from the exterior of the compressor.
3. Remove and discard the six hex head bolts that attach the cylinder head to the crankcase and remove the cylinder head valves and gaskets. **Figure 3.3.**



4. Use a mild cleaning solvent to clean the top of the crankcase.

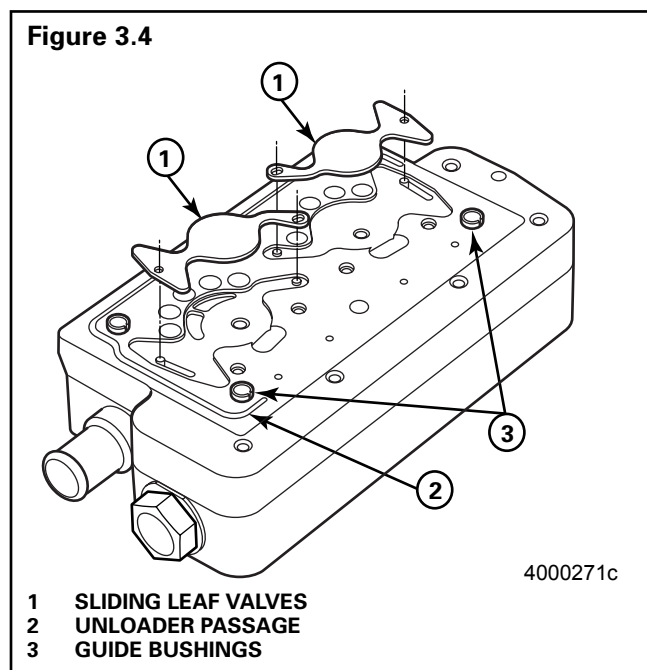
Installation

NOTE: A Torx® tool is required for this procedure.

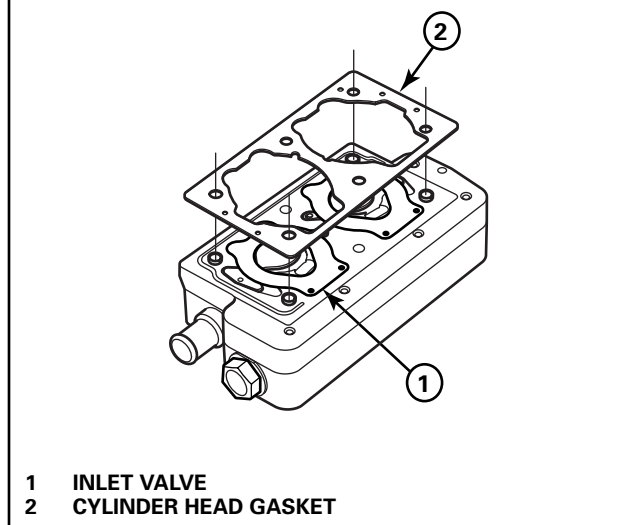
Cylinder head valve components **MUST** be aligned in the proper position in order for the compressor to function.

1. Install the sliding leaves. The two holes in each sliding leaf must be installed over the two pins on the base of the cylinder head. **Figure 3.4.**

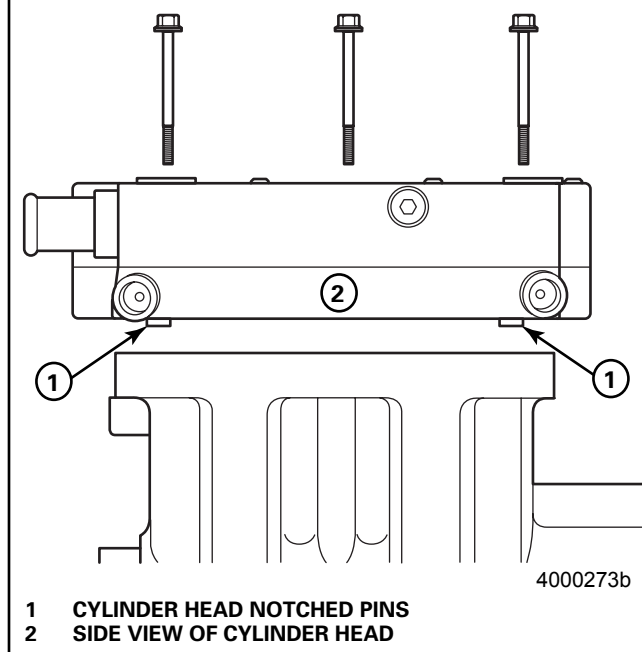
NOTE: A light application of engine oil will hold the sliding leaves to the inlet valves. **Figure 3.4.**



2. Lay the new cylinder head gasket in place, ensuring that it fits over the guide bushings and that the unloader hole allows air pressure communication from the cylinder head to the crankcase. **Figure 3.5.**
3. Place the inlet valves over the guide pins provided, ensuring that the pads are up and the valves will lie flat against the head openings. A small amount of Lubriplate grease can be used to ensure they remain in place for the remainder of the assembly. **Figure 3.5.**

Figure 3.5

4. Position the cylinder head on top of the compressor. Ensure the notched pins on the cylinder head align with the recesses in the block. Only four of the six bolt holes have notched pins. **Figure 3.6.**

Figure 3.6

Section 3 Compressor Replacement

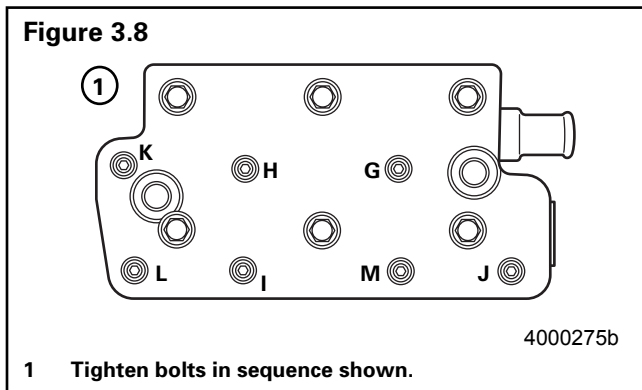
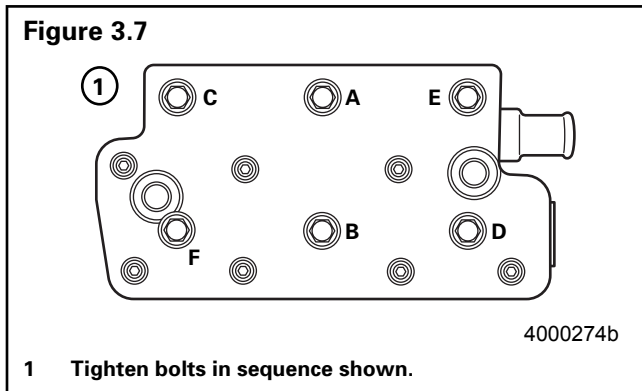
5. Install the six hex head mounting bolts that hold the cylinder head in place. Tighten the mounting bolts in sequence per Table B, following Steps 1-12. **Figure 3.7.**
6. Use a Torx® tool to tighten the seven Torx® head screws in sequence per Table B, following Steps 13-26. **Figure 3.8.**

CAUTION

Use the proper tools to perform this torque-turn bolt tightening sequence exactly as shown in Table B. Accuracy is CRITICAL to your field service success!

Table B: Bolt Tightening Sequence

Step	Bolt	Torque		Rotation (Degrees)
		(N·m)	lb-ft	
1	A	25 ⁺⁰ ₋₅	18.5 ⁺⁰ _{-3.7}	
2	B	25 ⁺⁰ ₋₅	18.5 ⁺⁰ _{-3.7}	
3	C	25 ⁺⁰ ₋₅	18.5 ⁺⁰ _{-3.7}	
4	D	25 ⁺⁰ ₋₅	18.5 ⁺⁰ _{-3.7}	
5	E	25 ⁺⁰ ₋₅	18.5 ⁺⁰ _{-3.7}	
6	F	25 ⁺⁰ ₋₅	18.5 ⁺⁰ _{-3.7}	
7	A			150° ⁺¹⁵ ₋₅
8	B			150° ⁺¹⁵ ₋₅
9	C			120° ⁺¹⁵ ₋₅
10	D			120° ⁺¹⁵ ₋₅
11	E			120° ⁺¹⁵ ₋₅
12	F			120° ⁺¹⁵ ₋₅
13	G	6 ⁺⁶ ₋₆	4.4 ^{+4.4} _{-4.4}	
14	H	6 ⁺⁶ ₋₆	4.4 ^{+4.4} _{-4.4}	
15	I	6 ⁺⁶ ₋₆	4.4 ^{+4.4} _{-4.4}	
16	J	6 ⁺⁶ ₋₆	4.4 ^{+4.4} _{-4.4}	
17	K	6 ⁺⁶ ₋₆	4.4 ^{+4.4} _{-4.4}	
18	L	6 ⁺⁶ ₋₆	4.4 ^{+4.4} _{-4.4}	
19	M	6 ⁺⁶ ₋₆	4.4 ^{+4.4} _{-4.4}	
20	G			135° ⁺¹⁵ ₋₅
21	H			135° ⁺¹⁵ ₋₅
22	I			135° ⁺¹⁵ ₋₅
23	J			135° ⁺¹⁵ ₋₅
24	K			135° ⁺¹⁵ ₋₅
25	L			135° ⁺¹⁵ ₋₅
26	M			135° ⁺¹⁵ ₋₅



7. Follow the steps listed in Compressor Installation to reinstall the compressor and test for leaks.

Performance Testing

Test the vehicle air system as follows:

1. Bleed the vehicle air system reservoir gauges down (apply brakes several times) to approximately 85 psig.
2. With the engine running at full governed speed (no load, no air accessories being used), the compressor should reach governor cutout pressure, then unload.

If the compressor does not reach governor cutout pressure, check for air leaks in the system. If reservoir volume and engine RPM are per original vehicle manufacturer's specifications, system plumbing leakage must be checked and, if necessary, repaired. See air system leakage test procedures which follow.

If the compressor fails to unload, verify proper governor operation.

Air System Leakage Test

(Conforms to North American Uniform Roadside Inspection Criteria)

1. Park the vehicle on a level surface. Apply the parking brakes. Disconnect any attached or towed vehicles (semi-trailer, full trailer, dolly, etc.). Leave engine on.
2. Chock the tires.
3. Release the parking brakes.
4. With the compressor in pumping mode, engine at idle and service brakes fully applied gauge must stay between 80-90 psi or gradually rise.

If pressure is not maintained (pressure drops) there is an air leak in the system.

Listen for air leaks. Soapy water or high frequency acoustic detectors may be used to detect any leaks. Make the necessary repairs.

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16579/24240

BA-921 BENDIX AIR POWER COMPRESSOR

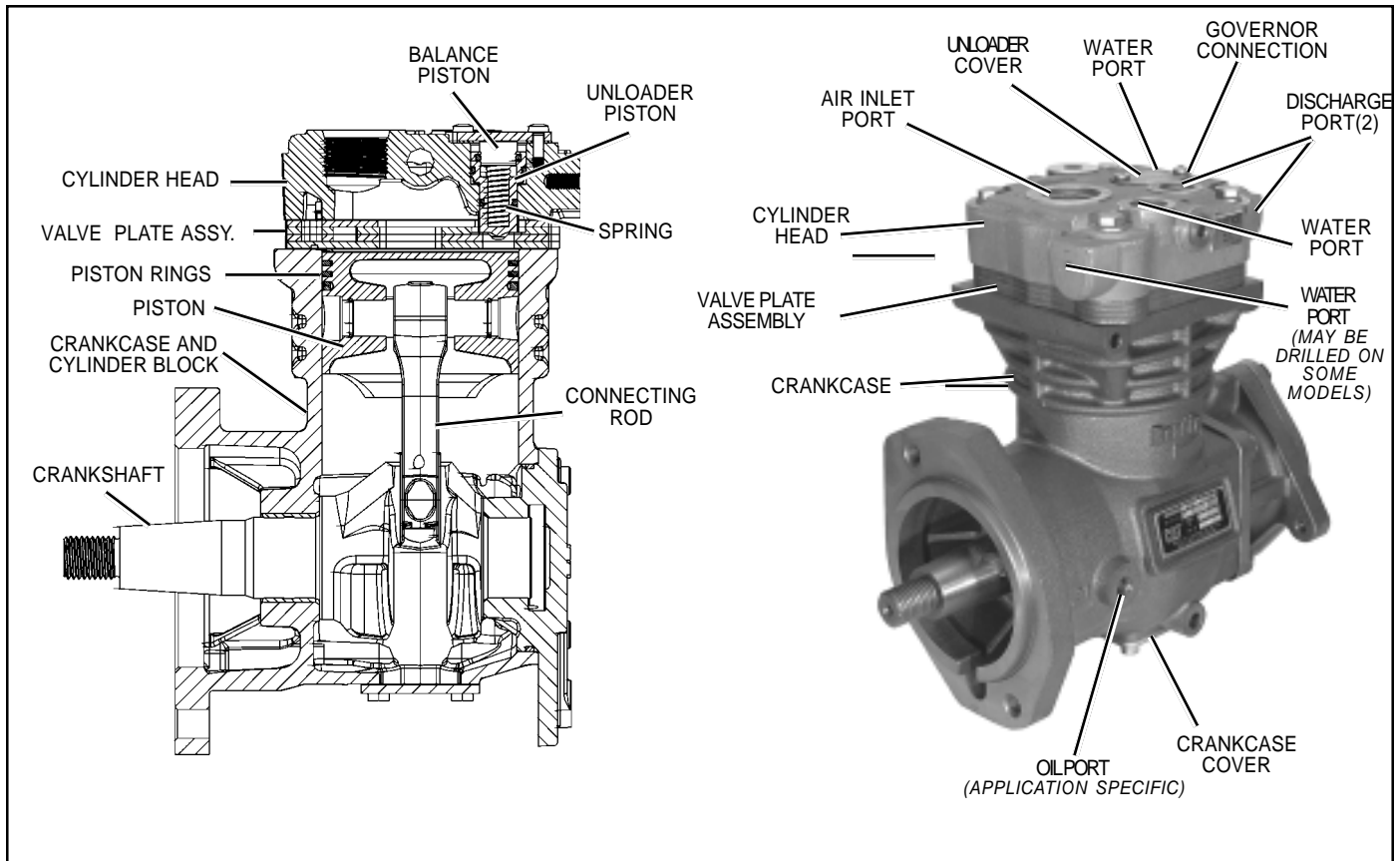


FIGURE 1 - BA-921 COMPRESSOR

DESCRIPTION

The function of the air compressor is to provide and maintain air under pressure to operate devices in the air brake and/or auxiliary air systems. The BA-921 compressor is a single cylinder reciprocating compressor with a rated displacement of 15.8 cubic feet per minute at 1250 RPM.

The compressor consists of a water cooled cylinder head and valve plate assembly and an air cooled integral crankcase and cylinder block. The cylinder head is an aluminum casting which contains the required air and water ports as well as an unloader piston. The valve plate assembly consists of laminated and brazed steel plates which incorporate various valve openings and channels for

conducting air and engine coolant into and out of the cylinder head.

The discharge valves are part of the valve plate assembly. The cylinder head, with the valve plate comprise a complete cylinder head assembly.

The cast iron crankcase and cylinder block assembly, houses the piston, connecting rod, crankshaft and related bearings.

The BA-921 crankcase cover is stamped with information identifying the compressor model, customer piece number, Bendix piece number and serial number. See figure 2.

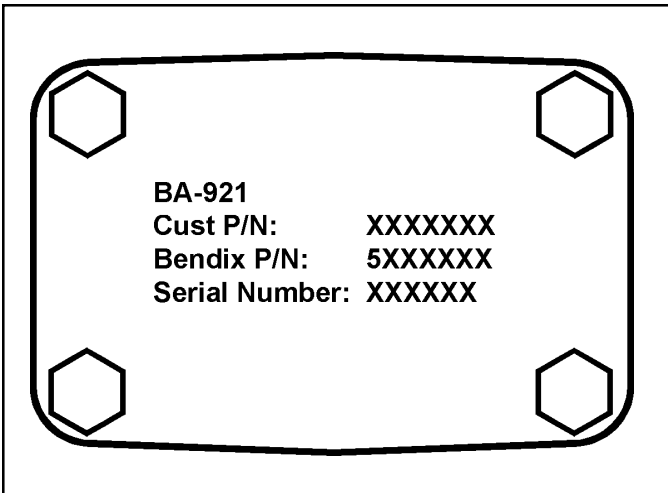


FIGURE 2 - BA-921 CRANKCASE COVER

OPERATION

The compressor is driven by the vehicle engine and functions continuously while the engine is in operation. Actual compression of air is controlled by the compressor unloading mechanism operating in conjunction with a governor.

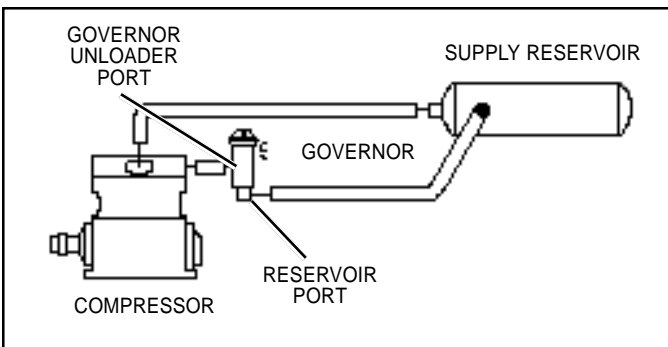


FIGURE 3 - BA-921 COMPRESSOR UNLOADER SYSTEM

AIR INTAKE (LOADED)

During the piston down stroke, a vacuum is created in the cylinder bore above the piston. The vacuum causes the inlet reed valve to flex open. Atmospheric air flows through the open inlet valve and fills the cylinder bore above the piston. See figures 4 & 7.

AIR COMPRESSION (LOADED)

When the piston reaches approximately bottom dead center (BDC), the inlet reed valve closes. Air above the piston is trapped by the closed inlet reed valve and is compressed as the piston begins to move toward top dead center (TDC). When air in the cylinder bore reaches a pressure greater than that of the system pressure the discharge reed valves open and air flows into the discharge line and air brake system.

Air, during the compression stroke, flows into the hollow center of the unloader piston through an opening in the end of the piston. Compressed air acts on the interior surfaces

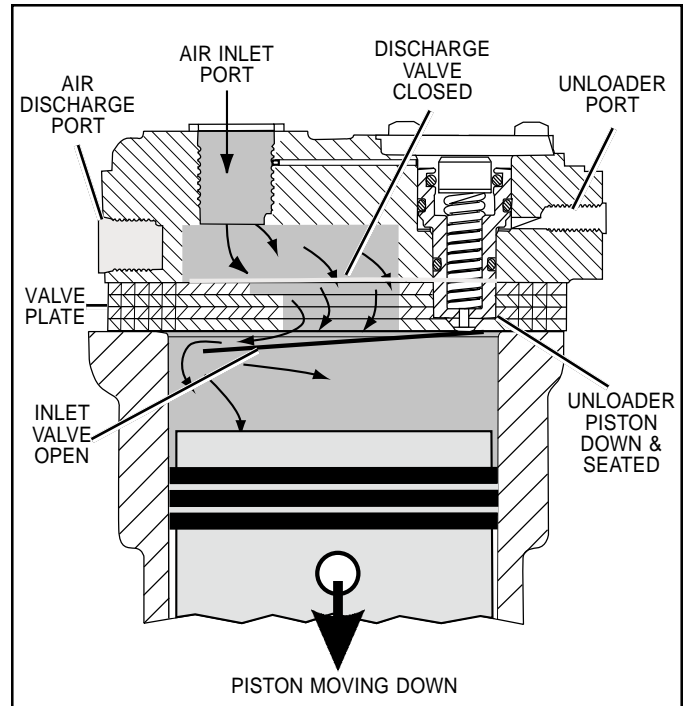


FIGURE 4 - OPERATIONAL-LOADED (INTAKE)

of the unloader piston and, along with the unloader piston spring, holds the unloader piston against its seat on the valve plate. See figures 5 & 7.

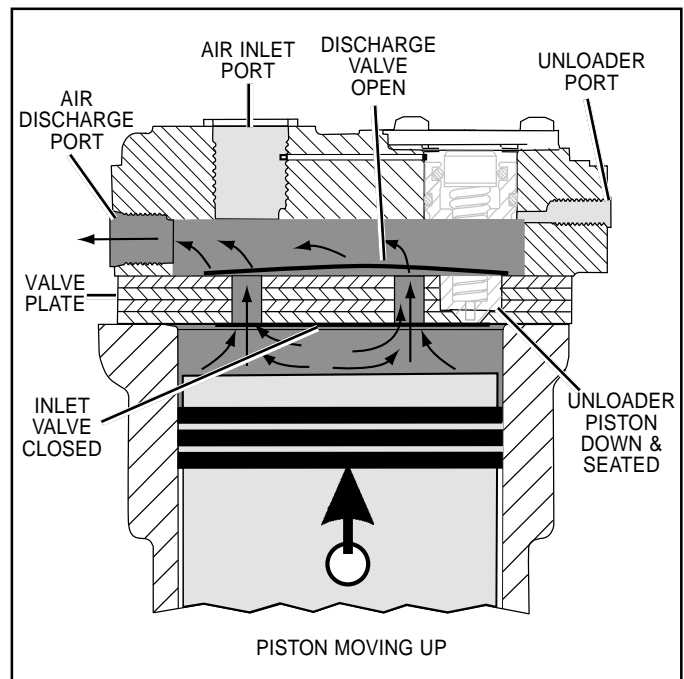


FIGURE 5 - OPERATIONAL-LOADED (COMPRESSION)

NON-COMPRESSION OF AIR (UNLOADED)

When air pressure in the supply reservoir reaches the cut-out setting of the governor, the governor delivers system air to the compressor unloader port. Air entering the unloader port acts on the unloader piston causing it to move away from its seat on the valve plate assembly. When the

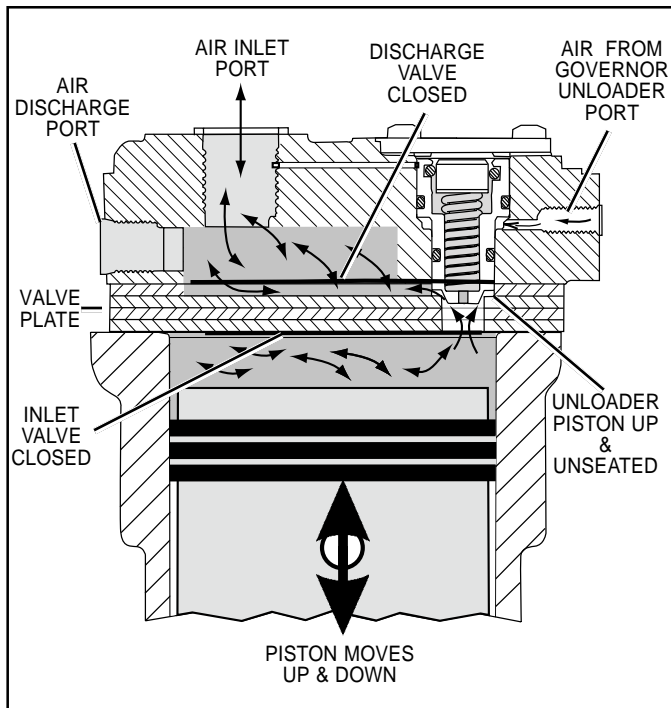


FIGURE 6 - OPERATIONAL-UNLOADED

unloader piston is unseated a passage is opened between the cylinder bore and the air inlet cavity in the cylinder head. Air compression ceases. See figures 6 & 7.

As the piston moves from bottom dead center (BDC) to top dead center (TDC) air in the cylinder bore flows past the unseated unloader piston, into the cylinder head inlet cavity and out the inlet port. On the piston down stroke (TDC to BDC) air flows in the reverse direction, from the inlet cavity past the unseated unloader piston and into the cylinder bore.

LUBRICATION

The vehicle's engine provides a continuous supply of oil to the compressor. Oil is routed from the engine to the compressor oil inlet. An oil passage in the crankshaft conducts pressurized oil to precision sleeve main bearings and to the connecting rod bearings. Spray lubrication of the cylinder bores, connecting rod wrist pin bushings, and ball type main bearings is obtained as oil is forced out around the crankshaft journals by engine oil pressure. Oil then falls to the bottom of the compressor crankcase and is returned to the engine through drain holes in the compressor mounting flange.

COOLING

Cooling fins are part of the crankcase/cylinder block casting. Coolant flowing from the engine cooling system through connecting lines enters the head and passes through internal passages in the cylinder head and valve plate assembly and is returned to the engine. Proper cooling is important in maintaining discharge air temperatures below the maximum recommended 400 degrees Fahrenheit. Figure 8 illustrates

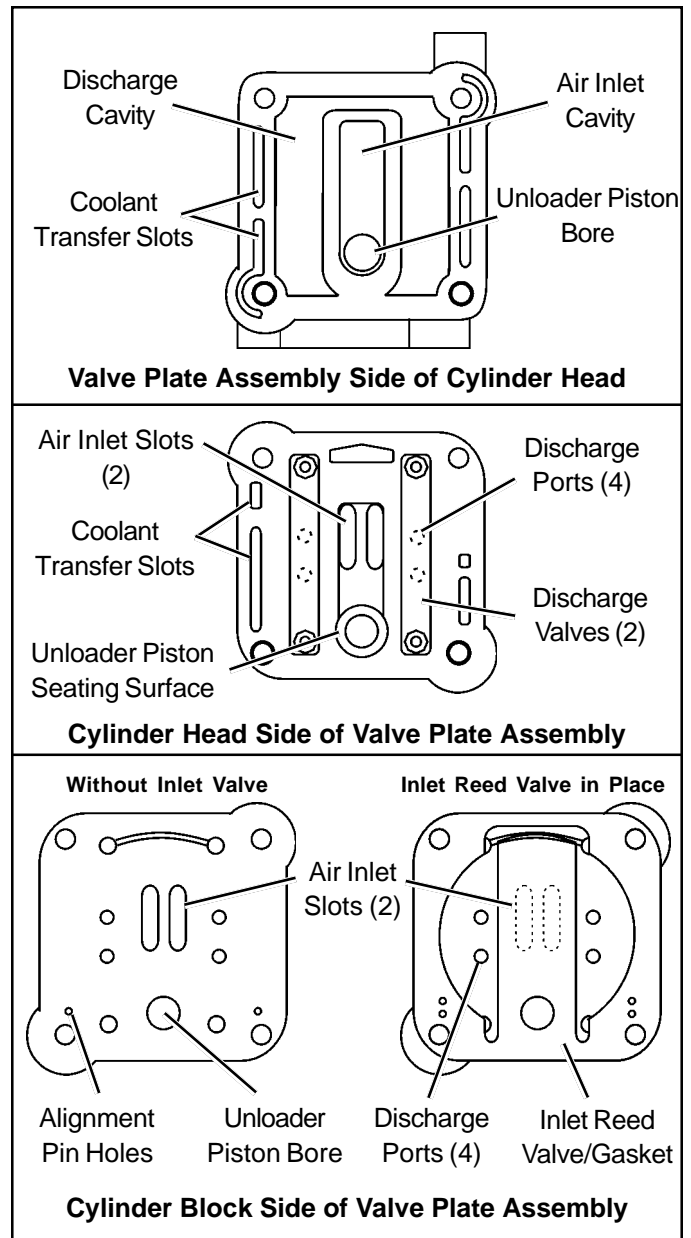


FIGURE 7 - CYLINDER HEAD AND VALVE PLATE ASSY.

the various approved coolant flow connections. See the tabulated technical data in the back of this manual for specific requirements.

PREVENTATIVE MAINTENANCE

Important Note: Review the warranty policy before performing any intrusive maintenance procedures. An extended warranty may be voided if intrusive maintenance is performed during this period.

EVERY 6 MONTHS, 1800 OPERATING HOURS OR AFTER EACH 50,000 MILES WHICHEVER OCCURS FIRST PERFORM THE FOLLOWING INSPECTIONS AND TESTS.

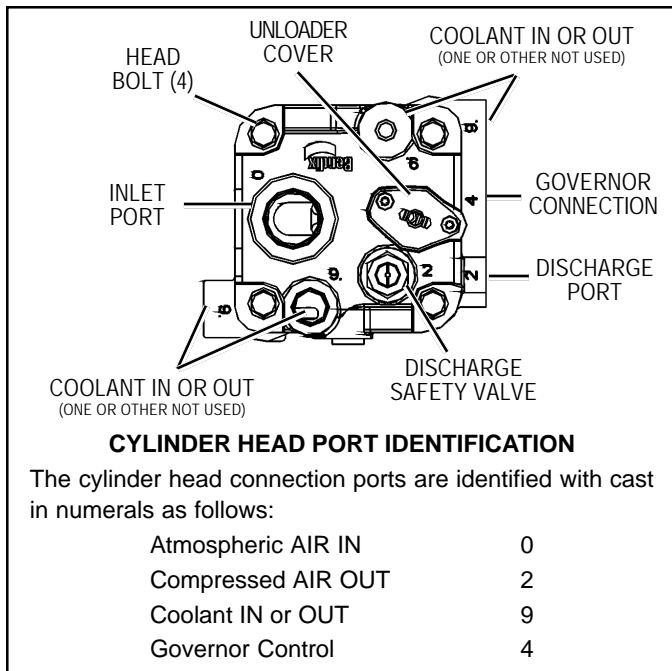


FIGURE 8- TYPICAL BA-921 CYLINDER HEAD

AIR INDUCTION

The BA-921 compressor is designed for either natural aspiration (connection to the vacuum side of the engine's air induction system) or turbocharging. When attached to the pressure side of the turbocharger, pressure at the BA-921 inlet port must not exceed 45 psig. See the tabulated technical data in the back of this manual.

One of the single most important aspects of compressor preventive maintenance is the induction of clean air. Since the BA-921 is connected to the engine air cleaner, proper periodic maintenance of the engine air filter eliminates the need for separate filter maintenance.

Inspect the compressor intake fittings, and the connecting hoses each time engine air cleaner maintenance is performed.

1. Inspect the intake hose adapters for physical damage. Make certain to check the adapters at both ends of the intake hose or tubing.
2. The intake hose clamps and tighten them if needed.
3. Inspect the intake hose or line for signs of drying, cracking, chafing and ruptures and replace it if necessary.

COMPRESSOR COOLING

Inspect the compressor discharge port, inlet cavity and discharge line for evidence of restrictions and carboning. If excessive buildup is noted, thoroughly clean or replace the affected parts. Since carbon buildup generally indicates inadequate cooling, closely inspect the compressor cooling system. Check all compressor coolant lines for kinks and

restrictions to flow. **Minimum** coolant line size is 3/8" I.D. Check coolant lines for internal clogging from rust scale. If coolant lines appear suspicious, check the coolant flow and compare to the tabulated technical data present in the back of this manual. Carefully inspect the air induction system for restrictions.

LUBRICATION

Check the external oil supply line for kinks, bends, or restrictions to flow. Supply lines must be a minimum of 3/16" I.D. Refer to the tabulated technical data in the back of this manual for oil pressure minimum values.

COMPRESSOR DRIVE

Check for noisy compressor operation, which could indicate excessive drive component wear. Adjust and/or replace as necessary. Check all compressor mounting bolts and retighten evenly if necessary. Check for leakage and proper unloader mechanism operation. Repair or replace parts as necessary.

COMPRESSOR UNLOADER & GOVERNOR

Test and inspect the compressor and governor unloader system for proper operation and pressure setting.

1. Make certain the unloader system lines are connected as illustrated in figure 3.
2. Cycle the compressor through the loaded and unloaded cycle several times. Make certain that the governor cuts out at its specified pressure (cut in should be approximately 15-20 psi less than cutout pressure). Adjust or replace the governor as required.
3. Note that the compressor cycles to the loaded and unloaded conditions promptly. If prompt action is not noted, repair or replace the governor and/or repair the compressor unloader.

SERVICE TESTS

GENERAL

The following compressor operating and leakage tests need not be performed on a regular basis. These tests should be performed when; it is suspected that leakage is substantially affecting compressor buildup performance, or when it is suspected that the compressor is "cycling" between the load and unloaded modes due to unloader plunger leakage.

OPERATING TESTS

Compressor Performance

Vehicles manufactured after the effective date of FMVSS 121 must have a compressor capable of raising air system pressure from 85-100 psi in 25 seconds or less, with the

minimum required reservoir volume for the vehicle. This test is performed with the engine operating at maximum recommended governed speed. The vehicle manufacturer must certify this performance on new vehicles with appropriate allowances for air systems with greater than the minimum required reservoir volume. As a less severe alternative to running a high RPM test, a new compressor's buildup time can be measured and recorded at high idle. Subsequent testing throughout the compressor's service life can be compared to the base line new compressor performance. Compressor buildup times should be recorded and kept with the vehicle maintenance files for reference. When testing compressor buildup times it is essential that air system leakage be kept below the allowed maximum for the vehicle type being tested. Before running buildup tests check the service and supply systems for excessive leakage and repair as necessary.

Note: Supply system leakage is not displayed on the vehicle dash gauges and must be tested separately. Supply system components such as the governor, air dryer, reservoir drain cocks, safety valve and check valves can leak without indication on the dash gauges. These components must be checked for leakage separately and individually. Refer to the various maintenance manuals for individual component leakage tests and the Bendix "Test and Checklist" published in the Air Brake System Handbook (BW5057) for air system leakage testing.

LEAKAGE TESTS

Cylinder Head

Check for cylinder head gasket air leakage.

1. With the engine running, lower air system pressure to 60 psi and apply a soap solution around the cylinder head. Check the gasket between the cylinder head and valve plate assembly and the reed valve/gasket between the valve plate assembly and cylinder block for air leakage.
2. No leakage is permitted. If leakage is detected replace the compressor or repair the cylinder head using a genuine Bendix maintenance kit available from an authorized Bendix parts outlets.

Unloader

In order to test the inlet and discharge valves and the unloader piston, it is necessary to have shop air pressure and an assortment of fittings. A soap solution is also required.

Build-Up tests

1. With the engine running, lower air system pressure to 90 psi and raise engine RPM to 1800. Measure and

record the time required to raise system pressure from 100 psi to 130 psi Run this test three times and use the average time.

Note: This test should be run with the engine and air system at normal operating temperature (i.e. not cold).

2. Compare the average time recorded in step 2 with previously recorded build up times to evaluate compressor performance.

Unloader leakage is exhibited by excessive compressor cycling between the loaded and unloaded condition.

1. With service and supply system leakage below the maximum allowable limits and the vehicle parked, bring system pressure to governor cutout and allow the engine to idle.
2. The compressor should remain unloaded for a minimum of 5-10 minutes. If compressor cycling occurs more frequently and service and supply system leakage is within tolerance replace the compressor or repair the compressor unloader system using a genuine Bendix maintenance kit available from authorized Bendix parts outlets.

COMPRESSOR REMOVAL & DISASSEMBLY

GENERAL

The following disassembly and assembly procedure is presented for reference purposes and presupposes that a rebuild or repair of the compressor is being undertaken. Several maintenance kits are available and the instructions provided with these parts and kits should be followed in lieu of the instructions presented here.

MAINTENANCE KITS & SERVICE PARTS

Cylinder Head Gasket Kit.

Unloader Kit.

Governor Adapter Kit.

Safety Valve.

Seal Kits.

All components shown in figure 9 with a key number are available in kits and/or as individual service parts.

IMPORTANT! PLEASE READ:

When working on or around a vehicle, the following general precautions should be observed:

1. **Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.**
2. **Stop the engine when working around the vehicle.**

3. If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle.
4. Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.
5. When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, extreme caution should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.
6. Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.
7. Never exceed recommended pressures and always wear safety glasses.
8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.
10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.
11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

REMOVAL

In many instances it may not be necessary to remove the compressor from the vehicle when installing the various maintenance kits and service parts. The maintenance technician must assess the installation and determine the correct course of action.

These instructions are general and are intended to be a guide. In some cases additional preparations and precautions are necessary. In all cases follow the instructions contained in the vehicle maintenance manual in lieu of the instructions, precautions and procedures presented in this manual.

1. Block the wheels of the vehicle and drain the air pressure from all the reservoirs in the system.

2. Drain the engine cooling system and the cylinder head of the compressor. Identify and disconnect all air, water and oil lines leading to the compressor.
3. Remove as much road dirt and grease from the exterior of the compressor as possible.
4. Remove the discharge and inlet fittings, if applicable, and note their position on the compressor to aid in reassembly.

Note: If a cylinder head maintenance kit is being installed, stop here and proceed to PREPARATION FOR DISASSEMBLY. If replacing the compressor continue.

3. Remove any supporting bracketing attached to the compressor and note their positions on the compressor to aid in reassembly.
5. Remove the flange mounting bolts and remove the compressor from the vehicle.
6. Inspect gear and associated drive parts for visible wear or damage. Since these parts are precision fitted, they must be replaced if they are worn or damaged. If replacing the compressor or replacing the drive gear, remove the drive gear from the compressor crankshaft using a gear puller.
7. If the compressor is being replaced stop here and proceed to "Installing The Compressor" at the end of the assembly procedure.

PREPARATION FOR DISASSEMBLY

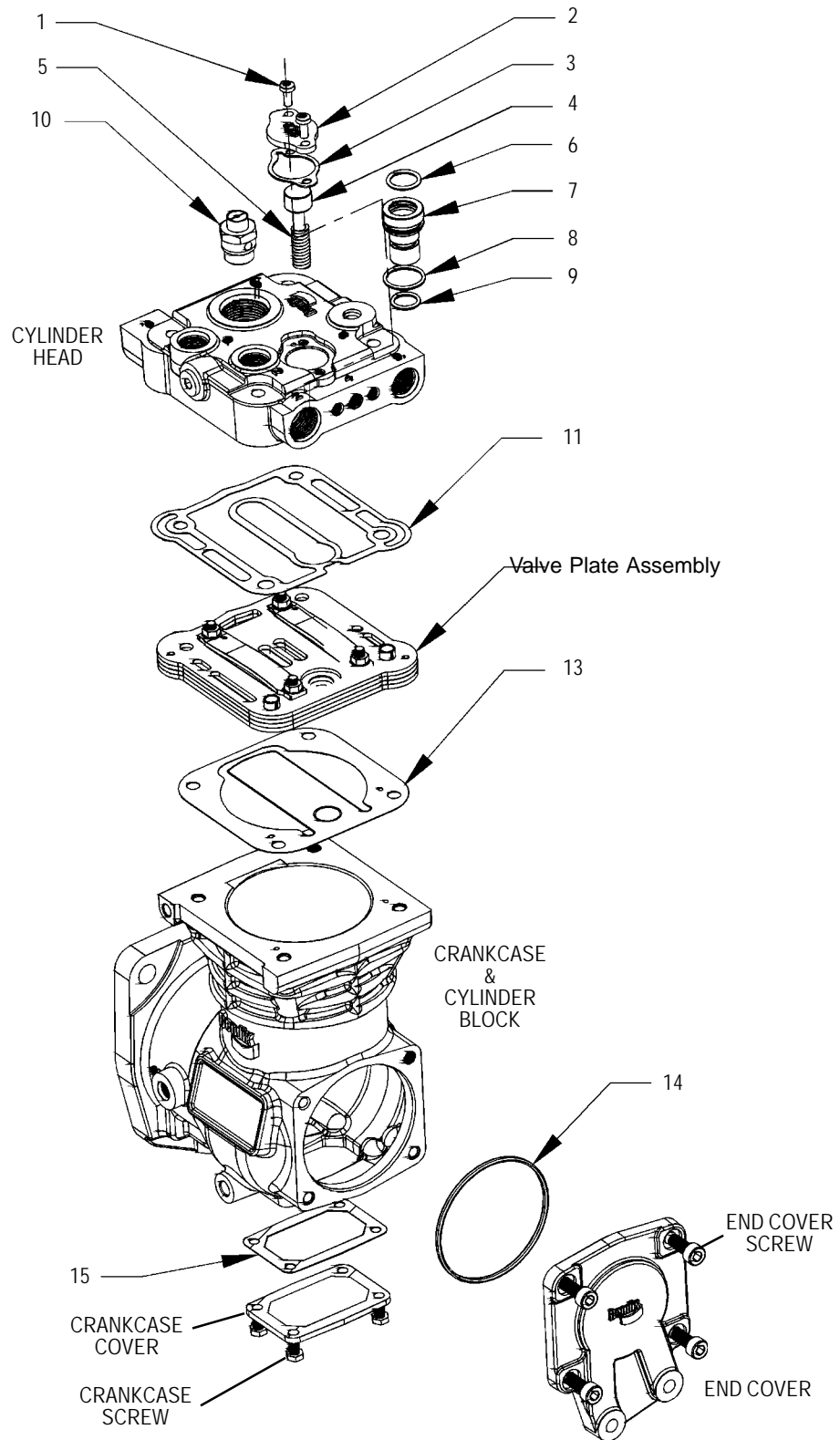
Remove the balance of road dirt and grease from the exterior of the compressor with a cleaning solvent. Mark the rear end cover or end cover adapter in relation to the crankcase. It is recommended but not specifically necessary to mark the relationship of the cylinder head to the valve plate assembly and crankcase and cylinder block assembly.

A convenient method to indicate the above relationships is to use a metal scribe to mark the parts with numbers or lines. Do not use marking methods such as chalk that can be wiped off or obliterated during rebuilding.

Prior to disassembly make certain that the appropriate kits and or replacement parts are available. Refer to figure 9 during the entire disassembly and assembly procedure.

CYLINDER HEAD

1. Remove the discharge safety valve (10) from the cylinder head.
2. To restrain the spring force exerted by balance piston spring (5), hold the unloader cover (2) in place while removing the two unloader cover cap screws (1). Carefully release the hold on the unloader cover until the spring force is relaxed, then remove the unloader cover (2).
3. Remove the unloader cover gasket (3).



Item	Qty.	Description	Item	Qty.	Description	Item	Qty.	Description
1	2	Unloader Cover Cap Screw	6	1	O-Ring	11	1	Head Gasket
2	1	Unloader Cover	7	1	O-Ring	12	--	Intentionally Left Blank
3	1	Unloader Cap Gasket	8	1	Unloader Piston	13	1	Inlet Reed Valve/Gasket
4	1	Unloader Balance Piston	9	1	O-Ring	14	1	O-Ring
5	1	Spring	10	1	Safety Valve	15	1	Bottom Cover Gasket

FIGURE 9- BA-921 EXPLODED VIEW OF SERVICEABLE PARTS

- Remove the balance piston (4) and its spring (5) from the cylinder head.
- Remove the four hex head bolts and washers from the cylinder head.
- Gently tap the head and valve plate assembly with a soft mallet to break the gasket seal. Lift the cylinder head and valve plate assembly (12) off the cylinder block.
- Remove the metal reed valve/gasket (13).
- Gently tap the head and valve plate assembly (12) with a soft mallet to break the gasket seal. Then separate the cylinder head from the valve plate assembly (12) and remove the gasket (11).
- Turn the aluminum cylinder head over to expose the interior portion of the head. Push the unloader piston (8) along with its o-rings (6, 7 & 9) out of the cylinder head.

CRANKCASE COVER

- Remove the four crankcase cover cap screws securing the crankcase cover to the crankcase. Using a soft mallet, gently tap the crankcase cover to break the gasket seal. Remove the crankcase cover gasket (15).

REAR END COVER OR END COVER ADAPTER

- Remove the four end cover cap screws that secure the rear end cover or end cover adapter to the crankcase.
- Remove the rear end cover or end cover adapter from the crankcase. Remove the o-ring seal (14) from the end cover.

CLEANING OF PARTS

GENERAL

All parts should be cleaned in a good commercial grade of solvent and dried prior to inspection.

CYLINDER HEAD

- Carefully remove all gasket material adhering to the aluminum cylinder head, steel valve plate assembly and cast iron cylinder block. Make certain not to deeply scratch or mar the gasket surfaces. Pay particular attention to the gasket surfaces of the aluminum head.
- Remove carbon deposits from the discharge and inlet cavities of the cylinder head and valve plate assembly. They must be open and clear in both assemblies. Make certain not to damage the aluminum head.
- Remove rust and scale from the cooling cavities and passages in the head and valve plate assembly (12) and use shop air to clear debris from the passages.
- Check the threads in all cylinder head ports for galling. Minor chasing is permitted.

- Make certain the unloader vent passage under the unloader cover (2) in the head is open and free of debris.

INSPECTION OF PARTS

CYLINDER HEAD & VALVE PLATE

- Carefully inspect the cylinder head gasket surfaces for deep gouges and nicks. If detected, the compressor must be replaced.
- Carefully inspect the valve plate assembly gasket surfaces for deep gouges and nicks. Pay particular attention to the metal gasket surface. A metal gasket (18) is used between the valve plate assembly and cylinder block. This surface must be smooth and free of all but the most minor scratching. If excessive marring or gouging is detected, the compressor must be replaced.
- Inspect the cylinder head for cracks or damage. With the cylinder head and head gasket secured to the valve plate assembly, apply shop air pressure to one of the coolant ports with all others plugged, and check for leakage by applying a soap solution to the exterior of the head. If leakage is detected in the cylinder head casting, replace the compressor.

END COVER OR END COVER ADAPTER

Check for cracks and external damage. Check the crankshaft main bearing surface in the end cover or end cover adapter, check for excessive wear and flat spots and replace the end cover if necessary. Check for galling of the oil port threads and replace the end cover or end cover adapter if necessary. Minor thread chasing is permitted but do not "recut" the threads if they are badly damaged.

CYLINDER BLOCK

- Check the cylinder head gasket surface on the cylinder block for nicks, gouges, and marring. A metal gasket is used to seal the cylinder head to the cylinder block. This surface must be smooth and free of all but the most minor scratching. If excessive marring or gouging is detected, the compressor must be replaced.

ASSEMBLY

General Note: All torques specified in this manual are assembly torques and typically can be expected to fall off after assembly is accomplished. **Do not re-torque** after initial assembly torques fall unless instructed otherwise. A compiled listing of torque specifications is presented at the end of this manual.

INCH POUNDS TO FOOT POUNDS

To convert inch pounds to foot pounds of torque, divide inch pounds by 12.

Example: $12 \text{ Inch Pounds} = 1 \text{ Foot Pound}$
 12

FOOT POUNDS TO INCH POUNDS

To convert foot pounds to inch pounds of torque, multiply foot pounds by 12.

Example: 1 Foot Pound x 12 = 12 Inch Pounds

CRANKCASE COVER

1. Position the crankcase cover gasket (15) on either the crankcase or crankcase cover and install the crankcase cover on the crankcase using the four cap screws. "Snug" the four cap screws then torque to 62-71 inch pounds using a crossing pattern.

CRANKCASE END COVER OR ADAPTER

1. Install the end cover o-ring (14) on the crankcase end cover.
2. Orient the crankcase end cover or end cover adapter to the crankcase using the reference marks made during disassembly. Carefully install the end cover or end cover adapter in the crankcase making certain not to damage the crankshaft bearing surface in it.
3. Install the four end cover screws or studs. "Snug" the screws then tighten to 195 to 213 inch pounds using a crossing pattern.

CYLINDER HEAD

1. Note the position of the protruding alignment pins on the cylinder block. Install the metal inlet reed valve/gasket (13) over the alignment pins on the cylinder block.
2. Position the valve plate assembly (12) on the cylinder block so that the alignment pins in the cylinder block fit into the corresponding holes in the valve plate assembly (12).
3. Position and install the metal gasket (11) over the alignment bushings protruding from the valve plate assembly (12). When properly installed, the outline of the gasket matches the outline of the valve plate.
4. Position and install the cylinder head over the alignment bushings protruding from the valve plate assembly (12).

Note: The alignment bushings will only fit into two of the four cylinder head bolt holes.

5. Install the four hex head cylinder head bolts and washers and snug them, then tighten evenly to a torque of 265 to 292 inch pounds using a crossing pattern.
6. Install the unloader piston (8) with its pre-installed o-rings in the cylinder head making certain not to damage them in the process.
7. Install the balance piston spring (5) in the unloader piston (8), then install the small diameter of the balance piston (4) through the center of the spring.
8. Install the unloader cover gasket (3) on the cylinder head making certain the unloader vent passage and both screw holes align.

9. Position the unloader cover (2) on top of the balance piston (4) making certain the stamped logo is visible.
10. Press and hold the unloader cover (2) in place on the cylinder head and install both unloader cover cap screws (1). Torque the cover cap screws (1) to 62 to 71 inch pounds.

INSTALLING THE COMPRESSOR

1. If the compressor was removed for replacement, install the drive components. **Torque the crankshaft nut to 250 foot pounds.**
2. Install any supporting bracketing on the compressor in the same position noted and marked during removal.
3. Install the gasket on the drive flange of the compressor. Make certain oil supply or return holes in the gasket are properly aligned with the compressor and engine. Gasket sealants are not recommended. Secure the compressor on the engine and tighten the mounting bolts.
4. Install the discharge, inlet and governor adapter fittings, if applicable, in the same position on the compressor noted and marked during disassembly. Make certain the threads are clean and the fittings are free of corrosion. Replace as necessary. See the Torque Specifications for various fitting sizes and types of thread at the rear of this manual.
5. Inspect all air, oil, and coolant lines and fittings before reconnecting them to the compressor. Make certain o-ring seals are in good or new condition. Tighten all hose clamps.
6. Clean oil supply line. Before connecting this line to the compressor. Run the engine briefly to be sure oil is flowing freely through the supply line.
7. Before returning the vehicle to service, perform the Operation and Leakage Tests specified in this manual. Pay particular attention to all lines reconnected during installation and check for air, oil, and coolant leaks at compressor connections. Also check for noisy operation.

TESTING REBUILT COMPRESSOR

In order to properly test a compressor under operating conditions, a test rack for correct mounting, cooling, lubricating, and driving the compressor is necessary. Such tests are not compulsory if the unit has been carefully rebuilt by an experienced person. A compressor efficiency or build up test can be run which is not too difficult. An engine lubricated compressor must be connected to an oil supply line of at least 15 psi. pressure during the test and an oil return line must be installed to keep the crankcase drained. Connect to the compressor discharge port, a reservoir with a volume of 1500 cubic inches, including the volume of the connecting line. With the compressor operating at 2100

RPM., the time required to raise the reservoir(s) pressure from 85 psi to 100 psi should not exceed 5 seconds. During this test, the compressor should be checked for gasket leakage and noisy operation, as well as unloader operation and leakage. If the compressor functions as indicated reinstall on the vehicle connecting all lines as marked in the disassembly procedure.

BA-921 SPECIFICATIONS

Typical weight	28 lbs.
Number of cylinders	1
Bore Diameter	92mm (3.622 in.)
Stroke	54 mm (2.125 in.)
Calculated displacement at 1250 RPM	15.8 CFM
Flow Capacity @ 1800 RPM & 120 PSI	11.8 CFM
Flow Capacity @ 3000 RPM & 120 PSI	18.0 CFM
Maximum recommended RPM	3000 RPM
Minimum coolant flow maximum RPM	1.3 Gals./Min.
Approximate horsepower required:	
Loaded 1800 RPM at 120 PSIG	4.5 HP
Unloaded 1800 RPM	1.3 HP
Maximum inlet air temperature	250 F°
Maximum discharge air temperature	400 F°
Minimum oil pressure required at engine idling speed	15 PSI
Minimum oil pressure required at maximum governed engine speed	15 PSI
Minimum oil-supply line size	3/16" I.D.
Minimum unloader-line size	3/16" I.D.
Minimum Governor Cutout Pressure	90 PSI

TORQUE SPECIFICATIONS

Assembly Torques in inch pounds (in. lbs.)	
M8x1.25-6g Cylinder Head	265 - 292
M5x0.75-6g Unloader Cap	62 - 71
M8x1.25-6g Governor Adapter	133 - 142
M8x1.25-6g Rear End Cover	195 - 213
M6x1.00-6g Crankcase Cover	62 - 71
M20x2.50-6g Crankshaft Nut	1858 - 2567
Inlet Port Fittings	
7/8"-12 UNF	221 - 248
3/4"-14 NPT	2 - 3 TFFT ¹
Discharge Port Fittings	
7/8"-12 UNF	221 - 248
3/4"-14 NPT	2 - 3 TFFT ¹
Water Port Fittings	
3/4"-16 UNF	221 - 248
3/8"-18 NPT	2 - 3 TFFT ¹
Unloader Port Fittings	
1/8"-27 NPT	2 - 3 TFFT ¹
Safety Valve Port	
3/4"-16 UNF	221 - 248
1/2"-14 NPT	2 - 3 TFFT ¹
Oil Port 7/16"-16 UNF	177 - 204

¹Note: TFFT = Turns From Finger Tight

COMPRESSOR TROUBLESHOOTING CHART

SYMPTOMS	CAUSE	REMEDY
1. Compressor passes excessive oil as evidenced by presence of oil at the exhaust ports of valving.	A. Restricted air intake.	A. Check engine air cleaner and replace if necessary. Check compressor air inlet for kinks, excessive bends and be certain inlet lines have minimum specified inside diameter. Recommended maximum air inlet restriction is 25" of water.
	B. Restricted oil return to engine.	B. Oil return to the engine should not be in any way restricted. Make certain oil drain passages in the compressor and mating engine surfaces are unobstructed and aligned. Correct gaskets must be used. Special care must be taken when seal ants are used with, or instead of, gaskets.
	C. Poorly filtered inlet air.	C. Check for damaged, defective or dirty air filter on engine or compressor. Check for leaking, damaged or defective compressor air intake components (e.g. induction line, fittings, gaskets, filter bodies, etc.). The compressor intake should not be connected to any part of the exhaust gas recirculation (E.G.R.) system on the engine.
	D. Insufficient compressor cooling (compressor runs hot).	D. For water-cooled portions of the compressor: <ol style="list-style-type: none"> 1. Check for proper coolant line sizes. Minimum recommended size is 3/8" I.D. tubing. 2. Check the coolant flow through the compressor. Minimum allowable flow is 2.5 gallons per minute at engine governed speed. If low coolant flow is detected, inspect the coolant lines and fittings for accumulated rust scale, kinks and restrictions. 3. Water temperature should not exceed 200 degrees Fahrenheit. 4. Optimum cooling is achieved when engine coolant flows, as shown in Figure 8 of this manual.
	E. Contaminants not being regularly drained from system reservoirs.	E. Check reservoir drain valves to insure that they are functioning properly. It is recommended that the vehicle should be equipped with functioning automatic drain valves, or have all reservoirs drained to zero (0) psi daily, or optimally to be equipped with a desiccant-type air dryer prior to the reservoir system.

COMPRESSOR TROUBLESHOOTING CHART (Continued)

SYMPTOMS	CAUSE	REMEDY
1. (Continued.)	F. Compressor runs loaded an excessive amount of time.	F. Vehicle system leakage should not exceed industry standards of 1 psi pressure drop per minute without brakes applied and 3 psi pressure drop per minute with brakes applied. If leakage is excessive, check for system leaks and repair.
	G. Excessive engine crankcase pressure.	G. Test for excessive engine crankcase pressure & replace or repair ventilation components as necessary. (An indication of crankcase pressure is a loose or partially lifted dipstick.)
	H. Excessive engine oil pressure.	H. Check the engine oil pressure with a test gauge and compare the reading to the engine specifications. Bendix does not recommend restricting the compressor oil supply line because of the possibility of plugging the restriction with oil contaminants. Minimum oil supply line size is 3/16" I.D. tubing.
	I. Faulty compressor.	I. Replace or repair the compressor only after making certain none of the preceding installation defects exist.
2. Noisy compressor operation.	A. Loose drive gear or components.	A.. Inspect the fit of the drive gear on the compressor crankshaft. The gear or coupling must be completely seated and the crankshaft nut must be tight. If the compressor crankshaft surface is damaged, it is an indication of loose drive components. If damage to the compressor crankshaft is detected, replace the compressor. When installing the drive gear or pulley, torque the crankshaft nut to the appropriate torque specifications and use care when pressing drive components onto the crankshaft. Do not back off the crankshaft nut once it is tightened to the proper torque. Do not use impact wrenches to install the crankshaft nut.
	B. Excessively worn drive couplings or gears.	B. Inspect drive gear and couplings and engine for excessive wear. Replace as necessary. (Nonmetallic gears should be replaced when the compressor is changed.)
	C. Compressor cylinder head or discharge line restrictions.	C. Inspect the compressor discharge port and discharge line for carbon build-up. If carbon is detected, check for proper cooling to the compressor. (See Cause and Remedy (D) under Symptom #1.) Inspect the discharge line for kinks and restrictions. Replace discharge line as necessary.

COMPRESSOR TROUBLESHOOTING CHART (Continued)

SYMPTOMS	CAUSE	REMEDY
2. (Continued.)	D. Worn or burned out bearings.	D. Check for proper oil pressure in the compressor. Minimum required oil pressure; 15 psi engine idling, 15 psi maximum governed engine rpm. Check for excessive oil temperature—should not exceed 240 degrees Fahrenheit.
	E. Faulty compressor.	E. Replace or repair the compressor after determining none of the preceding installation defects exist.
3. Excessive build-up and recover time. Compressor should be capable of building air system from 85-100 psi in 40 seconds with engine at full governed rpm. Minimum compressor performance is certified to meet Federal requirements by the vehicle manufacturer. Do not downsize the original equipment compressor.	A. Dirty induction air filter.	A. Inspect engine or compressor air filter and replace if necessary.
	B. Restricted induction line.	B. Inspect the compressor air induction line for kinks and restrictions and replace as necessary.
	C. Restricted discharge line or compressor discharge cavity.	C. Inspect the compressor discharge port and line for restrictions and carbon build-up. If a carbon build-up is found, check for proper compressor cooling. Replace faulty sections of the discharge line.
	D. Slipping drive components.	D. Check for faulty drive gears and couplings and replace as necessary. Check the condition of drive belts and replace or tighten, whichever is appropriate.
	E. Excessive air system leakage.	E. Test for excessive system leakage and repair as necessary. Use the following as a guide: Build system pressure to governor cutout and allow the pressure to stabilize for one minute. Using the dash gauge, note the system pressure and the pressure drop after two minutes. The pressure drops should not exceed: 1. 2 psi in each reservoir for a single vehicle. 2. 6 psi in each reservoir for a tractor and trailer. 3. 8 psi in each reservoir for a tractor and 2 trailers.
	F. Sticking unloader pistons.	F. Check the operation of the unloading mechanism. Check for proper operation of the compressor air governor. Make certain the air connections between the governor and compressor are correct. Refer to figure 3. If the governor is operating properly, replace the unloader mechanism. Inspect for bent, linked or blocked tubing leading to or from the governor.
	G. Faulty compressor.	G. Replace or repair the compressor after determining none of the preceding installation defects exist.

COMPRESSOR TROUBLESHOOTING CHART (Continued)

SYMPTOMS	CAUSE	REMEDY
4. Compressor fails to unload.	A. Faulty governor or installation.	A. Test the governor for proper operation and inspect air lines to and from it for kinks or restrictions. Replace or repair the governor or connecting air lines
	B. Faulty or worn unloader pistons or bores.	B. Inspect for worn, dirty or corroded unloader piston and bore. Replace as necessary.
5. Compressor leaks oil.	A. Damaged mounting gasket.	A. Check the compressor mounting bolt torque. If the mounting bolt torque is low, replace the compressor mounting gasket before re-torquing the mounting bolts.
	B. Cracked crankcase or end cover.	B. Visually inspect the compressor exterior for cracked or broken components. Cracked or broken crankcases or mounting flanges can be caused by loose mounting bolts. The end cover can be cracked by over-torquing fitting or plugs installed in the end cover. Replace or repair the compressor as necessary.
	C. Loose crankcase end cover or bottom cover.	C. Check the cap screw torques and tighten as necessary. Replace gaskets or o-ring.
	D. Loose oil supply or return line fittings.	D. Check the torque of external oil line fittings and tighten as necessary.
	E. Porous compressor casting.	E. Replace the compressor if porosity is found.
	F. Mounting flange or end cover, o-ring or gasket missing, cut or damaged.	F. Replace as necessary.
6. Compressor constantly cycles (compressor remains unloaded for a very short time).	A. Leaking compressor unloader piston.	A. Repair or replace as necessary. Remove the compressor inlet air strainer or fitting. With the compressor unloaded (not compressing air), listen for air escaping.
	B. Faulty Governor installation.	B. Test the governor for proper operation and inspect air lines for kinks or restrictions. Replace or repair the governor or connecting air lines as required.
	C. Excessive system leakage.	C. Test for excessive system leakage as instructed in Symptom #3 Remedy E. Reduce leakage wherever possible.
	D. Excessive reservoir contaminants.	D. Drain reservoirs.

COMPRESSOR TROUBLESHOOTING CHART (Continued)

SYMPTOMS	CAUSE	REMEDY
7. Compressor leaks coolant.	A. Improperly installed plugs and coolant line fittings.	A. Check torque of fittings and plugs and tighten as necessary. Over torqued fittings and plugs can crack the head or block casting.
	B. Freeze cracks due to improper antifreeze strength.	B. Test antifreeze and strengthen as necessary. Check coolant flow through compressor to assure the proper antifreeze mixture reaches the compressor.
	C. Faulty compressor (porous castings).	C. If casting porosity is detected, replace the compressor.
8. Compressor head gasket failure.	A. Restricted discharge line.	A. Clear restriction or replace line.
	B. Loose head bolts	B. Tighten evenly to a torque of 265-292 inch pounds.
	C. Faulty compressor or head gasket.	C. Check for rough or poorly machined head or block surfaces. Replace compressor as necessary.

Bendix™

The logo features the word "Bendix" in a bold, black, sans-serif font. A small "TM" trademark symbol is positioned at the top right of the letter "x". Below the text is a thick, black, curved graphic element that resembles a wide, shallow smile or a stylized arch.

LOW PRESSURE INDICATORS

*Formerly SD-06-2

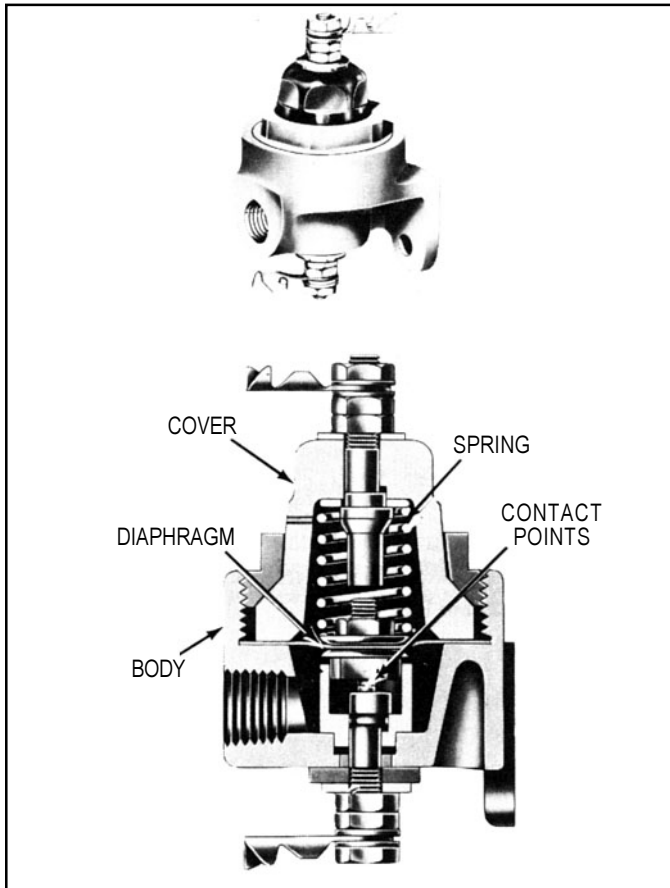


FIGURE 1 - LP-2

DESCRIPTION

The Low Pressure Indicator is a safety device designed to give an automatic warning to the driver whenever air pressure in the air brake system is below the safe minimum for normal vehicle operation. It is usually used to operate an electrical buzzer or warning light, or both, which are audible or visible to the driver.

Two styles of Low Pressure Indicators are currently manufactured.

The LP-2 Low Pressure Indicator, which is the older style and consists of a die cast body with a spring loaded diaphragm clamped between the body and the Bakelite cover.

The LP-3 Low Pressure Indicator is the newer style, consisting of a die cast body, nylon cover and employs a spring loaded O-Ring diaphragm and piston. The LP-3 is

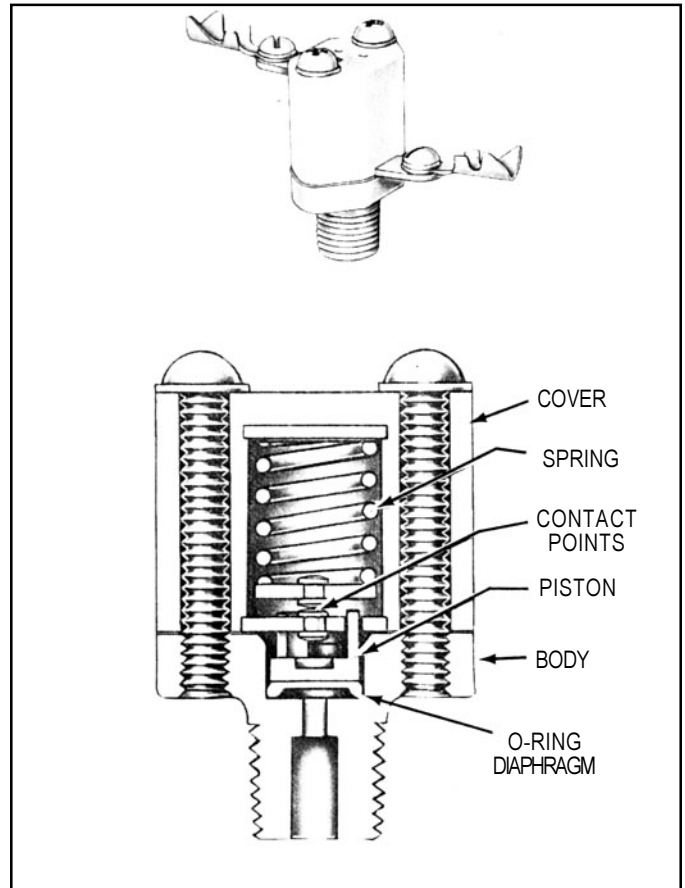


FIGURE 2 - LP-3

available with either one terminal or two. The single terminal unit utilizes a metallic gasket between body and case to ground the lower contact strip. The two terminal unit utilizes a phenolic insulating gasket to isolate both terminals from the vehicle frame.

The electrical contacts provided in both the LP-2 and LP-3 indicators remain closed by spring force until the air brake system pressure below the diaphragm is above the setting (force) of the Low Pressure Indicator spring. The setting of the indicator and piece number is marked on a label on the valve body. If a label is not present, then the vehicle manual should be consulted for the proper setting. The nominal setting of the indicator is 60 psi; however, pressure settings may vary depending upon the vehicle.

OPERATION

To describe the operation, we shall assume that the Low

Pressure Indicator is set for 60 psi. When air pressure at the supply port and under the diaphragm is above 60 psi, the electrical contacts remain open because the force exerted by air pressure underneath the diaphragm overcomes the force exerted by the spring above the diaphragm.

When air pressure below the diaphragm drops below 60 psi, the spring exerts a force which is greater than the force exerted by the air pressure below the diaphragm. This causes the diaphragm (and the piston in the LP-3) to move and allow the electrical contacts to close. This completes or closes the electrical circuit to the warning device, warning the driver of low air pressure in the system.

PREVENTIVE MAINTENANCE

Every six months, 1800 operating hours or 50,000 miles, check electrical connections. Low Pressure Indicator should be checked for proper operation by performing "Operating Test" as described elsewhere in this sheet.

TESTING FOR SERVICEABILITY

OPERATING TEST

1. If possible, determine the setting of the Low Pressure Indicator by referring to the label on the valve or the vehicle manual.
2. Operation of the Low Pressure Indicator may be checked with ignition switch "on" by reducing the system pressure and observing that low pressure warning occurs when system pressure drops below the setting of the Low Pressure Indicator. The contacts will be closed when the warning device operates. If the setting of the indicator is unknown, the contacts should close between approximately 70 psi and 50 psi.

LEAKAGE TEST

1. With air pressure present at the supply port, coat the indicator with soap solution. No leakage permitted.

REMOVING

1. Block the wheels. Otherwise, secure the vehicle with other than service brakes.
2. The ignition switch should be in the "off" position.
3. Drain the air from the system.
4. Disconnect the electrical connections at the Low Pressure Indicator.
5. Disconnect the air line and mounting bolts or unscrew the Indicator from the fitting and remove.

INSTALLING

1. Install in a convenient location for servicing.
2. Connect to a reservoir pressure line at a high point in the system for adequate drainage.

3. If installing an LP-2G Indicator, use a supply line of 1/4 O.D. minimum.
4. Connect the Indicator terminals in series with the ignition switch and the warning device.

DISASSEMBLY

NOTE: It is generally recommended that the Low Pressure Indicator, if faulty, be replaced with a new unit; however, service parts are available; and if repairs are necessary, the following will apply:

LP-2 Unscrew the cover retainer from the body. Remove cover and remove spring and diaphragm assembly.

LP-3. Remove cover screws, lockwashers. Remove cover, contact disc, spring, and shim(s). (Note: Shims may or may not be present.) Remove contact plate, gasket, piston, and O-Ring diaphragm.

CLEANING AND INSPECTION

Clean all metal parts in mineral spirits.

Inspect all parts for wear, cracks, or deterioration and replace all parts not considered serviceable with genuine Bendix parts.

If contact points are not pitted severely, they can be dressed with a fine file.

ASSEMBLY

LP-2

1. Place and position the diaphragm assembly in the body. Position the spring so that it rests on the upper diaphragm follower.
2. Place cover over the diaphragm and screw cover retainer to the body and tighten securely. (Torque to 110-130 inch pounds.)

LP-3

1. Lubricate bore of body and both sides of the O-Ring diaphragm with silicone lubricant BW-650-M (Bendix piece no. 291126).
2. Install O-Ring diaphragm in body. (Note: O-Ring portion of diaphragm should face supply port.)
3. Install piston in body. Flat side of piston should face O-Ring diaphragm.
4. Install gasket. (Always use a phenolic gasket in a two terminal switch and a metallic gasket in the single terminal.)
5. Position contact plate over fingers of piston. Contact plate should rest on face of gasket.
6. If shim(s) are used, place shim(s) in cover.
7. Place spring in cover.
8. Place contact point so that it rests on spring.

9. Install cover on body, using machine screws, making certain that the contact plate is in position over fingers of piston, and arm of contact plate is positioned so that it will fit in groove of cover.
10. Tighten screws securely. (Torque to 20-30 inch pounds).

TEST OF REBUILT LOW PRESSURE INDICATOR

After rebuilding, perform the leakage and operating tests as outlined in section "Testing for Serviceability."

IMPORTANT! PLEASE READ

When working on or around a vehicle, the following general precautions should be observed:

1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.
2. Stop the engine when working around the vehicle.
3. If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning ANY work on the vehicle.
4. Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.
5. When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact

- with moving, rotating, leaking, heated, or electrically charged components.
6. Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.
 7. Never exceed recommended pressures and always wear safety glasses.
 8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
 9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.
 10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.
 11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

PUSH-PULL TYPE CONTROL VALVES: PP-1, PP-2, PP-5, PP-8, & RD-3

*FORMERLY SD-03-61

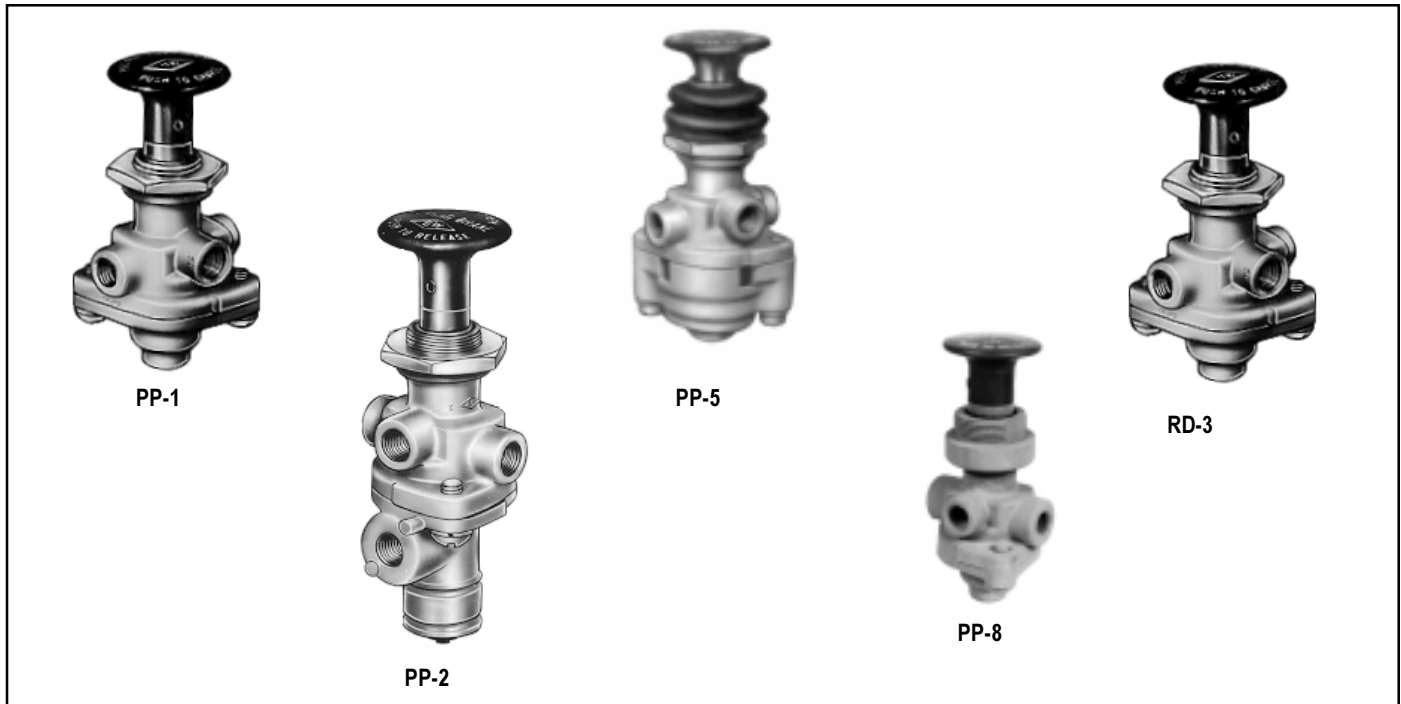


FIGURE 1 - PUSH-PULL TYPE CONTROL VALVES

DESCRIPTION

The PP valves are push-pull manually operable on-off air control valves with an exhaust function. Most are pressure sensitive, so that they will automatically move from the applied to the exhaust position as supply pressure is reduced to a certain minimum, depending on the spring installed. The exception to this is the PP-8 valve and some PP-1 valves which have no spring. The PP-8 valve also has a larger diameter shaft for button mounting so that when installed on the same panel with other PP valves the buttons cannot be inadvertently mixed. The PP-8 is normally used to operate tractor spring brakes independently from the trailer.

The PP-5 is unique in having an auxiliary piston in the lower cover which, upon receiving a pneumatic signal of 18 psi or more, will cause the valve to move from the applied to the exhaust position from a 100 psi application.

The RD-3 differs slightly in that it normally remains in the exhaust position and requires a constant manual force to hold it in the applied position.

The PP-2 has an auxiliary port which may be plumbed into a service brake line to release the spring brakes if a service application is made, preventing compounding of forces on the foundation brakes.

PREVENTIVE MAINTENANCE

Every six months, 50,000 miles or 1800 operating hours, disassemble, clean and replace parts if necessary.

REMOVAL

Block and/or hold the vehicle by a means other than air brakes and drain all reservoirs.

1. Drive the Button Roll-Pin out with a punch and remove the button.
2. Mark each air supply line and its port for easy reinstallation, then disconnect them. Remove the valve from the panel by removing the Panel Mounting Nut.

	AUTOMATIC EXHAUST	MOMENTARY APPLY	PILOT TRIP FEATURE	NON-AUTOMATIC
PP-1	20,30,40 or 60 psi			
PP-2	40 psi			
PP-5	40 psi		18 psi	
RD-3		Must be held manually		
PP-8				Will remain in either position

INSTALLING

1. Install valve in panel, securing with the Panel Mounting Nut.
2. Reconnect the air lines using marks made during removal as a guide.
3. Install the operating button. Secure the operating button by installing the Button Roll Pin.

DISASSEMBLY: PP-1, PP-8 AND RD-3

1. Remove the two cap screws (3) which retain the lower cover and remove cover. Remove the sealing ring (4).
2. Insert a small punch through the roll pin hole in the stem and remove the lock nut (5).
3. Remove inlet-exhaust valve (6) and plunger (7) and spring (8) (if any).
4. Remove o-ring (9) from plunger.

DISASSEMBLY: PP-5

1. Perform same operations as for PP-1.
2. Remove inlet seal (10) in Figure 4 from lower cover. Remove the ring diaphragm (4) from the inlet seat.
3. Remove piston (11) Figure 4 and o-ring (2).

DISASSEMBLY: PP-2

1. Insert a small punch through the roll pin hole in the plunger and remove the lock nut (1) from the plunger.
2. Withdraw the plunger and remove the spring (9) and o-ring (8).
3. Remove the two machine screws (2) and remove the lower cover (3).
4. Remove the inlet-exhaust valve (4), and piston (5).
5. Remove o-rings (6 & 7) from piston.

OPERATING AND LEAKAGE TESTS

PP-1, PP-8, RD-3

1. An accurate test gauge should be tee'd into the supply line and a means of controlling the supply pressure provided. Apply a 120 psi air source to the supply port. A small volume reservoir (e.g. 90 cu. in.) with a gauge should be connected to the delivery port.

2. With 120 psi supply pressure, and the button pulled out (exhaust position), leakage at the exhaust port should not exceed a 1" bubble in five seconds; at the plunger stem a 1" bubble in five seconds. There should be no leakage between upper and lower body.
3. Push the button in (applied position). Leakage at the exhaust port should not exceed a 1" bubble in 3 seconds; at the plunger a 1" bubble in three seconds. (The RD-3 will have to be manually held in this position.)
4. Reduce the supply pressure. At a pressure from 60 to 20 psi depending on the spring installed the button should pop out automatically, exhausting the delivery volume. (This does not apply to the RD-3, PP-8 or some PP-1's).

PP-5

1. Proceed as for PP-1 through Step 3.
2. Connect a modulated source of air pressure to the pilot air inlet. With the button pushed in (applied position) with 125 psi supply pressure and a gradually increasing pressure applied at the pilot air port the valve should move to the release position with a pilot pressure of not more than 18 psi. Leakage in this mode should not exceed a 1" bubble in three seconds at the exhaust port and a 1" bubble in five seconds at the plunger stem.

PP-2

1. Proceed as for PP-1 through Step 1.
2. With the button pulled out (exhaust position), leakage at the brake valve port or at the plunger stem should not exceed a 1" bubble in five seconds.
3. Push the button in. Supply pressure should be present in the delivery volume. Leakage at the exhaust port or around the plunger stem should not exceed a 1" bubble in five seconds.
4. Pull the button out and apply supply pressure at the brake valve port. Supply pressure should be present in the delivery volume and leakage at the exhaust port should not exceed a 1" bubble in five seconds.

Note: If any of the above push-pull valves do not function as described or if leakage is excessive, it is recommended they be returned to our nearest authorized distributor for a factory rebuilt or new valve.

IMPORTANT! PLEASE READ:

When working on or around a vehicle, the following general precautions should be observed:

1. **Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.**
2. **Stop the engine when working around the vehicle.**

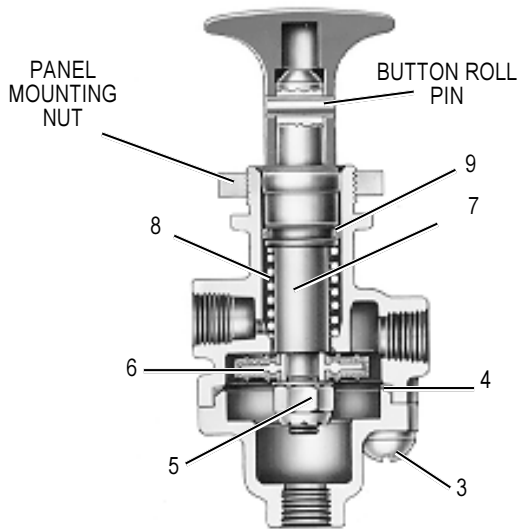


FIGURE 2 PP-1

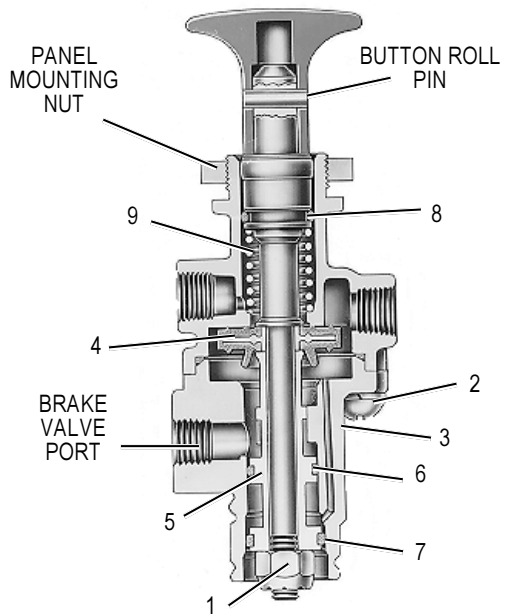


FIGURE 3 PP-2

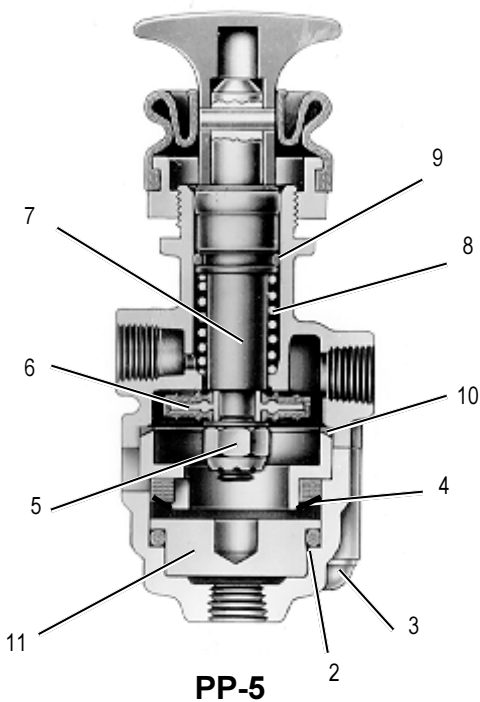


FIGURE 4 PP-5

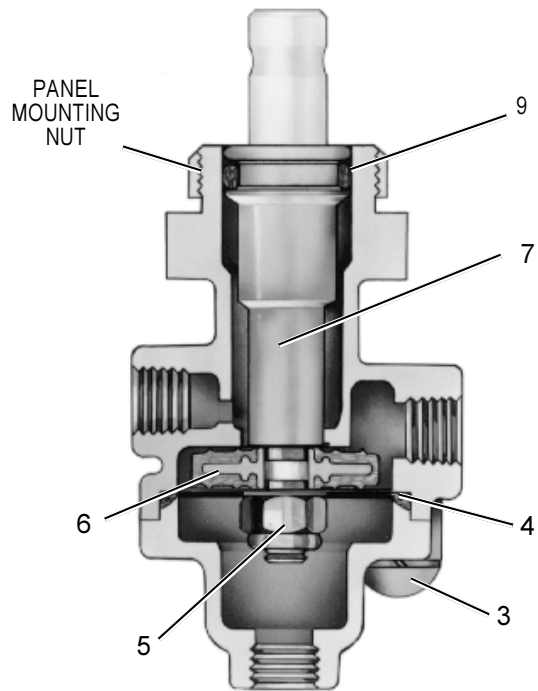
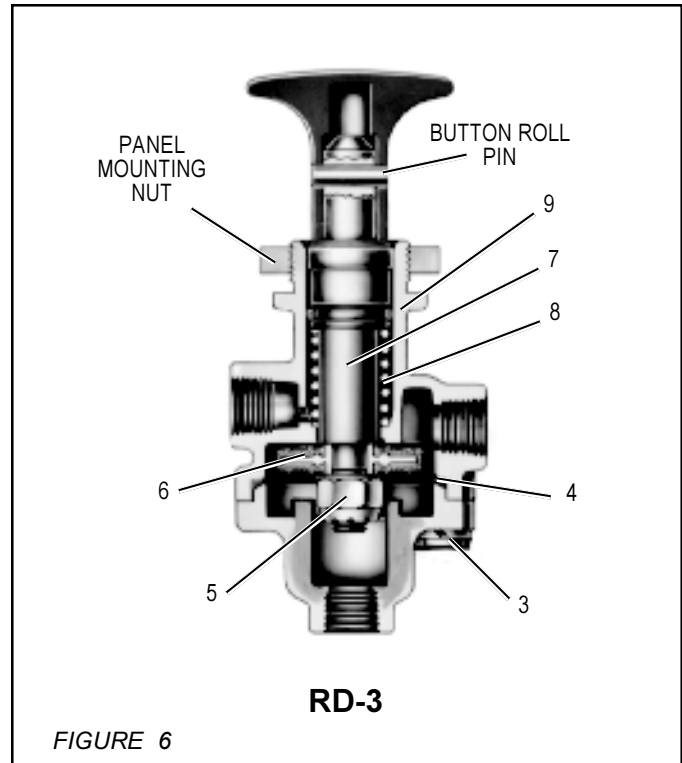


FIGURE 5 PP-8

3. If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle.
4. Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.
5. When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, extreme caution should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.

6. Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.
7. Never exceed recommended pressures and always wear safety glasses.
8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.
10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.
11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.





Service Data

SD-03-3602*

TW-1, TW-3, TW-4, TW-5 & TW-6 CONTROL VALVES

*Formerly SD-03-64

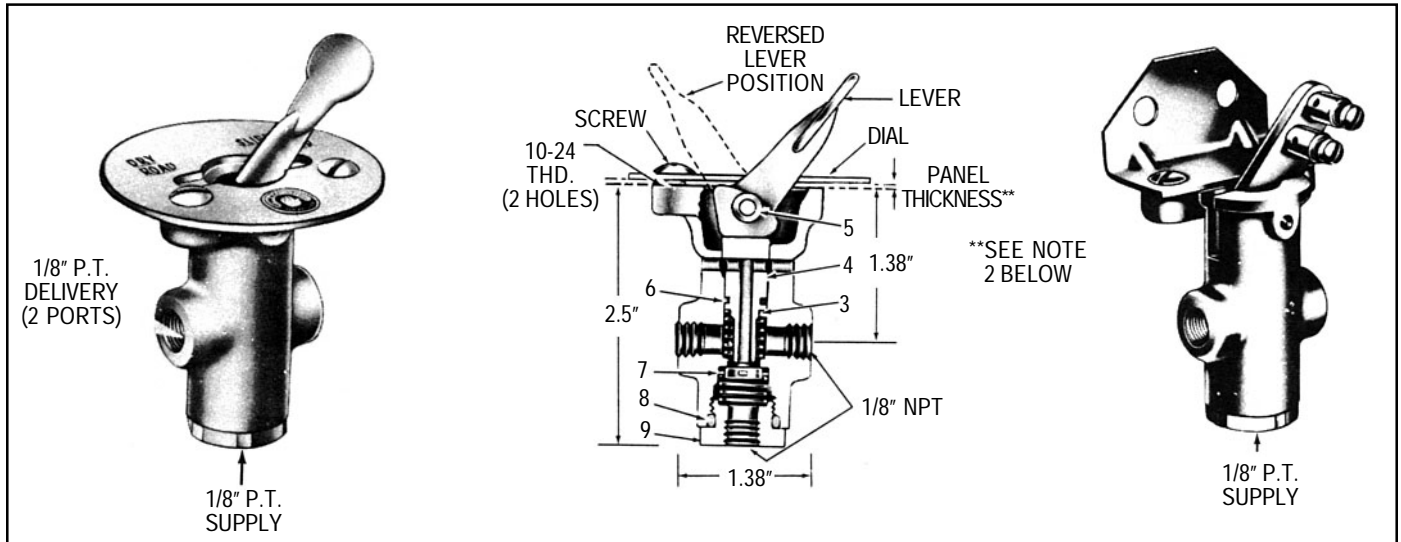


FIGURE 1 - TW-1

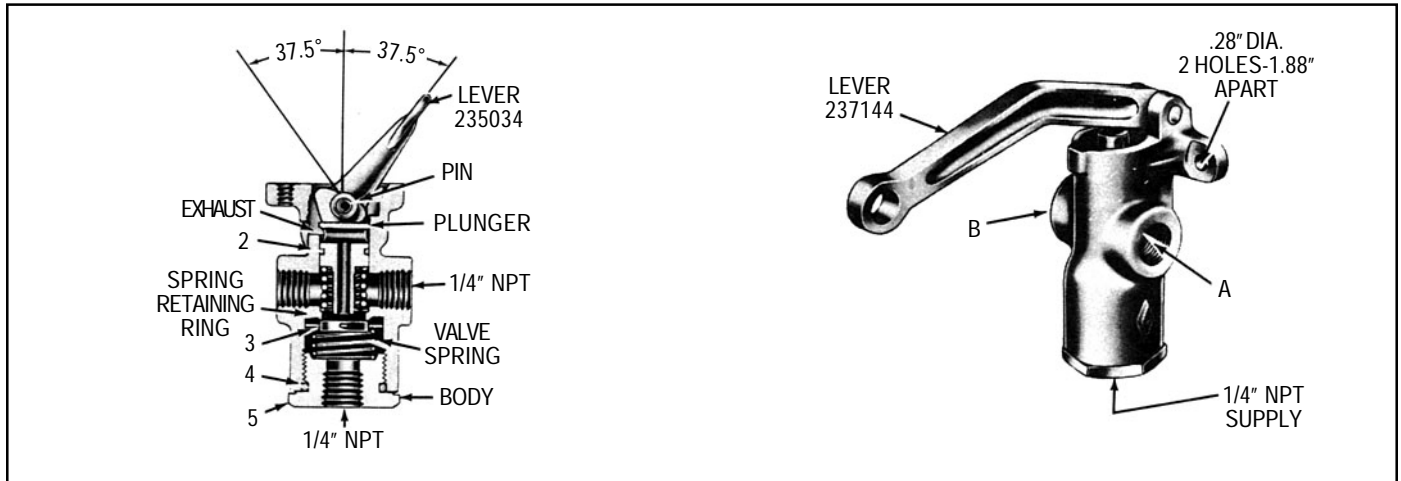


FIGURE 2 - TW-3

DESCRIPTION

The TW series valves are manually operated on-off valves. They are extensively used in air systems to control nonmodulating air controlled devices. They may be lever or button operated, direct or remote control.

The TW-1 (Figure 1) is normally panel mounted with a steel, zinc or nylon manually operated lever. Some are equipped with a steel lever with connectors for Bowden cable control. All TW-1's have 1/8" NPT ports.

The TW-3 (Figure 2) is lever operated, either direct or remote and differs from the TW-1 in having 1/4" NPT ports and larger capacity. Some versions have a heavy inlet valve spring making them suitable for vacuum control.

TW-4's and TW-5's (Figure 3) are similar to the TW-1 except the plunger is designed for a push button, giving momentary application whenever the button is depressed.

The TW-6 (Figure 4) is a TW-1 with a grounding switch included. In the exhaust position the switch is open. When the valve is applied the switch is closed.

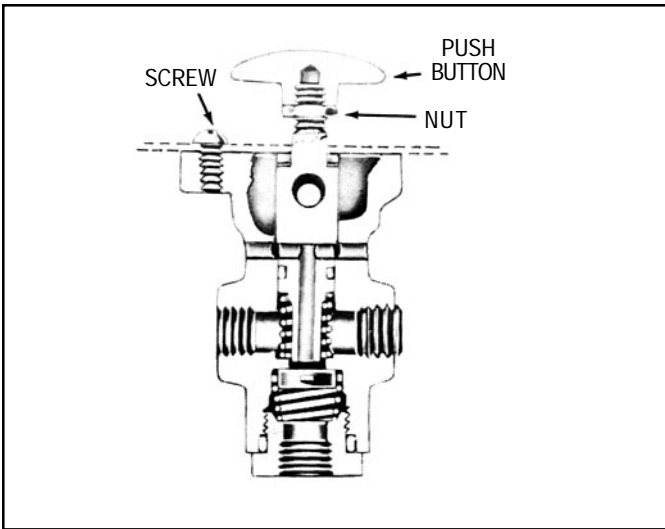


FIGURE 3 - TW-4

OPERATION

With air pressure at the supply port (Figure 1) and the plunger in the upward position the valve is in the exhaust position. The delivery ports are open to atmosphere through the exhaust passage in the center of the plunger.

When the plunger is depressed by the cam action of the lever (Figure 1) or by a direct force on a push button (Figure 3) the plunger contacts the inlet valve, closing the exhaust passage and pushes the inlet valve off the inlet seat in the body, allowing supply air to flow through the delivery ports to the controlled device.

PREVENTIVE MAINTENANCE

Every year, 100,000 miles or 1800 operating hours disassemble, clean and check all parts and replace if necessary.

SERVICE CHECKS

OPERATING AND LEAKAGE TESTS

Connect a 100 psi air pressure source to the supply port and connect delivery to an air gauge. (if there are two delivery ports, plug one.) With the valve in the released position, check for leakage at the exhaust holes with a soap solution. No leakage permitted. Place the valve in the applied position. Supply air pressure should show on the gauge. Check for leakage at the exhaust holes. No leakage permitted.

If the TW valve does not function as described or if leakage occurs, it is recommended that it be replaced with a new unit or repaired with genuine Bendix parts.

REMOVING

Secure the vehicle with other means than brakes and drain the reservoirs.

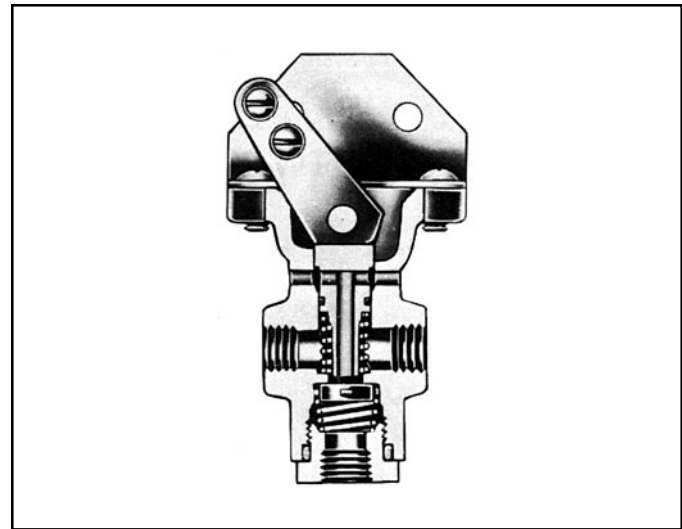


FIGURE 4 - TW-6

Disconnect all air lines and remove the valve.

INSTALLING

Place valve handle through appropriate hole in panel, place dial (if used) over handle and install mtg. screws. Connect air lines.

DISASSEMBLY

Remove operating handle or lever by driving the pin out of the body (Figure 1) and remove the lever, plunger and plunger spring. Remove the O-Ring from the plunger.

Remove the supply cap nut, inlet valve and spring. Remove the O-Ring from the supply cap nut.

CLEANING AND INSPECTION OF PARTS

Wipe rubber parts clean. Clean plastic and metal parts in mineral spirits and dry thoroughly. Inspect all rubber parts for wear or deterioration and replace where necessary. Polish the inlet seat in the body if nicked or corroded. Inspect all springs for cracks, distortion or corrosion and replace if necessary.

ASSEMBLY

Prior to assembly lubricate body bore, plunger, O-Rings, and cap nut threads with Bendix silicone lubricant BW 650M Pc. No. 291126.

Place inlet valve in body.

Place inlet valve spring on inlet valve.

Place O-Ring on cap nut and install cap nut.

Install plunger spring from top of body.

Install O-Ring on plunger and install plunger.

TW-1 TW-3 & TW-6

Depress plunger, place lever cam in slot in body, line up holes in body with hole in lever and insert pin.

TW-4 & TW-5

Depress plunger with button until hole in plunger lines up with holes in body. Insert pin.

LEAKAGE TEST

Test valve per instructions in paragraph on “Service Checks.”

IMPORTANT! PLEASE READ

When working on or around a vehicle, the following general precautions should be observed:

1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.
2. Stop the engine when working around the vehicle.
3. If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning ANY work on the vehicle.
4. Following the vehicle manufacturer’s recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.
5. When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact

with moving, rotating, leaking, heated, or electrically charged components.

6. Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.
7. Never exceed recommended pressures and always wear safety glasses.
8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.
10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.
11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.



DOUBLE CHECK VALVES

*FORMERLY SD-03-67

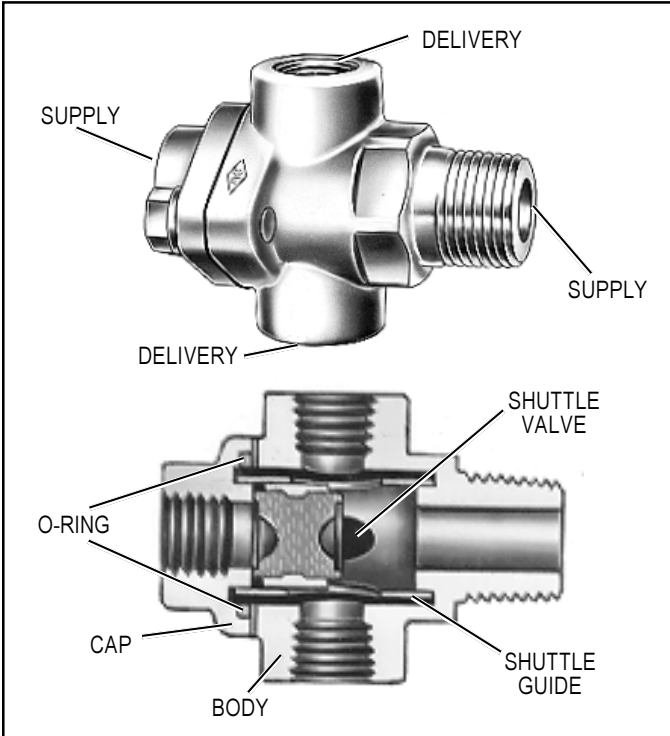


FIGURE 1 - DOUBLE CHECK VALVE (SHUTTLE TYPE)

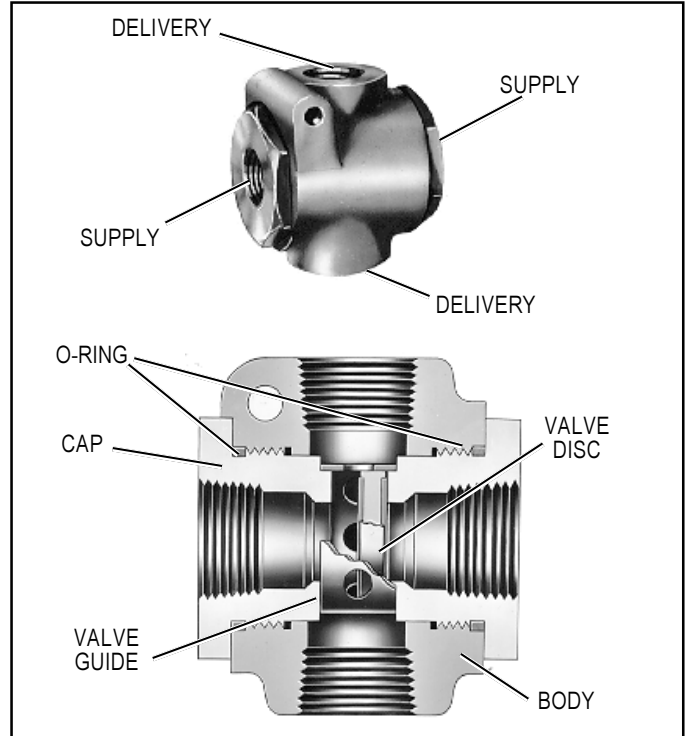


FIGURE 2 - DOUBLE CHECK VALVE (DISC TYPE)

DESCRIPTION

Double Check Valves are used in an air brake system to direct a flow of air into a common line from either of two sources, whichever is at the higher pressure. They may be used for directing air flow for specific functions or to select the higher pressure of either of two sources of air as a supply source.

AlliedSignal manufactures two types of Bendix Double Check Valves: shuttle and disc. Although the valves are somewhat different physically, the same function is performed by both types. The difference in the design of the two valves is that the shuttle type has a movable shuttle to seal off the lower pressure source, whereas the disc type has a movable disc.

OPERATION

As air under pressure enters either end of the Double Check Valve (inlet port) the moving shuttle or disc responds to the pressure and seals the opposite port, assuming it is at a lower pressure level than the other. The air flow continues out the delivery port of the Double Check Valve. The position

of the shuttle or disc will reverse if the pressure levels are reversed. Double Check Valves are designed so that the shuttle or disc can never impede the backflow of air in the exhaust mode.

Figure 3 (see page 2) illustrates a typical use of a Double Check Valve to control a given device, such as trailer brakes, from either of two control sources.

Figure 4 (see page 2) illustrates a typical use of a Double Check Valve to supply air to a system or systems from either of two separate sources, whichever is at the greater pressure level. In this type of installation the pressure differential to which the valve is subjected may under certain conditions be minimal. It is therefore suggested that performance of the Double Check Valve will be optimized if it is mounted in the horizontal position.

PREVENTIVE MAINTENANCE

Every 3600 operating hours, 100,000 miles, or yearly, disassemble, clean and inspect all parts. Install new parts if they show signs of wear or deterioration.

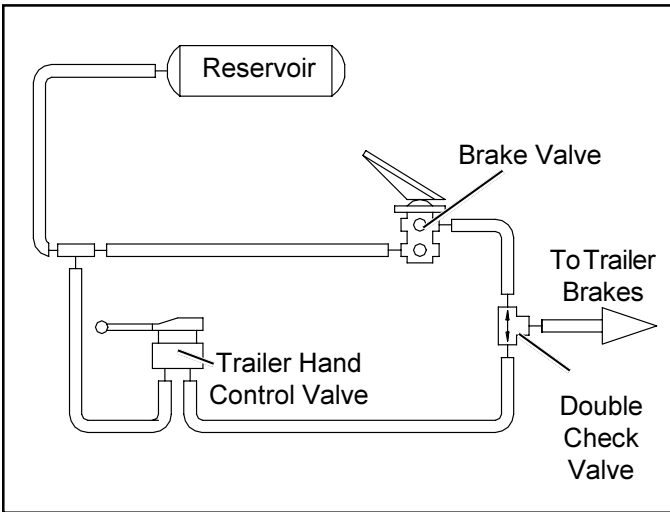


FIGURE 3 - DOUBLE CHECK VALVE: CONTROL OF SYSTEM FROM EITHER OF TWO CONTROL SOURCES

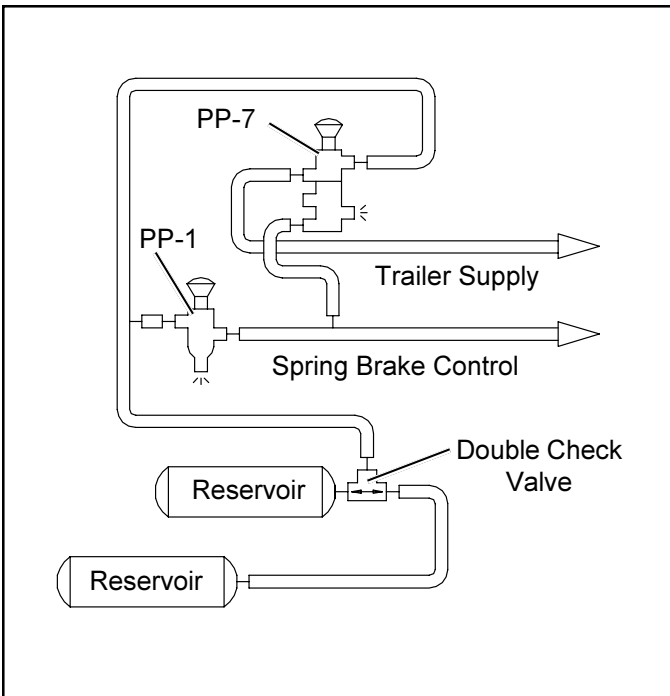


FIGURE 4 - DOUBLE CHECK VALVE: SYSTEM WITH TWO SUPPLY SOURCES

SERVICE CHECKS

OPERATING AND LEAKAGE TEST

- A. When the Double Check Valve is used in conjunction with a Trailer Control Valve, the following operating and leakage test can be made:
1. Apply and release foot brake valve and note that the brakes apply and release on both tractor and trailer.
 2. Apply and release the Trailer Control Valve and note that only the trailer brakes apply and release. With trailer control valve applied check exhaust port of foot brake valve for leakage with soap solution. Permissible leakage is a one inch bubble in five seconds (100 sccm).

3. Apply and hold a full foot brake valve application. Check exhaust port of Trailer Control Valve for leakage with soap solution. Permissible leakage is a one inch bubble in five seconds (100 sccm). (**Note:** On some vehicles, an exhaust line is connected to the exhaust port and piped outside the cab in which case it may be necessary to disconnect this line to make leakage check.)
- B. If Double Check Valve is to be bench tested or tested on the vehicle, two separately controlled air supplies must be connected to the inlet ports.
1. Install an accurate test gauge in the outlet port or in a line from outlet port.
 2. Apply and release air to one inlet port and note that gauge registers application and release.
 3. Repeat by applying and releasing air to other inlet port.
 4. Leakage check should be performed at inlet ports of valve in the following manner:
 - a. Disconnect line from one inlet port.
 - b. Apply air to other inlet port and coat opposite inlet port with soap solution. Permissible leakage is a one inch bubble in five seconds (100 sccm).
 - c. Repeat Step "b" applying air to other inlet port while checking opposite inlet port for leakage.

If the Double Check Valve does not function as described or if leakage is excessive, it is recommended that the valve be repaired or replaced with genuine Bendix parts. The following instructions should prove helpful:

DISASSEMBLY

1. Remove end cap(s) from valve.
2. Remove grommets (if applicable).
3. Remove shuttle and/or shuttle guide, disc and/or disc guide (depending upon type of valve).

CLEANING AND INSPECTION

1. Clean all metal parts in a cleaning solvent.
2. Inspect all metal parts for signs of cracks, wear or deterioration. Replace all parts not considered serviceable.
3. Replace all rubber parts.

ASSEMBLY

1. Install disc guide, disc and/or shuttle and shuttle guide.
2. Coat all static seals such as o-rings, grommets, etc. with BW 650M Silicone lubricant (BW 291126). It is not necessary to lubricate shuttles or discs.
3. Install grommets.
4. Install end cap(s).

TESTING OF REBUILT DOUBLE CHECK VALVE

Perform operating and leakage tests as described in “Service Checks” section.

IMPORTANT! PLEASE READ:

When working on or around a vehicle, the following general precautions should be observed:

- 1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.**
- 2. Stop the engine when working around the vehicle.**
- 3. If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning ANY work on the vehicle.**
- 4. Following the vehicle manufacturer’s recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.**
- 5. When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.**
- 6. Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.**
- 7. Never exceed recommended pressures and always wear safety glasses.**
- 8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.**
- 9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.**
- 10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.**
- 11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.**





Service Data

SD-03-2010*

PRESSURE PROTECTION VALVES

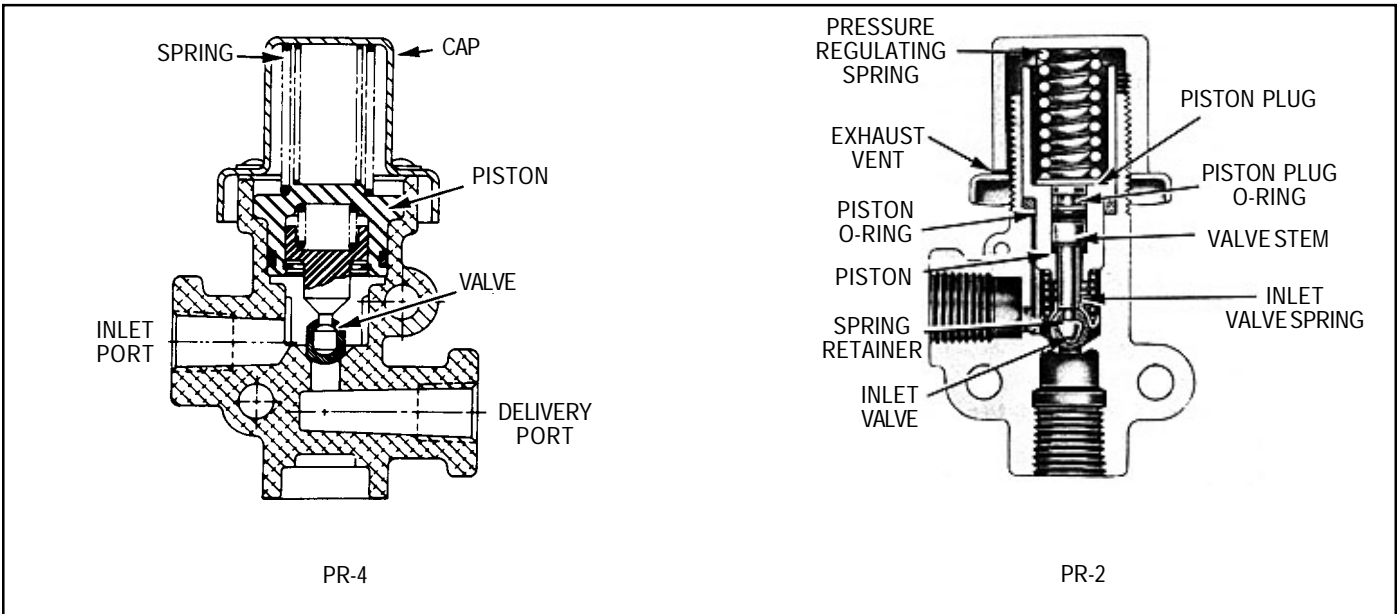
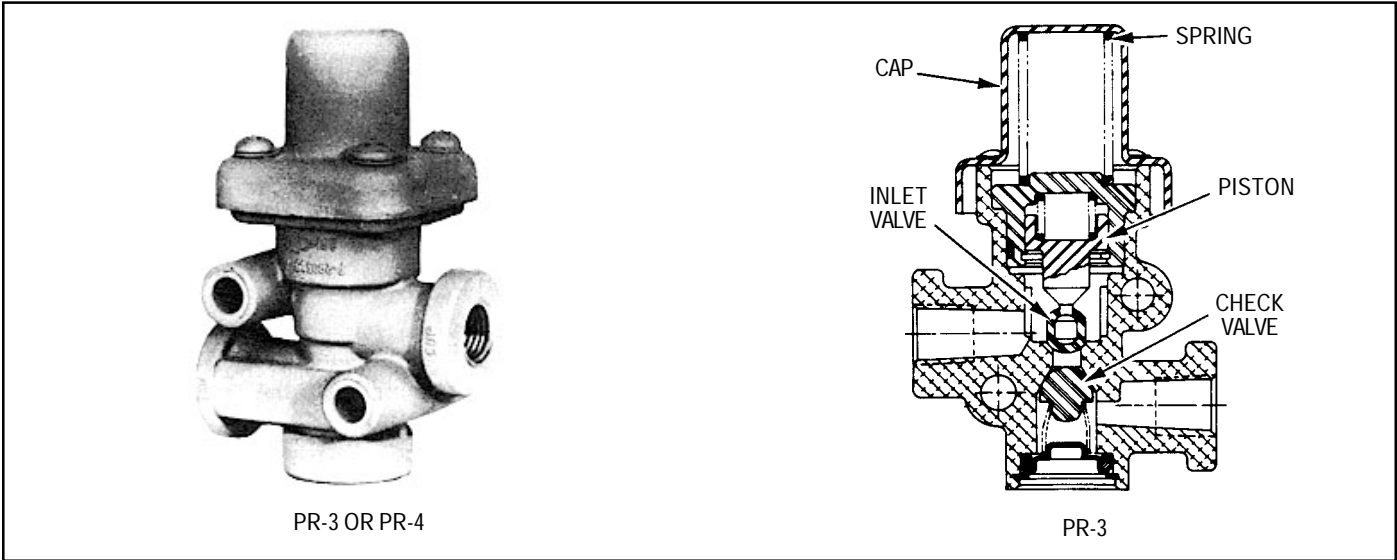
*Formerly SD-03-55

DESCRIPTION

The pressure protection valve is a normally closed, pressure control valve which can be referred to as a non-exhausting sequence valve. These valves are used in many different applications. An example would be in an air brake system to protect one reservoir, or reservoir system from another, by closing automatically at a preset pressure should a reservoir system failure occur. The valves can also be used

to delay filling of auxiliary reservoirs to insure a quick build-up of brake system pressure.

The PR-2 and PR-4 pressure protection valves have one 1/4" N.P.T.F. supply port and one 1/4" N.P.T.F. delivery port which are identified. Both valves are provided with two 9/32" mounting holes through the body. The closing pressure of the PR-2 is externally adjustable while the PR-4 has a fixed setting.



OPERATION

Air entering the supply port is initially prevented from flowing out the delivery port by the inlet valve which is held closed by the pressure regulating spring above the piston. When sufficient air pressure builds beneath the piston to overcome the setting of the regulating spring, the piston will move, causing the inlet valve to unseat (open), and allow air to flow out the delivery port. As long as air pressure at the supply port and beneath the piston remains above the specified closing pressure, the inlet valve will remain open.

NOTE: The PR-2 and PR-4 closing pressure is noted on the label affixed to the valve. Opening pressures of the valves are higher than closing pressures. The pressure ranges are noted below:

PR-2-Opening pressure 15-20 psi higher than closing pressure.

PR-3 & PR-4-Opening pressure approx. 10 psi higher than closing pressure.

PR-3-Check valve will retain maximum pressure in downstream reservoir.

If for any reason system air pressure is decreased below the specified closing pressure, the regulating spring will move the piston closing the inlet valve. The remaining air pressure at either the supply or delivery side, (depending upon where the pressure drop has occurred) will be retained.

PREVENTIVE MAINTENANCE

Every three months, 900 operating hours or 25,000 miles, whichever is first, it is recommended that the operation and leakage checks described in this manual be performed.

OPERATING AND LEAKAGE CHECKS

OPERATING CHECKS

1. Provide a pressure gauge and drain valve at the supply side and delivery side of the pressure protection valve being checked.
2. Build up the air system to full pressure and shut off the engine.
3. While watching the gauges on the supply and delivery sides of the valve, slowly begin to exhaust pressure from the delivery side. Note that both gauges will show pressure loss until the closing pressure of the pressure protection valve is reached.

The pressure protection valve should close at approximately (± 5 psi) the pressure indicated on the valve's label or in the vehicle handbook. The gauge on the delivery side of the valve should continue to show loss of pressure while the gauge on the supply side should stop at the same pressure as the setting of the valve.

4. (PR-3 only) Build pressure up again and shut off engine. Slowly exhaust air from the supply side of the PR-3. The gauge on the delivery side of the valve should remain at the highest pressure previously attained.

LEAKAGE CHECKS

1. Build up the air system to full pressure and shut off the engine.
2. Apply a soap solution around the cap of the pressure protection valve. A one-inch bubble in three seconds or longer is acceptable. PR-3 - No leakage permissible at bottom of valve.
3. Drain the air pressure from the delivery side of the pressure protection valve and disconnect the air line to it.
4. Apply a soap solution to the delivery port. A one inch bubble in five seconds or more is acceptable.

GENERAL

If the pressure protection valve does not operate as described or leakage is excessive, it is recommended that a replacement be obtained at the nearest authorized AlliedSignal Truck Brake Systems Co. distributor.

REMOVING AND INSTALLING

REMOVING

1. Block or hold the vehicle by means other than air brakes.
2. Drain all system reservoirs individually, to 0 psi.
3. Disconnect and identify (supply and delivery) the air lines leading to and from the pressure protection valve.
4. Remove the mounting bolts, if any, that secure the valve.

INSTALLING

1. Re-install the mounting bolts and secure the replacement valve to the vehicle.
2. Reconnect the supply delivery air lines to the proper ports of the replacement valve.

GENERAL

After installing a replacement valve, it is recommended that the operating and leakage checks be performed as outlined in this manual. If the closing pressure does not conform to that shown on the valve label or in the vehicle or a different setting is desired, the PR-2 may be adjusted by loosening the locknut and tightening or loosening the adjusting cap as required; however, if the proper setting cannot be attained by moderate adjustment of the cap, the valve may have the wrong spring and will have to be exchanged for the correct valve. The PR-3 and PR-4 are not adjustable.

IMPORTANT! PLEASE READ

When working on or around a vehicle, the following general precautions should be observed:

1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.
2. Stop the engine when working around the vehicle.
3. If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning **ANY** work on the vehicle.
4. Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.
5. When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, **EXTREME CAUTION** should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.
6. Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a

component or plug unless you are certain all system pressure has been depleted.

7. Never exceed recommended pressures and always wear safety glasses.
8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.
10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.
11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.



R-12 & R-14 RELAY VALVES

* FORMERLY SD-03-31

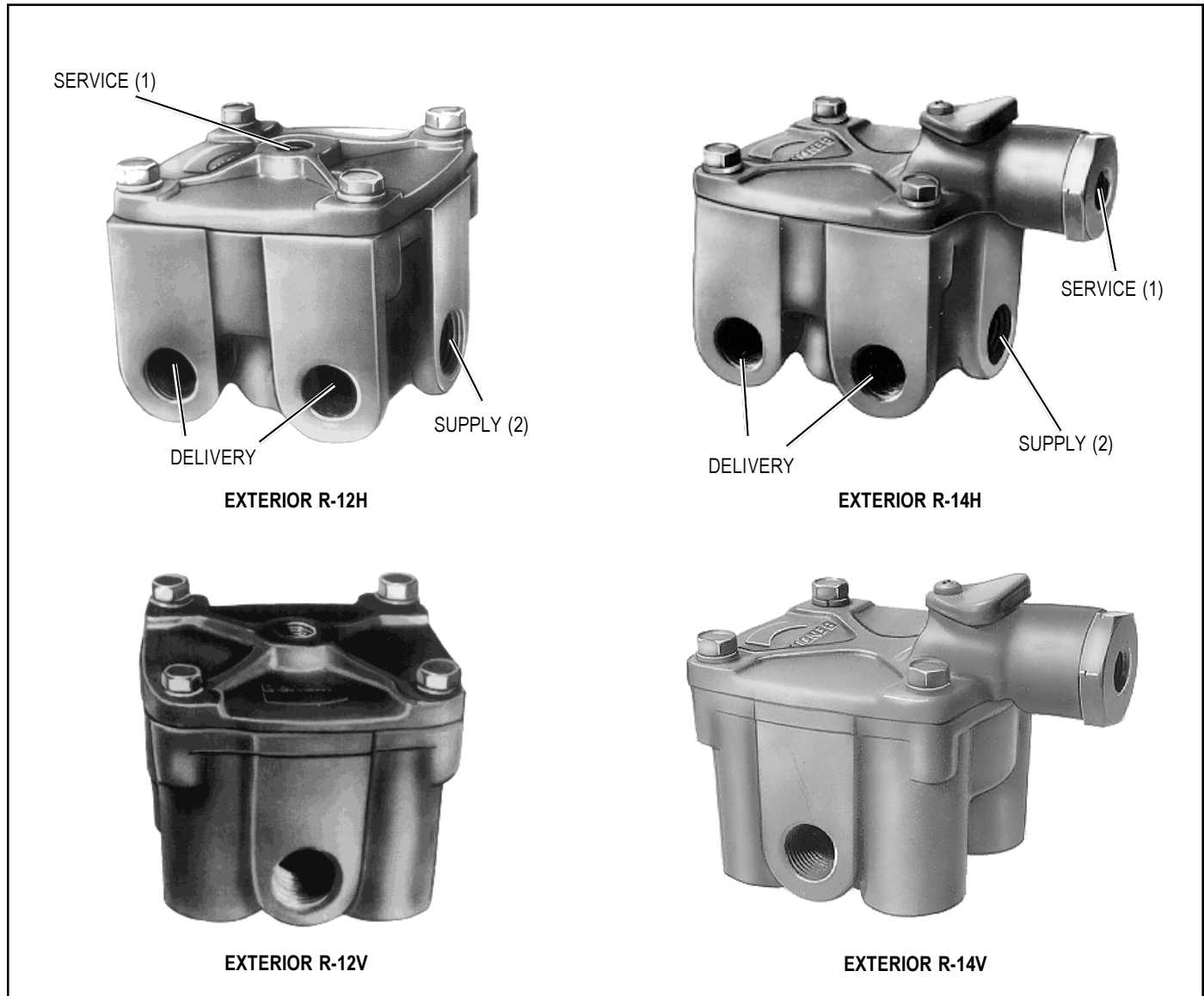


FIGURE 1 - EXTERIOR VIEWS

DESCRIPTION

The Relay Valve in an air brake system functions as a relay station to speed up the application and release of the brakes. The valve is normally mounted at the rear of the vehicle in proximity to the chambers it serves. The valve operates as a remote controlled brake valve that delivers or releases air to the chambers in response to the control air delivered to it from the foot brake valve or other source.

The R-12 and R-14 Relay Valves are designed for either reservoir or frame mounting. A universal mounting bracket is furnished that permits easy interchange with other Bendix relay valves. Both valves are available in the two body styles illustrated in Figure 1. The R-14 differs from the R-12 in that it incorporates a quick release and anti-compounding feature located above its horizontal service port. The R-14's anti-compound feature allows it

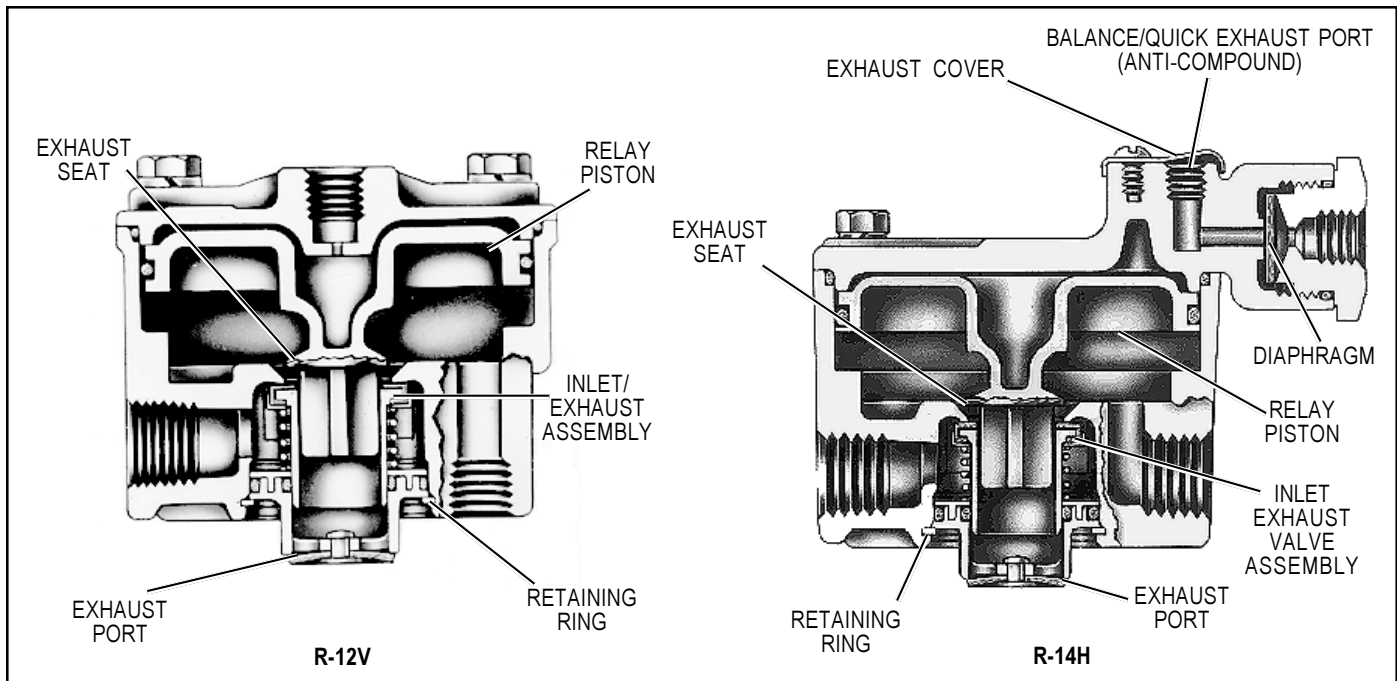


FIGURE 2 - SECTIONAL VIEWS

to be conveniently used as either a service or spring brake relay valve. An exhaust cover is installed that protects the 1/8" balance port when the R-14 anti-compound feature is not in use.

All parts are interchangeable between the R-12 and R-14 with the exception of the detail components of the R-14 cover. Both valves make extensive use of non-metallic internal components. For ease of servicing, the inlet/exhaust valve can be replaced without the need for line removal.

OPERATION

APPLICATION

Air pressure delivered to the service port enters the small cavity above the piston and moves the piston down. The exhaust seat moves down with the piston and seats on the inner or exhaust portion of the inlet/exhaust valve, sealing off the exhaust passage. At the same time, the outer or inlet portion of the inlet/exhaust valve moves off its seat, permitting supply air to flow from the reservoir, past the open inlet valve and into the brake chambers.

BALANCE

The air pressure being delivered by the open inlet valve also is effective on the bottom area of the relay piston. When air pressure beneath the piston equals the service air pressure above, the piston lifts slightly and the inlet spring returns the inlet valve to its seat. The exhaust remains closed as the service line pressure balances the

delivery pressure. As delivered air pressure is changed, the valve reacts instantly to the change, holding the brake application at that level.

EXHAUST OR RELEASE

When air pressure is released from the service port and air pressure in the cavity above the relay piston is exhausted, air pressure beneath the piston lifts the relay piston and the exhaust seat moves away from the exhaust valve, opening the exhaust passage. With the exhaust passage open, the air pressure in the brake chambers is then permitted to exhaust through the exhaust port, releasing the brakes.

ANTI-COMPOUNDING (SIMULTANEOUS SERVICE AND PARK APPLICATION)

In those applications where the R-14 Relay Valve is used to control spring brake chambers, the anti-compound feature may be utilized. With the anti-compound feature of the R-14 connected, a service application made while the vehicle is parked is countered by a release of the parking brakes. To utilize this feature, the exhaust cover of the quick release portion of the R-14 is removed and a line is installed which is connected to the delivery of the service brake valve or relay valve. With no air pressure at the service port of the R-14, the parking brakes are applied. If a service brake application is made, air from the service brake valve enters the exhaust port of the quick release of the R-14 and moves the diaphragm, blocking the service port. Air then proceeds into the cavity above the relay piston, forces the piston down, closing the exhaust and

opening the inlet to deliver air to the spring brake cavity as described under the section of this manual entitled *Application*.

PREVENTIVE MAINTENANCE

Important: Review the warranty policy before performing any intrusive maintenance procedures. An extended warranty may be voided if intrusive maintenance is performed during this period.

Because no two vehicles operate under identical conditions, maintenance and maintenance intervals will vary. Experience is a valuable guide in determining the best maintenance interval for any one particular operation.

1. Every three months or 25,000 miles or 900 operating hours check for proper operation.
2. Every twelve months or 100,000 miles or 3600 operating hours: disassemble valve, clean parts with mineral spirits. Replace all rubber parts and any part worn or damaged. Check for proper operation before placing vehicle in service.

OPERATIONAL AND LEAKAGE TEST

1. Chock the wheels, fully charge air brake system and adjust the brakes.
2. Make several brake applications and check for prompt application and release at each wheel.
3. Check for inlet valve and o-ring leakage.
 - A. Make this check with the service brakes released when the R-12 or R-14 is used to control the service brakes.
 - B. Make the check with the spring brakes applied (PARK) when the R-14 is used to control the spring brakes. Coat the exhaust port and the area around the retaining ring with a soap solution; a 1 inch bubble in 3 seconds leakage is permitted.
4. Check for exhaust valve leakage.
 - A. Make this check with the service brakes fully applied if the R-12 or R-14 control the service brakes.
 - B. Make this check with the spring brakes fully released if the R-14 is used to control the spring brakes. Coat the exhaust port with a soap solution; a 1 inch bubble in 3 seconds leakage is permitted. Coat the outside of the valve where the cover joins the body to check for seal ring leakage; no leakage is permitted.
5. If the R-14 is used to control the spring brakes, place the park control in the released position and coat the balance port with a soap solution to check the diaphragm and its seat. Leakage equivalent to a 1 inch bubble in 3 seconds is permitted.

Note: If the anti-compound feature is in use, the line attached to the balance port must be disconnected to perform this test.

If the valves do not function as described above, or if leakage is excessive, it is recommended that the valves be replaced with new or remanufactured units or repaired with genuine Bendix parts, available at any authorized Bendix parts outlet.

REMOVAL AND INSTALLATION

REMOVAL

1. Block and hold vehicle by means other than air brakes.
2. Drain air brake system reservoirs.
3. If entire valve is to be removed, identify air lines to facilitate installation.
4. Disconnect air lines from valve.*
5. Remove valve from reservoir or if remotely mounted, remove mounting bolts and then valve.

*It is generally not necessary to remove entire valve to service the inlet/exhaust valve. The inlet/exhaust valve insert can be removed by removing the snap ring, exhaust cover assembly and then inlet/exhaust valve.

Caution: Drain all reservoirs before attempting to remove the inlet exhaust valve.

DISASSEMBLY

Note: Prior to disassembly, mark the location of the mounting bracket to the cover and the cover to the body.

1. Remove the four (4) cap screws and lockwashers securing the cover to the body.
2. Remove the cover, sealing ring, and mounting bracket.
3. Remove the piston and o-ring from the body.
4. While depressing the exhaust cover, remove the retaining ring and slowly relax the spring beneath the exhaust cover.
5. Remove the exhaust cover assembly and o-rings.
6. Remove the inlet/exhaust valve return spring from the body.
7. Remove the inlet/exhaust valve from the body.
8. Remove the valve retainer from the inlet/exhaust valve.
9. Remove the Phillips head screw and exhaust cover from the R-14 cover.
10. Remove the service port cap nut and o-ring from the R-14.
11. Remove the diaphragm from the R-14 cover.

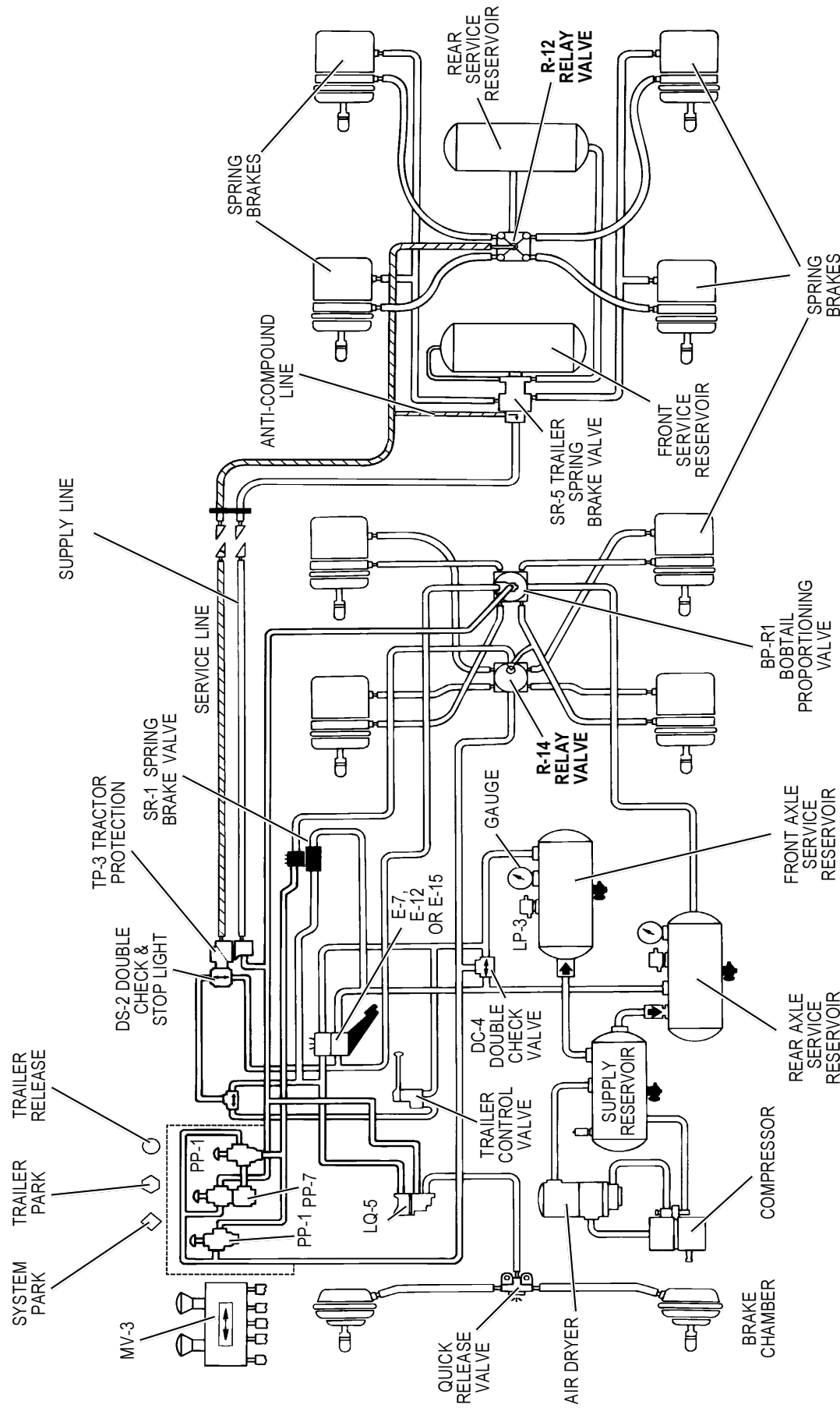


FIGURE 3 - TYPICAL PIPING SCHEMATIC

CLEANING AND INSPECTION

1. Wash all metal parts in mineral spirits and dry them thoroughly.
(**Note:** When rebuilding, all springs and all rubber parts should be replaced.)
2. Inspect all metal parts for deterioration and wear, as evidenced by scratches, scoring and corrosion.
3. Inspect the exhaust valve seat on the relay piston for nicks and scratches which could cause excessive leakage.
4. Inspect the inlet valve seat in the body for scratches and nicks, which could cause excessive leakage.
5. Inspect the exhaust seat of the quick release diaphragm in the R-14 cover and make sure all internal air passages in this area are open and clean and free of nicks and scratches.
6. Replace all parts not considered serviceable during these inspections and all springs and rubber parts. Use only genuine Bendix replacement parts, available from any authorized Bendix parts outlet.

ASSEMBLY

Note: All torque specified in this manual are assembly torque and can be expected to fall off slightly after assembly. **Do not re-torque** after initial assembly torque fall. For assembly, hand wrenches are recommended.

Prior to assembly, lubricate all o-rings, o-ring bores and any sliding surface with a silicone lubricant equivalent to Dow Corning #10.

1. Install large piston o-ring on piston.
2. Install inner and outer o-rings in the exhaust cover assembly.
3. Install the sealing ring on the cover.
4. Install piston in body, taking care not to damage the piston o-ring.
5. Noting the reference marks made during disassembly, install the cover on the valve body and the mounting bracket on the cover.
6. Secure the mounting bracket and cover to the body using the four (4) cap screws and lock washers. Torque to 80-120 inch pounds.
7. Install the valve retainer on the inlet/exhaust valve and install in the body.
8. Install the inlet/exhaust valve return spring in the body.
9. Install the exhaust cover assembly in the body, taking care not to damage the o-ring.
10. While depressing the exhaust cover, install the retaining ring. Make certain the retainer is completely seated in its groove in the body.

11. Install the R-14 service port cap nut o-ring on the cap nut. Install the diaphragm in the R-14 cover making certain it is positioned between the guide ribs in the cover.
13. Install the service port cap nut and torque to 150 inch pounds.
14. If the quick release exhaust port was protected with an exhaust cover, install the cover using the #10-24 Phillips head screw. Torque to approx. 15-25 inch pounds.
15. Test the valves as outlined in the *Operational and Leakage Test* section before returning the valve to service.

INSTALLATION

1. Clean air lines.
2. Inspect all lines and/or hoses for damage and replace as necessary.
3. Install valve and tighten mounting bolts.
4. Connect air lines to valve (plug any unused ports).
5. Test valve as outlined in *Operational and Leakage Tests*.

IMPORTANT! PLEASE READ

When working on or around a vehicle, the following general precautions should be observed:

1. **Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.**
2. **Stop the engine when working around the vehicle.**
3. **If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning ANY work on the vehicle.**
4. **Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.**
5. **When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.**
6. **Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.**
7. **Never exceed recommended pressures and always wear safety glasses.**



8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.
10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.
11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.



QR AND QR-1 QUICK RELEASE VALVES

*Formerly SD-03-69

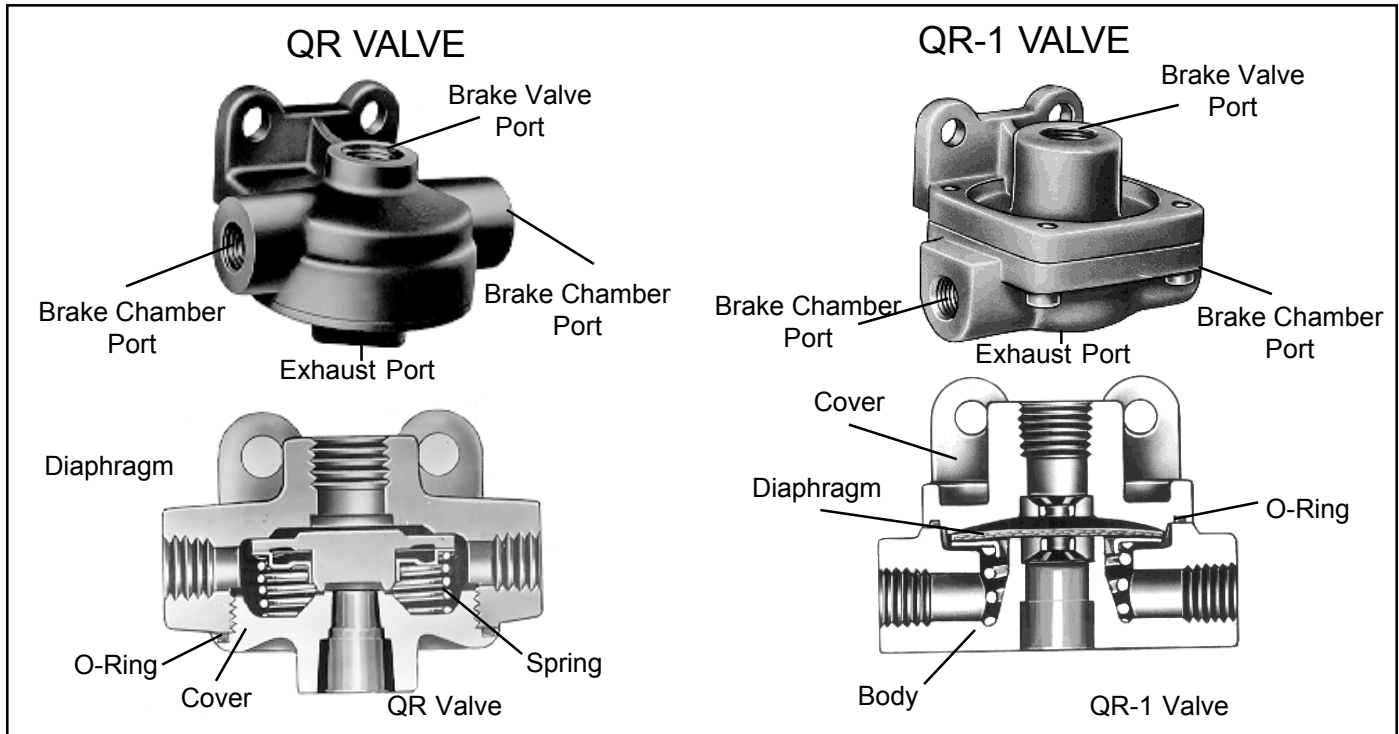


FIGURE 1

DESCRIPTION

The function of the Quick Release Valve is to speed up the exhaust of air from the air chambers. It is mounted close to the chambers it serves. In its standard configuration the valve is designed to deliver within one (1) psi of control pressure to the controlled device; however, for special applications the valve is available with greater differential pressure designed into the valve.

Reference Figure 1, two styles of Quick Release Valves are available and are functionally the same; the QR valve, which is of older design and utilizes a spring and spring seat, and the QR-1 valve, which in its standard configuration does not employ a spring or spring seat.

(Note: AR-1 Valves with a pressure differential employ a spring and spring seat.)

Porting consists of one (1) brake valve port, two (2) delivery ports and one (1) exhaust port.

OPERATION

When a brake application is made, air pressure enters the brake valve port; the diaphragm moves down, sealing the

exhaust. At the same time, air pressure forces the edges of the diaphragm down and air flows out the delivery port.

When air pressure being delivered (beneath the diaphragm) equals the pressure being delivered by the brake valve (above the diaphragm), the outer edge of the diaphragm will seal against the body seat. The exhaust port is still sealed by the center portion of the diaphragm when the brake valve application is released; the air pressure above the diaphragm is released back through the brake valve exhaust; air pressure beneath the diaphragm forces the diaphragm to rise, opening the exhaust, allowing air in the chambers to exhaust.

PREVENTIVE MAINTENANCE

Every 12 months, 100,000 miles or 3600 operating hours; disassemble valve, wash metal parts in mineral spirits, wipe rubber parts dry. It is recommended that all rubber parts be replaced. Inspect all parts and replace any part showing signs of wear or deterioration.

OPERATING AND LEAKAGE TESTS

While holding a foot brake valve application:

1. Coat exhaust port with soap solution; leakage of a one (1) inch bubble in three (3) seconds is permitted.
2. Coat body and cover with soap solution. No leakage permitted between body and cover.

If the valve does not function as described, or if leakage is excessive, it is recommended that it be replaced with a new or remanufactured unit, or repaired with genuine Bendix parts.

REMOVING AND INSTALLING

REMOVING

Block vehicle wheels and/or hold vehicle by means other than air brakes.

Drain all air brake system reservoirs.

Disconnect air lines from valve.

Remove mounting bolts, then valve.

INSTALLING

Mount valve with exhaust port pointing down; securely tighten mounting bolts.

Connect air lines to valve (brake valve application line to top port; brake chamber line to side ports.)

DISASSEMBLY

QR VALVE

1. Using wrench on square portion of exhaust port, remove cover.
2. Remove spring, spring seat and diaphragm. Remove cover O-Ring.

QR-1 VALVE

1. Remove four screws.
2. Remove spring and spring seat (if so equipped).
3. Remove diaphragm.
4. Remove cover O-Ring.

CLEANING AND INSPECTION

Clean all metal parts in mineral spirits. Wipe all rubber parts clean.

It is recommended that all rubber parts and any other part showing signs of wear or deterioration be replaced with genuine Bendix parts.

ASSEMBLY

QR VALVE

1. Position spring seat over the diaphragm and then install into body.
2. Install spring and cover O-Ring.
3. Install cover; tighten securely. (Torque to 150-400 inch pounds.)

QR-1 VALVE

1. If valve is equipped within spring and spring seat:
 - a. Position spring in body.
 - b. Position diaphragm over spring seat.

- a. Install O-Ring in cover groove; install cover and tighten screws evenly and securely. (Torque to 30-60 inch pounds.)
2. If valve is not equipped with spring and spring seat:
 - a. Install diaphragm.
 - b. Install O-Ring in cover groove; install cover and tighten screws evenly and securely. (Torque to 30-60 inch pounds.)
 3. Perform tests as outlined in "Operating and Leakage Tests" section.

IMPORTANT! PLEASE READ

When working on or around a vehicle, the following general precautions should be observed:

1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.
2. Stop the engine when working around the vehicle.
3. If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning ANY work on the vehicle.
4. Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.
5. When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.
6. Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.
7. Never exceed recommended pressures and always wear safety glasses.
8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.
10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.
11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

E-8P & E-10P DUAL BRAKE VALVES

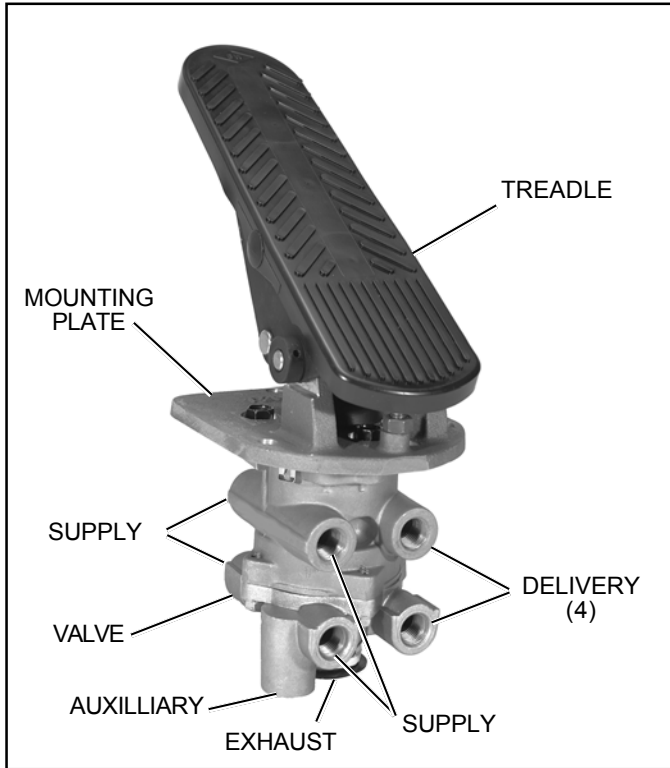


FIGURE 1 - E-8P

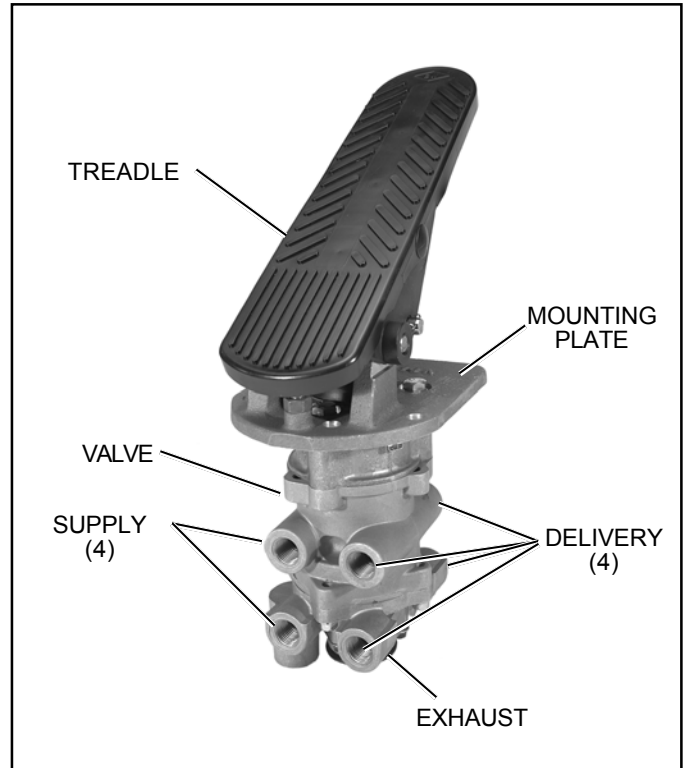


FIGURE 2 - E-10P

DESCRIPTION

Refer to Figures 4, 5 and 6 for item numbers referenced in parenthesis.

The E-8P (Figure 1) and E-10P (Figure 2) Dual Brake Valves are floor mounted, treadle operated type brake valves with two separate supply and delivery circuits for service (primary and secondary) braking, which provides the driver with a graduated control for applying and releasing the vehicle brakes.

The E-10P Dual Brake Valve (Figure 2) is similar to the E-8P Dual Brake Valve except that a metal coil spring (5) housed in an upper body assembly replaces the rubber spring (27) used in the E-8P valve. The use of a metal coil spring (and the upper body assembly) provides greater treadle travel and, therefore, provides the driver with a less sensitive "feel" when making a brake application. The E-10P Dual Brake

Valve is generally used on busses, where smooth brake applications contribute to passenger comfort.

The circuits in the E-8P/E-10P Dual Brake Valves are identified as follows: The No. 1 or primary circuit is that portion of the valve between the spring seat which contacts the plunger and the relay piston; the No. 2 or secondary circuit is that portion between the relay piston and the exhaust cavity.

The primary circuit of the valve is similar in operation to a standard single circuit air brake valve and under normal operating conditions the secondary circuit is similar in operation to a relay valve.

Both primary and secondary circuits of the brake valve use a common exhaust protected by an exhaust diaphragm.

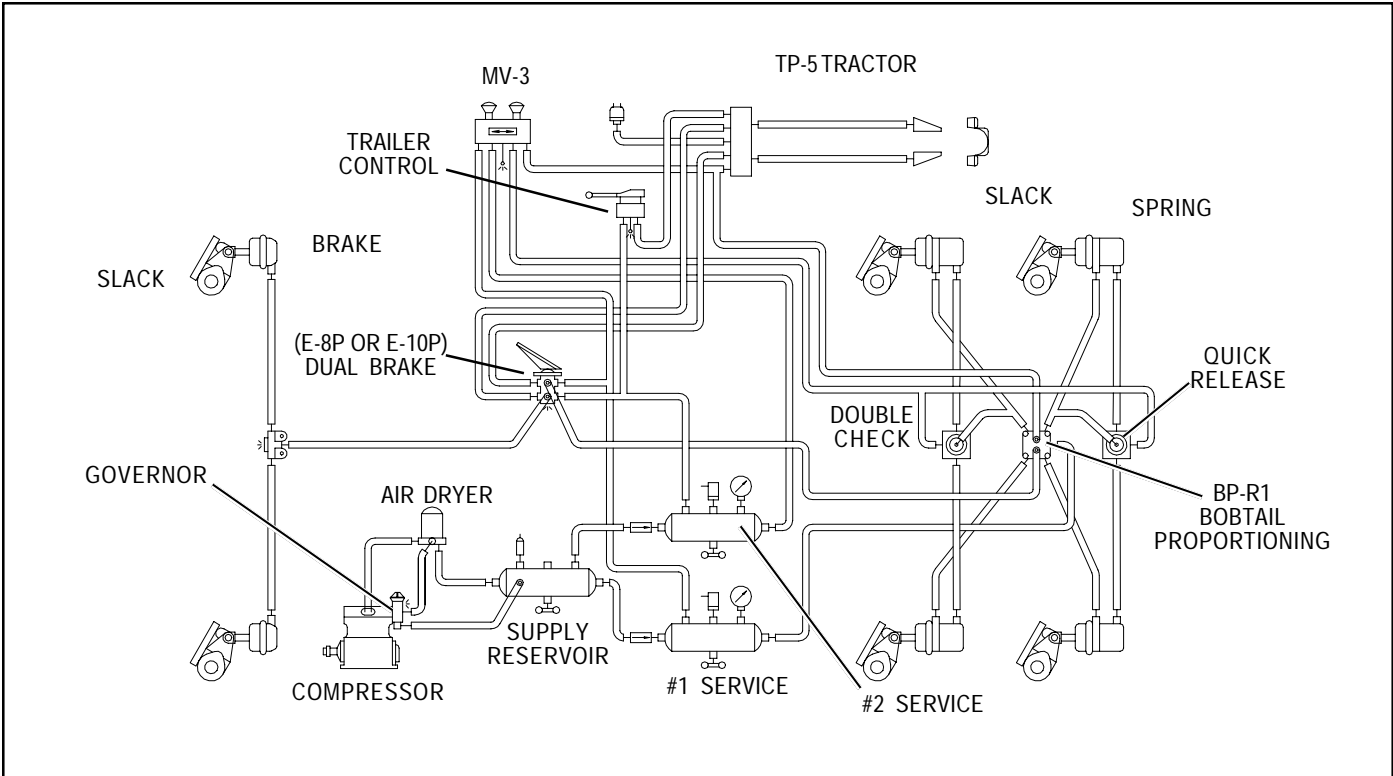


FIGURE 3 - TYPICAL PIPING SCHEMATIC

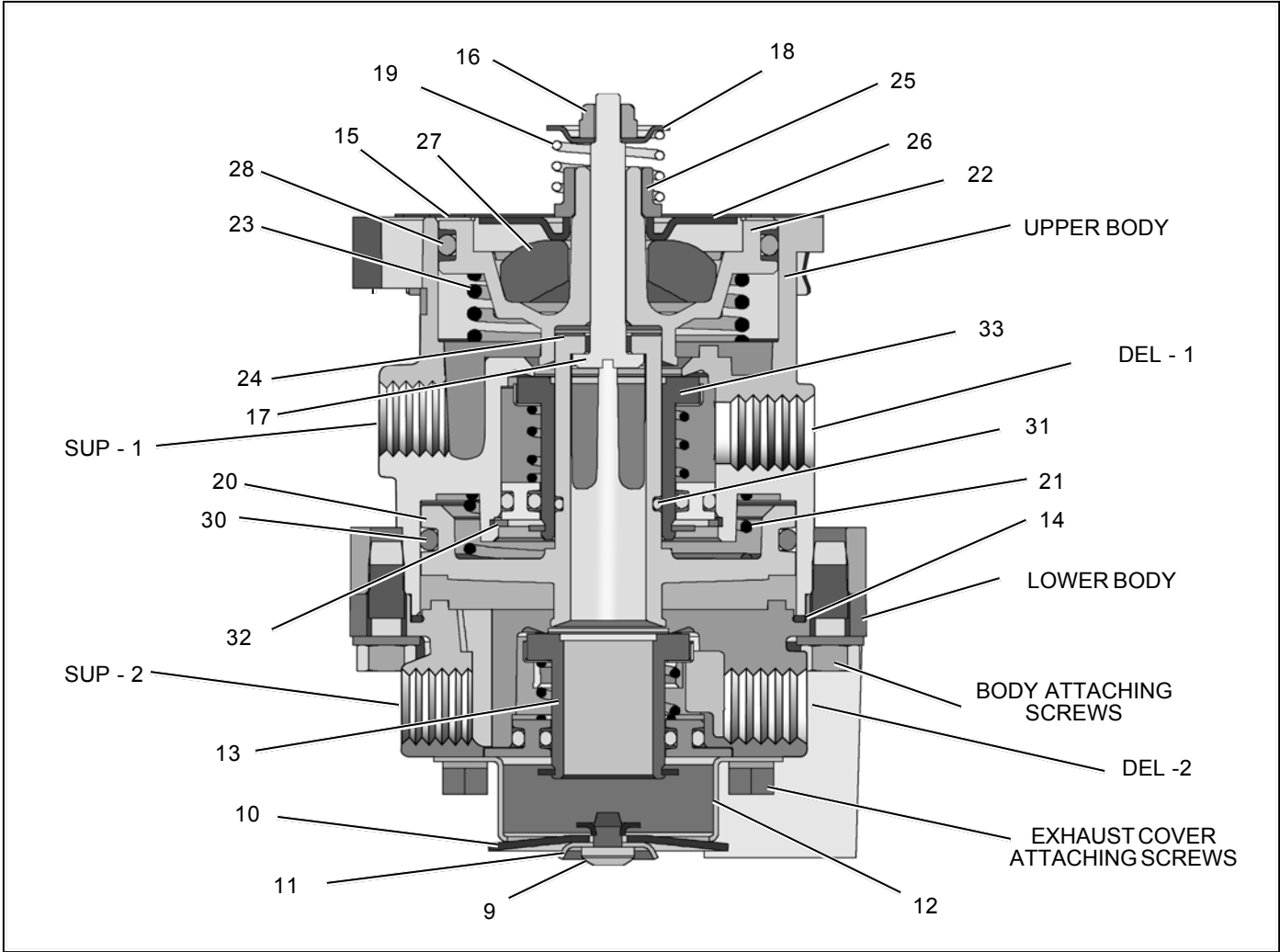


FIGURE 4 - E-8P SECTIONAL VIEW

OPERATION - Refer to Figure 3

APPLYING: NORMAL OPERATION - NO. 1 OR PRIMARY CIRCUIT PORTION

When the brake treadle is depressed, the plunger exerts force on the spring seat (26), graduating spring (23), and primary piston (22). The primary piston, which contains the exhaust valve seat, closes the primary exhaust valve. As the exhaust valve closes, the primary inlet valve is moved off its seat allowing primary air to flow out the No. 1 or primary delivery port.

APPLYING: NORMAL OPERATION - NO. 2 OR SECONDARY CIRCUIT

When the primary inlet valve (33) is moved off its seat, air is permitted to pass through the bleed passage and enters the relay piston cavity. The air pressure moves the relay piston (20), which contains the exhaust seat, and closes the secondary exhaust valve. As the secondary exhaust valve closes, the inlet valve (13) is moved off its seat allowing the secondary air to flow out the delivery of the same circuit. Because of the small volume of air required to move the relay piston (20), action of the secondary circuit of the valve is almost simultaneous with the primary circuit portion.

APPLYING: LOSS OF AIR IN THE NO. 2 OR SECONDARY CIRCUIT

Should air be lost in the No. 2 or secondary circuit, the No. 1 or primary circuit will continue to function as described above under *Normal Operation: No. 1 or Primary Circuit Portion*.

APPLYING: LOSS OF AIR IN THE NO. 1 OR PRIMARY CIRCUIT

Should air be lost in the primary circuit, the function will be as follows: As the brake treadle is depressed and no air pressure is present in the primary circuit supply and delivery ports, the primary piston (22) will mechanically move the relay piston (20), allowing the piston to close the secondary exhaust valve and open the secondary inlet valve and allow air to flow out the secondary delivery port.

BALANCED: NO. 1 OR PRIMARY CIRCUIT

When the primary delivery pressure acting on the primary piston (22) equals the mechanical force of the brake pedal application, the primary piston (22) will move and the primary inlet valve (33) will close, stopping further flow of air from the primary supply line through the valve. The exhaust valve remains closed preventing any escape of air through the exhaust port.

BALANCED: NO. 2 OR SECONDARY CIRCUIT

When the air pressure on the delivery side of the relay piston (20) approaches that being delivered on the primary side of the relay piston, the relay piston moves closing the secondary inlet valve and stopping further flow of air from the supply line through the valve. The exhaust remains closed as the secondary delivery pressure balances the primary delivery pressure.

When applications in the graduating range are made, a balanced position in the primary circuit is reached as the air pressure on the delivery side of the primary piston (22) equals the effort exerted by the driver's foot on the treadle. A balanced position in the secondary portion is reached when air pressure on the secondary side of the relay piston (20) closely approaches the air pressure on the primary side of the relay piston.

When the brake treadle is fully depressed, both the primary and secondary inlet valves remain open and full reservoir pressure is delivered to the actuators.

RELEASING: NO. 1 OR PRIMARY CIRCUIT

With the brake treadle released, mechanical force is removed from the spring seat (26), graduating spring (23), and primary piston (22). Air pressure and spring load moves the primary piston, opening the primary exhaust valve, allowing air pressure in the primary delivery line to exhaust out the exhaust port.

RELEASING: NO. 2 OR SECONDARY CIRCUIT

With the brake treadle released, air is exhausted from the primary circuit side of the relay piston (20). Air pressure and spring load move the relay piston, opening the secondary exhaust valve, allowing air pressure in the secondary delivery line to exhaust out the exhaust port.

PREVENTIVE MAINTENANCE

Important: Review the warranty policy before performing any intrusive maintenance procedures. An extended warranty may be voided if intrusive maintenance is performed during this period.

Because no two vehicles operate under identical conditions, maintenance and maintenance intervals will vary. Experience is a valuable guide in determining the best maintenance interval for any one particular operation.

Visually check for physical damage to the brake valve such as broken air lines and broken or missing parts.

Every 3 months, or 25,000 miles or 900 operating hours:

Clean any accumulated dirt, gravel, or foreign material away from the heel of the treadle, plunger boot, and mounting plate.

Using light oil, lubricate the treadle roller, roller pin, and hinge pin.

Check the rubber plunger boot for cracks, holes or deterioration and replace if necessary. Also, check mounting plate and treadle for integrity.

Apply 2 to 4 drops of oil between plunger and mounting plate - **do not over oil!**

Every year, or 100,000 miles, or 3,600 operating hours:

Disassemble, clean parts with mineral spirits, replace all rubber parts, or any part worn or damaged. Check for proper operation before placing vehicle in service.

SERVICE CHECKS

OPERATING CHECK

Check the delivery pressure of both primary and secondary circuits using accurate test gauges. Depress the treadle to several positions between the fully released and fully applied positions, and check the delivered pressure on the test gauges to see that it varies equally and proportionately with the movement of the brake pedal.

After a full application is released, the reading on the test gauges should fall off to zero promptly. It should be noted that the primary circuit delivery pressure will be about 2 PSI greater than the secondary circuit delivery pressure with both supply reservoirs at the same pressure. This is normal for this valve.

Important: A change in vehicle braking characteristics or a low pressure warning may indicate a malfunction in one or the other brake circuit, and although the vehicle air brake system may continue to function, the vehicle should not be operated until the necessary repairs have been made and both braking circuits, including the pneumatic and mechanical devices, are operating normally. Always check the vehicle brake system for proper operation after performing brake work and before returning the vehicle to service.

LEAKAGE CHECK

1. Make and hold a high pressure (80 psi) application.
2. Coat the exhaust port and body of the brake valve with a soap solution.
3. Leakage permitted is a one inch bubble in 3 seconds. If the brake valve does not function as described above or leakage is excessive, it is recommended that it be replaced with a new or remanufactured unit, or repaired with genuine Bendix parts available at authorized Bendix parts outlets.

Refer to figures 4, 5 and 6 for item numbers referenced in parenthesis.

REMOVAL

1. Chock the vehicle wheels or park the vehicle by mechanical means. (Block and hold vehicle by means other than air brakes.) Drain all air system reservoirs.
2. Identify and disconnect all supply and delivery lines at the brake valve.
3. Remove the brake valve and treadle assembly from the vehicle by removing the three cap screws on the outer bolt circle of the mounting plate. The basic brake valve alone can be removed by removing the three cap screws on the inner bolt circle.

DISASSEMBLY (Figures 4, 5 and 6)

1. If the entire brake valve and treadle assembly was removed from the vehicle, remove the three cap screws securing the treadle assembly to the basic brake valve.
2. Remove the screw (9) securing the exhaust diaphragm (10) and washer (11) to the exhaust cover (12).
3. Remove the four screws that secure the exhaust cover (12) to the lower body.
4. Remove the secondary inlet and exhaust valve assembly (13) from the lower body.
5. Remove the four hex head cap screws securing the lower body to the upper body and separate the body halves.
6. Remove the rubber seal ring (14) from the lower body.
7. **For E-8P only:** While applying thumb pressure to the primary piston (22), lift out and up on the three lock tabs of the primary piston retainer (15).
8. **For E-10P only:** While depressing spring seat (7), remove retaining ring (8). Remove spring seat (7) and coil spring (5).

Caution: Before proceeding with the disassembly, refer to Figures 3 and 4 and note that the lock nut (16) and stem (17) are used to contain the primary piston return spring (**for E-8P:** 23, **for E-10P:** 6), stem spring (19), and the relay piston spring (21). The combined force of these springs is approximately 50 pounds and care must be taken when removing the lock nut as the spring forces will be released. It is recommended that the primary piston and relay piston be manually or mechanically contained while the nut and stem are being removed.

9. Using a 3/8" wrench, hold the lock nut (16) on the threaded end of the stem (17). Insert a screwdriver to restrain the stem, remove the lock nut (16), spring seat, (18) and stem spring (19).
10. **For E-10P only:** Remove adapter (1) and o-ring (4). Remove the primary piston (2) from adapter (1) and o-ring (34) from the primary piston (2).

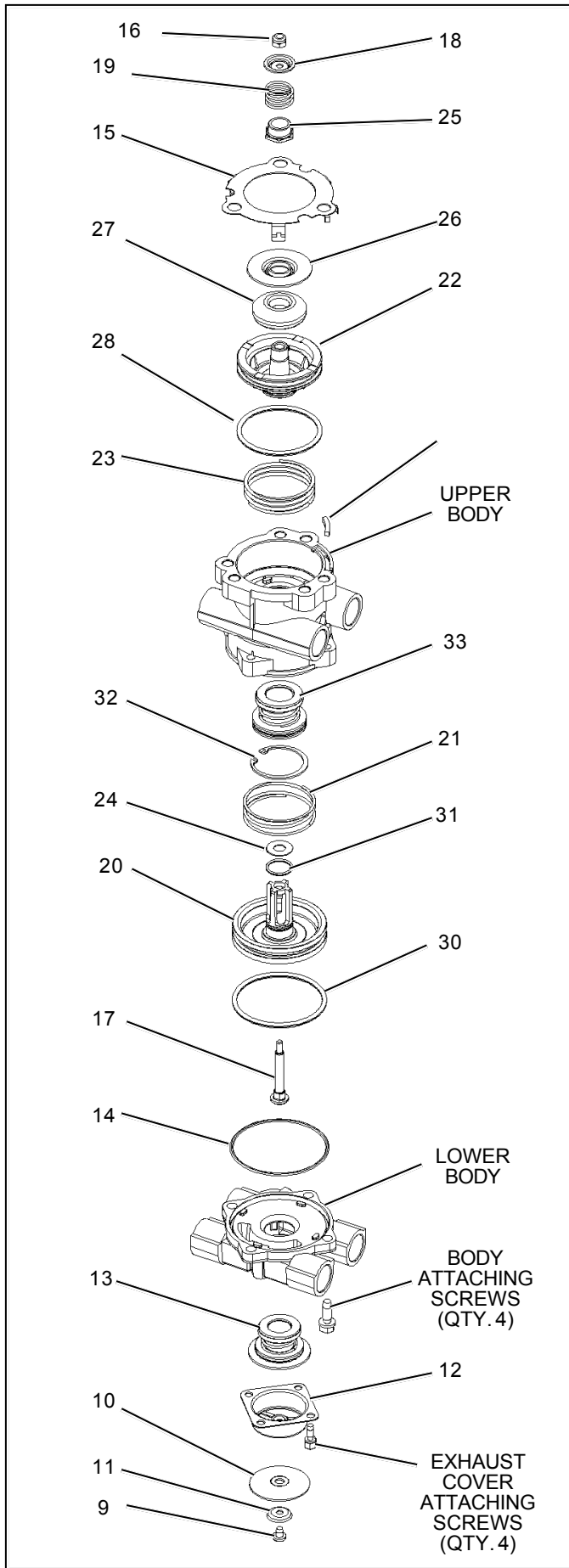


FIGURE 5 - E-8P BRAKE VALVE - EXPLODED VIEW

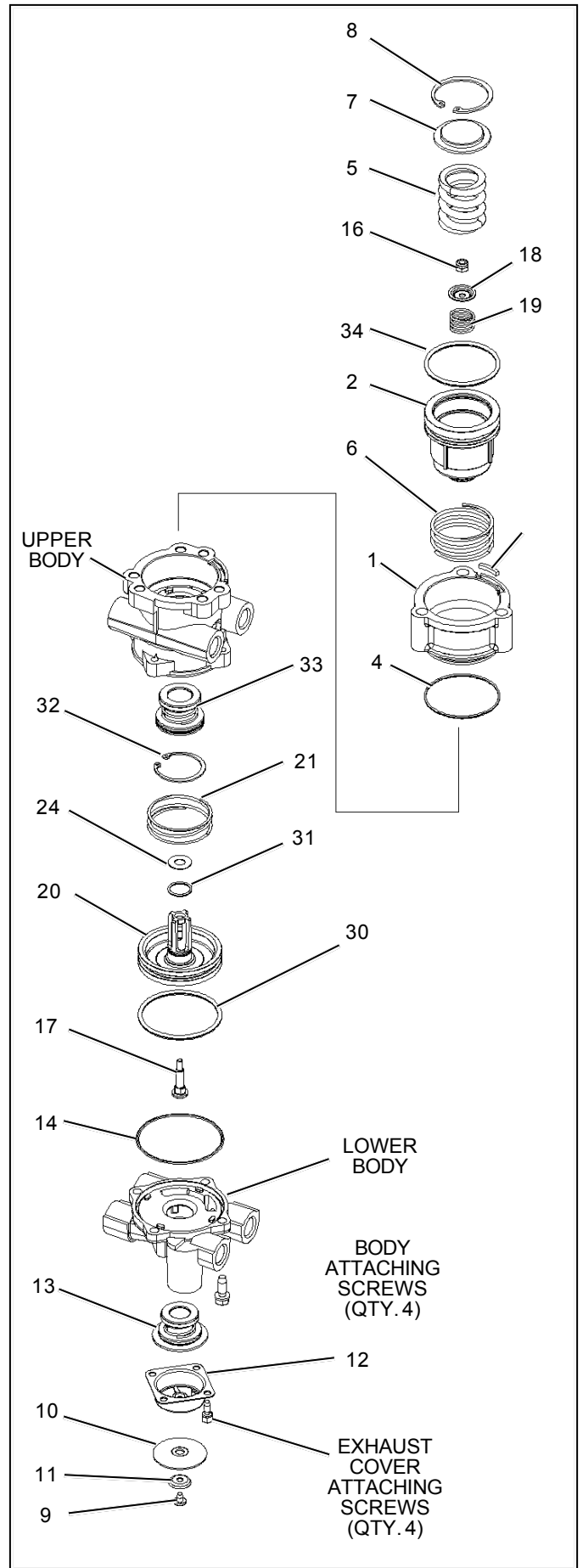


FIGURE 6 - E-10P BRAKE VALVE - EXPLODED VIEW

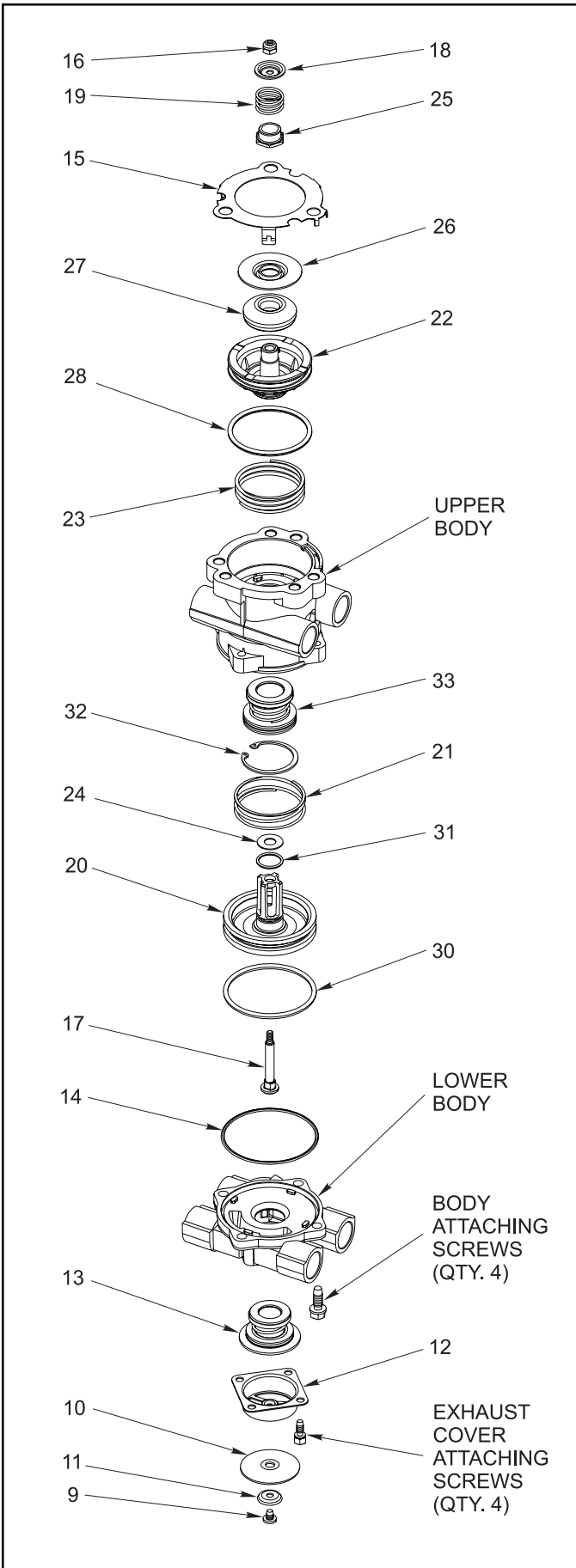


FIGURE 5 E-8P BRAKE VALVE EXPLODED VIEW

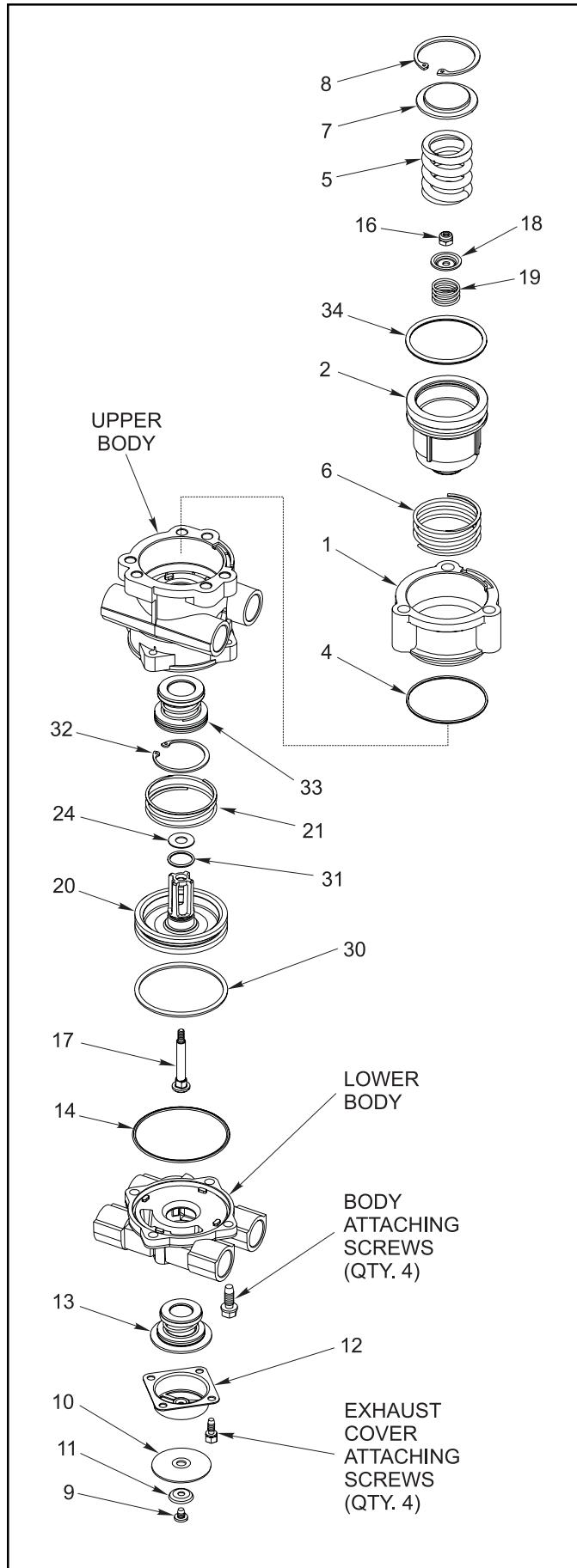


FIGURE 6 E-10P BRAKE VALVE EXPLODED VIEW

11. Remove the relay piston (20), relay piston spring (21), primary piston (**E-8P**: 22, **E-10P**: 2) and primary piston return spring (**E-8P**: 23, **E-10P**: 6) from the upper body. Use care so as not to nick seats.
12. A small washer (24) will be found in the cavity of the lower side of the primary piston (**for E-8P**: 22, **for E-10P**: 2).
13. **For E-8P only**: Disassemble the primary piston by rotating the spring seat nut (25) counterclockwise. Separate the spring seat nut, spring seat (26), and rubber spring (27) and remove the piston o-ring (28).
14. Remove the large and small o-rings (30 & 31) from the relay piston (20).
15. Remove the retaining ring (32) securing the primary inlet and exhaust valve assembly (33) in the upper body and remove the valve assembly.
6. Place relay piston spring (21) in concave portion of relay piston (20) and install relay piston through primary inlet/exhaust assembly (33) into under side of upper body.
7. **For E-10P only**: Install o-ring (4) on adapter (1) and install adapter on upper body. Install o-ring (34) on primary piston (2).
8. Place screwdriver, blade up, in vise. Insert stem (17) through the relay piston upper body sub assembly, slide this assembly over the blade of the secured screwdriver, engage the screwdriver blade in the slot in the head of the stem.
9. Place the washer (24) over the stem (17) and on top of the relay piston (20).
10. Install primary return spring (**E-8P**: 23, **E-10P**: 6) in upper body piston bore.
11. **For E-8P only**: Install the primary piston rubber spring sub assembly (steps 4 & 5) over the stem, into the upper body piston bore. **For E-10P**: Install primary piston sub-assembly (reference step 7).

CLEANING AND INSPECTION

1. Wash all metal parts in mineral spirits and dry.
2. Inspect all parts for excessive wear or deterioration.
3. Inspect the valve seats for nicks or burrs.
4. Check the springs for cracks or corrosion.
5. Replace all rubber parts and any part not found to be serviceable during inspection, use only genuine Bendix replacement parts.

ASSEMBLY

Prior to reassembling, lubricate all o-rings, o-ring grooves, piston bores, and metal to metal moving surfaces with Dow Corning 55 o-ring lubricant (Bendix piece number 291126).

Note: All torques specified in this manual are **assembly** torques and can be expected to fall off, after assembly is accomplished. **Do not retorque** after initial assembly torques fall.

1. Install the primary inlet and exhaust assembly (33) in the upper body and replace the retaining ring (32) to secure it. Be sure the retaining ring is seated completely in its groove.
2. Install the large and small o-rings (30 & 31) on the relay piston (20).
3. **For E-8P only**: Install o-ring (28) in the primary piston (22) o-ring groove.
4. **For E-8P only**: Install the rubber spring (do not lubricate) (27), concave side down in the primary piston (22) and place the spring seat (26), flat side up, over the rubber spring.
5. **For E-8P only**: Install the primary piston spring seat nut (25), with its hex closest to the spring seat, and rotate clockwise until the top surface of the spring seat is even with the top surface of the piston. Set aside.
12. Compress piston(s) (**For E-8P**: the relay piston (20), **for E-10P**: the primary and relay pistons (2 & 20)) and retaining ring into the upper body from either side and hold compressed, either manually or mechanically. **See the cautionary note under step 8 in the Disassembly section of this manual.**
13. Place the stem spring (19) (**E-8P**: place over the spring seat nut (25)), the spring seat (18) (concave side up) and lock nut (16) on the stem (17). Torque to 20 - 30 inch pounds.
14. **For E-8P only**: Install the primary piston retainer (15) over the piston, making certain all three lock tabs have engaged the outer lip of the body.
15. **For E-10P only**: Install coil spring (5), spring seat (7), and retaining ring (8) .
16. Replace the rubber seal ring (14) on the lower body.
17. Install the 4 hex head cap screws securing the lower body to the upper body. Torque to 30 - 60 inch pounds.
18. Install the secondary inlet and exhaust valve assembly (13) on the lower body.
19. Install the screws that secure the exhaust cover (12) to the lower body. Torque to 20 - 40 inch pounds.
20. Secure the screw (9) holding the exhaust diaphragm (10) and the diaphragm washer (11) to the exhaust cover (12). Torque to 5 - 10 inch pounds.
21. Install all air line fittings and plugs making certain thread sealant material does not enter valve.

VALVE INSTALLATION

1. Install the assembled brake valve on the vehicle.

2. Reconnect all air lines to the valve using the identification made during VALVE REMOVAL step 1.
3. After installing the brake valve assembly, perform the "OPERATION AND LEAKAGE CHECKS" before placing the vehicle in service.

IMPORTANT: MAINTENANCE PRECAUTIONS

When working on or around a vehicle, the following general precautions should be observed:

1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.
2. Stop the engine when working around the vehicle.
3. Drain the air pressure from all reservoirs before beginning ANY work on the vehicle.
4. Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.
5. When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, **EXTREME CAUTION** should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.
6. Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.
7. Never exceed recommended pressures and always wear safety glasses.
8. Do not attempt to install, remove, disassemble, or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.
10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.
11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.



SR-7 SPRING BRAKE MODULATING VALVE

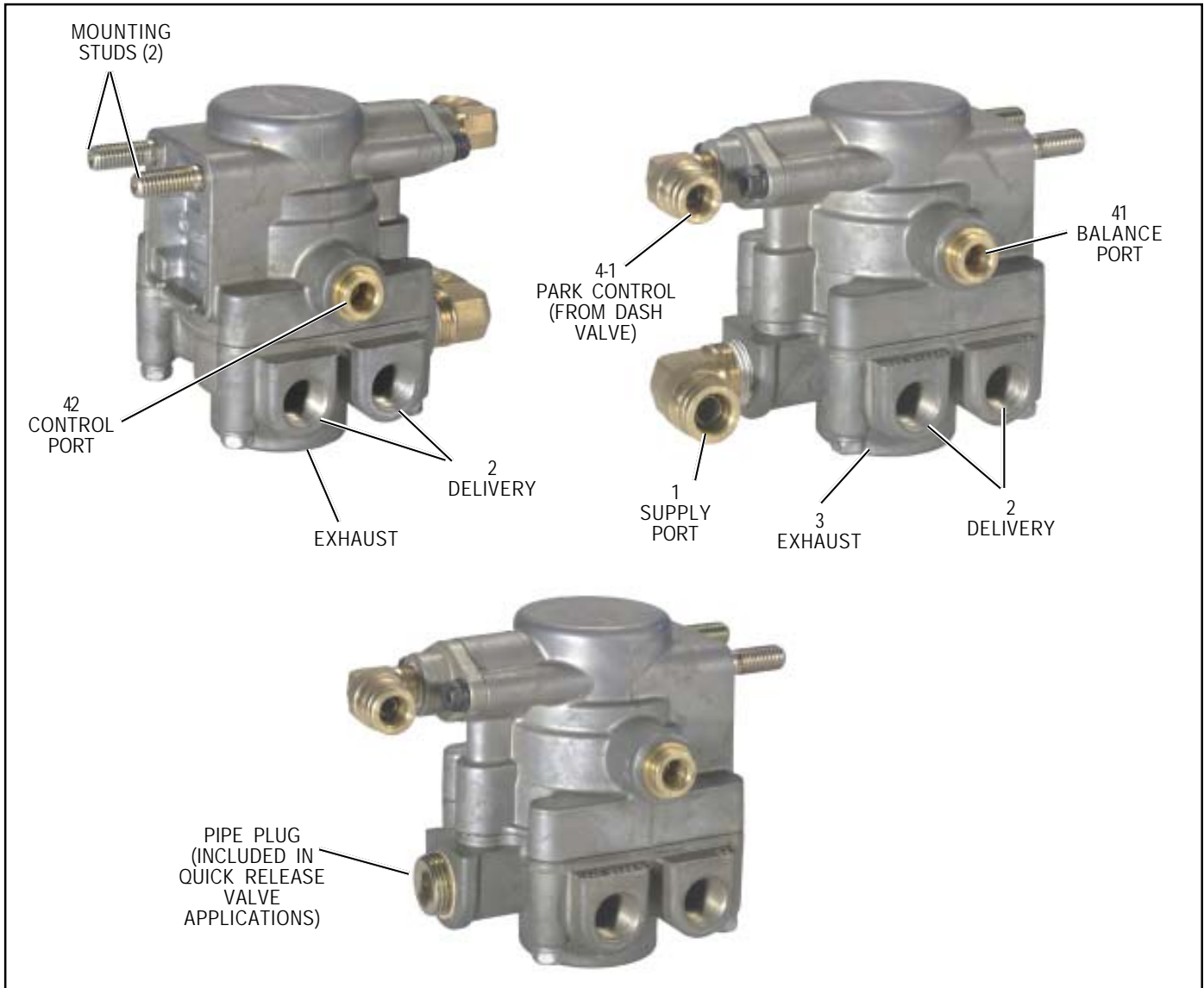


FIGURE 1 - EXTERIOR VIEW

DESCRIPTION

The SR-7 Spring Brake Modulating Valve is used in conjunction with a dual air brake system and spring brake actuator and performs the following functions:

1. Provides a rapid application of the spring brake actuator when parking.
2. Modulates the spring brake actuator application using the dual brake valve should a primary failure occur in the service brake system.
3. Prevents compounding of service and spring forces.

The valve has one park control, one service control, one supply, one balance, four delivery NPTF ports, and an exhaust port protected by an exhaust diaphragm. The valve incorporates two mounting studs for mounting the valve to the frame rail or cross member (where applicable).

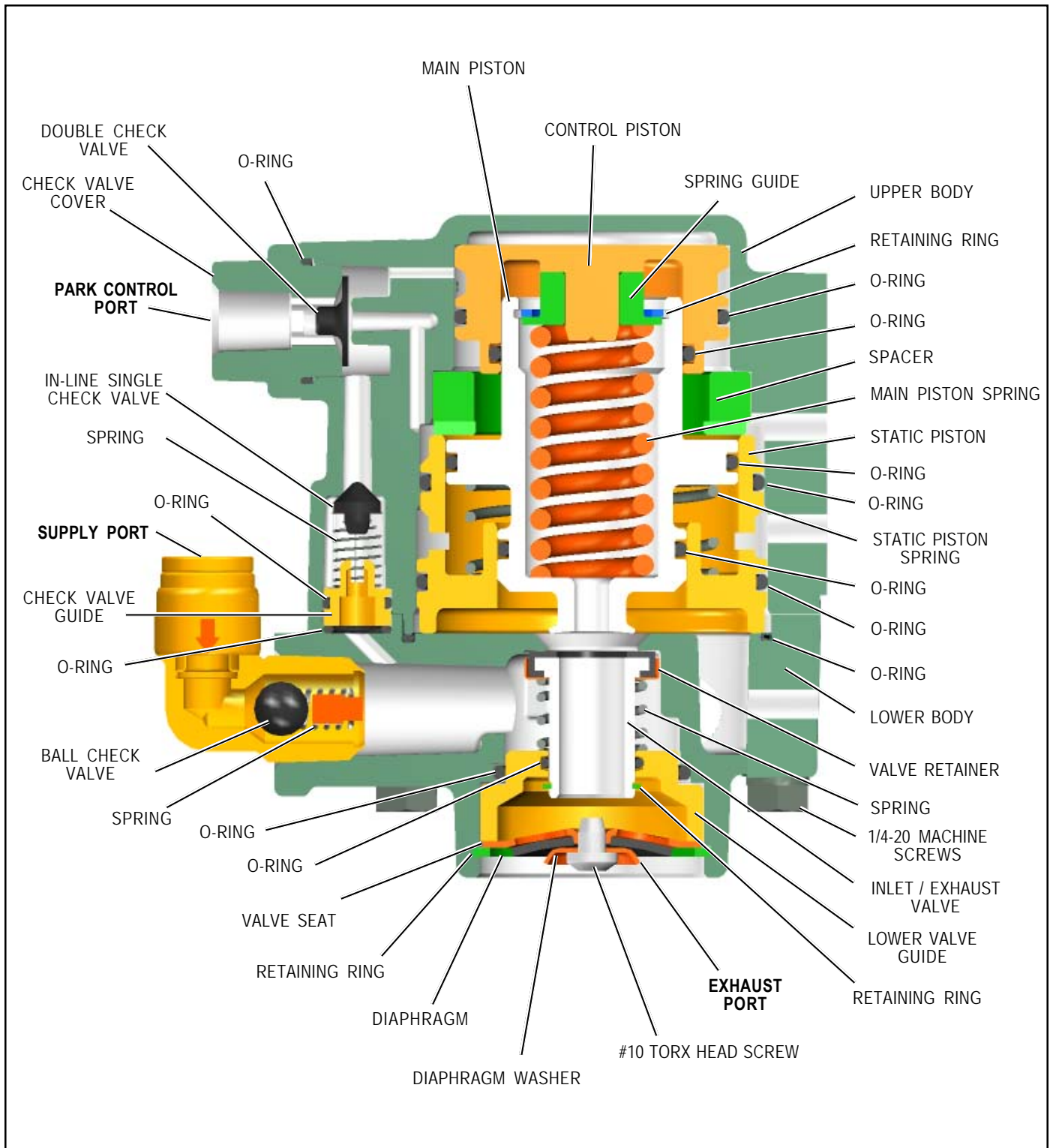


FIGURE 2 - SECTIONAL VIEW OF SR-7 USED IN RELAY VALVE APPLICATIONS

OPERATION

The operation guidelines shown in this manual represent the relay valve based SR-7 (refer to system schematic shown in figure 3). A quick release based valve functions similarly to the relay valve based version with the exception that all

air delivered to spring brakes passes through the park control port through the in-line single check valve. The quick release style SR-7 can be easily identified by the pipe plug in the supply port of the valve.

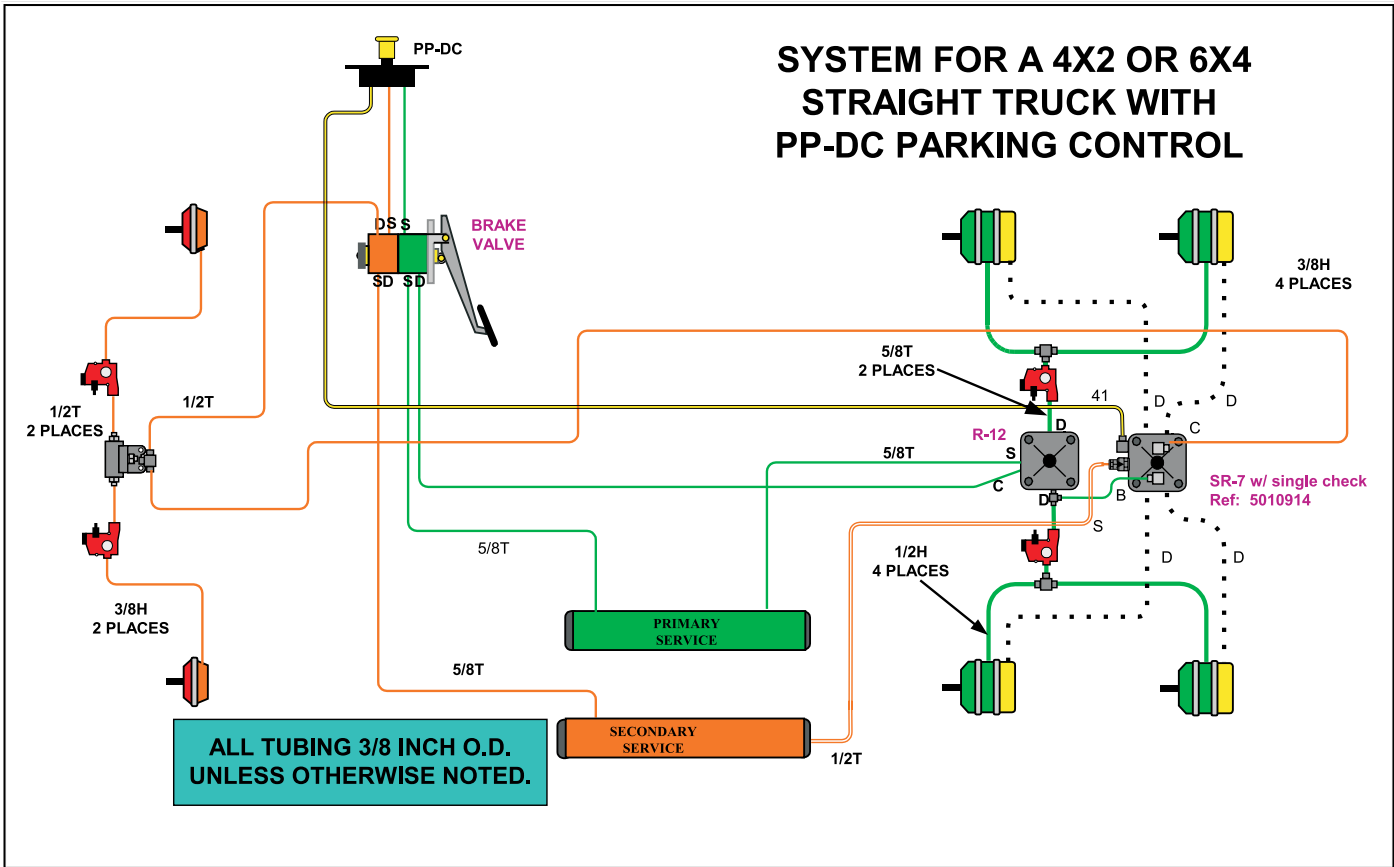


FIGURE 3 - SYSTEM SCHEMATIC WITH PP-DC PARK CONTROL

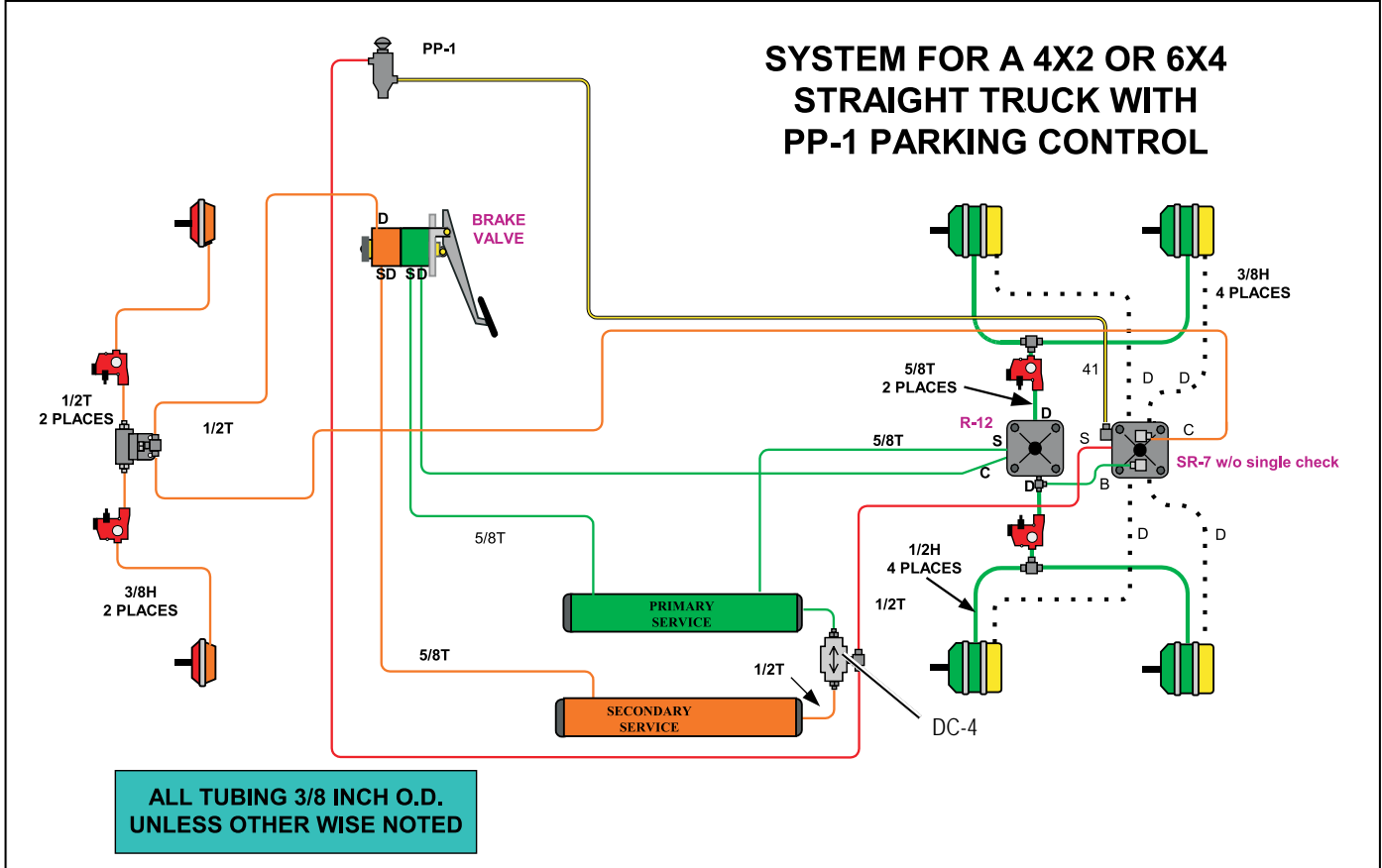


FIGURE 4 - SYSTEM SCHEMATIC WITH PP-1 PARK CONTROL AND DC-4 DOUBLE CHECK VALVE

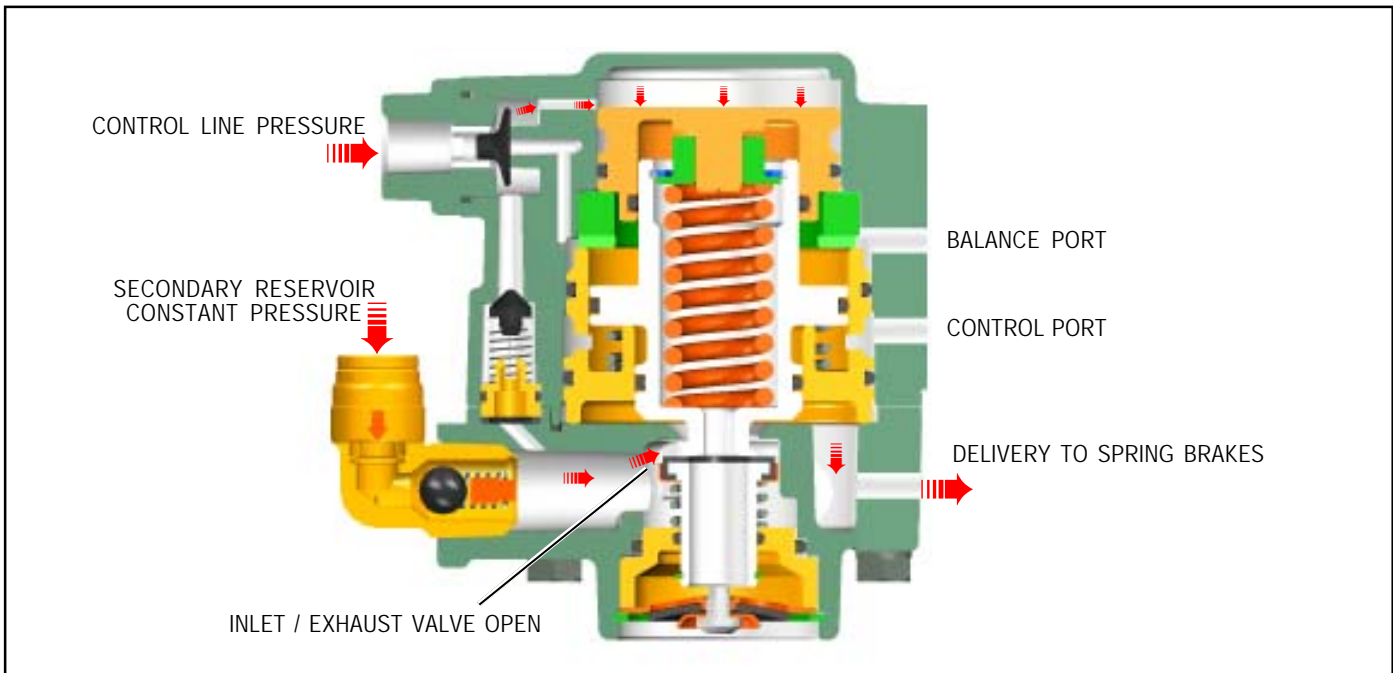


FIGURE 5 - CHARGING LESS THAN 107 PSI

CHARGING SPRING BRAKE ACTUATORS BELOW 107 PSI (FIGURE 5)

With the air brake system charged and the parking brakes released (by pushing the dash valve button in), air enters the park control port. This opens the SR-7 to supply air pressure to the spring brake chambers. As illustrated, air pressure in the chambers is below 107 psi (nominally).

CHARGING SPRING BRAKE ACTUATORS ABOVE 107 PSI (FIGURE 6)

Once the SR-7 valve delivery pressure reaches 107 psi (nominal), the inlet and exhaust are closed (valve lap position). This maintains the spring brake hold-off pressure at 107 psi (nominal).

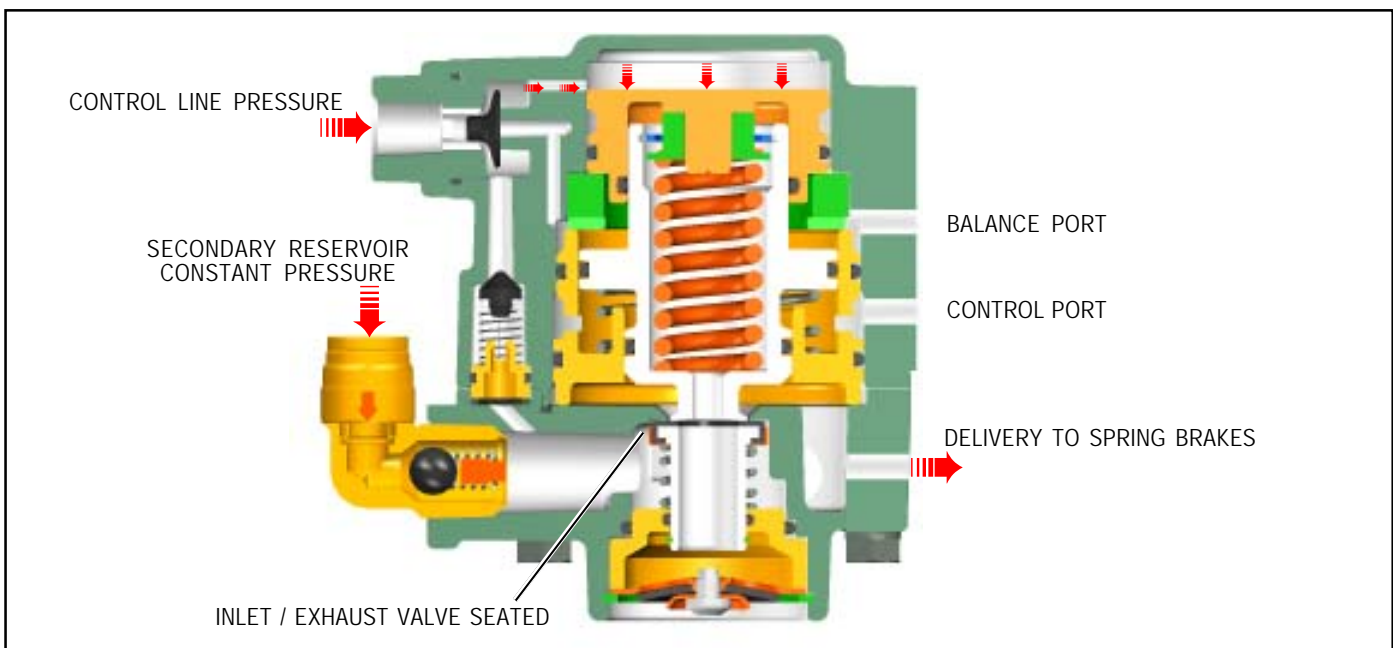


FIGURE 6 - CHARGING GREATER THAN 107 PSI

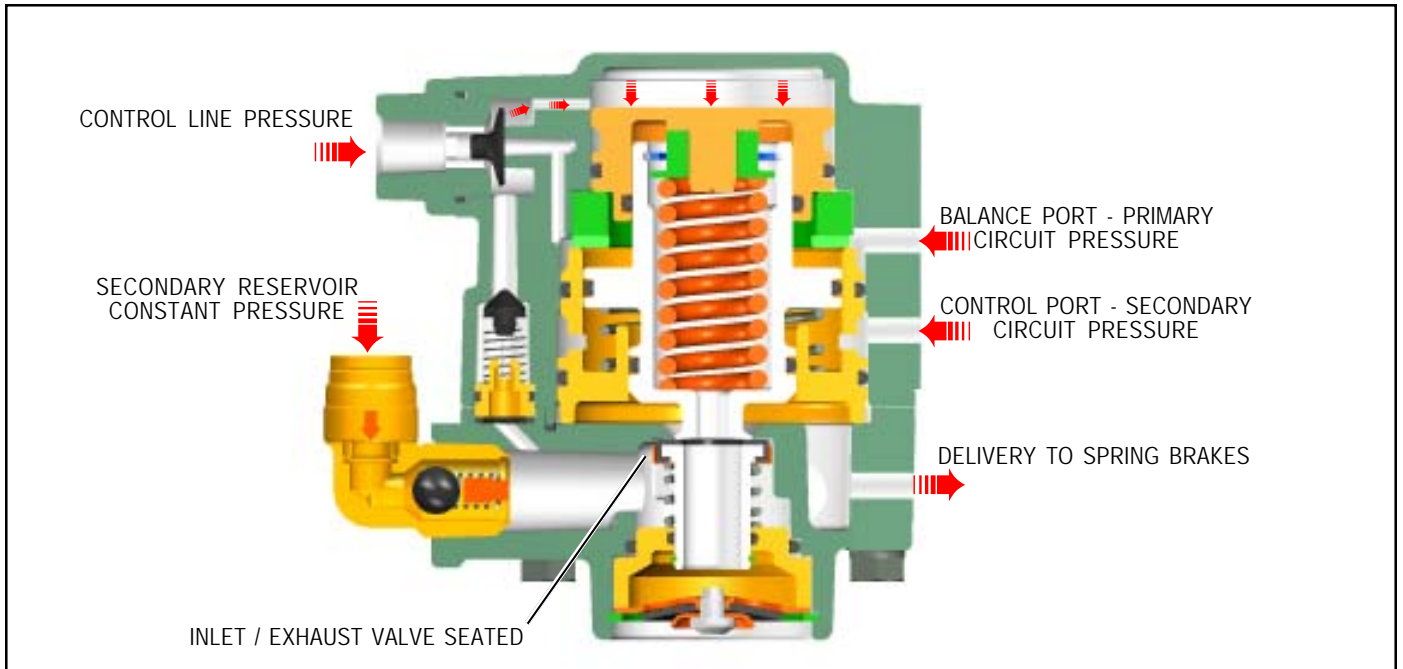


FIGURE 7 - NORMAL SERVICE APPLICATION

NORMAL SERVICE APPLICATION (FIGURE 7)

During a service brake application, the valve remains in the lap position. The SR-7 valve monitors the presence of air pressure in both primary and secondary delivery circuits.

PARKING (FIGURE 8)

Actuating the park brakes (by pulling the dash valve button out) exhausts spring brake air pressure through the SR-7 exhaust port.

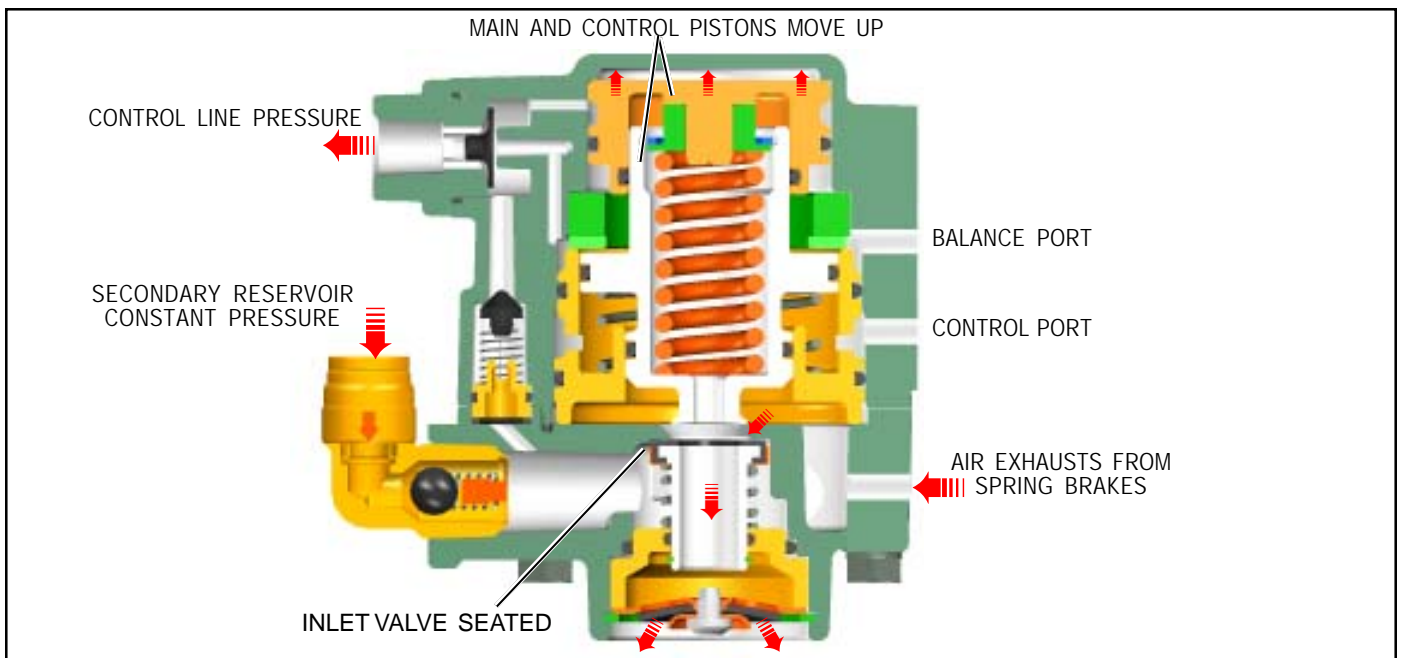


FIGURE 8 - PARKING

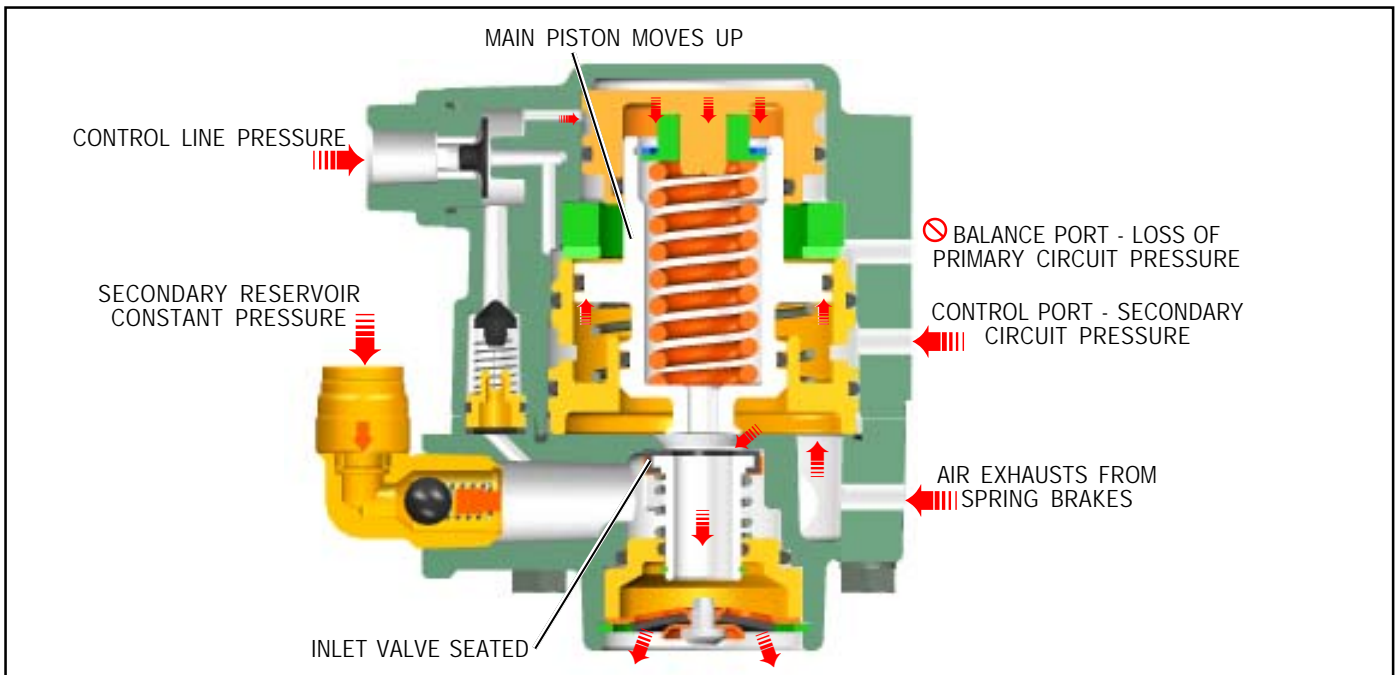


FIGURE 9 - SERVICE APPLICATION LOSS OF PRIMARY CIRCUIT

SERVICE APPLICATION WITH LOSS OF AIR IN PRIMARY CIRCUIT (FIGURE 9)

With the parking brakes released (dash valve button in) and the absence of air in the primary circuit delivery, a service brake application from the secondary circuit causes the pressure in the spring brakes to be exhausted proportionally to this application. This is known as spring brake modulation. A 30 psi service brake application will exhaust the spring brake pressure to approximately 60 psi.

SERVICE APPLICATION WITH LOSS OF AIR IN SECONDARY CIRCUIT (FIGURE 10)

With the parking brakes released (dash valve button in) and the absence of air in the secondary circuit reservoir, the external single check valve in the supply port seals to prevent air leakage to atmosphere from the SR-7 valve. The dash valve delivery air flows through the in-line single check valve and becomes SR-7 supply air. This air is delivered to maintain at least 107 psi (nominal) in the spring brake chambers.

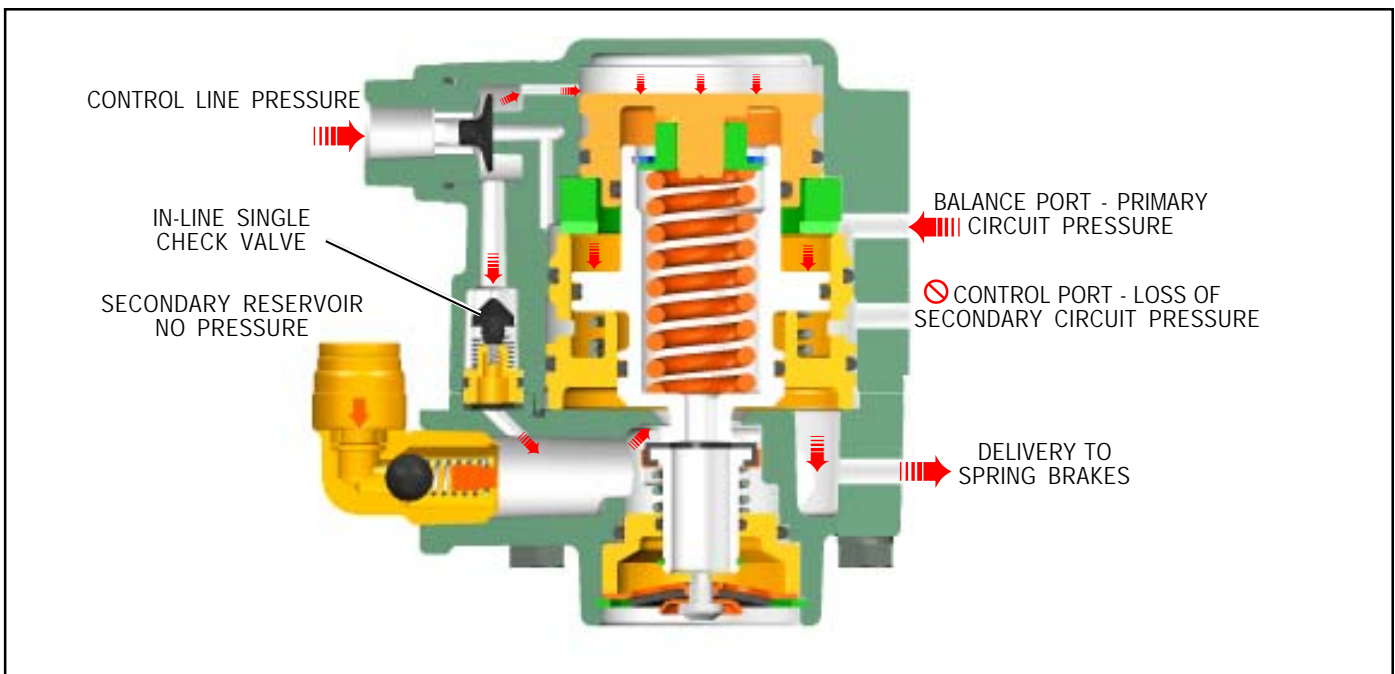


FIGURE 10 - SERVICE APPLICATION LOSS OF SECONDARY CIRCUIT

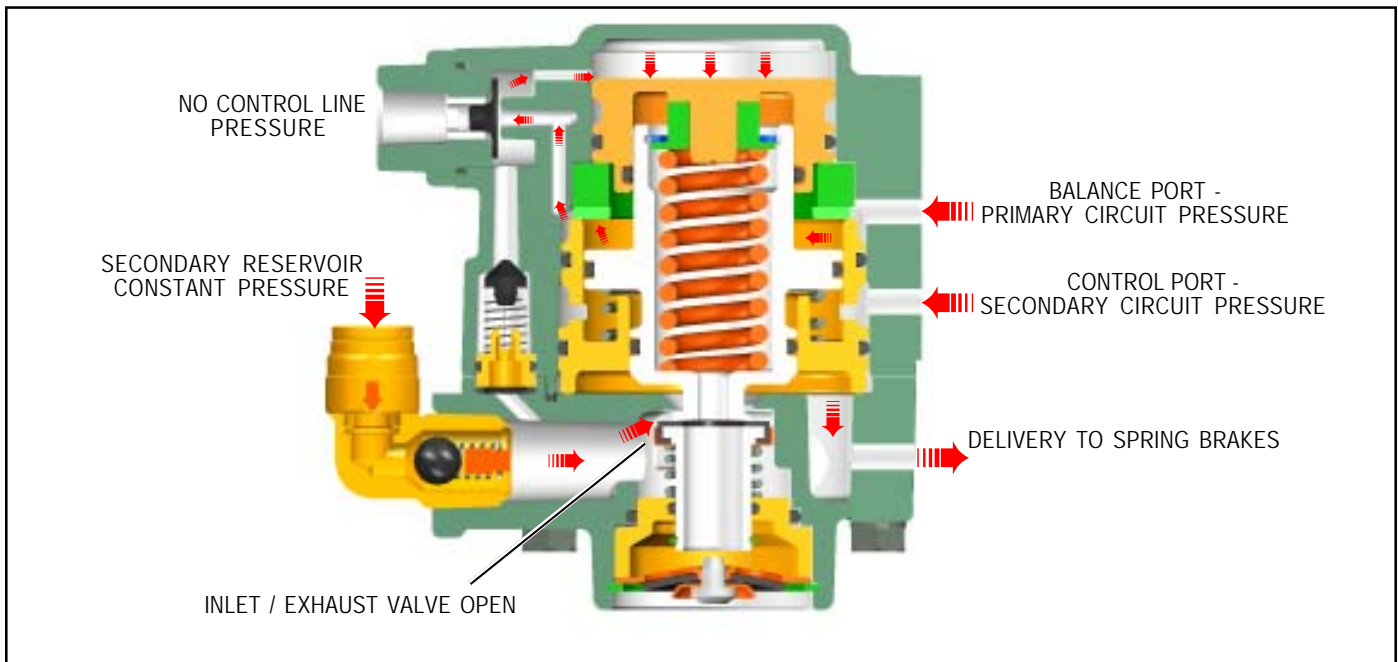


FIGURE 11 - ANTI-COMPOUNDING

ANTI-COMPOUNDING (FIGURE 11)

The SR-7 provides anti-compounding of the service and spring brake forces. When the park brakes are actuated (by pulling the dash valve button out), a service brake application will cause the SR-7 to deliver air pressure to the spring brake chambers. Thus the vehicle is held stationary using a service brake application. When the service brake application is released, the delivery pressure is exhausted from the spring brake chambers and the vehicle remains parked using the spring brake actuators.

PREVENTIVE MAINTENANCE

Important: Review the warranty policy before performing any intrusive maintenance procedures. An extended warranty may be voided if intrusive maintenance is performed during this period.

Because no two vehicles operate under identical conditions, maintenance intervals will vary. Experience is a valuable guide in determining the best maintenance interval for a vehicle.

OPERATING TEST

Block vehicle and hold by means other than vehicle brakes. Charge air brake system to governor cut-out pressure.

1. Place parking control valve in "park" position. Observe that spring brake actuators apply promptly. Remove one line from delivery port of the SR-7 valve and install test gauge known to be accurate. Place parking control valve in "release" position. Observe that spring brake actuators release fully.

2. With parking control valve in "release" position, note gauge pressure reading. (Correct spring brake actuator hold-off pressure is 107 psi nominally.)
3. Place parking control valve in "park" position - gauge reading should drop to zero promptly. A lag (more than 3 seconds) in drop of pressure would indicate faulty operation.
4. With the parking control valve in the "park" position, gradually apply foot brake valve and note a pressure reading increase on the gauge installed in the SR-7 delivery port.
5. Place parking control valve in "release" position.
6. Drain the reservoir, which supplies the rear service brake circuit, apply the foot brake valve several times and note that pressure reading on gauge decreases each time foot brake valve is applied (spring brake modulation). After the foot brake valve has been applied several times, pressure on gauge will drop to the point where release of the spring brake actuators will no longer occur.

LEAKAGE TEST

Place the park control valve in the "release" position; using a soap solution, coat all ports including the exhaust port. A 1 inch bubble in three seconds is permitted.

If the valve does not function as described, or if leakage is excessive, it is recommended that it be replaced with a new or remanufactured unit available from a Bendix parts outlet. **DO NOT ATTEMPT TO DISASSEMBLE THE SR-7. THE VALVE CONTAINS HIGH SPRING FORCES THAT COULD RESULT IN PERSONAL INJURY IF DISASSEMBLY IS ATTEMPTED!**

SERVICING THE SR-7

IMPORTANT! PLEASE READ AND FOLLOW THESE INSTRUCTIONS TO AVOID PERSONAL INJURY OR DEATH.

When working on or around a vehicle, the following general precautions should be observed at all times:

1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.
2. Stop the engine when working around the vehicle.
3. If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning ANY work on the vehicle.
4. Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.
5. When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, **EXTREME CAUTION** should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.
6. Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.
7. Never exceed recommended pressures and always wear safety glasses.
8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.

10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.

11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

VALVE REMOVAL

1. Prior to removing the SR-7 apply the parking brakes and drain all the vehicle reservoirs.
2. Identify all air lines before disconnecting.
3. Remove the two mounting nuts that secure the valve to the frame rail and remove the valve.

VALVE INSTALLATION

1. Align the mounting studs with the mounting holes on the vehicle frame rail. Tighten the mounting nuts to 180-220 in. lbs.
2. Install the valve onto the vehicle ensuring all ports are connected as marked during disassembly.

TESTING THE REPLACEMENT SR-7 SPRING BRAKE MODULATING VALVE

Perform operating and leakage tests as outlined in "Operating Tests" section.



Service Data

SD-13-4869

Bendix® EC-60™ ABS / ATC Controllers (Advanced Models)

See SD-13-4863 for Standard and Premium Controllers



FIGURE 1 - EC-60™ ADVANCED CONTROLLER

INTRODUCTION

The Bendix® EC-60™ advanced controller is a member of a family of electronic **Antilock Braking System (ABS)** devices designed to help improve the braking characteristics of air braked vehicles - including heavy and medium duty buses, trucks, and tractors. ABS controllers are also known as **Electronic Control Units (ECUs)**.

Bendix® ABS uses wheel speed sensors, ABS pressure modulator valves, and an ECU to control either four or six wheels of a vehicle. The EC-60™ controller monitors individual wheel turning motion during braking and adjusts or modulates the brake pressure at the wheel end. When excessive wheel slip, or wheel lock-up is detected, the EC-60™ controller will activate the pressure modulator valves to automatically reduce the brake pressure at one or more of the wheel ends. By these actions, the ABS system helps to maintain the vehicle's lateral stability and steerability during heavy brake applications and during braking on slippery surfaces.

In addition to the ABS function, advanced models of the EC-60™ controller provide an **Automatic Traction Control (ATC)** feature. Bendix ATC can improve vehicle traction during acceleration, and lateral stability while accelerating through curves. ATC utilizes **Engine Torque Limiting (ETL)** where the ECU communicates with the engine's controller and/or **Differential Braking (DB)** where individual wheel brake applications are used to improve vehicle traction.

Advanced EC-60™ controllers have a drag torque control feature which reduces driven-axle wheel slip (due to driveline inertia) by communicating with the engine's controller and increasing the engine torque.

The EC-60™ advanced model provides ABS-based stability features referred to as **ESP® Electronic Stability Program**. ESP® is a registered trademark of DaimlerChrysler and is used by BCVS under license from DaimlerChrysler.

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The Bendix ESP system is an ABS-based stability system that enhances vehicle stability by both reducing engine throttle and by applying vehicle braking based on actual vehicle dynamics. Accordingly, the ESP system is available only on specific approved vehicle platforms after vehicle application and development efforts and validation testing. Only certain limited variations of an approved vehicle platform are permitted without further validation of the ESP system application.

ESP stability system consists of Yaw Control (YC) and Roll Stability Program (RSP) features.

CAUTION

Even with ESP-equipped vehicles, the driver remains responsible for ensuring vehicle stability during operation.

The ESP system only functions within the limits of physics.

ESP functionality mitigates potential vehicle stability incidents, but cannot prevent them in all cases. Other factors such as driving too fast for road, traffic or weather conditions, oversteering, an excessively high vehicle Center of Gravity (CG), or poor road conditions can cause vehicle instability that is beyond the capability of any stability system to mitigate. In addition, the effectiveness of ESP can be greatly reduced on vehicles towing multiple trailer combinations.

CAUTION

The ESP stability system may only be used on vehicles tested and approved by Bendix engineering. ESP installations require on-vehicle testing and EC-60 parameter tuning. See "Advanced ABS with Stability Control" on page 9 for further details.

Accordingly, the EC-60 controller is provided with a corresponding parameter data set that is validated for a specific vehicle platform. Therefore, specific steps are necessary should a replacement ECU be required. See "Obtaining a New EC-60™ Controller" on page 13 for further details.

ESP-equipped vehicles should not be driven on high-banked roads – such as those found on high-speed test or race tracks. Test personnel must have ESP functionality disabled prior to operating an ESP vehicle on such tracks.

YAW CONTROL (YC)

Advanced ECU can include Yaw Control (YC) functionality, which has the ability to apply brakes to individual wheel ends, as well as applying the trailer brakes to counteract trailer "push" that, during certain maneuvers, could lead to a loss of control or a jackknife incident. See "Yaw Stability" on page 9 for further details.

ROLL STABILITY PROGRAM (RSP)

The Bendix Roll Stability Program (RSP), is an all-axle ABS solution that helps reduce vehicle speed by reducing the engine's throttle and applying all vehicle brakes as needed, reducing the vehicle's tendency to roll over. RSP focuses on reducing the vehicle's speed below the critical roll threshold during direction-changing maneuvers such as driving on curved highway exit ramps or obstacle avoidance maneuvers on dry, high friction surfaces. See "Advanced ABS with Stability Control" on page 9 for further details.

WARNING

During an RSP system intervention, the vehicle **automatically decelerates**. RSP can slow the vehicle with or **without the operator applying the brake pedal**, and **even when the operator is applying the throttle**.

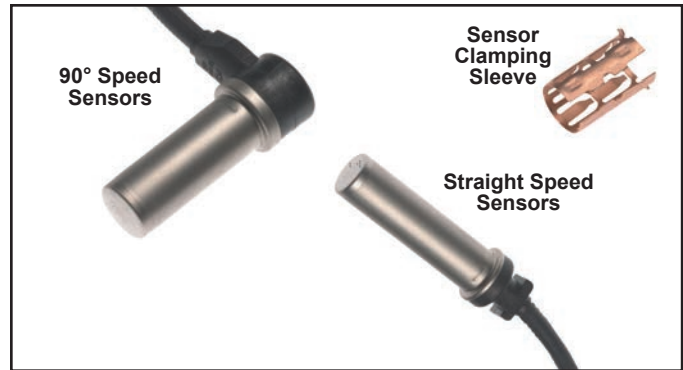


FIGURE 2 - BENDIX® WS-24™ WHEEL SPEED SENSORS

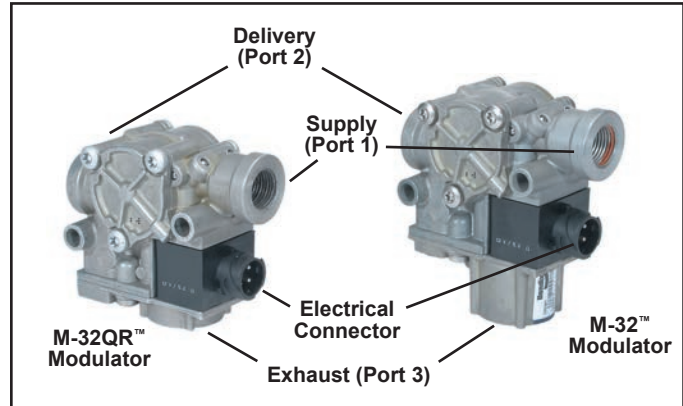


FIGURE 3 - M-32™ AND M-32QR™ MODULATORS

COMPONENTS

The EC-60™ controller's ABS function utilizes the following components:

- Bendix® WS-24™ wheel speed sensors (4 or 6, depending on configuration). Each sensor is installed with a Bendix Sensor Clamping Sleeve
- Bendix® M-32™ or M-32QR™ Pressure Modulator Valves (4, 5, or 6 depending on configuration)
- Dash-mounted tractor ABS Indicator Lamp
- Service brake relay valve
- Dash-mounted trailer ABS Indicator Lamp
- Optional blink code activation switch
- Optional ABS off-road switch

The EC-60™ controller ATC function utilizes the following additional components:

- Drive axle traction control valve (may be integral to the service brake relay valve or a stand-alone device)
- Dash-mounted ATC status/indicator lamp
- J1939 serial communication to engine control module
- Stop lamp switch input (may be provided using the ECU hardware input or J1939)
- Optional ATC mud/snow switch (sometimes referred to as an ATC off-road switch)

Input Voltage	Sensors	PMVs	ATC	ESP/RSP	Blink Codes	Serial Communication		PLC	ABS Off-Road	ATC Mud/Snow	Retarder Relay
						J1587	J1939				
12 VDC	4/6	4/5/6	✓	✓	✓	✓	✓	✓	✓	✓	✓

CHART 1 - EC-60™ ADVANCED CONTROLLER FEATURES

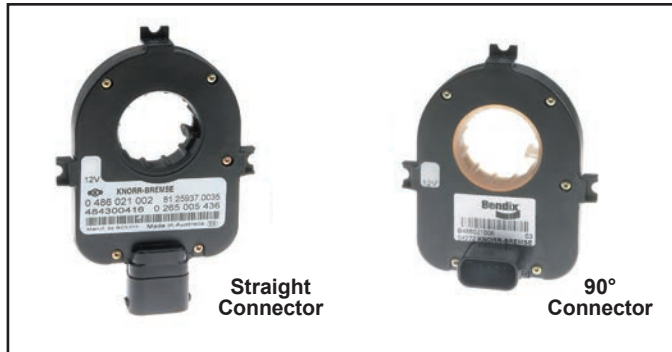


FIGURE 4 - STEERING ANGLE SENSORS

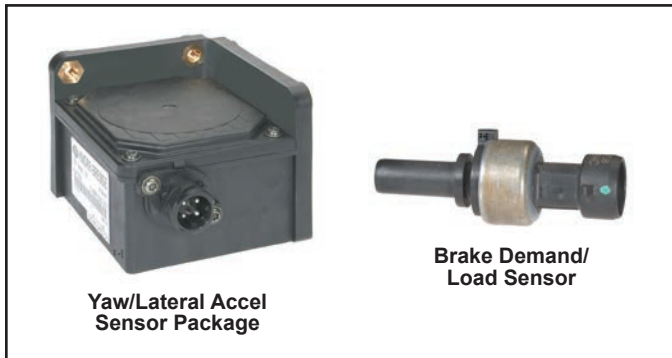


FIGURE 5 - YAW AND BRAKE DEMAND/LOAD SENSORS

The EC-60™ controller ESP/RSP function utilizes the following additional components:

- Steer Axle Traction Control Valve (may be integral to the service brake relay valve or a stand-alone device)
- Dash-mounted ESP status/indicator lamp (also serves as the ATC status/indicator lamp)
- Bendix SAS-60™ Steering Angle Sensor (mounted to the steering column)
- Bendix YAS-60™ Yaw Rate/Lateral Acceleration Sensor (typically mounted to a cross-member near the back of the vehicle cab)
- Brake Demand Sensors (installed in the primary and secondary delivery circuits)
- Load Sensor (typically installed in the suspension air bag)
- An additional Modulator Valve (Bendix® M-32™ or M-32QR™ Pressure Modulator Valve) that controls pressure apply to trailer brakes during system intervention

ECU MOUNTING

The Bendix® EC-60™ advanced cab-mounted controller is not protected against moisture, and must be mounted in an environmentally protected area.

All wire harness connectors must be properly seated. The use of secondary locks is strongly recommended.

Cab ECUs utilize connectors from the AMP MCP 2.8 product family.

HARDWARE CONFIGURATION

Advanced model EC-60™ controllers support applications up to six sensor/six modulator (6S/6M) installations with ATC and drag torque control. Available in 12 volt models, all advanced model EC-60™ controllers support PLC (See Chart 1).

ADVANCED EC-60™ CONTROLLERS USE POWER LINE CARRIER (PLC)

All new towing vehicles built since March 1, 2001 have had an in-cab trailer ABS Indicator Lamp installed.

Trailers built since March 1, 2001 transmit the status of the trailer ABS over the power line (the blue wire of the J560 connector) to the tractor using a Power Line Carrier (PLC) signal. See Figures 6 and 7. Typically the signal is broadcast by the trailer ABS ECU.

The application of PLC technology for the heavy vehicle industry in North America is known as “PLC4Trucks.”

The Advanced EC-60™ controller supports PLC communications in accordance with SAE J2497.



FIGURE 6 - POWER LINE WITHOUT PLC SIGNAL

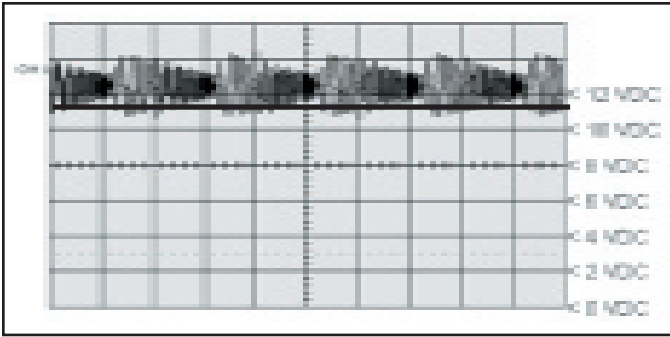


FIGURE 7 - POWER LINE WITH PLC SIGNAL

PLC SIGNAL

An oscilloscope can be used to measure or identify the presence of a PLC signal on the power line. The PLC signal is an amplitude and frequency modulated signal. Depending on the filtering and load on the power line, the PLC signal amplitude can range from 5.0mVp-p to 7.0 Vp-p. Suggested oscilloscope settings are AC coupling, 1 volt/div, 100 μ sec/div. The signal should be measured at the ignition power input of the EC-60™ controller.

Note: An ABS trailer equipped with PLC, or a PLC diagnostic tool, must be connected to the vehicle in order to generate a PLC signal on the power line.

EC-60™ CONTROLLER INPUTS

Battery and Ignition Inputs

The ECU operates at a nominal supply voltage of 12 volts. The battery input is connected through a 30 amp fuse directly to the battery.

The ignition input is applied by the ignition switch circuit through a 5 amp fuse.

Ground Input

The EC-60™ controller supports one ground input. See page 42 for a system schematic.

ABS Indicator Lamp Ground Input

Advanced EC-60™ cab ECUs require a second ground input (X1-12) for the ABS indicator lamp. The X1 wire harness connector contains an ABS indicator lamp interlock (X1-15), which shorts the ABS indicator lamp circuit (X1-18) to ground if the connector is removed from the ECU.

Bendix® WS-24™ Wheel Speed Sensors

Wheel speed data is provided to the EC-60™ controller from the WS-24™ wheel speed sensor (see Figure 2). Vehicles have an exciter ring (or “tone ring”) as part of the wheel assembly, and as the wheel turns, the teeth of the exciter ring pass the wheel speed sensor, generating an AC signal. The EC-60™ controller receives the AC signal, which varies in voltage and frequency as the wheel speed changes.

Vehicle axle configurations determine the number of WS-24™ wheel speed sensors that must be used. A vehicle with a single rear axle requires four wheel speed sensors. Vehicles with two rear axles can utilize six wheel speed sensors for optimal performance.

Diagnostic Blink Code Switch

A momentary switch that grounds the ABS Indicator Lamp output is used to place the ECU into the diagnostic blink code mode and is typically located on the vehicle’s dash panel.

Optional ABS Off-Road Switch and Indicator Lamp Operation

Advanced EC-60™ controllers use an optional dash-mounted switch for the operator to place the ECU into the ABS off-road mode. See “Optional ABS Off-Road Mode” on page 7 for further details. In some cases, ECUs may also be put into the ABS off-road mode by one of the other vehicle control modules, using a J1939 message to the EC-60™ controller.

(If you need to know if this EC-60™ controller uses a J1939 message to operate the lamp, e-mail ABS@bendix.com, specifying the ECU part number, or call 1-800-AIR-BRAKE and speak to the Bendix TechTeam.)

WARNING: The ABS off-road mode should not be used on normal, paved road surfaces because vehicle stability and steerability may be affected. When the ECU is placed in the ABS off-road mode, the ABS Indicator Lamp will flash constantly (at a rate of once per 2.5 seconds) to notify the vehicle operator that the off-road mode is active.

Optional ATC Mud/Snow (Off-Road) Switch and Indicator Lamp Operation (see also page 8.)

Advanced controllers use a dash-mounted switch for the operator to place the ECU into the ATC Mud/Snow mode.

Stop Lamp Switch (SLS)

The Advanced EC-60™ controller monitors the vehicle stop lamp status. Certain vehicle functions, such as ATC and All-Wheel Drive (AWD), use the status of the stop lamp to determine when the driver makes a brake application. This can be provided to the ECU via J1939 communications, or hardware input.

Brake Demand Sensors

The brake demand sensors provide the controller with an indication of driver-applied brake pressure. One is installed in the primary air brake circuit, and another is installed in the secondary air brake circuit.

Load Sensor

The load sensor provides the controller with an indication of the vehicle load. It is typically installed in one of the suspension air bags.

Bendix® SAS-60™ Steering Angle Sensor

The Steering Angle Sensor (SAS) is used to provide driver steering input to the controller. It reports the steering wheel position to the controller utilizing a dedicated serial communications link that is shared with the YAS-60™ sensor. The controller supplies the power and ground inputs to the SAS-60™ sensor.

The SAS-60 sensor is available with two different styles of wire harness connectors. (See Figure 4)

Bendix® YAS-60™ Yaw Rate/Lateral Acceleration Sensor

The Yaw Rate/Lateral Acceleration Sensor is used to provide the controller an indication of vehicle lateral acceleration and rotation around the vertical axis. This information is provided to the controller utilizing a dedicated serial communications link that is shared with the SAS-60™ sensor. The controller supplies the power and ground inputs to the YAS-60™ sensor.

EC-60™ CONTROLLER OUTPUTS

Bendix® M-32™ and M-32QR™ Pressure Modulator Valves (PMV)

The Bendix® M-32™ and M-32QR™ pressure modulator valves (PMV) are operated by the EC-60™ controller to modify driver applied air pressure to the service brakes during ABS, ATC, RSP or YC activation (See pages 7-8). The PMV is an electropneumatic control valve and is the last valve that air passes through on its way to the brake chamber. The modulator hold and release solenoids are activated to "modulate" or "control" the brake pressure during an antilock braking event. The hold solenoid is normally open and the release solenoid is normally closed, such that the PMV nominally allows air to flow through. This design allows for air delivery to brake chambers in the event of electrical trouble.

The Advanced EC-60™ controller also utilizes an additional PMV for control of the trailer service brakes during stability interventions.

Traction Control Valve (TCV)

Advanced EC-60™ controllers use two TCVs, one on the steer axle and one on the drive axle. The TCV may be a separate valve or integrated into the rear axle relay valve.

The controller will activate the drive axle TCV during differential braking ATC events.

During stability interventions, the ECU will activate both the steer axle and drive axle TCVs as required.

Stop Lamp Output

The controller provides an output to control a relay that illuminates the vehicle stop lamps during stability interventions. This information is also available using the J1939 serial communications link.

ABS Indicator Lamp Control with Optional Diagnostic Blink Code Switch

The Advanced EC-60™ controller has internal circuitry to control the ABS Indicator Lamp on the dash panel.

The ABS Lamp Illuminates:

1. During power up (e.g. when the vehicle is started) for approximately 3 seconds and turns off after the self test is completed, providing no **Diagnostic Trouble Codes (DTCs)** are present on the ECU.

2. When full ABS operation is not available due to presence of a DTC on the ECU.
3. If the ECU is unplugged or has no power.
4. When the ECU is placed into the ABS off-road mode (the lamp flashes steadily at a rate of once per 2.5 sec.).
5. To display blink codes for diagnostic purposes after the external diagnostic switch is activated.

The EC-60™ controller may communicate with other vehicle control modules to operate the ABS Indicator Lamp using serial communications. (If you need to know if this EC-60™ controller uses serial communications to operate the lamp, e-mail ABS@bendix.com, specifying the ECU part number, or call 1-800-AIR-BRAKE and speak to the Bendix Tech Team.)

Indicator Lamp Control Using Serial Communications Links

As mentioned above, depending on the vehicle manufacturer, the dash indicator lamps (ABS, ATC, ESP and trailer ABS) may be controlled using serial communications links. In these cases, the EC-60™ controller will send a serial communications message over the J1939 or J1587 links indicating the required status of the lamp(s). Another vehicle control module receives the message and controls the indicator lamp(s).

Retarder Relay Disable Output

The retarder relay disable output may be used to control a retarder disable relay. When configured to use this output, the ECU will energize the retarder disable relay and inhibit the use of the retarder as needed.

SAE J1939 Serial Communications

A Controller Area Network (CAN) data link (SAE J1939) is provided for communication. This link is used for various functions, such as:

- To disable retarding devices during ABS operation.
- To request torque converter lock-up during ABS operation.
- To share information such as wheel speed and ECU status with other vehicle control modules.

Advanced EC-60™ controllers utilize the J1939 data link for:

- ATC and drag torque control functions.
- Vehicle stability functions.

Trailer ABS Indicator Lamp Control

The Advanced EC-60™ controller will activate a trailer ABS Indicator Lamp (located on the dash panel) that indicates the status of the trailer ABS unit on one, or more trailers, or dollies that are equipped with PLC functionality. Typically, the EC-60™ controller directly controls the trailer ABS Indicator Lamp based on the information it receives from the trailer ABS, via PLC.

Alternatively, some vehicles require the EC-60™ controller to activate the trailer ABS Indicator Lamp by communicating with other vehicle controllers using serial communications.

(If you need to know if this EC-60™ controller uses a serial communications message to operate the lamp, e-mail ABS@bendix.com, specifying the ECU part number, or call 1-800-AIR-BRAKE and speak to the Bendix TechTeam.)

SAE J1708/J1587 Serial Communications

An SAE J1708 data link, implemented according to SAE J1587 recommended practice, is available for diagnostic purposes, as well as ECU status messages.

Interaxle Differential Lock Control (AWD Transfer Case)

Advanced ECUs can control the interaxle differential lock (AWD transfer case). This is recommended on AWD vehicles, but the ECU must be specially configured to provide this feature. E-mail to ABS@bendix.com for more details.

POWER-UP SEQUENCE

NOTICE: The vehicle operator should verify proper operation of all installed indicator lamps (ABS, ATC/ESP, and trailer ABS) when applying ignition power and during vehicle operation. Lamps that do not illuminate as required when ignition power is applied, or remain illuminated after ignition power is applied, indicate the need for maintenance.

ABS Indicator Lamp Operation (Bulb Check)

The ECU will illuminate the ABS Indicator Lamp for approximately three seconds when ignition power is applied, after which the lamp will extinguish if no diagnostic trouble codes are detected.

The ECU will illuminate the ABS Indicator Lamp whenever full ABS operation is not available due to a diagnostic trouble code. In most cases, partial ABS is still available.

ATC/ESP Status/Indicator Lamp Operation

The ECU will illuminate the ATC/ESP lamp for approximately 2.5 seconds when ignition power is applied, after which the lamp will extinguish, if no diagnostic trouble codes are detected. The ECU will continuously illuminate the ATC/ESP Indicator Lamp whenever ESP or ATC is disabled due to a diagnostic trouble code.

During an ESP or ATC intervention, the lamp will flash rapidly (2.5 times per second). When the ECU is placed in the ATC Mud/Snow (off-road) mode, the lamp will flash slowly at a rate of once every 2.5 seconds

Trailer ABS Indicator Lamp Operation

The ECU will control the Trailer ABS Indicator Lamp when a PLC signal (SAE J2497) from a trailer ABS ECU is detected.

ECU Configuration Test

Within two seconds of the application of ignition power, the ECU will perform a test to detect system configuration with regards to the number of wheel speed sensors and PMVs. This can be audibly detected by a rapid cycling of the PMVs.

(Note: The ECU will not perform the configuration test when wheel speed sensors show that the vehicle is in motion.)

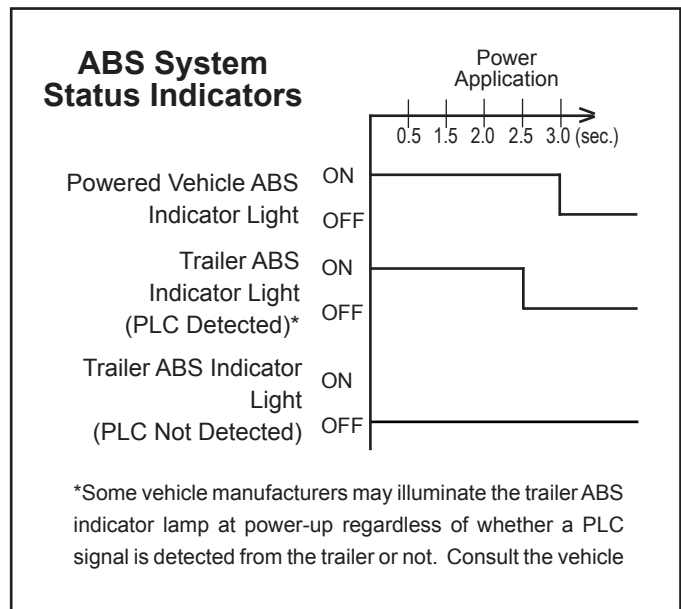


FIGURE 8 - ABS DASH LIGHTS START UP SEQUENCE

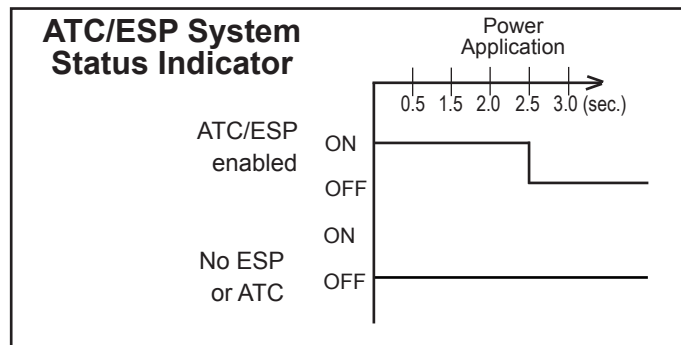


FIGURE 9 - ATC INDICATOR LIGHT START UP SEQUENCE

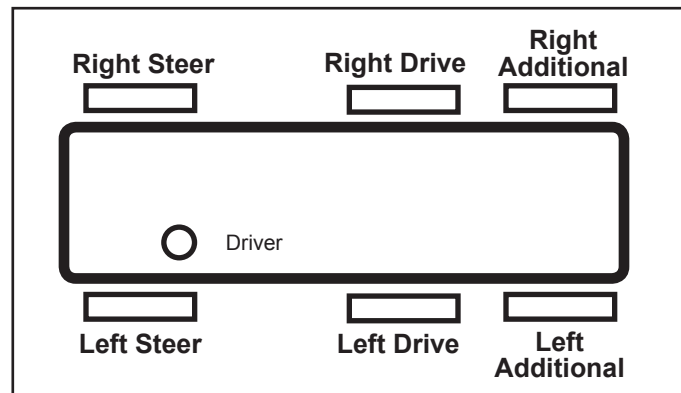


FIGURE 10 - VEHICLE ORIENTATION (TYPICAL)

Pressure Modulator Valve and Traction Control Valve Chuff Test

After the performance of the configuration test, the EC-60™ controller will perform a Bendix-patented PMV and TCV Chuff Test. The Chuff Test is an electrical and pneumatic PMV test that can assist maintenance personnel in verifying proper PMV wiring and installation.

With brake pressure applied, a properly installed PMV will perform one sharp audible exhaust of air by activating the hold solenoid twice and the release solenoid once. If the PMV is wired incorrectly, it will produce two exhausts of air or none at all.

The EC-60™ controller will perform a PMV chuff test on all installed modulators in the following order:

- Steer Axle Right PMV
- Steer Axle Left PMV
- Drive Axle Right PMV
- Drive Axle Left PMV
- Additional Axle Right PMV
- Additional Axle Left PMV
- Drive Axle TCV

The pattern will then repeat itself.

With the EC-60 advanced controller, at the completion of the second round of PMV & TCV chuff tests, the controller (if configured to do so) will perform a test to cross-check the trailer PMV operation with the vehicle stop lamps. If the trailer PMV circuit is mis-wired (including the steer axle TCV), the PMV will exhaust a large amount of air, or none at all.

NOTICE: If there are any active Diagnostic Trouble Codes, stop lamp cross-check portion of the chuff test will not be carried out until all DTCs are fully diagnosed and corresponding repairs are successfully conducted. The ESP/ATC dash indicator will also be illuminated when there are active ABS, ATC or ESP DTCs.

The ECU will not perform the PMV Chuff Test when wheel speed sensors show that the vehicle is in motion.

ABS OPERATION

Bendix® ABS uses wheel speed sensors, ABS pressure modulator valves, and an ECU to control either four or six wheels of a vehicle. The EC-60™ controller monitors individual wheel turning motion during braking and adjusts or modulates the brake pressure at the wheel end. When excessive wheel slip, or wheel lock-up is detected, the EC-60™ controller will activate the pressure modulator valves to automatically reduce the brake pressure at one or more of the wheel ends. By these actions, the ABS system helps to maintain the vehicle's lateral stability and steerability during heavy brake applications and during braking on slippery surfaces.

Steer Axle Control

Although both wheels of the steer axle have their own wheel speed sensor and pressure modulator valve, the EC-60™ controller blends the applied braking force between the two steering axle brakes. This Bendix patented brake application control, called Modified Individual Regulation (MIR), is designed to help reduce steering wheel pull during an ABS event on road surfaces with poor traction (or areas of poor traction, e.g. asphalt road surfaces with patches of ice).

Single Drive Axle Control (4x2 Vehicle)

For vehicles with a single rear drive axle (4x2), the brakes are operated independently by the EC-60™ controller, based on the individual wheel behavior.

Dual Drive Axle Control (4S/4M Configuration)

For vehicles with dual drive axles (6x4) using a 4S/4M configuration, one ABS modulator controls both right-side rear wheels and the other modulator controls both left-side rear wheels. Both wheels on each side receive equal brake pressure during an ABS stop. The rear wheel speed sensors must be installed on the axle with the lightest load.

Dual Rear Axle Control (6S/6M Configuration)

For vehicles with dual rear axles (6x4, 6x2) using a 6S/6M configuration, the rear wheels are controlled independently. Therefore, brake application pressure at each wheel is adjusted according to the individual wheel behavior on the road surface.

REVISED 5/31/05

6x2 Vehicles with 6S/5M Configuration

6x2 vehicles can utilize a 6S/5M configuration, with the additional axle (a non-driven rear axle) having two sensors, but only one Pressure Modulator Valve. In this case, the PMV controls both wheels on the additional axle. The additional axle wheels would receive equal brake pressure, based on the wheel that is currently experiencing the most wheel slip.

Normal Braking

During normal braking, brake pressure is delivered through the ABS PMV and into the brake chamber. If the ECU does not detect excessive wheel slip, it will not activate ABS control, and normal vehicle service braking is applied.

Retarder Brake System Control

On surfaces with low traction, application of the retarder can lead to high levels of wheel slip at the drive axle wheels, which can adversely affect vehicle stability.

To prevent this, the EC-60™ controller switches off the retarder as soon as a lock-up is detected at one (or more) of the drive axle wheels.

When the ECU is placed in the ABS off-road mode (on vehicles equipped with this optional feature), it will switch off the retarder only when ABS is active on a steer axle wheel and a drive axle wheel.

Optional ABS Off-Road Mode

On some road conditions, particularly when the driving surface is soft, the stopping distance with conventional ABS may be longer than without ABS. This can occur when a locked wheel on soft ground or loose gravel plows up the road surface in front of the tire, changing the rolling friction value. Although vehicle stopping distance with a locked wheel (in the absence of ABS) may be shorter than corresponding stopping distance with conventional ABS control, vehicle steerability and stability would be reduced.

Advanced EC-60™ controllers have an optional dash switch initiated modified ABS control mode (know as "offroad ABS) that more effectively accommodates these soft road conditions to shorten stopping distance while maintaining optimal vehicle steerability and stability.

WARNING: The ABS off-road mode should not be used on normal, paved road surfaces because vehicle stability and steerability may be reduced. The ABS Indicator Lamp will flash slowly to indicate to the driver that the ABS off-road mode is engaged.

CAUTION: When ABS off-road mode is engaged, stability functions are disabled at speeds below approximately 25 mph. The ATC/ESP dash lamp will illuminate to indicate to the driver that the stability system is disabled.

The vehicle manufacturer should provide the optional ABS off-road function only for vehicles that operate on unpaved surfaces or that are used in off-road applications, and is responsible for insuring that vehicles equipped with the ABS off-road function meet all FMVSS-121 requirements and have adequate operator indicators and instructions.

The vehicle operator activates the off-road function with a switch on the dash panel. A flashing ABS Indicator Lamp indicates to the driver that the ABS off-road function is engaged. To exit the ABS off-road mode, depress and release the switch. A new ignition cycle will also cause the ECU to exit the ABS off-road mode.

All-Wheel Drive (AWD) Vehicles

AWD vehicles with an engaged interaxle differential (steer axle to rear axle)/AWD transfer case may have negative effects on ABS performance. Optimum ABS performance is achieved when the lockable differentials are disengaged, allowing individual wheel control.

Advanced EC-60™ controllers can be programmed specifically for this configuration to control the differential lock/unlock solenoid in the AWD transfer case. When programmed to do so, the ECU will disengage the locked interaxle/AWD transfer case during an ABS event and reengage it once the ABS event has ended.

ATC OPERATION

ATC Functional Overview

Just as ABS improves vehicle stability during braking, ATC improves vehicle stability and traction during vehicle acceleration. The EC-60™ controller ATC function uses the same wheel speed information and modulator control as the ABS function. The EC-60™ controller detects excessive drive wheel speed, compares the speed to the front, nondriven wheels, and reacts to help bring the wheel spin under control. The controller can be configured to use engine torque limiting and/or differential braking to control wheel spin. For optimal ATC performance, both methods are recommended.

ATC/ESP Lamp Output/ATC Mud/Snow Switch Input

Advanced ECUs control the ATC/ESP dash lamp as follows.

The ATC/ESP dash lamp illuminates:

1. During power up (e.g. when the vehicle is started) for approximately 2.5 seconds and turns off after the self test is completed, providing no diagnostic trouble codes are present.
2. When ESP or ATC is disabled for any reason.
3. During an ESP or ATC event (the lamp will flash rapidly at a rate of 2.5 per second).
4. When the ECU is placed in the ATC off-road mode (the lamp will flash steadily at a rate of once per 2.5 seconds). This notifies the vehicle operator that the ATC Mud/Snow mode is active.
5. When the ECU is placed in the ABS off-road mode. When in this mode, ESP will be disabled below 25 mph and its inactive status will be indicated by a steadily illuminated ATC/ESP lamp.

Differential Braking

Differential braking within ATC is automatically activated when drive wheel(s) on one side of the vehicle are spinning excessively, which typically occurs on road surfaces with patches of ice. The traction system will then lightly apply the brake to the drive wheel(s) that are spinning excessively. The vehicle differential will then drive the wheels on the other side of the vehicle.

Differential braking as part of ATC functionality is available at vehicle speeds up to 25 MPH.

Disabling ATC Differential Braking

ATC differential braking is disabled under the following conditions:

1. During power up (e.g. when the vehicle is started), until the ECU detects a service brake application.
2. If the ECU receives a J1939 message indicating that the vehicle is parked.
3. When the dynamometer test mode is active. The dynamometer test mode is entered using the diagnostic blink code switch or by using a diagnostic tool (such as Bendix® ACom™ Diagnostics).
4. In response to a serial communications request from a diagnostic tool.
5. If "ATC Differential Braking" function is activated for a long time period to avoid overheating of the brakes, it would take approximately 3 continuous minutes of activation for the timeout to occur. Once timed out, approximately 2 minutes of "cool off" time would be required before ATC Differential Braking can be used again.
6. When certain diagnostic trouble code conditions are detected.

Engine Torque Limiting with Smart ATC™ Traction Control

The EC-60™ controller uses Engine Torque Limiting to control drive axle wheel slip. This is communicated to the engine control module (using J1939), and is available at all vehicle speeds.

Bendix® Smart ATC™ Traction Control

The EC-60™ controller has an additional feature known as Smart ATC™ traction control. Smart ATC™ traction control monitors the accelerator pedal position (using J1939) to help provide optimum traction and vehicle stability. By determining the driver's throttle input and adapting the target slip of the drive wheels to the driving situation, the Smart ATC™ traction control allows higher wheel slip when the accelerator pedal is applied above a preset level.

The wheel slip allowed by Smart ATC™ is decreased when driving through a curve for improved stability.

Disabling ATC Engine Control and Smart ATC™ Traction Control

ATC Engine Control and Smart ATC™ traction control will be disabled under the following conditions:

1. In response to a serial communications request from an off-board tool.
2. At power-up until the ECU detects a service brake application.
3. If the ECU receives a J1939 message indicating that the vehicle is parked.
4. If the dynamometer test mode is active. This may be accomplished via an off-board tool or the diagnostic blink code switch.

5. When certain diagnostic trouble code conditions are detected.

Optional ATC Mud/Snow (Off-Road) Mode

In some road conditions, the vehicle operator may desire additional drive wheel slip when ATC is active. The Advanced EC-60™ controller has an optional control mode to permit this desired performance.

The vehicle operator can activate the Mud/Snow function with a switch on the dash panel. Alternately, a J1939 message may be used to place the vehicle in this mode. The ATC/ESP Indicator Lamp will flash steadily at a rate of once every 2.5 seconds to confirm that the ATC mud/snow mode is engaged.

To exit the ATC Mud/Snow mode, depress and release the ATC Mud/Snow switch.

Drag Torque Control Functional Overview

Advanced EC-60™ controllers have a feature referred to as drag torque control which reduces wheel slip on a driven axle due to driveline inertia. This condition is addressed by increasing the engine torque to overcome the inertia.

Drag torque control increases vehicle stability on low-traction road surfaces during down-shifting or retarder braking.

ADVANCED ABS WITH STABILITY CONTROL

Overview

ESP stability system reduces the risk of rollovers, jackknifing and other loss of control. ESP features include Roll Stability Program (RSP) and Yaw Control. During operation, the ECU of the Bendix Advanced ABS system constantly compares performance models to the vehicle's actual movement, using the wheel speed sensors of the ABS system, as well as lateral, yaw, and steering angle sensors. If the vehicle shows a tendency to leave an appropriate travel path, or if critical threshold values are approached, the system will intervene to assist the driver.

Roll Stability Program

Bendix RSP, an element of the overall ESP system, addresses rollover conditions. In the case of a potential roll event, the ECU will override the throttle and quickly apply brake pressure at all wheel ends to slow the vehicle combination. The level of braking application during an RSP event will be proportional to roll risk.

See Figure 11.

Yaw Stability

Yaw stability counteracts the tendency of a vehicle to spin about its vertical axis. During operation, if the friction between the road surface and the tires is not sufficient to oppose lateral (side) forces, one or more of the tires can slide, causing the truck/tractor to spin. These events

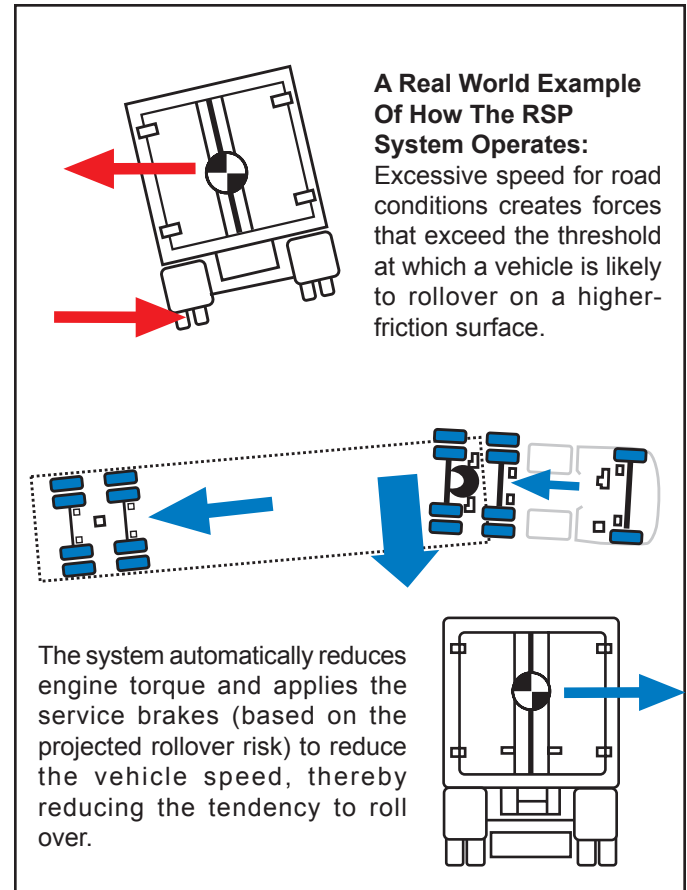


FIGURE 11 - RSP EXAMPLE

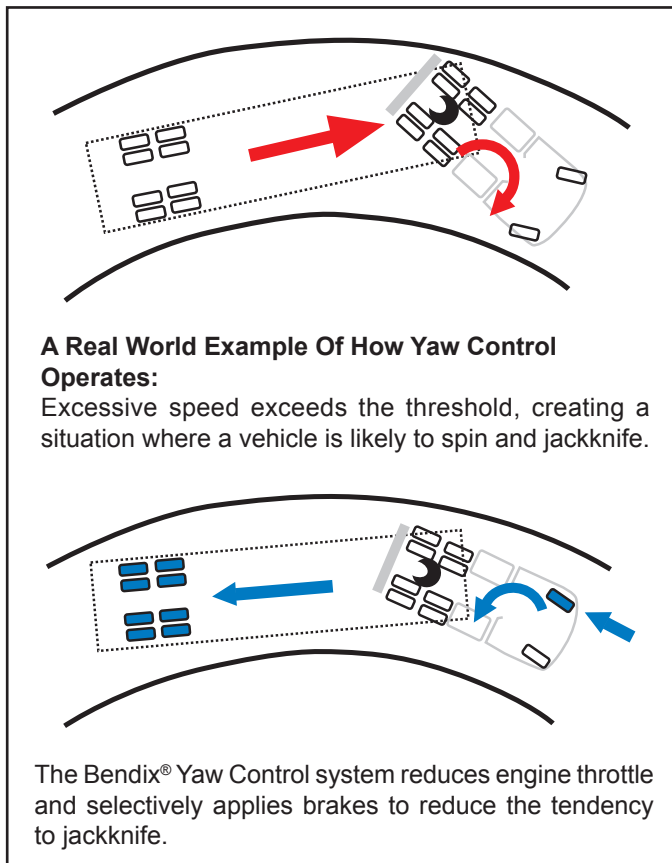


FIGURE 12 - YAW CONTROL EXAMPLE

are referred to as either an "under-steer" situation (where there is a lack of vehicle response to steering input due to tire slide on the steer axle) or an "over-steer" (where the tractor's rear end slides out due to tire slide on the rear axle) situation. Generally, shorter wheelbase vehicles (tractors, for instance) have less natural yaw stability, while longer wheelbase vehicles (straight trucks, for instance) have greater natural yaw stability. Factors that influence yaw stability are: wheelbase, suspension, steering geometry, weight distribution front to rear, and vehicle track width.

Yaw Control

Yaw Control responds to a wide range of low- to high-friction surface scenarios including rollover, jackknife and loss of control. It is the recommended system for all power vehicles and especially critical for tractors pulling trailers. In the case of vehicle slide (over-steer or under-steer situations), the system will reduce the throttle and then brake one or more of the "four corners" of the vehicle (in addition to potentially applying the trailer brakes), thus applying a counter-force to better align the vehicle with an appropriate path of travel.

For example, in an over-steer situation, the system applies the "outside" front brake; while in an under-steer condition, the "inside" rear brake is applied. (See Figure 12)

IMPORTANT SAFETY INFORMATION ABOUT THE BENDIX® ESP® STABILITY SYSTEM

ESP May Reduce The Vehicle Speed Automatically

ESP can make the vehicle **decelerate automatically**. ESP can slow the vehicle with or **without the operator applying the brake**, and **even when the throttle is being applied**.

To minimize unexpected deceleration and reduce the risk of a collision the operator must:

- Avoid aggressive driving maneuvers, such as sharp turns or abrupt lane changes at high speeds, which might trigger the stability system.
- Always operate the vehicle safely, drive defensively, anticipate obstacles and pay attention to road, weather and traffic conditions. ABS, ATC and ESP stability systems are no substitute for prudent, careful driving.

Towing Doubles Or Triples May Reduce The Effectiveness Of Stability Systems

ESP is designed and optimized for trucks and for tractors that tow single trailers. If a tractor equipped with ESP is used to power multiple trailer combinations (known as "doubles" or "triples") **the effectiveness of the ESP system may be greatly reduced**. Extremely careful driving is always required when towing doubles or triples. Excessive speed and aggressive maneuvers, such as sharp turns, sudden steering inputs or abrupt lane changes should be avoided.

Limitations Of Stability Systems

The ESP stability system's effectiveness may be greatly reduced if:

- The load shifts due to improper retention, accident damage or the inherently mobile nature of some loads (for example, hanging meat, live animals or partially laden tankers),
- The vehicle has an unusually high or off-set center of gravity (CG),
- One side of the vehicle drops off the pavement at an angle that is too large to be counteracted by a reduction in speed,
- The vehicle is used to haul double or triple trailer combinations,
- If very rapidly winding steering inputs are inputted at high speeds,
- There are mechanical problems with suspension leveling of the tractor or trailer resulting in uneven loads,
- The vehicle is maneuvering on a high banked road creating either additional side forces due to the weight (mass) of the vehicle or a deviation between expected & actual yaw rates,
- Gusty winds are strong enough to cause significant side forces on the vehicle and any towed vehicles.

To Maximize The Effectiveness Of ESP:

- Loads must be properly secured at all times.
- Drivers need to exercise extreme caution at all times, and avoid sharp turns, sudden steering inputs or abrupt lane changes at high speeds, particularly if:
 - › the vehicle hauls loads that could shift,
 - › the vehicle or load has a high or off-set center of gravity (CG) when loaded, or
 - › the vehicle tows doubles or triples.

Truck Chassis Modifications

If the vehicle's chassis components are altered (for example, a wheel base extension or reduction, tag axle addition or removal, a major body change such as conversion of a tractor into a truck, or an axle, suspension, or steering system component modification) the Bendix® ESP® system must be disabled. Have a qualified mechanic replace the Advanced EC-60 ECU with a Premium EC-60 ECU and secure the X4 connector which will no longer be used. The ATC/ESP indicator lamp would continue to function as an ATC indicator lamp, and should be designated as ATC only.

WARNING: If a modified vehicle does not have the ESP system disabled, serious vehicle braking and performance issues could result, including unnecessary ESP system interventions. This can lead to a loss of control of the vehicle. In addition, remove all cab signage (e.g. visor labels, etc.) used to show that Bendix ESP was installed and make any necessary notations in the vehicle manual(s), so that drivers do not misunderstand which ABS options are installed on the vehicle.

Sensor Location Modifications

The location and orientation of the Steering Angle Sensor and Yaw Rate Sensor must not be altered. When servicing, an identical component must be used in the same orientation (using OEM brackets & torque requirements). During installation follow the OEM leveling guidelines.

Steering Angle Sensor Re-Calibration

Whenever maintenance or repair work is performed to the steering mechanism, linkage, steering gear, adjustment of the wheel track, or if the steering angle sensor is replaced, a recalibration of the Steering Angle Sensor must be performed.

WARNING! If the Steering Angle Sensor is not recalibrated, the yaw control system may not function properly, which can result in incidents leading to loss of vehicle control. See page 14 of this document for more details on this procedure.

Dynamometer Test Mode

CAUTION: ATC and ESP must be disabled prior to conducting any dynamometer testing. When the Dynamometer Test Mode is engaged, ATC brake control and engine control along with drag torque control and ESP are turned off. This test mode is used to avoid torque reduction or torque increase and brake control activation when the vehicle is operated on a dynamometer for testing purpose.

The Dynamometer Test Mode may be activated by pressing and releasing the diagnostic blink code switch five times or by using a hand-held or PC-based diagnostic tool.

Advanced EC-60™ Contollers will remain engaged in the Dynamometer Test Mode even if power to the ECU is removed and re-applied. To exit the test mode, press and release the blink code switch three times, or use a hand-held or PC-based diagnostic tool.

Automatic Tire Size Calibration

The ECU requires a precise rolling circumference ratio between steer axle and drive axle tires in order for ABS, ATC, and ESP to perform in an optimal manner. For this reason, a continuously monitoring process takes place in which the precise ratio is calculated. This calculated value is stored in the ECU memory provided the following conditions are met:

1. Rolling-circumference ratio is within the permissible range.
2. Vehicle speed is greater than approximately 12 MPH.
3. No acceleration or deceleration is taking place.
4. There are no active speed sensor diagnostic trouble codes.

The ECU is provided with a ratio value of 1.00 as a default setting. If the automatic tire size alignment calculates a different value, this is used to overwrite the original figure in the memory. This process adapts the ABS and ATC function to the vehicle.

Acceptable Tire Sizes

The speed calculation for an exciter ring with 100 teeth is based on a default tire size of 510 revolutions per mile. This figure is based on the actual rolling circumference of the tires, which varies with tire size, tire wear, tire pressure, vehicle loading, etc.

The ABS response sensitivity is reduced when the actual rolling circumference is excessive on all wheels. For a 100 tooth exciter ring, the minimum number of tire revolutions per mile is 426, and the maximum is 567. The ECU will set diagnostic trouble codes if the number of revolutions is out of this range.

In addition, the size of the steer axle tires compared to the drive axle tires also has to be within the ABS system design. To avoid diagnostic trouble codes, the ratio of the effective rolling circumference of the steer axle, divided by the effective rolling circumference of the drive axle, must be between 0.85 to 1.15.

CAUTION: The ESP system effectiveness relies on the accuracy of vehicle speed. If a major change on the tire sizes occurs such that odometer setting needs to be changed, the Advanced ABS controller's setting of tire sizes must be reprogrammed to new values at the same time by a certified mechanic.

SYSTEM IMPACT DURING ACTIVE TROUBLE CODES

ABS PARTIAL SHUTDOWN

Depending on which component the trouble code is detected, the ABS, ATC, and ESP functions may be fully or partially disabled. Even with the ABS indicator lamp illuminated, the EC-60™ controller may still provide ABS function on wheels that are not affected. The ABS system controller should be serviced as soon as possible.

Steer Axle ABS Modulator Diagnostic Trouble Code

ABS on the affected wheel is disabled. ABS and ATC on all other wheels remains active. ESP is disabled.

Drive Axle/Additional Axle ABS Modulator Diagnostic Trouble Code

ATC is disabled. ABS on the affected wheel is disabled. ABS on all other wheels remains active. ESP is disabled.

Steer Axle Wheel Speed Sensor Diagnostic Trouble Code

The wheel with the diagnostic trouble code is still controlled by using input from the remaining wheel speed sensor on the steer axle. ABS remains active on the rear wheels. ATC and ESP are disabled.

Drive Axle/Additional Axle Wheel Speed Sensor Diagnostic Trouble Code

ATC and ESP are disabled. In a four sensor system, ABS on the affected wheel is disabled, but ABS on all other wheels remains active.

In a six sensor system, ABS remains active by using input from the remaining rear wheel speed sensor on the same side.

ATC Modulator Diagnostic Trouble Code

ATC and ESP are disabled. ABS remains active.

J1939 Communication Diagnostic Trouble Code

ATC and ESP are disabled. ABS remains active.

ECU Diagnostic Trouble Code

ABS, ATC, and ESP are disabled. The system reverts to normal braking.

Voltage Diagnostic Trouble Code

While voltage is out of range, ABS, ATC, and ESP are disabled. The system reverts to normal braking. When the correct voltage level is restored, full ABS and ATC function is available. Operating voltage range is 9.0 to 17.0 VDC.

Steering Angle Sensor Diagnostic Trouble Code

ESP is disabled. ABS and ATC remain active.

Yaw Rate/Lateral Acceleration Sensor Diagnostic Trouble Code

ESP is disabled. ABS and ATC remain active.

Brake Demand Pressure Sensor Diagnostic Trouble Code

ESP is disabled. ABS and ATC remain active.

Load Sensor Diagnostic Trouble Code

ESP is disabled. ABS and ATC remain active.

Steer Axle TCV Diagnostic Trouble Code

ESP is disabled. ABS and ATC remain active.

Trailer PMV Diagnostic Trouble Code

ESP is disabled. ABS and ATC remain active.

SYSTEM CONFIGURATION

The EC-60™ controller is designed to allow the technician to change the default system settings (chosen by the vehicle OEM) to provide additional or customized features.

Depending on the model, the customizable features include ABS control settings, engine module communication etc. Many of these settings can be reconfigured using a hand held or PC-based software, such as the Bendix® ACom™ Diagnostics program.

ECU RECONFIGURATION

Reconfiguring an EC-60™ controller may be carried out by using the Blink Code Switch or by using a hand-held or PC-based diagnostic tool.

Note: During the reconfiguration process, and independently from any reconfiguration being carried out by the technician, the ECU will automatically check the J1939 serial link and communicate with other vehicle modules. In particular, if the serial link shows that the vehicle has a retarder device present, the ECU will configure itself to communicate with the retarder device for improved ABS performance. For example, if the ECU detects the presence of a retarder disable relay during a reconfiguration, it will configure itself to control the relay to disable the retarding device as needed.

6S/5M Configuration

Advanced EC-60™ controllers will configure for 6S/5M operation when a reconfiguration event is initiated and the ECU detects that an additional axle PMV is wired as follows:

PMV Connector

Hold
Release
Common

ECU Connector

Right Additional Axle Hold
Left Additional Axle Release
Right Additional Axle Common

Reconfiguration Using the Blink Code Switch

With ignition power removed from the EC-60™ controller, depress the blink code switch. After the ignition power is activated, depress and release the switch seven times to initiate a reconfiguration event.

Diagnostic Tool

A reconfiguration event may be initiated using a hand-held or PC-based diagnostic tool to communicate with the ECU over the SAE J1587 diagnostic link.

Troubleshooting: General

SAFE MAINTENANCE PRACTICES

WARNING! PLEASE READ AND FOLLOW THESE INSTRUCTIONS TO AVOID PERSONAL INJURY OR DEATH:

When working on or around a vehicle, the following general precautions should be observed at all times:

1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels. Always wear safety glasses.
2. Stop the engine and remove ignition key when working under or around the vehicle. When working in the engine compartment, the engine should be shut off and the ignition key should be removed. Where circumstances require that the engine be in operation, **EXTREME CAUTION** should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated or electrically charged components.
3. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
4. If the work is being performed on the vehicle's air brake system, or any auxiliary pressurized air systems, make certain to drain the air pressure from all reservoirs before beginning **ANY** work on the vehicle. If the vehicle is equipped with an AD-IS™ air dryer system or a dryer reservoir module, be sure to drain the purge reservoir.
5. Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that safely removes all electrical power from the vehicle.
6. Never exceed manufacturer's recommended pressures.
7. Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.
8. Use only genuine Bendix® replacement parts, components and kits. Replacement hardware, tubing, hose, fittings, etc. must be of equivalent size, type and strength as original equipment and be designed specifically for such applications and systems.
9. Components with stripped threads or damaged parts should be replaced rather than repaired. Do not attempt repairs requiring machining or welding unless specifically stated and approved by the vehicle and component manufacturer.
10. Prior to returning the vehicle to service, make

certain all components and systems are restored to their proper operating condition.

11. For vehicles with Antilock Traction Control (ATC), the ATC function must be disabled (ATC indicator lamp should be ON) prior to performing any vehicle maintenance where one or more wheels on a drive axle are lifted off the ground and moving.

REMOVING THE EC-60™ CONTROLLER ASSEMBLY

1. Turn vehicle ignition off.
2. Remove as much contamination as possible prior to disconnecting electrical connections.
3. Note the EC-60™ controller assembly mounting position on the vehicle.
4. Disconnect the electrical connectors from the EC-60™ controller.
5. Remove and retain the mounting bolts that secure the EC-60™ controller.

CAUTION

The VIN of the vehicle is stored in the ECU internal memory, and is cross-checked by the ECU using information obtained from other vehicle controllers. If the VIN stored in the ECU does not match the VIN obtained from the other vehicle controller, the ECU will generate an ECU Internal VIN Mismatch DTC.

Accordingly, do not switch Advanced controllers from one vehicle to another.

OBTAINING A NEW EC-60™ ADVANCED CONTROLLER

Should the Advanced EC-60™ controller require replacement, certain steps must be followed:

1. Record the vehicle model, VIN, model year and date of manufacture from the vehicle.
2. Record the part number of the EC-60™ Advanced Controller.
3. Provide this information to your local OEM vehicle service department to obtain a new ECU. The OEM service department will install the same parameter set in the new controller that was loaded into the original ECU at the vehicle OEM assembly facility.

INSTALLING A NEW EC-60™ CONTROLLER

CAUTION! When replacing the EC-60™ controller, verify with the OEM service department that the unit you are installing has the correct parameter set. Failure to do so could result in a loss of features or degraded ESP performance.

For further information, contact either the vehicle manufacturer, Bendix or your local authorized Bendix dealer.

1. Position and secure the EC-60™ controller in the original mounting orientation using the mounting bolts retained during removal. Use no more torque than is necessary to firmly secure the ECU into position. Over-tightening the mounting hardware can cause damage to the EC-60™ controller.
2. Reconnect the electrical connectors to the EC-60™ controller.
3. Apply power and monitor the EC-60™ controller power-up sequence to verify proper system operation.

See Troubleshooting: Wiring section beginning on page 38 for more information on wire harnesses.

WARNING: Bendix ESP stability system is validated with specific Bendix® components. Always use Bendix® replacement parts to prevent compromising system performance. Bendix is not able to validate the safe and reliable use of substitute or alternate components that may be available from other manufacturers. Further, suppliers of a non-Bendix® ABS component may implement design changes in their component (without the knowledge or approval of Bendix) which could negatively affect antilock system reliability and braking performance issues.

REMOVAL OF THE STEERING ANGLE SENSOR

Service Checks:

1. Check all wiring and connectors. Some installations also include an intermediate connector from the steering angle sensor to the main vehicle wire harness. Make sure all connections are free from visible damage.
2. Examine the sensor. Make sure the sensor, its mounting screws, and the interface between the hub and the steering column are not damaged.

Diagnostics:

The steering angle sensor is only operational in conjunction with an Advanced ABS ECU. No independent diagnostics can be performed on the sensor.

Removal:

1. Remove steering column sheathing.
2. Depending upon manufacturer, the steering angle sensor could be located either near the steering wheel, necessitating the removal of the steering wheel, or near the joint to the vehicle steering mechanism, necessitating the disconnection of this linkage.
3. Unplug sensor cable assembly from body of sensor. Squeeze the mounting tabs and pull gently on connector until it disengages.
4. Unscrew all three of the mounting screws that hold the body of the sensor to the steering column body.
5. Slide the sensor over the column to remove. Take note if the sensor label is facing upward or downward.

Installation:

1. Obtain a new sensor. The sensor is not repairable in the field.
2. Slide the sensor over the column. The center hub of the sensor must be aligned with the corresponding notch in the column. Different column manufacturers may implement this hub alignment in different ways. The sensor label should be facing in the same direction as the removed sensor.
3. Assemble to column non-moving plate with three self-locking screws.
4. Tighten screws to 65N to 100N.
5. Reconnect the connector. Ensure that there will be no force applied to the sensor because the connector is pulling on the sensor body.
6. If the wire harness leading to the sensor is being replaced, ensure that it is adequately tie wrapped so that the full motion of the steering column can be achieved without pulling apart the connectors.
7. Reinstall the column sheathing. The sensor is not protected against dirt or water intrusion, so care must be taken not to introduce these elements during installation.

Steering Angle Sensor Calibration

The steering angle sensor calibration can only be achieved when the sensor is powered by the Advanced ABS ECU. No stand-alone sensor calibration can be carried out. The calibration procedure is performed using Bendix® ACom™ Diagnostic V4.0 or higher. See “Troubleshooting Diagnostic Trouble Codes: Steering Angle Sensor (SAS-60)” for the calibration procedure using this tool. The sensor must be recalibrated after any of these situations:

- Replacement of the steering angle sensor
- Any opening of the connector hub from the steering angle sensor to the column
- Any maintenance or repair work on the steering linkage, steering gear or other related mechanism
- Adjustment of the wheel alignment or wheel track
- After an accident that may have led to damage of the steering angle sensor or assembly

WARNING: If the steering angle sensor is not properly recalibrated as needed, the yaw control system may not function properly, which can result in a loss of vehicle control.

REMOVAL OF THE YAW RATE/LATERAL ACCELERATION SENSOR

Service Checks:

1. Check all wiring and connectors. Make sure all connections are free from visible damage.
2. Examine the sensor. Make sure the sensor, its mounting bolts, and the mounting bracket are not damaged.
3. Check vent hole in underbody of sensor housing. Vent hold should remain free from paint and debris at all times.

Diagnostics:

The yaw rate sensor is only operational in conjunction with an Advanced ABS ECU. No independent diagnostics can be performed on the sensor.

Removal:

1. Unplug sensor cable assembly from body of sensor. The connector must be twisted and pulled gently to release.
2. In some mounting configurations, the sensor can be removed independently from its mounting bracket. Otherwise, remove entire assembly, then remove sensor from bracket.
3. Take note of the direction in which the connector is pointed.

Installation:

1. Obtain a new sensor. The sensor is not repairable in the field. **WARNING:** Only Bendix-approved replacement sensors must be used to prevent negatively affecting antilock system reliability and braking performance issues.
2. Assemble yaw rate sensor housing to mounting bracket. The bracket must be the same design as used on the original vehicle configuration.
3. Using three M8 size bolts, the fixing torque should be between 18 and 22N. The connector should be facing in the same direction as the removed sensor. The unit must not be installed upside-down where there is a pressure-balancing hole.
4. The sensor should be as level as possible and parallel to the road surface when installed on the vehicle.
5. Reconnect the connector. Ensure that there will be no force applied to the sensor because the connector is pulling on the sensor body.

CAUTION: When removing or installing the sensor, care must be used to prevent damage. Do not strike or pry the sensor. Do not use an impact tool to install the mounting hardware.

Sensor Location Modifications

The location and orientation of the Yaw Rate Sensor must not be altered. When servicing, an identical component must be used in the same orientation (using OEM brackets & torque requirements). During installation follow the OEM leveling guidelines.

Yaw Rate Sensor Calibration:

The yaw rate sensor calibration can only be achieved via the Advanced ABS ECU. The sensor must be recalibrated after any of these situations:

- Replacement of the sensor
- After an accident that may have led to damage of the yaw rate sensor

The calibration procedure is performed using Bendix® ACom™ Diagnostics V4.0 or higher.

See “Troubleshooting Diagnostic Trouble Codes: Yaw Rate Sensor” for the calibration procedure.

BRAKE DEMAND SENSOR CALIBRATION

Calibration must be performed under the following conditions:

- After servicing any pressure sensor related DTCs
- Replacement of any sensor

The calibration procedure is performed using Bendix® ACom™ Diagnostics V4.0 or newer versions.

See “Troubleshooting Diagnostic Trouble Codes: Brake Demand Sensor/Load Sensor” for the calibration procedure.

PRESSURE SENSOR INSTALLATION REQUIREMENTS

Service Checks:

1. Check all wiring and connectors. Make sure all connections are free from visible damage.
2. Examine the sensor. Make sure the sensor and its interface to the pressure location are not damaged.

Diagnostics:

The pressure sensor can be independently diagnosed when supplied with a five volt voltage supply to the B location and ground to the A location. Signal output on the C location should read approximately 0.5V if there is no pressure applied. The signal output should increase proportionately as pressure is applied, up to a maximum of 4.5V at 150 psi.

Removal:

1. Unplug sensor cable assembly from body of sensor. Pull gently on the mounting tab and connector until it disengages.
2. Remove sensor from its pressure mounting using approved air brake push in fitting tools.

Installation:

1. Obtain a new sensor. The sensor is not repairable in the field.
2. Insert sensor into pressure fitting using approved tools.
3. Reconnect the connector. Ensure that there will be no force applied to the sensor because the connector is pulling on the sensor body.
4. If the wire harness leading to the sensor is being replaced, ensure that it is adequately tie wrapped.

Pressure Sensor Calibration:

There is no need for pressure sensor calibration as long as the part replaced its identical to the part removed and a component approved for use with the Bendix Advanced ABS system. However, replacement of brake demand sensors or clearing of demand pressure sensor related DTCs require the following:

1. Use of ACom V4 or newer to clear the active p-sensor fault.
2. Carrying out the demand p-sensor initialization procedure which involves applying service brakes of 90 psi or greater for 3 sec (while stationary).

Once this procedure is carried out successfully, if there are no other active DTCs, ATC/ESP indicator will no longer illuminate.

Troubleshooting: Blink Codes and Diagnostic Modes

ECU DIAGNOSTICS

The EC-60™ controller contains self-testing diagnostic circuitry that continuously checks for the normal operation of internal components and circuitry, as well as external ABS components and wiring.

Active Diagnostic Trouble Codes

When an erroneous system condition is detected, the EC-60™ controller:

1. Illuminates the appropriate indicator lamp(s) and disengages part or all of the ABS, ATC and ESP functions. (See ABS Partial Shutdown, on page 12.)
2. Places the appropriate trouble code information in the ECU memory.
3. Communicates the appropriate trouble code information over the serial communications diagnostic link as required. Hand-held or PC-based diagnostic tools attach to the vehicle diagnostic connector, typically located on or under the dash (see Figure 13).

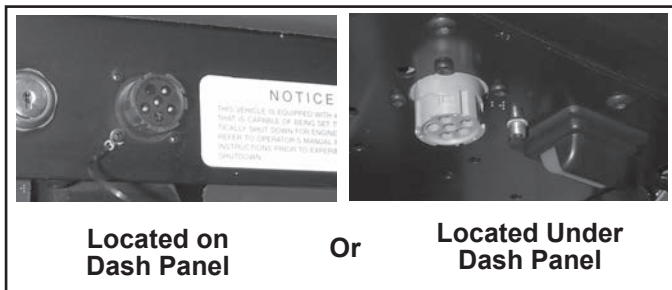


FIGURE 13 - TYPICAL VEHICLE DIAGNOSTIC CONNECTOR LOCATIONS (J1708/J1587, J1939)

BLINK CODES

Blink codes allow a technician to troubleshoot ABS problems without using a hand-held or PC-based diagnostic tool. Instead, information about the ABS system is communicated by the ECU using the ABS indicator lamp to display sequences of blinks.

Note: The ECU will not enter the diagnostic blink code mode if the wheel speed sensors show that the vehicle is in motion. If the ECU is in the diagnostic blink code mode and then detects vehicle motion, it will exit the blink code mode.

In addition, by operating the blink code switch as described below, one of several diagnostic modes can be entered. See Diagnostic Modes below.

Blink Code Switch Activation

When activating the blink code switch:

1. Wait at least two seconds after "ignition on." (Except when entering Reconfiguration Mode - see Reconfiguration section on page 12)
2. For the ECU to recognize that the switch is activated "on," the technician must press for at least 0.1 seconds, but less than 5 seconds. (If the switch is held for more than 5 seconds, the ECU will register a malfunctioning switch.)
3. Pauses between pressing the switch when a sequence is required, (e.g. when changing mode) must not be longer than 2 seconds.
4. After a pause of 3.5 seconds, the ECU will begin responding with output information blinks. See Figure 14 for an example.

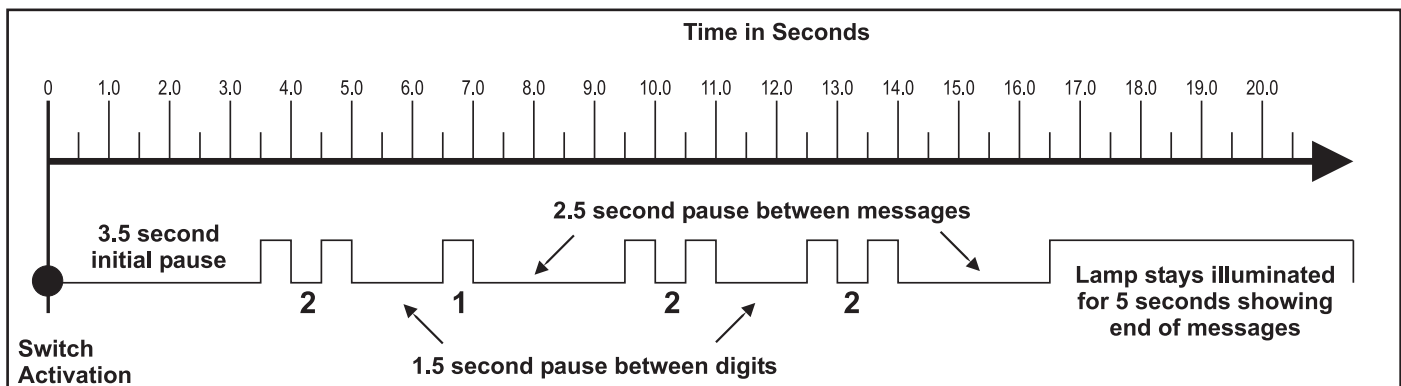


FIGURE 14 - EXAMPLE OF BLINK CODE MESSAGE

Blink Code Timing

The ECU responds with a sequence of blink codes. The overall blink code response from the ECU is called a “message.” Each message includes, depending on the mode selected by the technician, a sequence of one or more groups of blinks. Simply record the number of blinks for each sequence and then use the troubleshooting index on page 21 for active or inactive trouble codes and you will be directed to the page that provides troubleshooting information.

NOTE:

1. Sequences of blinks illuminate the ABS indicator lamp for half a second, with half-second pauses between them.
2. Pauses between blink code digits are 1.5 seconds.
3. Pauses between blink code messages are 2.5 seconds.
4. The lamp remains on for 5 seconds at the end of messages.

Once the ABS indicator lamp begins displaying a sequence of codes, it continues until all blink code messages have been displayed and then returns to the normal operating mode. During this time, the ECU will ignore any additional blink code switch activation.

All trouble codes, with the exception of voltage and J1939 trouble codes, will remain in an active state for the remainder of the power cycle.

Voltage trouble codes will clear automatically when the voltage returns within the required limits. All ABS functions will be re-engaged.

J1939 trouble codes will clear automatically when communications are re-established.

DIAGNOSTIC MODES

In order to communicate with the ECU, the controller has several modes that the technician can select, allowing information to be retrieved, or other ECU functions to be accessed.

Diagnostic Modes

To enter the various diagnostic modes:

No. of Times to Press the Blink Code Switch	System Mode Entered
1	Active diagnostic trouble code retrieval
2	Inactive diagnostic trouble code retrieval
3	Clear active diagnostic trouble codes
4	System configuration check
5	Dynamometer Test Mode
7*	Reconfigure ECU

* To enter the Reconfiguration Mode, the switch must be held in before the application of ignition power. Once the power is supplied, the switch is released and then pressed seven times.

CHART 2 - DIAGNOSTIC MODES

Active Diagnostic Trouble Code Mode

For troubleshooting, typically the Active and Inactive Diagnostic Trouble Retrieval Modes are used. The technician presses the blink code switch once and the ABS indicator lamp flashes a first group of two codes, and if there are more trouble codes recorded, this is followed by a second set of codes, etc. (See page 21 for a directory of these codes.) All active trouble codes may also be retrieved using a hand-held or PC-based diagnostic tool, such as the Bendix® ACom™ Diagnostics software.

To clear active diagnostic trouble codes (as problems are fixed), simply clear (or “self-heal”) by removing and re-applying ignition power. The only exception is for wheel speed sensor trouble codes, which clear when power is removed, re-applied, and the ECU detects valid wheel speed from all wheel speed sensors. Alternately, codes may be cleared by pressing the diagnostic blink code switch 3 times (to enter the Clear Active Diagnostic Trouble Code Mode) or by using a hand-held or PC-based diagnostic tool. Hand-held or PC-based diagnostic tools are able to clear wheel speed sensor trouble codes without the vehicle being driven.

Inactive Diagnostic Trouble Code Mode

The ECU stores past trouble codes and comments (such as configuration changes) in its memory. This record is commonly referred to as “event history.” When an active trouble code is cleared, the ECU stores it in the event history memory as an inactive trouble code.

Using blink codes, the technician may review all inactive trouble codes stored on the ECU. The ABS indicator lamp will display inactive diagnostic blink codes when the diagnostic blink code switch is depressed and released two times. See page 20 for the index showing trouble codes and the troubleshooting guide page to read for help.

Inactive trouble codes, and event history, may be retrieved and cleared by using a hand-held or PC-based diagnostic tool, such as the Bendix® ACom™ Diagnostics software.

Clearing Active Diagnostic Trouble Codes

The ECU will clear active trouble codes when the diagnostic blink code switch is depressed and released three times.

System Configuration Check Mode

The ABS indicator lamp will display system configuration information when the diagnostic blink code switch is depressed and released four times. The lamp will blink out configuration information codes using the following patterns. (See Chart 3). In this mode the ECU tells the technician, by means of a series of seven blink codes, the type of ABS system that the ECU has been set up to expect. For example, if the fourth blink code is a two, the technician knows that a 6S/4M sensor/modulator configuration has been set.

Dynamometer Test Mode

The Dynamometer Test Mode is used to disable ESP & ATC when needed (e.g. when performing any vehicle maintenance where the wheels are lifted off the ground and moving, including dyno testing). **For Advanced ABS controllers this mode will remain engaged even if power to the ECU is removed and re-applied.**

To exit the Dynamometer Test Mode, press and release the blink code switch three times, or use a hand-held or PC-based diagnostic tool.

Reconfigure ECU Mode

Controller reconfiguration is carried out by using the Reconfigure ECU Mode. (See page 11.)

Note: To enter the Reconfiguration Mode, the blink code switch must be held in before the application of ignition power. Once the power is supplied, the switch is released and then pressed seven times.

1st Number	System Power
1	12 Volts
2nd Number	Wheel Speed Sensors
4	4 Sensors
6	6 Sensors
3rd Number	Pressure Modulator Valves
4	4 Modulators
5	5 Modulators
6	6 Modulators
4th Number	ABS Configuration
1	4S/4M or 6S/6M
2	6S/4M
3	6S/5M
5th Number	Traction Control Configuration
2	No ATC
3	ATC Engine Control Only
4	ATC Brake Control Only
5	Full ATC (Engine Control & Brake Control)
6th Number	Retarder Configuration
1	No Retarder
2	J1939 Retarder
3	Retarder Relay
4	J1939 Retarder, Retarder Relay
7th Number	Stability Configuration
1	No Stability Program
2	Electronic Stability Program (ESP), which includes RSP
3	Roll Stability Program (RSP) Only

CHART 3 - SYSTEM CONFIGURATION CHECK

Troubleshooting: Using Hand-Held or PC-Based Diagnostic Tools

USING HAND-HELD OR PC-BASED DIAGNOSTICS

Troubleshooting and diagnostic trouble code clearing (as well as reconfiguration) may also be carried out using hand-held or PC-based diagnostic tools such as the Bendix® Remote Diagnostic Unit (RDU™), Bendix® ACom™ Diagnostics software, or the ProLink tool.

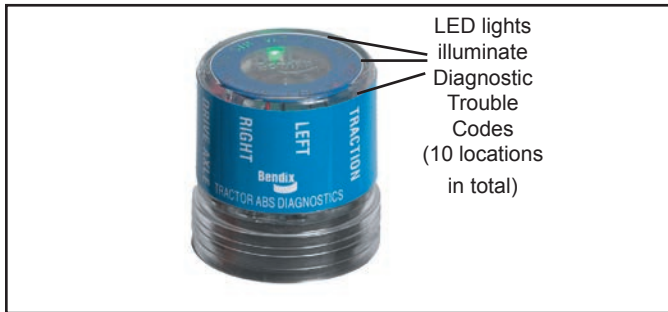


FIGURE 15 - THE BENDIX® REMOTE DIAGNOSTIC UNIT

Bendix® RDU™ (Remote Diagnostic Unit)

The Bendix® RDU™ tool provides the technician with a visual indication of Antilock Braking System (ABS) component **Diagnostic Trouble Code (DTC)** information. The RDU™ tool is specifically designed for use with Bendix® ABS systems and Bendix makes no claims for its operation and/or usability with other brands of ABS systems.

Features of the Bendix® RDU™ Tool

The RDU™ tool attaches to the 9 pin diagnostic connector in the cab of the vehicle. An adapter cable (Bendix part number 801872) is available to connect the RDU to vehicles with a 6-pin diagnostic connector.

The RDU™ tool allows the technician to:

- Troubleshoot ABS system component problems using Diagnostic Trouble Code reporting via LEDs.
- Reset Diagnostic Trouble Codes on Bendix® ABS ECUs by holding a magnet over the reset in center of RDU™ tool for less than 6 seconds.
- Enter the Self-Configuration Mode used by Bendix® ABS ECUs by holding a magnet over the reset area for greater than 6 seconds but less than 30 seconds.

How the Bendix® RDU™ Operates

See Figure 9 for typical vehicle connector locations.

When the RDU™ tool is plugged into the diagnostic connector, all the LEDs will illuminate, and the green LED will flash 4 times to indicate communications have been established.

If the ABS ECU has no active Diagnostic Trouble Codes, only the green LED will remain illuminated.

If the ABS ECU has at least one active Diagnostic Trouble Code the RDU™ tool displays the first diagnostic trouble code by illuminating the red LEDs, indicating the malfunctioning ABS component and its location on the

vehicle. (See Figure 15.) If there are multiple diagnostic trouble codes on the ABS system, the RDU™ tool will display one diagnostic trouble code first, then once that Diagnostic Trouble Code has been repaired and cleared, the next code will be displayed.

- MOD red LED illuminated, shows the "Common" connection of one or more modulators is shorted to battery or ground
- VLT (Flashing indicates either over- or under-voltage condition)

Typical Combination Diagnostic Trouble Codes are:

- Right steer sensor
- Left steer sensor
- Right drive sensor
- Left drive sensor
- Right additional sensor
- Left additional sensor
- Right steer modulator
- Left steer modulator
- Right drive modulator
- Left drive modulator
- Right additional modulator
- Left additional modulator
- Rear Axle Traction modulator
- ECU
- Engine serial communication

To pinpoint the root cause and to ensure the system diagnostic trouble code is properly corrected the first time, additional troubleshooting may be necessary. Note: The RDU is not capable of diagnosing ESP-specific diagnostic trouble codes including additional sensors: steering angle sensors, yaw sensors, pressure sensors, or modulator valves (trailer pressure modulating valves or front axle traction control valves.)

Bendix® RDU™ Reset Function

The magnetic reset switch is located in the center top of the RDU™ tool. Activation requires a magnet with 30 gauss minimum.

The reset operations are:

1. If the magnet is held over the switch for less than 6 seconds the "clear current diagnostic trouble codes" command is sent.
2. If the magnet is held over the switch for more than 6 seconds, but less than 30 seconds, the Bendix® ABS "self-configuration command" is sent.

Additionally, it is recommended at the end of any inspection that the user switches off and restores the power to the ABS ECU, then check the ABS Indicator Lamp operation and RDU™ tool to see if they indicate any remaining Diagnostic Trouble Codes.

Bendix® RDU™ Communication Problems

If the ABS ECU does not respond to the RDU™ tool's request for diagnostic trouble codes, the RDU™ tool will

LED Diagnostic Trouble Codes

LFT - Left	ECU - ABS Controller
RHT - Right	SEN - Wheel Speed Sensor
DRV - Drive Axle	MOD - Pressure Modulator Valve
ADD - Additional	TRC - Traction Control
STR - Steer Axle	
VLT - Power	

Example: If the Diagnostic Trouble Code is "Right Steer Axle Sensor", the RDU™ unit will display one green and three red



LEDs
Green
VLT
Red
SEN
STR

FIGURE 16 - DIAGNOSTIC TROUBLE CODES

illuminate each red LED in a clockwise pattern. This pattern indicates the loss of communication and will continue until the ABS ECU responds and communication has been established.

Possible sources of communication problems are:

1. A problem with the J1587 link at the in-cab off-board diagnostic connector (9 or 6 Pin).
2. The ECU does not support PID194.
3. No power is being supplied to the ECU and/or the diagnostic connector.
4. The J1587 bus is overloaded with information and the RDU can not arbitrate access.
5. A malfunctioning RDU™ tool.

Nexiq Bendix Application Card

Nexiq provides a Bendix application card for use with the ProLink tool. It can also be used to diagnose the EC-30™, EC-17™, Gen 4™, Gen 5™, and MC-30™ ABS Controllers.

For more information on the Bendix application card visit www.bendix.com, Nexiq at www.nexiq.com, or your local authorized Bendix parts outlet.

Bendix® ACom™ Diagnostics V4.0 Software

Bendix® ACom™ Diagnostics V4.0 is a PC-based software program and is designed to meet RP-1210 industry standards developed by the Truck Maintenance Council (TMC). This software provides the technician with access to all the available ECU diagnostic information and configuration capability, including:

- ECU information
- Diagnostic trouble codes and repair information
- Configuration (ABS, ATC, and more)
- Wheel speed information
- Perform component tests
- Save and print information

ACom™ Diagnostics V4.0 software is required to calibrate the Steering Angle Sensor, the Yaw Rate/Lateral Acceleration Sensor, the Brake Demand Sensors and the Load Sensor.



FIGURE 17 - NEXIQ (MPSI) PRO-LINK TOOL

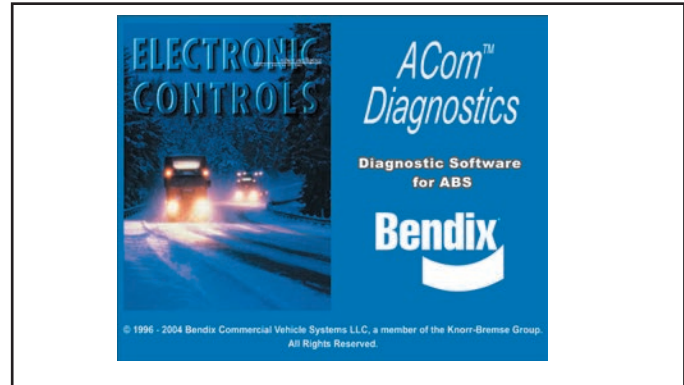


FIGURE 18 - BENDIX® ACOM™ DIAGNOSTICS

When using ACom™ Diagnostics V4.0 software to diagnose the EC-60™ ABS ECU, the computer's serial or parallel port needs to be connected to the vehicle's diagnostic connector.

For more information on ACom™ Diagnostics software or RP1210 compliant tools, go to www.bendix.com or visit your local authorized Bendix parts outlet.

See Page 44 for Appendix A: J1587 SID and FMI codes and their Bendix blink code equivalents.

www.bendix.com

Visit Bendix online for the latest information, and ways to find the Bendix contacts you need. Contact technical support, service engineers, Bendix account managers, and more — www.bendix.com is your complete Bendix resource.

Bendix Technical Assistance Team

For direct telephone technical support, call the Bendix technical assistance team at:

1-800-AIR-BRAKE (1-800-247-2725),

Monday through Friday, 8:00 A.M. to 6:00 P.M. EST, and follow the instructions in the recorded message.

Or, you may e-mail the Bendix technical assistance team at: tbs.techteam@bendix.com.

Active or Inactive Diagnostic Trouble Codes:

INDEX

How to interpret the first digit of messages received when Active or Inactive Diagnostic Trouble Code Mode

1st Blink Code Number	Go Here for Troubleshooting Tests
1	..... No faults (1,1)
2	..... Wheel Speed Sensors - page 22
3	..... Wheel Speed Sensors - page 22
4	..... Wheel Speed Sensors - page 22
5	..... Wheel Speed Sensors - page 22
6	..... Power Supply - page 27
7	..... Pressure Modulator Valves - page 24
8	..... Pressure Modulator Valves - page 24
9	..... Pressure Modulator Valves - page 24
10	..... Pressure Modulator Valves - page 24
11	..... J1939 - page 28
12	..... Miscellaneous - pages 30-31
13	..... ECU - page 29
14	..... Wheel Speed Sensors - page 22
15	..... Wheel Speed Sensors - page 22
16	..... Pressure Modulator Valves - page 24
17	..... Pressure Modulator Valves - page 24
18	..... Drive Axle Traction Control Valve - page 26
19	..... Steer Axle Traction Control Valve - page 26
20	..... Trailer Pressure Modulator Valve - page 24
21	..... Steering Angle Sensor - pages 33-33
22	..... Yaw Rate Sensor - pages 34-35
23	..... Lateral Acceleration Sensor - page 36
24	..... Brake Demand/Load Sensors - page 37

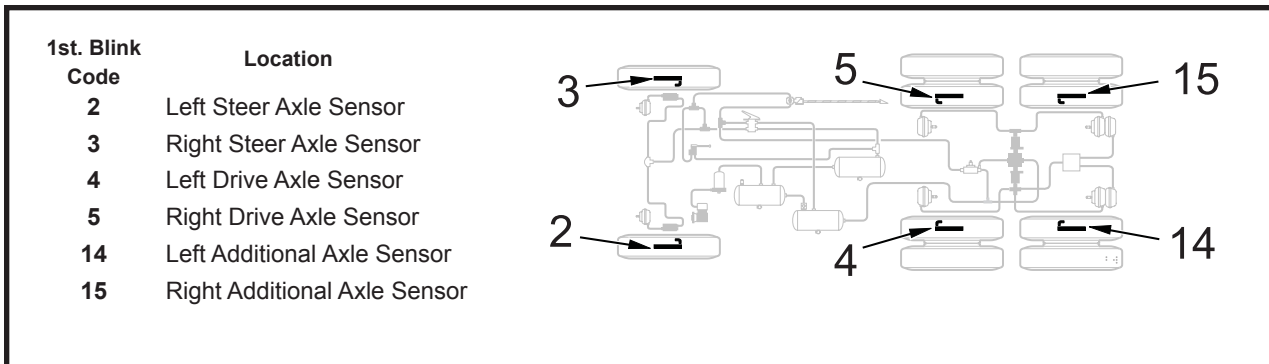
Example: For a message sequence of:

3, 2 12, 4

For the first sequence go to page 22 and for the second sequence go to page 30.

See Page 43 for Appendix A: J1587 SID and FMI Codes and Their Bendix Blink Code Equivalents

Troubleshooting Diagnostic Trouble Codes: Wheel Speed Sensors



2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Excessive Air Gap	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~ 0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping.
2	Output Low at Drive-off	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~ 0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping.
3	Open or Shorted	Verify 1500 – 2500 ohms across sensor leads. Verify no continuity between sensor leads and ground or voltage. Verify no continuity between sensor leads and other sensors. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
4	Loss of Sensor Signal	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~ 0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
5	Wheel End	Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check mechanical function of brake. Check for kinked or restricted air lines.
6	Erratic Sensor Signal	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~ 0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
7	Tire Size Calibration	Verify correct tire size as desired. Verify proper tire inflation. Verify correct number of exciter ring teeth.
10	Configuration Error	ECU is configured for four sensors, but has detected the presence of additional sensors. Verify sensor wiring and ECU configuration.

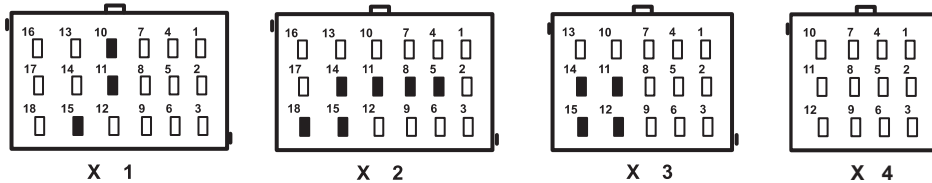
Speed Sensor Repair Tests:

1. Take all measurements at ECU harness connector pins in order to check wire harness and sensor.
Probe the connector carefully so that the terminals are not damaged.
2. Wheel speed sensor measurements should read:

Location	Measurement
Sensor	1500 - 2500 Ohms
Sensor to voltage or ground	Open Circuit (no continuity)
Sensor output voltage	>0.25 of VAC sensor output at ~ 0.5 revs/sec.

3. Clear DTC after issue is corrected. The sensor DTC will remain until the power is cycled to the ABS ECU and vehicle is driven above 15 MPH or DTC was cleared using either the diagnostic blink code switch or diagnostic tool.

Cab-mount ECU: Looking into wire harness connector

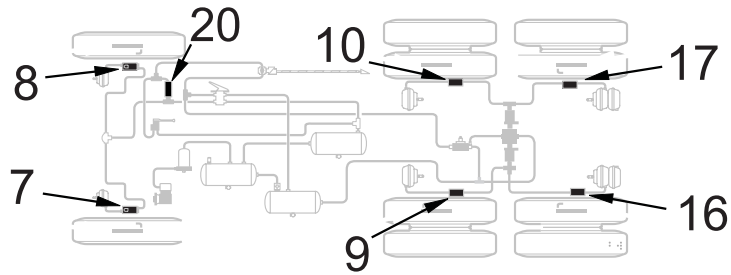


Connector	Pin	Wheel Speed Sensor Location
X1 18 Way	10	Right Drive Axle (+)
	11	Right Drive Axle (-)
X2 18 Way	5	Left Steer Axle (+)
	8	Left Steer Axle (-)
	11	Right Steer Axle (+)
	14	Right Steer Axle (-)
X3 15 Way (if ECU is configured for 6 sensors)	15	Left Drive Axle (+)
	18	Left Drive Axle (-)
	11	Left Additional Axle (+)
	14	Left Additional Axle (-)
	12	Right Additional Axle (+)
	15	Right Additional Axle (-)

Troubleshooting Diagnostic Trouble Codes: Pressure Modulator Valves

1st. Blink Code

1st. Blink Code	Location
7	Left Steer Axle
8	Right Steer Axle
9	Left Drive Axle
10	Right Drive Axle
16	Left Additional Axle
17	Right Additional Axle
20	Trailer PMV



2nd. Diagnostic Blink Code Description

Repair Information

1	Release Solenoid Shorted to Ground	Verify no continuity between PMV leads and ground. Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
2	Release Solenoid Shorted to Voltage	Verify no continuity between PMV leads and voltage. Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
3	Release Solenoid Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
4	Hold Solenoid Shorted to Ground	Verify no continuity between PMV leads and ground. Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
5	Hold Solenoid Shorted to Voltage	Verify no continuity between PMV leads and voltage. Verify 4.9 to 5.5 ohms from REL to CMN & HLD CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
6	Hold Solenoid Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between the ECU and PMV.
7	CMN Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between the ECU and PMV.
8	Configuration Error	A mis-match exists between the ECU configuration and the modulator installation and wiring. Verify PMV wiring and installation. Verify ECU configuration.

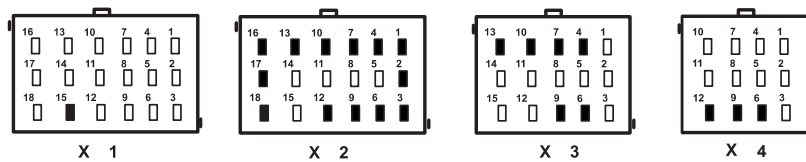
Pressure Modulator Valve Repair Tests:

1. Take all measurements at ECU harness connector pins in order to check wire harness and PMV. Probe the connector carefully so that the terminals are not damaged.
2. Pressure modulator resistance should read:

Location	Measurement
Release to Common	4.9 to 5.5 Ohms
Hold to Common	4.9 to 5.5 Ohms
Release to Hold	9.8 to 11.0 Ohms
Release, Hold, Common to Voltage or Ground	Open Circuit (no continuity)

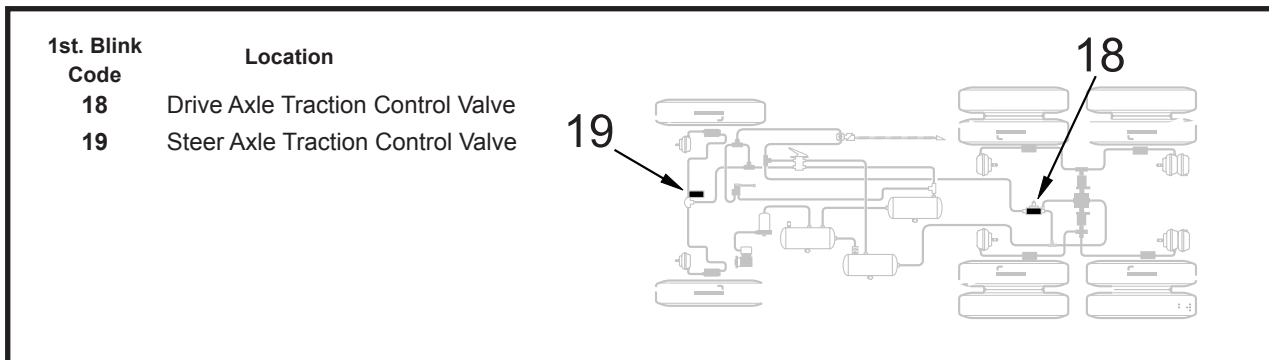
Caution: When troubleshooting modulator trouble codes, check inactive trouble codes and event history for over-voltage or excessive noise trouble codes. If one of these is found, troubleshoot these trouble codes first before the PMV.

Cab-mount ECU: Looking into wire harness connector



Connector	Pin	PMV Location	
X2 18 Way	1	Left Steer Axle Hold	
	2	Left Steer Axle Release	
	3	Left Steer Axle Common	
	4	Right Steer Axle Hold	
	6	Right Steer Axle Common	
	7	Right Steer Axle Release	
	9	Right Drive Axle Common	
	10	Right Drive Axle Hold	
	13	Right Drive Axle Release	
	12	Left Drive Axle Common	
	16	Left Drive Axle Hold	
	17	Left Drive Axle Release	
	4	Left Additional Axle Hold	
	X3 15 Way (if ECU is configured for 6 modulators)	6	Left Additional Axle Common
		7	Left Additional Axle Release
		9	Right Additional Axle Common
		10	Right Additional Axle Hold
X4 12 Way	13	Right Additional Axle Release	
	6	Trailer PMV Hold	
	9	Trailer PMV Release	
	12	Trailer PMV Common	

Troubleshooting Diagnostic Trouble Codes: Traction Control Valves



2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	TCV Solenoid Shorted to Ground	Verify 7 to 19 ohms between TCV and TCV common. Verify no continuity between TCV leads and ground. Check for corroded/damaged wiring or connectors between ECU and TCV.
2	TCV Solenoid Shorted to Voltage	Verify 7 to 19 ohms between TCV and TCV common. Verify no continuity between TCV leads and voltage. Check for corroded/damaged wiring or connectors between ECU and TCV.
3	TCV Solenoid Open Circuit	Verify 7 to 19 ohms between TCV and TCV common. Check for corroded/damaged wiring or connectors between ECU and TCV.
4	TCV Configuration Error	The ECU is not configured for ESP or ATC, but has detected the presence of a TCV. Verify TCV wiring. Inspect for the presence of a TCV. Verify ECU configuration.

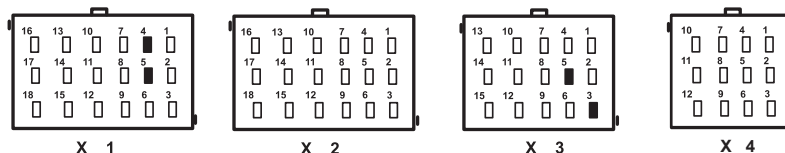
Traction Control Valve Repair Tests:

1. Take all measurements at ECU harness connector pins in order to check wire harness and traction control valve. Probe the connector carefully so that the terminals are not damaged.

Location	Measurement
TCV to TCV Common	7 to 19 Ohms
Release, Hold, Common to Voltage or Ground	Open Circuit (no continuity)

Cab-mount ECU:

Looking into wire harness connector



Connector	Pin	Traction Control Test
X1	4	Drive Axle Traction Control Valve Common
18 Way	5	Drive Axle Traction Control Valve

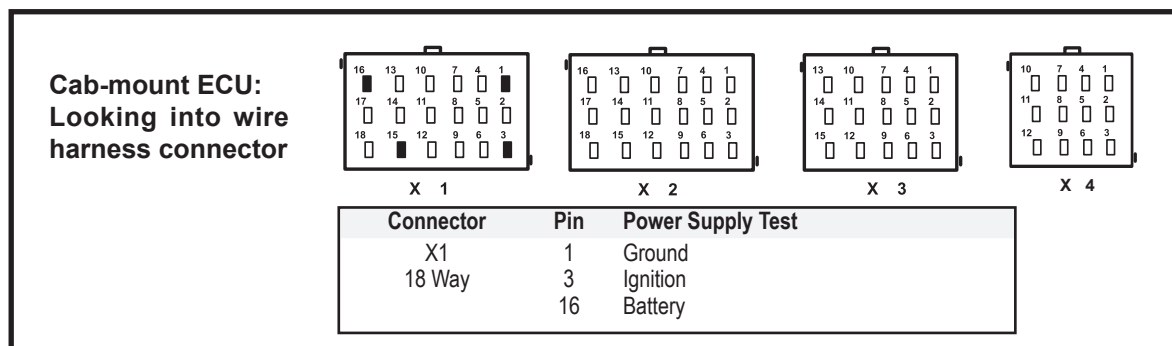
Connector	Pin	Traction Control Test
X3	3	Steer Axle Traction Control Valve Common
15 Way	5	Steer Axle Traction Control Valve

Troubleshooting Diagnostic Trouble Codes: Power Supply

1st. Blink Code	Location	2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
6	Power Supply			
1	Battery Voltage Too Low			Measure battery voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
2	Battery Voltage Too High			Measure battery voltage under load. Ensure that battery voltage is correct for the model of ECU. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
3	Battery Voltage Too Low During ABS			Measure battery voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
4	Battery Voltage Open Circuit			Measure battery voltage under load. Check condition of fuse. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
5	Ignition Voltage Too Low			Measure ignition voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections. Check condition of fuse.
6	Ignition Voltage Too High			Measure ignition voltage. Ensure that ignition voltage is correct for the model of ECU. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
7	Ignition Voltage Too Low During ABS			Measure ignition voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
8	Input Voltage Has Excessive Noise (Temporary)			Check alternator output for excessive noise. Check for other devices causing excessive noise.
9	Input Voltage Has Excessive Noise			Check alternator output for excessive noise. Check for other devices causing excessive noise.

Power Supply Tests:

- Take all measurements at ECU harness connector.
- Place a load (e.g. an 1157 stop lamp) across battery or ignition and ground connection, measure ignition and battery voltage with the load. Ignition to Ground should measure between 9 to 17 VDC. Battery to Ground should also measure between 9 to 17 VDC.
- Check for damaged wiring, damaged or corroded connectors and connections.
- Check condition of vehicle battery and associated components, ground connection good and tight.
- Check alternator output for excessive noise.



Troubleshooting Diagnostic Trouble Codes: J1939 Serial Communications

1st. Blink Code	Location	
11	J1939	

2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	J1939 Serial Link	Loss of communications between the EC-60™ controller and other devices connected to the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.
2	J1939 Retarder	Loss of communications between the EC-60™ controller and other devices connected to the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify presence of retarder on the J1939 link. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.
3	J1939 Engine Communications	Loss of communications between the EC-60™ controller and the engine ECU over the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify presence of engine ECU on the J1939 link. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.
4	J1939 Invalid Data (Engine Retarder)	Invalid data received from the engine or retarder. Check for damaged or reversed J1939 wiring. Check for damaged or corroded connectors. Verify presence of engine and/or retarder on J1939. Verify proper programming of engine and/or retarder. Check for other devices inhibiting J1939 communications.
5	J1939 Supply Pressure	Invalid pressure signals received from a vehicle controller. Verify proper operation of brake demand sensors. Check wiring between brake demand sensors and the vehicle controller. Verify proper programming of vehicle controller. Check for damaged or reversed J1939 wiring. Check for damaged or corroded connectors. Check for other devices inhibiting J1939 communications.
6	J1939 ESP Messages Invalid Data	Invalid ESP messages on the J1939 link. Check for damaged or reversed J1939 wiring. Check for damaged or corroded connectors. Verify presence of engine and/or retarder on J1939. Verify proper programming of engine and/or retarder. Check for other devices inhibiting J1939 communications.

J1939 Troubleshooting Tests:

1. Take all measurements at ECU harness connector
2. Check for damaged or reversed J1939 wiring
3. Check for corroded or damaged wiring connector problems such as (opens or shorts to voltage or ground)
4. Check for other J1939 devices which may be loading down (inhibiting) J1939 communication

Cab-mount ECU:
Looking into wire harness connector

Connector	Pin	J1939
X1	7	J1939 Low
18 Way	8	J1939 High

Troubleshooting Diagnostic Trouble Codes: ECU

1st. Blink Code	Location
13	ECU

2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	ECU (02)	
2	ECU (10)	
3	ECU (11)	
4	ECU (12)	
5	ECU (13)	
6	ECU (14)	
7	ECU (15)	
8	ECU (16)	
9	ECU (17)	
10	ECU (18)	
11	ECU (1A)	
12	ECU (1B)	
13	ECU (80)	
14	ECU (04)	
15	ECU (06)	
16	ECU (0E)	
17	ECU (0D)	
18	ECU (19)	
19	ECU (1C)	
20	ECU (27)	
21	ECU (1D)	
22	ECU (1E)	
23	ECU (28)	
24	ECU (37)	
25	ECU Internal VIN Mismatch - The ECU internally-stored VIN does not match the VIN of the vehicle. Ensure that the ECU is installed on the correct vehicle. Verify ECU programming. Verify engine programming.	

2-24: Check for damaged or corroded connectors. Check for damaged wiring. Clear trouble codes. If diagnostic trouble codes return, replace the ECU.

Troubleshooting Diagnostic Trouble Codes: Miscellaneous

1st. Blink Code	Location	
12	Miscellaneous	
2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Stop Lamp Switch Not Detected	ECU has not detected the presence of the stop lamp switch since ignition power was applied (note that stop lamp switch input may be applied to the EC-60™ controller using either hardwire input or J1939). Apply and release service brake. Check for brake switch input into ECU (see system wiring schematic). With service brake released, check for presence of the stop lamp bulb. With service brake applied, verify system voltage is now present at the stop lamp switch input to the ECU. Check for damaged wiring between ECU, stop lamp switch and bulb. Check for corroded or damaged connectors. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors on J1939 link. Verify presence of engine ECU on the J1939 link. Verify ECU configuration.
2	Stop Lamp Switch Defective	Apply and release service brake. Check for brake switch input into ECU (see system wiring schematic). With service brake released, check for presence of the stop lamp bulb. With service brake applied, verify system voltage is now present at the stop lamp switch input to the ECU. Check for damaged wiring between ECU, stop lamp switch and bulb. Check for corroded or damaged connectors. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors on J1939 link. Verify presence of engine ECU on the J1939 link. Verify ECU configuration.
3	Dynamometer Test Mode	ECU has been placed in the Dynamometer Test Mode by either the diagnostic blink code switch or a hand-held or PC-based diagnostic tool. ATC is disabled.
4	Retarder Relay Open Circuit or Shorted to Ground	Verify vehicle contains a retarder relay. Verify ECU configuration. Check wiring between ECU and retarder relay. Verify no continuity between retarder disable output of EC-60™ controller and ground. Verify condition and wiring of the retarder relay.
5	Retarder Relay Circuit Shorted to Voltage	Check wiring between ECU and retarder relay. Verify no continuity between retarder disable output of EC-60™ controller and voltage. Verify condition and wiring of the retarder relay.
6	ABS Indicator Lamp Circuit DTC	Check operation of diagnostic blink code switch. Check wiring of diagnostic blink code switch and ABS WL. Verify ABS WL ground input.
7	PMV Common Shorted to Ground	Verify no continuity between the CMN of all PMVs, TCV, and Diff Lock Solenoid and ground. Check for corroded/damaged wiring or connectors between the ECU and CMN of all PMVs, TCV, and Diff Lock Solenoid.
8	PMV Common Shorted to Voltage	Verify no continuity between the CMN of all PMVs, TCV, and Diff Lock Solenoid and voltage. Check for corroded/damaged wiring or connectors between the ECU and CMN of all PMVs, TCV, and Diff Lock Solenoid.
9	ATC Disabled to Prevent Brake Fade	ATC is temporarily disabled to prevent excessive heating of the foundation brakes.
10	Tire Size Out of Range (Front to Rear)	Verify correct tire size as desired. Verify proper tire inflation. Verify correct number of exciter ring teeth. Verify that the ECU has the proper tire size settings.
11	Wheel Speed Sensors Reversed on an Axle	Sensors are reversed (left to right) on one of the axles. Verify proper installation, connection, and wiring of the sensors.
12	Diff. Lock Solenoid Shorted to Ground or Open Circuit	Verify no continuity between the Diff Lock Solenoid and ground. Check for corroded/damaged wiring or connectors between the ECU and Diff Lock Solenoid.
13	Diff. Lock Solenoid Shorted to Voltage	Verify no continuity between the Diff Lock Solenoid and voltage. Check for corroded/damaged wiring or connectors between the ECU and Diff Lock Solenoid.
14	Sensor CAN Supply Voltage Error	Incorrect supply voltage for the SAS-60 and the YAS-60. Verify proper voltage at sensor connectors. Verify wiring between the ECU and the sensors. Verify proper output voltage from ECU.
15 - 21	Reserved	
22	ESP Sensor Voltage Out of Range	Incorrect supply voltage for the SAS-60 and the YAS-60. Verify proper voltage at sensor connectors. Verify wiring

Miscellaneous Troubleshooting (continued)

For all tests below, take all measurements at ECU harness connector pins in order to check wire harness and sensor. Probe the connector carefully so that the terminals are not damaged.

Stop Lamp Switch Test

Test	Measurement
Stop Lamp Switch to Ground	9 to 17 VDC

- Apply and release service brake, does lamp extinguish?
- Verify brake lamp switch is connected to ECU via hard wire or J1939.

Dynamometer Test Mode (ATC/ESP Indicator Lamp Continuously Illuminated)

- Clear the dynamometer test mode by depressing and releasing the blink code switch three times (or use an off-board diagnostic tool).

ABS Indicator Lamp

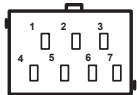
- Verify diagnostic blink code switch is open when not activated.

Steering Angle Sensor and Yaw Rate/Lateral Acceleration Sensor

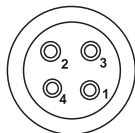
- Measure resistance between input voltage and ground at the sensor wiring harness connector.

Test	Measurement
Power and Ground Input	8 to 16 volts

Looking into wire harness connector



SAS Connector



Yaw Connector

Connector	Pin	PMV Location
SAS	2	Voltage Input
	1	Ground Input
YAS	1	Voltage Input
	2	Ground Input

Retarder Relay

- Measure resistance between retarder disable output of EC-60™ controller and voltage / ground.

Test	Measurement
Retarder disable to Voltage or Ground	Open Circuit (no continuity)

- Verify vehicle has retarder relay.
- Verify proper wiring from ECU to retarder relay.

PMV Commons

- Measure resistance between any common (PMV, TCV, and Diff.) and voltage or ground.

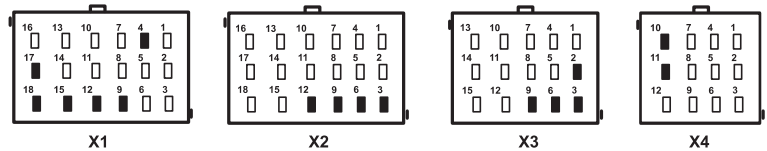
Test	Measurement
Any PMV, TCV, or Diff. Common to Voltage or Ground	Open Circuit (no continuity)

Differential Lock Solenoid

- Measure resistance between Diff lock solenoid and voltage or ground.

Test	Measurement
Diff. Lock Solenoid to Voltage or Ground	Open Circuit (no continuity)

Cab-mount ECU: Looking into wire harness connector

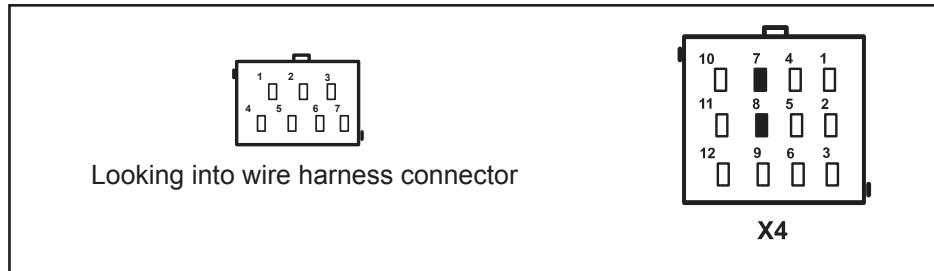


Connector	Pin	PMV Location
X1 18 Way	4	TCV Common
	9	Stop Lamp Switch
	12	ABS WL Ground
	15	ABS WL Interlock
	17	Retarder
X2 18 Way	18	ABS WL
	3	PMV Left Steer Axle Common
X3 15 Way	6	PMV Right Steer Axle Common
	9	PMV Right Drive Axle Common
	12	PMV Left Drive Axle Common
X4 12 Way	2	Diff Lock Solenoid
	3	Diff Lock Solenoid Common
X4 12 Way	6	PMV Left Additional Axle Common
	9	PMV Right Additional Axle Common
X4 12 Way	11	SAS-60/YAS-60 Voltage Input
	10	SAS-60/YAS-60 Ground Input

Troubleshooting Diagnostic Trouble Codes: Steering Angle Sensor (SAS-60™ sensor)

1st. Blink Code	Location	
21	Steering Angle Sensor	
2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	SAS Not Calibrated	SAS has not been calibrated. Perform SAS calibration procedure.
2	SAS Calibration in Progress	SAS calibration procedure is underway.
3	SAS Static Signal	SAS signal incorrect. Verify proper installation of the SAS. Verify proper wiring between the ECU and the SAS. Check SAS output.
4	SAS Signal Out of Range	SAS signal incorrect. Verify proper installation of the SAS. Verify proper wiring between the ECU and the SAS. Check SAS output. Perform SAS calibration procedure.
5	SAS Signal Reversed	SAS signal is reversed. Verify proper installation of the SAS. Verify proper wiring between the ECU and the SAS. Check SAS output.
6	SAS Invalid Signal	SAS signal is invalid. Verify proper installation of the SAS. Verify proper wiring between the ECU and the SAS. Check SAS output. Verify that correct SAS is being used.
7	SAS Gradient Error	SAS signal is invalid. Verify proper installation of the SAS. Verify proper wiring between the ECU and the SAS. Check SAS output. Verify that correct SAS is being used.
8	SAS CAN Timeout	Loss of CAN communications between the ECU and the SAS. Verify proper wiring between the ECU and the SAS. Check SAS output.
9	SAS Long Term Calibration Error	SAS calibration error. Verify proper installation of the SAS. Verify proper wiring between the ECU and the SAS. Check SAS output. Verify that correct SAS is being used. Verify proper ECU programming. Perform SAS calibration procedure.
10	SAS Plausibility Check	ECU has detected incorrect SAS signal as compared to the YAS-60 signal. Verify proper installation of the SAS. Verify proper wiring between the ECU and the SAS. Check SAS output. Verify that correct SAS is being used. Verify proper ECU programming. Perform SAS calibration procedure.

Troubleshooting Diagnostic Trouble Codes: Steering Angle Sensor (SAS-60™ sensor) (continued)



Steering Angle Sensor Tests

1. Measure resistance between input voltage and ground at the sensor wiring harness connector.

Test	Measurement
Power and Ground Input	8 to 16 volts
2 = Power Input	
1 = Ground Input	

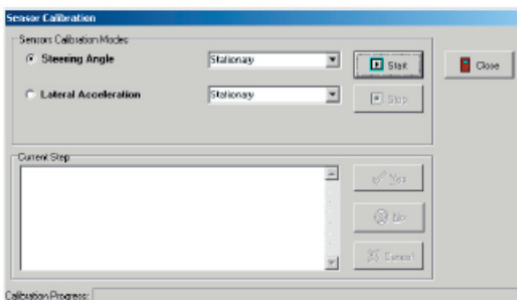
2. Verify wiring between the Steering Angle Sensor and the ECU.

SAS Wire Harness Terminal	ECU Wire Harness Terminal	Measurement
4	7	Verify Continuity
3	8	Verify Continuity

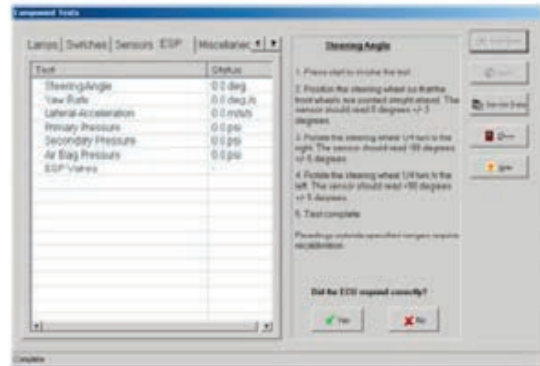
3. Verify wiring between the Steering Angle Sensor and power/ground.

SAS Wire Harness Terminal	Measurement
4 to Voltage & Ground	Verify open circuit (no continuity)
3 to Voltage & Ground	Verify open circuit (no continuity)

4. To perform a calibration procedure of the Steering Angle Sensor, ACom™ Diagnostics V4.0 is required. Using the program, select the “Configuration” option, followed by the “Calibrate” option. The following screen should be displayed.



5. Follow the prompts to perform a calibration of the Steering Angle Sensor.
6. To test the Steering Angle Sensor, ACom V4.0 is required. Using Bendix ACom V4.0, select the “Component Test” option, followed by the “ESP Test” option. The following screen should be displayed.

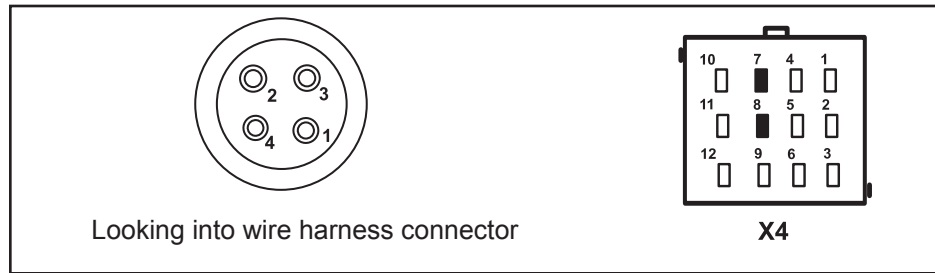


7. Follow the prompts to perform a test of the Steering Angle Sensor.

Troubleshooting Diagnostic Trouble Codes: Yaw Rate Sensor (YRS)

1st. Blink Code	Location	
22	Yaw Rate Sensor	
2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	YRS Signal Out of Range	YRS signal incorrect. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Perform YRS calibration procedure.
2	YRS Sensor Reversed Signal	YRS signal is reversed. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output.
3	YRS Invalid Signal	YRS signal is invalid. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used.
4	YRS Gradient Error	YRS signal is invalid. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used.
5	YRS CAN Timeout	Loss of CAN communications between the ECU and the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output.
6	YRS Static BITE Error	YRS signal fails static self-test. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
7	YRS Dynamic BITE Error	YRS signal fails self-test conducted while vehicle is in motion. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
8	YRS Fast Calibration Error	YRS calibration error. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
9	YRS Static Calibration Error	YRS calibration error. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
10	YRS Normal Calibration Error	YRS calibration error. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
11	YRS Sensitivity Calibration Error	YRS calibration error. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
12	YRS Plausibility Check (Ref Yaw Rate)	ECU has detected an incorrect YRS signal. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
13	YRS Plausibility Error (Inside Model Based Limits)	ECU has detected an incorrect YRS signal. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
14	YRS Plausibility Error (Outside Model Based Limits)	ECU has detected an incorrect YRS signal. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
15	YRS - SAS Signal Cross-check Incomplete	ECU (if configured) must confirm that YRS and SAS signals match. The vehicle must be exposed to an S-shaped driving maneuver for this DTC to automatically clear. If the DTC does not clear even after the S-shaped driving maneuver, check and correct the orientation of the YRS and repeat maneuver.

Troubleshooting Diagnostic Trouble Codes: Yaw Rate Sensor (YRS) (continued)



Yaw Rate Sensor Tests

1. Measure resistance between input voltage and ground at the sensor wiring harness connector.

Test	Measurement
Power and Ground Input	8 to 16 volts
1 = Power Input	
2 = Ground Input	

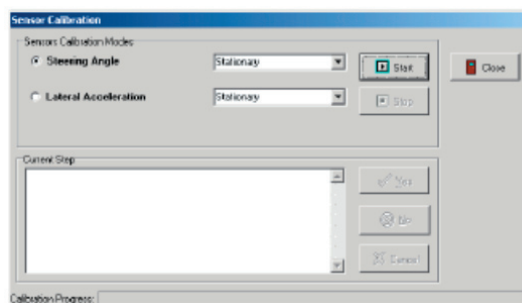
2. Verify wiring between the Yaw Rate Sensor and the ECU.

SAS Wire Harness Terminal	ECU Wire Harness Terminal	Measurement
4	7	Verify Continuity
3	8	Verify Continuity

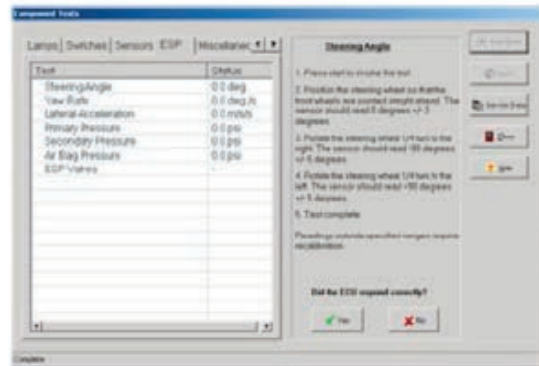
3. Verify wiring between the Yaw Rate Sensor and power/ground.

SAS Wire Harness Terminal	Measurement
4 to Voltage & Ground	Verify open circuit (no continuity)
3 to Voltage & Ground	Verify open circuit (no continuity)

4. To perform a calibration procedure of the Yaw Rate Sensor, ACom™ Diagnostics V4.0 is required. Using the program, select the “Configuration” option, followed by the “Calibrate” option. The following screen should be displayed.



5. Follow the prompts to perform a calibration of the Yaw Rate Sensor.
6. To test the Yaw Rate Sensor, ACom V4.0 is required. Using Bendix ACom V4.0, select the “Component Test” option, followed by the “ESP Test” option. The following screen should be displayed.



7. Follow the prompts to perform a test of the Yaw Rate Sensor.

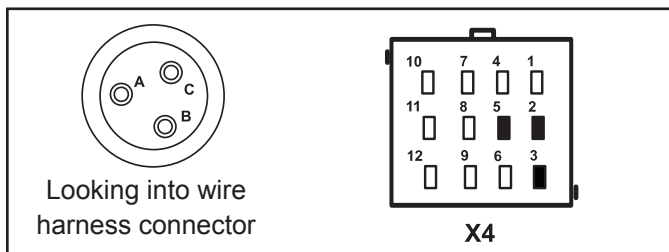
Troubleshooting Diagnostic Trouble Codes: Lateral Acceleration Sensor (LAS)

1st. Blink Code	Location	
23	Lateral Acceleration Sensor	
2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	LAS Signal Out of Range	LAS signal incorrect. Verify proper installation of the YRS/LAS. Verify proper wiring between the ECU and the YRS/LAS. Check YRS/LAS output. Perform LAS calibration procedure.
2	LAS Calibration in Progress	LAS calibration procedure is underway.
3	LAS Static Calibration Error	LAS calibration error. Verify proper installation of the YRS/LAS. Verify proper wiring between the ECU and the YRS/LAS. Check YRS/LAS output. Verify that correct YRS/LAS is being used. Verify proper ECU programming. Perform LAS calibration procedure.
4	LAS Long Term Calibration Error	LAS calibration error. Verify proper installation of the YRS/LAS. Verify proper wiring between the ECU and the YRS/LAS. Check YRS/LAS output. Verify that correct YRS/LAS is being used. Verify proper ECU programming. Perform LAS calibration procedure.
5	LAS Plausibility Error (Inside Model Based Limits)	ECU has detected an incorrect LAS signal. Verify proper installation of the YRS/LAS. Verify proper wiring between the ECU and the YRS/LAS. Check YRS/LAS output. Verify that correct YRS/LAS is being used. Verify proper ECU programming. Perform LAS calibration procedure.
6	LAS Plausibility Error (Outside Model Based Limits)	ECU has detected an incorrect LAS signal. Verify proper installation of the YRS/LAS. Verify proper wiring between the ECU and the YRS/LAS. Check YRS/LAS output. Verify that correct YRS/LAS is being used. Verify proper ECU programming. Perform LAS calibration procedure.
7	Erratic ESP Sensor Signal	ECU has detected an erratic signal. Verify proper installation of the YRS/LAS. Verify proper wiring between the ECU and the YRS/LAS. Check YRS/LAS output. Verify that correct YRS/LAS is being used. Verify proper ECU programming. Perform LAS calibration procedure.

1. Follow the steps shown in the Yaw Rate Sensor troubleshooting section for calibration and troubleshooting of the Lateral Acceleration Sensors.

Troubleshooting Diagnostic Trouble Codes Brake Demand/Load Sensors

1st. Blink Code	Location	2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
24	Brake Demand/Load Sensors	1	PS1 Open or Shorted	Check wiring between Brake Demand Sensor (primary brake circuit) and ECU. Verify operation of pressure sensor.
		2	PS2 Open or Shorted	Check wiring between Brake Demand Sensor (secondary brake circuit) and ECU. Verify operation of pressure sensor.
		3	PS3 Open or Shorted	Check wiring between Load Sensor and ECU. Verify operation of pressure sensor.
		4	PS1/2 Plausibility Error	ECU has detected an invalid pressure sensor signal from one of the Brake Demand Sensors.
		5	PS Supply Voltage Error	Incorrect supply voltage for the sensors. Verify proper voltage at sensor connectors. Verify wiring between the ECU and the sensors. Verify proper output voltage from the ECU.
		6	PS Not Calibrated	Perform static sensor calibration procedure.



Brake Demand/Load Sensor Tests

1. Measure resistance between input voltage and ground at the sensor wiring harness connector.

Test	Measurement
Power and Ground Input	4.75 to 5.25 volts
B = Power Input	
A = Ground Input	

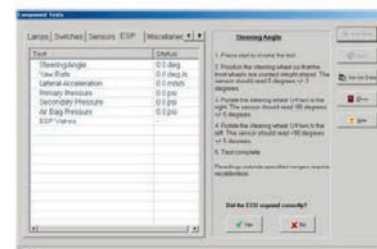
2. Verify wiring between the Load Sensor and the ECU.

Load Sensor Wire Harness Terminal	ECU Wire Harness Terminal	Measurement
C	X4 - 2 Brake Demand Sensor (primary brake circuit)	Verify Continuity
	X4 - 5 Brake Demand Sensor (secondary brake circuit)	Verify Continuity
	X4 - 3 Load Sensor	Verify Continuity

3. Verify wiring between the Load Sensor and power/ground.

Load Sensor Harness Terminal	Measurement
C to Voltage & Ground	Verify open circuit (no continuity)

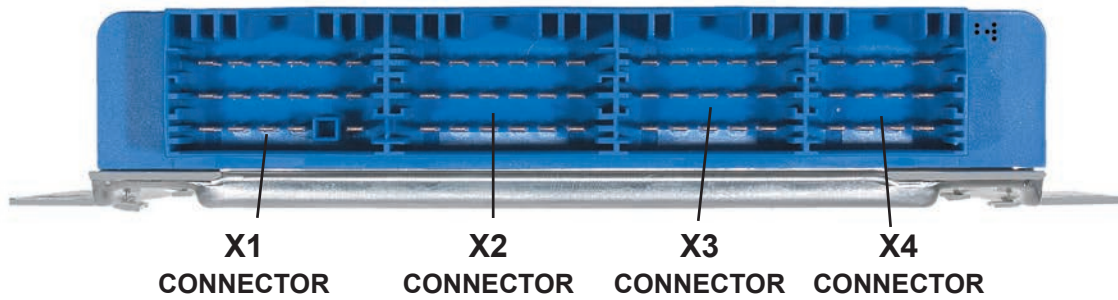
4. To perform a calibration procedure of the Brake Demand Sensor(s), ensure that the air system is fully charged. Apply ignition power, and wait 30 seconds. Perform a full application of the service brake and hold for 5 seconds. Release the service brake.
5. To test the Brake Demand Sensor and/or the Load Sensor, ACom V4.0 is required. Using the program, select the "Component Test" option, followed by the "ESP Test" option. The following screen should be displayed.



6. Follow the prompts to test of the Brake Demand Sensor(s) and/or the Load Sensor.

EC-60™ Controller Wire Harness Connector Part Numbers and Pin Assignments:

ADVANCED CAB



Advanced Cab Model EC-60™ Controller

Advanced cab models utilize four AMP connectors for wire harness connections.



X1 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	Ground	7	J1939 Low	13	J1587 (B)
2	Trailer ABS Indicator	8	J1939 High	14	J1587 (A)
3	Ignition	9	SLS Input	15	ABS Indicator Interlock
4	TCV CMN (DA)	10	WSS DA Right (+)	16	Battery
5	TCV (DA)	11	WSS DA Right (-)	17	Retarder
6	ATC/ESP Indicator and ATC ORS	12	ABS Indicator Ground	18	ABS Dash Indicator

X2 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	PMV SA Left HLD	7	PMV SA Right REL	13	PMV DA Right REL
2	PMV SA Left REL	8	WSS SA Left (-)	14	WSS SA Right (-)
3	PMV SA Left CMN	9	PMV DA Right CMN	15	WSS DA Left (+)
4	PMV SA Right HLD	10	PMV DA Right HLD	16	PMV DA Left HLD
5	WSS SA Left (+)	11	WSS SA Right (+)	17	PMV DA Left REL
6	PMV SA Right CMN	12	PMV DA Left CMN	18	WSS DA Left (-)

X3 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	ABS ORS	6	PMV AA Left CMN	11	WSS AA Left (+)
2	Diff. Lock SOL ¹	7	PMV AA Left REL	12	WSS AA Right (+)
3	TCV CMN (SA)	8	Stop Lamp Output	13	PMV AA Right REL
4	PMV AA Left HLD	9	PMV AA Right CMN	14	WSS AA Left (-)
5	TCV (SA)	10	PMV AA Right HLD	15	WSS AA Right (-)

X4 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	Pressure Sensor CMN	5	Brake Demand Secondary CKT Signal	9	PMV Trailer REL
2	Brake Demand Primary CKT Signal	6	PMV Trailer HLD	10	Sensor CAN Common
3	Load Sensor Signal	7	Sensor CAN Low	11	Sensor CAN Supply
4	Pressure Sensor Supply	8	Sensor CAN High	12	PMV Trailer CMN

¹AWD vehicles only. (AWD Transfer Case)

Troubleshooting: Wiring

ABS/ATC WIRING

ECU Wiring Harness Connectors

The Advanced EC-60™ controller is designed to interface with AMP MCP 2.8 connectors as referenced in Chart 4. Follow all AMP requirements for the repair of wire harnesses.

All wire harness connectors must be properly seated. The use of secondary locks is strongly advised.

CAUTION: All unused ECU connectors must be covered and receive proper environmental protection.

ABS Wiring Requirements

As a matter of good practice and to ensure maximum system robustness, always use the maximum size wire supported by the wire harness connectors for battery, ignition, ground, PMV, TCV, Interaxle Differential Lock and indicator lamp circuits.

All sensor and serial communications circuits (J1587 and J1939) must use twisted pair wiring (one to two twists per inch). See the appropriate SAE document for additional details.

WARNING: All wires must be carefully routed to avoid contact with rotating elements. Wiring must be properly secured approximately every 6 to 12 inches using UV stabilized, non-metallic hose clamps or bow-tie cable ties to prevent pinching, binding or fraying.

It is recommended that wires be routed straight out of a connector for a minimum of three inches before the wire is allowed to bend.




















Battery and ground wires should be kept to a minimum length.

If convoluted tubing is used, its I.D. must match the size of the wire bundle as closely as possible.

CAUTION: Wire harness lengths must be carefully selected for the vehicle. Excess lengths of wire are **not** to be wound to form coils, instead re-route, repair or replace wire harness to avoid the possibility of electrical interference and wire damage. Do not attempt to stretch harnesses that are too short, since mechanical strain can result in wire breakage.

SAS-60™ Sensors/YAS-60™ Sensor Wiring

If it is necessary to replace the wiring that connects the SAS-60 or the YAS-60 to the ECU, it is important to use the same wiring as that utilized by the vehicle OEM.

ABS Component	Connector	Wire Terminal	Wire Seal/ Plug	Terminal Lock	Terminal Crimp Tool
Controller Harness 17-Way AMP MCP 2.8 (X1)	 1718091-1	 927768-9 1 - 2.5 mm ² X1-12 & 18	N/A	 967634	 539723-2
Controller Harness 18-Way AMP MCP 2.8 (X2)	 8-968974-1	 968874 2.5 - 4 mm ²	N/A	N/A	
Controller Harness 15-Way AMP MCP 2.8 (X3)	 8-968973-1	 968873 1.0 - 2.5 mm ²	N/A	N/A	
Controller Harness 12-Way AMP MCP 2.8 (X4)	 8-968972-1		N/A	N/A	
ABS Modulator Harness AMP Twist-Lock (Bayonet)	 1-967325-2	 929975-1	N/A	N/A	 539635-1
ATC Modulator Harness AMP Twist-Lock (Bayonet)	 1-967325-3	 929975-1	N/A	N/A	
ABS Modulator Harness 3-pin Packard Metri-Pack 280 Series	 12040977	 12077411	 12015323	 12034145	 12155975

WS-24™ Wheel Speed Sensor Connectors



Packard GT
150 series



Packard Metripack
150.2 series



Deutsch DTM06
series



Packard Metripack
280 series (female)



Packard Metripack
280 series (male)



Deutsch DT04
series



Standard round
two pin

Not Shown:

SAS-60™ Sensor Connectors:

Straight Connector (4 contact, DIN 72575) (Schlemmer) part number 9800 351

90 degree Connector (4 contact, DIN 72575) (Schlemmer) part number 9800 331

Contact Pins (Schlemmer) part number 7814 125

YAS-60™ Wire Harness Connectors:

(Robert Bosch) part number 1 928 404 025

YAS-60™ Wire Harness Terminals:

(Robert Bosch) part number 1 928 498 001

Brake Demand Sensor/Load Sensor Wire Harness Connectors:

Metri-Pack Connector (Packard) part number 1206 5287

Contact Pins (Packard) part number 1210 3881

Troubleshooting: Wiring (Continued)

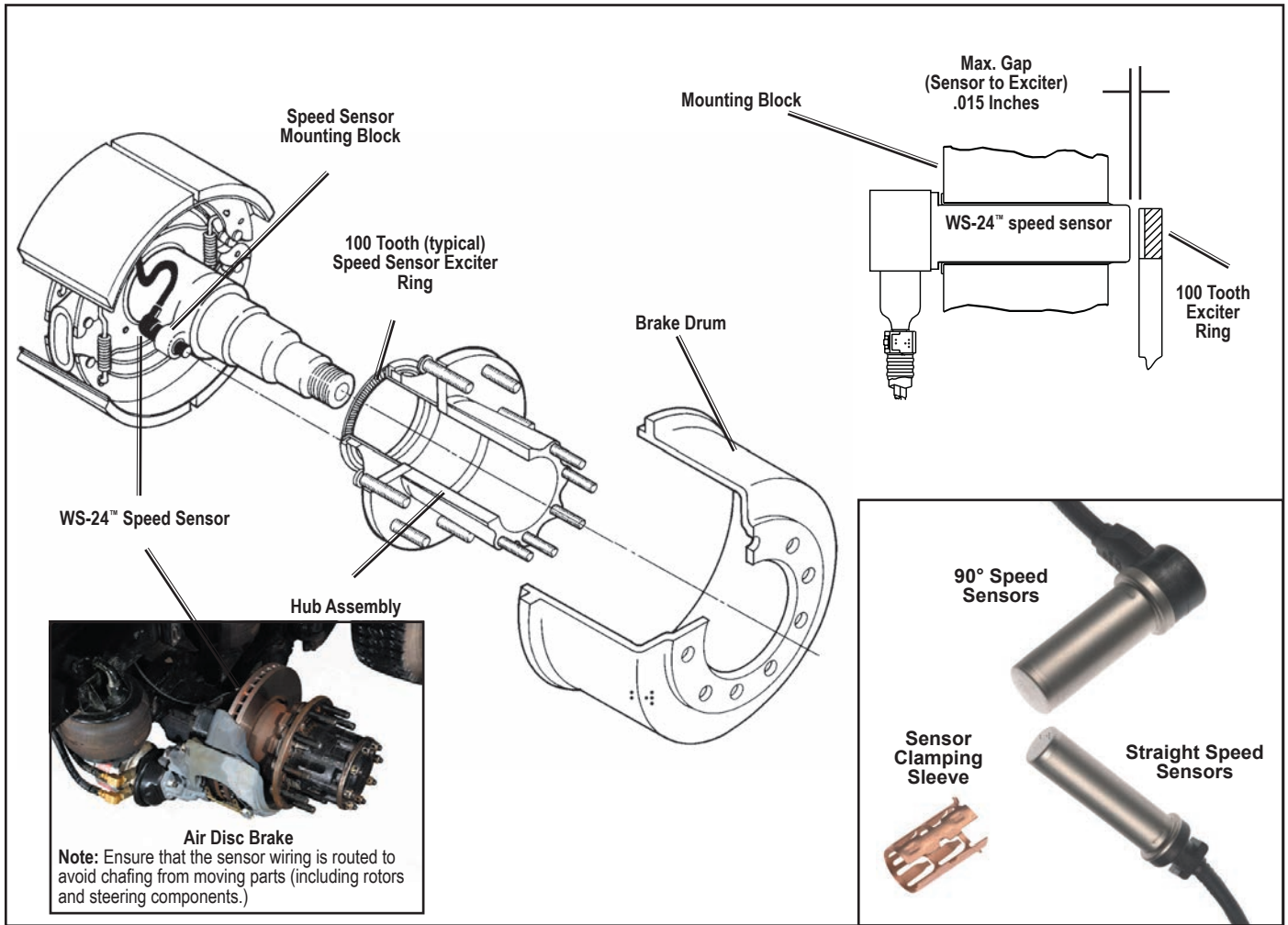


FIGURE 19 - WS-24™ WHEEL SPEED SENSOR INSTALLATION (S-CAM AND AIR DISC BRAKE)

Wheel Speed Sensor Wiring

Route sensor wiring coming out of the wheel ends away from moving brake components. Sensor wiring needs to be secured to the axle to prevent excess cable length and wiring damage. It is required that cable ties be installed to the sensor wire within 3 inches (76.2 mm) of the sensor head to provide strain relief.

Following the axle, the sensor wires must be attached along the length of the service brake hoses using cable ties with ultraviolet protection and secured every 6 to 8 inches (152 to 203 mm). Sufficient – but not excessive – cable length must be provided to permit full suspension travel and steering axle movement. Install wires so that they cannot touch rotating elements such as wheels, brake discs or drive shafts. Radiation protection may be necessary in the area of brake discs.

Bendix does not recommend using standard tie-wraps to secure wiring harnesses directly to rubber air lines. This may cause premature wiring failure from the pressure exerted on the wiring when air pressure is applied through the air line. Non-metallic hose clamps or bow-tie tie-wraps are preferred.

The use of grommets or other suitable protection is required whenever the cable must pass through metallic frame members.

All sensor wiring must utilize twisted pair wire, with approximately one to two twists per inch.

It is recommended that wires be routed straight out of a connector for a minimum of three inches before the wire is allowed to bend.

Glossary

ABS — Antilock Brake System.

ABS Event — Impending wheel lock situation that causes the ABS controller to activate the modulator valve(s).

ABS Indicator Lamp — An amber lamp which indicates the operating status of an antilock system. When the indicator lamp is on, ABS is disabled and the vehicle reverts to normal brake operation.

Air Gap — Distance between the Sensor and tone ring.

ASR — Automatic Slip Regulation. Another name for traction control.

ATC — Automatic Traction Control. An additional ABS function in which engine torque is controlled and brakes are applied differentially to enhance vehicle traction.

ATC/ESP Lamp — A lamp that indicates when stability functions, including traction control, roll stability program or yaw control are operating.

Channel — A controlled wheel site.

CAN — Controller Area Network. J1939 is an SAE version of the CAN link.

Clear Codes — System to erase historical diagnostic trouble codes from the ECU, from either the Diagnostic Switch or from a hand-held diagnostic tool (only repaired diagnostic trouble codes may be cleared).

Configuration — The primary objective is to identify a “normal” set of sensors and modulators for the Electronic Control Unit, so that it will identify future missing sensors and modulators.

Diagnostic Connector — Diagnostic receptacle in vehicle cab for connection of J1587 hand-held or PC based test equipment. The tester can initiate test sequences, and can also read system parameters.

Diagnostic Switch — A switch used to activate blinks codes.

Differential Braking — Application of brake force to a spinning wheel so that torque can be applied to wheels which are not slipping.

ECU — Electronic Control Unit.

ESP — Electronic Stability Program. Full stability function that includes RSP & YC subfunctions.

Diagnostic Trouble Code — A condition that interferes with the generation or transmission of response or control signals in the vehicle's ABS system that could lead to the functionality of the ABS system becoming inoperable in whole or in part.

FMVSS-121 — Federal Motor Vehicle Safety Standard which regulates air brake systems.

IR — Independent Regulation. A control method in which a wheel is controlled at optimum slip, a point where retardation and stability are maximized. The brake pressure that is best for the wheel in question is directed individually into each brake chamber.

J1587 — The SAE heavy duty standard diagnostic data link.

J1708 — An SAE standard which defines the hardware and software protocol for implementing 9600 baud heavy vehicle data links. J1587 version of a J1708 data link.

J1939 — A high speed 250,000 baud data link used for communications between the ABS ECU engine, transmission and retarders.

LAS — Lateral Acceleration Sensor.

MIR — Modified Independent Regulation. A method of controlling the opposite sides of a steer axle during ABS operation so that torque steer and stopping distance are minimized.

PLC — Power Line Carrier. The serial communication protocol used to communicate with the trailer over the blue full time power wire.

PMV — Pressure Modulator Valve. An air valve which is used to vent or block air to the brake chambers to limit or reduce brake torque.

QR — Quick Release. Quick release valves allow faster release of air from the brake chamber after a brake application. To balance the system, quick release valves have hold off springs that produce higher crack pressures (when the valves open).

Relay Valve — Increases the application speed of the service brake. Installed near brakes with larger air chambers (type 24 or 30). The treadle valve activates the relay valve with an air signal. The relay valve then connects its supply port to its delivery ports. Equal length air hose must connect the delivery ports of the relay valve to the brake chambers.

Retarder Relay — A relay which is used to disable a retarder when ABS is triggered.

RSP — Roll Stability Program. An all-axle ABS solution that helps reduce vehicle speed by applying all vehicle brakes as needed, reducing the tendency to roll over.

SAS — Steering Angle Sensor.

Sensor Clamping Sleeve — A beryllium copper sleeve which has fingers cut into it. It is pressed between an ABS sensor and mounting hole to hold the sensor in place.

Stored Diagnostic Trouble Codes — A diagnostic trouble code that occurred.

TCS — Traction Control System, another name for ATC or ASR.

Tone Ring — A ring that is usually pressed into a wheel hub that has a series of teeth (usually 100) and provides actuation for the speed sensor. Note maximum run out is .008.

YC — Yaw Control. Helps stabilize rotational dynamics of vehicle.

YRS — Yaw Rate Sensor.

Appendix A: J1587 SID and FMI Codes and Their Bendix Blink Code Equivalents

SID (J1587)	FMI (J1587)	General	Bendix Blink Code Equivalent(s) (1st Digit) (2nd Digit)	Diagnostic Trouble Code Description
-	-	No DTCs	1 1	No DTCs
1	1	Wheel Speed Sensor DTCs	2 1	SA Left WSS Excessive Air Gap
2	1	Wheel Speed Sensor DTCs	3 1	SA Right WSS Excessive Air Gap
3	1	Wheel Speed Sensor DTCs	4 1	DA Left WSS Excessive Air Gap
4	1	Wheel Speed Sensor DTCs	5 1	DA Right WSS Excessive Air Gap
5	1	Wheel Speed Sensor DTCs	14 1	AA Left WSS Excessive Air Gap
6	1	Wheel Speed Sensor DTCs	15 1	AA Right WSS Excessive Air Gap
1	14	Wheel Speed Sensor DTCs	2 2	SA Left WSS Output Low @ Drive-Off
2	14	Wheel Speed Sensor DTCs	3 2	SA Right WSS Output Low @ Drive-Off
3	14	Wheel Speed Sensor DTCs	4 2	DA Left WSS Output Low @ Drive-Off
4	14	Wheel Speed Sensor DTCs	5 2	DA Right WSS Output Low @ Drive-Off
5	14	Wheel Speed Sensor DTCs	14 2	AA Left WSS Output Low @ Drive-Off
6	14	Wheel Speed Sensor DTCs	15 2	AA Right WSS Output Low @ Drive-Off
1	2	Wheel Speed Sensor DTCs	2 3	SA Left WSS Open or Shorted
2	2	Wheel Speed Sensor DTCs	3 3	SA Right WSS Open or Shorted
3	2	Wheel Speed Sensor DTCs	4 3	DA Left WSS Open or Shorted
4	2	Wheel Speed Sensor DTCs	5 3	DA Right WSS Open or Shorted
5	2	Wheel Speed Sensor DTCs	14 3	AA Left WSS Open or Shorted
6	2	Wheel Speed Sensor DTCs	15 3	AA Right WSS Open or Shorted
1	10	Wheel Speed Sensor DTCs	2 4	SA Left WSS Loss of Sensor Signal
2	10	Wheel Speed Sensor DTCs	3 4	SA Right WSS Loss of Sensor Signal
3	10	Wheel Speed Sensor DTCs	4 4	DA Left WSS Loss of Sensor Signal
4	10	Wheel Speed Sensor DTCs	5 4	DA Right WSS Loss of Sensor Signal
5	10	Wheel Speed Sensor DTCs	14 4	AA Left WSS Loss of Sensor Signal
6	10	Wheel Speed Sensor DTCs	15 4	AA Right WSS Loss of Sensor Signal
1	7	Wheel Speed Sensor DTCs	2 5	SA Left WSS Wheel End
2	7	Wheel Speed Sensor DTCs	3 5	SA Right WSS Wheel End
3	7	Wheel Speed Sensor DTCs	4 5	DA Left WSS Wheel End
4	7	Wheel Speed Sensor DTCs	5 5	DA Right WSS Wheel End
5	7	Wheel Speed Sensor DTCs	14 5	AA Left WSS Wheel End
6	7	Wheel Speed Sensor DTCs	15 5	AA Right WSS Wheel End
1	8	Wheel Speed Sensor DTCs	2 6	SA Left WSS Erratic Sensor Signal
2	8	Wheel Speed Sensor DTCs	3 6	SA Right WSS Erratic Sensor Signal
3	8	Wheel Speed Sensor DTCs	4 6	DA Left WSS Erratic Sensor Signal
4	8	Wheel Speed Sensor DTCs	5 6	DA Right WSS Erratic Sensor Signal
5	8	Wheel Speed Sensor DTCs	14 6	AA Left WSS Erratic Sensor Signal
6	8	Wheel Speed Sensor DTCs	15 6	AA Right WSS Erratic Sensor Signal
1	13	Wheel Speed Sensor DTCs	2 7	SA Left WSS Tire Size Calibration
2	13	Wheel Speed Sensor DTCs	3 7	SA Right WSS Tire Size Calibration
3	13	Wheel Speed Sensor DTCs	4 7	DA Left WSS Tire Size Calibration
4	13	Wheel Speed Sensor DTCs	5 7	DA Right WSS Tire Size Calibration
5	13	Wheel Speed Sensor DTCs	14 7	AA Left WSS Tire Size Calibration
6	13	Wheel Speed Sensor DTCs	15 7	AA Right WSS Tire Size Calibration
1	9	Wheel Speed Sensor DTCs	2 9	SA Left WSS (RESERVED)
2	9	Wheel Speed Sensor DTCs	3 9	SA Right WSS (RESERVED)
3	9	Wheel Speed Sensor DTCs	4 9	DA Left WSS (RESERVED)
4	9	Wheel Speed Sensor DTCs	5 9	DA Right WSS (RESERVED)
5	9	Wheel Speed Sensor DTCs	14 9	AA Left WSS (RESERVED)
6	9	Wheel Speed Sensor DTCs	15 9	AA Right WSS (RESERVED)
5	13	Wheel Speed Sensor DTCs	14 10	AA Left WSS Configuration Error
6	13	Wheel Speed Sensor DTCs	15 10	AA Right WSS Configuration Error
251	4	Power Supply DTCs	6 1	Battery Voltage Too Low
251	3	Power Supply DTCs	6 2	Battery Voltage Too High
251	4	Power Supply DTCs	6 3	Battery Voltage Too Low During ABS
251	5	Power Supply DTCs	6 4	Battery Voltage Input Open Circuit
251	4	Power Supply DTCs	6 5	Ignition Voltage Too Low
251	3	Power Supply DTCs	6 6	Ignition Voltage Too High
251	4	Power Supply DTCs	6 7	Ignition Voltage Too Low During ABS
251	2	Power Supply DTCs	6 8	Input Voltage Excessive Noise (Temp.)
251	14	Power Supply DTCs	6 9	Input Voltage Excessive Noise (Latched)
48	4	Pressure Modulator Valve DTCs	7 1	SA Left PMV REL Solenoid Shorted to Ground
49	4	Pressure Modulator Valve DTCs	8 1	SA Right PMV REL Solenoid Shorted to Ground
50	4	Pressure Modulator Valve DTCs	9 1	DA Left PMV REL Solenoid Shorted to Ground
51	4	Pressure Modulator Valve DTCs	10 1	DA Right PMV REL Solenoid Shorted to Ground
52	4	Pressure Modulator Valve DTCs	16 1	AA Left PMV REL Solenoid Shorted to Ground

SID (J1587)	FMI (J1587)	General	Bendix Blink Code Equivalent(s)		Diagnostic Trouble Code Description
			(1st Digit)	(2nd Digit)	
53	4	Pressure Modulator Valve DTCs	17	1	AA Right PMV REL Solenoid Shorted to Ground
66	4	Pressure Modulator Valve DTCs	20	1	Trailer PMV REL Solenoid Shorted to Ground
48	3	Pressure Modulator Valve DTCs	7	2	SA Left PMV REL Solenoid Shorted to Voltage
49	3	Pressure Modulator Valve DTCs	8	2	SA Right PMV REL Solenoid Shorted to Voltage
50	3	Pressure Modulator Valve DTCs	9	2	DA Left PMV REL Solenoid Shorted to Voltage
51	3	Pressure Modulator Valve DTCs	10	2	DA Right PMV REL Solenoid Shorted to Voltage
52	3	Pressure Modulator Valve DTCs	16	2	AA Left PMV REL Solenoid Shorted to Voltage
53	3	Pressure Modulator Valve DTCs	17	2	AA Right PMV REL Solenoid Shorted to Voltage
66	3	Pressure Modulator Valve DTCs	20	2	Trailer PMV REL Solenoid Shorted to Voltage
48	5	Pressure Modulator Valve DTCs	7	3	SA Left PMV REL Solenoid Open Circuit
49	5	Pressure Modulator Valve DTCs	8	3	SA Right PMV REL Solenoid Open Circuit
50	5	Pressure Modulator Valve DTCs	9	3	DA Left PMV REL Solenoid Open Circuit
51	5	Pressure Modulator Valve DTCs	10	3	DA Right PMV REL Solenoid Open Circuit
52	5	Pressure Modulator Valve DTCs	16	3	AA Left PMV REL Solenoid Open Circuit
53	5	Pressure Modulator Valve DTCs	17	3	AA Right PMV REL Solenoid Open Circuit
66	5	Pressure Modulator Valve DTCs	20	3	Trailer PMV REL Solenoid Open Circuit
42	4	Pressure Modulator Valve DTCs	7	4	SA Left PMV HLD Solenoid Shorted to Ground
43	4	Pressure Modulator Valve DTCs	8	4	SA Right PMV HLD Solenoid Shorted to Ground
44	4	Pressure Modulator Valve DTCs	9	4	DA Left PMV HLD Solenoid Shorted to Ground
45	4	Pressure Modulator Valve DTCs	10	4	DA Right PMV HLD Solenoid Shorted to Ground
46	4	Pressure Modulator Valve DTCs	16	4	AA Left PMV HLD Solenoid Shorted to Ground
47	4	Pressure Modulator Valve DTCs	17	4	AA Right PMV HLD Solenoid Shorted to Ground
66	4	Pressure Modulator Valve DTCs	20	4	Trailer PMV HLD Solenoid Shorted to Ground
42	3	Pressure Modulator Valve DTCs	7	5	SA Left PMV HLD Solenoid Shorted to Voltage
43	3	Pressure Modulator Valve DTCs	8	5	SA Right PMV HLD Solenoid Shorted to Voltage
44	3	Pressure Modulator Valve DTCs	9	5	DA Left PMV HLD Solenoid Shorted to Voltage
45	3	Pressure Modulator Valve DTCs	10	5	DA Right PMV HLD Solenoid Shorted to Voltage
46	3	Pressure Modulator Valve DTCs	16	5	AA Left PMV HLD Solenoid Shorted to Voltage
47	3	Pressure Modulator Valve DTCs	17	5	AA Right PMV HLD Solenoid Shorted to Voltage
66	3	Pressure Modulator Valve DTCs	20	5	Trailer PMV HLD Solenoid Shorted to Voltage
42	5	Pressure Modulator Valve DTCs	7	6	SA Left PMV HLD Solenoid Open Circuit
43	5	Pressure Modulator Valve DTCs	8	6	SA Right PMV HLD Solenoid Open Circuit
44	5	Pressure Modulator Valve DTCs	9	6	DA Left PMV HLD Solenoid Open Circuit
45	5	Pressure Modulator Valve DTCs	10	6	DA Right PMV HLD Solenoid Open Circuit
46	5	Pressure Modulator Valve DTCs	16	6	AA Left PMV HLD Solenoid Open Circuit
47	5	Pressure Modulator Valve DTCs	17	6	AA Right PMV HLD Solenoid Open Circuit
66	5	Pressure Modulator Valve DTCs	20	6	Trailer PMV HLD Solenoid Open Circuit
7	5	Pressure Modulator Valve DTCs	7	7	SA Left PMV CMN Open Circuit
8	5	Pressure Modulator Valve DTCs	8	7	SA Right PMV CMN Open Circuit
9	5	Pressure Modulator Valve DTCs	9	7	DA Left PMV CMN Open Circuit
10	5	Pressure Modulator Valve DTCs	10	7	DA Right PMV CMN Open Circuit
11	5	Pressure Modulator Valve DTCs	16	7	AA Left PMV CMN Open Circuit
12	5	Pressure Modulator Valve DTCs	17	7	AA Right PMV CMN Open Circuit
66	5	Pressure Modulator Valve DTCs	20	7	Trailer PMV CMN Open Circuit
7	13	Pressure Modulator Valve DTCs	7	8	SA Left PMV Configuration Error
8	13	Pressure Modulator Valve DTCs	8	8	SA Right PMV Configuration Error
9	13	Pressure Modulator Valve DTCs	9	8	DA Left PMV Configuration Error
10	13	Pressure Modulator Valve DTCs	10	8	DA Right PMV Configuration Error
11	13	Pressure Modulator Valve DTCs	16	8	AA Left PMV Configuration Error
12	13	Pressure Modulator Valve DTCs	17	8	AA Right PMV Configuration Error
231	12	J1939 DTCs	11	1	J1939 Serial Link
231	14	J1939 DTCs	11	2	J1939 Retarder
231	2	J1939 DTCs	11	3	J1939 Engine Communications
231	2	J1939 DTCs	11	10	Invalid Data From Transmission
231	2	J1939 DTCs	11	4	J1939 Invalid Data (Engine/Retarder)
231	2	J1939 DTCs	11	5	J1939 Supply Pressure
231	2	J1939 DTCs	11	6	J1939 ESP Messages Invalid Data
55	7	Miscellaneous DTCs	12	1	Stop Lamp Switch Not Detected
55	2	Miscellaneous DTCs	12	2	Stop Lamp Switch Defective
17	14	Miscellaneous DTCs	12	3	Dynamometer Test Mode
13	2	Miscellaneous DTCs	12	4	Retarder Relay Open Circuit or Shorted to Ground
13	3	Miscellaneous DTCs	12	5	Retarder Relay Circuit Shorted to Voltage
23	2	Miscellaneous DTCs	12	6	ABS Dash Indicator Circuit DTC
93	4	Miscellaneous DTCs	12	7	PMV Common Shorted to Ground
93	3	Miscellaneous DTCs	12	8	PMV Common Shorted to Voltage
17	14	Miscellaneous DTCs	12	9	ATC Disabled to Prevent Brake Fade
79	13	Miscellaneous DTCs	12	10	Tire Size Out of Range (Front to Rear)

SID (J1587)	FMI (J1587)	General	Bendix Blink Code Equivalent(s) (1st Digit) (2nd Digit)		Diagnostic Trouble Code Description
22	7	Miscellaneous DTCs	12	11	Wheel Speed Sensors Reversed on an Axle
102	5	Miscellaneous DTCs	12	12	Diff Lock Solenoid Shorted to Ground or Open Circuit
102	3	Miscellaneous DTCs	12	13	Diff Lock Solenoid Shorted to Voltage
103	2	Miscellaneous DTCs	12	14	Sensor CAN Supply Voltage Error
N/A	N/A	Miscellaneous DTCs	12	15	Reserved
"	"	Miscellaneous DTCs	12	16	Reserved
"	"	Miscellaneous DTCs	12	17	Reserved
"	"	Miscellaneous DTCs	12	18	Reserved
"	"	Miscellaneous DTCs	12	19	Reserved
"	"	Miscellaneous DTCs	12	20	Reserved
"	"	Miscellaneous DTCs	12	21	Reserved
103	2	Miscellaneous DTCs	12	22	ESP Sensor Voltage Out of Range
254	12	ECU DTCs	13	1	ECU (02)
254	12	ECU DTCs	13	2	ECU (10)
254	12	ECU DTCs	13	3	ECU (11)
254	2	ECU DTCs	13	4	ECU (12)
254	2	ECU DTCs	13	5	ECU (13)
254	12	ECU DTCs	13	6	ECU (14)
254	2	ECU DTCs	13	7	ECU (15)
254	13	ECU DTCs	13	8	ECU (16)
254	13	ECU DTCs	13	9	ECU (17)
254	12	ECU DTCs	13	10	ECU (18)
254	12	ECU DTCs	13	11	ECU (1A)
254	12	ECU DTCs	13	12	ECU (1B)
254	12	ECU DTCs	13	13	ECU (80)
254	12	ECU DTCs	13	14	ECU (04)
254	12	ECU DTCs	13	15	ECU (06)
254	12	ECU DTCs	13	16	ECU (0E)
254	2	ECU DTCs	13	17	ECU (0D)
254	2	ECU DTCs	13	18	ECU (19)
253	12	ECU DTCs	13	19	ECU (1C)
253	12	ECU DTCs	13	20	ECU (27)
253	13	ECU DTCs	13	21	ECU (1D)
253	13	ECU DTCs	13	22	ECU (1E)
253	13	ECU DTCs	13	23	ECU (28)
254	12	ECU DTCs	13	24	ECU (37)
254	12	ECU DTCs	13	25	ECU Internal VIN Mismatch
18	4	TCV DTCs	18	1	TCV DA Solenoid Shorted to Ground
18	3	TCV DTCs	18	2	TCV DA Solenoid Shorted to Voltage
18	5	TCV DTCs	18	3	TCV DA Solenoid Open Circuit
18	13	TCV DTCs	18	4	TCV DA Configuration Error
19	4	TCV DTCs	19	1	TCV SA Solenoid Shorted to Ground
19	3	TCV DTCs	19	2	TCV SA Solenoid Shorted to Voltage
19	5	TCV DTCs	19	3	TCV SA Solenoid Open Circuit
19	13	TCV DTCs	19	4	TCV SA Configuration Error
89	13	Steering Angle Sensor DTCs	21	1	SAS Not Calibrated
89	13	Steering Angle Sensor DTCs	22	15	YRS Sign Check Not Finished
89	13	Steering Angle Sensor DTCs	21	2	SAS Calibration in Progress
89	2	Steering Angle Sensor DTCs	21	3	SAS Static Signal
89	2	Steering Angle Sensor DTCs	21	4	SAS Signal Out of Range
89	2	Steering Angle Sensor DTCs	21	5	SAS Signal Reversed
89	12	Steering Angle Sensor DTCs	21	6	SAS Invalid Signal
89	2	Steering Angle Sensor DTCs	21	7	SAS Gradient Error
89	9	Steering Angle Sensor DTCs	21	8	SAS CAN Timeout
89	2	Steering Angle Sensor DTCs	21	9	SAS Long Term Calibration Error
89	2	Steering Angle Sensor DTCs	21	10	SAS Plausibility Check (Ref Yaw Rate)
103	2	Yaw Rate Sensor DTCs	22	1	YRS Signal Out of Range
103	2	Yaw Rate Sensor DTCs	22	2	YRS Sensor Reversed Signal
103	2	Yaw Rate Sensor DTCs	22	3	YRS Invalid Signal
103	2	Yaw Rate Sensor DTCs	22	4	YRS Gradient Error
103	9	Yaw Rate Sensor DTCs	22	5	YRS CAN Timeout
103	2	Yaw Rate Sensor DTCs	22	6	YRS Static BITE Error
103	2	Yaw Rate Sensor DTCs	22	7	YRS Dynamic BITE Error
103	2	Yaw Rate Sensor DTCs	22	8	YRS Fast Calibration Error
103	2	Yaw Rate Sensor DTCs	22	9	YRS Static Calibration Error
103	2	Yaw Rate Sensor DTCs	22	10	YRS Normal Calibration Error
103	2	Yaw Rate Sensor DTCs	22	11	YRS Sensitivity Calibration Error

SID (J1587)	FMI (J1587)	General	Bendix Blink Code Equivalent(s) (1st Digit) (2nd Digit)	Diagnostic Trouble Code Description
103	2	Yaw Rate Sensor DTCs	22 12	YRS Plausibility Check (Ref Yaw Rate)
103	2	Yaw Rate Sensor DTCs	22 13	YRS Plausibility Error (Inside Model Based Limits)
103	2	Yaw Rate Sensor DTCs	22 14	YRS Plausibility Error (Outside Model Based Limits)
99	2	Lateral Acceleration Sensor DTCs	23 1	LAS Signal Out of Range
99	13	Lateral Acceleration Sensor DTCs	23 2	LAS Calibration in Progress
99	2	Lateral Acceleration Sensor DTCs	23 3	LAS Static Calibration Error
99	2	Lateral Acceleration Sensor DTCs	23 4	LAS Long Term Calibration Error
99	12	Lateral Acceleration Sensor DTCs	23 5	LAS Plausibility Error (Inside Model Based Limits)
99	12	Lateral Acceleration Sensor DTCs	23 6	LAS Plausibility Error (Outside Model Based Limits)
99	14	Lateral Acceleration Sensor DTCs	23 7	Erratic ESP Sensor Signal
77	2	Brake Demand/Load Sensor DTCs	24 1	Shorted Brake Demand Sensor (Primary CKT) Open
78	2	Brake Demand/Load Sensor DTCs	24 2	Shorted Brake Demand Sensor (Secondary CKT) Open
69	2	Brake Demand/Load Sensor DTCs	24 3	Open or Shorted Load Sensor
77	11	Brake Demand/Load Sensor DTCs	24 4	Plausibility Error Brake Demand Sensor
77	2	Brake Demand/Load Sensor DTCs	24 5	PS Supply Voltage Error
77	7	Brake Demand/Load Sensor DTCs	24 6	PS Not Calibrated
89	13	Yaw Rate Sensor	22 15	Check Incomplete





Service Data

SD-13-4870

Bendix® M-32™ and M-32QR™ AntiLock Modulators

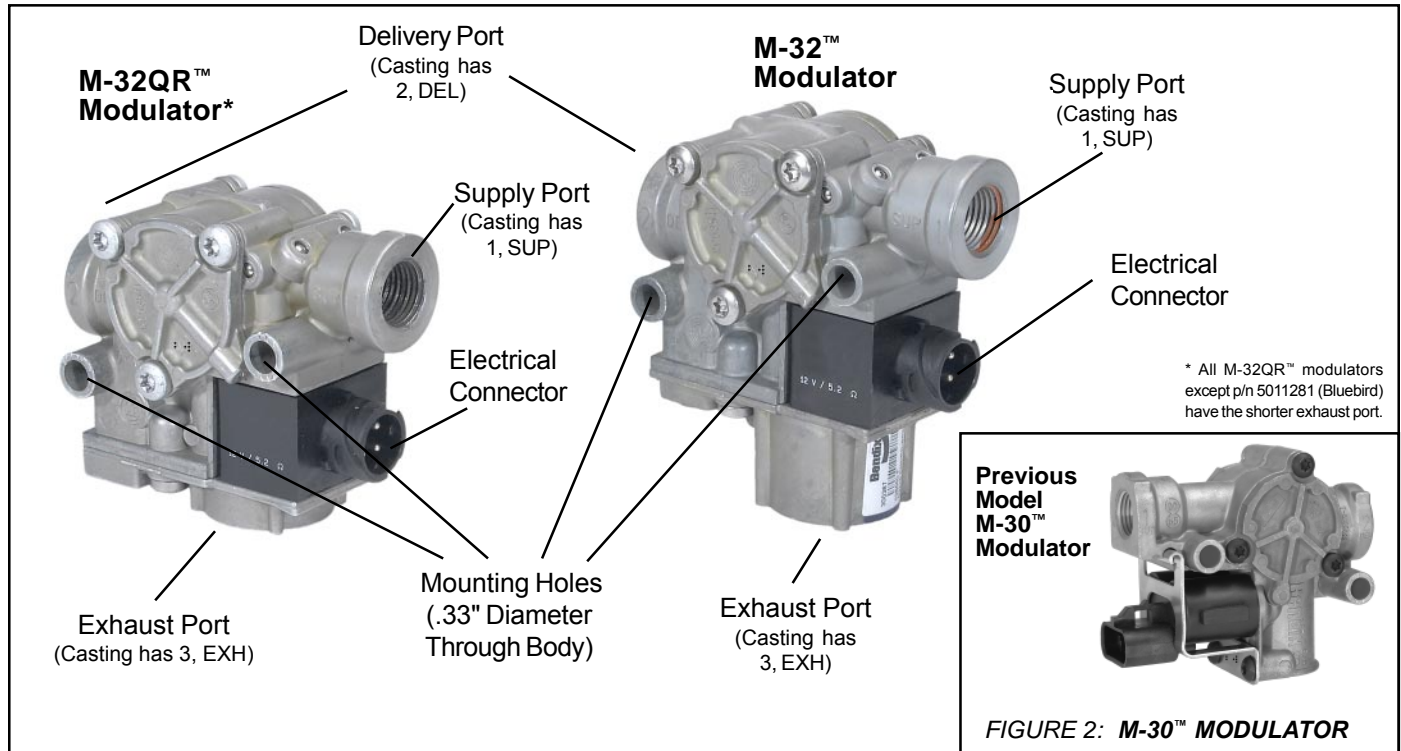


FIGURE 1: M-32™ AND M-32QR™ MODULATORS

DESCRIPTION

The M-32™ and M-32QR™ (quick release) antilock system modulators (Figure 1) are high capacity, on/off air valves that incorporate a pair of electrical solenoids for control. The solenoids provide the electro-pneumatic interface between the antilock controller electronics and the air brake system. The modulator is used to control the braking function on individual or dual service actuators during antilock activity.

The M-32QR™ modulator is the direct replacement for the M-30™ (Figure 2) modulator in all applications. The M-32QR™ modulator includes a bias valve to provide an internal quick release function. In applications using an M-32™ modulator, an external quick release valve may be required, depending on the system design (see Figure 3 for typical system schematics). When used to control both service chambers on an axle or two chambers on the same side of a tandem axle, the modulator is sometimes mounted ahead of a quick release valve, which provides quick exhaust of service applications during normal braking. In the case of individual wheel control applications, the modulator is always the last control valve through which air passes on its way to the service brake actuator.

The modulator consists of a die cast aluminum body and a solenoid assembly which contains one normally open solenoid, one normally closed solenoid, and an inlet and exhaust diaphragm valve. A three pin, weather resistant electrical connector is an integral part of the modulator solenoid assembly and serves to carry control commands from the antilock controller to the modulator. Two mounting holes are provided for frame or cross member mounting of the valve.

The supply, delivery and exhaust ports on the M-32™ modulator are identified with a cast, embossed numeral for positive identification.

Identification	Air Line Connection
1, SUP (incoming air from foot, relay or quick release valve)	Supply
2, DEL (air delivery to service actuators)	Delivery
3, EXH	Exhaust

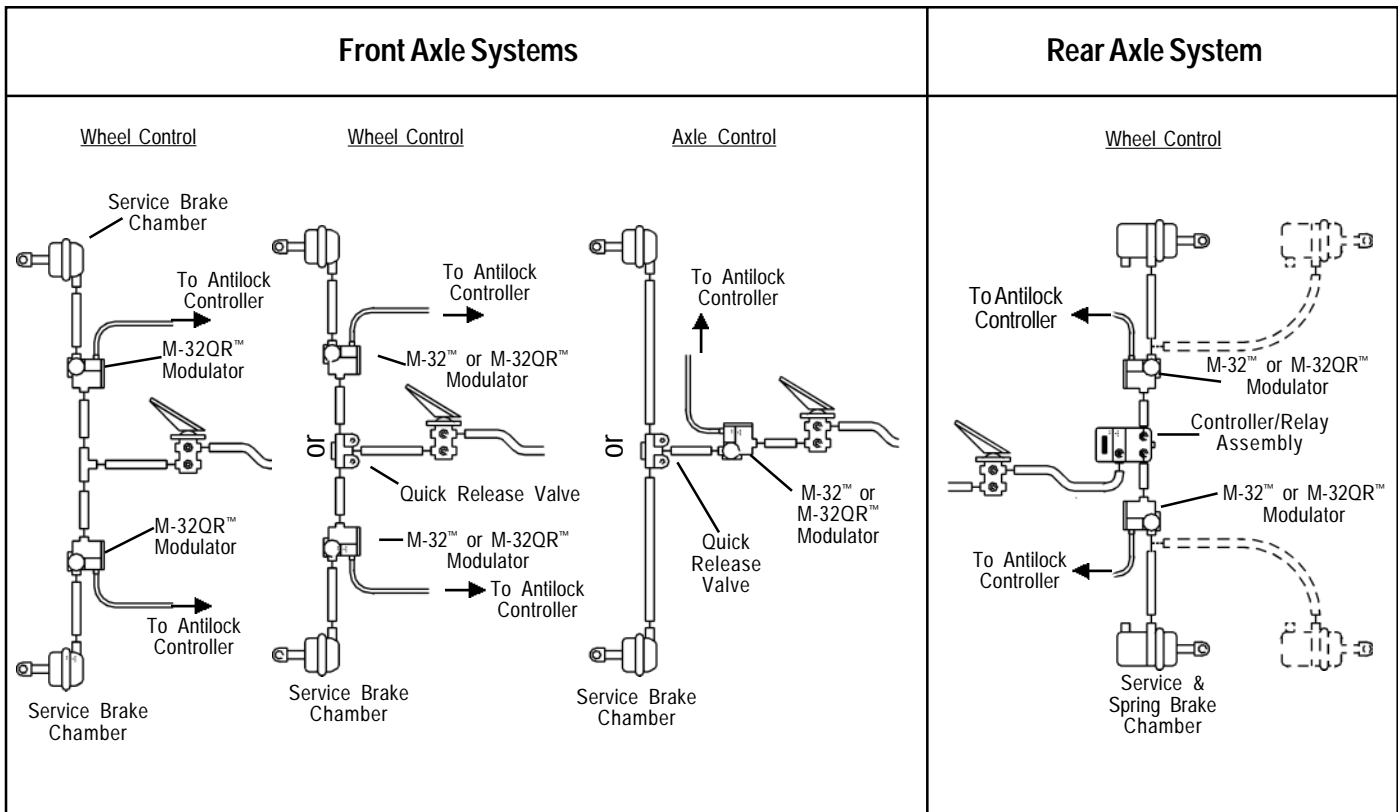


FIGURE 3: TYPICAL WHEEL AND AXLE CONTROL SYSTEMS

NOTE: use of a quick release valve is not typically required with the M-32QR™ modulator. Refer to vehicle specifications for recommended configuration.

FUNCTIONAL CHECK

A wiring harness connects the vehicle modulators to the controller. The ABS controller is able to simultaneously and independently control the individual modulators. When vehicle power is supplied to the ABS ECU, a modulator "chuff" test is performed. When the brake pedal is depressed and the ignition turned on, the modulator "chuff" test can be heard. This test will verify if the modulator is functioning pneumatically correct. The modulators will exhaust air in the sequence of right front, left front, right rear, left rear. If they do not follow this sequence, proceed with modulator troubleshooting.

OPERATION

NON-ANTILOCK BRAKE APPLICATION (Figure 4)

During normal, non antilock braking, both solenoids are de-energized (no electrical power). Brake application air enters the Supply port of the modulator and flows to the exhaust diaphragm. Air pressure, along with spring force, seats the exhaust diaphragm on the exhaust passage, thus preventing the escape of service air. Simultaneously, application air flows to the supply diaphragm and forces it away from its seat. Air flows past the open supply port and out the modulator delivery port to the service brake chambers.

NON-ANTILOCK HOLD (Figure 5)

When the desired air pressure is attained in the service brake chambers, the brake system is in the Holding position. In the Holding position, both solenoids in the modulator remain de-energized and the balance of the internal components remain in the same position as they assumed during application.

NON-ANTILOCK EXHAUST

The manner in which air exhausts through the modulator differs depends upon how rapidly the brake application is released by the driver.

Normal Exhaust (Figure 6) - During a normal, relatively "slow" brake release, air moves back through the modulator in the reverse direction as it flowed during application. The internal components of the modulator will remain in the same position as they assumed during application until air pressure decreases to approximately one half psi, at which time the supply diaphragm will seat on the supply passage. A relatively small amount of air will generally be expelled from the modulator exhaust port during "slow" brake release.

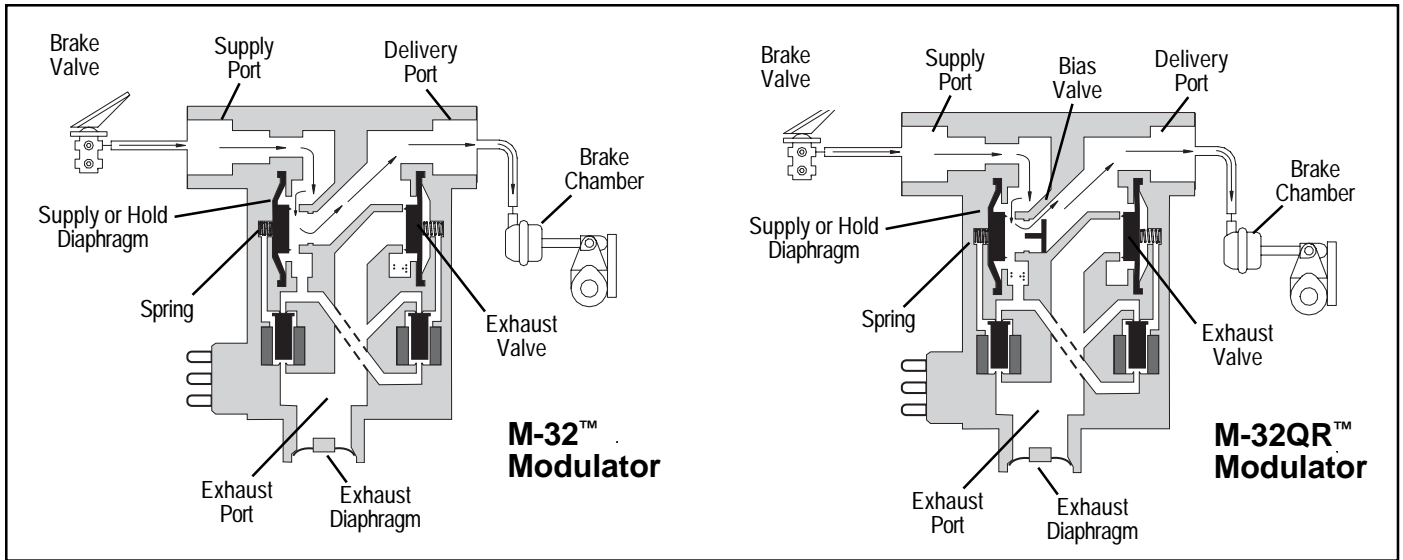


FIGURE 4: M-32™ AND M-32QR™ MODULATORS NON-ANTILOCK APPLICATION OF SERVICE BRAKES

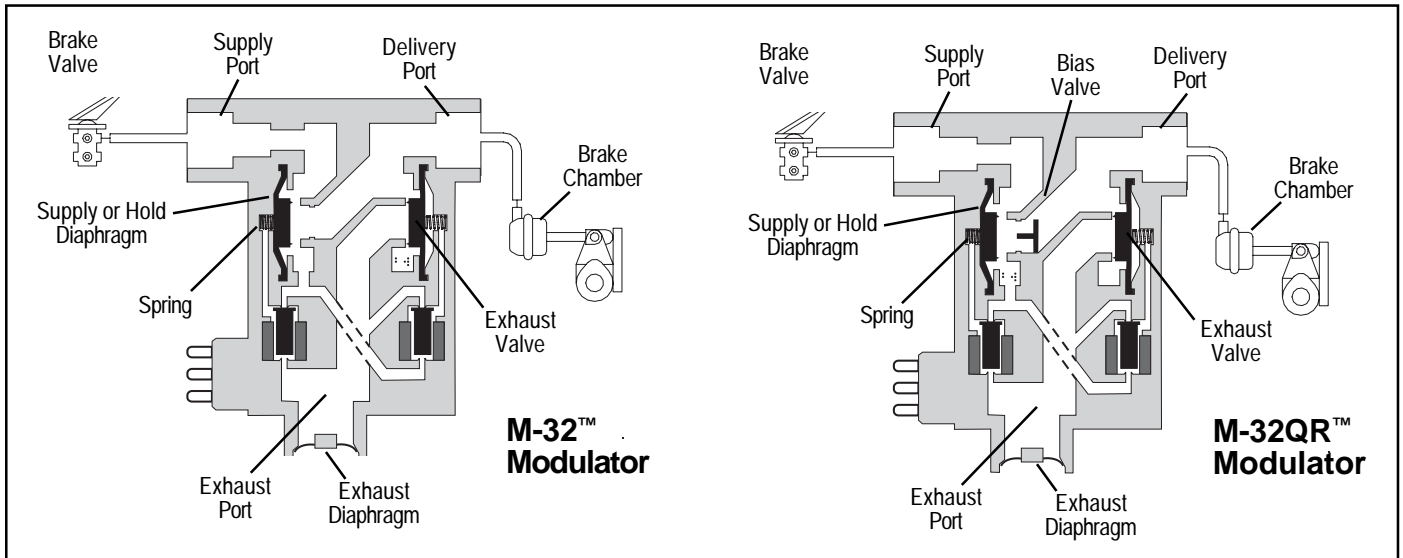


FIGURE 5: M-32™ AND M-32QR™ MODULATORS NON-ANTILOCK BRAKE APPLICATION HELD POSITION

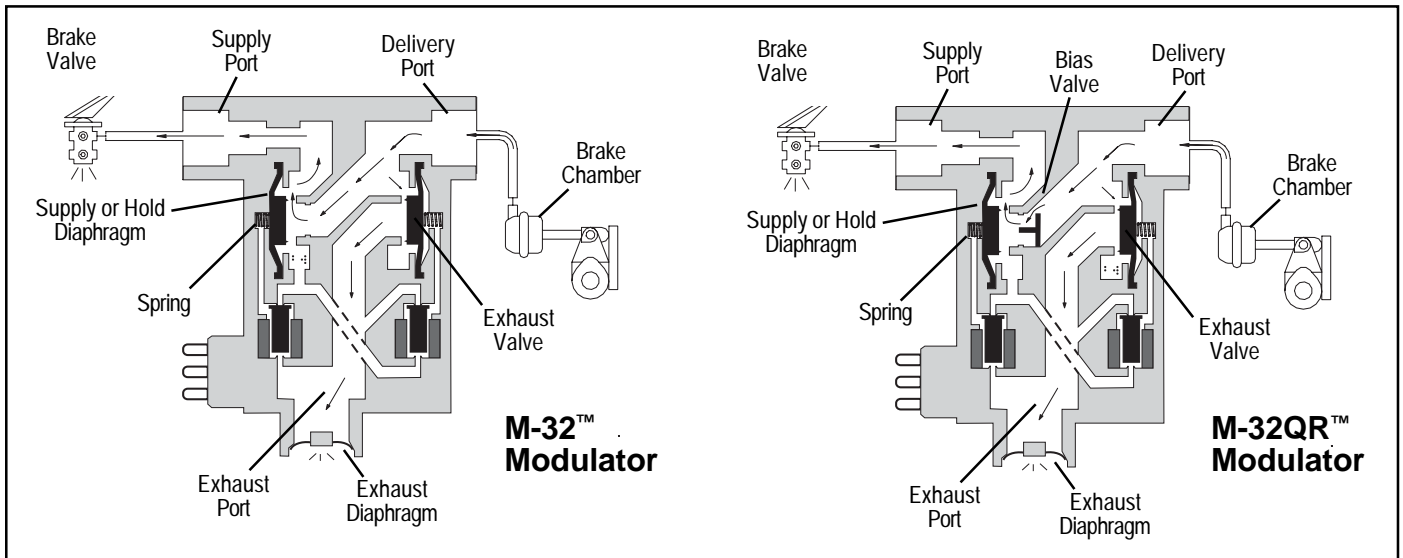


FIGURE 6: M-32™ and M-32QR™ MODULATORS "SLOW" NON-ANTILOCK EXHAUST OF SERVICE BRAKES

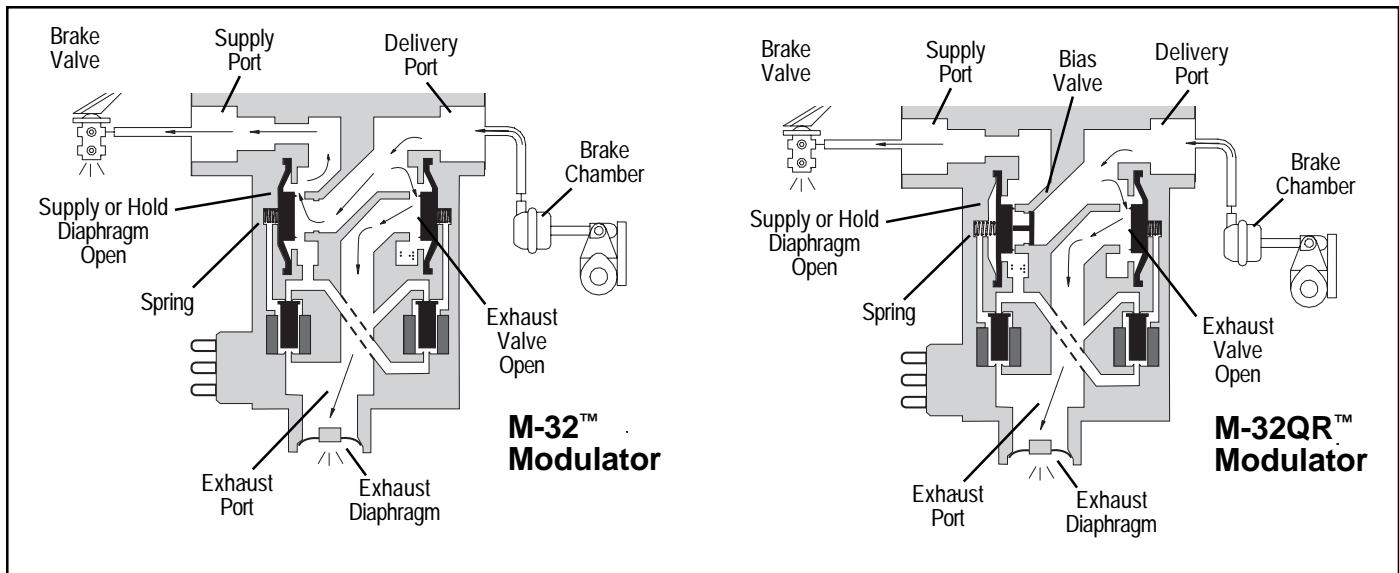


FIGURE 7: M-32™ AND M-32QR™ MODULATORS RAPID NON-ANTILOCK EXHAUST OF SERVICE BRAKES

Rapid Exhaust (Figure 7) - The Rapid Exhaust operation described in the following text occurs when the modulator is controlling service chamber(s). During a rapid brake release the quick release modulator will exhaust air differently to a “slow” brake release.

An example of this would be the case if the driver made a severe brake application then lifted his foot from the foot valve. During a rapid brake release, the air previously delivered to the brake chamber is vented through the M-32™ modulators as follows:

For the M-32QR™ Modulator: The bias valve moves to its closed position, closing the air return route to the brake valve’s exhaust. Air pressure against the exhaust valve within the M-32™ modulator overcomes the spring force and allows air to exhaust through the M-32QR™ modulator exhaust port. Residual air pressure between the bias valve and the brake pedal flows back to the brake valve exhaust.

For the M-32™ Modulator: As in the “slow” brake release, air pressure travels back to the brake valve’s exhaust, but also the air pressure against the exhaust valve within the M-32™ modulator overcomes the spring force and allows air to exhaust through the M-32™ modulator exhaust port.

ANTILOCK OPERATION

GENERAL

If a service brake application is made and the antilock system detects an impending wheel lockup, the antilock controller will make a controlled brake application using the modulator.

In order to control the brake application, the coils of the two solenoid valves contained in the modulator are energized or de-energized in a preprogrammed sequence by the antilock controller. When a solenoid coil is energized, and depending whether the exhaust or hold solenoid is energized, it either

opens or closes, thereby causing the exhaust or reapplication of air pressure to the brake actuator. The solenoids in the modulator are controlled independently by the antilock controller (ECU).

An experienced driver (of a vehicle without ABS) who encounters wheel lock-up may sometimes “pump the brakes” in order to attempt to prevent wheel lock-up and maintain vehicle control. In the case of an ABS braking system, the driver does not need to “pump the brakes” since the antilock controller is able to apply and release the brakes using the modulators, with far greater speed and accuracy. Depending on the number of modulators used, some systems are able to apply braking power to wheels independently (see page 2).

ANTILOCK EXHAUST (Figure 8)

When wheel lock is detected or imminent, the antilock controller energizes the supply and exhaust solenoids in the modulator.

Energizing the supply solenoid allows application air to flow to the control side of the supply diaphragm. Air pressure acting on the supply diaphragm, along with the spring force, enables the diaphragm to prevent further delivery of air to the brake chamber.

Energizing the exhaust solenoid shuts off the air normally applied to the control side of the exhaust diaphragm to keep it closed. Air pressure acting on the exhaust diaphragm, overcomes the spring force, and allows air to exhaust through the exhaust port.

ANTILOCK HOLD MODE (Figure 9)

The antilock controller will place the modulator in the Hold position when it senses that the correct wheel speed (braking force) has been attained. The antilock controller will also

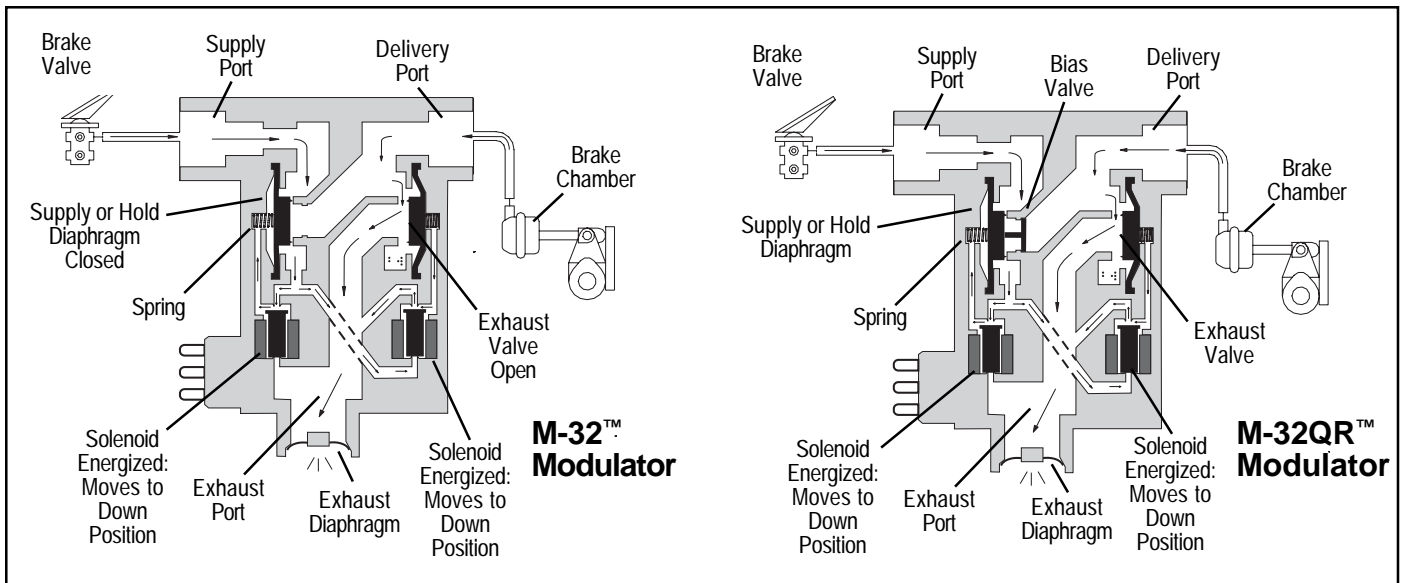


FIGURE 8: M-32™ MODULATOR ANTILOCK EXHAUST OF BRAKES

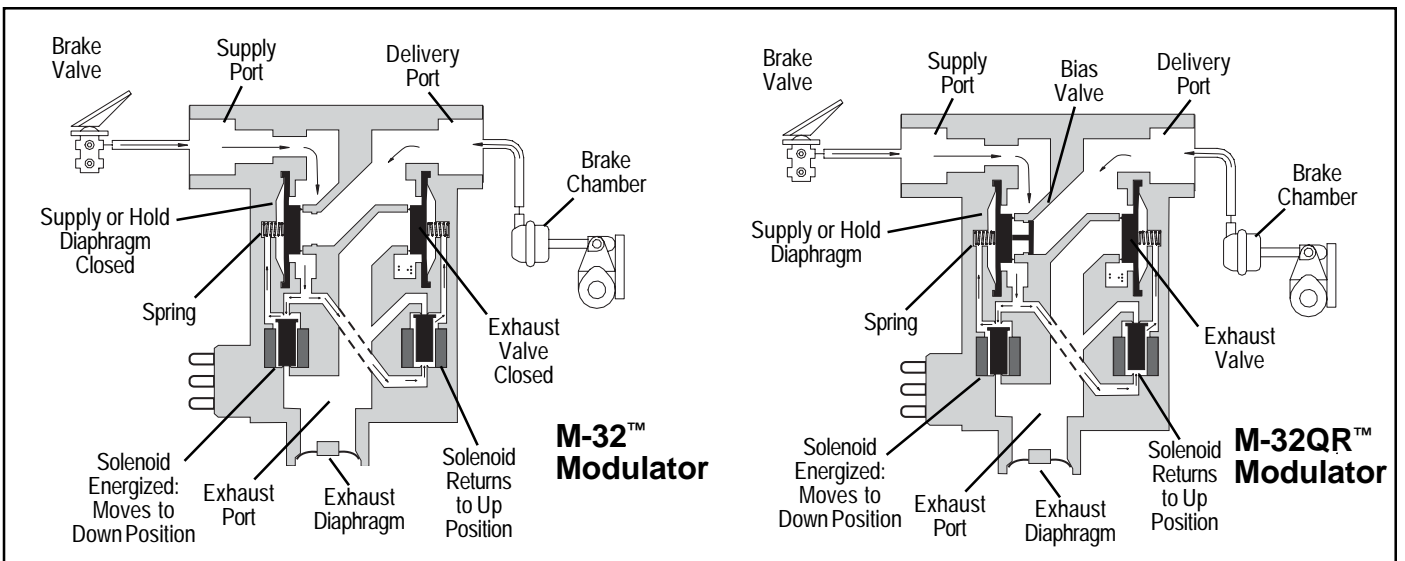


FIGURE 9: M-32™ AND M-32QR™ MODULATORS ANTILOCK APPLICATION HELD POSITION

place the modulator in the hold position, prior to entering the reapply mode, when it detects recovery from a locked wheel condition. In this mode of operation, the modulator supply/hold solenoid remains energized while the exhaust solenoid returns to its normal position. The exhaust solenoid allows application air to flow to the control side of the exhaust diaphragm, which then seals the exhaust passage. With the exhaust diaphragm seated, further exhaust of brake chamber air pressure is prevented. Because the supply solenoid remains energized, the supply diaphragm remains seated, thus preventing application air from flowing to the delivery port and out to the brake chamber. The modulator can enter both the antilock exhaust or reapply mode from the antilock hold mode depending on the needs of the antilock controller.

ANTILOCK “REAPPLY” MODE

If the antilock controller senses that wheel speed has increased sufficiently enough to allow re-application of braking pressure, without further wheel lock-up, it de-energizes the supply solenoid. With both solenoids de-energized, the modulator re-applies air to the brakes in the same manner it did during a non-antilock event.

PREVENTIVE MAINTENANCE

GENERAL

Perform the tests and inspections presented at the prescribed intervals. If the modulator fails to function as described, or leakage is excessive, it should be replaced with a new Bendix unit, available at any authorized parts outlet.

EVERY MONTH, 10,000 MILES OR 350 OPERATING HOURS

1. Remove any accumulated contaminants and visually inspect the exterior for excessive corrosion and physical damage.
2. Inspect all air lines and wire harnesses connected to the modulator for signs of wear or physical damage. Replace as necessary.
3. Test air line fittings for leakage and tighten or replace as necessary.
4. Perform the ROUTINE OPERATION AND LEAKAGE TESTING described in this manual.

OPERATION & LEAKAGE TESTS

LEAKAGE TEST

1. Park the vehicle on a level surface and block or chock the wheels. Release the parking brakes and build the air system to full pressure.
2. Turn the engine OFF and make 4 or 5 brake applications and note that the service brakes apply and release promptly.
3. Build system pressure to governor cut-out and turn the engine OFF.
4. After determining the pressure loss with the brakes released (2 PSI/minute allowed), make and hold a full service brake application. Allow the pressure to stabilize for one minute.
5. Begin timing pressure loss for two minutes while watching the dash gauges for a pressure drop. The leakage rate for the service reservoirs should not exceed 3 PSI/minute.
6. If either circuit exceeds the recommended two PSI/minute, apply soap solution to the exhaust port of the modulator and any other components in the respective circuit.
7. The leakage at the exhaust port of most Bendix components, including M-32™ modulators, should not exceed a one-inch bubble in three seconds. If leakage at the modulator is determined to exceed the maximum limits, replace the modulator.

OPERATION TEST

To properly test the function of the modulator will require two (2) service technicians.

1. Park the vehicle on a level surface and block or chock the wheels. Release the parking brakes and build the air system to governor cut out.
2. Turn the engine ignition key to the OFF position then make and hold a full brake application.
3. With the brake application held and one (1) service technician posted at one (1) of the modulators, turn the vehicle ignition key to the ON position. ONE OR TWO SHORT bursts of air pressure should be noted at the modulator exhaust. Repeat the test for each modulator on the vehicle. If at least a single burst of exhaust is not noted or the exhaust of air is prolonged and not short, sharp and well defined, perform the Electrical Tests.

ELECTRICAL TESTS

1. Before testing the solenoid assembly of a suspect modulator, its location on the vehicle should be confirmed using the Trouble Shooting or Start Up procedure for the specific antilock controller in use. (See the Service Data Sheet for the antilock controller for this procedure.)
2. Proceed to the modulator in question and inspect its wiring connector. Disconnect the connector and test the resistance between the pins ON THE MODULATOR. Refer to Figures 10 and 11.
 - A. HOLD TO SOURCE (41-42): Read 4.9 to 5.5 Ohms.
 - B. EXHAUST TO SOURCE (43-41): Read 4.9 to 5.5 Ohms.
 - C. EXHAUST TO HOLD (43-42): Read 9.8 to 11.0 Ohms.
 - D. Individually test the resistance of each pin to vehicle ground and note there is NO CONTINUITY.

If the resistance readings are as shown, the wire harness leading to the modulator may require repair or replacement. Before attempting repair or replacement of the wire harness, refer to the test procedures specified for the antilock controller in use for possible further testing that may be required to substantiate the wire harness problem. If the resistance values are NOT AS STATED, replace the modulator.

WARNING! PLEASE READ AND FOLLOW THESE INSTRUCTIONS TO AVOID PERSONAL INJURY OR DEATH:

When working on or around a vehicle, the following general precautions should be observed at all times.

1. **Park the vehicle on a level surface, apply the parking brakes, and always block the wheels. Always wear safety glasses.**

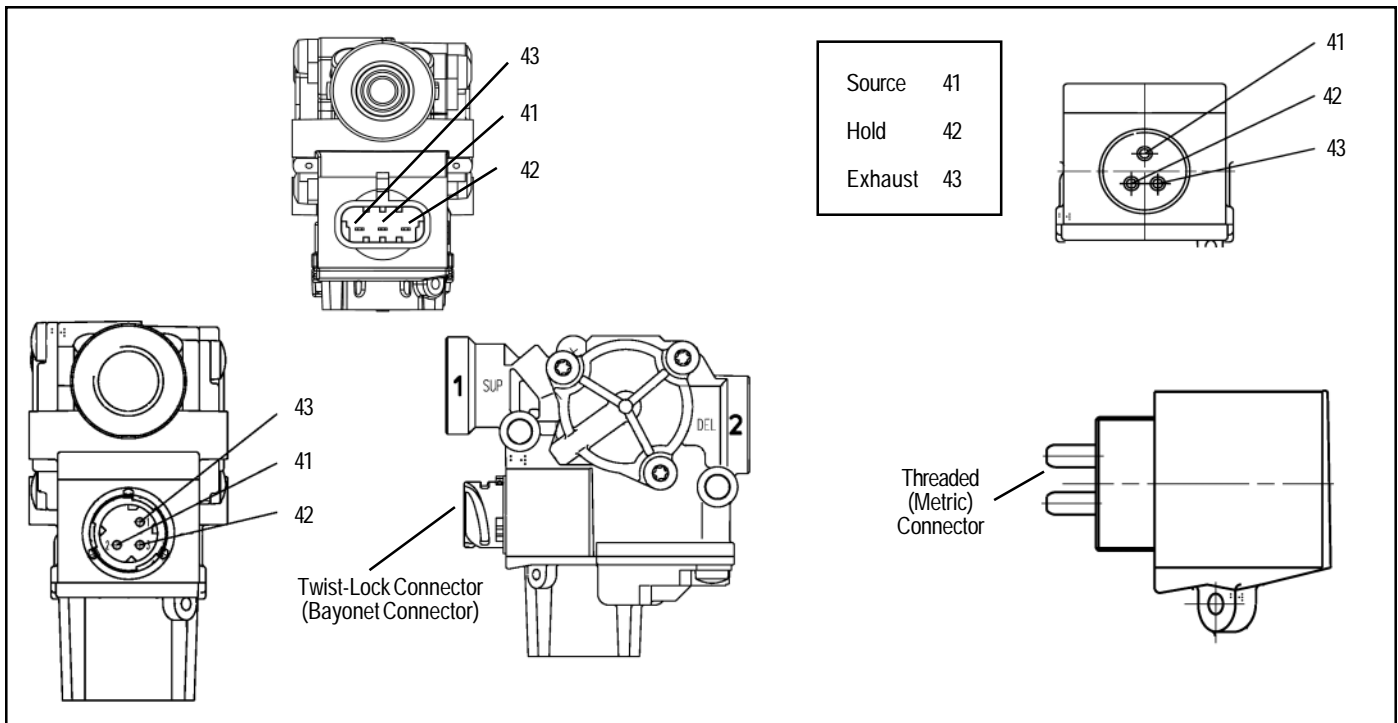


FIGURE 10: M-32™ AND M-32QR™ MODULATORS CONNECTOR VIEWS

2. Stop the engine and remove ignition key when working under or around the vehicle. When working in the engine compartment, the engine should be shut off and the ignition key should be removed. Where circumstances require that the engine be in operation, **EXTREME CAUTION** should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated or electrically charged components.
3. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
4. If the work is being performed on the vehicle's air brake system, or any auxiliary pressurized air systems, make certain to drain the air pressure from all reservoirs before beginning **ANY** work on the vehicle. If the vehicle is equipped with an AD-IS™ air dryer system or a dryer reservoir module, be sure to drain the purge reservoir.
5. Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that safely removes all electrical power from the vehicle.
6. Never exceed manufacturer's recommended pressures.
7. Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.
8. Use only genuine Bendix® replacement parts, components and kits. Replacement hardware, tubing, hose, fittings, etc. must be of equivalent

size, type and strength as original equipment and be designed specifically for such applications and systems.

9. Components with stripped threads or damaged parts should be replaced rather than repaired. Do not attempt repairs requiring machining or welding unless specifically stated and approved by the vehicle and component manufacturer.
10. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.
11. For vehicles with Antilock Traction Control (ATC), the ATC function must be disabled (ATC indicator lamp should be ON) prior to performing any vehicle maintenance where one or more wheels on a drive axle are lifted off the ground and moving.

MODULATOR REMOVAL

1. Locate the modulator that will be replaced and clean the exterior.
2. Identify and mark or label all air lines and their respective connections on the valve to facilitate ease of installation.
3. Disconnect both air lines and the electrical connector.
4. Remove the modulator from the vehicle.
5. Remove all air line fittings and plugs. **These fittings will be re-used in the replacement modulator.**

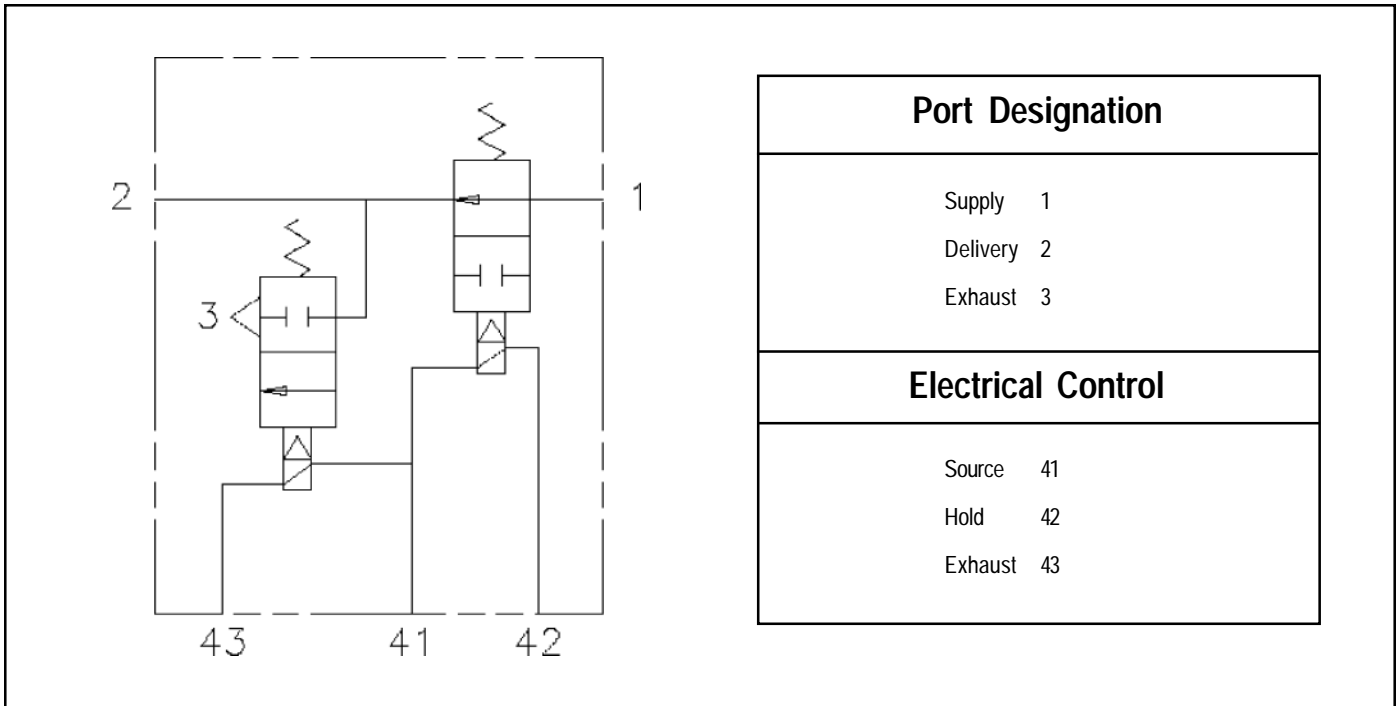


FIGURE 11: M-32™ AND M-32QR™ MODULATORS DIN SYMBOL

MODULATOR INSTALLATION

1. Install all air line fittings and plugs, making certain thread sealing material does not enter the valve.
2. Install the assembled valve on the vehicle.
3. Reconnect both air lines to the valve using the identification made during VALVE REMOVAL step 5.
4. Reconnect the electrical connector to the modulator.
5. After installing the valve, test all air fittings for excessive leakage and tighten as needed.

TECHNICAL INFORMATION

- Porting**
- 1 Supply Port (from brake, relay or quick release valve) - 1/2" NPT
 - 1 Delivery Port (brake actuator) - 1/2" NPT
- Optional:**
- 1 Push-to-connect for 1/2" tubing
 - 2 NPT supply, PTC delivery
- Solenoid Voltage:** 12 Volts DC Nominal, optional 24 Volt available.
- Weight:** 1.7 pounds
- Maximum Operating Pressure:** 150 psi Gauge
- Operating Temperature Range:** -40 to 185 degrees Fahrenheit
- Pressure Differential:** 1 psi maximum (supply to delivery)
- Mounting Hole Sizes:** 0.33" diameter through body



MERITOR WABCO

Technical Bulletin

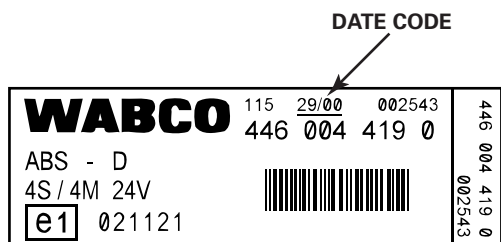
Engine Torque Reduction Diagnostics (J1922 Datalink Verification) for D-Version Meritor WABCO Pneumatic ECUs with Date Codes of 25/00 or Higher

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

The information in this technical bulletin explains the procedure for J1922 datalink verification for all D-version Meritor WABCO pneumatic ABS Electronic Control Units (ECUs) with date codes of 25/00 or higher. These ECUs require the ABS blink code be activated using **both** the vehicle ABS blink code switch **AND** a diagnostic tool — either TOOLBOX™ Software or the MPSI Pro-Link. Do not use the instructions in Maintenance Manual 30 for datalink verification if your ECU has a date code of 25/00 or higher.

NOTE: The date code appears on the ECU identification label, as illustrated. The date code is also displayed on the Main Screen of TOOLBOX™ Software and on the Program ID screen of the Pro-Link.



There are two ways to perform J1922 datalink verification, one using TOOLBOX™ Software and the other using the MPSI Pro-Link. Both methods require the use of the vehicle ABS blink code switch.

Using TOOLBOX™ Software for J1922 Datalink Verification

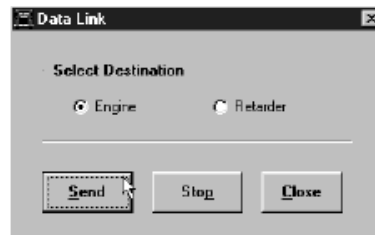
1. With TOOLBOX™ Software connected to the vehicle, turn the ignition ON.
 - A. Press the ABS blink code switch. Hold for 3 seconds. The ATC lamp will come on and stay on for the entire test. If vehicle is not equipped with ATC, the ATC lamp will not come on.

- B. The ABS lamp will come on and blink eight times. If the lamp does not blink eight times, there are faults that must be cleared **before** you continue with this test. The eight quick flashes will be followed by the system identification code. The system identification code will continue during the entire test.
2. Click on the Datalink Activation menu icon, or from the Component Tests pull down menu click on Engine Data Link.



3. Click on Engine.
4. Click on Send.

NOTE: TOOLBOX™ Software sends the engine torque reduction command continuously until you click on the Stop button.



5. Send the Blink Code J1922 engine torque reduction command, as follows:
 - A. Step on the accelerator. Bring the engine to 1000 RPM. Leave your foot on the accelerator during the entire test.
 - B. While the engine is at 1000 RPM, press the blink code switch twice, as follows:
 - Press and hold for one second.
 - Release for one second.
 - Press and hold for one second.
 - Release for one second.

The engine will alternate between 1000 RPM and idle indefinitely. Click the Stop button on the TOOLBOX™ screen. This stops the test and returns the RPM to accelerator control.

NOTE: To retest, begin at Step 4.

6. Click the Close button to exit the screen.
7. Take your foot off the accelerator. Turn the ignition OFF.

Engine torque reduction command verified.

Using the Pro-Link for J1922 Datalink Verification

1. With the Pro-Link connected to the vehicle, turn ignition ON.
 - A. Press the ABS blink code switch — hold for 3 seconds. The ATC lamp will come on and stay on for the entire test. If vehicle is not equipped with ATC, the ATC lamp will not come on.
 - B. ABS lamp will come on and blink eight times. If the lamp does not blink eight times, there are faults that must be cleared **before** you continue with this test. The eight quick flashes will be followed by the system identification code. This indicates the ECU is in the Datalink Verification mode. The system identification code will continue during the entire test.

2. Select the Pro-Link Engine Datalink choice, as follows:
 - A. Press the arrow key(s) to find the Component Test choice.
 - B. Press the Enter key to enter Component Test.
 - C. Press the arrow key(s) to find the Engine Datalink choice.
3. Prepare the Pro-Link Engine Datalink command, as follows:
 - A. Press the Enter key once to enter the first stage of the Datalink setup. The Pro-Link screen will display the following message: “run engine 1000 RPM/engine torque will change during test/[ENTER] to continue.”
 - B. **DO NOT** press Enter at this time.
4. Prepare the Blink Code J1922 Engine Datalink command, as follows:
 - A. Step on the accelerator.
 - B. Bring the engine to 1000 RPM. Leave your foot on the accelerator during the entire test.
 - C. While engine is at 1000 RPM, press the blink code switch twice, as follows:
 - Press and hold for one second.
 - Release for one second.
 - Press and hold for one second.
 - Release for one second.

This mode remains active for 10 seconds, which means you must start Step 5 within 10 seconds.

5. Send the Pro-Link J1922 engine torque reduction, as follows:

Press the Enter key on the Pro-Link. The engine will alternate between 1000 RPM and idle for approximately 10 seconds, then return to 1000 RPM.

NOTE: To repeat the test, start with Step 3.

6. Take your foot off the accelerator. Turn ignition OFF.

Engine torque reduction command verified.

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1. WHEELS

The vehicle is equipped with hub-mounted wheels as standard equipment, all studs and nuts have right-hand threads. When the vehicle is provided with stud-mounted wheels, wheel studs and nuts on the left side of the vehicle have left-hand threads whereas those on the right side have right-hand threads. Either steel wheels or optional aluminum-polished wheels may be installed on the vehicle. Both are mounted with radial tubeless tires.

All wheel dimensions are 22.50 X 9.0 inches (571.5 X 228.6 mm) for 315/80 R 22.5 tires except inner drive wheels, which are always steel wheels and 22.50 X 8.25 inches (571.5 X 209.6 mm) for 315/80 R 22.5 tires. All other wheels can either be steel or aluminum wheels.

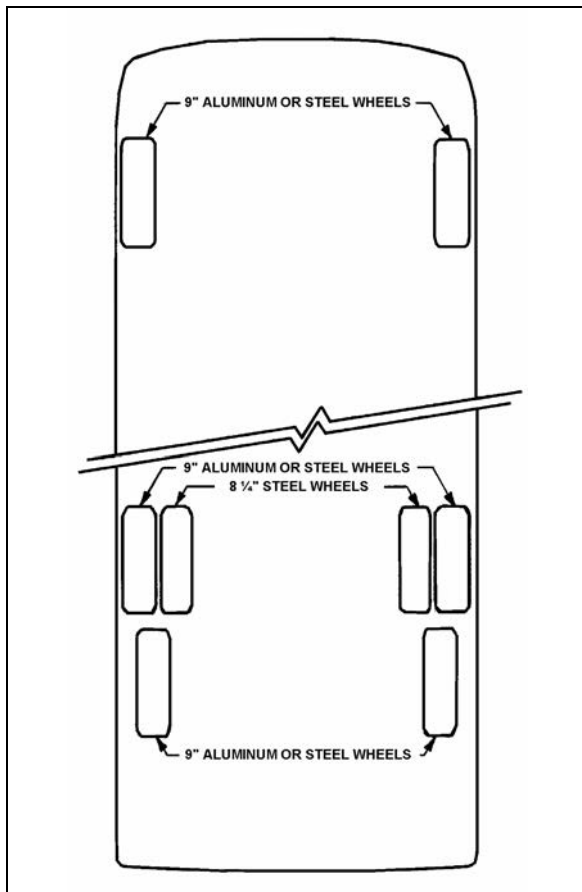


FIGURE 1: ALUM/STEEL WHEEL ARRANGEMENT 13001

2. WHEEL MAINTENANCE

Wheel maintenance consists of periodic inspections. Check all parts for damage and make sure that wheel nuts are tightened to the proper torque. In the case of a new vehicle, or after a wheel installation, stud nuts should be

tightened every 100 miles (160-km) for the first 500 miles (800-km) to allow setting in of clamping surfaces.

Wheel studs and nuts must be kept free from grease and oil. No lubricant whatsoever should be used. Cleanliness of the wheel and its rotor mating surfaces is important for proper wheel mounting.

However, for hub mounted wheels, it is recommended to add some rust protection lubricant on the pilot diameter of the hub (to facilitate future removal).

It is also important that wheel stud nuts be tightened alternately on opposite sides of the wheel. Refer to Figure 2 for the suggested tightening sequence.

2.1 INSPECTION

Tighten stud nuts progressively as shown in Figure 2. The final tightening should be done with a torque wrench. Tighten stud nuts to 450 - 500 lbf-ft (610 - 680 Nm) for aluminum as well as steel wheels.

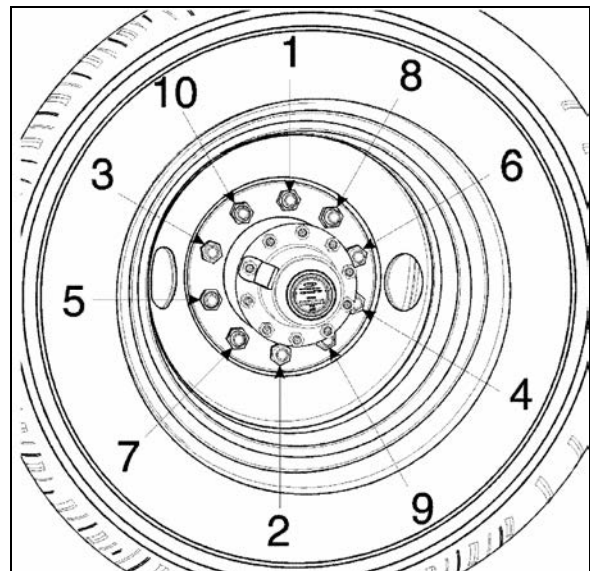


FIGURE 2: TIGHTENING SEQUENCE 13018

2.2 SINGLE WHEEL REMOVAL

1. Stop engine and apply parking brake.
2. Loosen wheel nuts about one turn (do not remove the nuts). This is not necessary if equipped with hydraulic powered gun.

Section 13: WHEELS, HUBS & TIRES

NOTE

For stud-mounted wheels, turn nuts counterclockwise for R.H. side and clockwise for the L.H. side of vehicle. For hub-mounted wheels, turn nuts counterclockwise on both sides of the vehicle.

3. Raise the vehicle by its jacking points on the body. See Section 18, "Body", under heading "Vehicle Jacking Points";
4. Unscrew wheel hex stud nuts and remove the wheel;



CAUTION

Always mark position of the wheel on the axle prior to removal in order to replace wheel at the same location, thus avoiding a new wheel balancing.

2.3 SINGLE WHEEL INSTALLATION

1. Mount the wheel over studs, being careful not to damage stud threads;
2. Screw in the hex stud nuts (refer to Figure 2 for sequence) so that wheel will position itself concentrically with hub. This is important, otherwise wheel may be eccentric with hub and will not run straight. In this initial step, slightly tighten the nuts to correctly position the wheel;
3. Tighten stud nuts progressively as shown in Figure 2. The final tightening should be done with a torque wrench. Tighten stud nuts to 450 - 500 lbf-ft (610 - 680 Nm) for aluminum as well as steel wheel.



CAUTION

Insufficient mounting-torque can result in damage to parts. Excessive mounting torque can cause studs to break and the wheel to crack in stud hole area.

3. DUAL WHEELS

3.1 OUTER WHEEL REMOVAL

Same as described in "Single Wheel Removal" procedure described previously.

3.2 INNER WHEEL

1. Remove outer wheel;

2. Unscrew inner cap nuts
3. Remove inner wheel.

3.3 INNER WHEEL INSTALLATION

1. Mount the wheel over studs, being careful not to damage stud threads;
2. Screw in the inner cap nuts (Fig. 4), so that wheel will position itself concentrically with hub. Refer to Figure 2 for sequence;
3. Tighten inner cap nuts progressively according to sequence shown in Figure 2. Final tightening should be done with a torque wrench. Tighten inner cap nuts to 450 - 500 lbf-ft (610 - 680 Nm) for aluminum as well as steel wheel.



CAUTION

Insufficient mounting-torque can result in damage to parts. Excessive mounting torque can cause studs to break and the wheel to crack in stud hole area.

3.4 OUTER WHEEL INSTALLATION

With inner wheel installed, tighten the hex stud nuts (Fig. 4) using the single wheel installation procedure described previously.

NOTE

On dual wheel assemblies, position the wheels with the tire valves 180° apart in order to have access to both the inner and outer valves.

3.5 INSPECTION

1. Loosen a hex stud nut three turns (Fig. 4);
2. Tighten the inner cap nut to 450 - 500 lbf-ft (610 - 680 Nm);
3. Tighten the hex stud nut to 450 - 500 lbf-ft (610 - 680 Nm).

Repeat for each of the 10 "hex stud nut - inner cap nut assemblies" according to the tightening sequence in figure 2.



CAUTION

Do not attempt to tighten an inner cap nut without having previously loosened the hex stud nut.



CAUTION

The actual length of thread engagement present in an assembled wheel can not always be determined by visual inspection or measurement of a tightened assembly. The relationship of the wheel cap nut seat to the end of the stud may vary. If there is any doubt that enough thread engagement is present, the number of engaged threads may be counted. Tighten all nuts in the regular manner, then loosen one to hand-tightness. The number of turns to disengage a 1-1/8-inch nut should be at least five full turns. At least seven full turns should be required to disengage a 3/4-inch nut or a M22 nut. Ideally, when torqued to the proper load, the stud should be flush with the face of the nut. The face of the nut may be recessed in nuts that are taller for improved wrenching. With most of the nuts in present use, a few unengaged threads at the outer end will cause no problem provided at least 5-7 full turns are required to disengage the nut depending on thread size.

4. ALUMINUM WHEEL ANTI-CORROSION PROTECTION

Clean wheels often by means of a high pressure water jet. Cleaning may be accelerated with mild soap. Do not use concentrated alkaline cleaning products.

When tire is removed, clean and inspect wheel thoroughly. Remove dirt and corrosion on rim by means of a wire brush. Do not use a wire brush on the outer surface of the wheel.

The following measures should be taken to maintain original appearance of the aluminum wheels:

1. Remove any tar from wheel surface with a good quality tar remover.
2. Spray Alcoa Cleaner (Prévost #683529) evenly on cool outer surface of wheel. Let work 15-20 minutes (keep wet by spraying more Cleaner if necessary).
3. Rinse thoroughly with clean water and let air dry. Heavy oxidation may require a repeat application of cleaner.
4. Apply Alcoa Polish (Prévost #683528) sparingly to a small area using a clean, soft cloth. Work polish into surface as you would a rubbing compound.

5. Buff, turning cloth frequently, until surface is clean and shiny. Let air dry. Use power buffer to improve ease of use and gloss uniformity.
6. On completely dry, clean and polished surface, generously apply Alcoa sealant (Prévost #683527). Rinse thoroughly with water while surface is still wet in appearance (have water source ready as the dry time is very short, usually less than 2 minutes).
7. For best results, finish by wiping the surface with a clean rag to remove excess water, then allow surface to dry.

Clean aluminum wheels as required to maintain original look.



WARNING

Wheel surfaces may have sharp or cutting edges that may cause injury to the hands. To prevent contact with sharp edges, it is strongly recommended to wear rubber gloves when washing or polishing wheels.

5. WHEEL STRAIGHTNESS TEST

1. Slightly raise axle to be checked and place a safety support underneath;
2. Check wheel lateral run-out. Install a dial gauge as shown in figure 3, then rotate the wheel by hand one full turn. As the wheel turns, note any variation on the dial gauge;



CAUTION

Damage to the dial gauge could occur if it strikes a wheel balancing weight.

3. If the variation in lateral run-out exceeds 0.0625 inch (1,6 mm), the wheel must be replaced.

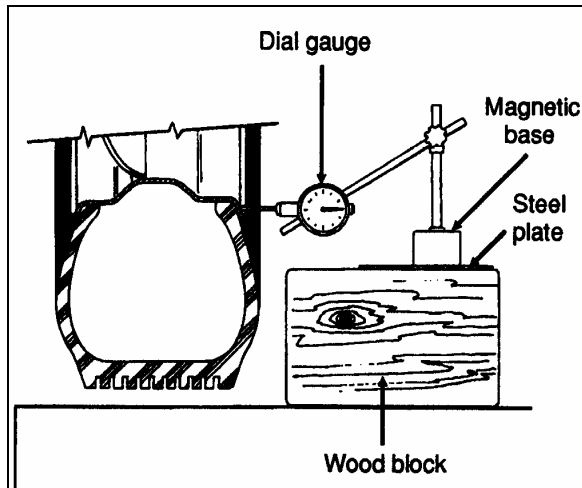


FIGURE 3: DIAL GAUGE INSTALLATION 13008

If doubt exists whether wheel or hub is distorted, hub may be checked as follows:

- Replace the existing wheel with a wheel known to be correct;
- Check wheel lateral run-out as outlined in step 2;
- If, within specifications, the hub is correct but the suspected wheel must be replaced.



WARNING

NEVER STRAIGHTEN ALUMINUM WHEELS. Never heat aluminum wheels to repair damages incurred after hitting a curb or resulting from other causes. The special alloy in wheels has been heat treated, and any uncontrolled heating could alter wheel structure. Furthermore, never weld aluminum-forged wheels for any reason whatsoever.

6. WHEEL STUDS

Stripped threads may be the result of excessive torquing or may have been damaged during wheel installation when placing the wheel over the studs. A stud having damaged threads must be replaced. Broken studs are a direct result of operating with loose stud nuts or improperly seated wheels. When a broken stud is replaced, the adjacent studs, on each side of the broken one must also be replaced since they could have been subjected to excessive strain and may be fatigued.

When installing wheel studs to hubs, check nuts retaining the wheel stud to wheel hub and replace if they are deformed, damaged or severely corroded. Install nut (and washer where applicable) to new stud. Torque to 450 - 500 Ft-lbs (610 - 680 Nm).

NOTE

For stud-mounted wheels, turn nuts counterclockwise for R.H. side and clockwise for the L.H. side of vehicle. For hub-mounted wheels, turn nuts counterclockwise on both sides of the vehicle.

6.1 DRIVE AXLE STUDS

Stud-mounted wheels are mounted on the drive axle with $\frac{3}{4}$ "-16 studs with an inner cap nut, and a 1-1/8"-16 nut. Hub-mounted wheels are mounted with M22 x 1.5 studs and an M22 flange nut.

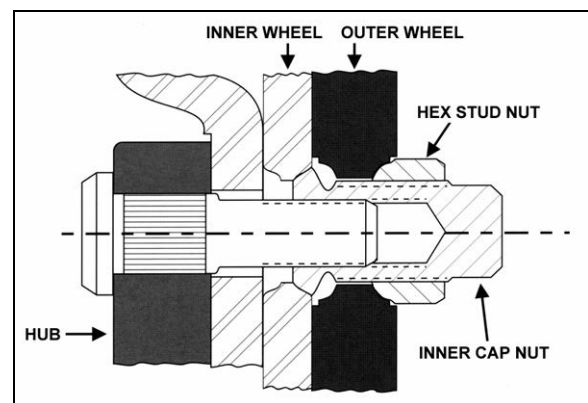


FIGURE 4: STUD-MOUNTED WHEELS 13007

6.2 FRONT AND TAG AXLE STUDS

Wheel can be mounted on tag axle with studs (1-1/8"-16 thread) or hub mounted (M22 x 1.5 thread).

NOTE

Wheel studs and nuts must be kept free from grease and oil. No lubricant whatsoever should be used.



WARNING

The two wheel mounting systems are not interchangeable. They have their specific wheel, nut and stud types. Use only the specific hardware suitable for a mounting type. Always install a wheel to the corresponding mounting type hub.

7. HUB MOUNTED WHEELS

Wheel surfaces in contact with hubs, nuts or other wheels should be kept free of all rust, grease and paint (except for initial "E" coat protection, applied to stop rusting and to facilitate wheel removal). The reason for this is to assure that all faces are clamped together without buildup of any coating. The threads of the wheel studs and the wheel nuts should be clean and undamaged.

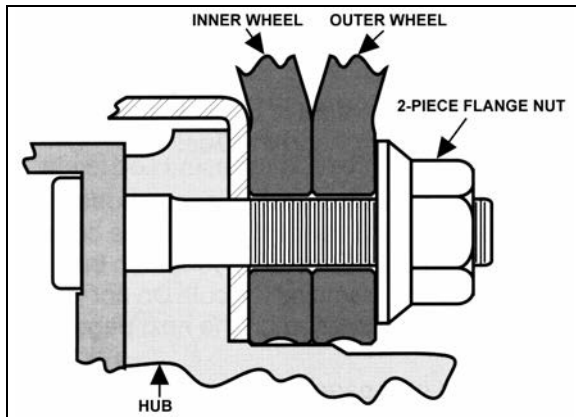


FIGURE 5: HUB-MOUNTED WHEELS

13025

NOTE

When painting wheels, make sure to mask all surfaces identified above.

Using a calibrated torque wrench, tighten wheel nuts to 450 - 500 lbf-ft (610 - 680 Nm) of torque. Do not use power tools or long bars for tightening. Tighten wheel nuts alternately as shown in figure 2.

NOTE

Tightening should not be done immediately after prolonged braking or when wheel ends are hot

Check wheel nut torque at every 100 miles (160 km) for 500 miles (800 km) after fitting wheels. Let cool before checking. If any relaxation of the initial 450 - 500 lbf-ft (610 - 680 Nm) of torque has occurred, retighten. Relaxation of initial torque may occur because of the "bedding down" of the hub and wheel surfaces.

NOTE

Torque relaxation occurs when wheel ends are hot but should revert to original setting when cool. Retightening when hot will produce a higher torque reading than recommended.

7.1 CARE OF WHEELS

Check for cracks in wheels, especially around the fixing holes, studs, nuts and washers. If in doubt, renew.

Do not simply retighten very loose wheel fixings or wheels that are continually becoming loose. Find out why they are loose and whether any damage has been caused.

Use trained personnel and keep records of all attention to wheels and fixings, including which parts were renewed and when.

8. FRONT AND TAG AXLE WHEEL HUBS

The unitized hub bearings used on the NDS range of axles, are non-serviceable items. Bearings are pre-adjusted, lubricated and have seals fitted as part of the manufacturing process. The bearings are greased for life and there is no need or facility for re-lubrication

8.1 HUB BEARING INSPECTION

An inspection should be made at intervals of 30,000 miles (48 000 km).

- Apply parking brake, raise wheels off the ground and support axle on stands. When the wheels are raised, they should revolve quite freely without roughness.
- Place magnetic base of a dial indicator on brake caliper and position dial indicator stem against a convenient marked spot on face of hub flange.
- With dial indicator in position pull hard but steadily on hub flange and oscillate at same time until a steady reading is achieved.
- Without releasing the pressure, turn bearing so that dial indicator stem contacts marked spot and note reading on indicator.
- Push bearing flange hard and oscillate as before until a steady reading is achieved.
- Without releasing the pressure, turn bearing so that indicator stem again contacts the marked spot and note new reading on indicator.
- The difference between readings is the amount of mounted end play in bearing unit.
- The mounted end play figure should not exceed 0.050 mm (0.002") for a new bearing and 0.20 mm (0.008") for a bearing which has been in service.

Section 13: WHEELS, HUBS & TIRES

NOTE

If original bearing unit is re-fitted, and end-float is measured at 1 mm, with hub not fully tightened to correct torque, then the retaining clip within the unit is damaged and a new unit must be fitted.

NOTE

For more information on front and tag axle wheel hub, refer to "DANA SPICER Maintenance Manual Model NDS and Maintenance Manual NDS Axles" annexed at the end of Section 11.

9. DRIVE AXLE WHEEL HUBS

Drive wheels use a single oil-seal assembly. They are lubricated from the oil supply in the differential housing. Bearings are tapered rollers, adjustable to compensate wear. Maintain differential oil level with general-purpose gear lubricant (refer to Section 24 "Lubrication" for proper oil grade selection) to ensure adequate oil supply to wheel bearings at all times.

9.1 BEARING ADJUSTMENT

To adjust drive wheel bearings:

1. Raise vehicle until both dual wheels can be turned freely (approximately 6 inches from the ground). Position jack stands under drive axle, then lower vehicle approximately 2 inches in order to avoid entire weight of the axle being supported by the suspension air bellows and the shock absorber pins.
2. Remove axle shaft as indicated in "Meritor - Maintenance Manual No. 5" under heading "Single Reduction Differential Carriers" annexed to "Section 11" of this manual. Remove gaskets. Unscrew lock nut and remove adjusting nut lock ring.
3. To adjust, tighten adjusting nut until the wheel binds. Rotate the wheel while tightening so that all surfaces are in proper contact. Back off adjusting nut approximately, $\frac{1}{4}$ to $\frac{1}{3}$ turn to assure 0.001/0.007" (0.0254/0.1778 mm) endplay and to ensure that wheel turns freely. Replace the lock ring, and adjust nut dowel pin in one of the holes. The ring may be turned over if necessary to allow more accurate bearing adjustment.

4. Tighten lock nut and check bearing adjustment. Replace the axle shaft using a new gasket.

9.2 DISASSEMBLY AND REPAIR

1. Jack vehicle as per "Bearing Adjustment" and remove axle shaft as indicated in "Meritor - Maintenance Manual No. 5" entitled "Single Reduction Differential Carriers" annexed to Section 11 of this manual.
2. Remove wheels and tires.



CAUTION

To replace wheel at the same location, always mark position of the wheel on the axle before removal, thus avoiding a new wheel balancing.

3. Remove lock nut, lock ring and adjusting nut from axle housing to prevent the outer bearing from falling out. Remove outer bearing cone and roller assembly.
4. Remove screws attaching inner oil seal retainer to hub, and remove inner oil seal assembly. Remove inner bearing cone and roller assembly. Bearing cups can be separated from the hub using a hammer and a long brass drift.
5. Thoroughly clean all parts. Bearing cone and roller assemblies can be cleaned in a suitable cleaning solvent using a stiff brush to remove old lubricant.
6. In case that excessive wear, deterioration, cracking or pitting is present on the bearing cups, rollers or cones, the bearings should be replaced. Seals should be replaced each time they are removed from the hub. To install new oil seal, use a suitable adapter and drive the seal into the retainer bore until it bottoms.
7. When installing wheel on spindle, center the wheel hub with spindle to avoid damaging the seal with the end of the spindle. Push wheel straight over the spindle until inside diameter of seal press fits on wiper ring. Fill hub cavity with general-purpose gear lubricant (refer to Section 24 "Lubrication" for proper oil grade selection). Lubricate, then install outer bearing cone. Adjust bearing and lock.

- Assemble axle flange to axle using a new gasket. Apply sealant in stud area. After both wheels have been assembled according to above procedure, fill the differential with the recommended lubricant to the proper factory recommended level.

NOTE

During regular inspection, do not forget to check lubricant level in differential. Clean thoroughly or replace vent as required.

10. SPARE WHEEL

Tire failure is a rare event if tires are properly cared for. In case of a flat tire, move vehicle a safe distance away from traffic and apply parking brake. Remember to use the hazard flashers and according to the Highway Code regulations, set up the triangular reflectors (see "Emergency Warning Reflectors" in the Operator's Manual) at an adequate distance, to warn incoming motorists. This kit is located at the ceiling of the first baggage compartment, on the R.H. side.

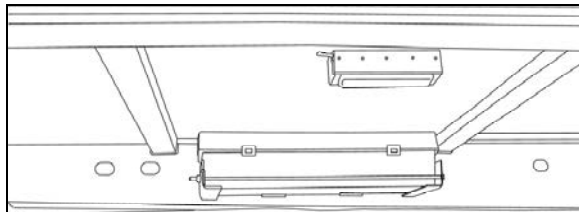


FIGURE 6: WARNING REFLECTORS LOCATION 23376

The spare wheel is stored in a dedicated compartment behind the front bumper. To access, pull the release handle located in the front service compartment. Although the bumper is heavy, sprung hinges permit one person operation.

When closing bumper compartment, make sure bumper is securely installed.

WARNING

This compartment has not been designed for storage. Never leave loose objects in this area since they may interfere with steering linkage mechanism. Make sure bumper is safely locked in place after closing the compartment.

10.1 PULLING OUT SPARE WHEEL

To remove the spare, untighten the pressure screw holding the tire in place, then press down

on the spring loaded locking pin located at the top of the retaining bracket and remove the bracket. Using the strap, pull the spare out of the compartment (refer to the following illustrations). Rollers ease manipulation. Remove the protective cover. Install the flat in place of the spare by reversing the procedure. Do not forget to have the flat repaired as soon as possible.

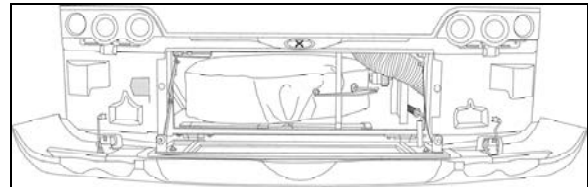


FIGURE 7: SPARE WHEEL COMPARTMENT 18614

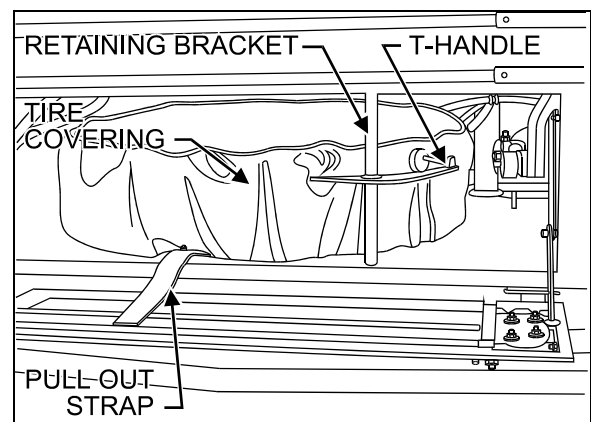


FIGURE 8: SPARE WHEEL AND TIRE 18415

NOTE

The jack and wheelnut wrench are stored in front service compartment.

The jack/tools kit stowed in the front service compartment contains a:

- 30 ton hydraulic jack;
- Wheel nut wrench and lever.

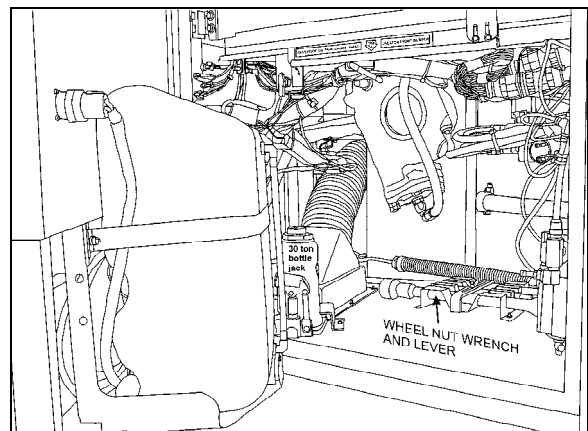


FIGURE 9: FRONT SERVICE COMPARTMENT 23377

Section 13: WHEELS, HUBS & TIRES

NOTE

Check the inflation pressure of the spare tire periodically to keep it ready for use. Inflate spare tire to the pressure of the tire, which has the highest pressure on the vehicle. When installing, deflate to correct pressure if necessary.

10.2 CHANGING A FLAT

In case of flat tire, refer to appropriate procedure under "Wheel Maintenance" heading in this section.

NOTE

For hydraulic jack placement, refer to Section 18 "Body", under heading "Vehicle Jacking Points".



DANGER

Place jack on stable and level ground; if necessary, place a board under the jack. Do not raise the vehicle until you are sure the jack is securely engaged.



WARNING

To prevent personal injury and/or equipment damage, use only the recommended jacking points. Passengers must not remain inside vehicle while wheel is being replaced.



CAUTION

Adjust tire pressure according to the appropriate cold tire inflation-pressure.

NOTE

Store damaged wheel in spare tire compartment. Repair and balance the flat tire as soon as possible.

10.3 SPARE WHEEL MAINTENANCE

Maintenance of the spare wheel and tire consists in ensuring that tire inflation pressure is the same as the tire on the coach that has the highest inflation pressure (refer to "Specifications" in this section for the recommended tire inflation pressure). Inspect rim to ensure that there is no important

corrosion. In addition, check if spare wheel covering is in good condition and check that spare tire is securely fastened in compartment.

11. TIRE MAINTENANCE

The most critical factor in tire maintenance is proper inflation (Fig. 9). No tire is impervious to loss of air pressure. To avoid the hazards of under inflation, always maintain tires at their recommended inflation pressure. Improper inflation decreases tire life.

An under inflated tire builds up heat that can cause sudden tire destruction, resulting in improper vehicle handling and possible loss of vehicle control. At least once a week, before driving (when tires are cold), check inflation pressure on all the tires, including the spare tire. This is especially important in cases when different drivers operate the vehicle.



WARNING

Failure to maintain correct tire inflation pressure may result in sudden tire destruction, improper vehicle handling, and will cause rapid and irregular tire wear. Inflation pressure should be checked weekly and always before long distance trips.

11.1 INFLATION PRESSURE

- Vehicles equipped with BERU TPMS

On vehicles equipped with the Beru Tire Pressure Monitoring System (TPMS), it is better to use the TPMS display as the primary reference to judge when tire pressure need adjustment.

The TPMS presents pressure readings of each tire as a +/- deviation from the wanted target.

If a tire reads within +/- 3 PSI no adjustment is needed.

If a tire reads -4 PSI and below, re-inflate by the marked amount.

If a tire reads +4 PSI and above, deflate by the marked amount.

Relying on the TPMS system is better than relying on a hand gage since the TPMS is temperature compensated and remain accurate no matter if the tires are cold or hot.

Tires take up to 3 hours to get down to ambient temperature after a ride. A common mistake

consist of checking pressure while the tires have not fully cooled down which leads into under-inflated tires. Relying on the TPMS eliminate this mistake.

Running tires at optimal pressure reduce tire wear, improve safety and fuel economy.

NOTE

It is more accurate to use the TPMS display to set the tire pressures than a pressure gauge.

The TPMS target pressures are factory set to equal the prevailing tire pressure at delivery time.

When tire pressures are increased to account for higher vehicle weight, the TPMS set point need to be increased accordingly.

- Vehicles not equipped with BERU TPMS

The condition and pressure of the tires can greatly affect both useful tire life and road safety.

At regular intervals, verify the tire pressures. Use an accurate tire pressure gauge when checking inflation pressures. Never exceed the maximum inflation pressure specified on each tire.

NOTE

Inflation pressure should be checked when tires are cold. Cold tire inflation pressure can be measured when a vehicle has not been driven for at least 3 hours or less than 1 mile (1.6 km). Driving, even for a short distance, causes tires to heat up and air pressure to increase. Check inflation pressure on all tires (including the spare tire) using an accurate tire gauge.

NOTE

The recommended tire inflation pressures are given in the applicable documents supplied with the vehicle. In addition, cold tire inflation pressures are listed on the Department of Transport's certification plate, affixed on the panel behind the driver's seat. For special tire selection, a "PRÉVOST COACH SPECIAL SPECIFICATION" chart is supplied with the vehicle and is affixed on the left wall near the driver's seat. Remember, tire inflation pressure must be adjusted according to vehicle loading - see table in "Coach Final Record"

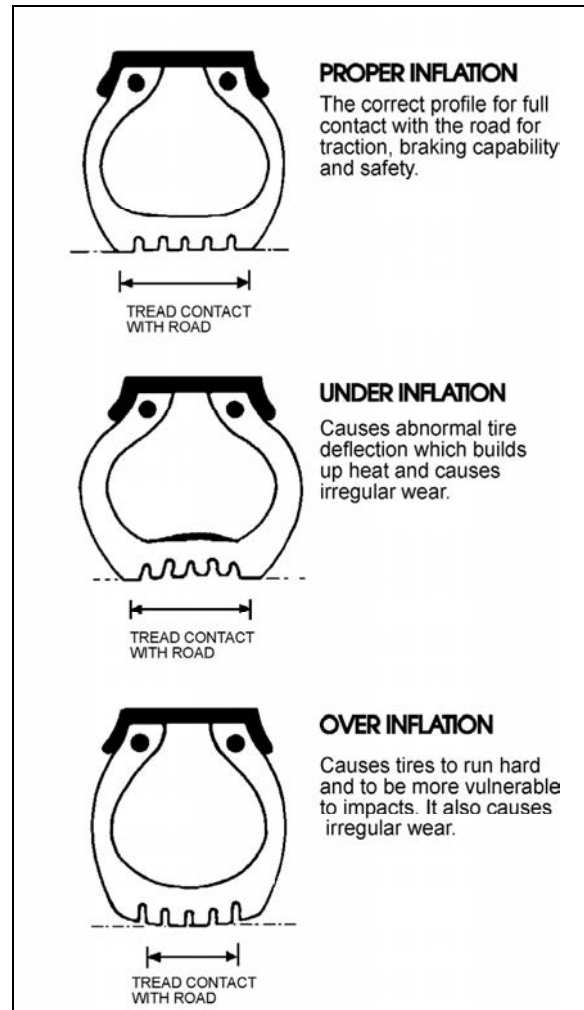


FIGURE 10: TIRE INFLATION

13009



CAUTION

Never bleed air from hot tires as tires will then be under inflated. Use an accurate tire gauge to check pressures (Do not kick tires as an inflation check. This is an unreliable method).



CAUTION

These tire pressures are established in accordance with the maximum allowable load on each axle. A lower pressure is recommended if the axle load is less than the above specifications. Weigh vehicle fully loaded and pressurize according to tire manufacturer's recommendations. For other tire and wheel specifications, see Prévost tire pressure tabulation in "Coach Final Record".

WARNING

Incorrect tire pressures cause increased tire wear and adversely affect road holding of the vehicle, which may lead to loss of vehicle control.

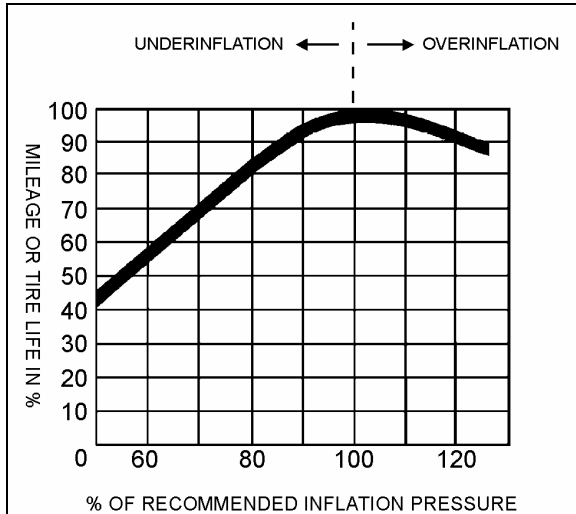


FIGURE 11: TIRE LIFE / INFLATION PRESSURE 13010

WARNING

Recommended tire inflation pressures and maximum allowable loads apply to speeds up to 65 mph (105 km/hr). Do not drive vehicle at a higher speed than 65 mph (105 km/h) or above the posted speed limit.

WARNING

All tires on the same axle should always be inflated to the same pressure. There should not be a difference in pressure between right and left tires on the same axle. A 5-psi (35-kPa) underinflation in one front tire can not only reduce vehicle maneuverability, but will create steering hazards which can lead to an accident.

11.2 TIRE MATCHING

Unmatched tires on drive axle will cause tire wear and scuffing, as well as possible damage to the drive unit. Consequently, we recommend that tires be matched within 1/8" (3 mm) of the same rolling radius.

NOTE

It is recommended that all tires on coach be of the same type.

11.3 WHEEL BALANCING

Before balancing, wheels must be clean and free from all foreign matter. The tires should be in good condition and properly mounted. An unbalanced wheel can be due to a bent wheel or improper mounting. Before removing the wheel from the vehicle, check for swaying movement and if necessary, check the wheel lateral runout as outlined under heading "Wheel Straightness Check".

WARNING

When balancing wheel and tire assemblies, it is strongly recommended to closely follow instructions covering the operation of wheel balancer.

CAUTION

A maximum of 16-oz (450 g) of balancing weight is recommended. If more weight is necessary, check and correct the cause.

11.4 TIRE ROTATION

Radial tires should be rotated only when necessary. If the tires are wearing evenly, there is no need to rotate. If irregular wear becomes apparent or if the wear rate on the tires is perceptively different (from axle to axle), then tires should be rotated in such a manner as to alleviate the condition.

NOTE

There is no restriction on criss-cross rotation.

12. SPECIFICATIONS

STEEL WHEELS (except inner drive axle)

Wheel size..... 9.0" X 22.5"
 Wheel nut torque..... 450 - 500 lbf-ft (610 - 680 Nm)
 Tire size..... 315/80 R 22.5

STEEL WHEELS (inner drive axle)


Wheel size..... 8.25" X 22.5"
 Wheel nut torque..... 450 - 500 lbf-ft (610 - 680 Nm)
 Tire size..... 315/80 R 22.5


ALUMINUM WHEELS (All wheels are 9" X 22.5" except inner drive axle)

Wheel size..... 9" X 22.5"
 Wheel nut torque..... 450 - 500 lbf-ft (610 - 680 Nm)
 Tire size..... 315/80 R 22.5

RECOMMENDED TIRE INFLATION PRESSURE AT MAXIMUM LOAD (cold)

NOTE
<i>Vehicle is delivered with the specific inflation pressure certification plate according to the tire selection.</i>

 WARNING
Special tire selection may lower maximum allowable speed limit, even below posted speed limit. For maximum safety, check with tire manufacturer.

 WARNING
Recommended tire inflation pressures and maximum allowable loads apply to speeds up to 65 mph (105 km/hr). Do not drive vehicle at a higher speed than 65 mph (105 km/h) or above the posted speed limit.

ALUMINUM WHEEL CLEANING AND MAINTENANCE PRODUCTS

Aluminum Wheel Cleaner (22 Oz bottle)Prévost #683529
 Aluminum Wheel Polish (16 Oz bottle)Prévost #683528
 Aluminum Wheel Sealer (13 Oz bottle)Prévost #683527

TRUCK AND TRAILER

ALCOA DURA-BRIGHT® WHEELS

MORE SHINE. LESS MAINTENANCE.



You said you wanted aluminum wheels that kept their brilliant good looks with as little effort as possible. And, we listened.

Introducing the first aluminum wheels you don't polish or scrub – just spray with soap and water. And, of course, they're from the aluminum wheel experts, Alcoa.

It's not a coating. It's not a finish. It's a patented treatment that penetrates the aluminum. Alcoa Dura-Bright® wheels need no painting, no polishing, no special chemicals. We think you'll agree. Alcoa Dura-Bright® wheels are the closest to a maintenance-free shine you'll ever see.

Available exclusively from Alcoa, Dura-Bright® wheel treatment:

- protects wheels against oxidation and corrosion.
- cleans easily, so brake dust, road salt, dirt and oil residue quickly wash away.
- brightens the wheel.

Now your wheels can look their best with less effort than with any previous steel or aluminum wheel. That lets you save money and time – and still hit the road with clean, bright, good-looking wheels on your trucks and trailers.

Along with faster, easier cleaning and maintenance, you get all the advantages you've come to expect from Alcoa aluminum wheels, including:

- less weight for increased payload and greater fuel efficiency.
- better heat dissipation for extended tire and brake life.
- higher resale value (historically up to \$1,500 on trucks with regular Alcoa aluminum wheels. Alcoa Dura-Bright® wheels may result in even more).
- one-piece, forged-in strength.
- the widest selection of wheels and wheel accessories in the industry.

Leave it to the company that invented the first practical aluminum truck wheel in 1948 to come up with Dura-Bright® wheels – the next revolution in wheel maintenance.

Alcoa Wheels – Look Smart



Dura-Bright® is a federally registered trademark of Alcoa Inc.



Dura-Bright® Wheel Specifications

Alcoa aluminum disc wheel mounting dimensions are consistent with SAE Recommended Practice J694 August '98. Part numbers listed for all sizes are Dura-Bright® brushed finish. Buffed finishes are indicated by changing the last digit of the part number listed to one of the following: For buffed outside only, part number should end in "1". For buffed inside only, part number should end in "2". For buffed both sides, part number should end in "3". Valve hole is on the inside. To protect the surface of Dura-Bright® wheels used in dual applications, Alcoa recommends the use of Alcoa DiscMate™ wheel spacers.

Dura-Bright® finished wheels currently available are listed below. Other wheel part numbers may be available upon request. Contact your Alcoa sales representative for availability.

CLASSIC TUBELESS WHEELS (round hand holes) – ENGLISH UNITS															
Wheel description	Maximum wheel load ¹ in pounds	Wheel wt. lbs.	Outset inches ²	Inset inches	Maximum inflation PSI – cold	Valve stem	Part number ²	DiscMate™	Stabilizer	Front outer cap nuts	Rear inner cap nuts A/I/AI	Rear inner cap nuts AI/St†	Rear outer cap nuts	Lug nut covers	Hub cover system kits front/rear
10-hole, stud located ball seat mounting – 11.25 in. bolt circle, 8.73 in. hub bore, 1.219 in. bolt hole diameter															
22.5x8.25-15°DC	7200	53	6.66	5.68	120	TR545D	883110DB	3/4" - 016000 1-1/8" - 017000	2225	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	5996 L&R	150	Front - 076015 Rear - 077015
22.5x9.00-15°DC	9000	60	6.94	5.94	130	TR543C	893000DB	3/4" - 016000 1-1/8" - 017000	2127	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	5996 L&R	150	Front - 076015 Rear - 077015
24.5x8.25-15°DC**	7200	59	6.6	5.59	120	TR545D	983120DB	3/4" - 016000 1-1/8" - 017000	—	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	150	Front - 076015 Rear - 077015
10-hole, hub piloted mounting – 285.75mm bolt circle, 220.1mm hub bore, 26.75mm bolt hole diameter (use two-piece flange nuts)															
22.5x8.25-15°DC**	7300	47	6.66	5.81	120	TR545D	883620DB	011000	2227	39874	—	—	39874	181	Front - 076018 or 076085† Rear - 077018 or 077085†
22.5x9.00-15°DC**	9000	60	6.94	6.04	130	TR543C	893600DB	011000	2127	39874	—	—	39874	181	Front - 076018 or 076085† Rear - 077018 or 077085†
24.5x8.25-15°DC**	7300	55	6.6	5.73	120	TR545D	983620DB	011000	2247	39874	—	—	39874	181	Front - 076018 or 076085† Rear - 077018 or 077085†
10-hole, hub piloted bus mounting – 11.25 in. bolt circle, 8.670 in. hub bore, 1.219 in. bolt hole diameter (use two-piece flange nuts)															
22.5x8.25-15°DC	7300	53	6.66	5.82	120	TR545D	883610DB	015000	2225	—	—	—	—	1821	—
24.5x8.25-15°DC	7300	62	6.6	5.77	120	TR545D	983610DB	015000	2245	—	—	—	—	1821	—
CLASSIC TUBELESS WHEELS (round hand holes) – ENGLISH UNITS (METRIC UNITS)															
Wheel description	Maximum wheel load ¹ in lbs. (kgs)	Wheel wt. lbs. (kgs)	Outset inches ² (mm)	Inset inches (mm)	Maximum inflation PSI-cold (Kpa)	Valve stem	Part number ²	DiscMate™	Stabilizer	Front outer cap nuts	Rear inner cap nuts A/I/AI	Rear inner cap nuts AI/St†	Rear outer cap nuts	Lug nut covers	Hub cover system kits front/rear
10-hole, hub piloted mounting – 335mm bolt circle, 281.2mm hub bore, 26.75mm bolt hole diameter (use two-piece flange nuts)															
22.5x8.25-15°DC (26mm)	7830* (3550)	55.1 (25.0)	6.60 (168)	5.70 (145)	138 (952)	60MS27	885530DB†	013000	—	39874	—	—	39874	181	—
22.5x9.00-15°DC (26mm)	8820* (4000)	58.0 (26.3)	6.93 (176)	6.02 (153)	142 (978)	60MS27	894530DB†	013000	—	39874	—	—	39874	181	—
10-hole, hub piloted mounting – 335mm bolt circle, 281.2mm hub bore, 32.87mm bolt hole diameter (use two-piece flange nuts)															
22.5x8.25-15°DC (32mm)	7830* (3550)	55.1 (25.0)	6.60 (168)	5.70 (145)	138 (952)	60MS27	885550DB†	018000	—	430632	—	—	430732	—	—
22.5x9.00-15°DC (32mm)	8820* (4000)	57.1 (25.9)	6.93 (176)	6.02 (153)	142 (978)	60MS27	894550DB†	018000	—	430632	—	—	430732	—	—

Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating. Do not overinflate. Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire, perform a wheel fitment check to ensure proper clearance from any obstructions. Valve hole is on the inside unless noted otherwise.

- ¹ Capacity ratings as dual or single in highway service – bias-ply or radial. Load ratings in lbs. for items 6 and 7 are rounded to nearest multiple of 5.
- ² Some wheels may bear part numbers not shown in this manual. Before servicing these wheels, contact your Alcoa wheel representative for proper load, inflation and part compatibility information.
- ³ Outset (positive)/inset (negative) – The distance from the rim centerline to the mounting face of wheel. Inset (negative) places the rim centerline inboard of the wheel mounting face, and outset (positive) places the rim centerline outboard of the wheel mounting face (1/2 dual spacing = offset).
- ** The lighter-weight Alcoa New Generation wheels.
- † Indicates European Mount New Generation wheel for North American market.
- ‡ Hub cover system kits P/N 076085 (front) and P/N 077085 (rear) contain screw-on Hug-a-Lug® nut covers and require a minimum of four threads of the stud to extend above the tightened cap nut for use.

Dura-Bright® wheels should be cleaned with soap and water only. No abrasives or brushing. Detailed care and maintenance instructions for Dura-Bright® finished wheels are available in the Alcoa Dura-Bright® Wheel Finish Care and Maintenance publication by Alcoa. For your free copy, contact Alcoa Wheel Products, 1600 Harvard Avenue, Cleveland, OH 44105, (800) 242-9898.

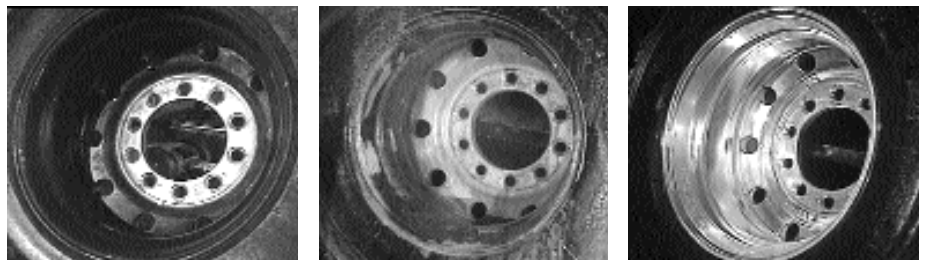
Alcoa Wheel Products
1600 Harvard Avenue
Cleveland, Ohio 44105
800.242.9898



www.alcoawheels.com

Alcoa Inter-America, Inc.
115-A Matheson Blvd. West, Suite 207
Mississauga, Ontario L5R 3L1
800.668.1150

Alcoa Dura-Bright® Wheel Finish Care and Maintenance



*New Dura-Bright® wheels shed dirt, brake dust and grease.
Wash them off - no scrubbing, no special chemical solutions - and watch them shine.*





Alcoa Dura-Bright® Wheel Care and Maintenance

Maintenance against corrosion

1. Clean frequently with high-pressure water from a hose. The use of a mild detergent will speed the cleaning process. Do not clean with abrasives, abrasive brushes, steel wool, scouring pads or strong chemicals, such as acids or lye-based products. Never spray cold water on extremely hot wheels. Always allow time to cool before cleaning.
2. When tires are removed, the entire rim must be cleaned and inspected (see section 2, page 3 of the Alcoa Wheel Service Manual, July 2002). With a brush, remove any foreign products **from the tire side of the rim** (portion of the wheel that supports the tire). Do not use an abrasive brush to remove dirt, corrosion or other foreign products from the Dura-Bright® wheel surfaces. Generously coat the entire air chamber surface with an approved surface protectant and lubricate each time the tire is removed (see 3-1, page 11 of the Alcoa Wheel Service Manual, July 2002).
3. To maintain the original appearance of your Alcoa Dura-Bright® wheels, the following procedures are recommended:
 - a. After installing new wheels and prior to operating your vehicle, use a sponge or cloth to wash exposed wheels surfaces with a mild detergent and warm water. Do not use abrasives, abrasive brushes, steel wool, scouring pads or strong chemicals (such as acids or lye-based products). Standard off-the-shelf car wash and wheel detergents are sufficient.
 - b. Rinse thoroughly with clean water. Warm water and a mild detergent will speed the cleaning process.
 - c. Wipe dry to avoid water spots.
 - d. Clean your Alcoa Dura-Bright® wheels using the above procedures as frequently as required to maintain their appearance. Typical road soils, grime and brake dust trap moisture, which can cause corrosion over a period of time. These must be removed regularly. To assist in the removal of excessive dust, dirt and road grime, the use of warm, high-pressure water with a mild detergent is recommended. The surface of Alcoa Dura-Bright® wheels will be damaged, discolored or removed if abrasives, abrasive brushes, steel wool, scouring pads or strong chemicals (such as acids or lye-based products) are used to clean the wheel. **DO NOT USE** the Alcoa Aluminum Care System on Dura-Bright® wheels at any time during their service life.
4. Once in service, Dura-Bright® wheels can become nicked or scratched by road debris and/or mechanical damage. If this occurs, continue to follow the normal washing and cleaning instructions provided above. The surface of Alcoa Dura-Bright® wheels is designed to limit cracking and peeling if nicked or scratched while in service.
5. Even as durable as Dura-Bright® wheels are, the mounting area can become scratched, marred or discolored when mounted against another wheel, hub or drum. Keeping this surface consistently located. The use of a wheel mounting surface guard, such as Alcoa DiscMates™, is highly recommended. The use of the Alcoa Hub Cover System on Alcoa Dura-Bright® wheels will also assist in limiting such damage and help maintain the appearance of your Alcoa Dura-Bright® wheels.

Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire, perform a wheel fitment check to ensure proper clearance from any obstructions.

Avoid abuse

Abuse can shorten the life of a wheel. Lack of care in changing a tire, heavy pounding on the wheel rim, overloading or hitting curbs at high speed or a sharp angle can damage wheels.

Rim flange wear

Irregular wear on the surface of the rim flange is caused by the chafer and side wall area of the tire working on the surface of the rim flange. Remove the wheel from service when rim flange wear is excessive. Excessive wear can be determined using an Alcoa approved wear gauge and procedures. For availability, contact Alcoa Wheel Products at 800-242-9898 or 1600 Harvard Avenue, Cleveland, Ohio 44105. If rim flange wear becomes sharp and/or cuts the tire, contact Alcoa Wheel Products for recommended maintenance procedures.

Valves

Alcoa drop center wheels for tubeless tires come from the factory with air valves installed. If it becomes necessary to replace an air valve, install it using the following torque values.

10 to 14 foot-pounds for part numbers

TR 509

TR 510

TR 511

7 to 11 foot-pounds for part numbers

TR 542 Series

TR 543 Series

TR 544 Series

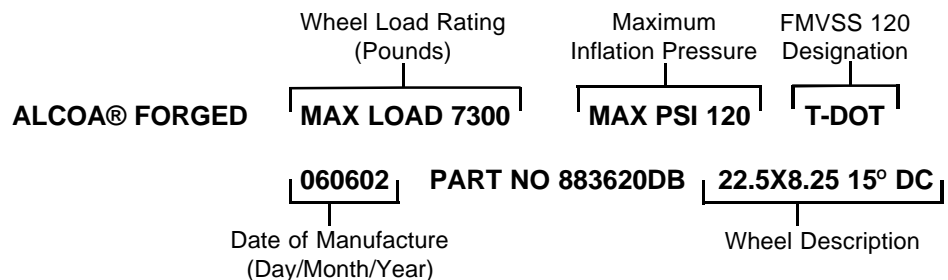
TR 545 Series

Replacement valves may be obtained from your authorized Alcoa wheel distributor. Always use silicone O-rings - not rubber - when reinstalling valve stems. Metal valve stem caps are recommended over plastic.

Identification

Alcoa wheel identification

Since 1977, all Alcoa aluminum disc wheels have been identified with a stamp that shows the wheel load rating, maximum inflation pressure, date of manufacture, part number, wheel description and DOT marking designation (shown below).



Prior to June 1996, all Alcoa heavy duty truck wheels has the Alcoa identification symbol Σ on the outside of the disc near the hand hole and in line with the valve location. This marking was phased out on heavy duty truck wheels manufactured after June 1996.

Note: Prior to June 1999, all heavy duty truck wheels manufactured by Alcoa Wheel Products were date stamped with the month and year only.

Keep wheel nuts tight

Wheel cap nuts must be kept tight (see section 4 of the Alcoa Wheel Service Manual, July 2002). When checking the cap nuts on dual disc wheels using the stud located ball seat mounting system, loosen every other outer cap nut and then check the torque of the inner cap nuts. Re-torque the loosened outer cap nuts. Repeat these steps on the remaining studs. Check all cap nuts for proper torque after the first use or any removal. Inspect wheels and check wheel nuts during service stops (see section 2 of the Alcoa Wheel Service Manual, July 2002). Dirt streaks from cap nuts may indicate looseness.

Flange nuts must be kept tight, and studs and nuts should be checked frequently. At tire changes, nuts and studs should be inspected to be sure they are in good condition. If nuts require frequent tightening or studs break frequently, hardware and mounting practices should be reviewed.

The proper torque for ball seat cap nuts is between 350 and 400 foot-pounds for stud threads lubricated with SAE 30W oil and between 450 and 500 foot-pounds for threads that are not lubricated. The proper torque for M22-1.5 two-piece flange nuts (33 mm hex head) is between 450 and 500 foot-pounds.

Lead balance weights (clip-on)

Lead balance weights for Alcoa wheels are available from your Alcoa wheel distributor. With radial tires, it may be necessary to temporarily reduce the tire pressure to allow clearance of the weight clamp over the rim flange.

Do not straighten wheels

Do not heat wheels in an attempt to soften them for straightening to repair damage from striking curbs or other causes. The special alloy used in these wheels is heat-treated, and uncontrolled heating will weaken the wheel.

Do not rework, weld, heat or braze Alcoa aluminum wheels for any reason. This does not include normal wheel maintenance as described and approved by Alcoa.

Owner/in-service identification

Some fleets wish to specially identify wheels with OWNERSHIP and IN-SERVICE DATE information. If this practice is adopted:

1. Use "Lo-Stress" stamps or equivalent.
2. Location of stamped areas on outside disc should be in space outward from a line between hand hole centers and a minimum of one inch from the periphery of any hand hole.
3. Location of stamped identification on inside of wheel should be as close to the factory identification stamping as possible.

Note: Use of an impression stamp on Dura-Bright® wheels can affect the appearance and performance of the Dura-Bright® surface treatment local to the stamp.

Limited Warranty FOR HEAVY DUTY TRUCKS, TRUCK TRAILERS AND BUSES

**Dura-Bright wheels
denoted by Alcoa part
numbers ending with
a “4” and “7” with bead
seat diameters measured
in 0.5-inch increments**

Alcoa Inc. warrants to the original purchaser from Alcoa or its authorized distributor that a new Alcoa Dura-Bright® aluminum disc heavy duty truck, truck trailer or bus wheel is free from defects in material and workmanship. Alcoa agrees, without charge, to repair or replace a Dura-Bright® wheel that fails in normal use and service because of defects in material or workmanship. Wheels are structurally warranted for 60 months from the date of manufacture, and the Dura-Bright® surface treatment is also warranted for 60 months from the date of manufacture. Alcoa bus mount wheels (10-hole, 11.25-inch bolt circle, 8.670-inch hub bore with 1.22-inch diameter bolt holes) and other wheels used in transit bus service are structurally warranted for 120 months from the date of manufacture, and the Dura-Bright® surface treatment is warranted for 60 months from the date of manufacture. In all cases, the date of manufacture is shown on the wheel. Alcoa does not warrant and will not repair, replace or make adjustments with respect to normal wear or for any wheel that has been damaged or subjected to misuse or abuse including, without limitation, the following:

- (a) Using a tire that is improperly sized according to standards recommended by Alcoa or the Tire and Rim Association, Inc.;
- (b) Loading beyond the applicable maximum wheel load as specified by Alcoa;
- (c) Inflating the tire beyond the applicable maximum as specified by Alcoa;
- (d) Changing the original condition of the wheel by alteration or by subjecting it to processing, such as heating, welding, straightening or machining;
- (e) Accidents, road conditions, abnormal or severe operating conditions;
- (f) Failure to follow instructions and recommended maintenance on the wheel as set forth in the Alcoa Wheel Service Manual, Alcoa Technical Bulletins and other Alcoa literature. Recommended maintenance includes, without limitation, periodic cleaning with standard non-abrasive wheel and/or car wash cleaners/detergents, valve replacement and rim flange wear inspections and procedures.

This limited warranty in regards to the Dura-Bright® wheel finish (denoted by Alcoa part numbers ending in “4” and “7”) does not cover corrosion or other damage associated with the conditions addressed above or associated with the following: damage in areas of the mounting surfaces (such as lug holes, hubs, drums and against other wheels in dual position), damage due to cleaning with abrasives, abrasive brushes, steel wool, scouring pads or strong chemicals (such as acids or lye-based products), and removal/damage of the Dura-Bright® wheel finish, including chipping, by contact with road obstacles such as stones, gravel, concrete curbs, metallic barriers, signs, etc. Alcoa recommends cleaning the wheels with mild soap and water. For detailed recommended use and maintenance instructions, see the Alcoa Wheel Service Manual and the Alcoa Dura-Bright® Wheel Finish Care and Maintenance instructions.

Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

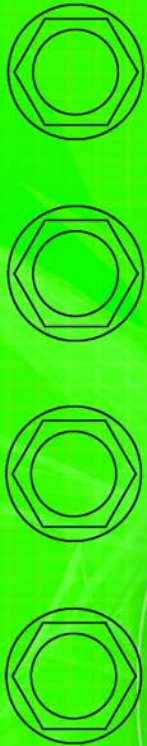
Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire, perform a wheel fitment check to ensure proper clearance from any obstructions.

THERE IS NO WARRANTY THAT THE WHEEL IS MERCHANTABLE OR SATISFACTORY FOR ANY PARTICULAR PURPOSE. NOR IS THERE ANY OTHER WARRANTY, EXPRESSED OR IMPLIED, ON THE WHEEL.

ALCOA WILL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES FOR ANY BREACH OF WARRANTY, ITS LIABILITY AND THE PURCHASER'S EXCLUSIVE REMEDY BEING EXPRESSLY LIMITED TO REPAIR OR REPLACEMENT OF THE WHEEL.

Repair or replacement will be handled by any authorized Alcoa wheel distributor or by any Alcoa wheel representative under Alcoa's return policy. This warranty gives you specific legal rights. You may also have other rights under other applicable laws.

To obtain a copy of the Alcoa Wheel Service Manual, the Alcoa Dura-Bright® Wheel Finish Care and Maintenance instructions, or other product and specification literature, contact Alcoa Wheel Products at 800-242-9898 or at 1600 Harvard Avenue, Cleveland, Ohio 44105. For additional information on our warranty or to submit a warranty claim, contact the Alcoa Wheel Service Center at 800-242-9898 (option 2) or 888-279-3055.



Part number	Valve hole diameter	Disc diameter
663170	3/4" - 0.160	1.18" - 0.174
663070	3/4" - 0.160	1.18" - 0.174
873100	3/4" - 0.160	1.18" - 0.174
893110	3/4" - 0.160	1.18" - 0.174
893000	3/4" - 0.160	1.18" - 0.174
823000	3/4" - 0.160	1.18" - 0.174
823050	3/4" - 0.160	1.18" - 0.174
823060A	3/4" - 0.160	1.18" - 0.174
823070A	3/4" - 0.160	1.18" - 0.174
893000	3/4" - 0.160	1.18" - 0.174
893050	3/4" - 0.160	1.18" - 0.174
893060A	3/4" - 0.160	1.18" - 0.174
841100	3/4" - 0.160	1.18" - 0.174
983120	3/4" - 0.160	1.18" - 0.174
833070A	3/4" - 0.160	1.18" - 0.174
TR543	3/4" - 0.160	1.18" - 0.174
TR543D	3/4" - 0.160	1.18" - 0.174
TR543E	3/4" - 0.160	1.18" - 0.174
TR543F	3/4" - 0.160	1.18" - 0.174
TR543G	3/4" - 0.160	1.18" - 0.174
TR543H	3/4" - 0.160	1.18" - 0.174
TR543I	3/4" - 0.160	1.18" - 0.174
TR543J	3/4" - 0.160	1.18" - 0.174
TR543K	3/4" - 0.160	1.18" - 0.174
TR543L	3/4" - 0.160	1.18" - 0.174
TR543M	3/4" - 0.160	1.18" - 0.174
TR543N	3/4" - 0.160	1.18" - 0.174
TR543O	3/4" - 0.160	1.18" - 0.174
TR543P	3/4" - 0.160	1.18" - 0.174
TR543Q	3/4" - 0.160	1.18" - 0.174
TR543R	3/4" - 0.160	1.18" - 0.174
TR543S	3/4" - 0.160	1.18" - 0.174
TR543T	3/4" - 0.160	1.18" - 0.174
TR543U	3/4" - 0.160	1.18" - 0.174
TR543V	3/4" - 0.160	1.18" - 0.174
TR543W	3/4" - 0.160	1.18" - 0.174
TR543X	3/4" - 0.160	1.18" - 0.174
TR543Y	3/4" - 0.160	1.18" - 0.174
TR543Z	3/4" - 0.160	1.18" - 0.174

WHEEL SERVICE MANUAL

SAFETY AND MAINTENANCE INSTRUCTIONS
FOR ALCOA TRUCK, TRAILER, BUS AND MOTOR HOME WHEELS

March 2005

Supersedes July 2004

LIMITED WARRANTY

FOR HEAVY DUTY TRUCKS, TRUCK TRAILERS,
BUSES, RV and MOTORHOME WHEELS

(Wheels with bead seat diameters measured in .5 inch increments and Alcoa tube type wheels)

Alcoa warrants to the original purchaser, from Alcoa or its authorized distributor, that a new Alcoa aluminum disc heavy duty truck, truck trailer, bus, 19.5-inch and 22.5-inch RV or motorhome wheel is free from defects in material and workmanship. Alcoa agrees, without charge, to repair or replace a wheel that fails in normal use and service because of defects in material and workmanship. Truck, truck trailer, Dura-Flange® and the Dura-Bright® surface treatment wheels not used in transit service are warranted for 60 months from the date of manufacture as shown on the wheel except the Dura-Flange® rim flange treatment is warranted for a period of 24 months. Alcoa bus mount wheels (10-hole, 11.25 inch bolt circle, 8.670 inch hub bore with 1.22 inch diameter bolt holes) and other wheels used in transit service are warranted for 120 months from date of manufacture, except the Dura-Bright® surface treatment on bus and transit service wheels is warranted for a period of 60 months from the date of manufacture and the Dura-Flange® rim flange treatment is warranted for 24 months. Satin finish, polished and Dura-Bright® surface treatment 19.5-inch and 22.5-inch RV and motorhome wheels are warranted for 120 months from the date of manufacture as shown on the wheel. Alcoa does not warrant and will not repair or replace or make adjustment with respect to any wheel that has been subjected to misuse or abuse including the following:

- (a) Using a tire that is oversized according to standards recommended by the Tire and Rim Association, Inc. or other recognized tire and rim agencies such as ETRTO (Europe) or others;
- (b) Loading the wheel beyond the applicable maximum wheel load as specified by Alcoa;
- (c) Inflating beyond the applicable maximum as specified by Alcoa;
- (d) Changing the original condition of the wheel by alteration or by subjecting it to any processing such as welding or straightening.
- (e) Accidents, abnormal or severe operating conditions including without limitation tire fires, brake fires, severe brake system drags or seizures or running with a flat tire; or
- (f) Failure to follow maintenance and other instructions and warnings set forth in the Alcoa Heavy Duty Wheel Service Manual, Alcoa Technical Bulletins and other Alcoa literature. Recommended maintenance includes, without limitation, using proper torque, periodic cleaning, polishing, valve replacement, periodic inspection for damage, loose lug nuts and rim flange wear inspections and procedures.
- (g) Nicks, scratches and other surface blemishes resulting from improper maintenance, cleaning, road debris, curbing, accident or operation are not warrantable.
- (h) Damage due to cleaning with abrasives, abrasive brushes, steel wool, scouring pads, or strong chemicals (acids or alkaline).

Dura-Bright® Surface Treated Wheels are warranted against:

- (a) Filiform corrosion (worm or hair like lines, generally milky in appearance, underneath surface protective treatment and emanating from damage to the surface treatment such as nicks, scratches or damage from mounting hardware or wheel weights)
- (b) Blistering due to loss of adhesion of the surface treatment,
- (c) Lift off of the surface treatment due to physical damage (nicks, scratches, gouges)

If nicks, dings, scratches or other damage does occur to the Dura-Bright® treatment that exposes the aluminum underneath, the metal exposed may naturally oxidize, but any corrosion will be confined to the metal exposed and will not extend into or underneath the Dura-Bright® treatment.

Normally, any washing materials or chemicals (including mild acid washes) that can safely be used on a vehicle, its painted surfaces and components, can safely be used on the Dura-Bright® surface treatment. The Dura-Bright® treatment prevents corrosion of aluminum wheels and protects their shine. So long as the treatment remains in place (see comments (g) and (h) above) and is maintained in accordance with the Alcoa Dura-Bright® Care and Maintenance manual, it is warranted against corrosion. If corrosion does occur within the treatment warranty period, subject to the limitations stated above, Alcoa will replace any wheel exhibiting such corrosion.

There is no warranty that the wheel shall be merchantable or fit for any particular purpose, nor is there any other warranty, express or implied, except such as is expressly set forth herein.

Alcoa shall not be liable for any incidental or consequential damages for any breach of warranty, its liability and the purchaser's exclusive remedy being limited to repair or replacement of the wheel as stated in this limited warranty.

Alcoa Wheel Service Manual. This limited warranty should be used in conjunction with the Alcoa Wheel Service Manual and the Alcoa Dura-Bright® Wheel Finish Care and Maintenance Manual. The Wheel Service Manual contains important safety information and warnings, and failure to read and understand this information may result in serious injury or death. The limited warranty is included with the Wheel Service Manual, but may appear elsewhere. If you do not have copies of the Wheel Service Manual you may obtain copies free of charge from Alcoa Wheel and Forged Products, 1600 Harvard Avenue, Cleveland, Ohio 44105, (800) 242-9898 and on the web at www.alcoawheels.com.

How to use this manual

This manual is written in a style called structured text.

Throughout the manual you will find numbers which look like this (See 3-1, page 18). These numbers are cross references to other sections of the manual. The numbers (3-1) refer to section 3, subtopic 1. When you turn to page 18 you will find the section number and subtopic number under the heading in each section as shown below:

Recommendations for mounting tubeless tires

3-1

The cross references will help you find related information in the manual. For example in section 4-1 you will read the following sentence...

"Make sure all wheel cap nuts are properly torqued—check them often (see 4-9, page 29)."

By turning to section 4, subtopic 9, on page 29 you will find information on proper torquing.

Note: The **Alcoa Heavy Duty Wheel Service Manual** contains information for proper service and operation of Alcoa heavy duty wheels. Alcoa heavy duty wheels for heavy duty trucks, truck trailers and buses are Alcoa tubeless wheels with bead seat diameters measured in .5 inch increments and Alcoa tube type wheels.

Note: Dura-Bright® wheels produced after November 2002 have Alcoa wheel part numbers ending with "DB" (earlier wheels have part numbers ending in a 4 or 7) with bead seat diameters measured in 0.5-inch increments. Not all Alcoa wheels are available with the Dura-Bright® surface treatment.



WARNING

WARNING Wheels that are not properly installed or maintained may not work properly.

Failure to follow proper wheel installation or maintenance practices may result in injury or death.

Follow the proper wheel installation and maintenance practices as contained in this Alcoa Service Manual. For additional copies of the manual, available free of charge from Alcoa, or for the most recent updates, contact Alcoa Wheel and Forged Products at 1-800-242-9898 option 1 or on the web at www.alcoawheels.com.

To obtain Alcoa rim flange wear gauge(s) at no charge and information on free training on proper installation and maintenance procedures, contact Alcoa Wheel and Forged Products at (800) 242-9898 option 1 or on the web at www.alcoawheels.com.

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1 Specifications

Alcoa aluminum disc wheel mounting dimensions are consistent with SAE Recommended Practice J694 February 2001. Part numbers listed for all sizes are satin finish. Polished finishes are indicated by changing the last digit of the part number listed to one of the following. For polished outside only, part number should end in "1." For polished inside only, part number should end in "2." For polished both sides, part number should end in "3." Valve hole is on the inside. Only for item numbers marked with an asterisk(*), part numbers ending in "9" are inset position wheels satin finished (see footnote).

Dura-Bright® surface treatment wheels are identified by using the regular numerical part number and the addition of "DB" at the end. Finishes are indicated by changing the last numerical digit of the part number to one of the following. For brushed both sides, the number is "0." For buffed outside only, the number is "1." For buffed inside only, the number is "2." For buffed both sides, the number is "3." Currently, only the wheel item numbers marked with "DB" are available with the Dura-Bright® surface treatment. Dura-Flange® wheels are identified by using the regular numerical part number and the addition of "DF" at the end. Only the wheel item numbers marked with DF are available with the Dura-Flange® option and are available in all polished finishes.

TUBELESS WHEELS (round hand holes) ENGLISH UNITS

Item no.	Wheel description	Maximum wheel load ¹ in lbs.	Wheel wt. lbs.	Outset inches ³	Inset inches	Maximum inflation PSI—cold	Valve stem	Part number ²	DiscMate	Stabilizer	Front outer cap nuts	Rear inner cap nuts A/I	Rear inner cap nuts A/Sl	Rear outer cap nuts	Lug nut covers	Hub cover system kits front / rear
Six-hole, stud located, ball seat mounting—8.750 in. bolt circle, 6.495 in. hub bore, 1.219 in. bolt hole diameter																
1	17.5x6.75-15°DC	5070	32	5.55	4.72	125	TR543C	663170	-	2125	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	5996 L&R	150	-
10-hole, stud located, ball seat mounting—8.750 in. bolt circle, 6.495 in. hub bore, 1.219 in. bolt hole diameter																
2	17.5x6.75-15°DC	5070	31	5.55	4.72	125	TR543C	663070	-	2125	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	5996 L&R	150	-
10-hole, stud located, ball seat mounting—11.25 in. bolt circle, 8.73 in. hub bore, 1.219 in. bolt hole diameter																
3	22.5x7.50-15°DC	7200	53	6.28	5.32	120	TR545D	873100	3/4" - 016000, 1-1/8" 017000	2225	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	5996 L&R	150	Front - 076015 Rear - 077015
^{DB} 4	22.5x8.25-15°DC	7200	53	6.66	5.68	120	TR545D	883110	3/4" - 016000, 1-1/8" 017000	2225	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	5996 L&R	150	Front - 076015 Rear - 077015
5	22.5x9.00-15°DC	9000	60	6.94	5.94	130	TR543C	893000	3/4" - 016000, 1-1/8" 017000	2127	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	5996 L&R	150	Front - 076015 Rear - 077015
6	22.5x12.25-15°DC	11,400	62	⁵⁶ Reversible	—	125	TR543E	823000	3/4" - 016000, 1-1/8" 017000	-	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	-	-	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	150	Front - 076015 Rear - 077015
*7	22.5x12.25-15°DC	11,400	66	3.88	2.76	125	TR543E outset TR545E inset	823050	3/4" - 016000, 1-1/8" 017000	-	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	-	-	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	150	Front - 076015 Rear - 077015
8	22.5x12.25-15°DC	11,000	70	5.84	4.68	120	TR545E	823060A	3/4" - 016000, 1-1/8" 017000	-	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	-	-	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	150	Front - 076015 Rear - 077015
9	22.5x13.00-15°DC	12,300	72	3.5	2.38	125	TR543E	833050	3/4" - 016000, 1-1/8" 017000	-	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	-	-	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	150	Front - 076015 Rear - 077015
*10	22.5x14.00-15°DC	12,800	71	2.0	0.87	125	TR543E outset TR545E inset	841100	3/4" - 016000, 1-1/8" 017000	-	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	-	-	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	150	Front - 076015 Rear - 077015
11	24.5x8.25-15°DC	7200	59	6.6	5.59	120	TR545D	983120	3/4" - 016000, 1-1/8" 017000	-	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	150	Front - 076015 Rear - 077015
10-hole, stud located, ball seat mounting—13.19 in. bolt circle, 10.65 in. hub bore (valve hole is on outside), 1.360 in. bolt hole diameter																
*12	22.5x13.00-15°DC	11,000	76	—	6.12	120	TR543	833070A	-	-	-	-	-	-	-	-
Eight-hole, hub piloted mounting—275mm bolt circle, 221.1mm hub bore, 26.75mm bolt hole diameter (use two-piece flange nuts)																
^{DB} 13	22.5x7.50-15°DC	7300	53	6.28	5.44	120	TR545D	873400	014000	2225	39874	-	-	39874	181	-
^{DF} **14	22.5x8.25-15°DC	7300	50	6.66	5.82	120	TR545D	883420	014000	2227	39874	-	-	39874	181	-
^{DB} **15	22.5x8.25-15°DC	7400	50	6.66	5.82	130	TR544D	883440	014000	8344	39874	-	-	39874	181	-
*16	22.5x14.00-15°DC	12,800	71	2.0	0.87	125	TR543E outset TR545E inset	841400	014000	-	39874	-	-	39874	181	-
17	24.5x8.25-15°DC	7300	62	6.6	5.77	120	TR509	983400	014000	2245	39874	-	-	39874	181	-

Continued on next page

1 Specifications cont'd.

TUBELESS WHEELS (round hand holes) ENGLISH UNITS *continued*

Item no.	Wheel description	Maximum wheel load ¹ in lbs.	Wheel wt. lbs.	Outset inches ³	Inset inches	Maximum inflation PSI—cold	Valve stem	Part number ²	DiscMate	Stabilizer	Front outer cap nuts	Rear inner cap nuts A/AI	Rear inner cap nuts A/STI	Rear outer cap nuts	Lug nut covers	Hub cover system kits front / rear
10-hole, hub piloted mounting—285.75mm bolt circle, 220.1mm hub bore, 26.75mm bolt hole diameter (use two-piece flange nuts)																
DB18	22.5x7.50-15"DC	7300	53	6.28	5.44	120	TR545D	873600	011000	2225	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DB DF **19	22.5x8.25-15"DC	7400	48	6.66	5.81	130	TR544D	883640	011000	8364	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DB DF **20	22.5x8.25-15"DC	8000	55	6.66	5.69	120	TR543C	885600	011000	-	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DB **21	22.5x9.00-15"DC	9000	60	6.94	6.04	130	TR543C	893600	011000	2127	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DB **22	22.5x9.00-15"DC	9000	60	6.94	6.04	130	TR544D	893640	011000	8964	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DB23	22.5x9.00-15"DC	10,000	53	—	3.12	130	TR545E	893630	011000	-	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DB24	22.5x10.50-15"DC	10,500	68	6.61	5.5	130	TR543	803600	011000	-	39874	-	-	-	181	Front - 076018 or 076085‡
25	22.5x12.25-15"DC	12,300	63	.56 Reversible	—	125	TR543E	823600	011000	-	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DB DF *26	22.5x12.25-15"DC	11,400	66	3.88	2.75	125	TR543E outset TR545E inset	823650	011000	-	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DB DF **27	22.5x12.25-15"DC	11,000	71	5.8	4.68	120	TR545E	823660A	011000	-	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
10-hole, hub piloted mounting—285.75mm bolt circle, 220.1mm hub bore, 26.75mm bolt hole diameter (use two-piece flange nuts) — continued from previous page																
DB DF **28	22.5x12.25-15"DC	11,000	71	5.8	4.68	130	TR542	823640	011000	-	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
29	22.5x12.25-15"DC	10,000	74	6.24	5.12	120	TR545E	823670A	011000	-	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
*30	22.5x13.00-15"DC	12,300	73	3.5	2.38	125	TR543E outset TR545E inset	833650	011000	-	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
**31	22.5x13.00-15"DC	11,000	74	6.42	5.3	120	TR545E	833660A	011000	-	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
**32	22.5x13.00-15"DC	11,000	74	6.42	5.3	130	TR542	833640	011000	-	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DF DB 11 *33	22.5x14.00-15"DC	12,800	71	2.0	0.87	130	TR543E outset TR545E inset	841600	011000	-	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DF DB 11 *34	22.5x14.00-15"DC	12,800	71	1.13	0	130	TR545E outset TR543E inset	841610	011000	-	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DB DF **35	24.5x8.25-15"DC	7400	56	6.6	5.73	130	TR545D	983640	011000	9364	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DB36	24.5x8.25-15"DC	8000	65	6.6	5.63	120	TR545D	985600	011000	2245	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
10-hole, hub piloted bus mounting—11.25 in. bolt circle, 8.670 in. hub bore, 1.219 in. bolt hole diameter (use two-piece flange nuts)																
DB DF 37	22.5x8.25-15"DC	7300	53	6.66	5.82	120	TR545D	883610	015000	2225	-	-	-	-	182	-
DB38	24.5x8.25-15"DC	7300	62	6.6	5.77	120	TR545D	983610	015000	2245	-	-	-	-	182	-

Continued on next page

1 Specifications cont'd.

TUBELESS WHEELS (round hand holes) ENGLISH UNITS (METRIC UNITS)

Item no.	Wheel description	Maximum wheel load ¹ in lbs. (kilograms)	Wheel wt. lbs. (kilograms)	Outset inches ³ (mm)	Inset inches (mm)	Maximum inflation PSI—cold (KPa)	Valve stem	Part number ²	DiscMate	Stabilizer	Front outer cap nuts	Rear inner cap nuts AI/AI	Rear inner cap nuts AI/StI	Rear outer cap nuts	Lug nut covers	Hub cover system kits front / rear
Eight-hole, hub piloted mounting—275mm bolt circle, 221.1mm hub bore, 24.75mm bolt hole diameter (use two-piece flange nuts)																
39	17.5x6.75-15°DC	5515 (2500)	29.5 (13.4)	5.55 (141)	4.72 (120)	142 (978)	TR543C	663470	014000	2126	39874	-	-	39874	181	-
40	19.5x6.75RW-15°DC	5515 (2500)	37.0 (16.8)	5.55 (141)	4.72 (120)	142 (978)	TR543C	764480	014000	2126	39874	-	-	39874	181	-
41	19.5x7.50RW-15°DC	6615 (3000)	37.7 (17.1)	6.10 (155)	5.28 (134)	142 (978)	TR543C	773400	014000	2126	39874	-	-	39874	181	-
10-hole, hub piloted mounting—225mm bolt circle, 176.1mm hub bore, 26.50mm bolt hole diameter (use two-piece flange nuts)																
42	17.5x6.00-15°DC	5515 (2500)	28.0 (12.7)	5.24 (133)	4.49 (114)	142 (978)	TR543D	663200	-	2125	39874	-	-	39874	-	-
10-hole, hub piloted mounting—285.75mm bolt circle, 220.1mm hub bore, 26.75mm bolt hole diameter (use two-piece flange nuts)																
43	19.5x7.50RW-15°DC	6615 (3000)	37.7 (17.1)	6.10 (155)	5.28 (134)	142 (978)	TR543C	773600	011000	2126	39874	-	-	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
10-hole, hub piloted mounting—335mm bolt circle, 281.2mm hub bore, 26.75mm bolt hole diameter (use two-piece flange nuts)																
^{DB} 144	22.5x8.25-15°DC	7830 (3550)	55.1 (25.0)	6.60 (168)	5.70 (145)	138 (952)	60MS27	885530	013000	-	39874	-	-	39874	181	-
^{DB} 145	22.5x9.00-15°DC	8820 (4000)	58.0 (26.3)	6.93 (176)	6.02 (153)	142 (978)	60MS27	894530	013000	-	39874	-	-	39874	181	-
[†] 46	22.5x13.00-15°DC	12,800 (5806)	76.0 (34.5)	—	6.12 (155)	120 (827)	TR543	833580	013000	-	39874	-	-	39874	181	5811 polished with view port
47	24.5x8.25-15°DC	8500 (3855)	62.6 (28.4)	6.79 (172.5)	5.81 (147.5)	120 (827)	TR544D	983500	013000	-	39874	-	-	-	181	-
10-hole, hub piloted mounting—335mm bolt circle, 281.2mm hub bore, 32.87mm bolt hole diameter (use two-piece sleeved cap nuts)																
^{DB} 148	22.5x8.25-15°DC (32mm bolt hole)	7830 (3550)	55.1 (25.0)	6.60 (168)	5.70 (145)	138 (952)	60MS27	885550	018000	-	4306.32	-	-	4307.32	-	-
^{DB} 149	22.5x9.00-15°DC (32mm bolt hole)	8820 (4000)	57.1 (25.9)	6.93 (176)	6.02 (153)	142 (978)	60MS27	894550	018000	-	4306.32	-	-	4307.32	-	-
6-hole, hub piloted mounting—205mm bolt circle, 160.2mm hub bore, 21.5mm bolt hole dia. (use two-piece flange nuts)																
50	17.5x6.00-15°DC	4000 (1814)	29.6 (13.4)	5.0 (127)	4.25 (108)	110 (758)	60MS27	664220	-	-	-	-	-	-	-	-

Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating. Do not overinflate. Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire, perform a wheel fitment check to ensure proper clearance from any obstructions. Valve hole is on the inside unless noted otherwise.

¹Capacity ratings as dual or single in highway service — bias-ply or radial. Load ratings in lbs. for items 39 through 50 rounded to nearest multiple of 5.

²Some wheels may bear part numbers not shown in this manual. Before servicing these wheels, contact your Alcoa wheel representative for proper load, inflation and part compatibility information.

³Outset (positive)/inset (negative) — The distance from the rim centerline to the mounting face of wheel. Inset (negative) places the rim centerline inboard of the wheel mounting face and outset (positive) places the rim centerline outboard of the wheel mounting face (½ dual spacing = offset).

⁴These wheels must be installed only in the inset position because spherical ball seats are on only one side of the disc.

* Part numbers should end in "1" or "9" when used in an inset position and "0" or "2" when used in an outset position.

** Disc Brake Compliant — As of January 2005: 883640 replaces 883620 and 884620, 983640 replaces 983620; As of March 2005: 883440 replaces 883420, 893640 replaces 893600, 823640 replaces 823660A, 833640 replaces 833660A

[†] Indicates European New Generation Wheels. ^{††}Check with vehicle manufacturer or axle manufacturer before retrofitting to outset wide base wheels to insure compatibility with axle and wheel end components. P/Ns 841100, 841400, 841600 and 841610 are recommended for use on drive axle and trailer axle positions, but with some restrictions on "N" trailer spindles.

[‡] Hub cover system kits P/N 076085 (front) and P/N 077085 (rear) contain screw-on Hug-a-lug[®] nut covers and require a minimum of four threads of the stud to extend above the tightened cap nut for use.

[§] The minimum stud stand-out required for P/N 833580 is 2.375 inches (60.3mm) when using wheel nut P/N 39874. Taller nuts will require more stud stand-out. P/N 833570 will be phased out 1st quarter 2005 and will be replaced by the higher load rated 833580.

[§] P/Ns 885600 and 985600 are Alcoa Severe Service Wheels.

Specifications subject to change without notice. To request a copy of the current Alcoa Specifications Data brochure for aluminum wheels for trucks, trailers and buses, call toll-free 800-242-9898, option 1. To view online, go to www.alcoawheels.com. The Spec Data brochure contains current part number availability and complete specifications such as wheel dimensions, load rating, wheel weight, outset and inset, inflation pressure and accessory part numbers.

Alcoa provides training, live or on video, on proper wheel installation and maintenance practices free of charge. Contact Alcoa Wheel and Forged Products at 1-800-242-9898, option 4.

Note: Dura-Bright[®] wheels produced after November 2002 have Alcoa wheel part numbers ending with "DB" (earlier wheels have part numbers ending in a 4 or 7) with bead seat diameters measured in 0.5-inch increments. Not all Alcoa wheels are available with the Dura-Bright[®] surface treatment.

Note: The Dura-Bright[®] surface treatment and the Dura-Flange[®] options are not currently available together on the same wheel. Dura-Bright[®] and Dura-Flange[®] are available in all polished finishes.

2 Inspection

Inspect thoroughly and frequently

2-1

Safe operation requires thorough examination of wheels and attaching hardware, at frequent intervals, both on and off the vehicle.

Wheels that have been in service need to be inspected at regular intervals to assure proper and safe performance.

Like tires and other vehicle components that work hard, wheels will eventually wear out. It isn't always possible to predict exactly when the useful life of a wheel will end. But generally, older wheels and wheels operating in extreme conditions should be examined more frequently for obvious signs that they should be removed from service.

As an aid to the owner in determining the period of time a wheel has been in service, it is recommended the owner stamp an "in service" date onto the wheel at the time of receipt. See 5-5, page 36 for recommended stamping locations.

Pay particular attention to front-end assemblies. Examine all exposed areas frequently. Clean wheels and look for cracks or other damage. Also check the inner dual wheel when the outer wheel is removed.

During tire changes, thoroughly examine the entire wheel. Pay particular attention to the rim contour and the surfaces of the rim. On tube-type wheels, carefully inspect the gutter area normally concealed by the side rings.

Be sure that the best wheels are on the front of the vehicle.

Hidden damage

Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Do not overinflate. Use the tire manufacturer's recommended pressure, but under no circumstances exceed cold tire pressures listed in *Section 1 Specifications* of this manual. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.

Some forms of wheel damage can be hidden beneath the tire, so whenever a tire is removed, thoroughly examine the complete wheel. Remove all grease and road dirt. Use a wire brush or steel wool to remove rubber from the bead seats.

Check mounting holes for the enlargement and elongation which can occur if the cap nuts are not kept tight (see 2-5, page 9). Dirt streaks radiating from stud holes may indicate loose cap nuts (see 4-9, page 29).

Excessive heat damage

2-2



WARNING Excessive heat from fire, brake malfunction, wheel bearing failure or other sources may weaken the metal and cause the wheel/tire assembly to separate explosively.

Exploding wheel/tire assembly can cause death or serious injury.

Immediately and permanently remove from service any wheel that has been exposed to excessive heat.

Inspect for exposure to excessive heat. A wheel that has been subjected to excessive heat may appear charred or burned. A wheel that has been exposed to excessive heat may appear to be in good condition if it has been cleaned. Even if a wheel does not appear to be obviously burned, check the valve hole and labels for evidence of charring, melting, blistering or burning.

A wheel may discolor from excessive heat. It can appear a dull grayish color and will not polish to a bright finish as a typical wheel would.

Any wheel run with a flat tire longer than the time necessary to immediately pull off the road should be checked for excessive heat damage.



A blistered, charred, blackened or cracked-looking logo decal on an Alcoa wheel may indicate that the wheel has been exposed to excessive heat.

Dimension checks

Open side circumference check

2-3



WARNING

WARNING Wheels that have been subjected to high pressure tire and rim separation, run flat, excessive heat or other physical damage may no longer have sufficient dimension and contour to retain tire bead while under pressure.

Rims that lack proper dimension and contour can lead to explosive separation of tire and rim, causing injury or death.

Follow dimension check procedures described in this section during each wheel inspection.

The circumference of the bead seat on the open side of the wheel should be checked with each tire change. The open side is the side opposite the disc face. In the case of center flange wide base wheels, or wheels with insets less than 3 inches, both rim flanges should be checked. Measure the circumference of the bead seat on the open side (see illustration below) with a ball tape. Ball tapes used for measuring wheel circumference can be purchased from the Tire and Rim Association, Inc., 175 Montrose West Avenue, Copley, Ohio 44321.



If the circumference of the bead seat does not match the required dimension as indicated by the ball tape, remove the wheel from service. Be sure to clearly mark the wheel as out-of-service or otherwise render the wheel unusable.

Any wheel known to have been run with a flat tire or operated under abnormal conditions should be checked before continued service. If a ball tape is unavailable, roll the unmounted wheel without a tire several revolutions over a smooth, flat, level, clean surface. Any deviation from rolling in a straight line is an indication of a potential lack of proper dimension and contour. Remove the wheel from service until it can be properly checked with a ball tape.

Continued on the next page

Dimension checks (continued)

Tire wear or ride problems

If you experience tire wear or ride problems it may be helpful to check radial run out. Remove the wheel from the vehicle, deflate and remove the tire (see 3-5, page 22 for recommendations and instructions for demounting tubeless tires and 6-5, page 43 for recommendations and instructions for demounting tube-type tires).

Remount the wheel on the vehicle without the tire. Be sure to follow proper mounting procedures to assure the wheel is well centered on the hub. Place a dial indicator as illustrated below to trace the bead seats of the wheel. Rotate the wheel noting the amount of variation shown on the dial indicator. *Note:* Alcoa aluminum wheels should be tested for radial run out only at the bead seat surface. A total indicator reading of .045 inches is acceptable.



Tire wear can also be caused by improperly seated tires. Inspect the tire for proper seating on the wheel. The tire beads may not be seated properly. If so, remove the wheel from the vehicle, deflate and break the bead seats (see 3-5, page 22 for recommendations and instructions for demounting tubeless tires and 6-5, page 43 for recommendations and instructions for demounting tube-type tires). Adequately lubricate the bead seats and properly reseal the tire beads. Reinflate the wheel in a safety cage or other suitable restraint (refer to OSHA rule 1910.177, paragraph b, see Section 7, page 44).

Cracked or damaged wheel checks

2-4



WARNING Cracked or damaged wheels may cause wheels to fail or come off the vehicle while the vehicle is moving.

Wheels that fail or come off the vehicle while it is moving can cause serious injury or death.

Immediately remove cracked or damaged wheels from service.

Inspect wheels for cracks or damage according to the following sections of Chapter 2. Remove wheels from service with known or suspected damage.

Mounting area

Stud hole cracks are usually caused by improper torquing (see 4-9, page 29 and 5-2, page 35), excessive loading or insufficient mounting flange support by the hub or brake drum. Remove wheel from service.

2-5



Shown below are stud hole cracks emanating from stud hole to stud hole. Causes are: undersized diameter of wheel support surface (see specifications below), support surface not flat, incorrect attachment parts (see 4-12, page 34) and insufficient torque (see 4-9, page 29 and 5-2, page 35). Remove wheel from service.

Support surface should be flat to the diameter recommended on the chart on the following page.



Inspect the hub/drum contact area thoroughly for cracks or other damage.

Mounting area (continued)

Support surface diameters

Support surface (backup diameter) should be flat to the diameter recommended on the chart below:

Number of Bolts	Bolt Circle	Mounting Type	Backup Diameter	Thread Size
10	11.25 inch	U.S. Stud pilot	13.2-13.5 in.	.750/1.125 in.
10	285.75mm	Hub pilot	13.2-13.4 in.	22mm
10	335mm	Hub pilot	15.0-15.2 in.	22mm
8	275mm	U.S. Stud pilot	13.2-13.5 in.	22mm
8	275mm	ISO Hub pilot	12.4-12.6 in.	20mm

Corrosion

2-6

Due to aluminum's natural resistance to corrosion, Alcoa aluminum disc wheels do not need to be painted for most operating conditions. However, certain environments can lead to corrosion. Some of these are: salt, chloride compounds used for snow removal and highly alkaline materials. If the air used to fill tubeless tires, or the tire itself, is not dry, the areas of the wheel under the tire can corrode severely.



Bead seat and valve stem corrosion often are caused by entrapped moisture which contains corrosive elements. Mild corrosion should be removed thoroughly by wire brush and the rim protected with a coating of non-water-based lubricant (see 3-1, page 18). Remove any severely corroded wheel from service.



CAUTION

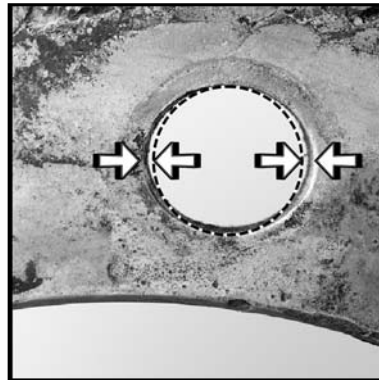
CAUTION The use of liquid tire balancers or sealants in Alcoa wheels may cause extremely rapid corrosion of the wheel rim surface.

Severely corroded wheels are unsuitable for service. Alcoa wheels corroded by the use of liquid tire balancers or sealants will not be replaced under the Alcoa limited warranty.

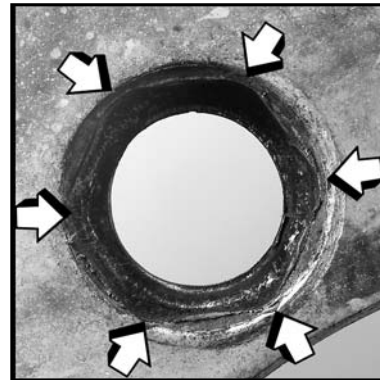
Stud holes

2-7

If wheels are run loose, both stud located wheels and hub piloted wheels can be damaged. Look for wallowed out or elongated ball seats on stud located wheels. On hub piloted wheels look for elongated stud holes. Over torquing can lead to damaged ball seats on stud located wheels and can damage the disc surface of hub piloted wheels. Remove damaged wheels from service.



Damaged hub piloted bolt hole. Elongation from true round (dashed circle) indicated by arrows.



Damaged ball seat contact area. Pouncing of nut on ball seat contact area identified by arrows.

Disc area

2-8



Inspect both sides of disc area for hand hole cracks. If cracks are found, remove the wheel from service.

Rim area

Check the entire rim area for nicks, gouges and cracks. Loss of air may be caused by cracks in areas around the valve stem hole. Remove the wheel from service.

2-9



Gutter area

Projections on the side of the wheel gutter area on tube type wheels can cause uneven seating of the side and lock ring and chipping of the gutter. Such projections must be removed. Remove the wheel from service if damaged.

2-10



Cracking in bottom of gutter flange. Occasionally, circumferential cracks may appear in the bottom of the gutter area. This area should be thoroughly cleaned and carefully inspected after a tire is removed from the wheel. Also check the side underneath gutter flange for circumferential cracks. Gutter flange cracks can ultimately lead to the separation of the rim area from the disc. Immediately remove from service a wheel that exhibits any cracks.



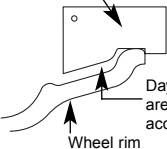
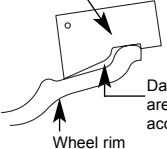
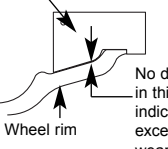
Rim flange wear

2-11



Irregular wear on the surface of the rim flange is caused by abrasion from the tire chafer and sidewall. Rim flange wear happens most often in applications with heavy or shifting loads. If you are experiencing excessive rim flange wear in your operation, consider using Alcoa Dura-Flange® aluminum wheels. These wheels have been specially treated to significantly reduce rim flange wear. Remove wheels from service when rim flange wear is excessive. Excessive wear can be determined using an Alcoa approved wear gauge and procedures detailed below. If rim flange wear becomes sharp and/or cuts the tire, contact Alcoa for recommended maintenance procedures.

Alcoa Rim Flange Wear Gauge Instructions

Rim Acceptable	Rim Acceptable	Rim NOT Acceptable
<p>Rim Gauge Alcoa P/N 000700</p>  <p>Daylight in this area indicates acceptable rim.</p> <p>Wheel rim</p>	<p>Rim Gauge Alcoa P/N 000700</p>  <p>Daylight in this area indicates acceptable rim.</p> <p>Wheel rim</p>	<p>Rim Gauge Alcoa P/N 000700</p>  <p>No daylight in this area indicates excessive wear</p> <p>Wheel rim</p> <p>Remove from service immediately.</p>

To obtain a gauge(s) at no charge and information on free training on proper installation and maintenance procedures, contact **Alcoa Wheel and Forged Products** at (800) 242-9898 option 1 or on the web at www.alcoawheels.com.

Determining Rim Flange Wear

STEP 1. Remove the wheel/tire assembly from the vehicle. Remove the valve core to deflate the tire completely. Remove the tire from the wheel according to OSHA regulations, TMC recommended practices for tire and rim safety procedures and/or the Alcoa Wheel Service Manual.



Photo 1. Acceptable Rim Flange Wear Condition

Rim flange wear (continued)

STEP 2. After the wheel is separated from the tire, use a ball tape to verify the circumference of the bead seat on the open side is acceptable (see 2-3, page 7). Check the wheel flange with the Alcoa Rim Flange Wear Gauge to determine if the wheels must be removed from service for excessive rim flange wear (photo 1 on page 13).

See **Rim Flange Wear Gauge Instructions** illustrations above to make this determination. If you do not have an Alcoa Rim Flange Wear Gauge, contact Alcoa Wheel and Forged Products to obtain a gauge(s) at no charge.

STEP 3. If the wheel is deemed to be serviceable by the rim flange gauge, examine the wheel flange edge for sharpness by using a rubber sharpness gauge. These gauges are constructed by having a section of tire side wall or a suitable piece of rubber attached to a block of wood (photo 2). By running the sharpness indicator gauge along the wheel in the area of the wear, determine if the wear is sharp enough to cut or damage the rubber on the sharpness indicator (photo 3). If the rubber is cut, then follow the edge removal instructions below.



Photo 2. A rubber sharpness gauge constructed from a section of tire side wall or a suitable piece of rubber attached to a block of wood.

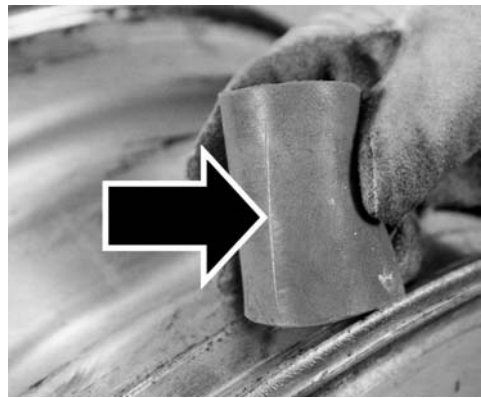



Photo 3. Run the sharpness indicator gauge along the wheel in the area of the wear to determine if the wear is sharp enough to cut or damage the rubber on the sharpness indicator.

NOTICE: Examine the tire for cuts in the bead area and side wall. If no damage occurred to these areas, return the tire to service. Cut tires should be removed from service. The tire should be inspected at this time for any other damage and be treated per normal tire procedures recommended by the tire manufacturer.

If the flange cuts or appears close to being sharp enough to cut the rubber on the sharpness indicator gauge, the edge can be removed per the edge removal procedures below. If the rubber is not cut, then the wheel can be returned to service without further work for rim flange wear.

NOTICE: Check the wheel at every tire change or **ONCE PER YEAR** for rim flange wear and any sharp edges. If you follow this practice, you will significantly reduce the possibility of a rim flange cutting into the tire.

 CAUTION	CAUTION Do not run unprotected hands or fingers across worn rim flange areas of used wheels.
	Worn rim flange areas are sharp and can cut hands or fingers. Cuts can lead to infection.
	Always wear gloves when handling used wheels or when testing for edge sharpness.

Rim flange wear (continued)

Edge Removal Procedures

There are many tools available to remove the sharp edge on the wheel caused by rim flange wear. Here are some examples of commonly used tools:

File. A file can be used very effectively to remove the edge (photo 4).



Photo 4. Removing sharp edge by hand with a metal file.

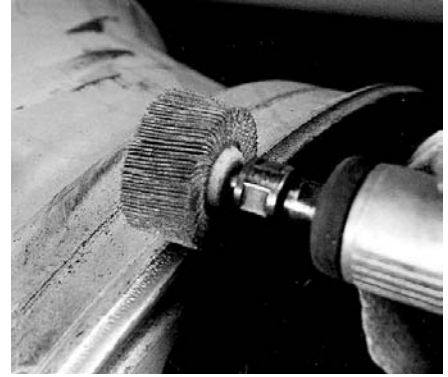


Photo 5. Air or electric power sander.

Air or Electric Powered Sander. This provides a very quick and effective method of removing the edge. Operators should use all care to keep a uniform edge when using these tools (photo 5).

Air or Electric Grinder. Another quick and effective method of removing the sharp edge caused by rim flange wear. Be careful as grinding pads may “gum up” from the aluminum that is removed (photo 6). Care must be used to avoid gouging the wheel.



Photo 6. Air or electric grinder



Photo 7. Die grinder.

Rim flange wear (continued)

Die Grinder. Used with a sanding wheel, cutting stone or grinding tool, this is a version of an electric grinder. This tool is very quick and effective as well, and care must be taken to remove metal as uniformly as possible and not to gouge the wheel (photo 7 on page 15).



CAUTION Removing sharp edges with hand or power tools produces metal filings and sparks. Many power tools have edges that are sharp or may become hot during use. Some power tools produce excessive noise when used.

Metal filings can be sharp and, when projected by the action of power tools, can cause serious skin or eye damage. Excessive noise from power tools can harm hearing. Sharp edges can produce cuts and hot surfaces can cause burns. Cuts and burns can lead to infection.

Always wear appropriate safety gear such as protective eye wear, gloves, protective clothing and hearing protection when using hand or power tools.

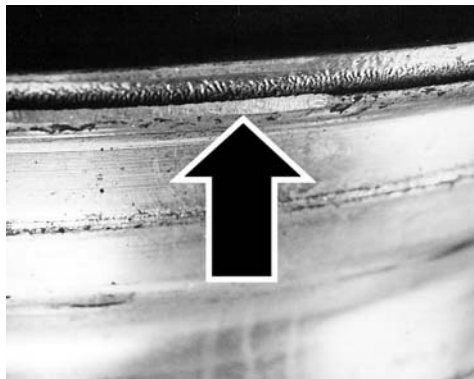


Photo 8. Adequate repair for sharp edge resulting from rim flange wear removes just enough metal to smooth the edge.

STEP 4. The photographs show the process of removing the edge. With whatever tool is selected, work the tool around the wheel's circumference removing only enough material to eliminate the sharp edge. This should only be a small amount of metal. Perform this work on both flanges if there is evidence of sharpness.

Regardless of the method which you choose, the objective is to remove the sharp edge (photo 8). Remove just enough metal to smooth the edge. Take care to make sure the edge removal is as uniform as possible. Avoid gouging the wheel.

Rim flange wear (continued)

STEP 5. After the edge is removed, run the sharpness indicator gauge along the area of edge removal to check for any remaining sharpness. If the rubber is still cut, perform the steps again to remove the sharp edge. Always remove the minimum amount of material necessary to eliminate the sharp edge.

STEP 6. Check the rim flange height with the Alcoa Rim Flange Wear gauge to make sure there is adequate height remaining to safely support the tire. The photograph again shows how this gauge is used (photo 1). Be sure to move the gauge all around the wheel's circumference and make sure that no area of the flange is below what the gauge indicates is acceptable. If the entire wheel flange is within the limits of the rim flange wear gauge, the wheel may be returned to service.

STEP 7. Always inspect the wheel for any other conditions that would warrant removal from service. Consult the Alcoa Wheel Service Manual or the TMC User's Guide to Wheels and Rims.



WARNING

WARNING Welding or brazing the rim flange or any area of an Alcoa aluminum wheel will weaken the wheel. Weakened or damaged wheels can lead to an explosive separation of tires and wheels or wheel failure on the vehicle.

Explosive separations of tires and wheels or wheel failure on the vehicle could cause injuries or death.

Never attempt to weld or braze any surface of an Alcoa aluminum wheel.



WARNING

WARNING Returning wheels to service with inadequate flange height as determined by the Alcoa Rim Flange Wear Gauge can lead to an explosive separation of tires and wheels.

Explosive separation can result in serious injury or death.

Wheels with flange height that falls below the Alcoa gauge have inadequate rim flange height to support the tire on the rim. Permanently remove any wheel from service that has inadequate rim flange height.



WARNING

WARNING Excessive heat from fire, brake malfunction, wheel bearing failure or other sources may weaken the metal and cause the wheel/tire assembly to separate explosively.

Exploding wheel/tire assembly can cause death or serious injury.

Immediately and permanently remove from service any wheel that has been exposed to excessive heat.

Always follow safe mounting procedures as recommended using OSHA approved tire inflation cages. See the Alcoa Wheel Service Manual or OSHA safety wall charts and procedures.

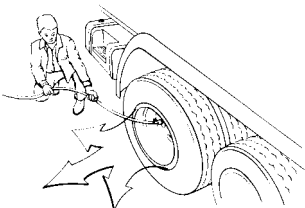
3 Alcoa 15° Drop Center Wheel for Tubeless Tires

Recommendations for mounting tubeless tires

3-1

NOTICE: For complete information on tube type wheels, contact Alcoa.

NOTICE: Alcoa aluminum 19.5" RW and non-symmetrical well wide base wheels require special tire mounting techniques, See Section 3-2.



WARNING

WARNING Damaged tires or wheels can lead to an explosive separation of tires and wheels.

Explosive separation can result in serious injury or death.

Inspect tires and wheels for damage before removing from vehicle. If damage is found, the tire must be completely deflated before loosening cap nuts. Remove damaged tires or wheels from service.



WARNING

WARNING Use of inner tubes in tubeless wheels will hide slow leaks. Slow leaks may indicate cracked (see section 2-9, page 12) or damaged wheels which lead to wheel failures.

Wheel failures can cause accidents which may result in serious injury or death.

Never use an inner tube on an Alcoa tubeless wheel, and always remove cracked or damaged wheels from service.

1. Do not gouge or nick the wheel. Place aluminum wheels on clean wooden floor or rubber mat when hand mounting tires. Additional care should be used when mounting Alcoa Dura-Bright® surface treated wheels since minor nicks and scratches cannot be polished out (see section 5-8, pages 37 & 38 for specific cautions, care and maintenance procedures). DiscMate wheel spacers are recommended for use with Alcoa Dura-Bright® surface treated wheels to protect the wheel contact surfaces from marring.
2. Always use a rubber, leather-faced or plastic mallet.
3. Inspect the wheel for damage. Do not use a damaged or severely corroded wheel. (See Section 2, page 5).
4. Clean the wheel face with mild detergent and the tire bead seat areas with a wire brush. Be sure the wheel is dry before applying tire lubricant.
5. Inspect the tire for damage. Be sure the inside of the tire is dry before it is mounted.
6. Use of a non-water-based lubricant is recommended as a rim surface protectant and tire mounting lubricant. Coat the entire rim surface. (See 3-2, page 19).
7. Lubricate the rim and tire bead immediately before mounting the tire. Do not use any lubricant which contains water. Water-based lubricants can promote corrosion attack on the rim surface. The use of non-water-based lubricants is especially important when mounting tubeless tires as the air in the tire is contained by the seal between the bead and tire rim.
8. Never lubricate the rim or tire bead with a flammable solution. This can lead to an explosion during airing of the tire or in subsequent operation of the vehicle (**see Warning below**).
9. If using a tire mounting/demounting machine on aluminum wheels, care should be taken to prevent gouging the wheel.
10. Use only dry air for tire inflation. The use of moisture traps in the air compressor feed line is recommended.
11. Do not overinflate. Use the tire manufacturer's recommended pressure, but under no circumstances exceed cold tire pressures listed in **Section 1 Specifications** of this manual (see page 2).
12. When inflating a tire in an inflation cage or while mounted on a vehicle, always use a clip-on air chuck or threaded straight chuck and a remote valve with pressure gauge. Securely anchor the inflation cage and during inflation or handling of an inflated wheel and tire assembly, stay out of the path of potential exploding parts or air blasts.

Recommendations for mounting tubeless tires (continued)



WARNING

WARNING Use of a volatile or flammable material, such as ether or gasoline, as an aid to seating the tire beads on the wheel can lead to an uncontrolled pressure build-up in the tire and may result in an explosion.

Explosive separation of the tire and wheel can occur while seating beads in this manner, while adding air to the tire on or off the vehicle, or later on the road. Loss of vehicle control can result, which can cause serious injury or death.

Use only approved mechanical or pneumatic bead seating devices.



WARNING

WARNING A pressurized tire/wheel assembly can explode and separate violently.

This violent separation can cause serious injury or death.

Always contain the tire/wheel assembly in an inflation cage during inflation.

3

Mounting tubeless tires

3-2

NOTICE: Not all tire mounting/demounting machines work alike. Be sure to read the operating or instruction manual for your particular machine before attempting to mount or demount tires.

NOTICE: Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.

NOTICE: When match mounting tires on Alcoa wheels locate valve stem adjacent to low point mark on the tire.

NOTICE: Alcoa aluminum 19.5" RW and non-symmetrical wide base wheels require tires to be mounted and demounted over the disc side of the wheel only.

NOTICE: Refer to tire manufacturer's recommendation for proper tire pressure.



Position wheel on machine. Lubricate wheel (entire air chamber surface) and tire bead using approved lubricant. Tire beads should be mounted over the rim flange closest to the wheel well. Push bead over flange as far as possible.



Insert curved end of tool between bead and wheel flange with tool stop against flange. In circular motion, use short successive bites to work the bead over the flange. Push down on tool as bead is worked over flange.



Lubricate the second tire bead. Start second bead into the well, holding it in position with the clamp to the rim flange. Lubricate bead half way around. With curved end of tool between tire bead and flange, and the stop towards the wheel, push tool outward to work tire over flange. Continue to pry bead over flange using the tool until remaining bead is over flange. Seat the tire bead using an air ring or other mechanical bead seating aid.



Place tire/wheel assembly inside safety cage or other suitable restraint (refer to OSHA rule 1910.177, paragraph b, see Section 7, page 44). **Refer to tire manufacturer's recommendation for proper tire pressure.** Using a clip-on air chuck or a self-locking straight chuck with remote valve and pressure gauge, inflate the tire/wheel assembly to proper pressure. If air escapes, roll tire or use bead expander to force tire beads against rim. Be sure to stay out of the path of potential exploding parts or air blasts.

Mounting tubeless tires continued



NOTICE: Not all tire mounting/demounting machines work alike. Be sure to read the operating or instruction manual for your particular machine before attempting to mount or demount tires.

NOTICE: Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.

NOTICE: When match mounting tires on Alcoa wheels locate valve stem adjacent to low point mark on the tire.

NOTICE: Alcoa aluminum 19.5" RW and non-symmetrical wide base wheels require tires to be mounted and demounted over the disc side of the wheel only.

NOTICE: Refer to tire manufacturer's recommendation for proper tire pressure.

NOTICE: Alcoa aluminum 19.5" RW and non-symmetrical wide base wheels require tires be mounted and demounted **over the disc side of the wheel only**. For a free instruction wall chart, contact: Alcoa Inquiry Fulfillment, Markinetics Inc., P.O. Box 809, Marietta, OH 45750.



WARNING

WARNING Use of a volatile or flammable material, such as ether or gasoline, as an aid to seating the tire beads on the wheel can lead to an uncontrolled pressure build-up in the tire and may result in an explosion.

Explosive separation of the tire and wheel can occur while seating beads in this manner, while adding air to the tire or later on the road. Loss of vehicle control can result, which can cause serious injury or death.

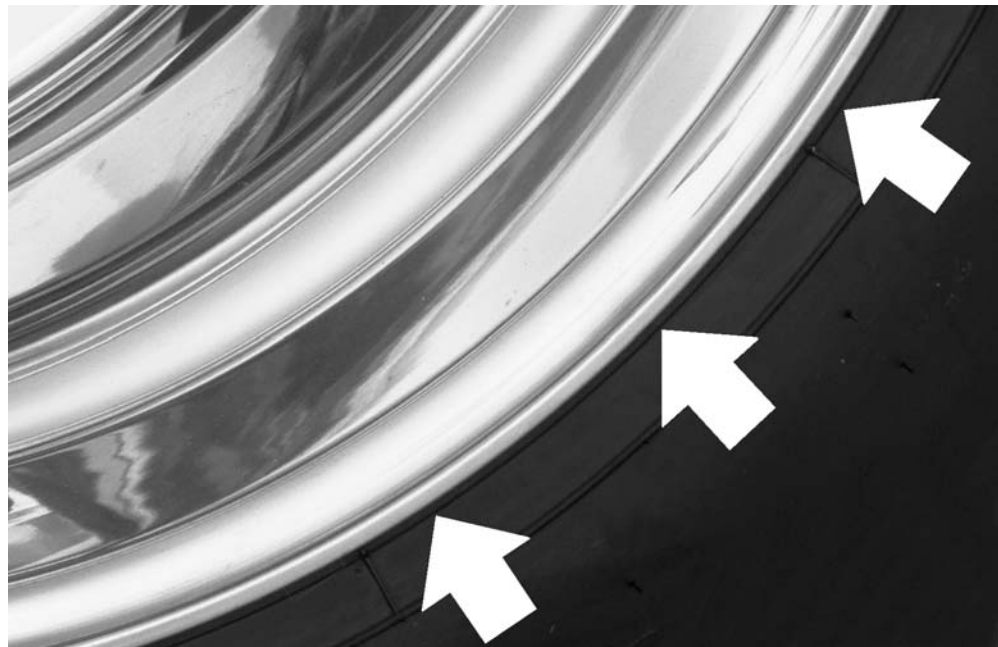
Use only approved mechanical or pneumatic bead seating devices.



CAUTION

CAUTION The use of liquid tire balancers or sealants in Alcoa wheels may cause extremely rapid corrosion of the wheel rim surface.

Severely corroded wheels are unsuitable for service. Alcoa wheels corroded by the use of liquid tire balancers or sealants will not be replaced under the Alcoa limited warranty.



Heavy duty truck tires have a "guide rib" molded into the sidewall next to the tire bead. When the tire is inflated this ring should be evenly spaced from the wheel rim all the way around the wheel. Check the position of the ring before removing the assembly from the inflation cage. If the ring and wheel are not concentric, deflate the assembly in the cage and remount the tire.

Rim width to tire matching

3-3

Rim to tire matching chart for medium and heavy trucks.

Tire Size (for both radial and bias tires)			Approved Rim Widths		Tire Size (for both radial and bias tires)			Approved Rim Widths	
8R	17.5HC	6.00HC	8	22.5	5.25, 6.00, 6.75	9	22.5	6.00, 6.75, 7.50	
215/75R	17.5	6.00, 6.75	10	22.5	6.75, 7.50, 8.25	245/75R	22.5	6.75, 7.50	
9R	17.5HC	6.75HC	11	22.5	7.50, 8.25	255/70R	22.5	7.50, 8.25	
10R	17.5HC	6.75HC, 7.50HC	265/75R	22.5	7.50, 8.25	295/75R	22.5	8.25, 9.00	
245/75R	17.5	6.75, 7.50	12	22.5	8.25, 9.00	305/85R	22.5	8.25, 9.00	
11R	17.5HC	8.25HC	15	22.5	11.75, 12.25	315/80R	22.5	9.00, 9.75	
			385/65R	22.5	11.75, 12.25	425/65R	22.5	11.75, 12.25, 13.00	
			445/50R	22.5	14.00	16.5	22.5	12.25, 13.00	
			445/55R	22.5	14.00	18	22.5	13.00, 14.00	
			445/65R	22.5	12.25, 13.00, 14.00				
8	19.5	5.25, 6.00, 6.75	11	24.5	7.50, 8.25	275/80R	24.5	7.50, 8.25	
225/70R	19.5	6.00, 6.00RW, 6.75, 6.75RW	285/75R	24.5	8.25	12	24.5	8.25, 9.00	
245/70R	19.5	6.75, 6.75RW, 7.50, 7.50RW	305/75R	24.5	8.25, 9.00				
265/70R	19.5	7.50, 7.50RW, 8.25, 8.25RW							
285/70R	19.5	8.25, 8.25RW, 9.00							
305/70R	19.5	8.25, 8.25RW, 9.00							
445/65R	19.5	13.00, 14.00							

There may be additional rim to tire matches not shown above. Contact the tire manufacturer or your Alcoa wheel representative for additional information.

Recommendations for demounting tubeless tires

3-4



WARNING

WARNING An aluminum wheel can be structurally weakened by uncontrolled excessive heat.

Tire/wheel assemblies using wheels that have been exposed to excessive heat may experience a sudden and unpredictable tire/wheel separation causing serious injury or death.

Immediately and permanently remove any wheel from service that has been subjected to uncontrolled excessive heat (such as a tire fire, wheel bearing failure or braking system drag/seize) or a high pressure tire/wheel separation.



WARNING

WARNING Damaged tires or wheels can lead to an explosive separation of tires and wheels.

Explosive separation can result in serious injury or death.

Inspect tires and wheels for damage before removing from vehicle. If damage is found, tire must be completely deflated before loosening cap nuts. Remove damaged tires or wheels from service.

Recommendations for demounting tubeless tires (continued)

1. When hand demounting tires from wheels, placing aluminum wheels on a clean wooden floor, or rubber mat is recommended. Additional care should be used when demounting Alcoa Dura-Bright® surface treated wheels since minor nicks and scratches can not be polished out (see section 5-8, pages 37-38 for specific cautions, care and maintenance procedures).
2. Always use a rubber, leather-faced or plastic mallet.
3. Keep tire tools smooth. Use them with care. Rim gouges or nicks may cause cracks.
4. If using a tire mounting/demounting machine on aluminum wheels, care should be taken to prevent gouging the wheel.

3

Demounting of tubeless tires

3-5

NOTICE: Not all tire mounting/demounting machines work alike. Be sure to read the operating or instruction manual for your particular machine before attempting to mount or demount tires.



Remove the valve core from the valve stem to ensure complete deflation. Place wheel on machine and position tool so flat end can be driven between tire bead and rim flange. Straighten tool to a vertical position until bead is separated from wheel.



Repeat procedure at intervals until bead is totally separated from wheel. Repeat procedure on other side of tire. Tire is now ready for demounting. Lubricate the tire bead.



Insert curved end of tire tools between tire and wheel, approximately 10 inches apart. Pull one tool toward center of wheel, then pull second tool in the same manner. To free bead, leave one tool in position, take out and reinsert the other tool, curved end between bead and flange, a short distance from the spanned area. Pry bead free of rim, repeating process until entire bead is free from wheel.



Insert straight end of tire tool between beads and both rim flanges, hooking stop on the tool over second flange. Position inserted tool at 90° angle to tire assembly at top of wheel and lubricate bead areas on both sides of tool. Lean tire assembly toward tool and rock or bounce to pry off the tire.

4 Wheel Installation

Recommendations for proper installation of wheels

4-1

NOTICE: Do not exceed maximum wheel load.

Customer must compare OEM vehicle load rating to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.

1. For the same reason the best tires are run on the front axle, the best wheels also should be used on the front axle.
2. Make sure all wheel cap nuts are properly torqued — check them often (see section 4-9, page 29). If the wheel is loose, the holes will pound out (deform). If some cap nuts are tight and others are loose, the wheel may develop cracks or studs may break. Dirt streaks radiating from stud holes can indicate loose nuts (see Section 2, pages 5-17).
3. Be sure the end of the wheel wrench is smooth or cover the wheel mounting surface with a protective shield prior to tightening the cap nuts. The wrench end will mar the wheel around the cap nuts if it is not smooth.
4. Keep all component contact surfaces smooth and clean. Dirt or projections on mounting surfaces may lead to loose wheels. Remove all projections resulting from burrs, nicks, etc. Be sure that loose dirt does not fall onto mounting surface during assembly.
5. Check for and replace bent, broken, cracked or damaged studs. When replacing broken studs, always replace the studs on each side of the broken stud. If two or more studs are broken, replace all the studs for that wheel position. Check with the stud manufacturer for regular maintenance and stud replacement practices. All wheel fastener hardware should be grade 8 or metric conversion 10.9. Follow the hardware manufacturer's recommendations when replacing studs.
6. Do not introduce any foreign objects such as spacers or high hats into the contact surface areas of the mounting system unless approved by Alcoa. Do not paint Alcoa forged aluminum wheels.
7. Additional care should be used when mounting Alcoa Dura-Bright® surface treated wheels since minor nicks and scratches cannot be polished out (see section 5-8, page 37-38 for specific cautions, care and maintenance procedures).
8. DiscMates are a protection gasket designed to be placed between the wheels and also the brake drum/wheel contact surfaces (see sections 4-5, page 24; 4-6, page 25; 4-7, page 26 and 4-10, page 31). DiscMates are recommended to be replaced when the tire/wheel assemblies are removed and reinstalled.



WARNING

WARNING Wheels that are not properly installed or maintained may not work properly.

Failure to follow proper wheel installation or maintenance practices may result in injury or death.

Follow the proper wheel installation and maintenance practices as contained in this Alcoa Wheel Service Manual. For training on proper installation and maintenance, available free of charge from Alcoa, or for the most recent updates, contact Alcoa Wheel and Forged Products at 1-800-242-9898 option 1 or on the web at www.alcoawheels.com.

Wheel cap nuts

4-2



WARNING Use of chrome-plated cap nuts which have chrome plating on the surfaces which contact the wheel can cause reduced and inconsistent wheel clamping.

This condition can cause wheels to loosen and disengage from the vehicle, causing injury or death.

Never use cap nuts with chrome-plated contact surfaces. Use only recommended hardware on Alcoa aluminum wheels.

There are many types of nuts and studs in use, and their design and specifications are not standardized. The "R" and "L" on cap nut part numbers indicate right and left-hand threads respectively. Alcoa recommends the following cap nuts for use with Alcoa aluminum truck wheels:

Cap Nuts



2-piece 33mm hex head flange nut. Mounts single and dual wheels to wheel centering hubs. Right hand threads used on both sides of vehicle. Single wheels require 2" (50.8 mm) stud standout. Dual wheels require 2-13/16 (71.44 mm) stud standout. P/N 39874 (supersedes P/Ns 39701 and 39691); M22-1.5 RH threads.



2 piece 1-1/16" hex head flange nut. Mounts single and dual wheels to wheel centering hubs. Right hand threads used in both sides of vehicle. P/N 39946; 5/8"x18 RH threads



2-piece 30mm hex head flange nut. Mounts single and dual wheels to wheel centering hubs. Right hand threads used on both sides of vehicle. P/N 39708; M20x1.5 RH threads.



2-piece 33mm hex head flange nut. Mounts single wheels to wheel centering hubs with 32mm bolt holes. Right hand threads used on both sides of vehicle. P/N 4306.32; M22x1.5 RH threads.



2-piece 33mm hex head flange nut. Mounts dual wheels with 32mm bolt holes to wheel centering hubs. Right hand threads used on both sides of vehicle. P/N 4307.32; M22x1.5 RH threads.



Inner cap nut, inner thread 3/4"x16, outer thread 1-1/8"x16. For use with steel inner dual wheel an aluminum outer dual wheel with 1.31" (1-5/16) to 1.44" (1-7/16) stud standout. P/N 7896R, 7896L (Grade 8).



1-1/8" cap nut. Mounts standard single wheels and wide base wheels to 1-1/8" studs. Also mounts outer dual wheel to 1-1/8" inner cap nut. P/N 5996R, 5996L (replaces P/N 5552R, 5552L).



Inner cap nut, inner thread 3/4"x16, outer thread 1-1/8"x16. For use with standard length studs (1.31" [1-5/16] to 1.44" [1-7/16]) stud stand-out) or longer studs not to exceed 1.88" [1-7/8] stud standout. Full internal and external threads. P/N 5978R, 5978L (Grade 8). For studs without exposed shoulders. Do not use with steel inner dual wheel.



3/4"x16 cap nut. Mounts Alcoa wide base wheels to 3/4" studs. Do not use on steel wheels. P/N 5995R, 5995L (replaces P/N 5554R, 5554L).

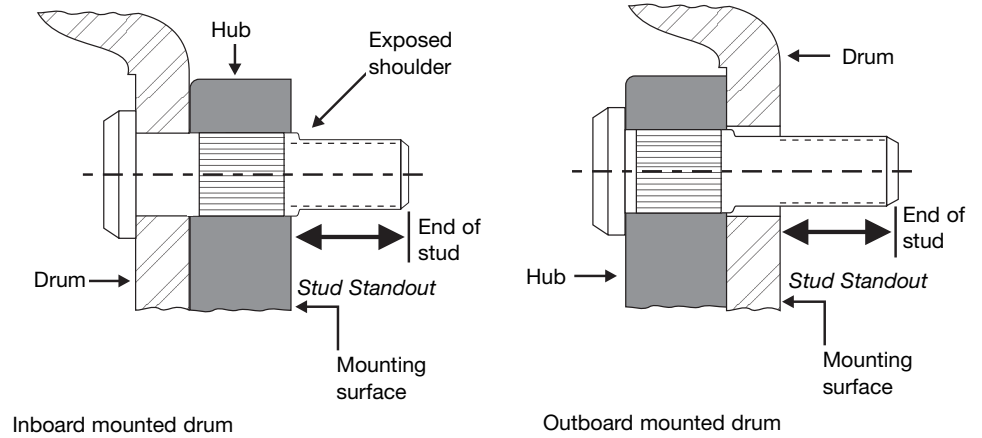


Inner cap nut for use with standard length studs (1.31" [1-5/16] to 1.44" [1-7/16]) stud stand-out) or longer studs not to exceed 1.88" (1-7/8) stud standout. Full internal and external threads, counter bore 5/16" deep at open end. Prevents stud from bottoming out in cap nut. P/N 5988R, 5988L (Grade 8). For use with studs with exposed shoulders. Do not use with steel inner dual wheel.

How to measure stud standout

Stud standout is measured from the axle end mounting surface to the end of the stud.

4-3

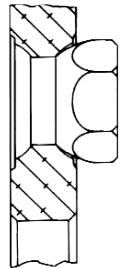


4

Stud located ball seats are spherical

4-4

The nut seat for the stud located ball seat mounting system is a precision-machined spherical surface. Cap nuts must be properly manufactured to assure correct seating. Never use one or two-piece flange nuts on a wheel designed with ball seats (see 4-12, page 34). Ball seat cap nuts may be obtained from your Alcoa Wheel Distributor.



Single wheel, stud located, ball seat mounting

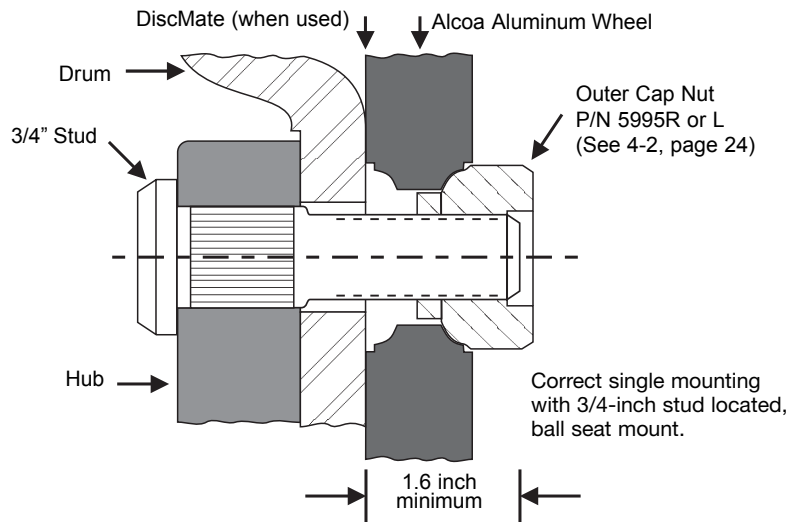
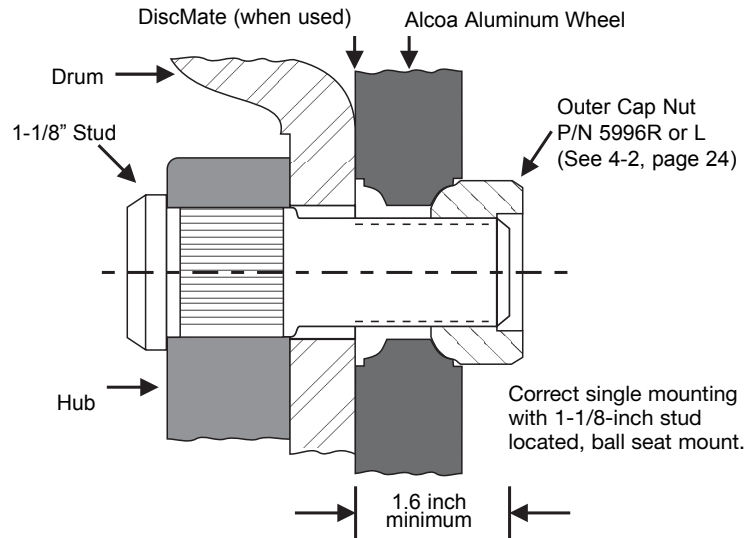
4-5

NOTICE: Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.

Front wheels are mounted as singles and require 1.6" (1-39/64") minimum stud standout. Most vehicles have 1-1/8-inch studs on the front hubs. Alcoa single cap nuts, Part Nos. 5996R and 5996L, or equivalents, should be used. Some front hubs have 3/4-inch studs. On these hubs, use Alcoa single cap nuts, Part Nos. 5995R and 5995L or equivalents.

DiscMate wheel spacers are recommended for use with Alcoa Dura-Bright® surface treated wheels to protect the wheel contact surfaces from marring. DiscMate wheel spacers are placed between the contact surfaces of the Dura-Bright® wheel and the brake drum as shown below.



Dualed wheels, stud located, ball seat mounting

4-6

Rear wheels are most frequently mounted as duals. Each inner aluminum wheel is attached by 10 inner cap nuts. Alcoa recommends use of inner cap nuts 5978R, 5978L, or 5988R, 5988L (see 4-2, page 24).

Cap nuts recommended by Alcoa are compatible with Alcoa wheels. Hardware of equal dimensions and strength may be used.

Continued on next page.

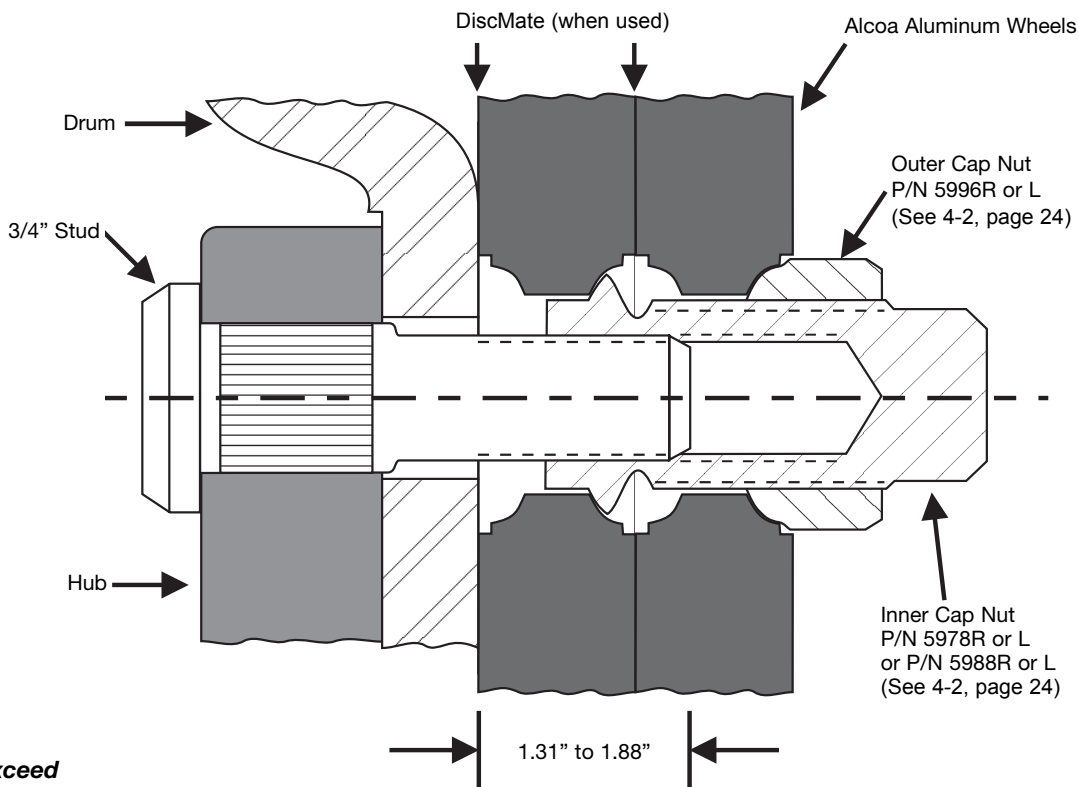
Dualed wheels, stud located, ball seat mounting (continued)

Most vehicles have standard length studs (1.31" [1-5/16"] to 1.44" [1-7/16"] stud stand out). Some vehicles use studs longer than standard (up to 1.88" [1-7/8"] stand out).

When changing types of brake drums be sure to check for excessive stud stand out (greater than 1.88" [1-7/8"]). Excessive stud stand out may cause the inner cap nut to bottom out on the longer stud preventing proper seating of the wheel.

Each outer dual wheel is attached by 10 single cap nuts which thread on the inner cap nuts. Use Alcoa outer cap nuts, Part Nos. 5996R, 5996L or equivalents. Match mounted dual wheels should be put on the vehicles with the valve stems 180° apart.

DiscMate wheel spacers are recommended for use with Alcoa Dura-Bright® surface treated wheels to protect the wheel contact surfaces from marring. DiscMate wheel spacers are placed between the contact surfaces of the Dura-Bright® wheel and the brake drum and between the dual aluminum wheels as shown below.



Correct mounting for dual aluminum, stud located, ball seat mount, wheels.

NOTICE: Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.



WARNING

WARNING Incorrect inner cap nuts used with dualed aluminum wheels can bottom out on the unthreaded portion of the stud before the wheels are properly seated.

Improperly seated wheels can run loose, cause stud breakage and disengage from the vehicle which can cause serious injury or death. Loose running wheels can lead to stud breakage.

Use only cap nut 5978R or L, 5988R or L, or their equivalent when mounting dual aluminum wheels.

On occasion Alcoa aluminum truck wheels are operated dualed with a steel inner wheel. In the event a steel inner wheel is used, extreme care must be exercised to properly seat it to the hub or drum prior to mounting the outer aluminum wheel. Selection of an inner cap nut capable of fixing the steel inner wheel and providing adequate external thread length to secure the outer aluminum dualed wheel is critical to a safe assembly. Alcoa recommends the use of inner cap nuts 7896R and L (Grade 8), or equivalent, for this purpose.

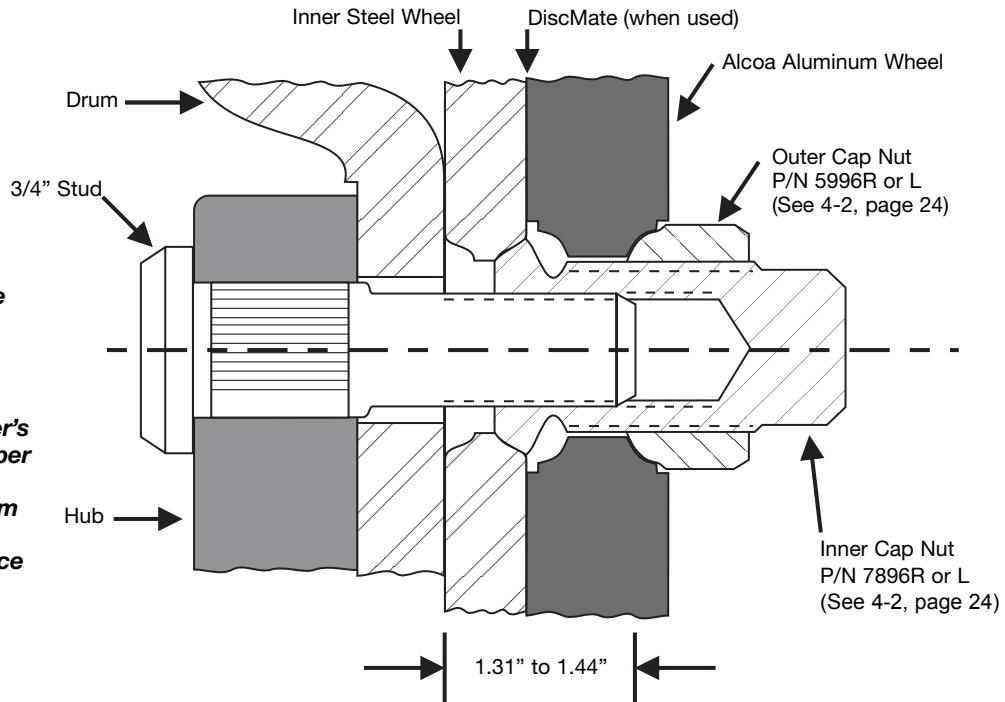
Dualed wheels, steel inner/ aluminum outer stud located ball seat mounting

DiscMate wheel spacers are recommended for use with Alcoa Dura-Bright® surface treated wheels to protect the wheel contact surfaces from marring. DiscMate wheel spacers are placed between the contact surfaces of the Dura-Bright® wheel and the brake drum and between the steel and aluminum wheels as shown below.

4-7

NOTICE: Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.



Correct dual mounting for steel inner/aluminum outer stud located ball seat mount.



WARNING

WARNING Incorrect inner cap nuts used with steel wheels can bottom out on the unthreaded portion of the stud before the wheels are properly seated.

Improperly seated wheels can run loose, cause stud breakage and disengage from the vehicle which can cause serious injury or death. Loose running wheels can lead to stud breakage.

Use only cap nut 7896R or L or its equivalent when mounting steel inner duals.



WARNING

WARNING Inadequate wheel support surface can lead to stud hole-to-stud hole fracture resulting in separation of the outer disc and rim from the vehicle.

Separation of the wheel from the vehicle can cause injury or death.

Alcoa aluminum wheels with 11-1/4" diameter bolt circle require a support surface at least 13-3/16" in diameter. Check the outer support surface of the inner steel wheel for flatness and adequate diameter before installing the outer wheel. When the wheels are serviced, check the mounting surfaces of both wheels for stud hole to stud hole cracks. If cracks are found, remove the wheel from service. For the support surface diameter required by other bolt circle sizes, ask your Alcoa representative.



WARNING

WARNING Use of two-piece flange nuts on ball seat wheels or ball seat cap nuts on hub piloted wheels is dangerous.

Using the wrong cap nuts can cause loss of torque, broken studs and cracked wheels, conditions which can lead to injury or death.

Use only hardware designed specifically for each wheel type. See 4-2, page 24 for proper hardware assemblies.

Cap nut thread engagement, stud located wheels, ball seat mounting

4-8

The actual length of thread engagement present in an assembled wheel can not always be determined by visual inspection or measurement of a tightened assembly. The relationship of the wheel cap nut seat to the end of the stud may vary. If there is any doubt that enough thread engagement is present, the number of engaged threads may be counted. Tighten all nuts in the regular manner, then loosen one to hand-tightness. The number of turns to disengage a 1-1/8-inch nut should be at least five full turns. At least seven full turns should be required to disengage a 3/4-inch nut. Ideally, when torqued to the proper load, the stud should be flush with the face of the nut. The face of the nut may be recessed in nuts that are taller for improved wrenching. With most of the nuts in present use, a few unengaged threads at the outer end will cause no problem provided at least 5-7 full turns are required to disengage the nut depending on thread size.

Cap nuts made to Alcoa specification usually give more than the necessary thread engagement on a given stud.

Some states have laws which dictate full thread engagement or thread engagement past the nut body. Make sure you know the laws for the states in which you operate and comply.

Tightening stud located, ball seat cap nuts

4-9



The number of turns to disengage a 1-1/8-inch nut should be at least five full turns. At least seven full turns should be required to disengage a 3/4-inch nut.



WARNING

WARNING Lubricants should not be applied to the cap nut seat or to the cap nut-to-wheel contact surface.

Oiled seats can lead to over-torquing which can stretch studs causing failure of studs. Failed studs can cause the wheel to disengage from the vehicle, causing injury or death.

Lubricants must be completely removed from the cap nut seats and contact surfaces if applied accidentally.

Cap nuts must be kept tight, and studs and nuts should be checked frequently. Nuts should be retorqued if necessary. At tire changes, nuts and studs should be inspected for cracks and stripped or damaged threads. After each wheel mounting, cap nut torque should be checked with a torque wrench.

Impact wrenches, if used, should be carefully adjusted to apply torques within the limits recommended. Torquing of cap nuts should be done in recommended sequences.



WARNING

WARNING Undertorqued cap nuts allow wheels to run loose, pounding out (deforming) the ball seats, fatiguing studs or losing nuts. Overtorquing can stretch studs causing them to fail.

Both under and overtorquing can lead to wheels coming off, causing injury or death.


Check all parts, including wheels, studs and cap nuts. Check mounting faces of wheels, hubs and drums. Check for dirt, corrosion or damage. Remove dirt and rust; replace damaged parts. Follow correct tightening sequences and torque levels.

Continued on next page

Tightening stud located, ball seat cap nuts (continued)

Stud located, ball seat mounting system.

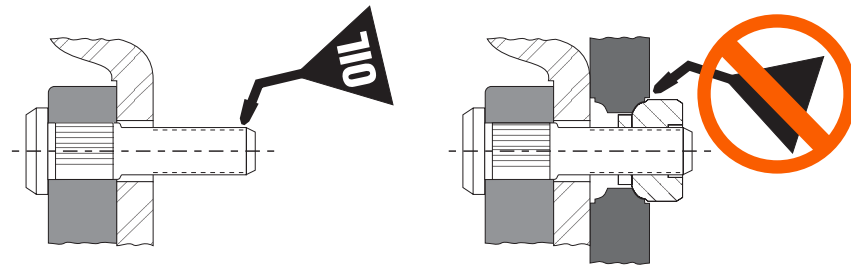
It is recommended that stud threads on stud located mounting systems be lubricated with SAE 30W oil and torqued between 350 and 400 foot-pounds. If threads are not lubricated, torque to between 450 and 500 foot-pounds. Note: when dualing steel wheels with Alcoa aluminum wheels, follow the steel wheel manufacturer's recommendations regarding the proper torque and use of thread lubricants to mount the wheel.



WARNING Application of lubricant to the ball seats can cause excessive torque. Over torque can stretch studs causing them to fail.

Overtorquing can lead to wheel disengagement causing injury or death.

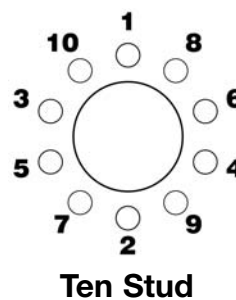
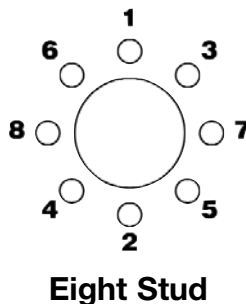
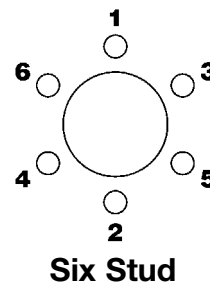
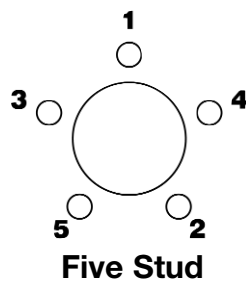
WARNING Do not allow oil to contact ball seats or mounting surfaces of the wheel, hub or drum. Do not use aerosol cans for lubrication of stud threads.



On vehicles equipped to accept wheels manufactured for use with the stud located ball seat mounting system, wheel studs on the right side of the vehicle have right-hand threads and those on the left have left-hand threads. The "R" and "L" on the studs and nuts indicate right and left-hand threads respectively (see 4-2, page 24).

After mounting a wheel over the studs, snug up the cap nuts in the order shown in the illustrations that follow. After all the cap nuts have been snugged, tighten the cap nuts to the recommended torques, following the same tightening sequence.

NOTICE: In service, stud dimensions and condition may change over time due to environmental conditions, multiple re-installations, improper torquing and other factors. Consult with your hub and stud manufacturer for maintenance and replacement recommendations.



Continued on the next page

Tightening stud located, ball seat cap nuts (continued)

After 50-100 miles of operation, torque should be rechecked. Loosen outer cap nuts on every other stud to check the torque on inner cap nuts, then retorque outer cap nuts. Repeat steps on remaining studs. **Check torque frequently from then on.** If nuts require frequent tightening, studs break frequently, or wheel nut seats are pounding out, hardware and mounting practices should be reviewed. Note: whenever the outer cap nut is loosened **ALWAYS** retorque the inner cap nut before retorquing the outer cap nut.

Single, dual and wide base wheels, hub piloted mounting, two-piece flange nuts

4-10

NOTICE: Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.

Most U.S. manufacturers of highway trucks, tractors and trailers which incorporate the hub piloted wheel mounting system require wheel studs and cap nuts with metric threads. Most frequently these are M22x1.5.

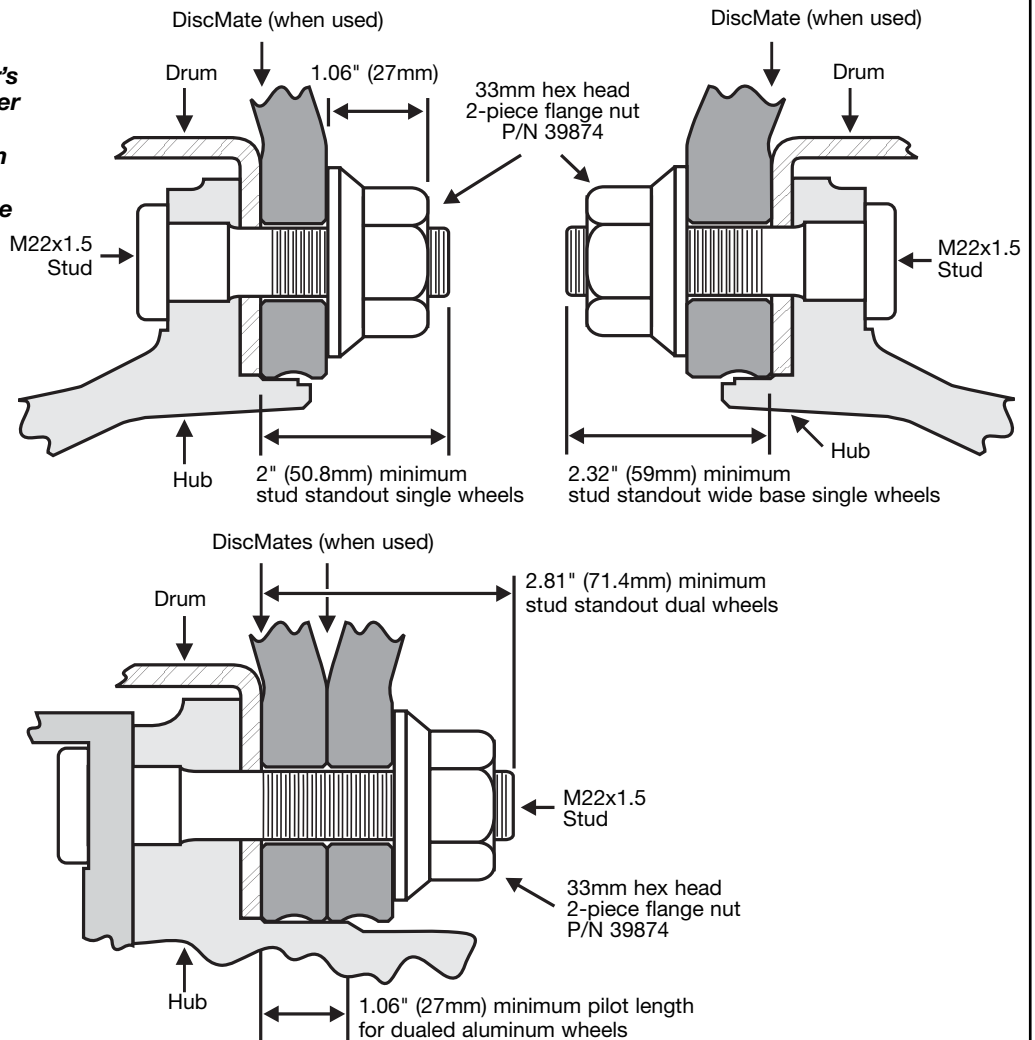
Generally the same diameter stud is used to mount either single or dual wheels.

Studs on both sides of the vehicle are right-hand threads thereby eliminating the need for flange nuts peculiar to either the right or left side of the vehicle. The same flange nut is used to mount dual or single wheels. Proper stud standout for single wheels is 2-inch (50.8mm) minimum, dual wheels require 2.81-inch (71.4mm) minimum and single wide base wheels require 2.32-inch (59mm).

Some states have laws which dictate full thread engagement or thread engagement past the nut body. Make sure you know the laws for the states in which you operate and comply.

DiscMate wheel spacers are recommended for use with Alcoa Dura-Bright® surface treated wheels to protect the wheel contact surfaces from marring. DiscMate wheel spacers are placed between the contact surfaces of the Dura-Bright® wheel and the brake drum and between the dual wheels as shown below.

Note: Some stud located ball seat wheels have the same number of holes and bolt circle diameter as hub piloted wheels. They should not be mixed.



Typical assembly of single and dual wheels of hub piloted type with 33mm hex head two-piece flange nut, Part No. 39874. If hex nuts with greater overall height are used, more stud length is required.

Continued on the next page.

Single, dualed and wide base wheels, hub piloted mounting, two-piece flange nuts (continued)

Hubs designed for steel hub piloted wheels may not have enough pilot length to locate dualed aluminum wheels. Pay close attention to pilot length, particularly when converting from steel to aluminum duals. Measure the hub pilot to make sure the hub has a minimum pilot length of 1.06-inch or 27mm for dualed wheels.

When mounting painted steel inner dual wheels with outer aluminum wheels, be cautious of excessive paint build-up on the inner steel wheel. Excessive paint can reduce the clamping force and allow the wheels to become loose.

Match mounted dual wheels should be put on the vehicle with the valve stems 180° apart.

Tightening hub piloted mounting, two-piece flange nuts

Flange nuts must be kept tight, and studs and nuts should be checked frequently. At tire changes, nuts and studs should be inspected to be sure they are in good condition. If nuts require frequent tightening or studs break frequently, hardware and mounting practices should be reviewed.

Impact wrenches, if used, should be carefully adjusted to apply torques within the limits recommended. Torquing of flange nuts should be done in recommended sequences.

4-11



WARNING Undertorqued flange nuts allow wheels to run loose and fatigue studs or lose nuts. Overtorquing can stretch studs causing them to fail.

Both under and overtorquing can lead to wheel disengagement causing injury or death.

Check all parts including wheels, studs and flange nuts. Check mounting faces of wheels, hubs and drums. Check for dirt, corrosion or damage. Remove dirt and rust; replace damaged parts. Follow correct tightening sequences and torque levels.

Two-piece flange nuts with a 33mm hex head design (see 4-2, page 24), used with hub piloted wheels should be tightened to a torque of 450 to 500 foot-pounds. Two-piece flange nuts with 1-1/2-inch hex head design and other designs have different torque requirements. Inquire of the manufacturer for the proper torque values.

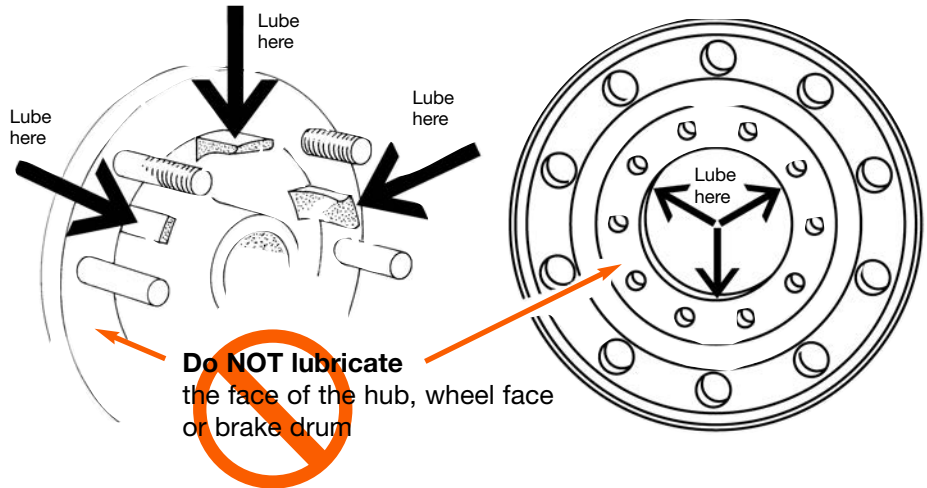
Wheel studs on both the right and left side hubs of vehicles utilizing the hub piloted wheel system have right-hand threads.

Prior to mounting hub piloted wheels, generously coat the wheel pilot or hub pads with a non-water-based lubricant to minimize corrosion product build-up between the wheel and hub pilot. Excessive corrosion build-up between the wheel and hub pilots can make wheel removal difficult. Do not lubricate the face of the wheel, hub or brake drum (see illustration on the next page).

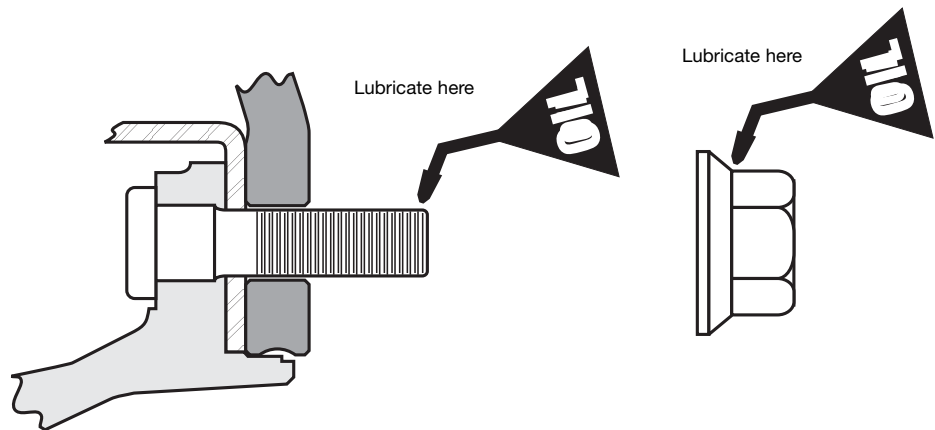
Continued on the next page.

Tightening hub piloted mounting, two-piece flange nuts (continued)

Lubricate the hub pads or the wheel hub bore generously with a non-water-based lubricant.

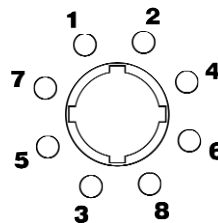


Before installing two-piece flange nuts, lightly lubricate the stud threads and the contact surfaces between the cap nut and the washer as illustrated below with an SAE 30W oil. This will minimize corrosion between the mating surfaces. Lubrication is not necessary with new hardware.

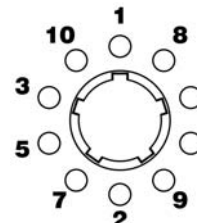


Position one of the hub's pilot pads at the twelve o'clock position. After positioning wheels on the pilot pads, hand tighten all two-piece flange nuts, then tighten to the recommended torque following the proper sequence shown below for your type wheel. After 50-100 miles of operation, torque should be rechecked. **Check torque frequently from then on.** If nuts require frequent tightening, studs break frequently, or wheel bolt holes are pounding out, hardware and mounting practices should be reviewed.

NOTICE: In service, stud dimensions and condition may change over time due to environmental conditions, multiple re-installations, improper torquing and other factors. Consult with your hub and stud manufacturer for maintenance and replacement recommendations.



Eight Stud



Ten Stud

Incorrect assemblies

4-12



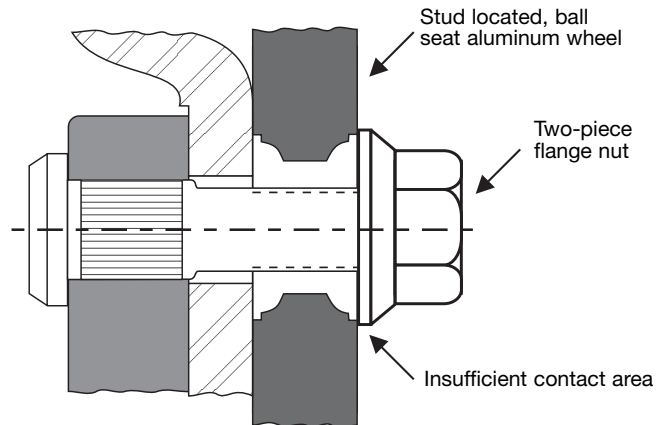
WARNING

WARNING Use of two-piece flange nuts on ball seat wheels, ball seat cap nuts on hub piloted wheels or single-piece flange nuts in place of 2-piece flange nuts is dangerous.

Using the wrong wheel nuts can cause loss of torque, broken studs and cracked wheels, conditions which can lead to injury or death.

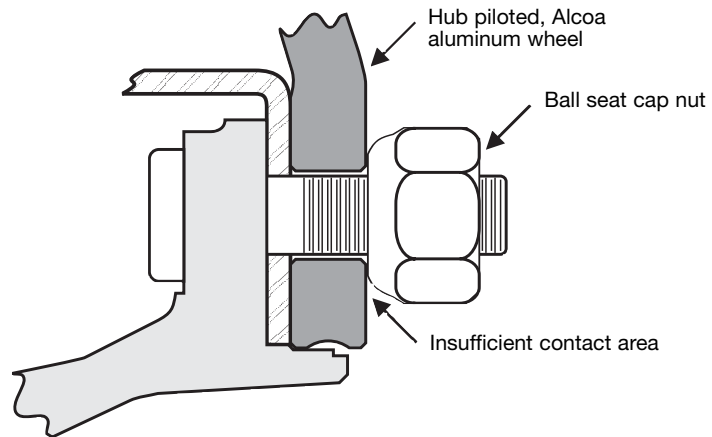
Use only hardware designed specifically for each wheel type. See 4-2, page 24 for proper hardware assemblies.

The following are examples of **incorrect** wheel assemblies.



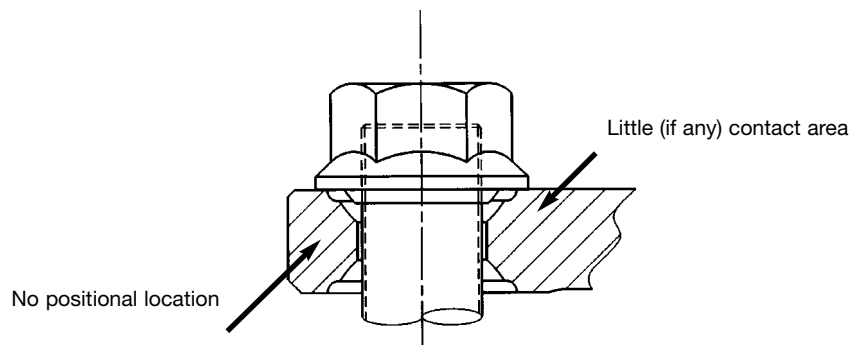
Incorrect use of two-piece flange nut.

Do not use two-piece flange nuts with ball seat wheels.



Incorrect use of ball seat cap nut.

Do not use ball seat cap nuts with hub piloted wheels.



Incorrect use of one-piece flange nut positioned on Alcoa ball seat wheel.

Do not use one-piece flange nut on ball seat wheels.

5

Proper Torque, Wheel Identification, Valves and Surface Maintenance

Avoid abuse

Abuse can shorten the life of a wheel. Lack of care in changing a tire, heavy pounding of the wheel rim, overloading, exposure to excessive heat or hitting curbs at high speed or a sharp angle can damage wheels.

5-1

Do not overinflate. Use the tire manufacturer's recommended pressure, but under no circumstances exceed cold tire pressures listed in Section 1 Specifications of this manual. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.

Keep wheel nuts tight

5-2

Wheel cap nuts must be kept tight (see 4-9, page 29). When checking the cap nuts on dual disc wheels utilizing the stud located ball seat mounting system, loosen every other outer cap nut and then check the torque of the inner cap nuts. Retorque the loosened outer cap nuts. Repeat procedure with the rest of the nuts. Check all cap nuts for proper torque after the first use or any removal. Inspect wheels and check wheel nuts during service stops. (See Section 2, page 5). Dirt streaks from cap nuts may indicate looseness.

Flange nuts must be kept tight, and studs and nuts should be checked frequently. At tire changes nuts and studs should be inspected to be sure they are in good condition. If nuts require frequent tightening or studs break frequently, hardware and mounting practices should be reviewed.

For proper nut torque, refer to the chart below:

Mount Type	Nut Thread	Torque Level Ft-Lb Lubricated*	Torque Level Ft-Lb Dry*
Hub piloted using two-piece flange nut	11/16" - 16	300-400	
	M20 x 1.5	280-330	
	M22 x 1.5	450-500	
Stud piloted, double cap nut standard type (7/8" radius)	3/4" - 16	350-400	450-500
	1-1/8" - 16	350-400	450-500
Stud piloted, double cap nut heavy duty type (1-3/16" radius)	15/16" - 12		750-900
	1-1/8" - 16	650-800	750-900
	1-5/16" - 12		750-900

For nuts used on **hub piloted wheels, apply two drops of oil to the point between the nut and flange and two drops to the first two or three threads at the tip of each stud (see 4-11, page 32).*

*For nuts used on **stud piloted wheels**, apply two drops of oil to the first two or three threads at the tip of each stud only (see 4-9, page 29).*

NOTE:

1. If using specialty fasteners (cap nuts), consult the manufacturer for recommended torque values.
2. Tightening wheel nuts to their specified torque is extremely important. Undertightening which results in loose wheels can damage wheels, studs and hubs, and can result in wheel loss. Overtightening can damage studs, nuts and wheels and results in loose wheels as well.
3. Regardless of the torque method used, all torque wrenches, air wrenches and any other tools should be calibrated periodically to ensure the proper torque is applied.

Lead balance weights (clip on)

5-3

Lead balance weights for Alcoa wheels are available from your Alcoa Wheel Distributor. With radial tires it may be necessary to temporarily reduce the tire pressure when installing clip-on weights to allow clearance of the weight clamp over the rim flange. Use of coated balance weights is recommended to avoid staining and corrosion of the aluminum wheel surface.

Excessive rim flange wear (see section 2-11, pages 13-17) could dictate the use of “stick-on” or adhesive wheel weights if there is inadequate rim to properly hold a clip-on style weight.


Improperly installed weights could “fly off” during use and damage the vehicle or cause personal injury. Always follow the recommended procedures in this manual or the wheel weight manufacturer. Adhesive weights should be applied only to a clean surface on the brake side of the wheel rim. These weights should be installed only in a location where they will not contact the brake components during vehicle operation.

Do not straighten wheels

5-4

Do not heat wheels in an attempt to soften them for straightening to repair damage from striking curbs or other causes. The special alloy used in these wheels is heat treated, and uncontrolled heating will weaken the wheel.

Do not rework, weld, heat or braze Alcoa aluminum wheels for any reason. This does not include normal wheel maintenance as described and approved by Alcoa.



WARNING Welding or brazing the rim flange or any area of an Alcoa aluminum wheel will weaken the wheel. Weakened or damaged wheels can lead to an explosive separation of tires and wheels or wheel failure on the vehicle.

WARNING Explosive separations of tires and wheels or wheel failure on the vehicle could cause injuries or death.

Never attempt to weld or braze any surface of an Alcoa aluminum wheel.

Owner/in-service identification

5-5

Some fleets wish to specially identify wheels as to OWNERSHIP and IN-SERVICE dates. Alcoa recommends that fleets and owner-operators adopt the practice of permanently stamping wheels with the date they are first placed into service.

1. Use “Lo-Stress” stamps or equivalent.
2. Location of stamped areas on outside disc should be in space outward from a line between hand hole centers and a minimum of one inch from the periphery of any hand hole.
3. Location of stamped identification on inside of wheel should be as close to the factory identification stamping as possible.

Note: Use of an impression stamp on Dura-Bright® surface treated wheels can affect the appearance and performance of the Dura-Bright® surface treatment local to the stamp.

Valves

5-6

Alcoa drop center wheels for tubeless tires come from the factory with air valves installed. If it becomes necessary to replace an air valve, install it using the following torque values.

10-14 foot-pounds for Part Nos.	7-11 foot-pounds for Part Nos.
TR 509 TR 510 TR 511	TR 542 Series TR 543 Series TR 544 Series TR 545 Series 60MS27N

Replacement valves may be obtained from your authorized Alcoa Wheel Distributor. Always use silicone o-rings – not rubber – when reinstalling valve stems. Metal valve stem caps are recommended instead of plastic.

When replacing valve stems, it is recommended to lubricate the threads and o-ring with a non-waterbased lubricant.

Maintenance against corrosion (non-Dura-Bright® surface treated wheels)

5-7

NOTICE: Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire, perform a wheel fitment check to ensure proper clearance from any obstructions.

The following information is for standard Alcoa forged aluminum wheels **without** the Dura-Bright® surface treatment. See section 5-8, page 37 for specific instructions on the care and clearing of Alcoa Dura-Bright® surface treated wheels.

1. Clean frequently with high pressure water from a hose. The use of a mild detergent will speed the cleaning process. Use no harsh alkaline cleaners.
2. When tires are removed the entire wheel must be cleaned and inspected. (See Section 2, page 5). With a wire brush, remove any foreign products from the tire side of the rim. Do not use a wire brush to remove dirt and corrosion products from the appearance surface of the wheel. Generously coat the entire air chamber surface with an approved surface protectant and lubricant each time the tire is removed (See 3-1, page 18).
3. To maintain the original appearance of your Alcoa wheels, the following procedures are recommended:
 - a. After installing new wheels and prior to operating your vehicle, use a sponge, cloth or soft fiber brush to wash exposed wheel surfaces with a mild detergent and warm water solution.
 - b. Rinse thoroughly with clean water.
 - c. Wipe dry to avoid water spots.
 - d. Wax the cleaned surface with **Alcoa Advanced Aluminum Care System Polish** or Simonize, Mothers, California Gold paste wax, No. 7 Car Wax or equivalent.
 - e. Clean your Alcoa truck wheels as frequently as required to maintain their appearance.

Dura-Bright® surface treated wheels cleaning and maintenance

5-8

NOTICE: Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire, perform a wheel fitment check to ensure proper clearance from any obstructions.

1. Clean frequently with high-pressure water from a hose. The use of a mild detergent will speed the cleaning process. Do not clean with abrasives, abrasive brushes, steel wool, scouring pads or strong chemicals, such as acids or lye-based products. Never spray cold water on extremely hot wheels. Always allow time to cool before cleaning.
2. When tires are removed, the entire rim must be cleaned and inspected (see section 2, page 5). With a brush, remove any foreign products from the tire side of the rim (portion of the wheel that supports the tire). Do not use an abrasive brush to remove dirt, corrosion or other foreign products from the Dura-Bright® wheel surfaces. Generously coat the entire air chamber surface with an approved surface protectant and lubricate each time the tire is removed (see 3-1, page 18 of the Alcoa Wheel Service Manual, July 2002).
3. To maintain the original appearance of your Alcoa Dura-Bright® wheels, the following procedures are recommended:
 - a. After installing new wheels and prior to operating your vehicle, use a sponge or cloth to wash exposed wheels surfaces with a mild detergent and warm water. Do not use abrasives, abrasive brushes, steel wool, scouring pads or strong chemicals (such as acids or lye-based products). Standard off-the-shelf car wash and wheel detergents are sufficient. Warm water and a mild detergent will speed the cleaning process.
 - b. Rinse thoroughly with clean water.
 - c. Wipe dry to avoid water spots.

Dura-Bright® surface treated wheels cleaning and maintenance (continued)

d. Clean your Alcoa Dura-Bright® wheels using the above procedures as frequently as required to maintain their appearance. Typical road soils, grime and brake dust trap moisture, which can cause corrosion over a period of time. These must be removed regularly. To assist in the removal of excessive dust, dirt and road grime, the use of warm, high-pressure water with a mild detergent is recommended. The surface of Alcoa Dura-Bright® wheels will be damaged, discolored or removed if abrasives, abrasive brushes, steel wool, scouring pads or strong chemicals (such as acids or lye-based products) are used to clean the wheel. **DO NOT USE** the Alcoa Aluminum Care System on Dura-Bright® wheels at any time during their service life.

4. Once in service, Dura-Bright® wheels can become nicked or scratched by road debris and/or mechanical damage. If this occurs, continue to follow the normal washing and cleaning instructions provided above. The surface of an Alcoa Dura-Bright® wheel is designed to limit cracking and peeling if nicked or scratched while in service.

5. Even as durable as Dura-Bright® wheels are, the mounting area can become scratched, marred or discolored when mounted against another wheel, hub or drum. The use of a wheel mounting surface guard, such as Alcoa DiscMates™, is highly recommended. The use of the Alcoa Hub Cover System on Alcoa Dura-Bright® wheels will also assist in limiting such damage and help maintain the appearance of your Alcoa Dura-Bright® wheels.


5

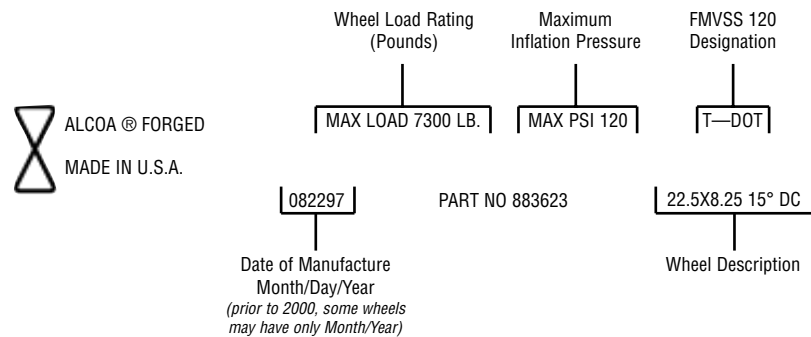
Identification

5-9

Alcoa wheel identification

Since 1977, all Alcoa aluminum disc wheels have been identified with a stamp that shows the wheel load rating, maximum inflation pressure, date of manufacture, part number, wheel description and DOT marking designation.

Prior to June 1996, all Alcoa heavy duty truck wheels had the Alcoa identification symbol  on the outside of the disc near the hand hole in line with the valve location. This marking was phased out on heavy duty truck wheels manufactured after June 1996.



All Dura-Bright® surface treated wheels are designated by the letters "DB" following the part number such as 883620DB.

Note: Dura-Bright® wheels produced after November 2002 have Alcoa wheel part numbers ending with "DB" (earlier wheels have part numbers ending in a 4 or 7) with bead seat diameters measured in 0.5-inch increments. Not all Alcoa wheels are available with the Dura-Bright® surface treatment.

All Dura-Flange® wheels are designated by the letters "DF" following the part number such as 883620DF.

6 Flat Base Wheel for Tube-type Tires

Tube-type wheel part interchangeability

6-1



WARNING Mismatched rim/wheel components can lead to explosive separation of wheel components.

Explosive separation of wheel parts can cause serious injury or death.

See chart below for matching components.

Multipiece Rim Matching Chart

The following is the Alcoa Aluminum Wheel interchangeability information from the OSHA Multipiece Rim Matching Chart. For a complete matching chart, write to: **U.S. Department of Labor, Occupational Health and Safety Administration, Publications Department, Room N4101, Washington, DC 20210**

Read across the chart to find interchangeable components for specific size and type of Alcoa wheel. The information which is found in the shaded areas of the OSHA Multipiece Rim Matching Chart is represented in the table below.

RIM SIZE	RIM BASE IDENTIFICATION STAMPING	2 PIECE ASSEMBLIES		3 PIECE ASSEMBLIES	
		SIDE RING IDENTIFICATION STAMPING	LOCK RING IDENTIFICATION STAMPING	FLANGE IDENTIFICATION STAMPING	
20 x 7.5	20x7.5FL; B7520FL	20x7.5FL; R20X7.5FL; R7520FL	20X7.5FL; LR20X7.5FL; LR7520FL	20X7.5-5°-FL; 20X7.5-8.05°-7.5FL; F20X7.5FL; F7520FL	
	1020 20-7.5; T/M 20-7.5 8-A3-190	1020 RC20-7.5; T/M 20-7.5 8-A3-190	NONE	NONE	
	1120 10-7.5; D-13520 20-7.5; A-AA2951 20-7.5; K-H 20X7.5	1120 RC 20-7.5; D 20-7.5 D 13520SR; F20-7.5 A-AA2951-1	NONE	NONE	
	20X7.5-5°; 20X7.50-5°; F20750B (2)	NONE	20X7.0-7.5-8.0-5°	20X7.5-5°-FL; 20X7.5-8.05°-7.5FL; F7520FL	
	20X7.5LA; 20X7.5MS; B7520LA	R20X7.5LA; 20X7.5MS; R7520LA	NONE	NONE	
	20X7.5LB; 20X7.5DT-LB (3); B7520LB; G20750B (2)	R20X7.5-8.0-9.0LB-LW; 20X7.5-8.0DT-LB-LW (3); R8020LW	NONE	NONE	
	20X7.5LW; 20X7.50LW; B7520LW; G20750B (2)	20X7.5-8.0-9.0LW; 20X7.5-8.0-DT-LB-LW (3); R8020LW	NONE	NONE	
	20X7.5M	R20X7.5-8.0-9.0LB-LW; 20X7.5-8.0DT-LB-LW (3); R8020LW	LR20X7.5-8.5-10.0M; LR20M	F20X7.5-8.5M; F7520M	
	20X7.5DA5°	20X7.5DA5°; 20X7.5FLN; 20X7.5N5°	NONE	NONE	
	20X7.5FLN	20X7.5FLN; 20X7.5DA5°; 20X7.5N5°	NONE	NONE	
	20X7.5N5°	20X7.5N5°; 20X7.5FLN; 20X7.5DA5°	NONE	NONE	
	B7520KB	R8020KW	NONE	NONE	
	B7520KW	R8020KW	NONE	NONE	
	B7520KWX	R8020KW	NONE	NONE	
	BW-5 20X7.5	BW-5 20X7.5	BW-5 20X7.5-8.0V-8.5V	B-5° 20X7.5	
20 x 8.0	20X8.0-5°; 20X8.00-5°; F20800B (2)	NONE	20X7.0-7.5-8.0-5.0°	20X8.0-5°; 20X7.5-8.05°-7.5FL	
	20X8.0LW; 20X8.00LW; B8020LW; G20800B (2)	R20X7.5-8.0-9.0LB-LW; 20X7.5-8.0DT-LB-LW (3); R8020LW	LR20X7.5-8.5-10.0M; LR20M	F20X7.5-8.5M; F7520M	
	B8020KW	R7520K	NONE	NONE	
	BW-5 20X8.0	NONE	BW-5 20X7.5-8.0V-8.5V	BW-5 20X8.0V-8.5V	
22 x 7.5	1022 22-7.5; T/M 22-7.5 8-A3-191	1022 RC22-7.5; T/M 22-7.5 8-A3-191	NONE	NONE	
	1122 22-7.5; D-13522 22-7.5; A-AA2952 22-7.5	1122 RC22-7.5; D 22-7.5 D 13522-SR; F 22-7.5 A-AA2952-1	NONE	NONE	
	22X7.5-5°; 22X7.50-5°; F22750B (2)	NONE	22X7.0-7.5-8.0-5°	22X7.5-5°-FL; 22X7.5-8.05°-7.5FL; F7522FL	
	22X7.5FL; B7522FL	22X7.5FL; R22X7.5FL; R7522FL	22X7.5FL; LR22X7.5FL; LR7522FL	22X7.5-5°-FL; 22X7.5-8.05°-FL; F22X7.5FL; F7522FL	
	22X7.5LB; 22X7.5DT-LB (3); B7522LB; G22750B (2)	R22X7.5-8.0-9.0LB-LW; 22X7.5-8.0DT-LB-LW (3); R8022LW	NONE	NONE	
	22X7.5LW; 22X7.50LW; B7522LW; G22750B (2)	R22X7.5-8.0-9.0LB-LW; 22X7.5-8.0DT-LB-LW (3); R8022LW	NONE	NONE	
	22X7.5M	R22X7.5-8.0LB-LW; R8022LW	LR22M; LR22X7.5-8.5-10.0M	F7522M	
	22X7.5DA5°	22X7.5DA5°; 22X7.5FLN; 22X7.5N5°	NONE	NONE	
	22X7.5FLN	22X7.5FLN; 22X7.5DA5°; 22X7.5N5°	NONE	NONE	
	22X7.5N5°	22X7.5N5°; 22X7.5FLN; 22X7.5DA5°	NONE	NONE	
	B7522KB	R8022KW	NONE	NONE	
	B7522KW	R8022KW	NONE	NONE	
	B7522KWX	R8022KW	NONE	NONE	
	BW-5 22X7.5	BW-5 22X7.5	BW-5 22X7.5-8.0V-8.5V	B-5° 22X7.5	
	22 x 8.0	22X8.0-5°; 22X8.00-5°; F22800B (2)	NONE	22X7.0-7.5-8.0-5°	22X8.0-5°
22X8.0LW; 22X8.00LW; B8022LW; G22800B (2)		R22X7.5-8.0-9.0LB-LW; 22X7.5-8.0DT-LB-LW (3); R8022LW	LR22M	F7522M	
B8022KW		R7522KW	NONE	NONE	
BW-5 22X8.0		NONE	BW-5 22X7.5-8.0V-8.5V	BW-5 22X8.0V-8.5V	

Part numbers listed by Alcoa are followed by one of the characters X-T-N-B, or current Alcoa part numbers (i.e., 371010) end in 0-1-2 or 3, indicating a finish condition which does not affect the interchangeability of parts as shown on the chart.

6

Mounting recommendations for tubed tires

6-2

1. Inspect the wheel for damage. Do not use a bent, cracked, damaged or severely corroded wheel. (See Section 2, page 5).
2. Inspect ring(s) for corrosion, bending or other damage and discard if any is apparent.
3. Thoroughly clean the wheel and rings. Clean the wheel face with a mild detergent. Clean the tire bead seat areas and gutter flange with a wire brush.
4. Do not gouge or nick the wheel. Place wheels on a wooden floor or rubber mat. Always use a rubber, leather-faced or plastic mallet.
5. Inspect and clean the tire, tube, and flap before mounting — replace if damaged, badly worn or defective.
6. Insert lubricated tube and flap in tire.
7. Lubricate the tire beads and rim, then mount tire, tube and flap assembly onto rim. Do not use any lubricant which contains water or a solvent which can injure rubber.
8. Select the proper rim components and assemble to rim (see 6-3, page 41). Discard bent, damaged or corroded side and lock rings. Do not use any side or lock ring which is not clearly identifiable.

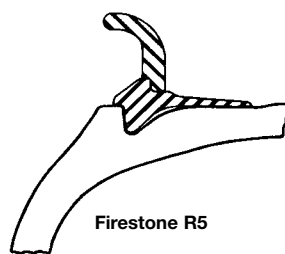


WARNING

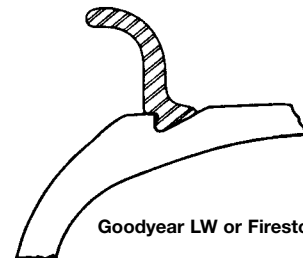
WARNING Use of a Firestone 5° side and lock ring assembly with a wheel machined for Firestone DT or Goodyear LW split side ring and vice versa can lead to explosive separation of wheel and tire.

An explosive separation of miss-matched wheel components can lead to injury or death.

Alcoa Aluminum Disc Wheels are available to accept (1) Firestone 5° side and lock rings or (2) Goodyear LW and Firestone DT split side rings. Select the proper side and lock rings by referring to the Multipiece Rim/Wheel Matching Chart on page 39 of this manual.

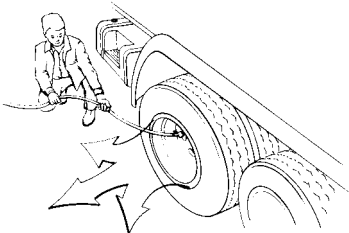


Firestone R5



Goodyear LW or Firestone DT

Always use the proper side and lock ring assembly or split side rings required for each particular wheel.



9. Do not overinflate. Use the tire manufacturer's recommended pressure, but under no circumstances exceed cold tire pressures listed in **Section 1 Specifications** of this manual (see page 2).

10. When inflating a tire in an inflation cage or while mounted on a vehicle, always use a clip-on air chuck and a remote valve with pressure gauge. During inflation or handling an inflated wheel and tire assembly, stay out of the path of potential exploding parts or air blasts.

Mounting of tubed tires

6-3

When mounting Alcoa flat base wheels for tube-type tires you must use the proper side ring or side and lock ring required for each wheel. The table below lists the Alcoa tube-type wheels currently in production and the proper side ring or side and lock ring identification recommended for each wheel. See the Multipiece Rim Matching Chart on page 39 for information on older wheels with part numbers not shown here.

Alcoa Flat Base Wheels for Tube-type Tires That Use Goodyear LW or Firestone DT Split Side Rings Only (2 Piece Assemblies)		
Wheel Size	Alcoa Part Number Identification Stamping	Side Ring Identification Stamping
22x8.00 LW	481010	R8022LW recommended or: R22X7.5-8.0-9.0LB-LW 22X7.5-8.0DT-LB-LW (3)
22x7.50 LW	471010	R8022LW recommended or: R22X7.5-8.0-9.0LB-LW 22X7.5-8.0DT-LB-LW (3)

Current Alcoa part numbers (i.e., 481010) end in 0-1-2 or 3, indicating a finish condition which does not affect the compatibility of parts as shown in the table.



1
Lubricate tube, flap and wheel. Insert tube and flap into tire. Place them on the wheel so that the valve is aligned with the valve slot.

Place side ring on wheel and tire and stand on the ring to position it below the lock ring groove. If a split side ring is required, start the leading edge and walk the side ring onto the wheel



2
If the wheel requires a lock ring, start the leading edge of the lock ring being sure that it is seating in the machined groove. Then walk the lock ring onto the wheel, as illustrated



3
Seat the second end of the split side ring or lock ring with a rubber, plastic or leather-facet mallet as shown. Check carefully to see that the split side ring or side ring and lock ring assembly is in the proper position. If not, completely remove the components and start over.



4
Inflate to 10 psi. Check to see that all components are properly in place. If not, deflate the tire by removing the valve core and reposition components properly. Place in a safety cage or other suitable restraining device (refer to OSHA rule 1910.177, paragraph B, see Section 7, page 44). Use clip-on chuck and stand behind barrier during inflation. Do not lean on cage. Inflate to recommended pressure. Deflate completely to avoid localized over-stretching of the tube. Reinflate to the tire manufacturer's recommended pressure.

Demounting recommendations for tubed tires

6-4



WARNING

WARNING An inflated tire contains air under pressure which can be a dangerous explosive force.

Explosive separation of a tire and wheel can cause serious injury or death.

Follow proper service procedures to avoid injury or death.



WARNING

WARNING An aluminum wheel can be structurally weakened by uncontrolled excessive heat.

Tire/wheel assemblies using wheels that have been exposed to excessive heat may experience a sudden and unpredictable tire/wheel separation causing serious injury or death.

Immediately and permanently remove any wheel from service that has been subjected to uncontrolled excessive heat (such as a tire fire, wheel bearing failure or braking system drag/seize) or a high pressure tire/wheel separation.

1. Before removing wheel from vehicle, remove the valve core from the valve stem to ensure complete deflation of tire.
2. Do not gouge or nick the wheel. Place aluminum wheels on a clean wooden floor or rubber mat.
3. Always use a rubber, leather-faced or plastic mallet.
4. Keep tire tools smooth. Use them with care. Rim gouges or nicks near the fixed flange can cause cracks.
5. Remove steel side rings carefully. If bead is well-loosened, rings can be removed without gouging the wheel.
6. Discard bent, damaged or corroded side and lock rings. Using bent, damaged or corroded rings can shorten service life of wheel and introduce the danger of an explosive separation.

Demounting of tubed tires

6-5

NOTICE: Tire must be completely deflated and valve core removed before demounting.



If manually breaking the tire beads from the wheel, it is important to use the proper tools. Tire tools may be inserted next to the tire side wall and the side ring or locking ring. Tools must be smooth and used with care if gouging the rim is to be avoided. A stop, welded to the tool, is recommended.



Once the tool is inserted, pry down and out as illustrated. Leaving one tool in position, work the other around the tire until the bead is completely free.



Insert the tapered end of the tire tool into the notch on the locking ring. Pry up carefully to avoid bending the ring and gouging the wheel.



Using the same procedures as outlined in Step 1, loosen the bead on the opposite side of the wheel. Do not drive tools into rim area. Lift wheel from tire.

7 OSHA Regulations

OSHA Regulations

7-1

Sec. 1910.177 Servicing multi-piece and single piece rim wheels.

(a) Scope

- (1) This section applies to the servicing of multi-piece and single piece rim wheels used on large vehicles such as trucks, tractors, trailers, buses and off-road machines. It does not apply to the servicing of rim wheels used on automobiles, or on pickup trucks and vans utilizing automobile tires or truck tires designated "LT".
- (2) This section does not apply to employers and places of employment regulated under the Construction Safety Standards, 29 CFR part 1926; the Agriculture Standards, 29 CFR part 1928; the Shipyard Standards, 29 CFR part 1915; or the Longshoring Standards, 29 CFR part 1918.
- (3) All provisions of this section apply to the servicing of both single piece rim wheels and multi-piece rim wheels unless designated otherwise.

(b) Definitions

Barrier means a fence, wall or other structure or object placed between a single piece rim wheel and an employee during tire inflation, to contain the rim wheel components in the event of the sudden release of the contained air of the single piece rim wheel.

Charts means the U.S. Department of Labor, Occupational Safety and Health Administration publications entitled "Demounting and Mounting Procedures for Truck/Bus Tires" and "Multi-piece Rim Matching Chart," the National Highway Traffic Safety Administration (NHTSA) publications entitled "Demounting and Mounting Procedures Truck/Bus Tires" and "Multi-piece Rim Matching Chart," or any other poster which contains at least the same instructions, safety precautions and other information contained in the charts that is applicable to the types of wheels being serviced.

Installing a rim wheel means the transfer and attachment of an assembled rim wheel onto a vehicle axle hub. Removing means the opposite of installing.

Mounting a tire means the assembly or putting together of the wheel and tire components to form a rim wheel, including inflation. **Demounting means the opposite of mounting.**

Multi-piece rim wheel means the assemblage of a multi-piece wheel with the tire tube and other components.

Multi-piece wheel means a vehicle wheel consisting of two or more parts, one of which is a side or locking ring designed to hold the tire on the wheel by interlocking components when the tire is inflated.

Restraining device means an apparatus such as a cage, rack, assemblage of bars and other components that will constrain all rim wheel components during an explosive separation of a multi-piece rim wheel, or during the sudden release of the contained air of a single piece rim wheel.

Rim manual means a publication containing instructions from the manufacturer or other qualified organization for correct mounting, demounting, maintenance, and safety precautions peculiar to the type of wheel being serviced.

Rim wheel means an assemblage of tire, tube and liner (where appropriate), and wheel components.

Service or servicing means the mounting and demounting of rim wheels, and related activities such as inflating, deflating, installing, removing, and handling.

Service area means that part of an employer's premises used for the servicing of rim wheels, or any other place where an employee services rim wheels.

OSHA Regulations (continued)

Single piece rim wheel means the assemblage of single piece rim wheel with the tire and other components.

Single piece wheel means a vehicle wheel consisting of one part, designed to hold the tire on the wheel when the tire is inflated.

Trajectory means any potential path or route that a rim wheel component may travel during an explosive separation, or the sudden release of the pressurized air, or an area at which an airblast from a single piece rim wheel may be released. The trajectory may deviate from paths which are perpendicular to the assembled position of the rim wheel at the time of separation or explosion. (See appendix A for examples of trajectories.)

Wheel means that portion of a rim wheel which provides the method of attachment of the assembly to the axle of a vehicle and also provides the means to contain the inflated portion of the assembly (i.e., the tire and/or tube).

(c) Employee Training

- (1) The employer shall provide a program to train all employees who service rim wheels in the hazards involved in servicing those rim wheels and the safety procedures to be followed.
 - (i) The employer shall assure that no employee services any rim wheel unless the employee has been trained and instructed in correct procedures of servicing the type of wheel being serviced, and in the safe operating procedures described in paragraphs (f) and (g) of this section.
 - (ii) Information to be used in the training program shall include, at a minimum, the applicable data contained in the charts (rim manuals) and the contents of this standard.
 - (iii) Where an employer knows or has reason to believe that any of his employees is unable to read and understand the charts or rim manual, the employer shall assure that the employee is instructed concerning the contents of the charts and rim manual in a manner which the employee is able to understand.
- (2) The employer shall assure that each employee demonstrates and maintains the ability to service rim wheels safely, including performance of the following tasks:
 - (i) Demounting of tires (including deflation);
 - (ii) Inspection and identification of the rim wheel components;
 - (iii) Mounting of tires (including inflation with a restraining device or other safeguard required by this section);
 - (iv) Use of the restraining device or barrier, and other equipment required by this section;
 - (v) Handling of rim wheels;
 - (vi) Inflation of the tire when a single piece rim wheel is mounted on a vehicle;
 - (vii) An understanding of the necessity of standing outside the trajectory both during inflation of the tire and during inspection of the rim wheel following inflation; and
 - (viii) Installation and removal of rim wheels.
- (3) The employer shall evaluate each employee's ability to perform these tasks and to service rim wheels safely, and shall provide additional training as necessary to assure that each employee maintains his or her proficiency.

(d) Tire servicing equipment.

- (1) The employer shall furnish a restraining device for inflating tires on multi-piece wheels.
- (2) The employer shall provide a restraining device or barrier for inflating tires on single piece wheels unless the rim wheel will be bolted onto a vehicle during inflation.
- (3) Restraining devices and barriers shall comply with the following requirements:

OSHA Regulations (continued)

- (i) Each restraining device or barrier shall have the capacity to withstand the maximum force that would be transferred to it during a rim wheel separation occurring at 150 percent of the maximum tire specification pressure for the type of rim wheel being serviced.
 - (ii) Restraining devices and barriers shall be capable of preventing the rim wheel components from being thrown outside or beyond the device or barrier for any rim wheel positioned within or behind the device;
 - (iii) Restraining devices and barriers shall be visually inspected prior to each day's use and after any separation of the rim wheel components or sudden release of contained air. Any restraining device or barrier exhibiting damage such as the following defects shall be immediately removed from service:
 - (A) Cracks at welds;
 - (B) Cracked or broken components;
 - (C) Bent or sprung components caused by mishandling, abuse, tire explosion or rim wheel separation;
 - (D) Pitting of components due to corrosion; or
 - (E) Other structural damage which would decrease its effectiveness.
 - (iv) Restraining devices or barriers removed from service shall not be returned to service until they are repaired and reinspected. Restraining devices or barriers requiring structural repair such as component replacement or rewelding shall not be returned to service until they are certified by either the manufacturer or a Registered Professional Engineer as meeting the strength requirements of paragraph (d)(3)(i) of this section.
- (4) The employer shall furnish and assure that an air line assembly consisting of the following components be used for inflating tires:
 - (i) A clip-on chuck;
 - (ii) An in-line valve with a pressure gauge or a presettable regulator; and
 - (iii) A sufficient length of hose between the clip-on chuck and the in-line valve (if one is used) to allow the employee to stand outside the trajectory.
 - (5) Current charts or rim manuals containing instructions for the type of wheels being serviced shall be available in the service area.
 - (6) The employer shall furnish and assure that only tools recommended in the rim manual for the type of wheel being serviced are used to service rim wheels.

(e) Wheel component acceptability.

- (1) Multi-piece wheel components shall not be interchanged except as provided in the charts or in the applicable rim manual.
- (2) Multi-piece wheel components and single piece wheels shall be inspected prior to assembly. Any wheel or wheel component which is bent out of shape, pitted from corrosion, broken, or cracked shall not be used and shall be marked or tagged unserviceable and removed from the service area. Damaged or leaky valves shall be replaced.
- (3) Rim flanges, rim gutters, rings, bead seating surfaces and the bead areas of tires shall be free of any dirt, surface rust, scale or loose or flaked rubber build-up prior to mounting and inflation.
- (4) The size (bead diameter and tire/wheel widths) and type of both the tire and the wheel shall be checked for compatibility prior to assembly of the rim wheel.

(f) Safe operating procedure - multi-piece rim wheels.

The employer shall establish a safe operating procedure for servicing multi-piece rim wheels and shall assure that employees are instructed in and follow that procedure. The procedure shall include at least the following elements:

- (1) Tires shall be completely deflated before demounting by removal of the valve core.
- (2) Tires shall be completely deflated by removing the valve core before a rim wheel is removed from the axle in either of the following situations:

OSHA Regulations (continued)

- (i) When the tire has been driven underinflated at 80% or less of its recommended pressure, or
 - (ii) When there is obvious or suspected damage to the tire or wheel components.
- (3) Rubber lubricant shall be applied to bead and rim mating surfaces during assembly of the wheel and inflation of the tire, unless the tire or wheel manufacturer recommends against it.
 - (4) If a tire on a vehicle is underinflated but has more than 80% of the recommended pressure, the tire may be inflated while the rim wheel is on the vehicle provided remote control inflation equipment is used, and no employees remain in the trajectory during inflation.
 - (5) Tires shall be inflated outside a restraining device only to a pressure sufficient to force the tire bead onto the rim ledge and create an airtight seal with the tire and bead.
 - (6) Whenever a rim wheel is in a restraining device the employee shall not rest or lean any part of his body or equipment on or against the restraining device.
 - (7) After tire inflation, the tire and wheel components shall be inspected while still within the restraining device to make sure that they are properly seated and locked. If further adjustment to the tire or wheel components is necessary, the tire shall be deflated by removal of the valve core before the adjustment is made.
 - (8) No attempt shall be made to correct the seating of side and lock rings by hammering, striking or forcing the components while the tire is pressurized.
 - (9) Cracked, broken, bent or otherwise damaged rim components shall not be reworked, welded, brazed, or otherwise heated.
 - (10) Whenever multi-piece rim wheels are being handled, employees shall stay out of the trajectory unless the employer can demonstrate that performance of the servicing makes the employee's presence in the trajectory necessary.
 - (11) No heat shall be applied to a multi-piece wheel or wheel component.

(f) Safe operating procedure - single piece rim wheels.

The employer shall establish a safe operating procedure for servicing single piece rim wheels and shall assure that employees are instructed in and follow that procedure. The procedure shall include at least the following elements:

- (1) Tires shall be completely deflated by removal of the valve core before demounting.
- (2) Mounting and demounting of the tire shall be done only from the narrow ledge side of the wheel. Care shall be taken to avoid damaging the tire beads while mounting tires on wheels. Tires shall be mounted only on compatible wheels of matching bead diameter and width.
- (3) Nonflammable rubber lubricant shall be applied to bead and wheel mating surfaces before assembly of the rim wheel, unless the tire or wheel manufacturer recommends against the use of any rubber lubricant.
- (4) If a tire changing machine is used, the tire shall be inflated only to the minimum pressure necessary to force the tire bead onto the rim ledge while on the tire changing machine.
- (5) If a bead expander is used, it shall be removed before the valve core is installed and as soon as the rim wheel becomes airtight (the tire bead slips onto the bead seat).
- (6) Tires may be inflated only when contained within a restraining device, positioned behind a barrier or bolted on the vehicle with the lug nuts fully tightened.
- (7) Tires shall not be inflated when any flat, solid surface is in the trajectory and within one foot of the sidewall.
- (8) Employees shall stay out of the trajectory when inflating a tire.
- (9) Tires shall not be inflated to more than the inflation pressure stamped in the sidewall unless a higher pressure is recommended by the manufacturer.

**OSHA
Regulations
(continued)**

- (10) Tires shall not be inflated above the maximum pressure recommended by the manufacturer to seat the tire bead firmly against the rim flange.
- (11) No heat shall be applied to a single piece wheel.
- (12) Cracked, broken, bent, or otherwise damaged wheels shall not be reworked, welded, brazed, or otherwise heated.

[GRAPHIC] [TIFF OMITTED] TC27OC91.036

Appendix B - Ordering Information for NHTSA Charts

OSHA has printed two charts entitled "Demounting and Mounting Procedures for Truck/Bus Tires" and "Multi-piece Rim Matching Chart," as part of a continuing campaign to reduce accidents among employees who service large vehicle rim wheels.

Reprints of the charts are available through the Occupational Safety and Health Administration (OSHA) Area and Regional Offices. The address and telephone number of the nearest OSHA office can be obtained by looking in the local telephone directory under U.S. Government, U.S. Department of Labor, Occupational Safety and Health Administration.

Single copies are available without charge.

Individuals, establishments and other organizations desiring single or multiple copies of these charts may order them from the OSHA Publications Office, U.S. Department of Labor, Room N-3101, Washington, DC 20210, Telephone (202) 219-4667.

[49 FR 4350, Feb. 3, 1984, as amended at 52 FR 36026, Sept. 25, 1987; 53 FR 34737, Sept. 8, 1988; 61 FR 9239, Mar. 7, 1996]

8

Glossary of Common Terms

Glossary of Common Terms

8-1

1/2 DUAL SPACING - One half the distance between the two center lines of dual wheels. The dimension is the same as the OUTSET dimension.

2-PIECE FLANGE NUT - A two-piece washer and nut combination used to secure hub piloted wheels.

AIR CHAMBER - The space enclosed by a tire and wheel rim or inner tube.

BEAD SEAT - The area along the outer edges of the rim where the mounted tire and rim are in contact.

BOLT CIRCLE - The circle defined by the centers of the bolt holes (stud holes) of a wheel, dimensions stated in diameter inches or millimeters.

BOLT HOLE - Hole found in the disc of the wheel through which the bolt (stud) passes.

BORE - See "HUB BORE."

CENTER BORE - See "HUB BORE."

CONE LOCK CAP NUT - See "2-PIECE FLANGE NUT."

DC - Abbreviation for drop center.

DISC AREA - The vertical wheel face which supports the rim.

DISC WHEEL - A one-piece (forged) or two-piece (welded) assembly of a disc and a rim.

DROP CENTER - The well or center portion of the wheel rim.

FLAT BASE WHEEL - A multi-piece wheel with a removable side ring.

FOOT-POUNDS - The measure of the amount of torque applied to a cap nut or other part. May be measured with a torque wrench.

GUTTER FLANGE - A groove which supports the removable portion of a multi-piece wheel.

HUB BORE - The center hole of a disc wheel, dimensions stated in diameter inches or millimeters.

HUB PILOTED MOUNTING - A wheel mounting system which uses the hub to center the wheel and two-piece flange nuts to secure it.

in. - Abbreviation for inches.

INNER CAP NUT - Cap nut used to mount the inner wheel in a dual stud located wheel system.

INSET - The distance from the wheel mounting surface to the rim centerline when the centerline is placed inboard of the mounting surface.

kg - Abbreviation for kilogram (weight measurement), equal to 1000 grams.

kPa - Abbreviation for kilo Pascals (pressure measurement).

Glossary of Common Terms (continued)

LOCK RING - The third piece of a three rim assembly which positions and supports the side ring to the rim base.

MAXIMUM INFLATION - The highest amount of air pressure allowed, measured at normal ambient temperatures.

mm - Abbreviation for millimeters.

MULTI-PIECE WHEEL - A wheel assembly in which the rim portion of the wheel consists of two or more separate parts.

OFFSET - See "OUTSET."

OPEN SIDE - The side of the wheel opposite the disc face.

OSHA - Abbreviation for the U.S. Department of Labor, Occupational Health and Safety Administration.

OUTER CAP NUT - A cap nut used to secure the outer stud located wheel in a dual wheel pair and thread onto the inner cap nut.

OUTSET - The distance from the mounting surface of the wheel to the rim centerline when the rim centerline is mounted outboard of the hub face. This dimension is the same as the 1/2 DUAL SPACING dimension.

PILOT PAD - The raised surfaces on a hub used to center a hub piloted wheel.

PSI - Abbreviation for pounds per square inch.

REVERSIBLE - Term applied to a disc wheel which can be reversed on the hub without changing the position of the tire centerline.

RIM CENTERLINE - A line to the radial axis of the wheel running through the mid point between the rim flanges.

RIM FLANGE - That portion of the rim which extends above the rim surface which retains the tire bead.

RIM - That portion of the wheel which supports the tire.

SIDE RING - A removable piece of a multi-piece wheel assembly which provides lateral support for one tire bead.

SINGLE CAP NUT - A cap nut used to secure single wheels or outer dual wheels.

STUD - A threaded bolt extending from the hub surface to which the wheels are secured by the cap nuts.

STUD LOCATED, BALL SEAT MOUNTING - A wheel mounting system which uses the studs and spherical ball seat cap nuts to center and secure the wheel.

TIRE BEAD - That surface of the tire which contacts the angled surface of the wheel rim.

TORQUE - The amount of force used to tighten cap nuts. Usually stated in foot-pounds or kilograms and measured with a torque wrench.

WHEEL MOUNTING FACE - That portion of the wheel face which contacts the hub or brake drum.

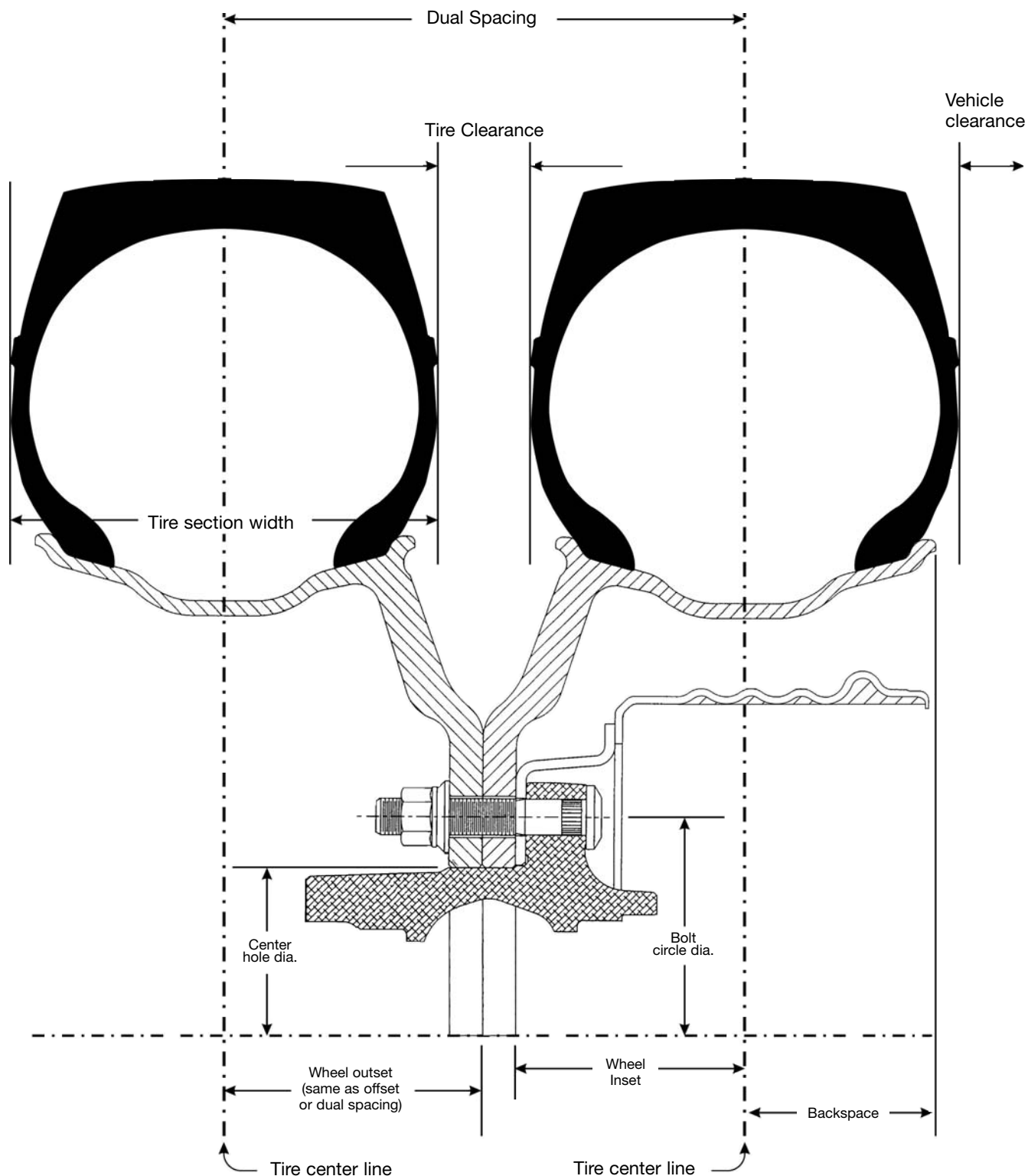
wt. - Abbreviation for weight.

Wheel measurement

8-2

How to measure minimum dual spacing

Minimum dual spacing measurement is determined by the tire manufacturer and may be obtained from the tire manufacturer's handbook. To determine if the Alcoa aluminum dual wheel assembly has adequate minimum dual spacing for the selected tires, double the wheel outset measurement of the Alcoa wheel used. If the doubled outset measurement is equal to or greater than the tire manufacturer's recommendation, there will be sufficient minimum dual spacing. Wheel inset and outset is given for each Alcoa wheel on pages 2 and 3. Both inset and outset wheels are measured from the mounting surface of the wheel to the center line of the rim. Maintaining proper tire inflation and load ratings are essential to maintaining proper minimum dual spacing.



9 Conversion Tables

Inch
Fraction,
Decimal and
Millimeter
Equivalents
Chart
(Up to 1
inch)

9-1

Inches	Decimals	Millimeters
1/64	0.0156	0.3969
1/32	0.0313	0.7938
3/64	0.0469	01.1906
1/16	0.0625	1.5875
5/64	0.0781	1.9844
3/32	0.0938	2.3813
7/64	0.1094	2.7781
1/8	0.1250	3.1750
9/64	0.1406	3.5719
5/32	0.1563	3.9688
11/64	0.1719	4.3656
3/16	0.1875	4.7625
13/64	0.2031	5.1594
7/32	0.2188	5.5563
15/64	0.2344	5.9531
1/4	0.2500	6.3500
17/64	0.2656	6.7469
9/32	0.2813	7.1438
19/64	0.2969	7.5406
5/16	0.3125	7.9375
21/64	0.3281	8.3344
11/32	0.3438	8.7313
23/64	0.3594	9.1281
3/8	0.3750	9.5250
25/64	0.3906	9.9219
13/32	0.4063	10.3188
27/64	0.4219	10.7156
7/16	0.4375	11.1125
29/64	0.4531	11.5094
15/32	0.4688	11.9063
31/64	0.4844	12.3031
1/2	0.5000	12.7000

Inches	Decimals	Millimeters
33/64	0.5156	13.0969
17/32	0.5313	13.4938
35/64	0.5469	13.8906
9/16	0.5625	14.2875
37/64	0.5781	14.6844
19/32	0.5938	15.0813
39/64	0.6094	15.4781
5/8	0.6250	15.8750
41/64	0.6406	16.2719
21/32	0.6563	16.6688
43/64	0.6719	17.0656
11/16	0.6875	17.4625
45/64	0.7031	17.8594
23/32	0.7188	18.2563
47/64	0.7344	18.6531
3/4	0.7500	19.0500
49/64	0.7656	19.4469
25/32	0.7813	19.8438
51/64	0.7969	20.2406
13/16	0.8125	20.6375
53/64	0.8281	21.0344
27/32	0.8438	21.4313
55/64	0.8594	21.8281
7/8	0.8750	22.2250
57/64	0.8906	22.6219
29/32	0.9063	23.0188
59/64	0.9219	23.4156
15/16	0.9375	23.8125
61/64	0.9531	24.2094
31/32	0.9688	24.6063
63/64	0.9844	25.0031
1	1.000	25.4000

Conversion Factors

9-2

Inches to Millimeters

$$\text{Inches} \times 25.4 = \text{Millimeters}$$

Millimeters to Inches

$$\text{Millimeters} \times 0.03937 = \text{Inches}$$

PSI to kPa

$$\text{PSI} \times 6.8948 = \text{kPa}$$

kPa to PSI

$$\text{kPa} \times 0.145 = \text{PSI}$$

Pounds to Kilograms

$$\text{Pounds} \times 0.4536 = \text{kg}$$

Kilograms to Pounds

$$\text{kg} \times 2.2050 = \text{Pounds}$$

Foot-pounds to Kilogram Meters

$$\text{Ft-lbs} \times 0.13826 = \text{kgm}$$

Kilogram Meters to Foot-pounds

$$\text{kgm} \times 7.23 = \text{Ft-lbs}$$

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1. STEERING SYSTEM

1.1 I-BEAM AXLE STEERING SYSTEM DESCRIPTION

The steering system consists of the steering wheel and column assembly, a vane-type hydraulic pump, reservoir, filter, interconnecting system lines and hoses, integral power steering gear, linkage and steering damper (Fig. 1). The steering linkage includes the pitman arm, drag link, steering arm, tie rod arms and tie rod.

Hydraulic components are added to transmit, increase and regulate steering control forces.

These elements are:

1. Steering stabilizer (damper);
2. A vane type hydraulic pump; and
3. Hydraulic reservoir and hoses.

The steering stabilizer reduces road shocks and vibrations in the system. The steering gearbox is self powered and provides movement with power assistance to the left wheel.

Steering stability and tire wear are influenced by wheels, hubs, tires, air suspension, brakes, front suspension and front end alignment which are all covered in their respective sections in this manual.

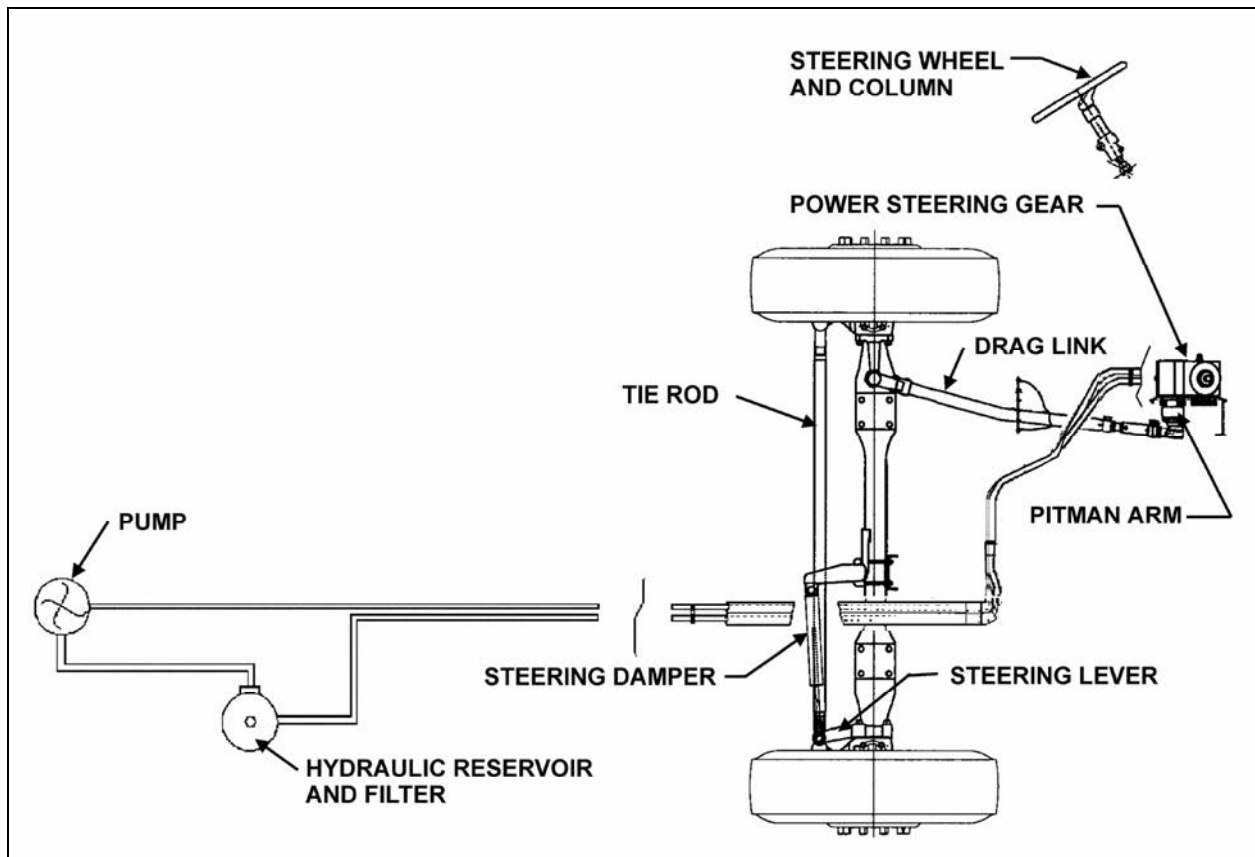


FIGURE 1: I-BEAM AXLE STEERING SYSTEM SETUP

14041

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1.2 INDEPENDENT FRONT SUSPENSION STEERING SYSTEM DESCRIPTION

The steering system consists of the steering wheel and column assembly, a vane-type hydraulic pump, reservoir, filter, interconnecting system lines and hoses, integral power steering gear and linkage (Fig. 2). The steering linkage consists of tie rods connected to the bell crank and the steering arm at the left side of the coach, and to the idler arm and steering arm at the right side of the coach. The bell crank and idler arm are connected by a relay rod. A drag link connected to the bell crank and the pitman arm, which is mounted to the steering gear, transfers the turning motion of the steering wheel to the steering arms.

Hydraulic components are added to transmit, increase and regulate steering control forces.

These elements are:

1. A vane type hydraulic pump; and
2. Hydraulic reservoir and hoses.

The steering gearbox is self powered and provides movement with power assistance to the left wheel.

Steering stability and tire wear are influenced by wheels, hubs, tires, air suspension, brakes, front suspension and front end alignment which are all covered in their respective sections in this manual.

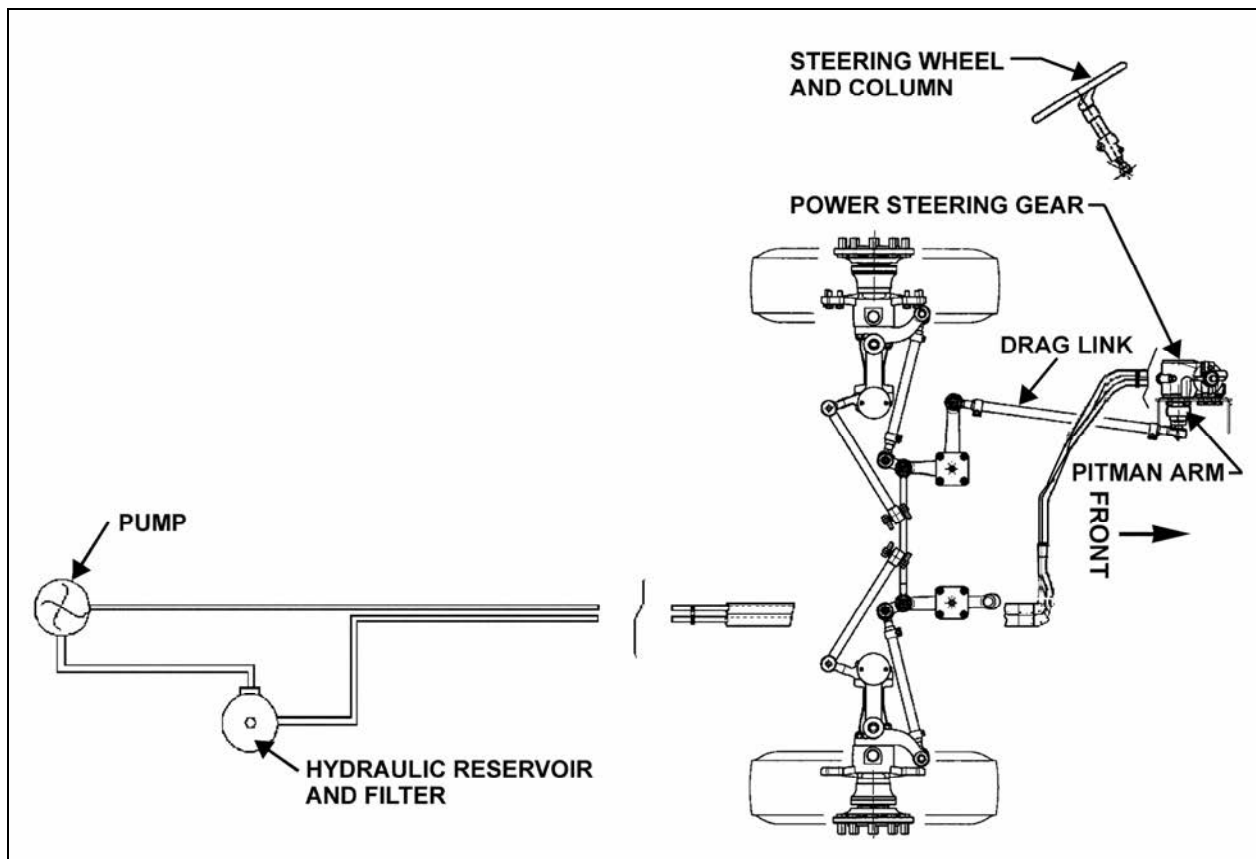


FIGURE 2: IFS STEERING SYSTEM SETUP

14060

2. POWER STEERING GEAR

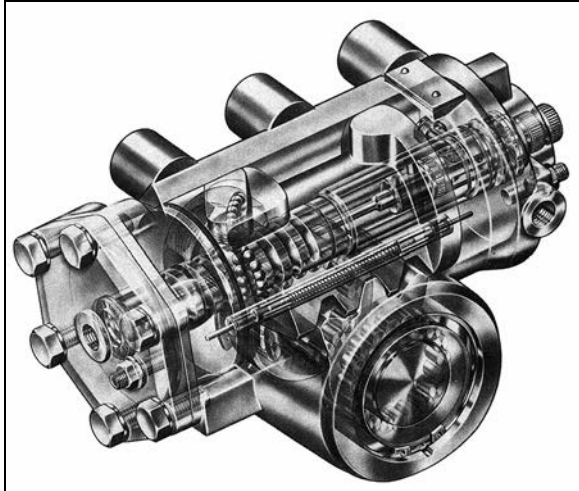


FIGURE 3: POWER STEERING GEAR 14035

2.1 DESCRIPTION

The power steering gear is located in the lower part of front service compartment (Figs. 3 & 4). The housing of the ZF-Servocom contains a control valve, working cylinder and a complete mechanical steering gear. The pressure oil for the steering is delivered by a motor-driven oil pump which is supplied with oil from an oil tank.

The housing is designed as a cylinder for the piston, which converts the rotation of the steering shaft and the worm into an axial movement and transfers this to the steering worm sector shaft. The serration of the sector shaft is straight-cut with a high surface quality in such a way that it is only possible to set a unique setting without play on installation in the straight-ahead driving area by means of the two eccentrically designed lateral housing covers.

The piston and worm are connected via a ball chain. When the worm is turned, the balls are collected by a circulating pipe at one end of the chain and fed in again at the other end, thus producing an endless ball chain.

The control valve consists of the valve slide in a needle bearing in the worm, with six control grooves on the circumference and the control sleeve on the worm, which also has six control grooves. The valve slide, designed with steering shaft connection, turns together with the worm as the steering wheel is turned.

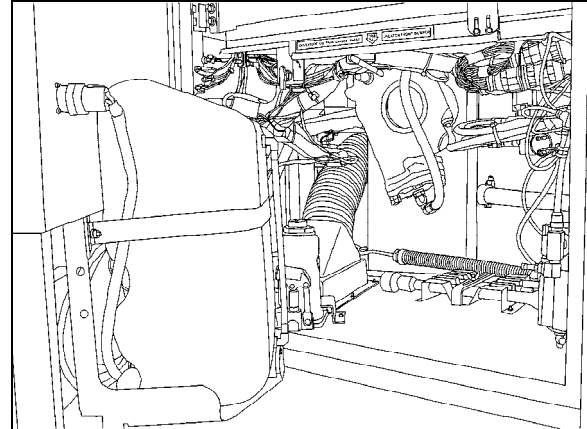


FIGURE 4: FRONT SERVICE COMPARTMENT 18611

A torsion bar, which is pinned with the valve slide and the worm, keeps the control valve in the neutral position as long as no opposing force is applied to the steering wheel. The steering housing contains a pressure relief valve, which limits the discharge pressure of the oil pump to the maximum value required. A replenishing valve can also be used, through which oil is sucked from the return if steering is not hydraulically boosted.

Compared with constant ratio, steering versions with variable ratio are more directly designed in the center area than outside the center area. The resulting smaller steering corrections benefit steering behavior in straight-ahead driving. At the same time, the indirect transmission means that there is a higher hydraulic torque available at the steering arm in parking movement. If the hydraulic assistance fails, the operating forces on the steering wheel are correspondingly lower in this area. This is achieved through a piston/steering worm sector shaft serration with differing modulus and angle of pressure.

Upon transfer of a torque from the steering shaft to the worm, or vice versa, the torsion bar is deformed in the elastic area so that there is torsion between the valve slide and the control sleeve. When the steering wheel is released, the torsion bar ensures that the valve is returned to the neutral position.

Refer to the "ZF-SERVOCOM Repair Manual" and "ZF-SERVOCOM Operating, Servicing /Maintenance and Inspection Instructions" annexed to this section for the functional aspects and maintenance procedure of the steering gear.

NOTE

Also available is the ZF-Servocomtronic, which provides variable assistance in function of speed.

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2.2 POWER STEERING GEAR REMOVAL



WARNING

The steering gearbox weighs approximately 100 lbs (45 kg) dry. Exercise caution when handling.

1. Put a container into place, then disconnect both the inlet and outlet hoses from the power steering gear. Cover fittings to prevent fluid contamination.
2. Mark both the pitman arm and sector shaft with a line, then remove pitman arm. Refer to "11.1 Pitman Arm Removal" procedure.
3. Mark both the steering shaft universal joint yoke and steering gear input shaft with a line, then disconnect universal joint.
4. Unscrew and remove the power steering gear.

2.3 POWER STEERING GEAR INSTALLATION

Reverse "Power Steering Gear Removal" procedure paying particular attention to the following:

1. Tighten fasteners as recommended under paragraph 14: "Torque Specifications".
2. Bleed air from the system as per step 3, next.

3. BLEEDING POWER STEERING HYDRAULIC SYSTEM

To bleed the power steering hydraulic system, refer to the "ZF-SERVOCOM Repair Manual" annexed to this section, under heading "Setting And Functional Test".

4. HYDRAULIC PRESSURE TEST

Perform a pressure test as outlined in the "ZF-SERVOCOM Repair Manual" annexed to this section under heading "Setting And Functional Test".

5. TROUBLESHOOTING

Perform troubleshooting of the steering gear as outlined in the "ZF-SERVOCOM Repair Manual", the "ZF-SERVOCOM Operating, Servicing /Maintenance and Inspection Instructions and the "TRW - Power Steering Pump Service Manual".

NOTE

For vehicles equipped with ZF-SERVOCOMTRONIC unit, refer to the supplement to the repair manual ZF-SERVOCOM.

6. POWER STEERING HYDRAULIC PUMP

6.1 WITH DDC SERIES 60 ENGINE

6.1.1 Description

The TRW PS Series power steering pump is a vane type, gear driven, hydraulic unit which supplies hydraulic pressure for the operation of the steering gear. The pump is mounted on the engine, on the crankshaft pulley's R.H. side.

6.1.2 Removal And Installation

The pump is accessible through the engine compartment rear door.

To remove the pump, proceed as follows:

1. Put an empty container directly below pump, then disconnect both the inlet and outlet hoses from the pump. Block fitting cavities to prevent fluid contamination.
2. Remove the two (2) mounting screws, then slowly pry out the pump.
3. Remove and discard gasket.



CAUTION

Inspect the drive coupling thoroughly, and replace if necessary (the drive coupling is a fiber component located between the engine and the pump).

For pump installation, reverse the removal procedure paying particular attention to the following:



CAUTION

Ensure that drive coupling is correctly positioned before reinstalling the pump.

1. Install a new gasket (Prévost P/N 510488).
2. Bleed air from the system as per step 3, "Bleeding Power Steering Hydraulic System".

6.1.3 Maintenance

Refer to the "ZF-SERVOCOM Repair Manual" and the "TRW - Power Steering Pump Service Manual" annexed to this section.

6.2 WITH VOLVO D13 ENGINE

6.2.1 Description

The power steering pump is a gear driven hydraulic unit which supplies hydraulic pressure for the operation of the steering gear. The pump is mounted on the engine, at the flywheel end and is also used for driving the fuel pump.

6.2.2 Removal And Installation

The pump is accessible through the engine compartment R.H. access door.

To remove the pump, proceed as follows:

- You must first remove the fuel feed pump.
- Clean around the fuel pump and fuel lines. Position a container to catch any fuel that might drain from the pump or lines.
- Remove the fuel pump.

NOTE
Only unfasten the bolts marked with arrows.

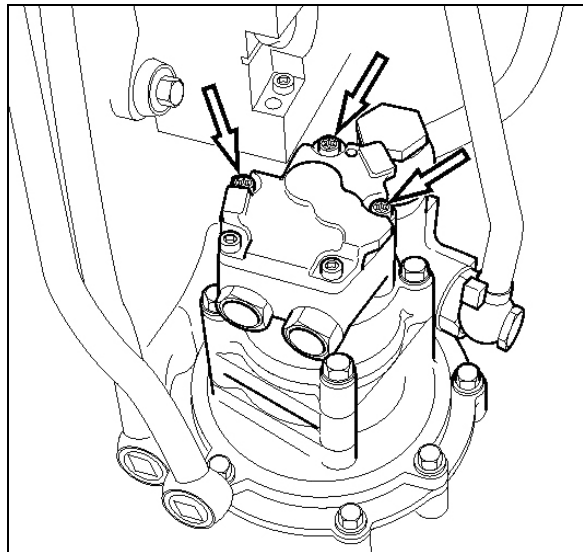


FIGURE 5: FUEL PUMP REMOVAL

CAUTION
Ensure to clean around the head of the bolts. Debris will prevent the tool from fitting properly and cause damage to the fasteners.

- Check that the adapter and fuel pump drive axle are not damaged.

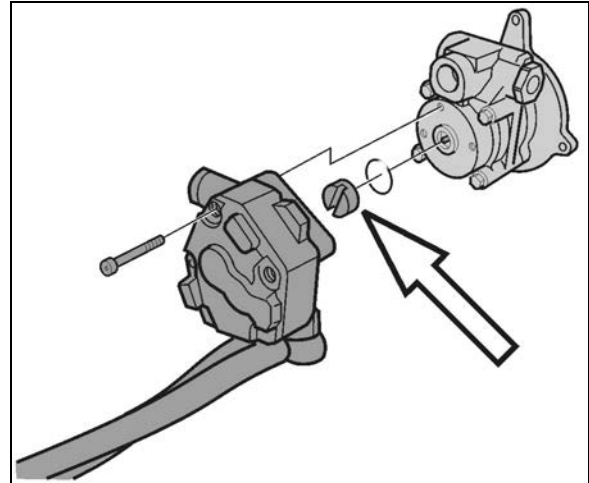


FIGURE 6: FUEL PUMP DRIVE AXLE

- Set the fuel pump aside.
- Clean around the power steering pump and loosen the steering lines. Position a container to catch any hydraulic fluid that might drain from the pump or lines.
- Unfasten the power steering pump bolts.

NOTE
Only unfasten the bolts marked with arrows.

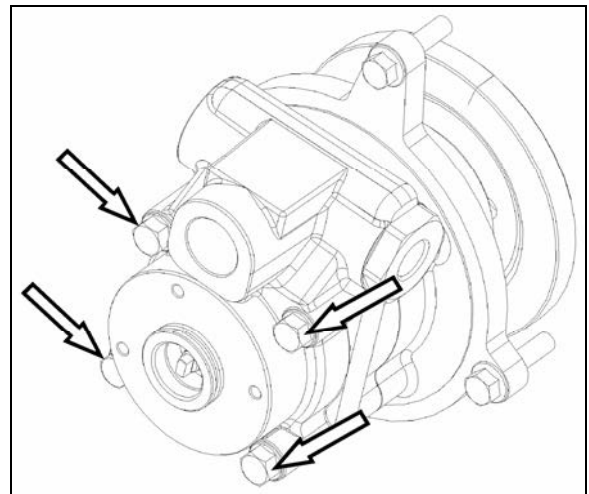


FIGURE 7: POWER STEERING PUMP REMOVAL

- Install the new power steering pump. Torque-tighten bolts to specification.

NOTE
Use a new gasket.

Section 14: STEERING

- Connect the hydraulic lines to the power steering pump.
- Install the fuel pump. Torque-tighten bolts to specification.

NOTE

Use a new sealing ring. Check that the fuel pump drive axle sits correctly in the power steering pump.

- Start the engine and let run for 5 minutes. Make sure that there are no leaks.

7. STEERING COLUMN

7.1 REMOVAL

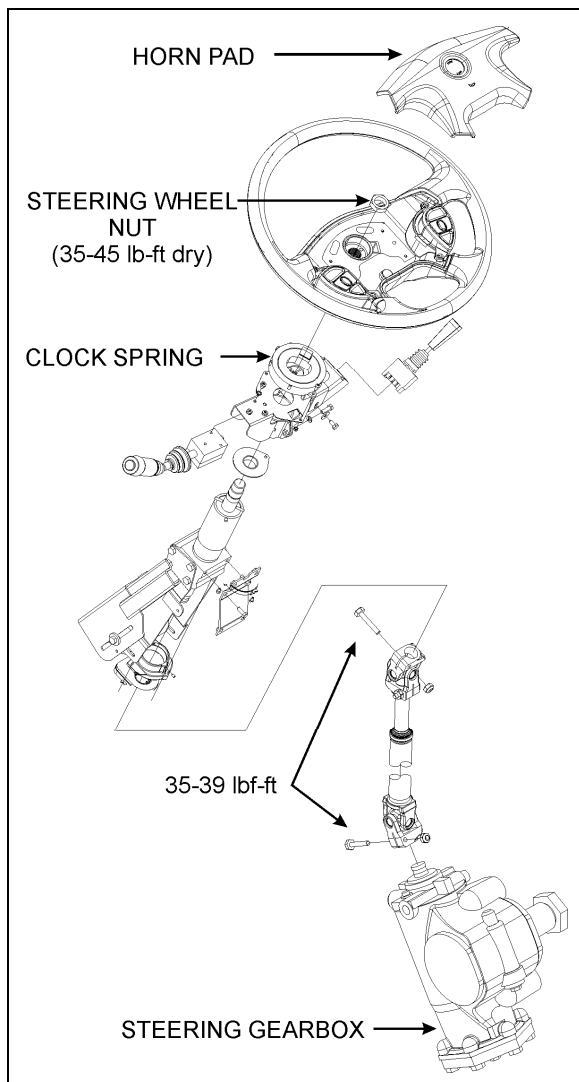


FIGURE 8: STEERING COLUMN

To disassemble the steering column from system, refer to figure 8 & 9. The steering column has no lubrication points. The lower steering column U-joint is easily accessible through the front service compartment. The upper steering column U-joint and the steering slip joint are accessible from the front driver's area. To access these joints, proceed as follows:

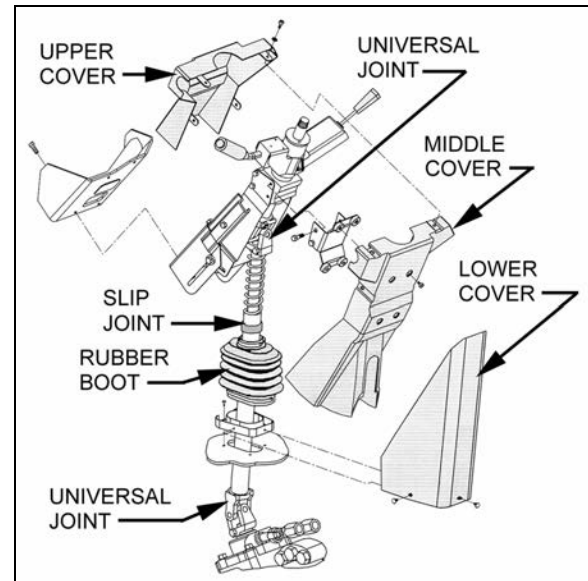


FIGURE 9: STEERING COLUMN COVERS

14040

1. From the front driver's compartment area, remove the three plastic fasteners on steering column lower cover. Remove the lower cover (Fig. 9).
2. Unscrew the four retaining screws on steering column middle cover.
3. Unscrew the four retaining screws fixing steering column upper cover to middle cover. Remove the steering column middle and upper covers.
4. Position the steering wheel in order to gain access to the joints.

8. STEERING WHEEL

8.1 REMOVAL

NOTE

Before undertaking the steering wheel removal, assure that the front wheels are pointing straight ahead, aligned with the vehicle.

1. Set the battery master switch located in the rear electrical compartment to the "OFF" position.
2. Pull the horn pad straight up gently to detach it from the steering wheel (Fig. 10).
3. Disconnect the horn wire (white) connected to the horn pad and the steering wheel harness 4-pin connector.

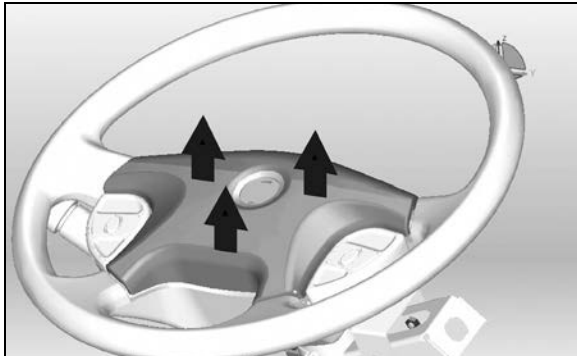


FIGURE 10: REMOVING THE HORN PAD

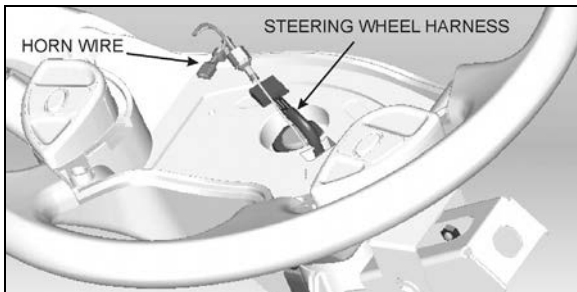


FIGURE 11: STEERING HARNESS & HORN WIRE

4. Unscrew the steering wheel nut. To simplify installation and ensure steering wheel alignment, mark the relationship of the spline shaft to the steering wheel hub (if marks don't already exist or don't line up).
5. Using an appropriate puller, separate the steering wheel from the spline shaft.
6. From behind the steering wheel, pull gently on the electrical wires passing through the rectangular opening in the steering wheel to finish removal of the steering wheel.
7. Once the steering wheel is removed, it is important to block any rotating movement of the clockspring in order to prevent it from losing its neutral position. Use two pieces of masking tape to lock it in place (Fig. 12).

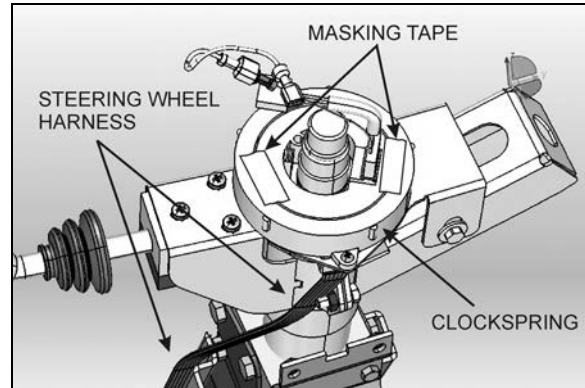


FIGURE 12: LOCKING THE CLOCKSPRING IN PLACE

NOTE

The clockspring mechanism permits a certain number of turns in each direction. At the moment of reinstalling the steering wheel, if the clockspring is not at its neutral position, the number of available turns will be reduced. That may damage the clockspring if the steering wheel is turned to its maximum amplitude.

8.2 INSTALLATION

1. Route the white horn wire and the 4-pin connector through the opening on the steering wheel.
2. Align the mark on the steering wheel hub with the mark on the spline shaft and slide the wheel onto the shaft.
3. Tighten wheel retaining nut to a torque of 35-45 lbf-ft.
4. Plug the 4-pin connector and connect the white horn wire to the center pad.
5. Reinstall the center pad and test for proper horn functioning.

8.3 CLOCKSPRING REPLACEMENT

1. Remove the steering wheel.
2. Remove the 2 clockspring mounting screws and then remove the clockspring. You will have to disconnect the clockspring harness connector located lower along the steering wheel column. If necessary, remove the steering column covers (Fig. 9).
3. Route the new clockspring harness through the opening in the clockspring support (Fig. 13). Plug the connector at the base of the

Section 14: STEERING

steering wheel column and fix harness along the steering wheel column.

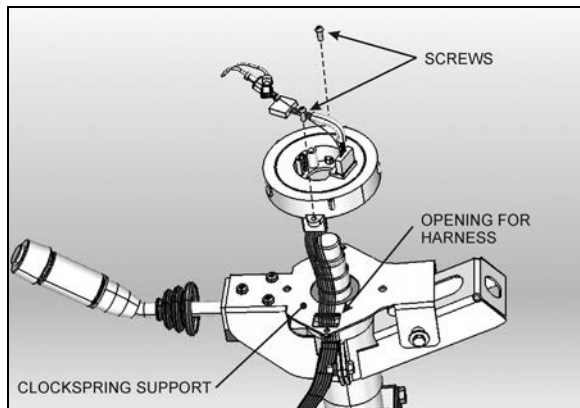


FIGURE 13: CLOCKSPRING INSTALLATION

4. Mount the clockspring in place with 2 screws.
5. Break the paper seal and rotate the center part of the clockspring about 50° clockwise (Fig. 14). This step is necessary for the installation of the steering wheel.

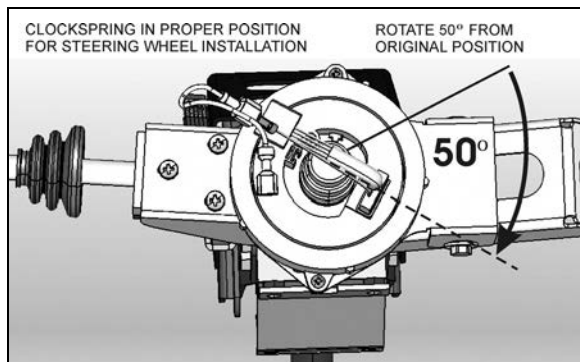


FIGURE 14: PROPER CLOCKSPRING POSITION

6. Reinstall the steering wheel.

9. TURNING ANGLE ADJUSTMENT

The maximum turning angle is set through two (2) steering stop screws installed on the axle center. Steering stop screws are factory adjusted to accommodate the chassis design, and therefore, do not require adjustment on new vehicles. However, these should be checked and adjusted if necessary, any time a steering system component is repaired, disassembled or adjusted. Refer to section 10 "Front Axle" under heading "6.4 "Turning Angle Adjustment".



CAUTION

To prevent the steering damper from interfering with the adjustment of turning angles, make sure its fixing bracket is at correct location on the axle (refer to "12.2 Steering Stabilizer Cylinder (Damper)").

Hydraulic Stop



CAUTION

Reduce or shut off the power steering hydraulic pressure before the boss on the axle touches the stop screw. If not, the components of the front axle will be damaged (refer to "ZF-SERVOCOM Repair Manual" and "ZF-SERVOCOM Operating, Servicing/Maintenance and Inspection Instructions" annexed to this section, under heading "Setting The Steering Limiter").



CAUTION

Never maintain the relief pressure for more than 5 seconds, since damage to the power steering pump may occur.

10. STEERING LINKAGE ADJUSTMENT

The steering linkage includes the pitman arm, drag link, steering arm, tie rod arms and tie rod.

Perform lubrication according to "DANA SPICER NDS Axles Lubrication and Maintenance" annexed to section 10 "Front Axle".

Drag link ends are provided with grease fittings. Under normal conditions, these should be serviced every 6,250 miles (10 000 km). Refer to section 24 "Lubrication".

Steering linkage pivot points should be checked each time they are lubricated. Looseness can be visually detected while rotating the steering wheel in both directions. Replace defective parts.




CAUTION


Front wheel alignment should be checked and adjusted if necessary, any time a component of the steering system is repaired, disassembled or adjusted. Refer to section 10 "Front Axle" under heading 6. "Front Wheel Alignment".


11. PITMAN ARM

11.1 REMOVAL

1. Remove cotter pin, nut and washers from drag link ball stud at pitman arm.
2. Disconnect drag link from pitman arm, using jaw style pullers (pressure screw type).

	<h3>WARNING</h3>
<p>Always wear approved eye protection when operating pullers.</p>	

	<h3>CAUTION</h3>
<p>Do not drive (hammer in) pitman arm on or off pitman shaft as this can damage the steering gear.</p>	

	<h3>CAUTION</h3>
<p>Heating of components to aid in disassembly is not allowed because it has a detrimental effect on axle components and steering linkages.</p>	

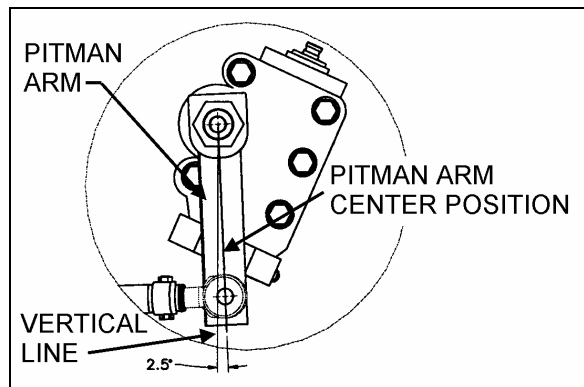


FIGURE 15: PITMAN ARM ADJUSTMENT 14037

3. Using a cold chisel, undo punch mark that locks fixing nut to the pitman arm.
4. Remove pitman arm fixing nut.
5. Check the radial position of the pitman arm in relation to the sector shaft prior to removal of pitman arm.
8. Add reference marks to the arm and shaft if necessary to ensure correct alignment at reassembly.
7. You must use a puller to remove pitman arm.

11.2 INSTALLATION

1. Position pitman arm on sector gear shaft with reference marks aligned.
2. Install fixing nut (Prévost #661050). Tighten nut to 470-570 lbf-ft (637-773 Nm).

<p><i>NOTE</i></p>
<p><i>Use a new nut if the previously removed nut was punched.</i></p>

3. Lock nut with sector shaft using a punch mark into the groove (Refer to figure 16).

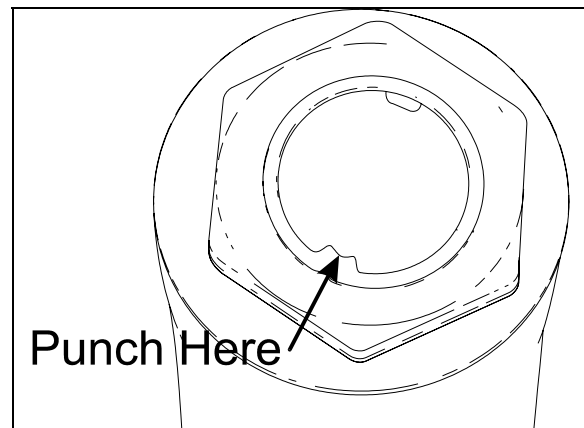



FIGURE 16: FIXING NUT PUNCH MARK 16098

4. Connect drag link to pitman arm while ensuring that rubber stabilizer is in place on the rod end. Install washers. Tighten nut to 160-215 lbf-ft (220-290 Nm). Afterwards, install a new cotter pin.

	<h3>CAUTION</h3>
<p>Input shaft marks must be aligned before adjusting pitman arm.</p>	

11.3 ADJUSTMENT

1. Disconnect the drag link from pitman arm. Center steering wheel by dividing the total number of steering wheel turns in two. Scribe a reference mark on steering gearbox at the center previously determined.
2. Using a protractor, check the angle of the pitman arm (refer to Fig. 15 for details).
3. The pitman arm should be adjusted to an angle of 2.5° in relation with the vertical axis (towards front of vehicle). If not, unscrew and remove fixing nut. Remove the pitman arm according to the procedure outlined under

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previous heading "Pitman arm removal". Adjust to the proper angle.

4. When adjustment is achieved, replace fixing nut and torque to 400-450 lbf-ft (545-610 Nm).

11.4 TAG AXLE UNLOADING SWITCH ADJUSTMENT

1. Make sure vehicle wheels are straight and facing forward.
2. Line up switch lever with reference to the bracket center (Refer to figure 17).

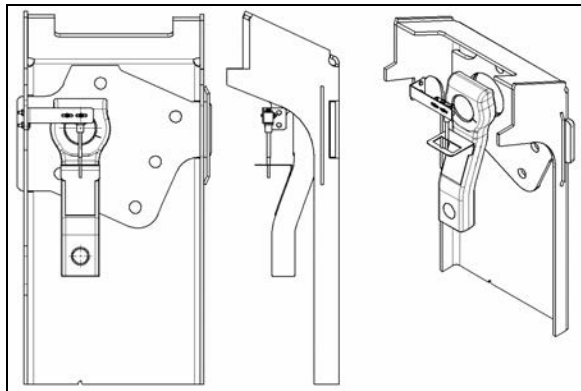


FIGURE 17: TAG AXLE UNLOADING SWITCH ADJUSTMENT 14061

12. MAINTENANCE

The power steering system requires little maintenance. However, the system should be kept clean to ensure maximum operating performance and troublefree service. Periodic inspections should also be made to check for leakage and all parts for damage or distortion. Insure all fasteners are tight (see "14. Specifications" for recommended tightening torques).

When the slightest evidence of dirt, sludge or water is discovered in the system, disconnect fluid lines at the power steering gear to drain the system. Drain and refill the system with "Dexron-II E or Dexron-III" automatic transmission oil.

Air in the hydraulic system will cause spongy action and noisy operation. When a hose has been disconnected or when fluid has been lost for any reason, the system must be bled. Bleed system as outlined under heading 3: "Bleeding Power Steering Hydraulic System".



CAUTION

Do not operate the pump without fluid in the power steering fluid reservoir.

If the steering linkage between the steering gear and the two front wheels is not properly adjusted, or if it is bent, twisted or worn, the steering of the vehicle will be seriously impaired. Whenever a steering linkage part is repaired, replaced or adjusted, steering geometry and front wheel alignment must be checked and necessary corrections made. Refer to section 10 "Front Axle" under heading 6: "Front Wheel Alignment".

At regular lubrication intervals, the steering linkage should be thoroughly inspected for worn or loose components.

After the vehicle has been operated continually and high mileage figures have been reached, overhaul of the various steering units will be required. General overhaul procedure normally requires removal of the entire assembly, cleaning and inspection of all parts and final assembly. Careful inspection of all parts during overhaul is very important and must not be neglected.

Lubrication fittings must all be cleaned before applying lubricant. Moreover, always be sure the equipment used in applying lubricant is clean. Every precaution should be taken to prevent entry of dirt, grit, lint or other foreign matter into lubricant containers. Replace fittings that have become broken or damaged. Lubrication intervals, as well as the recommended lubricants for the steering components, are given in the "Lubrication And Servicing Schedule" in Section 24 of this manual. The intervals given in the schedule are recommended for normal service. More frequent intervals may be required under severe operating conditions.

12.1 POWER STEERING RESERVOIR AND FILTER

The power steering reservoir is located on R.H. side of engine compartment and accessible through the engine compartment doors. (Fig. 18).

12.1.1 Oil Level Check Procedure

1. Stop engine. Open engine compartment doors.
2. Unscrew and remove the dipstick located on top of reservoir and wipe with a clean rag.

3. Insert dipstick in reservoir. Remove it again to check fluid level (Fig. 19).
4. Adjust level to "FULL" mark using proper dipstick side depending on fluid temperature, use "Dexron-II E or Dexron-III" automatic transmission oil.
5. Reinsert and tighten the dipstick.

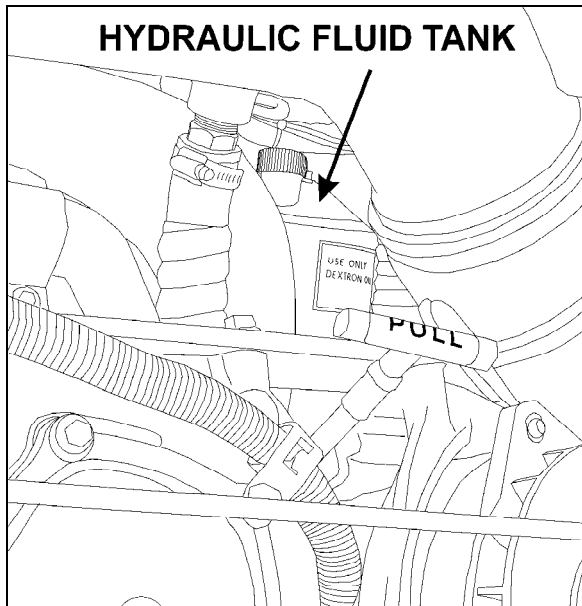


FIGURE 18: HYDRAULIC FLUID RESERVOIR LOCATION
14059

At regular intervals, fluid level should be checked in the reservoir and filter assembly. Furthermore, the oil filter cartridge element in the power steering reservoir should be replaced every 50,000 miles (80 000 km) or once a year, whichever comes first.

12.1.2 Filter Replacement

1. Unscrew and remove the cover nut located on top of the power steering reservoir.
2. Remove the reservoir cover and the gasket.
3. Remove the retaining spring and finally the filter cartridge element.

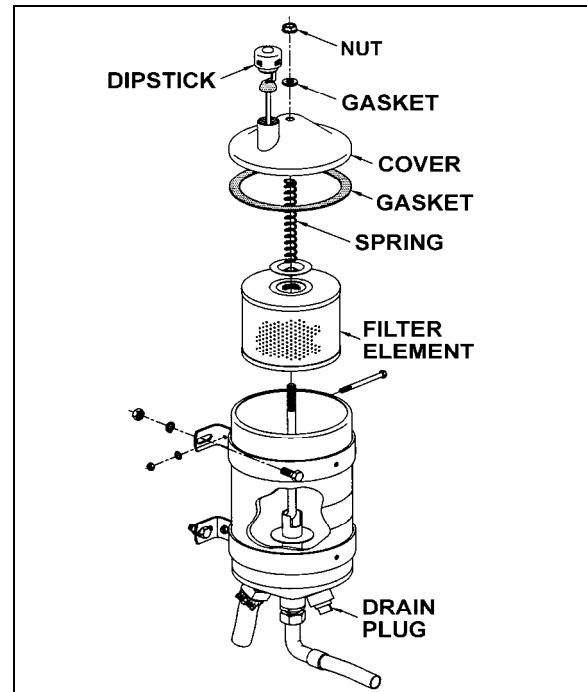


FIGURE 19: POWER STEERING FLUID RESERVOIR
14018A

12.2 STEERING STABILIZER CYLINDER (DAMPER)

The steering damper is located on R.H. side, at back of front axle (Fig. 20).

The cylinder is nonadjustable and non-repairable. Check for oil leaks or lack of resistance. Disconnect the cylinder from axle, then carefully attempt to extend and collapse it manually.

The rod end (ball joint) is provided with a grease fitting. Under normal conditions, it should be serviced every 6,250 miles (10 000 km) or twice a year, whichever comes first. Good quality lithium-base grease NLGI No. 1 and 2 are recommended (refer to section 24 "Lubrication"). Check the ball joint for wear, and replace if necessary.

12.3 DRAG LINK

Lubricate the fittings every 6,250 miles (10 000 km) or twice a year, whichever comes first. Good quality lithium-base grease NLGI No. 1 and 2 are recommended (refer to section 24 "Lubrication").

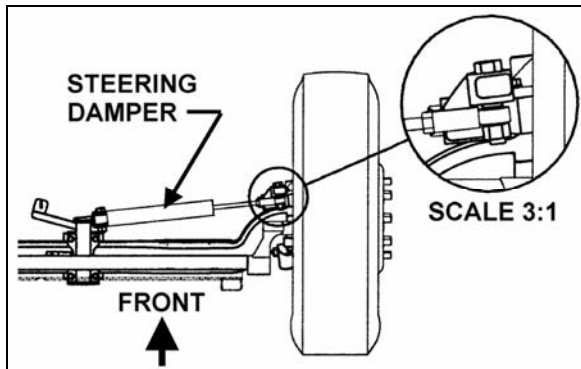


FIGURE 20: STEERING STABILIZER (DAMPER) 14042

12.4 POWER STEERING HYDRAULIC PUMP

- **With DDC Series 60 Engine**

For maintenance of the power steering hydraulic pump, refer to the *"TRW - Power Steering Pump Service Manual"* annexed to this section.

13. DRIVING TIPS

In order to maximize power steering pump service life, do not attempt to turn the steering wheel when the vehicle is stationary, and especially when service brakes are applied (wheel locking will oppose the effect of steering geometry which tends to make the front wheels rotate in opposite directions).

Persisting in turning, or maintaining the steering wheel with an extra effort, could make the hydraulic system work at the relief pressure, and consequently, cause the hydraulic fluid to become overheated.



CAUTION

Never maintain the hydraulic system at the relief pressure for longer than 5/10 seconds to avoid damaging the power steering pump.

NOTE

Unequal or low tire pressure, oversize tires, and vehicle overloading are some of the causes that may increase steering effort.

14. TORQUE SPECIFICATIONS

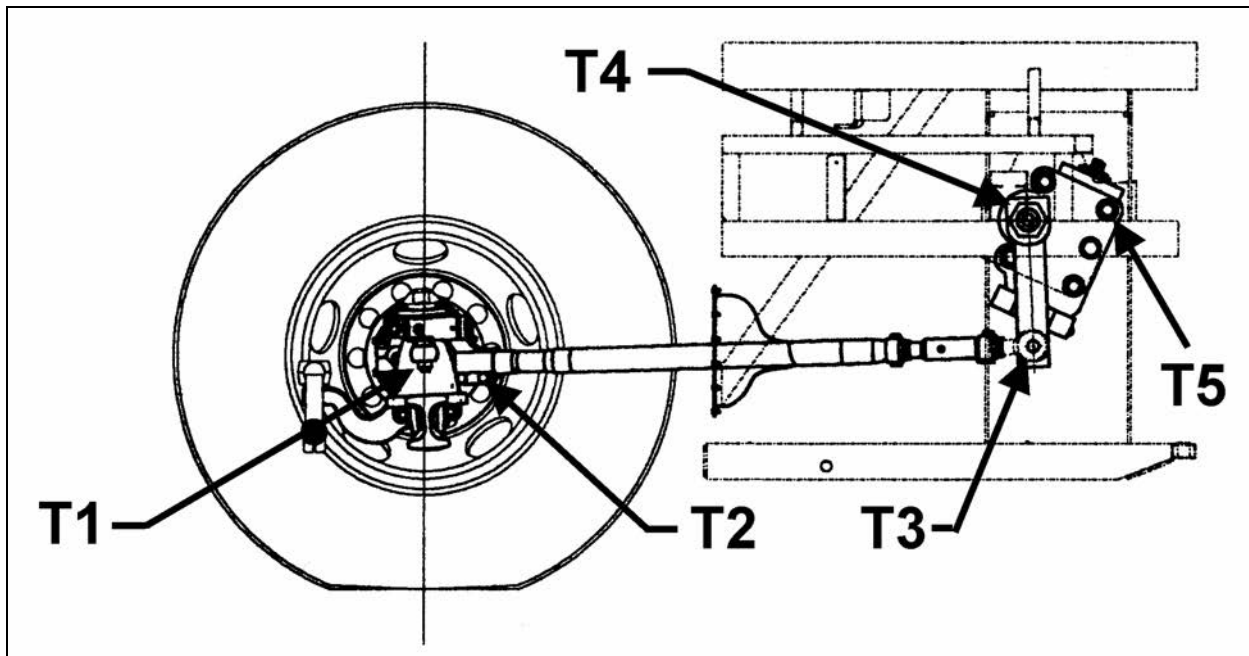


FIGURE 21: DRAG LINK COMPONENTS

14038

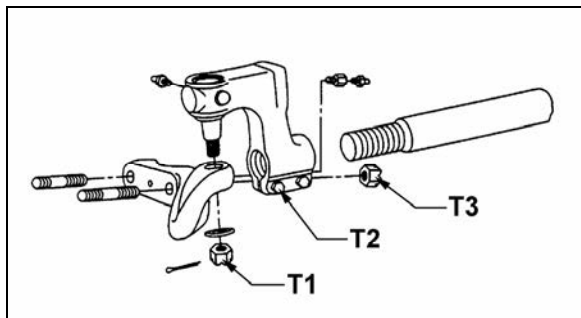


FIGURE 22: TIE ROD END

14036

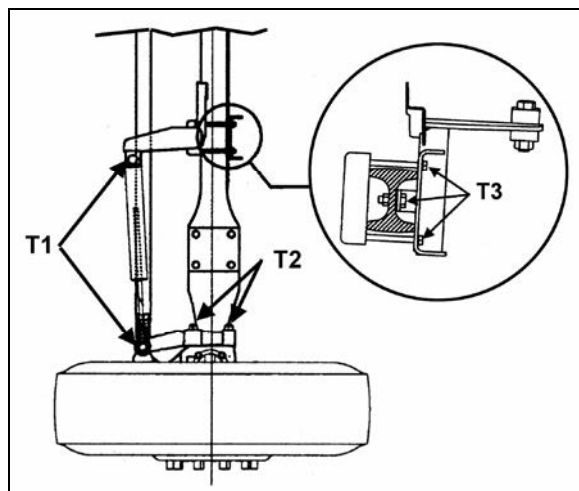


FIGURE 23: FRONT AXLE COMPONENTS

14045

Section 14: STEERING

DRY TORQUES			
Description	Reference	Lbf-ft	Nm
Drag Link End Stud Nut (on steering arm)	Fig. 21, T1	160-300	220-410
Drag Link End Pinch Bolt Nuts	Fig. 21, T2	40-60	55-80
Drag Link End Stud Nut (on pitman arm)	Fig. 21, T3	150-200	203-271
Pitman Arm Fixing Nut	Fig. 21, T4	470-570	637-773
Steering Gear Fixing Bolts (5)	Fig. 21, T5	365-405	495-550
Tie Rod End Screw Pin Nut	Fig. 22, T1	100-175	135-240
Tie Rod End Pinch bolt Nuts	Fig. 22 T2	65-75	90-100
Lower Lever Stud Nuts	Fig. 22, T3	190-275	260-375
Steering Stabilizer (damper) Fixing Nuts	Fig. 23, T1	100-120	135-165
Steering Top Lever Nuts	Fig. 23, T2	150-200	205-275
Steering Damper Mounting Support Nuts	Fig. 23, T3	65-70	90-95

15. SPECIFICATIONS

Power Steering Gear

Make ZF-SERVOCOMTRONIC
 Model 8098
 Supplier number 8098-988-571
 Prevost number 661044
 F.E.W. 16,600 lbs (7 545 kg)
 Pressure rating 2,175 psi (150 Bar)
 Gear ratio (center) 22.2 : 1
 Gear ratio (extremities)..... 26.2 : 1
 Minimum pump flow for 1.5 hwt/sec 4.22 gpm (16 lpm)

Power Steering Gear

Make ZF-SERVOCOM
 Model 8098
 Supplier number 8098-988-570
 Prevost number 661045
 F.E.W. 16,600 lbs (7 545 kg)
 Pressure rating 2,175 psi (150 Bar)
 Gear ratio (center) 22.2 : 1
 Gear ratio (extremities)..... 26.2 : 1
 Minimum pump flow for 1.5 hwt/sec 4.22 gpm (16 lpm)

Power Steering Pump (with Detroit Diesel Series 60 Engine)

MakeTRW
 TypePS Series
 Relief valve setting2,175 psi (14 990 kPa)
 Controlled flow rate4.23 gpm (16 lpm)
 Inlet port1 1/4 NPT
 Outlet port3/4-16 straight thread SAE O' ring boss conn.
 Supplier numberPS251615L10200
 Prevost number661009
 Gasket - Supplier number23516100
 Gasket - Prevost number510488

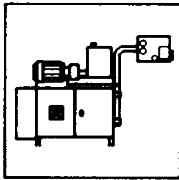
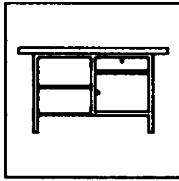
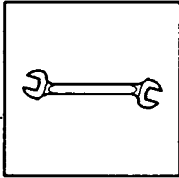
Power Steering Reservoir

MakeNelson Muffler
 Oil capacity4 US qts (3.7 liters)
 Supplier number91410A
 Prevost number660982
 MakeNelson Muffler
 Element filter - Supplier number83804 E
 Element filter - Prevost number660987

Steering Stabilizer Cylinder (Damper)

MakeArvin
 Extended length.....32.73±0.12"
 Collapsed length.....20.26±0.12"
 Stroke.....12.47±0.12"
 Supplier number651535
 Prevost number660979
 Dust cap - Prevost number660980

Service



ZF Lenksysteme

Design

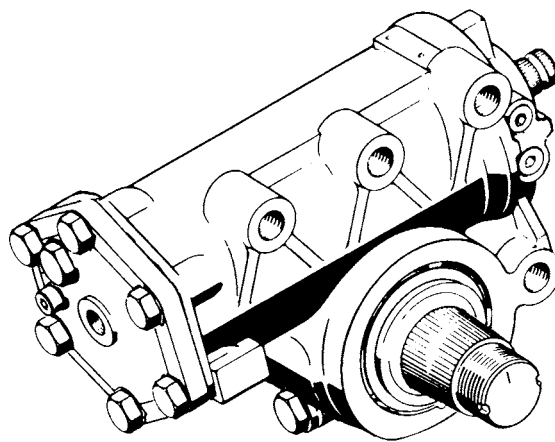
Operation

Maintenance

Inspection

ZF Servocom[®]

Types 8090, 8095, 8097 and 8098



ZF Lenksysteme GmbH

D-73522 Schwäbisch Gmünd

Telephone (07171) 31-0 Fax (07171) 31-4396

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I. Safety note



Attention: Important safety note for the driver and the workshop personnel, respectively

If the steering system is in a perfect working order, the steering efforts the driver has to exert on the steering wheel are low (e.g., 30 N corresponding to approx. 3 kg).

In the event of a failure of the hydraulic assistance (for example owing to lack of oil) the effort needed to carry out a steering motion will increase considerably (for example to 450 N corresponding to approx. 45 kg).

As this happens very seldom and unexpectedly, the driver may be led to believe, erroneously, that the steering system cannot be moved at all any longer.

However, even in the event of a failure of the hydraulic assistance, there is always a mechanical connection between the steering wheel and the road wheel ensuring that manual steering at increased steering efforts can take place.

To avoid damages inside the steering gear and damages to the steering column, the steering effort at the steering wheel rim must not exceed 700 N (approx. 70 kg) when steering motions are carried out without hydraulic assistance and at vehicle standstill.

II. Design and operation

1 Design

The housing of the ZF Servocom steering gear houses the steering valve, the steering cylinder and a complete manual steering gear.

The oil flow and the pressure required by the steering gear is supplied by an engine-driven pump. To achieve this, the oil is taken in from the oil tank and fed back to the tank via the pump and the steering gear.

The housing (A) - see **Fig. 1** - and the piston (B) have the function of a cylinder. The piston transforms the rotation of the steering input shaft (C) and of the worm (D) into an axial motion which it transmits to the sector shaft (F).

The piston (B) and the worm (C) are positively connected with each other by means of a ball chain. As the worm rotates, the balls at one end of the chain are taken up by a recirculation tube and fed back to the other end so that an endless ball chain is formed.

The teeth of the piston (B) and of the sector shaft (F) cause the sector shaft to rotate when the piston is displaced.

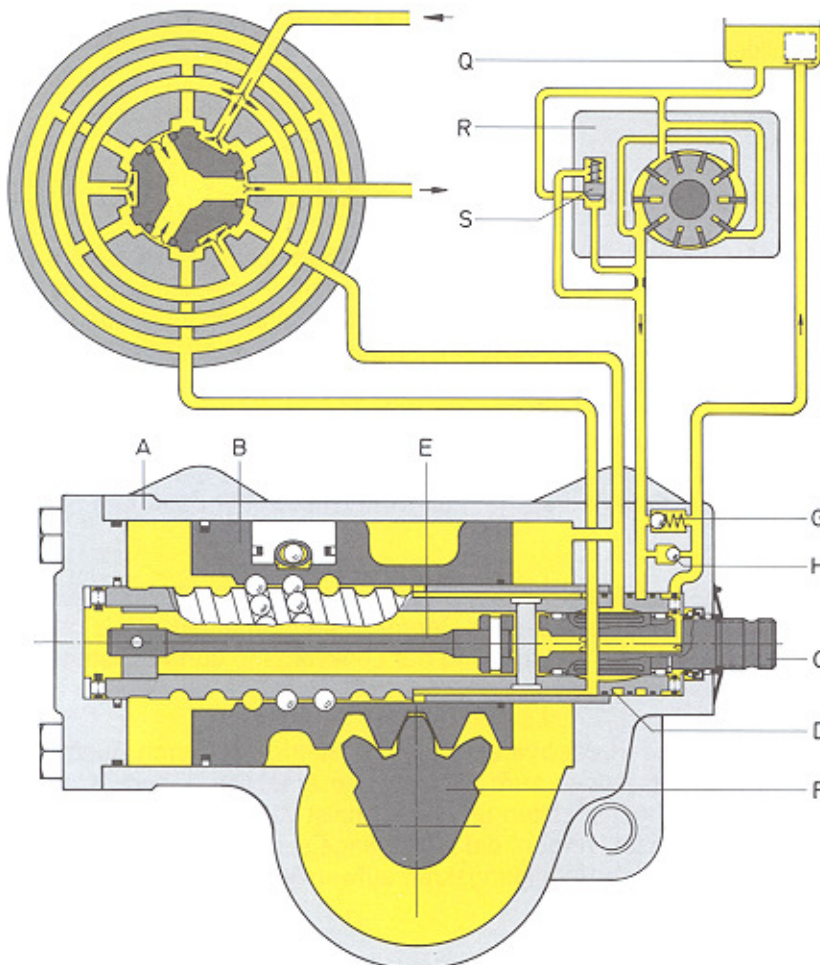


Fig. 1
Valve rotor in mid-position

- A Housing
- B Piston
- C Valve rotor/steering input shaft
- D Valve sleeve/worm
- E Torsion bar
- F Sector shaft
- G Pressure relief valve
- H Replenishment valve
- Q Oil tank
- R Vane pump
- S Flow limiting valve

 Return line pressure

The steering valve consists of the valve rotor (C) which is carried in a needle bearing in the worm and is provided with six control grooves on the circumference, and of the valve sleeve (D) on the worm.

A torsion bar (E) pinned to the valve rotor (C) and the worm (D) keeps the steering valve in mid-position as long as no effort is exerted on the steering wheel.

A pressure relief valve (G) limiting the maximum pressure within the steering system may be integrated in the steering gear housing.

In addition, a replenishment valve (H) sucking oil from the return oil line when a steering motion without hydraulic assistance takes place can be fitted to the housing or to the steering valve.

In comparison with constant ratio steering gears, variable ratio steering gears are more direct around centre than outside the mid-position area, which has a favourable effect on the steering performance during straight ahead driving as minor steering corrections only, if any, are required.

At the same time, in the static parking range requiring a wider steering wheel turning angle a higher hydraulic torque is available at the sector shaft owing to the more indirect steering ratio.

In the event of a failure of the hydraulic assistance the steering efforts at the steering wheel rim are lower in this range than they would be for a constant ratio steering gear.

The 3 functional drawings to **Figs. 1 to 3** give a simplified representation of the steering valve and the oil flow. In addition, these figures give a cross-sectional view of the steering valve in order to schematically represent the connections from the steering valve to the cylinder chambers and the mode of operation of the valve.

2 Operation

When a torque is transmitted from the steering input shaft to the worm or vice-versa, the torsion bar is subjected to a deformation in the elastic area of its length, causing a torsion to occur between the valve rotor and the valve sleeve and, thus, to move the control grooves of the valve rotor away from the mid-position as compared with the position of the valve sleeve control grooves.

When the steering wheel is released, the action of the torsion bar will make the steering valve return to the neutral (mid) position.

Through the bore in the housing, the oil flows into the annular groove of the valve sleeve and is fed to the arcuate control grooves of the inner valve rotor through three symmetrically-arranged radial bores.

The position of the control grooves in the valve rotor and the valve sleeve is such that, in the mid-position of the steering valve, the oil can flow through the inlet slots (J and K) to the axial grooves (N and O) of the valve sleeve, which are also arcuate. From there, the oil can freely flow through radial bores to the cylinder chambers.

As long as the steering valve is in the mid-position, the oil can flow to both cylinder chambers, and via the three return grooves (P) in the valve rotor it can also flow off to the oil tank.

2.1 Forward steering motion to the right (piston with right-handed thread)

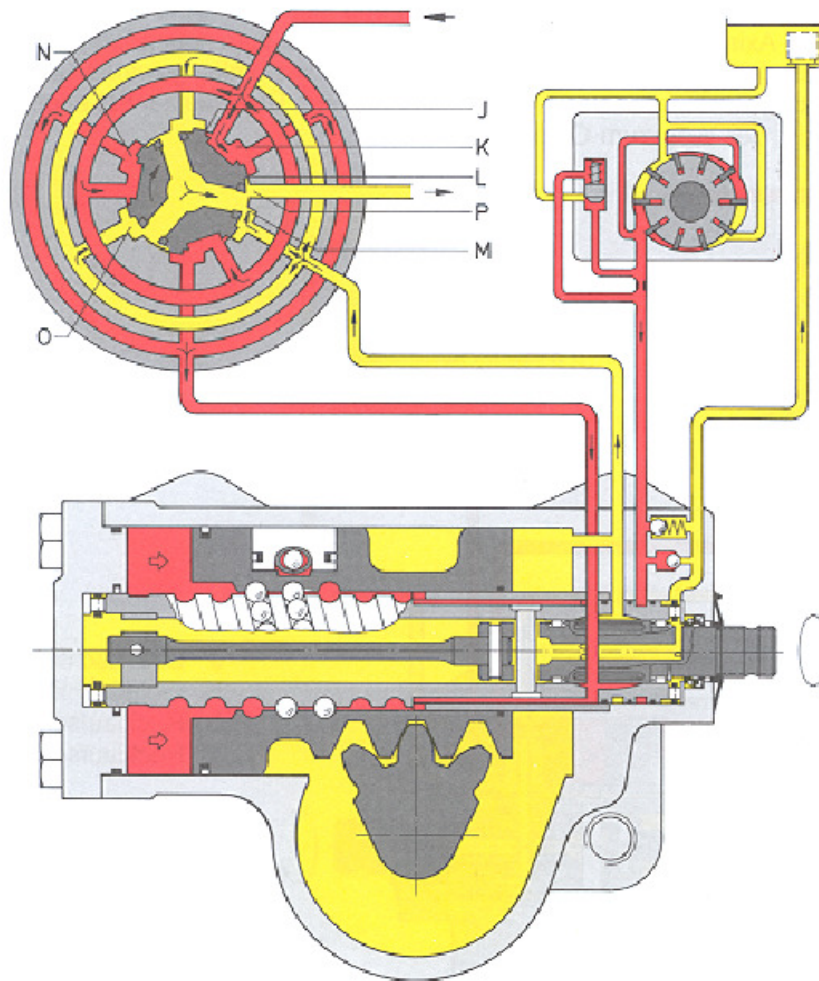


Fig. 2
Valve rotor in
operating position
Steering wheel turned
clockwise

- J Inlet slot
- K Inlet slot
- L Return slot
- M Return slot
- N Axial groove
- O Axial groove
- P Return groove

- Operating pressure
- Return line pressure

When the steering wheel is turned to the right, the piston will shift to the right (**Fig. 2**). A pressure will now build up in the left-hand cylinder chamber which is a function of the steering effort required.

To achieve this, the control grooves of the valve rotor are displaced clockwise and the inlet slots (K) are opened wider to admit the oil, while the inlet slots (J) are closed to the same extent and thus obstruct the feeding of oil to the axial grooves (O) of the valve sleeve.

The oil will now flow through the inlet slots (K) to the axial grooves (N) of the valve sleeve and, from there, will pass through the ball screw thread and flow to the left-hand cylinder chamber. The closed inlet slots (J) prevent the oil from flowing off to the tank and, thus, cause a pressure to build up.

The oil from the right-hand cylinder chamber is displaced. Via the opened return slots (M), it flows to the return grooves (P) of the valve rotor. From there, it can at any time flow through the central oil bore in the valve rotor and the worm and off to the oil tank.

2.2 Forward steering motion to the left (piston with right-handed thread)

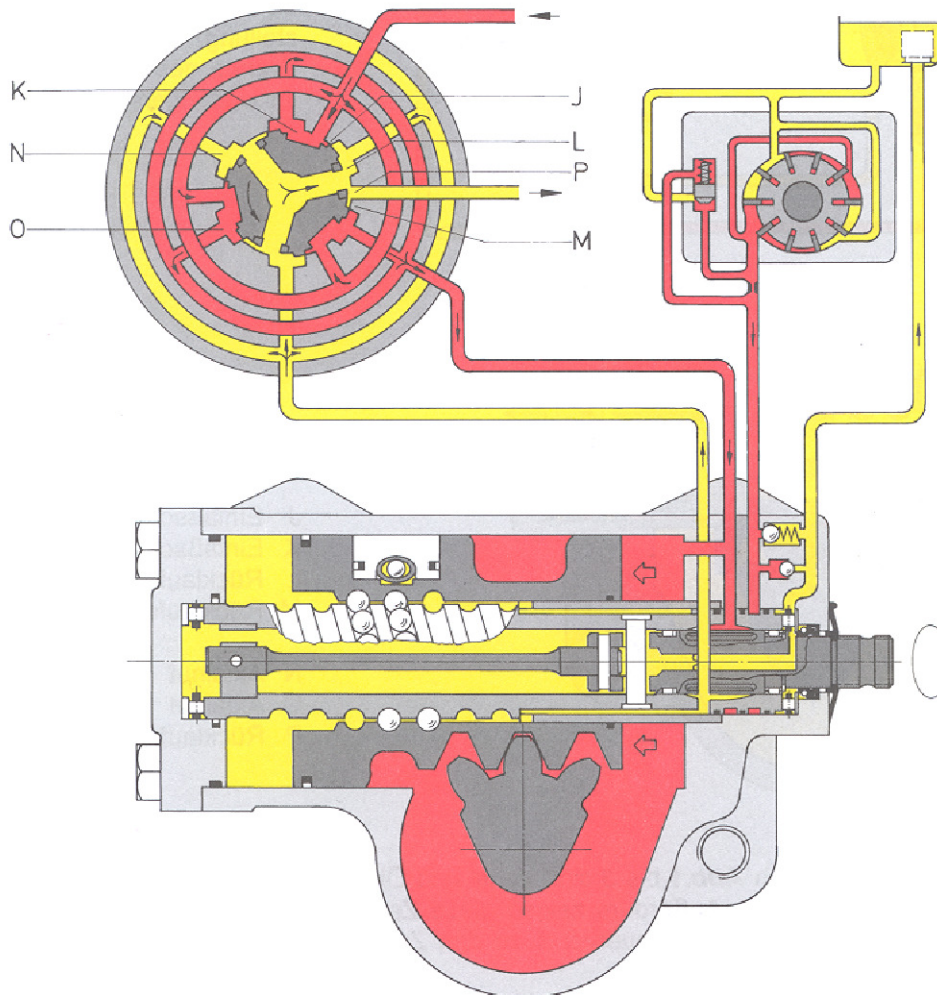


Fig. 3

Valve rotor in operating position

Steering wheel turned counter-clockwise

- J Inlet slot
- K Inlet slot
- L Return slot
- M Return slot
- N Axial groove
- O Axial groove
- P Return groove

- Operating pressure
- Return line pressure

When the steering wheel is turned to the left, the piston will shift to the left (**Fig. 3**). Therefore, pressure build-up now takes place in the right-hand cylinder chamber.

The control grooves of the valve rotor are displaced counter-clockwise and allow the oil to flow through the opened inlet slots (J) to the axial grooves (O) from where there is a connection to the right-hand cylinder chamber.

The oil from the left-hand cylinder chamber flows to the return grooves (P) of the valve rotor, via the ball screw thread and the opened return slots (L), and can then freely flow off to the oil tank through the central bore in the valve rotor and the worm.

3 Operation of the hydraulic steering limitation

The hydraulic steering limitation prevents a steering to the lock stops at full hydraulic pressure. It, thus, protects the pump and the steering linkage and prevents high oil temperatures.

A double-acting steering limiting valve with spring-loaded valve pins (T and U) is arranged in the longitudinal direction in the piston (B). The valve pins project over the right-hand and the left-hand front faces of the piston (**Fig. 4**).

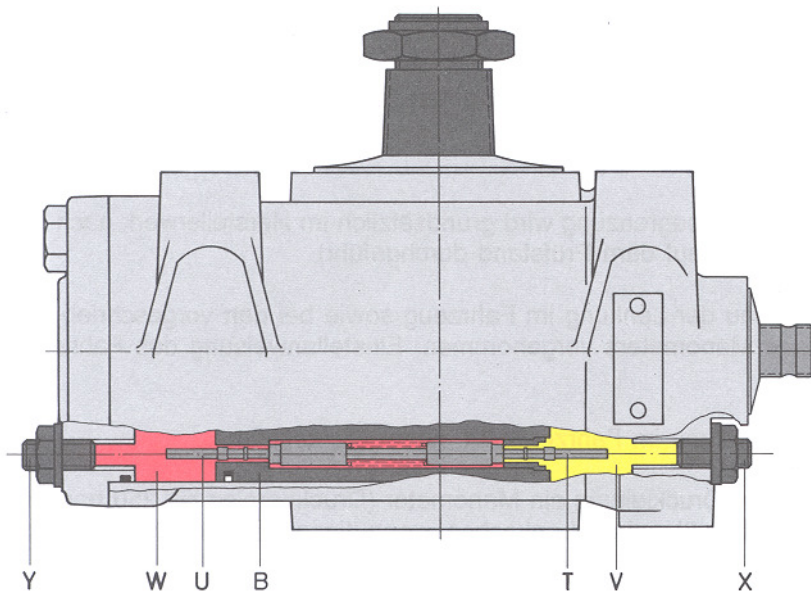


Fig. 4 Steering limiting valve closed

T Right-hand valve pin of steering limiting valve

U Left-hand valve pin of steering limiting valve


V Right-hand cylinder chamber

W Left-hand cylinder chamber

X Right-hand adjusting screw

Y Left-hand adjusting screw

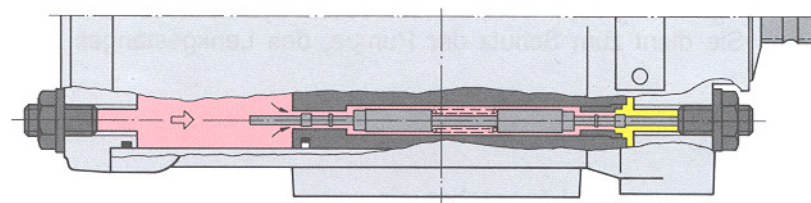
 Operating pressure


 Return line pressure


If the piston is shifted to the right or to the left towards the lock stop, the valve pins (T and U) are actuated by the adjusting screws (X and Y) fastened in the housing and the cylinder cover, respectively. The steering limiting valve remains closed until one of the valve pins hits against an adjusting screw.

If for instance the piston is displaced to the right (**Fig. 5**), the right-hand valve pin will hit against the adjusting screw (X) before the piston end position is reached. Valve pin (U) is displaced by the oil pressure so that the oil can flow away from cylinder chamber (W) to cylinder chamber (V) and from there to the return line. When the piston is displaced to the left, the same sequence of operations as described above will take place by analogy.

Fig. 5 Piston displacement to the right. Right-hand valve pin open. Oil pressure greatly reduced.



 Reduced operating pressure

 Return line pressure

As soon as the steering limiting valve is open, the steering gear can be turned forward further at an increased steering effort and with greatly reduced hydraulic assistance until the lock stop is reached.

III. Servicing work

1 Hints

In a number of countries a safety inspection (Sicherheitsprüfung = SP) is prescribed by law for vehicles with more than 8 passenger seats or a gross vehicle weight rating in excess of 7.5 t.



Attention:

On vehicles not subject to the safety inspection (SP), the work detailed in Chapter III. Servicing work, para.s 3.5...3.10, has to be carried out in addition.

Following a **test drive** and a subsequent visual inspection of the complete steering system (steering column, bevel box, steering gear, drag links, pump, and hydraulic lines) we recommend to carry out the following work.

Within the scope of **maintenance** the proper functioning of the steering system is checked by a test drive and a visual inspection.

During an **inspection**, safety-critical characteristics are tested.

2 Maintenance

Maintenance intervals:

We recommend to carry out the following work within the scope of the general maintenance work. ^[1]

2.1 Test driving

During the test drive, in particular look out for the following characteristics:

- return to neutral
- sticking
- increased friction
- play

2.2 Checking and inspecting for external leakproofness/damages

Check the steering gear (with bellows), the protecting caps, the pumps (engine-driven and ground-driven), the valves and the steering cylinders, the lines and the screwed connections for leakproofness and damages. The piston rod of the steering cylinder may be covered by a thin oil film but there must not be any oil drops.

Note:

When cleaning with a high pressure cleaning machine, make sure not to direct the water jet directly towards the sealing elements of the steering system. Ingressing water and impurities can cause malfunctions.

2.3 Checking the oil level

Oil grade required: please refer to List of Lubricants TE-ML 09

Prior to pulling out the oil dipstick, thoroughly clean the oil tank and its immediate vicinity to protect the hydraulic oil from being soiled by impurities.



Attention:

Too low an oil level may cause malfunctions which can entail a failure of the hydraulic assistance of the steering system.

^[1] see vehicle manufacturer's instructions

For vehicles with ZF Servocom RAS (Rear Axle Steering System)

Check the oil level in the straight ahead driving position.

If the oil level is above the top mark, there may be a leakage in the master cylinder of the ZF Servocom RAS steering.

Check the ZF Servocom RAS as specified in the Instructions for the Functional Check, Maintenance and Inspection of ZF Servocom RAS steering gears.

- **Oil level check with the engine stopped:**

The oil must be topped up to the upper mark of the oil dipstick.


- **Oil level check with the engine running:**

When the engine is running, the oil level must be between the lower and the upper marks.

When the engine is stopped, the oil level may rise by 1...2 cm (depending on the capacity of the steering system)

If the oil level rises by more than 2 cm, the steering system has to be bled

Start the engine.

For vehicles equipped with an additional ground-driven emergency steering pump: jack up the drive axle of the emergency steering pump  and engage a gear.

 see vehicle manufacturer's instructions

3 Inspection



Attention:

The inspection intervals depend on how the vehicle is used.

Therefore, the table below distinguishes between different kinds of use which may, though, be overlapping.

For the sake of increased traffic safety, we recommend to inspect the steering system in accordance with the inspection intervals listed below.

Minor variations in inspection intervals are permissible if it is desirable to adjust these intervals to the vehicle-specific inspection intervals.

Note:

The work listed below also includes work that has to be carried out within the scope of the safety inspection (SP).

Such work is marked "(part of SP)". Therefore, inspection steps bearing this mark can be omitted when vehicles subject to safety inspection (SP) are checked within the scope of the normal inspection.

In addition, the safety inspection (SP) rules applying in the country of registration of the vehicle being inspected have to be complied with.

3.1 Inspection intervals

up to date of manufacture 12/93

Kind of use	Ist inspection Inspection on the vehicle	IIInd inspection Inspection on the vehicle	IIIrd inspection
Long-distance vehicles	100 000 km 60 000 miles	200 000 km 120 000 miles	300 000 km 180 000 miles
Vehicles in long and short distance use	100 000 km 60 000 miles	175 000 km 105 000 miles	250 000 km 150 000 miles
Construction site vehicles and vehicles in off-road use	80 000 km 50 000 miles 2 500 op.hrs	150 000 km 90 000 miles 4 500 op.hrs	200 000 km 120 000 miles 6 000 op.hrs

Additionally, at the time of the IIIrd inspection, the mechanical transmission elements of the ZF Servocom steering gear have to be inspected.

To this effect, dismantle the steering gear and visually inspect and crack test all transmission elements (see Repair Instructions).

starting from date of manufacture/repair 1/94

Kind of use	Ist inspection Inspection on the vehicle	Further inspections Inspection on the vehicle
Long-distance vehicles Coaches with high mileages	600 000 km	after a further 300 000 km, ea.
Buses Construction site vehicles Vehicles in short-distance use Vehicles subject to extreme loads	300 000 km 7 500 op.hrs	every 300 000 km 7 500 op.hrs

3.2 Test driving

During test driving, in particular look out for the following characteristics:

- return to neutral
- sticking
- increased friction
- play

3.3 Visual inspection

- Check the screws of the complete steering system (steering column, bevel box, steering gear, drag links and steering cylinder) for correct fastening.
- Check whether the locking plate and the split pin are still perfectly secured.
- By turning the steering wheel to both sides or by applying a load to it, check whether the fit of the drop arm on the sector shaft is still tight.
- Check the steering column, bevel box, steering gear, axle stops, drag links and tie rods for damages, cracks and corrosion.
- With the engine running, check the complete steering system for external leakproofness.

3.4 Replacing the oil filter



Attention:

Before taking off the oil tank cover, thoroughly clean the oil tank and its immediate vicinity to prevent the ingress of impurities into the hydraulic fluid.

Pull the filter insert out of the oil tank.

Avoid any dripping of oil from the insert into the tank.

If heavily soiled, clean the oil tank.

Fit a new filter insert.



Attention:

Below is a list of all work that has to be carried out on the steering gear within the scope of the safety inspection (SP).

This list represents the currently valid status and is not subject to the Updating Service.

3.5 Steering gear play (part of SP)

- Start the engine
- Rotate the steering gear to the straight ahead driving position.
- Slowly turn the steering wheel and, simultaneously, watch the front wheel to see how far the steering wheel has to be turned to make the front wheel move.
perm. total displacement (stg. wheel \varnothing 500 mm): max. 50 mm
max. 55 mm for version with bevel box

3.6 Hydraulic steering limitation (part of SP)

The hydraulic steering limitation causes the pressure to drop in the area of the steering stop, thus protecting the steering pump and the steering linkage and preventing increased temperatures.

- For a check of the setting please refer to Chapter III., para. 5.

3.7 Light operation of the steering gear (part of SP)

If the steering system has a hydraulic defect, this is indicated by increased steering efforts.

- Start the engine.
- At vehicle standstill, quickly rotate the steering gear twice from lock to lock and look out for stiff operation of the steering.

3.8 Points of stiff operation (part of SP)

Defective transmission elements (steering column, universal joints, ...) may cause a temporarily stiff operation of the steering gear.

- Relieve the front axle (conform to vehicle manufacturer's instructions)
- With the engine cut off, rotate the steering gear from lock to lock and look out for points of stiff operation.

3.9 Automatic return to neutral (part of SP)

The axle geometry ensures automatic return to neutral during driving.

- Test drive the vehicle on a cordoned-off ground.
- During the test drive, rotate the steering gear to full lock.
- Release the steering wheel and find out whether the steering gear automatically returns to mid-position.

3.10 Steering wheel (part of SP)

- Check whether the steering wheel is properly fastened.
- Check the steering wheel for damages.

4 Oil change and bleeding

4.1 Oil change

4.1.1 Draining the oil

Note:

An oil change is only required if steering gear units were repaired or replaced.

Do not use any drained oil to refill the system. Avoid any blending of oils.

4.1.2 Draining the steering system

Jack the steered axle up. ¹

Unscrew the pressure and return lines from the steering gear.

Then have the engine run for a short time (maximum 10 seconds) to allow the oil to be sucked from the pump and the oil tank. Collect any escaping oil in a pan.

Screw in again all components unscrewed earlier.

4.1.3 Draining the steering gear

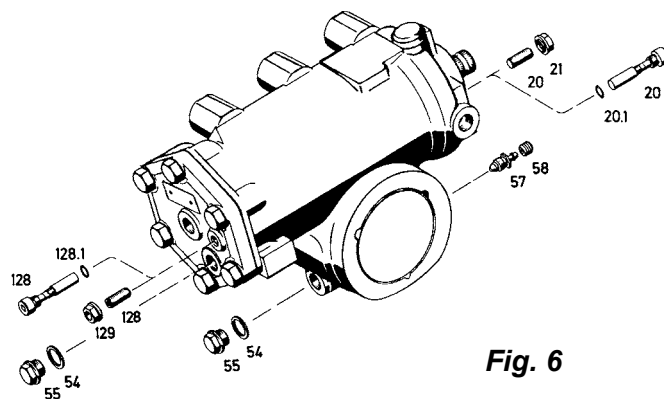


Fig. 6

If existing on the version inspected, unscrew

- the screw plugs (55) from the cylinder cover or the housing
- the set screw or the collar nut (20 or 128)
- the screw (20 or 128)
- the bleeder (57)

(Fig. 6).

¹ see vehicle manufacturer's instructions

To achieve a quick draining, open the one among the components referred to above which is lowest in the installed position.

Rotate the steering gear manually from lock to lock until no more oil is draining.

Unscrewed components must be screwed in again at the following tightening torques:

Screw plug (55):	40 Nm (M16x1.5)
	50 Nm (M18x1.5)
Collar nut (21 and 129):	20+10 Nm
Screw (20 and 128):	12+3 Nm
Bleeder (57):	30 Nm

Note:

Even after unscrewing all components mentioned above, a residual oil quantity may be left over in the steering gear.

A complete draining of the steering gear may be necessary depending on the amount of impurities in the oil. To this effect the steering gear has to be removed from the vehicle and opened at a ZF Service Centre.

4.2 Oil filling



Attention:

When the steering system is filled with oil, there is a risk of impurities getting into the steering oil circuit. To avoid malfunctions caused by foreign bodies in the system, maximum cleanliness is of paramount importance both at initial fill and when topping up with oil.

For admitted oil grades, refer to the List of Lubricants TE-ML 09.

Fill the tank with oil to the rim.

Start the engine and have it run at idling speed to fill the steering system with oil.

During this operation, the oil level in the tank will quickly drop.

Therefore, to avoid any suction of air, the oil tank has to be topped up constantly.

In addition, for vehicles equipped with a ground-driven emergency steering pump:

Jack up the drive axle. ¹

Select a gear and have the engine run at idling speed.

To avoid any suction of air, constantly top up with oil.

¹ see vehicle manufacturer's instructions

4.3 Bleeding

- For steering gear versions with automatic bleeding:

Steering gear versions with automatic bleeding do not have any bleed screws. These steering gears automatically bleed any air remaining within the steering system.

Note:

Automatic bleed valves operate in the idle pressure range only; therefore, any unnecessary pressure build-up should be avoided.

When the steering system is filled to an extent preventing the oil level from dropping below the upper mark of the oil dipstick:

Have the engine run at low speed for 2...3 minutes.

Rotate the steering wheel several times from lock to lock and, while doing so, watch the oil level.

Top up with oil if required.

- In addition, for vehicles equipped with a ground-driven emergency steering pump:

Jack up the drive axle. ¹

With a gear selected and the engine running, bleed the emergency steering pump.

2...3 minutes later rotate the steering wheel several times from lock to lock.

Note:

In the end positions, do not pull heavier at the steering wheel than is necessary to rotate the steering gear.

Top up with oil if required.

- Versions with additional steering cylinder:

The line connections of the steering cylinder must point upward to allow for an escaping of the air in the cylinder.

If required turn the steering cylinder to a suitable position and mount it again in its original position after air bleeding.

¹ see vehicle manufacturer's instructions

- Versions with bleeder (57):

With the engine running, open the bleeder (57) until nothing but oil is coming out (**Fig. 7**). Afterwards, close the bleeder again until it is oil-tight.

On versions without automatic bleeding (installed position horizontal, steering output shaft in the bottom position) the topmost screw/set screw (20 and 128, respectively) can be used for bleeding.

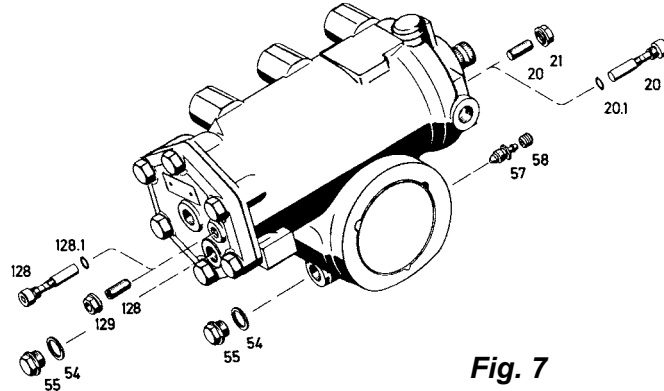


Fig. 7

- Versions with screw (20 and 128):

Open the topmost screw (20 and 128, respectively) until nothing but oil is coming out. Re-tighten the screw (20 or 128) using a torque of 12+3 Nm.

- Versions with set screw (20 and 128):

Slacken the collar nut (21 or 129) of the topmost set screw (20 or 128) until nothing but oil is coming out.

Re-tighten the collar nut (21 and 129) using a torque of 20+10 Nm.

The hydraulic steering limitation must be checked after bleeding.

- For versions with flange (335), in addition:

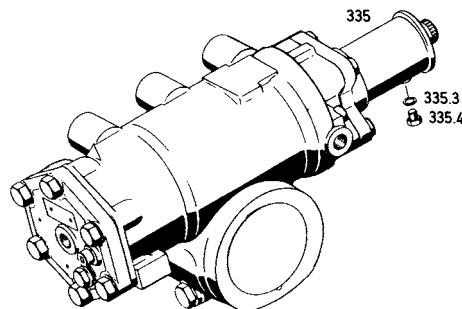


Fig. 8

Open the screw plug (335.4) until nothing but oil is coming out (**Fig. 8**).

Then close the screw plug again.

Tightening torque: 8+1 Nm (M8x1)

- If bleeding was done correctly, the oil level in the tank must not rise by more than 1 to 2 cm when the engine is stopped.
Turn the engine off and lower the jacked-up steered axle or drive axle to the ground.

5 Setting the hydraulic steering limitation

A setting of the steering limitation is necessary if or when

- a new or repaired steering gear is fitted or
- new screws (20 and 128) were fitted to the automatically adjusting steering limitation or
- alterations to or adjustments of the front axle were carried out.

5.1 Hydraulic steering limitation with manual setting (Fig. 9)

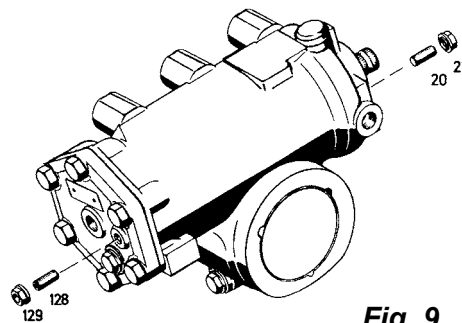


Fig. 9

Fit a pressure gauge (pressure range up to 250 bar) or tool [1] (ZF Servotest power steering tester) to the pressure line between the pump and the steering gear (see Fig. 10).

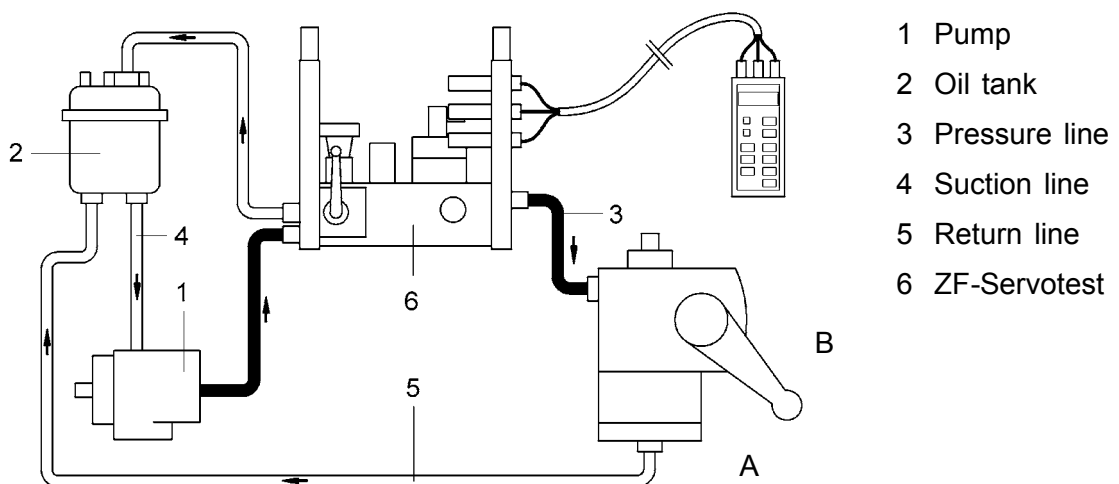


Fig. 10

If the setting takes place at set screw (128) the drop arm will be caused to move in direction “B” (Fig. 10).

If the setting takes place at set screw (20) the drop arm will be caused to move in direction “A”.

Test temperature: 50° C ±10°

- Rigid axle:

Relieve the axle by jacking it up or place it on swivel plates. ^[1]

- Single-wheel suspension:

Place the steered wheels on swivel plates.

- With the engine running at **idling speed**, rotate the steering gear to the lock stop.

Upon reaching the lock stop, overcome the return force of the steering valve by rotating the steering wheel further for a short time (5 sec. maximum) until a positive steering stop is reached.

Read the pressure at the pressure gauge or at tool [1] (ZF Servotest power steering tester).

Specified values:	Steering systems	up to 16 dm ³ /min:	40...50 bar
		up to 20 dm ³ /min:	50...60 bar
		above 20 dm ³ /min:	70...80 bar

To correct, slacken the corresponding collar nut (21 or 129) and screw the set screw (20 or 128) **Fig. 14** in or out.

If a higher pressure is measured, the corresponding set screw must be **screwed in** further.

If a lower pressure is measured, the corresponding set screw must be **screwed out** further.

While doing so, release the steering wheel so that idle pressure only can build up during this work.

Then tighten the collar nut (21 or 129) using a torque of 20+10 Nm.



Attention:

During the setting operation as well as in the built in condition, the set screws (20 and 128) must be screwed in at least 3 threads deep for otherwise, because of insufficient thread overlap, they would run the risk of being ejected when maximum pressure is built up in the steering gear.

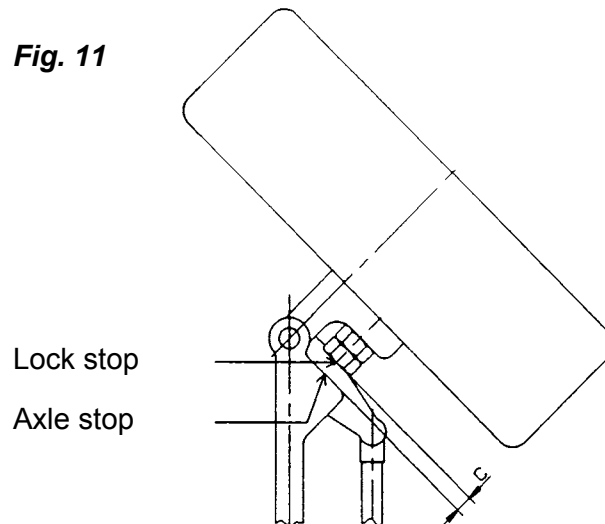
^[1] see vehicle manufacturer's instructions

Proceed as described above for the setting of the second lock stop.

Note:

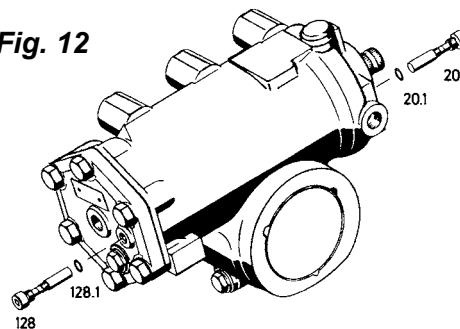
At variance with the setting described above, the vehicle manufacturer may specify a different way of adjustment, e.g. by inserting a spacer to ensure that, when the steering limitation responds, a distance dimension "C" can be kept (**Fig. 11**).

Fig. 11



5.2 Automatically adjusting hydraulic steering limitation (**Fig. 12**)

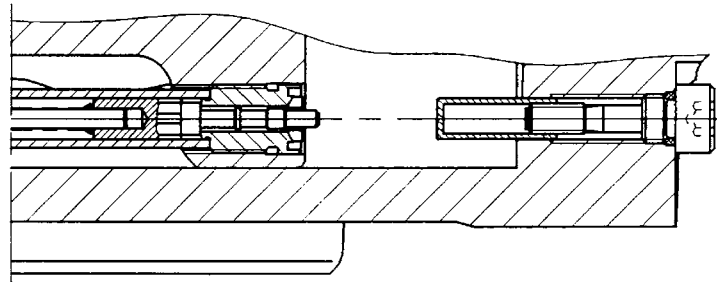
Fig. 12



Attention:

Steering gears with automatically adjusting steering limitations must not be rotated manually to the end positions when the steering linkage is removed or when the steering gear is removed from the vehicle, for the sliding bushes of the screws (20 and 128, respectively) would, thereby, be shifted to the cut-off position that is at maximum possible, and an automatic adjustment on the vehicle would only be possible with **new** screws (20 and 128) (**Fig. 12**). The screws (20 and 128) and the set screws (20 and 128) are **not** interchangeable.

Fig. 13 Initial position
Sliding bushes not yet adjusted



5.2.1 Operating mode of the automatically adjusting steering limitation

In the end positions, the valve piston tappets run up against the sliding bushes (20 and 128, respectively) and open the steering limiter valves (U and T, respectively).

The opening of the steering limiter valve is determined by the position of the sliding bushes on the screws (20 and 128).

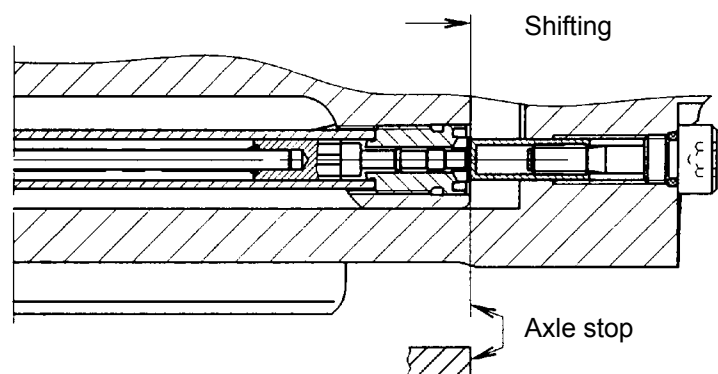
5.2.2 Setting

Note:

This setting (**Fig. 14**) can only be carried out after the steering gear was fitted to the vehicle. To enable the setting, the steering linkage and the axle stops must be installed and set.

Fig. 14 Setting operation

Positioning of the sliding bushes



- For vehicles with a rigid axle:

Relieve the steered axle by jacking it up (there must, however, still be a load on the steered axle) or place it on swivel plates. ¹

¹ see vehicle manufacturer's instructions

- For vehicles with single-wheel suspension:
Place the wheels on swivel plates.
- Rotate the steering wheel, with and without hydraulic assistance, to the maximum lock stop.
This will cause the piston to push the sliding bush on the screw (20 and 128) up to the required cut-off position (**Fig. 15**).

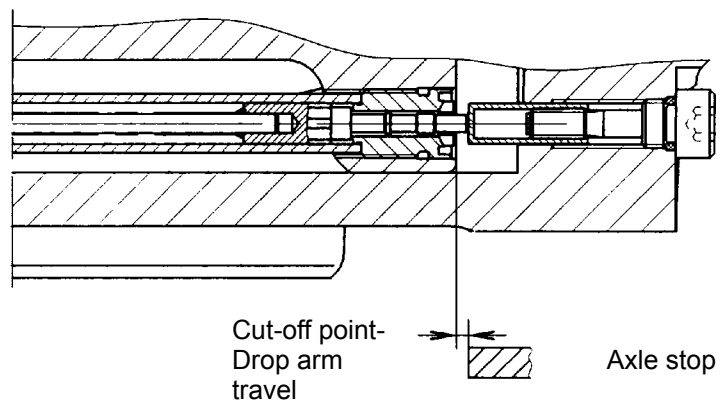
Note:

During this setting operation the steering limiter valve is constantly open which means that, with as well as without hydraulic assistance, the steering wheel can only be rotated further at an increased effort.

Repeat the setting operation for the other direction of rotation.

Fig. 15

Left-hand steering limiter valve open, oil pressure highly reduced



5.2.3 Correcting the drop arm travel

Increasing the drop arm travel:

Carry out the setting as described above.

Reducing the drop arm travel:

Fit new screws (20 and 128, respectively).



Attention:

The sliding bushes on the screws (20 and 128) may not be pulled back.

Tightening torque for the screws (20 and 128, respectively): 12+3 Nm

IV. Repair of external leakages

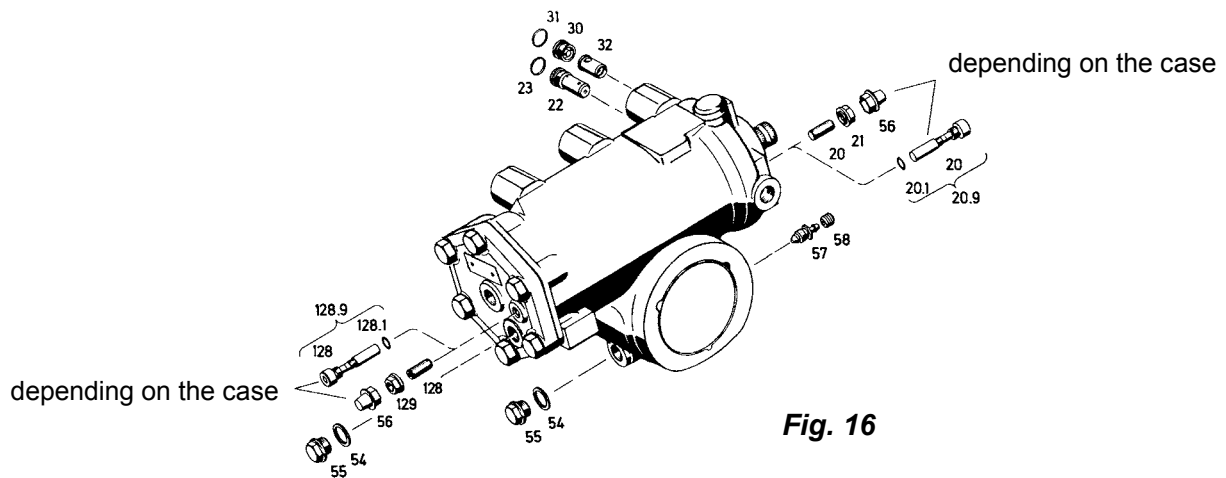


Fig. 16

- 1 Valve insert (22) - Pressure relief valve**
 Unscrew the valve insert (22) from the housing (**Fig. 16**) and remove O ring rests. If the pressure does not conform to the specified value or if there is any leakage, replace the complete valve insert (22).
 Fit a new greased O ring (23) to the valve insert (22) and screw it in again.
 Tightening torque: 30+10 Nm
- 2 Valve insert (32) - Replenishment valve**
 Unscrew the screw (30) and the valve insert (32).
 Put the valve insert (32) into the housing bore. Remove o ring rests.
 Fit a new greased O ring (31) to the screw (30) and screw it in again.
 Tightening torque: 30+10 Nm
- 3 Screws (20 and 128)**
 Screw in new screws (20 and 128)
 Tightening torque: 12+3 Nm
 Setting the steering limitation - please refer to Chapter III., para. 5.
- 4 Collar nuts (21 and 129)**
 Screw in new collar nuts (21 and 129).
 Tightening torque: 20+10 Nm
 Setting the steering limitation - please refer to Chapter III., para. 5.
- 5 Screw plug (55)**
 Unscrew the screw plug (55), fit a new sealing ring (54) and screw it in again.
 Tightening torque: 40 Nm (M16x1.5)
 50 Nm (M18x1.5)
- 6 Bleeder (57)**
 Screw in a new bleeder (57).
 Tightening torque: 30 Nm



Attention:

Apart from the work detailed above, no further repair work may be carried out. Any repair work exceeding the extent described above has to be done by a ZF Service Centre.

V. Replacing and setting the switch (222) and the potentiometer (232)

1 Replacing the switch (222)

Unscrew the switch (222) and replace it by a new one (tightening torque: 50 Nm).

Starting from mid-position, rotate the steering gear to the left and to the right. The contact of the switch (222) must open after drop arm travels of $5^\circ (\pm 10\%)$, each ($110^\circ \pm 10\%$ drop arm travel corresponding to 0.3 steering wheel turns) (**Fig. 17**). Make sure that the steer angles to the left and to the right are uniform. If required, correct the symmetry of the switching range by rotating the cover (221).

Tightening torque:

Cap screws (223): 5.5 Nm

Testing tool: Multimeter

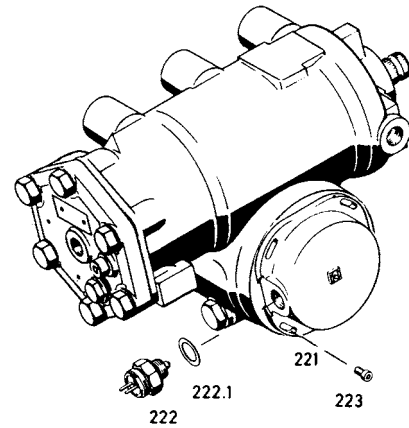


Fig. 17

Note:

The switching range is set by varying the screw-in depth of the switch (222). Washers (222.1) of different thicknesses are available to enable this setting.

Do not use more than 3 washers (222.1) for the setting operation. (A washer thickness of approx. 0.25 mm corresponds to a drop arm travel of $1^\circ - 22^\circ$ at the steering wheel). The cover (221) must be filled with 50 cm³ of oil (see list of lubricants TE-ML 09).

2 Replacing the potentiometer

2.1 Removing the potentiometer (232)

Rotate the steering gear to mid-position.

Clean the area surrounding the potentiometer (232) (**Fig. 18**).

Mark the position of the potentiometer (232).

Unscrew the cap screws (235).

Remove the potentiometer (232) along with the screening plate (234), the spacing sleeves (233) and the O ring (232).

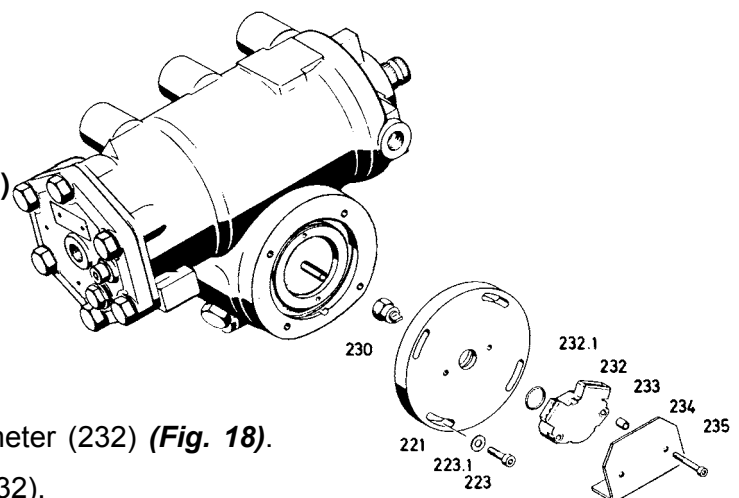


Fig. 18

2.2 Fitting the potentiometer (232) again

Check whether the steering gear is in mid-position.

Fit an O ring (232.1) to the potentiometer (232).

Place the deep groove of the potentiometer (232) drive on the carrier (230).

Note:

The slider of the potentiometer (232) being spring-loaded, it will return to its initial position when disassembled.

Therefore, check whether the potentiometer (232) can be turned through 50° minimum to either side when the steering gear is in mid-position.

Fasten the potentiometer (232) along with the spacing sleeves (233), the screening plate (234) and the cap screws (235).

Tightening torque: 2.8 Nm

Check:

The installed position of the potentiometer (232) must be identical with the position as marked during disassembly.

2.3 Setting the potentiometer (232)



Attention:

A maximum value of 6 V must not be exceeded for otherwise the potentiometer (232) would be destroyed.

The tumbler switch of the Servotronic test tester (tool [7]) must not be switched to speedo position as otherwise the potentiometer would be destroyed.

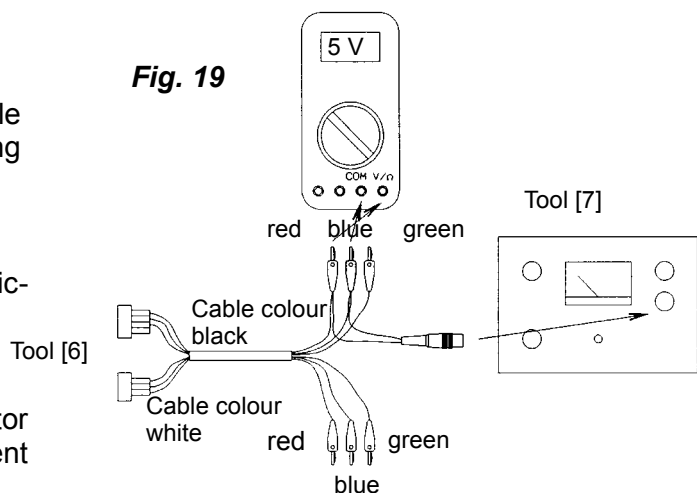
Rotate the steering gear to mid-position (dividing the total number of steering wheel turns in two).

• Setting a voltage of 5V

Connect tools [6] and [7] (or use a suitable transformer) and the Multimeter measuring instrument as shown in **Fig. 19** .

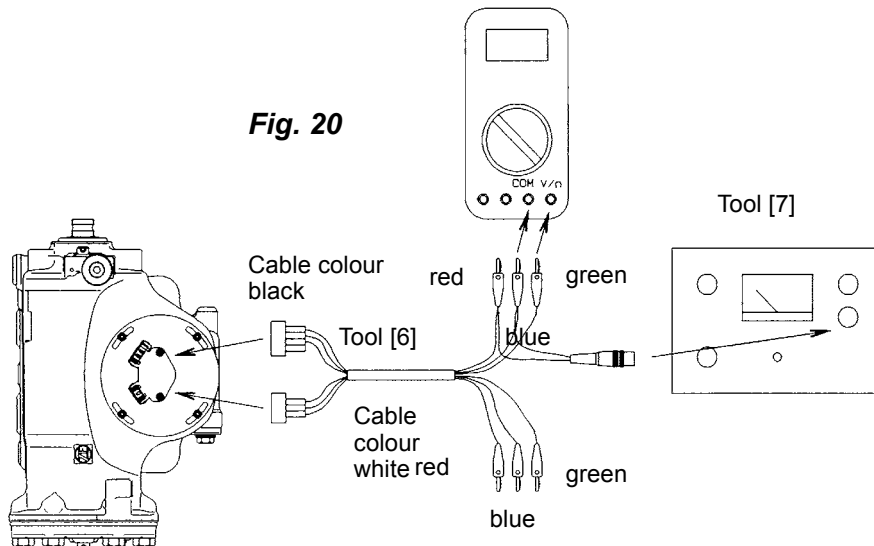
Switch the tumbler switch of the Servotronic test tester (tool [7]) to transducer position.

Continue adjusting the transducer regulator until the Multimeter measuring instrument reads 5V.



- **Setting the potentiometer (232) to steering gear mid-position**

Connect tools [6] and [7] and the Multimeter measuring instrument as shown in **Fig. 20**.



Rotate the potentiometer (232) together with the cover (221) until the Multimeter measuring instrument reads half the voltage applied, namely $2.5\text{ V} + 0.03\text{ V}$.

In this position, tighten the cap screws (223) (tightening torque: $4+1.5\text{ Nm}$).

Instructions on measurements, paths 1 and 2

Measurement, path 2:

See **Fig. 20**

Measurement, path 1:

See **Fig. 20**

Additionally:

- Plug in a jumper from blue to blue
- Plug in a jumper from red to red
- Unplug the green cable of path 2

At variance: Plug the green cable of path 1 in the Multimeter

Rotate the potentiometer (232) along with the cover (221) until the same voltage (specified value: $2.3\text{...}2.7\text{ V}$) is indicated for both paths.

In this position, tighten the cap screws (223) (tightening torque $4 + 1.5\text{ Nm}$).

Rotate the steering gear to the right-hand lock and measure the voltages of paths 1 and 2 (specified value: $0.122\text{ V...}4.88\text{ V}$).

Rotate the steering gear to the left-hand lock and, again, measure the voltages of paths 1 and 2 (specified value: $0.122\text{ V...}4.88\text{ V}$).

Note:

If the specified values are not attained, a new potentiometer has to be used.

VI. Removal and re-installation of the steering gear

1 Removing the steering gear

- 1.1 Thoroughly clean the steering gear and its immediate surroundings, in particular the pipe connections.

Drain the oil as described in Chapter III..

Take a note of the pressure and return lines' position.

Unscrew the pressure and return lines.

Obturate all oil pipes (danger of soiling).

- 1.2 Check whether the marks on the sector shaft and the drop arm coincide.

Note:

If the marks are offset from each other, prior to fitting the drop arm inquire with the vehicle manufacturer whether differing assembly instructions exist.

Screw out the locking screw (50).

Pull the drop arm off, using tool [5].



Attention:

Heating up the drop arm or driving in a wedge between the housing and the drop arm or removing the drop arm by means of hammer blows is not permitted as such action may cause changes to the material and/or inner damages to the steering gear.

- 1.3 Additionally, for vehicles with adjustable steering column:

- Adjust the driver's workplace to the topmost position to relieve the ball-track relay shaft as much as possible.
- By means of a suitable tool, for instance a ratchet belt, relieve the ball-track relay shaft in such a way that no thrust force can act towards the steering gear.

When a ratchet belt is used, pass the belt through the yoke spaces if possible (see arrows in **Fig. 21**). Tension the belt to an extent avoiding any damage to the sealing elements or the steering gear protection cap caused by a dislocation of the universal joints at the moment the clamping screws are unscrewed.

- 1.4 Unscrew the universal joint or the elastic coupling between the steering gear and the steering column or the separately mounted bevel box.

Unscrew the mounting screws and remove the steering gear.

Note:

If a fitting bolt was used, write its position down.

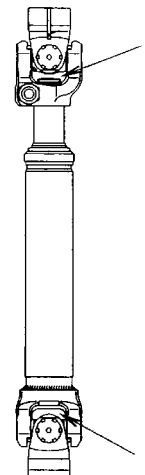


Fig. 21

2 Re-installing the steering gear



Attention:

To guarantee a safe operation of the steering system, maximum cleanliness is an absolute must when re-installing all units that are part of the system.

Note:

To avoid malfunctions caused by foreign bodies or impurities in the oil circuit of the steering gear, the plugs in the ports of the steering gear, the oil pump, the steering cylinder, the valves etc. ... should only be removed at the moment the lines are connected. Remove protecting sleeves in the installed position, only, if this is possible. Connecting lines and screwed connections must be thoroughly cleaned and deburred.

2.1 Rotate the steering wheel to the straight ahead driving position.

Clean the locating surfaces of the mounting bracket and the steering gear.

2.2 Additionally, for vehicles with adjustable driver's workplace:

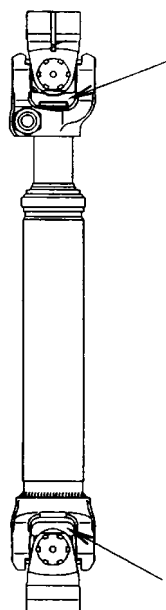
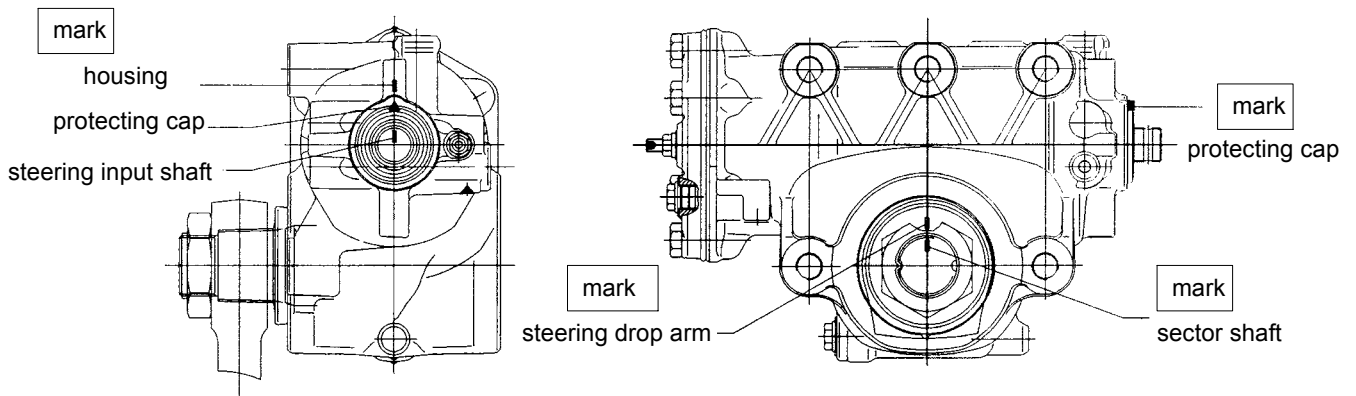


Fig. 22

Using a suitable tool, for example a ratchet belt, constrict the ball-track relay shaft until there is sufficient space for the steering gear to be built in without constricting the ball-track relay shaft any further. (**Fig. 22**).

2.3 Rotate the steering gear to mid-position by dividing the total number of steering wheel turns in two. Then continue to rotate until the marks (see **Fig. 23**) on the input shaft, the protection cap and the housing coincide.

Fig. 23



2.4 Place the steering gear into the mounting bracket and fasten it with screws.

Note:

Make sure that the position of the fitting bolt is correct.
For the tightening torque, please refer to the technical cover sheet of the spare parts list.
If no data is given in the list, the values below shall apply.

Depending on the vehicle type, space restrictions may require a previous fitment of the drop arm.

Tightening torque:

Thread	Screw grade	Tightening torque
M18x1.5	10.9	410+10% Nm
M20x1.5	10.9	520+10% Nm



Attention:

Conform to vehicle manufacturer's instructions.

2.5 Fit the universal joint or the elastic coupling between the steering column and the steering gear.

Note:

The clamping slot in the universal joint must point towards the mark on the cover cap or on the input shaft.

2.6 Additionally, for vehicles with adjustable driver's workplace:

Put the universal joint on without damaging the steering gear seal.

Tighten the clamping screw (M10x1,25) applying a torque of 48+5 Nm.

Relieve the tool, e.g. the ratchet belt (see **Fig. 22**), **cautiously** and remove it.

2.7 Move the steered wheels of the vehicle to the straight ahead driving position.

This position is reached when the steered wheels are in line with or parallel to, respectively, the second pair of road wheels (place a graduated ruler against the front and rear wheels).

2.8 Put the drop arm on the serration, making sure that the marks on the drop arm and on the sector shaft coincide (**see Fig. 23**).

Screw the locking nut (50) on and tighten it, applying the torques specified below.

- For versions with tapered serration:

Note:

For the tightening torque, please refer to the technical data sheet of the spare parts list. If no data is given in the list, the following values shall apply:

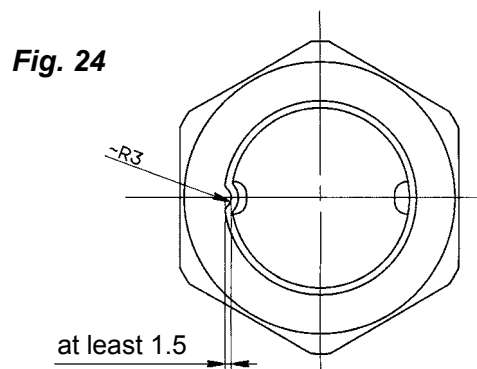
Thread	Serration	Tightening torque	Exception
M30x1.5	1 3/8"x36	250 Nm +10%	
M30x1.5	1 1/2"x36	300 Nm +10%	
M30x1.5	1 5/8"x36	330 Nm +10%	
M35x1.5		400 Nm +10%	
M42x1.5		500 Nm +10%	
M45x1.5		550 Nm +10%	MAN: 850 Nm+10%

If the vehicle manufacturer specifies different values, manufacturer's values shall apply.

- For versions with cylindrical serration and/or clamping screws:

Apply the tightening torque specified by the vehicle manufacturer.

2.9 Peen the locking nut (50) as shown in **Fig. 24**. 1



Put the drag link or the tie rod into place and tighten it. 1

Rotate the steering gear to the left until reaching the stop.

Take off the drag link or the tie rod.

2.10 Additionally, for versions with automatically adjusting steering limitation:

Unscrew the screws (20 and 128).

2.11 Check at the steering wheel whether any further movement to the left is possible.

If the steering gear cannot be rotated any further to the left, the lock stop and the axle stop, respectively, must be re-set.

 **Attention:**

It must be guaranteed that the steering angle limitation takes place at the lock stops and the axle stops, respectively, and is not done by the steering gear.

Mount the drag link or the tie rod. 1

Repeat the check for the right-hand side and, if required, re-set the lock stop and the axle stop, respectively.

2.12 Additionally, for versions with automatically adjusting steering limitation:

Screw in the screws (20 and 128). Tightening torque: 12+3 Nm

2.13 Mount the drag link or the tie rod. 1

1 see vehicle manufacturer's instructions

2.14 Connect the pressure and return lines between the pump, the steering gear and the steering cylinder according to the notes taken on the removal.

Fill the steering system with oil and bleed it.

See Chapter III.

2.15 Set the hydraulic steering limitation

See Chapter III.

2.16 Check the oil level

Before pulling out the oil dipstick, thoroughly clean the oil tank and its immediate vicinity to prevent dirt from getting into the hydraulic fluid.



Attention:

If the oil level is too low, it can entail malfunctions which, in turn, may cause a failure of the hydraulic steering assistance.

Additionally, for vehicles equipped with a ZF Servocom RAS (rear axle steering system):

Check the oil level in the straight ahead driving position.

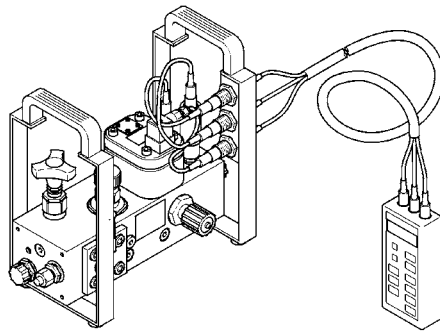
If the oil level is above the upper mark, there may be a leakage in the master cylinder of the ZF Servocom RAS.

VII. Special tools

Note:

The tools described below are universal tools. For special applications, special tools recommended by the vehicle manufacturer may therefore be necessary.

Tool [1]
ZF Servotest 600 tester



Ordering ref. No.

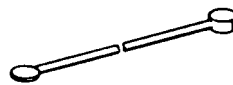
7418 798 600

Tool [2]
Dial with pointer



7418 798 452

Tool [3]
Thrust pad



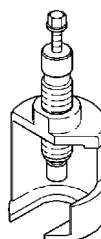
7418 798 556

Tool [4]
1 pair of expanders



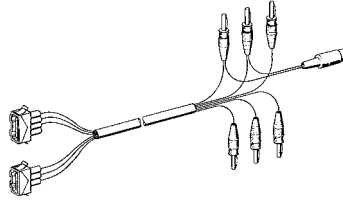
7418 798 653

Tool [5]
Extracting device



7418 798 219

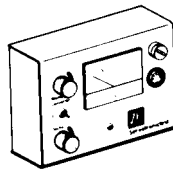
Tool [6]
Adapter cable



Ordering ref. No.

7418 798 567

Tool [7]
Servotronic test tester



7418 798 545

VIII. Troubleshooting

1 Troubleshooting on the steering system, incl. checking the hydraulic functions

1.1 Checking the play of the input shaft bearing in the steering column

By moving (shaking) the steering wheel sideward to and fro, check whether there is any play. If so, replace or repair the steering column/the bearing.

1.2 Checking the universal joint, the telescopic shaft and the bevel box for angular play or stiff operation

If play (can be identified by the noticeable rattling noise occurring when the steering wheel is turned to and fro) or stiff operation are ascertained, replace the defective components.

1.3 Checking for leakage

- Start the engine.
- Check whether all screwed connections, lines and sealing elements of the complete steering system (bevel box, steering gear, pump and steering cylinder) are leakproof.
- Check all hoses and lines, protecting caps and bellows for possible traces of chafing and embrittlement cracks.
- Switch the engine off.



Attention:

When you replace hose lines or parts with externally visible damages such as for instance cracks, only use spare parts that are pressure-tested and released by the vehicle manufacturer.

1.4 Checking the straight ahead driving position of the steering gear and the vehicle

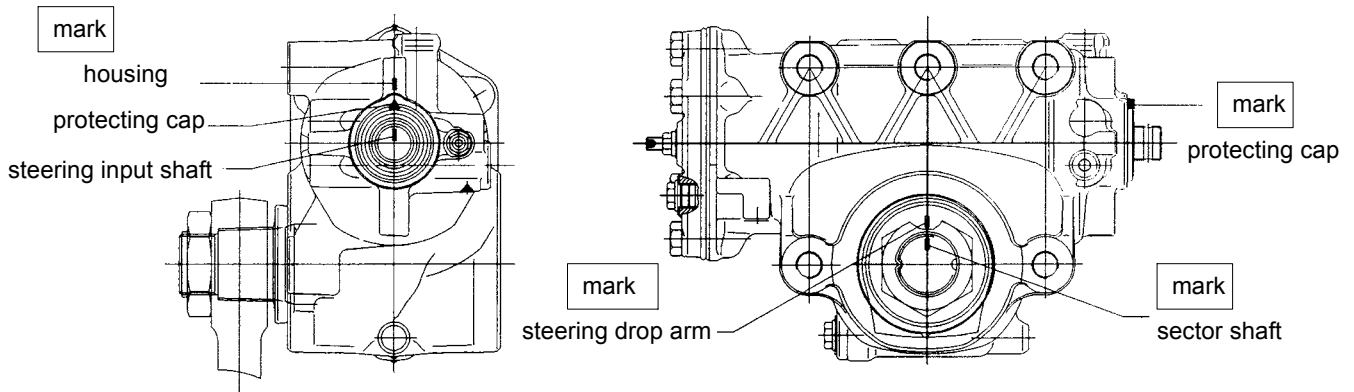


Attention:

Steering gears equipped with an automatically adjusting hydraulic steering limitation must not be rotated to the end positions if the steering linkage had been removed previously.

- Vehicles with single-wheel suspension:
Place the wheels of the steered axle on swivel plates.
- Vehicles with a rigid axle:
Jack the steered axle up. ¹
- Move the steering gear to mid-position by rotating it half the total number of steering wheel turns. Then rotate it further until the marks (*see Fig. 25*) coincide.

Fig. 25



Now turn the steered wheels to the straight ahead driving position.

Corrections can be made by screwing the ball joint on the drag link further in or out.



Attention:

If the steering wheel position is not correct or if a length correction of the steering linkage turns out to be necessary, it may well be that this necessity originates in a preceding accident-like event. We, therefore, recommend to check whether the serration of the sector shaft (30) is twisted (to do so, pull the drop arm off), whether the input shaft is installed in a twisted position and whether some or all further transmission elements are bent or have cracks. In addition, check the play as detailed in Chapter III., para. 3. Deformed components may not be re-bent to shape but must be replaced.

Additionally, for versions with automatically adjusting hydraulic steering limitation:

If required, fit new screws (20 and 128, respectively) and reset the steering limitation - see Chapter III., para. 5.

¹ see vehicle manufacturer's instructions

1.5 Checking the belt tension of the pump drive

Check the tension of the drive belt. ¹

Even at maximum pump pressure, the drive belt must transmit the power without any slip.

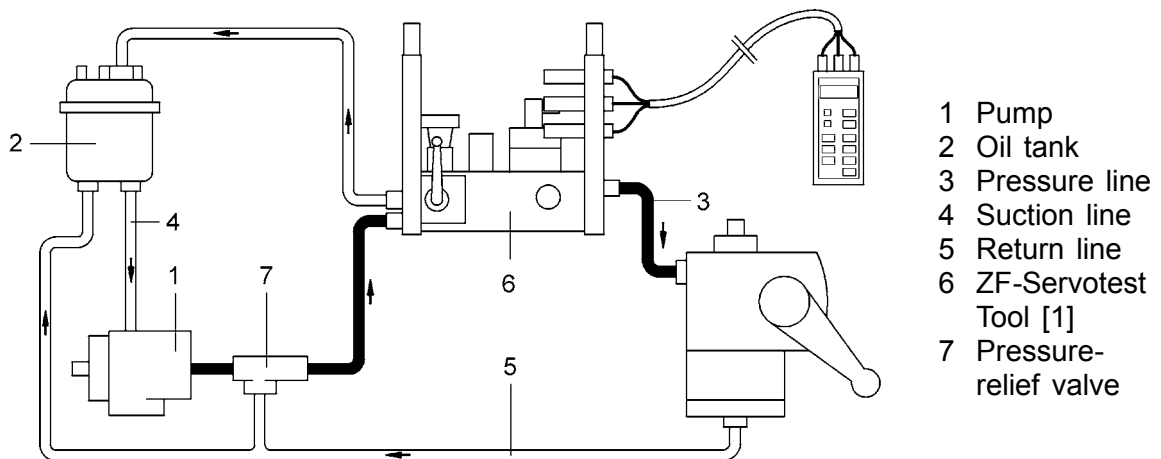
1.6 Checking the hydraulic functioning of pump and steering gear

1.6.1 Installing tool [1] (ZF Servotest tester)

For the implementation of the pressure and leakage oil tests described below, it is necessary to distinguish 2 kinds (variants ① and ②) of steering systems.

Variant ①

Steering systems with the **pressure relief valve arranged in the pump or in the pressure line between the pump and tool [1] (ZF Servotest power steering tester) (Fig. 26)**. This means that pressure relief takes place ahead of built-in tool [1]. On steering systems of this type the nameplate of the pump or of the pressure relief valve will indicate the maximum pressure, e.g. 130 bar.



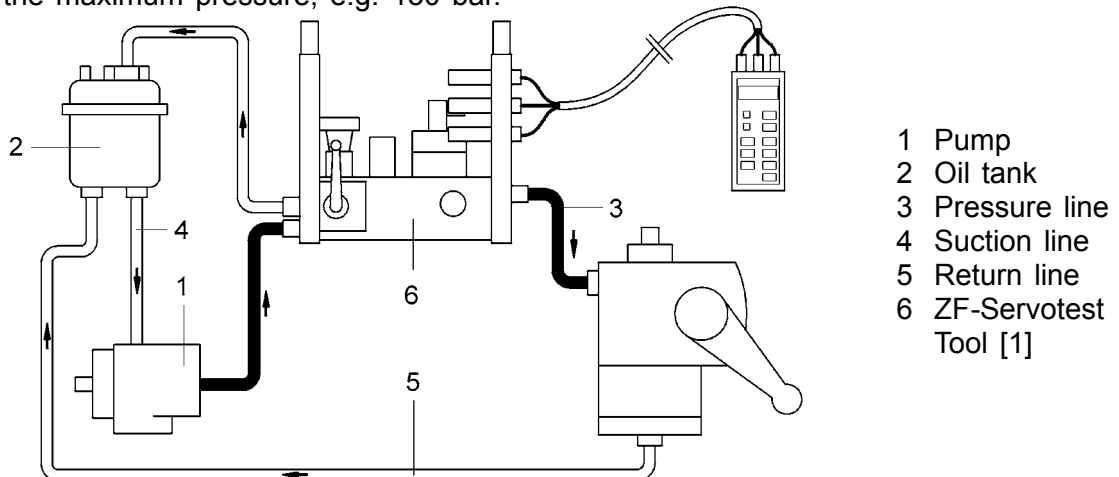
- 1 Pump
- 2 Oil tank
- 3 Pressure line
- 4 Suction line
- 5 Return line
- 6 ZF-Servotest Tool [1]
- 7 Pressure-relief valve

Variant ②

Fig. 26

Steering systems with the **pressure relief valve arranged in the steering gear or in the pressure line between tool [1] (ZF Servotest power steering tester) and the steering gear (Fig. 27)**.

On steering systems of this type the nameplate of the steering gear or of the pressure relief valve will indicate the maximum pressure, e.g. 130 bar.



- 1 Pump
- 2 Oil tank
- 3 Pressure line
- 4 Suction line
- 5 Return line
- 6 ZF-Servotest Tool [1]

¹ see vehicle manufacturer's instructions

Fig. 27

Fit tool [1] (ZF Servotest) to variants ① or ② in such a way that the readings can be seen from the driver's seat.

Check the oil level and bleed the steering system - see Chapter III.

Test conditions: oil temperature 50°C

1.6.2 Checking the maximum pressure of the ZF pump

Read the maximum permissible pressure from the nameplate of the steering gear/the pump or of the separately arranged pressure relief valve. Start the engine.

Set the pressure relief of tool [1] (ZF Servotest) to a value excluding any damages to the steering system during the tests described below.

1.6.2.1 For steering systems with pressure relief **ahead of** tool [1]: **Variant ①**

Have the engine run at idling speed.

Close the shut-off valve of tool [1] (ZF Servotest) and read the maximum pressure.



Attention:

Admit maximum pressure for a short time only (10 seconds maximum) to avoid an excessive heating-up of the inner parts of the pump and, in consequence, a premature wear of these parts.

Specified value: maximum pressure (see nameplate) +10 %

Open the shut-off valve again.

Wird der Sollwert nicht erreicht Pumpe ersetzen bzw. reparieren.

1.6.2.2 For steering systems with pressure relief **aft of** tool [1]: **Variant ②**



Attention:

If tool [1] is installed to variant ② make absolutely sure that during the entire period of pressure testing the engine is running at idling speed, only. An increase in engine speed would entail an immediate and sharp rise in system pressure which could cause a damage to the pressure line/the pump.

Have the engine run at idling speed.

While watching the pressure gauge of tool [1], slowly close the shut-off valve until the maximum pressure indicated is reached.

Do not close the shut-off valve any further. Admit maximum pressure for a short time only (maximum 10 seconds) to avoid an excessive heating of the inner parts of the pump.

Have the shut-off valve return to its initial position.

If maximum pressure is not reached during this measurement, the pump has to be replaced or repaired.

1.6.3 Checking the flow rate of the ZF pump

Note:

Specified values for flow rate, test pressure and test speed: see table below. Designations and operation of tool [1] (ZF Servotest power steering tester 6..): see separate operating instructions for ZF Servotest 6.. .

- **Checking the controlled flow rate**

Raise the engine speed until the pump flow rate remains constant despite a further increase in speed (approx. 1300 r.p.m.)

The pump is now in the flow setting range.

Specified value: see spare parts list

- **Checking the minimum flow rate**

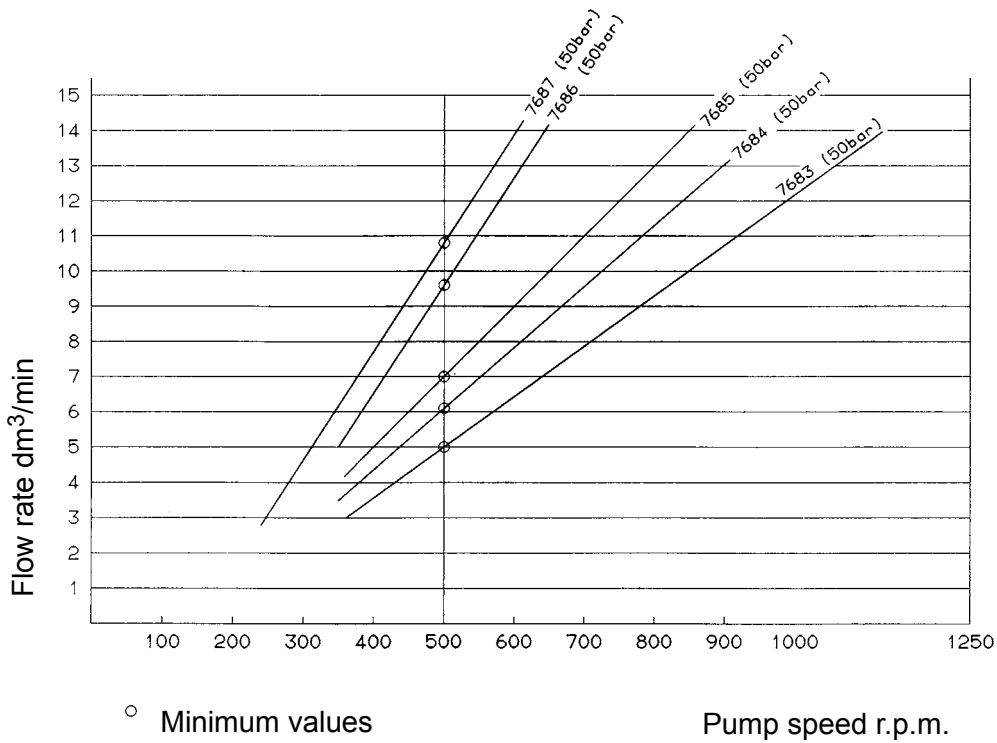
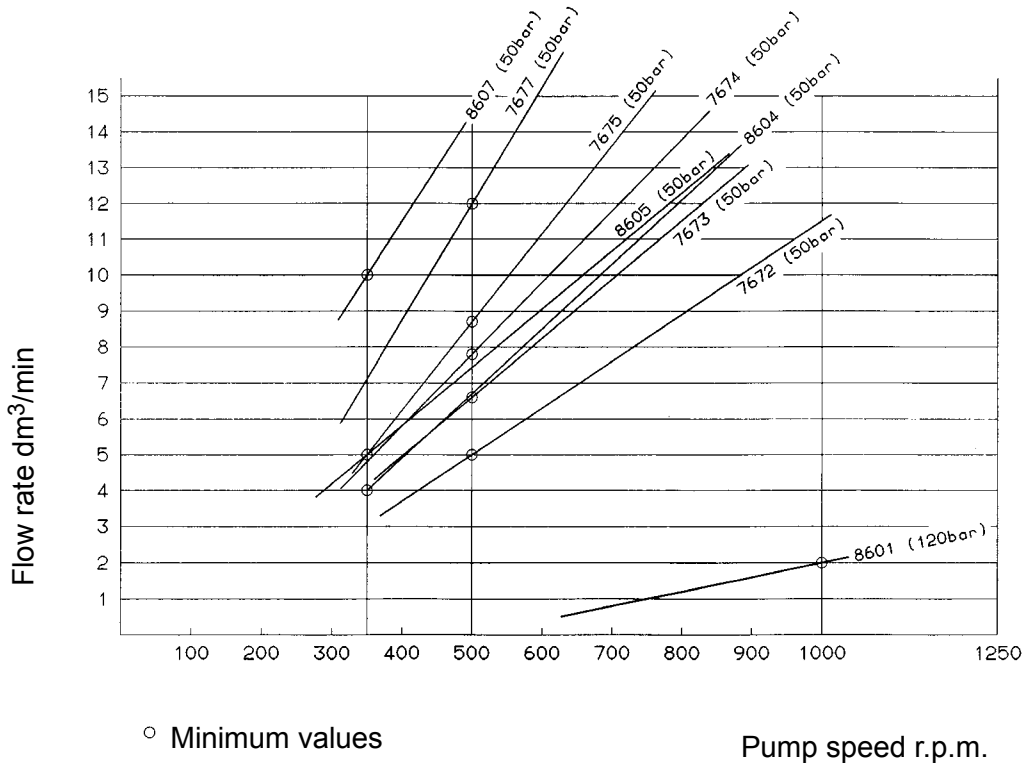
With the engine running at idling speed, progressively close the shut-off valve until the test pressure specified for the pump type in question is built up.

Read the flow rate.

Make sure the engine speed/pump speed ratio is correct.

Pump Type	Test Speed [r.p.m.]	Test Pressure [bar]	Minimum Flow Rate [dm ³ /min]
7672	500	50	5.0
7673	500	50	6.6
7674	500	50	7.8
7675	500	50	8.7
7677	500	50	12
7683	500	50	5.0
7684	500	50	6.1
7685	500	50	7.0
7686	500	50	9.6
7687	500	50	10.8
8601	1000	120	2.0
8604	350	50	4.0
8605	350	50	5.0
8607	350	50	5.0

Graphs see next page.



1.6.4 Checking the hydraulic steering limitation

1.6.4.1 Manually adjustable hydraulic steering limitation

- Vehicles with a rigid axle:
Jack the steered axle up. ¹
- Vehicles with single-wheel suspension:
Place the wheels of the steered axle on swivel plates.
- Rotate the steering wheel clockwise. When the axle stop and the lock stop, respectively, are reached, continue to rotate the steering wheel until a positive stop is reached.

In this position read the pressure at the pressure gauge:

Specified values: Steering systems	up to 16 dm ³ /min:	40...50 bar
	up to 20 dm ³ /min:	50...60 bar
	above 20 dm ³ /min:	70...80 bar

Repeat this test for the other direction of rotation.

Setting the steering limitation: see Chapter III., para. 5.

1.6.4.2 Automatically adjusting hydraulic steering limitation

Carry out the test as described in para. 1.6.4.1.

If there is no more space left at the lock stop components or if the oil pressure does not drop to the specified value, fit new screws (20) and (128), respectively, and reset the steering limitation as specified in Chapter III., para. 5.

Specified values: Steering systems	up to 16 dm ³ /min:	40...50 bar
	up to 20 dm ³ /min:	50...60 bar
	above 20 dm ³ /min:	70...80 bar

If there is too much space available at the lock stop components and if the oil pressure does not drop to the specified value, reset the steering limitation as specified in Chapter III., para. 5.

Repeat this test for the other direction of rotation.

¹ see vehicle manufacturer's instructions

1.6.5 Checking the maximum pressure and the leakage oil of the steering gear

For steering systems with pressure relief ahead of tool [1]: Variant ①

Between the lock stops, insert tool [3] or approx. 15 mm thick thrust pads (**Fig. 28**) ensuring that the steering motion is stopped 1/2 to 3/4 steering wheel turn before reaching the axle stop/lock stop. The restriction of the steering motion must take place at tool [3] or at the said thrust pads and must not be done by the piston in the steering gear.

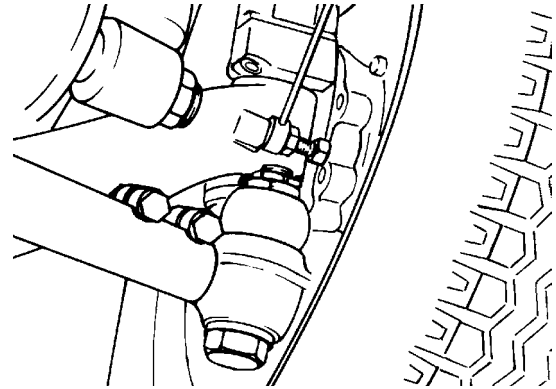


Fig. 28



Attention:

A tool under pressure may be ejected - avoid any direct visual contact with the tool. Danger of accidents by squeezing.

Use the special tool specified by the vehicle manufacturer for the axle version in question.

At engine idling speed, rotate the steering wheel to the stop and continue to turn for abt. 5 seconds with an effort of 100...200 N at the steering wheel. Read the maximum pressure and the leakage oil.

Repeat this test in the opposite direction of rotation.

Maximum permissible leakage oil values:	Type 8090:	2.0 dm ³ /min
	Types 8095...8098:	2.5 dm ³ /min

Checking the leakage oil at a reduced flow rate:

Set tool [1] (ZF Servotest) 6.. to a flow rate which is 0.5 dm³/min higher than the maximum permissible leakage oil value.

Repeat the leakage oil test as described above. The leakage oil value measured in this repetition test must not exceed the value measured previously - see above.

Cause of insufficient maximum pressure/too much leakage oil:

- Pressure relief valve and/or replenishment valve defective.
- Pressure cut-off of steering limitation valve comes too early - refer to Chapter III., para. 5 for setting.
- Seals in the steering gear defective.

For steering systems with pressure relief aft of tool [1]: Variant ②

The shut-off valve (4) must be closed completely and the throttle valve (5) must be closed progressively until a pressure is achieved that is 30 bar lower than maximum pressure. Re-open the shut-off valve (4).

Repeat this test as described above.

1.6.6 Checking the return to neutral of the valve

Note:

Make sure the steering column has sufficient clearance (floor carpets, coverings).

By rotating the steering wheel, close the steering valve, thus causing maximum pressure to build up. Then rotate the steering wheel back until idle pressure is available. Next, raise the pressure to idle pressure +10 bar.

Release the steering wheel and watch the pressure which must drop to idle pressure (at maximum 0.5 bar higher) within 1 second.

Example: Idle pressure: 4.0 bar Maximum permissible value: 4.5 bar

1.6.7 Checking the steering gear play

Prerequisite for the test described below:

The transmission parts between the steering wheel and the road wheel must be free from play.

- Versions with leaf spring:

Lock the LH front wheel (the RH front wheel if the vehicle is RH steered) in the straight ahead driving position by fitting tool [4] between the wheel rim (rear and front) and the front spring (**Fig. 29**).

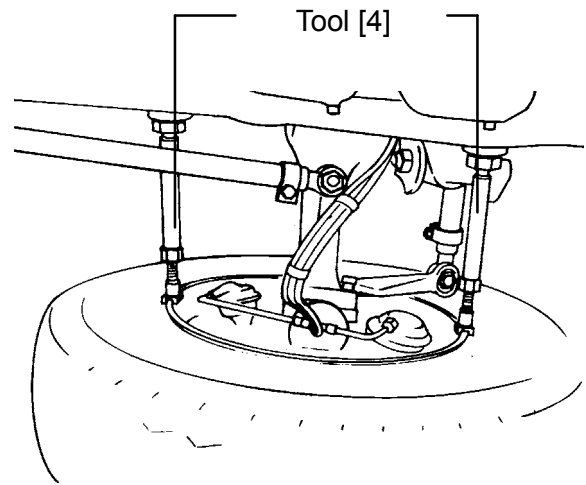


Fig. 29

Attention:

Do not exert any pressures in excess of those mentioned below on the tools and the wheel rim in order to avoid damages to the wheel rim.

- Versions with single-wheel suspension:

Lock the LH front wheel (the RH front wheel if the vehicle is RH steered) as per vehicle manufacturer's instructions.

- Put tool [2] on the steering wheel and attach the pointer to the dashboard or to the wind-screen (**Fig. 30**).

Raise the engine speed to approx. 1000 r.p.m..

Read the idle pressure at tool [1] (ZF Servotest/pressure gauge).

Rotate the steering wheel to the left until a pressure of 1 bar above idle pressure is indicated.

On tool [2] read the dial value.

Rotate the steering wheel to the right until a pressure of 1 bar above idle pressure is indicated.

On tool [2] read the dial value.

Calculate the total travel covered.

Specified value: max. 50 mm (steering wheel Ø 500 mm)

For versions with bevel box:

Specified value: max. 55 mm (steering wheel Ø 500 mm)

If the maximum value is exceeded, check the play of the steering column and, if required, repair or replace the steering gear.

Remove tool [1] (ZF Servotest)/the pressure gauge.

Check the oil level and bleed the steering system - see Chapter III.

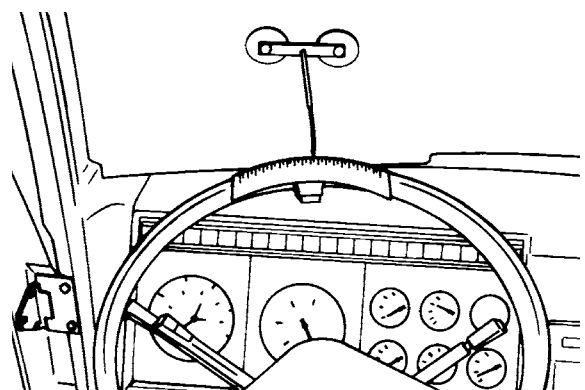


Fig. 30

2 Troubleshooting aid

Fault	Cause	Remedial action
Noise	Air in the oil Oil level too low	Bleed steering system ³ Top up with oil
	Pump defective	Repair ² Replace ²
Stiff operation to either side	Oil level too low	Repair leakage Top up with oil ³
	Steering system is sucking in air (Suction area)	Repair leakage Top up with oil ³ Bleed steering system ⁴
	Universal joints/steering column Stiff operation	Check Replace ¹
	Oil filter soiled	Replace ³
	Steering gear defective	Repair ² Replace ²
	Pump defective	Repair ² Replace ²
Stiff operation in one direction	Incorrect setting of steering limitation	Set ³
	Steering gear defective	Repair ² Replace
Stiff operation during fast steering motion	Steering system is sucking in air (Suction area)	Repair leakage Top up with oil Bleed steering system ³
	Pump defective or wrong version	Replace pump ²

¹ see vehicle manufacturer's instructions

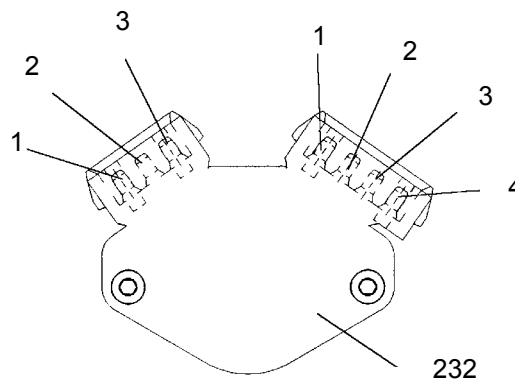
² approach ZF Service Centre

³ see Chapter III.

Fault	Cause	Remedial action
Self-centring hampered	Stiff operation of axle/ axle guide components	Repair [1]
	Steering gear/steering column fitted in twisted position	Eliminate twisting [1]
	Stiff operation of steering column	Eliminate stiff operation [1]
	Steering gear defective	Repair [2] Replace [2]
Exact straight ahead driving impossible	Oil level too low	Repair leakage Top up with oil [3] Bleed steering system [3]
	Axle/axle guide components/ steering column not play-free	Check [1] Replace [1]
	Steering gear not play-free	Check [3] Replace [2]

Additionally, for versions with potentiometer (232):

Pin assign-
ment at poten-
tiometer and
plug, respec-
tively (vehicle
electrical sys-
tem)



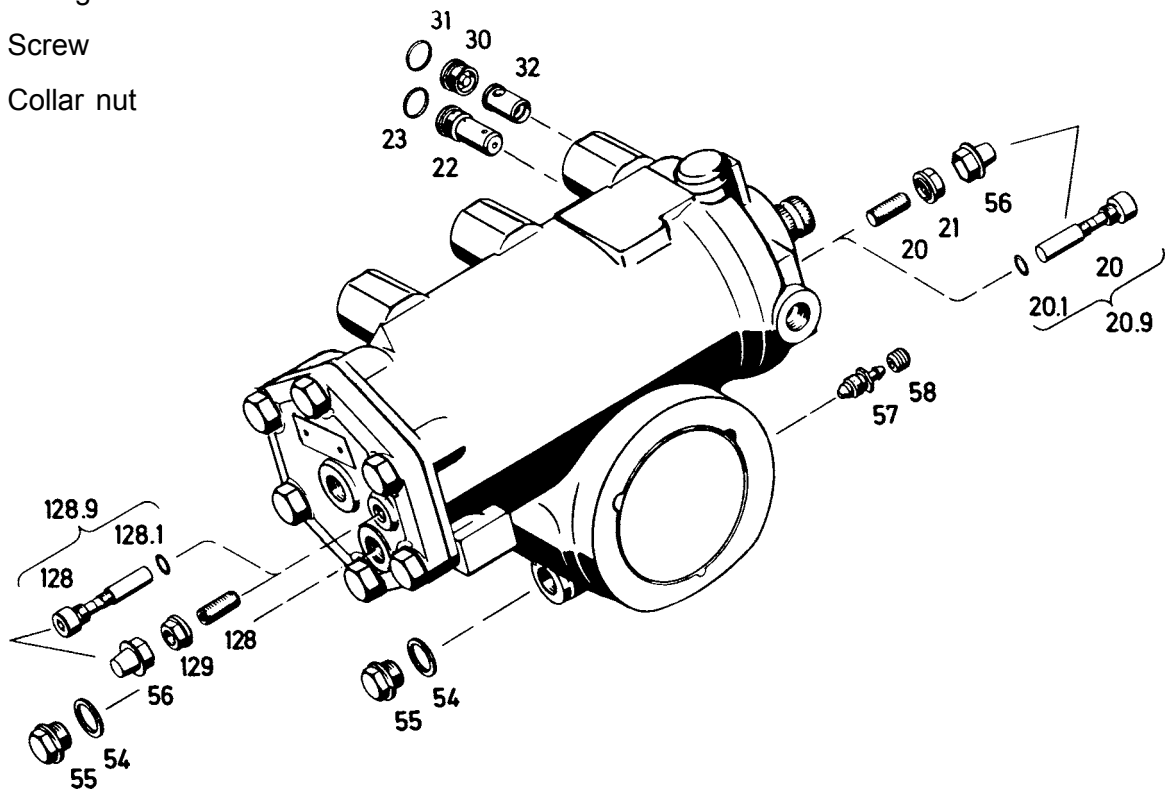
Potentiometer (232) does not work	No operating voltage	At plug (vehicle electrical sys- tem) measure between pins 1-3 Specified value: operating volt- age [1]
	Contact problems	Remove dirt and/or corrosion

Fault	Cause	Remedial action
	Internal malfunction	Check potentiometer (see below)
	No tripping of potentiometer (232)	Replace steering gear ²
Wrong operation of potentiometer (232)	Wrong setting	Set potentiometer ⁴
	Wrong cabling	Check cabling ⁴
	Cap screws (223 and 235) loose	Check and tighten ⁴
	Potentiometer (232) mounted incorrectly	Check ⁴

- ¹ see vehicle manufacturer's instructions
- ² approach ZF Service Centre
- ³ see Chapter III.
- ⁴ see Chapter V.

IX. Key to numbers in figures and exploded drawing

- 20 Set screw/screw
- 20.1 O ring
- 20.9 Screw
- 21 Collar nut
- 22 Valve insert
- 23 O ring
- 30 Screw
- 31 O ring
- 32 Valve insert
- 54 Sealing ring
- 55 Screw plug
- 57 Bleeder
- 128 Set screw/screw
- 128.1 O ring
- 128.9 Screw
- 129 Collar nut



Maintenance Report for ZF Servocom Steering Gears

Original for duplicating



Customer: Steering gear version:

Vehicle manufacturer: Pump manufacturer:

Vehicle type (or model): Pump version:

Mileage: Emergency steering pump:

1 Test drive carried out yes no

Complaints:

2 Tested or checked for external leakproofness / damages yes no

Complaints:

3 Oil level checked yes no

Remarks:
.....

Checked by (name): Date:

Inspection Report for ZF Servocom Steering Gears

Original for duplicating



Customer: Steering gear version:

Vehicle manufacturer: Pump manufacturer:

Vehicle type (or model): Pump version:

Mileage: Emergency steering pump:

1 Inspection intervals (see Chapter III.)

2 Test drive carried out yes no

Complaints:

3 Visual inspection carried out yes no

Complaints:

4 Oil filter replaced yes no

5 Steering gear play checked yes no

Specified value: Measured value: mm

max. 50 mm

max. 55 mm (for versions with bevel box)

6 Safety inspection (SP) checks carried out yes no

Remarks:

Checked by (name):

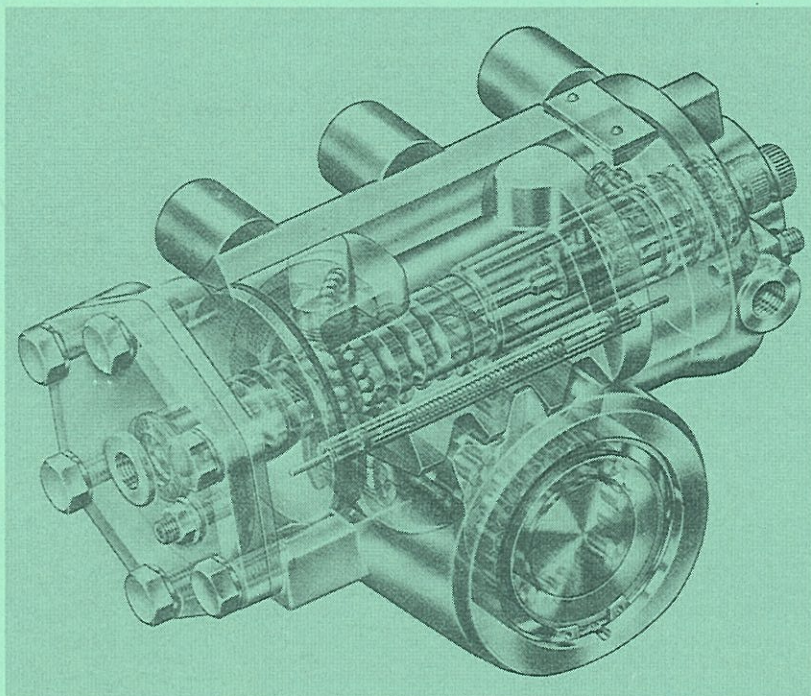
Date:



ZF-Servocom

**Types 8090 - 8099
(Single and dual-circuit versions)**

Repair Manual



**ZF-FRIEDRICHSHAFEN AG
Geschäftsbereich Lenkungstechnik**

D- 73522 Schwäbisch Gmünd

Telephone (07171)31-0
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Telex 7248801
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- The present Manual aims to help the user properly to execute the necessary maintenance and repair work on the ZF product.
- Read the Manual before starting any inspection and repair work.
- On completion of the maintenance and repair work, the specialist personnel must make certain that the product is once more operating flawlessly.

→ ***Please note that the ZF product must be repaired only in workshops that***

- ☞ ***employ trained personnel***
- ☞ ***have the prescribed equipment, including a test rig, crack detector and special tools***
- ☞ ***use ZF genuine spare parts.***

- This Manual is only for foremen and fitters who have undergone practical and theoretical training in our Customer Service School. Together with service information bulletins, it is intended to supplement their knowledge.
- All work carried out on ZF products must be executed with extreme care and diligence. This applies in particular to products and transmission components from vehicles damaged in accidents.
- The manufacturer does not, of course, accept any liability for damage and its consequences arising from incorrectly or inexpertly executed repairs.
- This Manual draws attention to notes on safety as follows:

Note: Where incorrect and careless work can cause damage to the product.



Attention: Where incorrect and careless work can lead to personal injury and endanger life.

- This Manual is not part of the updating service.
 - The contents of the additional service information bulletins must also be observed.
-



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I. Disassembly



Attention:

Utmost cleanliness must be maintained when disassembling and storing the parts in order to ensure that the steering operates reliably. Force must never be used when disassembling parts, as this may damage the sealing ring seats, sealing faces, etc. The resultant damage may lead to partial or total failure of the steering.

Notes:

- The figures in round brackets, e.g. (348), refer to the part numbers used in Chapter VIII and the list of spare parts.
- The figures in square brackets, e.g. [1], refer to the special tools listed in Chapter VII.

1 Preparing the steering for disassembly

Clamp steering in tool [1] or between the soft jaws of a standard vice.

Turn the steering through from end to end and note the total number of turns (reference value for function tests).

Set the steering to straight-ahead position (half the total number of turns) and check or restore the markings for straight-ahead.

2 Removal and disassembly of the bevel box

2.1 Versions with cross disc (348)

2.1.1 Remove bevel box

Mark position of bevel box and intermediate flange (335).

Unscrew cap screws / hexagon screws (352) with washers (350) (*Fig.1*).

Remove complete bevel box.

Remove shim plate (330) and O-ring (333).

2.1.2 Disassembly of intermediate flange (335)

Unscrew cap screws (334).

Remove intermediate flange (335) with cross disc (348) and ball bearing (343).

Remove O-ring (341).

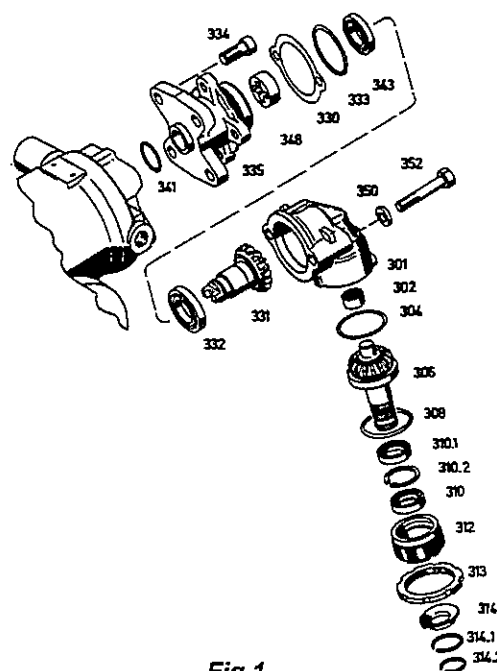


Fig.1

2.1.3 Disassembly of bevel box

Note:

The bevel gear (306) must not be forced off in order to replace the ball bearing, as it cannot be ensured that the notched gearing locks securely when the bevel gear (306) is pressed into position a second time.

Remove snap ring (314.1 and 314.2) and draw dust seal (314) off steering shaft stub.

Unscrew slotted nut (313) and unscrew adjusting screw (312) from housing with tool [25].

Remove O-ring (308). Remove shaft seal (310), retaining ring (310.2) and shaft seal (310.1).

Draw bevel gear (306) out of housing with ball bearing. Remove washer (304).

Note:

Needle sleeve (302) should only be removed if the bearing journal of the bevel gear assembly is found to be damaged. If necessary, needle sleeve (302) can be drawn out with tools [26] and [27].

Dismantle ball bearing (332) and remove bevel gear (331).

2.2 Versions with coupling sleeve (349)

2.2.1 Remove bevel box

Mark position of bevel box in relation to housing (1).

Unscrew hexagon screw (352) and remove complete bevel box (*see Fig.4*).

Remove coupling sleeve (349), centering ring (346) and O-ring (333).

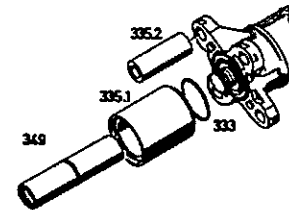


Fig.2

2.2.2 Remove pipes

Remove pipes (335.1 and 335.2). Dismantle O-ring (333) (*Fig.2*).

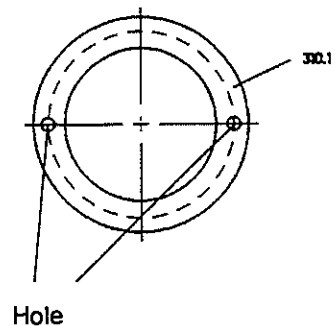


Fig.3

2.2.3 Disassembly of bevel box

Remove protecting cap (314) and draw off shaft seal (310) with tool [33] (*see Fig.4*).

Unspring retaining ring (310.2). Drill holes through shaft seal (310.1) as shown in *Fig.3* (diameter of holes approx. 0.3 mm smaller than core diameter of the sheet metal screws required to pull out the shaft seal).

Screw in the sheet metal screws and pull out complete with shaft seal (310.1) with the aid of two pliers.



Unspring retaining ring (310.3) and remove any burr produced (*Fig.4*).

Clamp bevel gear (306) in soft jaws and drive it out of the housing by knocking against the housing (301) with a plastic mallet.

Unspring retaining ring (310.4), remove any burr produced and remove the bevel gear (331).

Note:

Needle sleeves (302) should only be removed if the bearing journal of the bevel gears (306 and 331) is damaged.

Use tools [27] and [34] for this purpose.

Tool [35] must also be used additionally to remove the lower-level needle sleeve (302).

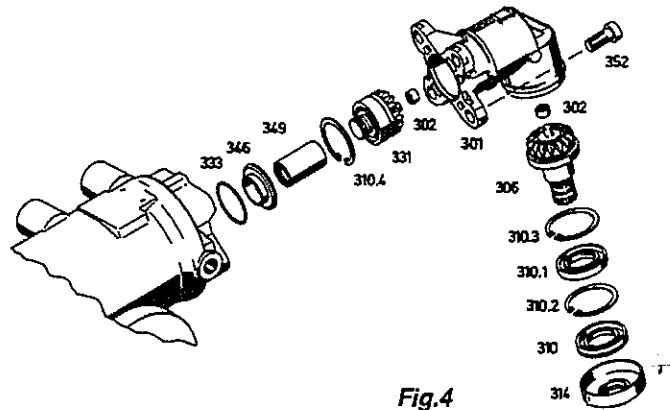


Fig.4

3 Removal and disassembly of valve housing (203)

Remove protecting cap (53) and gasket (53.3) (*Fig.5*).

Mark position of valve housing (203).

Remove piping (225 and 226) and pipe unions (205 and 206) in the case of versions with add-on cylinder (250) *see Fig.8*.

Unscrew cap screws (204) and lift off valve housing (203).

Remove control sleeve (174), bearing ring (201) and ball cage (200).

Dismantle screw (30) with O-ring (31) and valve insert (32) (replenishing valve).

Unscrew valve insert (22.1) with O-ring (23) (pressure limiting valve).

Note:

Valve inserts (22.1 and 32) cannot be dismantled. The complete valve insert must be replaced if a fault develops.

Remove sealing elements (8 and 202).

Unscrew adjusting screw (20) and remove O-ring (20.1).

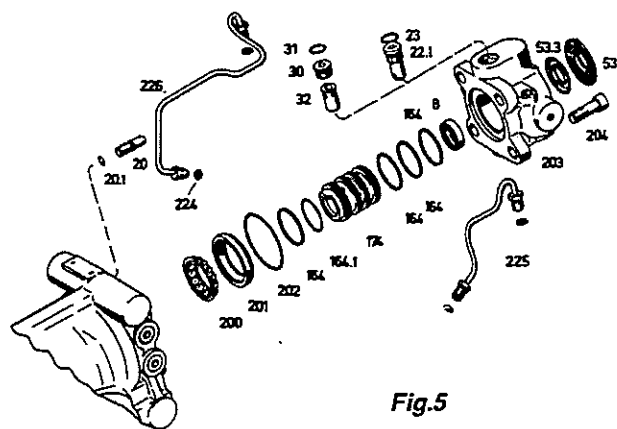


Fig.5

4 Removal and disassembly of housing cover (221)

4.1 Versions with valves (36) - steering limiter valves

Unscrew hex nut (38) and remove washers (37) (*Fig.6*).

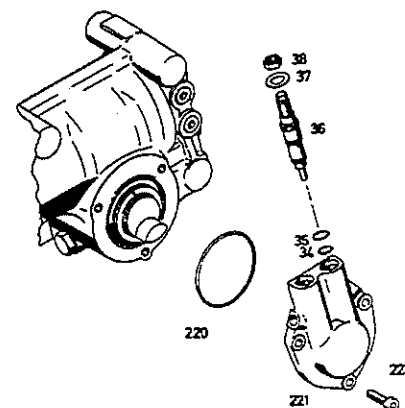


Fig.6

Disassembly

Unscrew valves (36) and remove O-rings (34 and 35). Remove cap screws (223) and lift off housing cover (221).

4.2. For versions with switch (222)

Mark position of cover (221) in relation to housing (1). Unscrew cap screws (223) and remove cover (221) with cam disc (227) and retaining ring (228) (*Fig.7*).

Remove O-ring (220). Unspring retaining ring (228) and remove cam disc (227).

Remove switch (222) with washer (222.1).

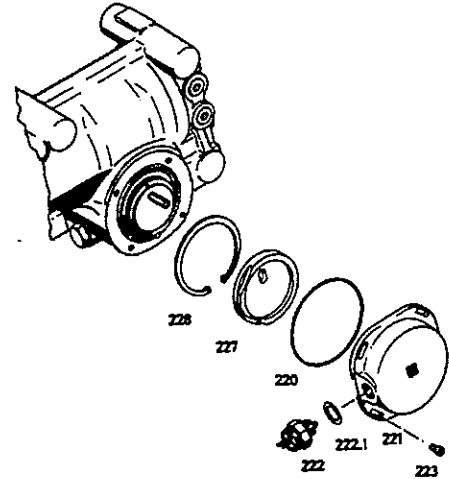


Fig.7

5 Removal and disassembly of add-on cylinder (250)

Unscrew pipe unions (205 and 206).

Unscrew hexagon screws (252) with washers (251) and remove add-on cylinder (250) (*Fig.8*).

Unspring retaining rings (261). Prise off cylinder cover (259) and remove O-ring (260).

Draw out piston (258) and remove gaskets (257) and O-rings (256).

Remove gear (254) and bush (253), as well as O-ring (255).

Unscrew Torx screws (250.1).

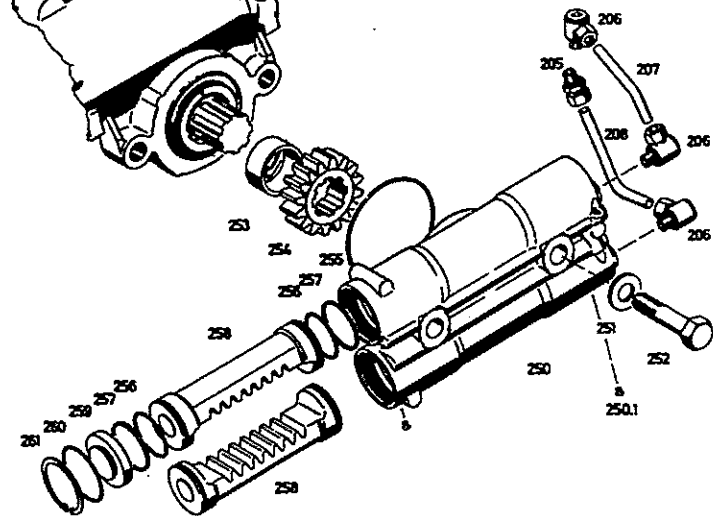


Fig.8

6 Removal and disassembly of cylinder cover (125)

Unscrew hexagon screws (127) with or without washers (126) (*Fig.9*).

Note:

Retract piston (101) towards bottom of housing so that the valve tappet of valve insert (109) is not damaged when turning the cylinder cover (125).

Slip steering drop arm onto sector shaft (80).

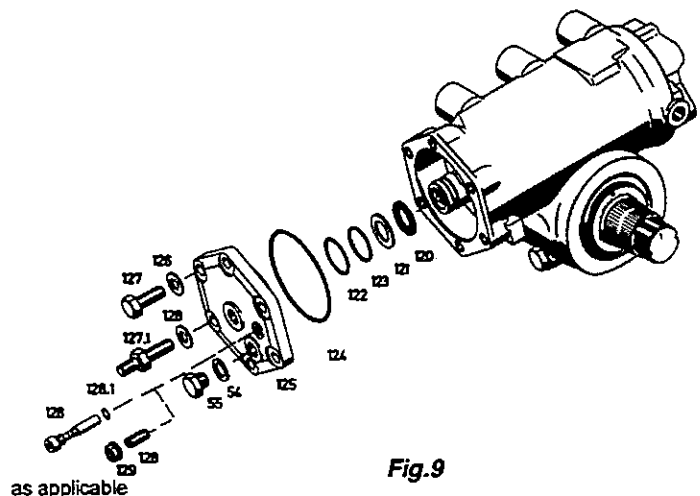


Fig.9

Disassembly

Turn worm (151) to remove cylinder cover (125).

Remove needle cage (120) and washer (121). Remove screw (128) and O-ring (128.1) and set aside for later use (required for function tests, chapter IV).

Remove sealing elements (122, 123 and 124). Unscrew screw plug (55) with sealing ring (54).

Unscrew set screw (128) and collar nut (129).

7 Removal and disassembly of piston (100)

7.1 Draw piston (100) out of housing (1) together with worm (151), turning the steering drop arm which is still mounted on the sector shaft (80) at the same time (**Fig.10**).



Attention:

The tappet of the valve insert (109) (*see Fig. 13*) installed in piston (101) must not be damaged.

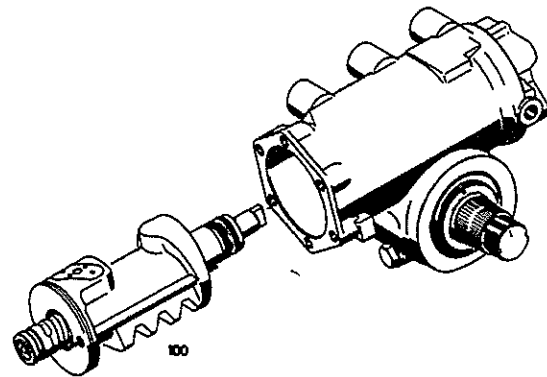


Fig.10

7.2 Remove gasket/plug (112) complete with compensating plate (113.1), gasket (113), sealing elements (114 and 115), pin (113.2) and recirculating half tubes (111) (**Fig.11**).

Turn worm (151) to release the balls (110) and carefully set them aside for later use.

Remove sealing elements (116, 117, 118 and 119).

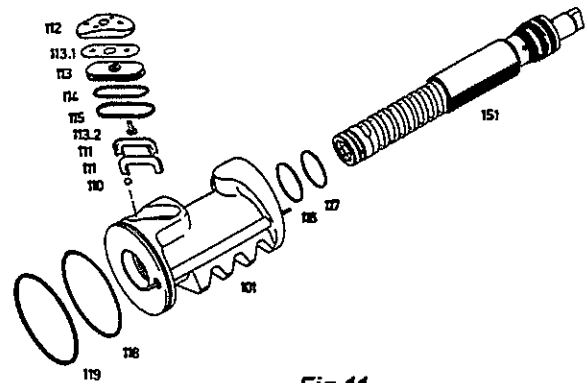


Fig.11

7.3 Check the valve insert (109) installed in piston (101) (*see Fig.13*) for radial or axial play, mechanical damage and any internal leaks.

Check caulking of valve insert (109).

The complete valve insert (109) must be replaced if any of the above defects is observed.

7.3.1 Versions with caulked valve insert (109) - steering limiter valve

Position piston (101) upright so that the caulking on valve insert (109) points upwards (**Fig.12**).

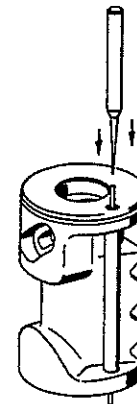


Fig.12

Disassembly

Using a cylindrical punch, dia. 4.5 mm, press tappet inwards and drive valve insert (109) down and out.

7.3.2 Versions with screwed valve insert (109) - steering limiter valve

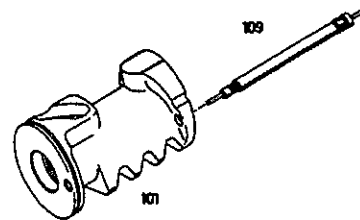


Fig.13

Release caulking and screw valve insert (109) out of piston (101) with tool [2] (Fig.13).

8 Disassembly of worm (151)

8.1 Unspring snap ring (155) and pull off sliding tube (156) (Fig.14).

Remove plug (163) and pin (162).

Remove sealing elements (158, 159, 164).

Further disassembly of the worm (151) is not permitted, since the hydraulic centre is then no longer set correctly.

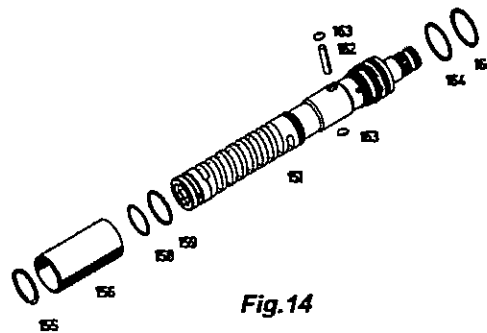


Fig.14

8.2 Exception:

Sealing ring (170) may be replaced by specially trained personnel:

Mark position of valve slide (168) and worm (161) (Fig.15).

Remove caulking from worm (161).

Drive out pin (160).

Pull valve slide (168) out of worm (161) together with torsion bar (165).

Remove O-ring (169) and sealing ring (170).

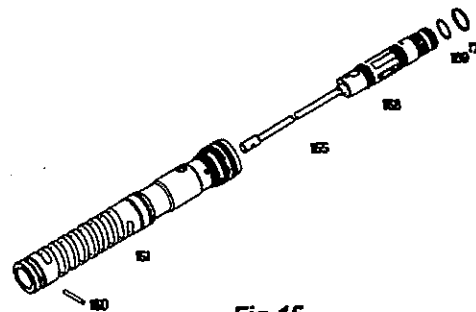


Fig.15

8.3 Additionally required for dual-circuit versions:

Remove sealing elements (172 and 173) (Fig.16).

Remove sealing rings (164) and O-ring (164.1) from control sleeve (174).

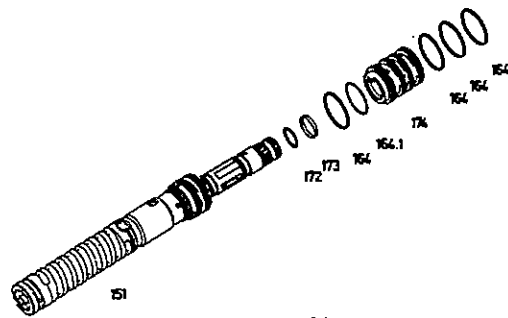


Fig.16

9 Removal of sector shaft (80)

Remove dust seal (51), stop-ring (51.1), gasket (51.2) and plug (52) on both sides (Fig.17).

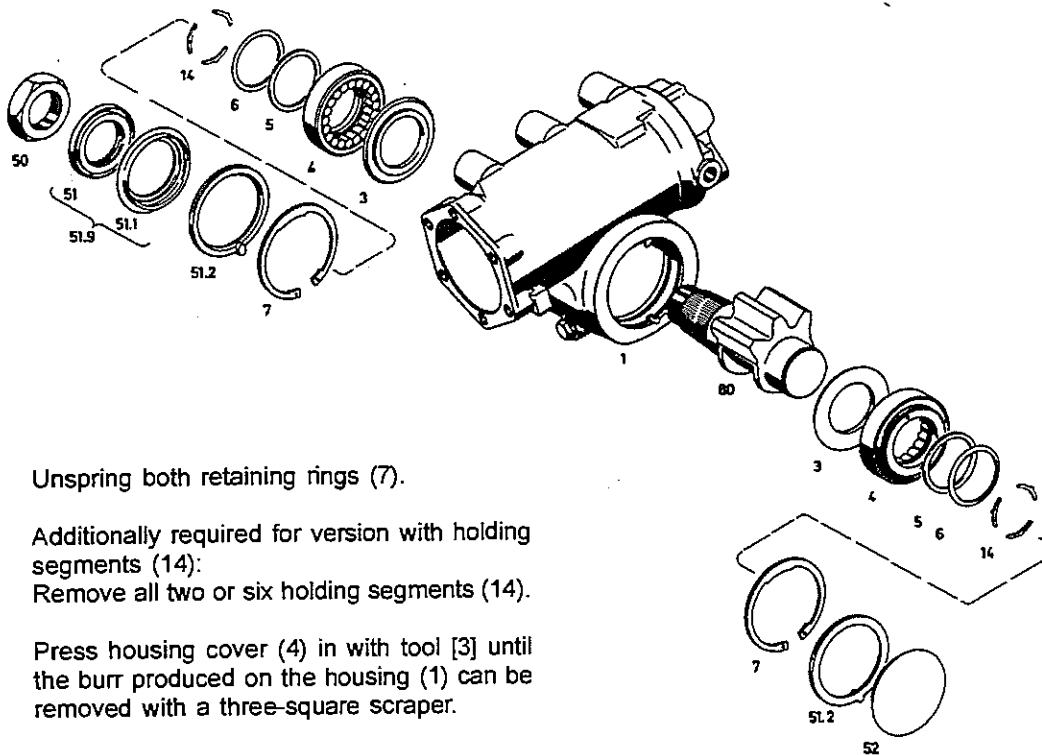


Fig.17

Unspring both retaining rings (7).

Additionally required for version with holding segments (14):
Remove all two or six holding segments (14).

Press housing cover (4) in with tool [3] until the burr produced on the housing (1) can be removed with a three-square scraper.

Remove chips.

Draw housing cover (4) out with tool [4].

Note:

The spindle of tool [4] must not be inserted in the centering bore of the sector shaft (80), otherwise the sector shaft (80) may tilt due to eccentricity.

Draw support rings (6) and gaskets (5) out of the grooves.

Disassembly

Notes:

- The housing covers (4) must not be refitted in the same position otherwise they cannot be caulked correctly.
- The individual rolls must not be exchanged between housing covers (4).
- If one of the rolls is defective, the complete housing cover (4) must be replaced.

Draw washers (3) off the sector shaft (80).

Mark the side on which the notched serration of the sector shaft (80) is installed.

Remove sector shaft (80) from housing (1).

10 Disassembly of housing (1)

10.1 Remove needle cage (10), washer (9) and shaft seal (8) from housing (1) (**Fig.18**).

Remove O-rings (2).

Disassemble set screw (20) with collar nut (21) or screw (20) with O-ring (20.1) and set aside for later use (required for function testing).

Unscrew screw plug (55) with sealing ring (54).

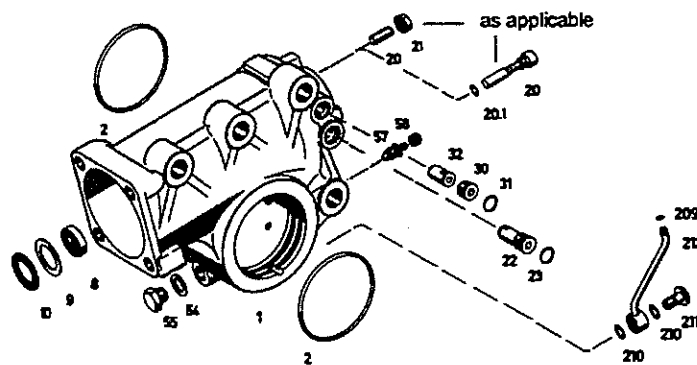


Fig.18

Remove breather (57) with protective cap (58).

Unscrew screw (30) with O-ring (31) and remove valve insert (32) - replenishment valve.

Unscrew valve insert (22) - pressure limiting valve - with O-ring (23).

Note:

Valve inserts (22 and 23) cannot be disassembled. The complete valve inserts must therefore be replaced if a defect develops.

10.2 Additionally required for versions with pipe (212)

Unscrew union screw (211).

Remove pipe (212) with O-rings (209 and 210).



Examining the individual parts

II. Examining the individual parts

- All parts must be cleaned thoroughly.

Note:

Sealing rings and other rubber parts must not be allowed to come in contact with chlorinated hydrocarbons, as they may swell.

- All parts must be examined for wear, corrosion, pressure damage or other defects and assessed from the point of view of reusability.
- Flange faces and sealing faces (e.g. the mating faces of sealing rings) must be repolished or ground if necessary.



Attention:

Experience and a conscientious approach are essential when examining the parts. The fitter must personally decide whether or not the parts need to be replaced.

The following must be examined:

1 Housing (1)

- Cylinder bore: minor scoring must be eliminated by removing the elevations, e.g. with the aid of a serrated washer.
- Recesses in retaining rings: any elevations must be removed to avoid scratches when fitting the housing covers (absence of leaks).
- Running faces of the worm head (151)
- Screw thread
- Outer seat of shaft seal must be examined for signs of rubberization
- Face side of housing must be examined for signs of sag due to sudden, accidental impacts around the axial needle bearing for the worm. Apply a ruler to the machined face side for the protecting cap (53). Housing (1) must be replaced if a distinct sag is evident.

2 Cylinder cover (125)

- Outer seat of shaft seal must be examined for signs of rubberization
- Face side of cover must be examined for signs of sag due to sudden, accidental impacts around the axial needle bearing for the worm (151). Apply a ruler to the machined face for the return port. Cylinder cover (125) must be replaced if a distinct sag is evident.

3 Piston (101)

- Outside diameter
- Valve insert (109) - steering limiter valve - must be examined for leaks, loose fit, damage (even slight external mechanical damage can cause the valve to jam).



Examining the individual parts

- Serration must be examined for wear (longitudinal and transverse crack testing using a suitable method, e.g. ferrofluxing).



Attention:

Cracked parts must be scrapped.

- Recirculating ball screw:
Both piston (101) and worm (151) must be replaced if any signs of damage or wear are observed.

- Check friction value in assembly with worm (151) - see chapter III.

- **Caulked valve insert (109) - steering limiter valve:**

Tight fit: radial or axial play and damage are not permissible.

- **Screwed valve insert (109) - steering limiter valve:**

Check that valve insert (109) is not twisted or damaged.

Caulking

4 Worm (151)

- Recirculating ball screw: piston (101) and worm (151) must both be replaced if any signs of damage or wear are observed. Check friction value in assembly with piston (101) - see chapter III.

- Notched serration of valve slide (168)

- Running surfaces of needle bearings and shaft seal. Indentations on the face-end running surfaces of the needle bearings (10 and 120) may be due to accidental impacts. In this case, the housing (1) and cylinder cover (125) must be examined for signs of sagging around the needle bearing (120).

- Longitudinal and transverse crack testing (using suitable methods, e.g. ferrofluxing). (The liquid jet must be directed in such a way that the valve body is not wetted so that iron particles cannot enter the control grooves.)



Attention:

Cracked parts must be scrapped.

- O-ring recesses must be examined for hammer marks

- The complete worm (151) must be replaced if the O-rings are found to have hardened on account of excessive service temperatures, since the O-ring (169) between valve slide (168) and worm (151) will also have been damaged in this case.

5 Sector shaft (80)

- Toothed segment

- Serrations

- Running surfaces of the sealing rings

- Running surfaces of the roller bearings



Examining the individual parts

- Longitudinal and transverse crack testing (using suitable methods, e.g. ferrofluxing).



Attention:

Cracked parts must be scrapped.

- Caulking points on housing cover (4)
- Longitudinal scoring on outside diameter
- Screw thread
- Radial run-out (warping) of the sector shaft (80) need only be checked if roller bearing imprints due to impacts have been observed, for instance on the face ends of the worm.
Mount the sector shaft (80) between centres and measure the maximum permissible radial run-out on the running surface of the roller bearing on the steering drop arm side, beside the tooth segment. The max. permissible radial run-out must not exceed 0.1 mm.

Additionally required for versions with switch (222):

- Check grooved pin for tight fit and wear
- Slot on grooved pin must point towards the middle tooth or be at 180° to it.

6 Housing cover(4)

- Scoring and rust on outside diameter
- Sealing faces

7 Needle, cage and roller bearings

- The corresponding bearings must be replaced if indentations and wear are observed on the running surfaces of the steering elements.
- Check needles, balls and rollers for signs of wear and damage.

8 Valve insert (22, 22.1 and 32) and breather (57)

- Outside diameter (scoring, wear, damage and jamming in the valve bore)
- Ensure that bore holes are clean

9 Additionally required for dual-circuit versions

9.1 Housing cover (221)

- Screw thread
- Flange face
- O-ring seats
- Pipe / line connections

9.2 Valve housing (203)

- Screw thread
- Rubberization on seat of shaft seal
- Pipe connections
- Running surface of sealing rings
- O-ring seats



Examining the individual parts

9.3 Additionally required for versions with add-on cylinder (250)

9.3.1 Add-on cylinder (250)

- Scoring in cylinder bores
- O-ring seats
- Pipe connections

9.3.2 Piston (258)

- Sealing ring seats
- Signs of wear on serration (longitudinal and transverse crack testing using suitable methods, e.g. ferrofluxing)



Attention:
Cracked parts must be scrapped.

9.3.3 Gear (254)

- Signs of wear on serrations (longitudinal and transverse crack testing using suitable methods, e.g. ferrofluxing)



Attention:
Cracked parts must be scrapped.

10 Additionally required for versions with switch (222)

- Easy movement of actuating cam on switch (222)
- Check cam ways of cam disc (227) for signs of wear

11 Additionally required for versions with bevel box

- Bevel gears (306 and 331):
Signs of wear and indentations on serrations
Damage and corrosion on running surfaces of shaft seals

Longitudinal and transverse crack testing (using suitable methods, e.g. ferrofluxing), particularly for cracks at the bottom of the teeth.



Attention:
Cracked parts must be scrapped

- Intermediate flange (335) and housing (301):
Flange faces, screw thread and sealing ring seats
- Cross disc (348): signs of wear in driving grooves
- Screw thread



III. Assembly



Attention:

Utmost cleanliness must be maintained during assembly in order to ensure that the steering operates reliably. Force must never be used when assembling parts, as this may damage the sealing ring seats, sealing faces, etc. The resultant damage may lead to partial or total failure of the steering.

Notes:

- All parts must be cleaned thoroughly before assembling the steering. Each part must be examined for signs of wear and other defects (see chapter II.) and oiled before being assembled.
- New gaskets, shaft seals and O-rings must always be fitted and the face ends of the housings and covers ground down to remove any paint residues and damage.
- In the case of shaft seals, the space between the sealing lip and dust lip must be filled with grease type Spectron FO 20 made by Messrs. DEA or an equivalent calcium complexing grease of consistency class 2.
- The accuracy of the measuring and adjusting tools used for repairs must be verified at regular intervals.
- The specified tightening torques apply when tightening screws and bolts with a torque wrench by hand.
- Before starting the assembly work, the spare parts list must be consulted to determine whether it specifies tightening torques and insertion depths or information on the installed position of special screws and holders. The following values and descriptions apply if nothing is specified in the spare parts list.

1 Preassembly of housing (1)

- 1.1 Screw in valve insert (22) - pressure limiting valve - with preassembled O-ring (23) (tightening torque: 30+10 Nm) (**Fig.19**).

Fit valve insert (32) - replenishing valve - in housing. Fit screw (30) with fitted O-ring (31) (tightening torque: 30+10 Nm).

Screw in breather (57) (tightening torque: 30 Nm) and plug on protective cap (58).

Fit screw plug (55) with sealing ring (54) (tightening torque: M16: 40 Nm; M18: 50 Nm).

Insert O-rings (2) in housing (1).

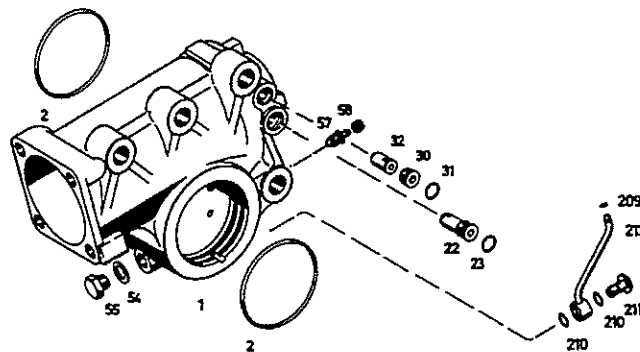


Fig.19

- 1.2 Additionally required for versions with pipe (212)

Mount pipe (212) with new O-rings (209 and 210). Torque union screw (211) down with 20±2 Nm.

Assembly

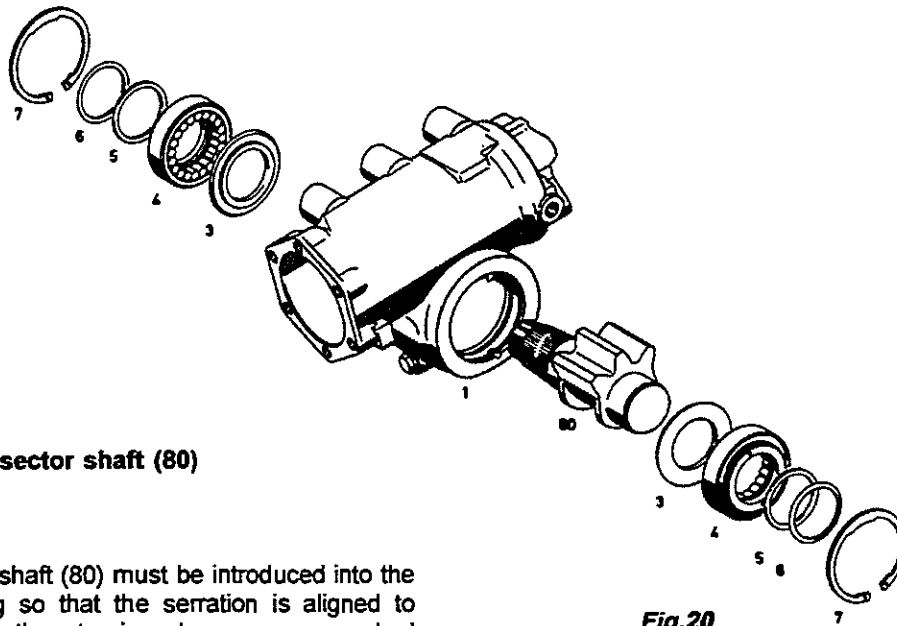
2 Preassembly of housing cover (4)

Notes:

- The housing covers (4) must not be reinstalled on the same side.
- The individual rollers must not be interchanged between housing covers (4).
- The complete housing cover (4) must be replaced if one of the rollers is defective.

Any rollers which have dropped out must be bonded into the housing cover (4) with grease (type of grease, see Note in chapter III.) and a pad fitted in the roller gap.

Fit gasket (5) and support ring (6) in housing cover (4) (**Fig.20**).



3 Install sector shaft (80)

Sector shaft (80) must be introduced into the housing so that the serration is aligned to receive the steering drop arm as marked during disassembly.

Fit washers (3) on sector shaft (80).

Place housing (1) on a flat surface underneath a hand-operated press with the steering drop arm side facing upwards.

Mount tool [5] on the serration.

Press the preassembled housing cover (4) up to the recess in the retaining ring (7) with tool [3] and with the larger of the two face-end holes or marks facing upwards (towards the piston).

Fit retaining ring (7) so that the gap is on the caulked side opposite the piston (101).



Attention:
Check that retaining rings (7) are seated correctly.

4 Adjustment of recirculating ball element

4.1 Assembly of recirculating ball element

Insert worm (151) into the bore in piston (101) so that the balls (110) from the front piston bore for the recirculating pipe can be filled into the threaded bore of worm (151) (Fig.21).

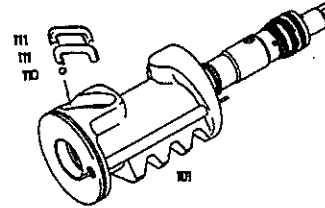


Fig.21



Attention:

37 balls (110) must be used. All the balls (110) used must belong to the same tolerance group.

The balls (110) must be filled in separately and the worm (151) turned slowly at the same time so that all balls (110) are lined up side-by-side (direction of rotation depends on the spiral direction of the worm (151)).

The recirculating ball screw is not full until the first ball (110) inserted reaches the edge of the rear bore in the recirculating pipe (30 balls).



Attention:

None of the balls (110) may drop out of the threaded bore into the longitudinal bore of the piston (101), as this could result in partial or complete failure of the steering.

Place the remaining balls (110) in the recirculating half tube (111).

To facilitate assembly, the outer balls (110) can be bonded into place with grease. Type of grease, see note in chapter III.

Insert both the filled recirculating half tubes (111) into the bore holes.

4.2 Check the friction torque

New parts

The friction torque of the recirculating ball element must be measured in a horizontal position using tools [8], [9] and [10] while simultaneously holding the recirculating half tubes (111) tight in the piston (100).

→ In the middle area:

The following friction torques must be obtained when turning the worm through 90°:

Type 8090:	5 - 20 Ncm
Types 8095-8099:	5 - 30 Ncm

→ Outside the middle area:

The friction torque measured in the middle area must increase by no more than 15 Ncm.

Assembly

□ Used parts

Check friction torque and tilting clearance (hold recirculating half tubes (111) tight)

The friction torque of the recirculating ball element (111) must be measured in a horizontal position with tools [8], [9] and [10]. **Fig.22.** The tilting clearance must be measured in a horizontal position as shown in **Fig.22.**

→ In middle area:

The value measured must lie within the following range when worm (151) is turned through 90°.

Upper limit: max friction torque: 8090: 5-20 Ncm
8095-99: 5-30 Ncm

Lower limit: max. tilting clearance: 0.1 mm

→ Outside the middle area:

The friction torque may increase to max. 35 Ncm for type 8090 and to max. 60 Ncm for types 8095-8099.

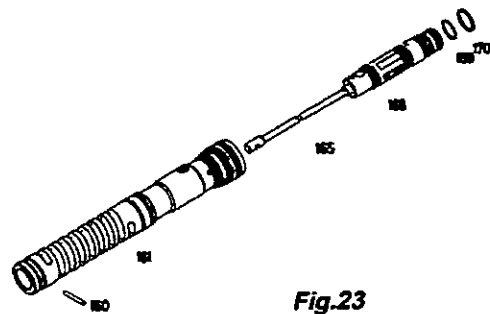
4.3 If a higher friction torque is obtained, the balls (110) must be removed and replaced with balls from a smaller tolerance group.

If the friction torque is below the permissible minimum value or if the tilting clearance is too large, larger balls (110) must be fitted and the measurement repeated.

Once the correct balls (110) have been chosen, piston (100) must be disassembled again and the selected balls (110) carefully set aside.

5 Preassembly of worm (151)

5.1 Fit O-ring (169) and sealing ring (170). Install torsion bar (165) with valve slide (168) as marked during disassembly. Press in pin (160) and caulk to the same depth and form as before (**Fig.23**).



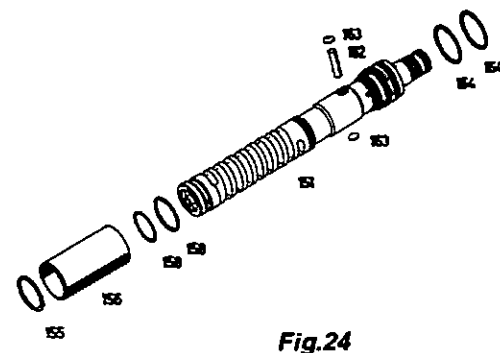
5.2 Place O-ring (158) in radial groove and slip on sealing ring (159) (**Fig.24**).

Fit pin (162) with plug (163). Carefully slide on sliding tube (156).

Fit snap ring (155) and check axial play of sliding tube (156).

The axial play must not exceed max. 0.1 mm and can be corrected by using a different snap ring (155).

Use tool [11] to slip on sealing rings (164) and press them home with tool [12].



Measurement of friction torque



Measurement of tilting clearance



Fig.22

5.3 Additionally required for dual-circuit versions:

Slip O-ring (164.1) and sealing rings (164) onto control sleeve (174) with tool [11] (Fig.25).

Then draw in sealing ring (164) with tool [11].

Mount tool [13] on worm (151).

Fit O-ring (172) and sealing ring (173) and press home with a suitable tool (e.g. hose clip).

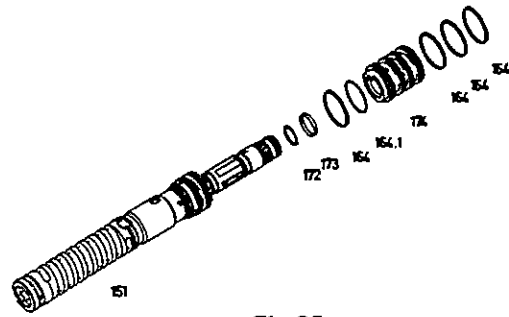


Fig.25

6 Preassembly of piston (100)

Note:

This preassembly is only required if the valve insert (109) - steering limiter valve - was disassembled.

6.1 Versions with caulked valve insert (109) - steering limiter valve

Introduce valve insert (109) as far as possible in piston (100). Mount piston in tool [6] with the caulked area pointing upwards (Fig.26).

At the same time, ensure that valve tappet protruding beyond the piston is introduced into the bore in tool [6].

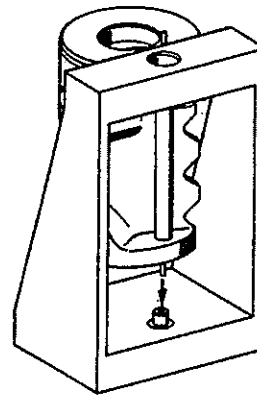


Fig.26

Adjust the supporting screw of tool [6] so that a gap of 0.1 - 0.2 mm is obtained between the fixture and piston when the latter has been fitted (Fig.27).

Screw caulking die of tool [6] onto a pressure pickup and insert it in the upper bore of tool [6].

Caulk the metal edge of the valve insert with a press applying a force of 7000 N + 800 N without backlash.



Attention:

Correct operation of the steering may be impaired if the caulking force is too high or too low.

Check that the valve insert (109) is seated securely.

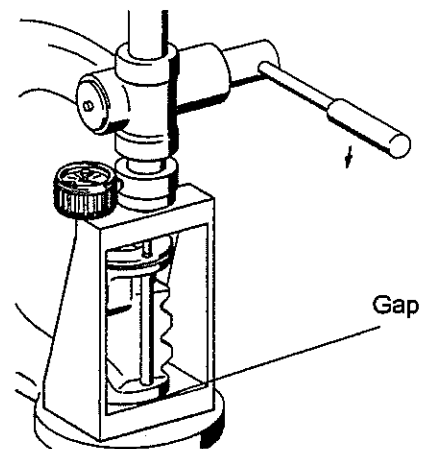


Fig.27

Assembly

6.2 Versions with screwed valve insert (109) - steering limiter valve

Screw valve insert (109) into piston as far as possible with tool [2] (*Fig.28*) (tightening torque: 15 ± 1 Nm).

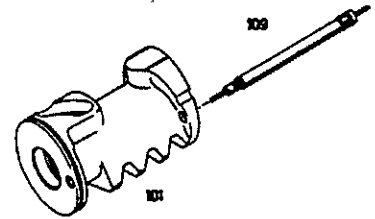


Fig.28

Note:

Hold the tube of the valve insert (109) tight when screwing in the valve insert so that only the larger threaded sleeve is entrained.

Align tool [7] with the two cutting edges so that they are centered in the groove. Then press tool [7] towards the piston until it rests against valve insert (109).

Caulk with tool [7] as shown in *Fig.29* (caulk to the same depth on both sides).

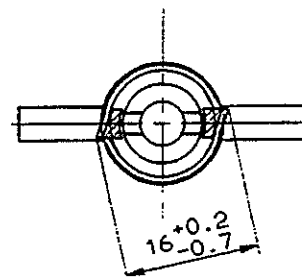


Fig.29



Attention:

Check that the valve insert (109) is tightly seated and that the valve tappet moves easily.

7 Assembly of piston (100) and worm (151)

First fit sealing ring (116) and then insert sealing ring (117) (*Fig.30*).

Fit O-ring (118) and then slip on gasket (119).

Reinsert worm (151) into piston (100) so that the balls (110) selected earlier can be fitted and the recirculating tube (111) can be inserted in piston (100) (*see Fig.21*).

Note for steering versions 8095 to 8099:

New parts (111, 112, 113 and 113.2) must be used if a pin (113.2) was not present during removal.

Place gasket (113) and plug (112) in piston without O-ring (114) or sealing ring (115).

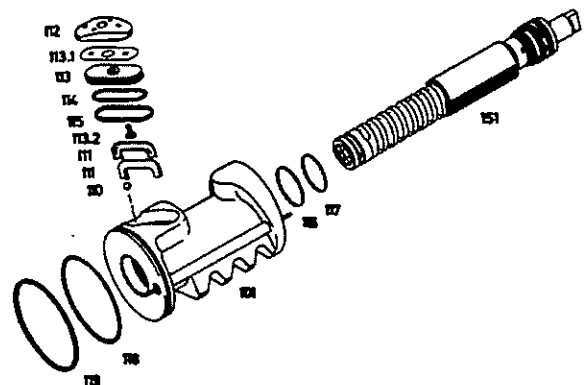


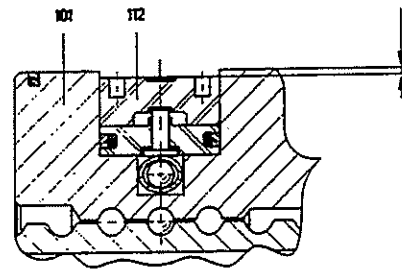
Fig.30



Check that plug (112) is flush with the piston surface (**Fig.31**) or does not exceed the following maximum clearance:

Max. permissible clearance:

Type 8090:	max. 0.1 mm
Types 8095-8099:	max. 0.5 mm
Type 8099: (with add-on cylinder)	max. 0.2 mm



Max. permissible clearance

Fig.31

If necessary, insert a compensating plate (113.1) between gasket (113) and plug (112) (even if a compensating plate was not present during removal).

Ensure that the plug does not protrude in a way leading to increased friction.

Remove plug (112), compensating plates (113.1) and gasket (113).

Fit O-ring (114) and sealing ring (115) on gasket (113).

Press pin (113.2) into piston (101) with complete gasket (113).

Place the compensating plates (113.1) and plug (112) selected beforehand on gasket (113) and check again that plug (112) is flush with the piston face or does not exceed the maximum clearance.

8 Installation of piston/worm assembly

8.1 For 1-circuit versions and versions with bevel box

Fill space between sealing lip and dust lip of shaft seal (8) with grease (see note in chapter III.).

Press shaft seal (8) in as far as possible with tool [14] (**Fig.32**).

Place washer (9) and needle cage (10) in turned recess of housing (1). Washer must be free of grease.

Slip tool [15] onto serration of worm (151).

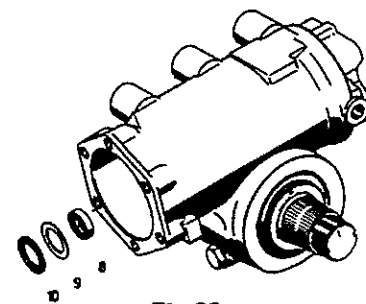


Fig.32

8.2 All versions

Turn sector shaft (80) so that the toothed segment swings towards the cylinder cover (125).

First introduce piston (100) into housing complete with worm (151) until toothed segment engages the first gap in the teeth of piston (100) when swung upwards (**Fig.33**).

In this position, insert piston (100) completely by turning the sector shaft (80) with the aid of the provisionally attached steering drop arm.

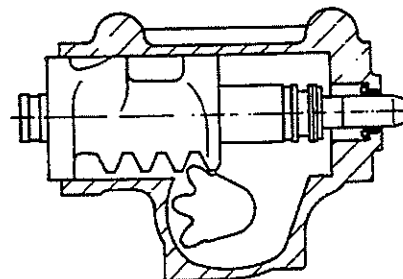


Fig.33

Assembly

9 Assembly of cylinder cover (125)

Note:

Only for 1-circuit version and versions without bevel box

Screw in screw plug (55) with sealing ring (54).

Tightening torque: M16: 40 Nm
M18: 50 Nm

Place washer (121), which was removed during disassembly, in the recess in cylinder cover (125) with the bevelled side first; needle cage (120) must be fitted without grease (*Fig.34*).

Note:

The following sealing elements should not be fitted until the worm bearing - section 12 - has been adjusted.

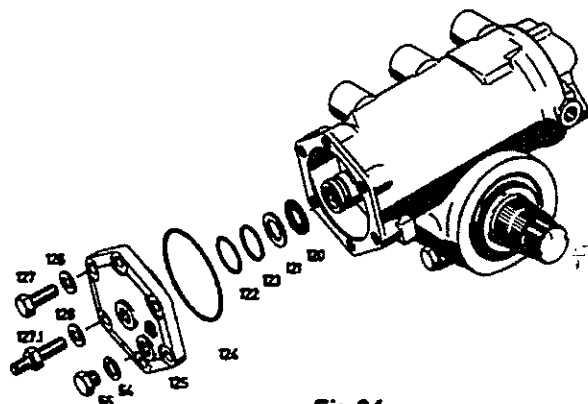


Fig.34

Place O-ring (122) in the inner radial groove in cylinder cover (125) and lay sealing ring (123) on top of it.

Place the greased O-ring (124) in the outer radial groove.

Place cylinder cover (125) on housing (1) without damaging the sealing elements.



Attention:

The inserted washer (121) may be too thick if any of the parts housing (1), worm (151) or cylinder cover (125) has been replaced. A complete readjustment as described in section 12 is required in this case.

If present during disassembly, the hex screws (127) with washers (126) must be carefully tightened while constantly turning the steering shaft in order to ensure that the worm bearing is not subjected to axial pressure.

Hex screws (127) and screw (127.1) must be torqued down as specified below.

Type 8090: (M12x1.5)	135 Nm
Type 8095/8096/8097: (M16x1.5)	285 Nm
Type 8098/8099: (M14x1.5)	189 Nm

10 Assembly of valve housing (203)

Note:

Dual-circuit version only

Screw in valve insert (22.1) - pressure limiting valve - with O-ring (23) (*Fig.35*)
(Tightening torque: 30+10 Nm).

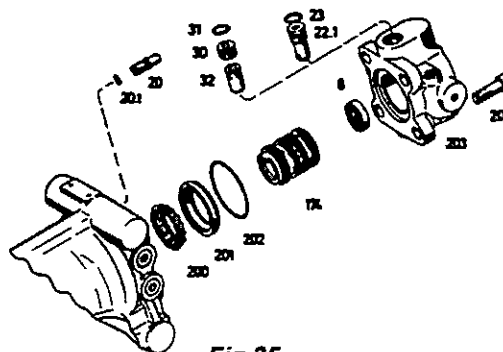


Fig.35



Fit valve insert (32) - replenishing valve - and screw (30) with O-ring (31) (tightening torque: 30+10 Nm).

Press bearing ring (201) into valve housing (203).

Position ball cage (200) on worm (151).

Insert preassembled control sleeve (174) in worm (151) (note position of drivers).

Screw adjusting screw (20) in by at least three turns.

Fill space between sealing lip and dust lip of shaft seal (8) with grease (see note in chapter III.).

Press shaft seal (8) in as far as possible with tool [14].

Mount tool [15] on serration of worm (151).

Insert O-ring (202) and mount valve housing (203) as marked during disassembly.

Torque cap screws (204) down to 140 Nm.

Fit pipes (225 and 226) (see Fig.43) with new O-rings (224).

Tightening torque: 8096: 12+2 Nm
8099: 18+2 Nm

11 Check sector shaft position and total turns of steering wheel

Turn the steering through from one end to the other and check that the number of turns equals that counted during disassembly.

Turn steering to straight-ahead position and check that the mark on the sector shaft is at the top and perpendicular to the piston axis (Fig.36).

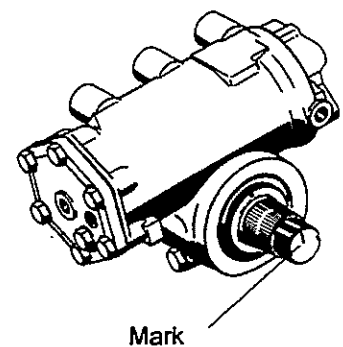


Fig.36

12 Adjustment of worm bearing

Note:

This setting must be checked at room temperature.

Strip paint from face end of housing in order to mount the dial gauge of tool [17].

Assembly

Secure tools [16] and [17] on the steering shaft stub (**Fig.37**).

Turn sector shaft (80) until worm (151) axially comes to rest on one side. Set dial gauge to "zero".

Turn sector shaft (80) until worm (151) axially comes to rest on the opposite side without tool [16] being radially entrained and check the permissible axial backlash.

Required values:

Type 8090:	0.005 - 0.025 mm
Types 8095/8096:	0.010 - 0.030 mm
Type 8097:	0.015 - 0.035 mm
Types 8098/8099:	0.020 - 0.040 mm

Fit a different washer (121) to correct a divergent axial backlash.

Remove cylinder cover (125).

Install sealing elements as described in section 9 and fit cylinder cover (125).

13 Set pressure point

Note:

The bevel box must be installed first as described in section 17 in versions with bevel box.

Clamp steering horizontally and mount tools [18] and [19].

Turn housing cover (4) so that the larger of the two face-end bores and the mark point towards piston (100).

Move steering to one of the limit positions.

Measure the friction torque required to turn the steering outside the straight-ahead range (approx. half a turn short of the limit position).

Turn steering approx. one half-turn to the right and left beyond the middle position with tools [8], [9] and [10]. Measure the associated increase in friction torque.

Required increase in friction torque:

Type 8090:	20-60 Ncm
Type 8095/8096:	20-80 Ncm
Type 8097-8099:	20-100 Ncm

Turn both housing covers (4) with tools [18] and [19], keeping the same angle (in the direction of the arrow), until the required increase in friction torque is obtained (**Fig.38**).

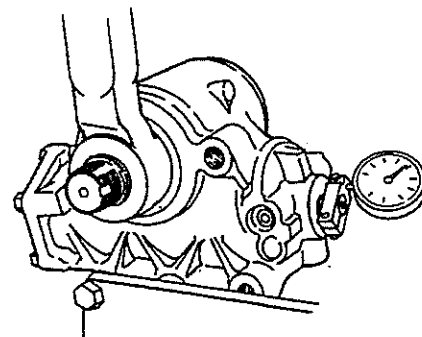


Fig.37

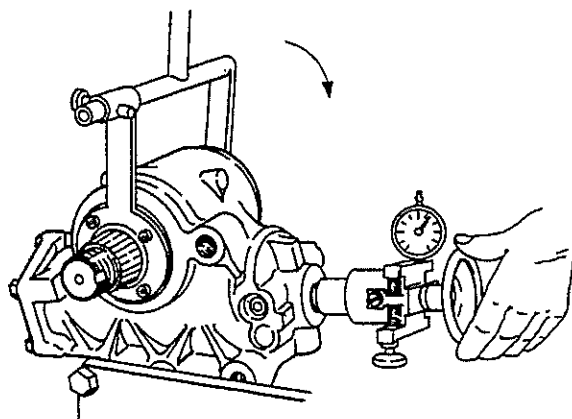


Fig.38

While making the adjustment with tools [18] and [19], use tools [8], [9] and [10] to turn the steering several times approx. one half-turn to the right and left beyond the middle position.

Note:

The max. permissible friction torque should be set if possible when making this adjustment.

14 Caulking housing cover (4)

14.1 Versions with single caulk

14.1.1 Screw tool [20] onto the steering so that it is parallel to the steering. The caulking tool must fit into the caulking groove as accurately as possible (*Fig.39*).

Tool [21] must be used additionally for steering versions with a C-value greater than 137 mm.

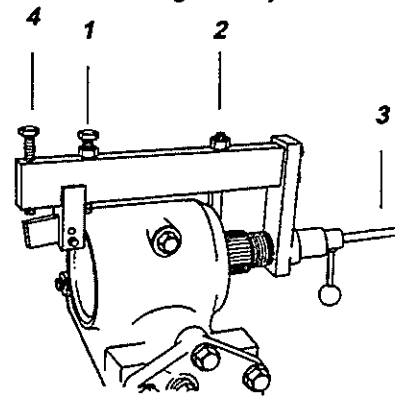


Fig.39

In this position, set adjusting screw **1** on the fixture so that the caulking tool is horizontal.

Secure fixing hook **2** on the opposite side of the housing at the height indicated by thrust spindle **3**.

Tighten thrust spindle **3** until housing cover (**4**) comes to rest on retaining ring (**7**) on the caulking side.

Tighten screw **4** on the fixture by hand (without using additional tools) until it rests on the caulking tool.

Turn screw **4** through - value specified below - with a torque wrench (maximum value of 18 Nm must not be exceeded, otherwise the tool may break !).

Turns of screw 4 :	Types 8090-8097: approx. 2.75
	Types 8098/8099: approx. 3.50

Remove fixture and check caulked area.

The housing has been caulked correctly when the collar of the housing cover is pressed into the housing groove to the depth specified in the following table.

Caulking depth:

Types 8090/8095/8096:	1.3+0.4 mm
Type 8097:	1.4+0.4 mm
Types 8098/8099:	1.7+0.4 mm

Slight cracks are permissible in the caulking edge at the edge of the groove (*Fig.40*).

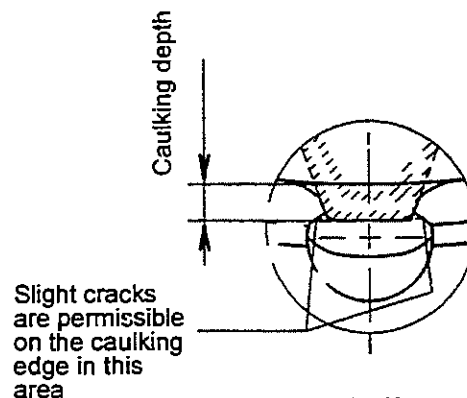


Fig.40

Assembly

Additionally required for versions with holding segments (14):

Holding segments (14) must be pressed in until flush (**Fig.41**).

Fit retaining ring (7) so that the gap is located at the caulking point opposite the piston (100).



Attention:

Check that retaining ring (7) is seated securely.

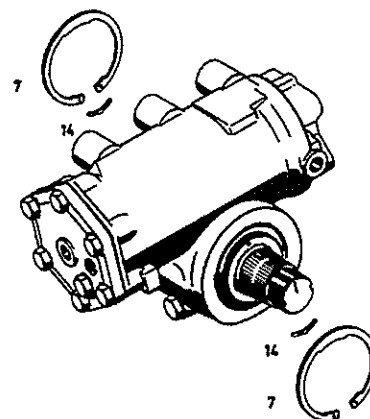


Fig.41

14.1.2 Repeat the complete procedure for the other side as described in section 14.1.1.

14.2 Versions with three-fold caulking

14.2.1 Carry out single caulking on both sides as described in section 14.1.

Remove retaining ring (7) and insert tool [22] (without caulking tool) in the caulking grooves of the housing with the three pilot pins.

Turn tool [22] through 60° in the groove of the retaining ring until one of the two caulking points is reached. Secure tool [22] with a stop pin to prevent it twisting and fit the caulking tool.

Proceed as described in section 14.1. Remove caulking tool. Release stop pin and turn fixture through 120° until the third caulking point is reached.

Proceed as described in section 14.1 for the third caulk.

Dismount tool [22] from the steering and check the caulked area as described in section 14.1.1.

Additionally required for versions with holding segments (14):

Press holding segments (14) in until flush (**Fig.42**).

Fit retaining ring (7) so that the gap is located on the caulking point opposite the piston (100).



Attention:

Check that retaining ring (7) is seated securely.

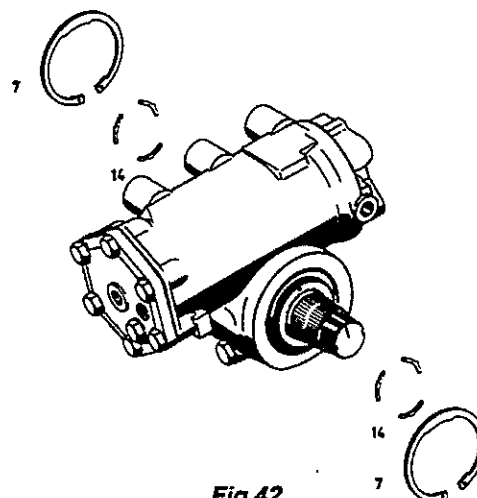


Fig.42

14.2.2 Repeat the complete procedure for the other side as described in section 14.1.1.

Assembly

15 Assembly of housing cover (221)

15.1 Dual-circuit versions

Insert O-ring (220) (*Fig.43*).

Install housing cover (221) with cap screws (223) (tightening torque: 37 Nm).

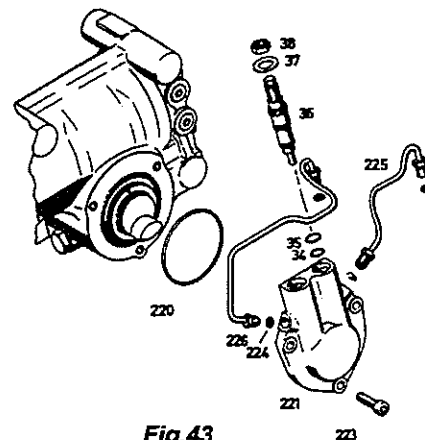


Fig.43

Install pipes (225 and 226) with new O-rings (224).

Tightening torque: Type 8096: 12+2 Nm
 Type 8099: 18+2 Nm

Screw in valves (36) - steering limiter valves - with O-rings (34 and 35).

Fit hex nut (38) with washer (37) and torque down to 25-35 Nm after adjustment.

15.2 Versions with switch (222)

Note:

The housing cover should not be installed until the setting and functional test - chapter IV. - is complete, otherwise it cannot be tested for leakages.

Insert cam disc (227) in housing cover (221) so that the cam ways point towards switch (222) (*Fig.44*).

Fit retaining ring (228).

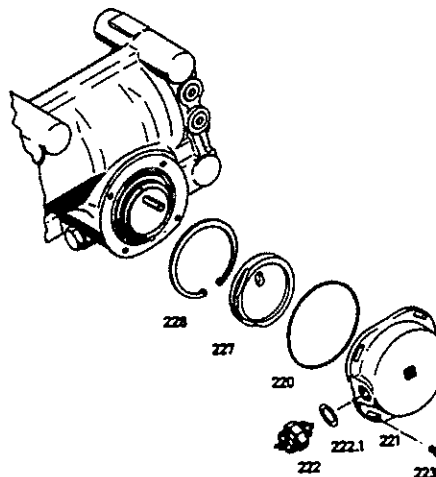


Fig.44

Place O-ring (220) in annular groove of housing cover (221).

Fit complete housing cover (221) as marked during disassembly so that the driver in the sector shaft engages in the longitudinal groove in cam disc (227).

Turn housing cover (221) so that the cam points towards the threaded bore of switch (222) when the steering is in the straight-ahead position.

Torque cap screws (223) down to 5.5 Nm.

Note:

The switching range of switch (222) can be adjusted on a test bench by using washers (222.1) of a different thickness.

Fill cover area with 50 cm³ oil (oil sort see List of Lubricants TE-ML 09).

Screw in switch (222) with washer (222.1) (tightening torque: 50 Nm).

16 Assembly and installation of add-on cylinder (250)

Set steering to straight-ahead position.

Slide bush (253) and gear (254) as far as possible onto sector shaft (80) (Fig.45).

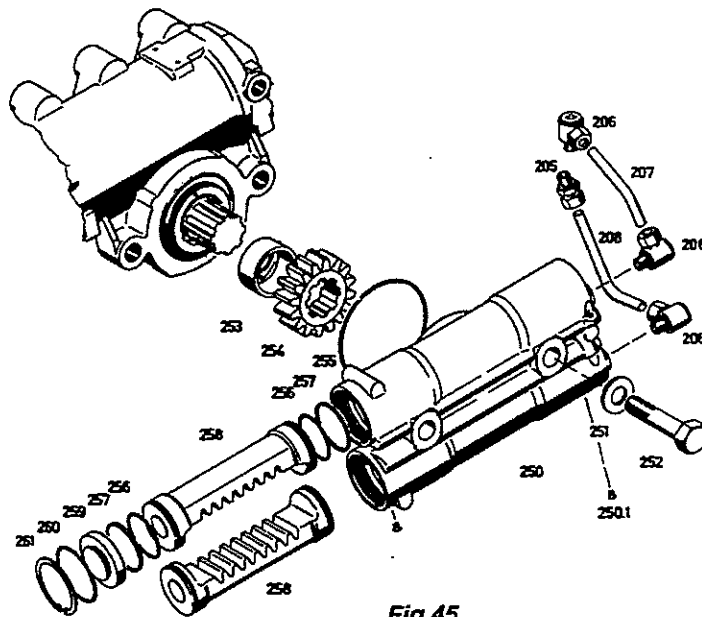


Fig.45

Slip two O-rings (256) and two gaskets (257) onto each piston (258).

Slide both pistons (258) into add-on cylinder (250) up to the middle position (installed value 60.7 ±0.2 mm) (Fig.46).

Notes:

- The middle tooth of both pistons (258) is marked on both face ends.
- The centered bore (with installed breather valve) in pistons (258) must point towards the closed end of add-on cylinder (250).

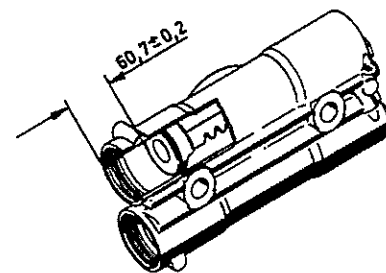


Fig.46

Assembly

Screw add-on cylinder (250) onto the steering so that the middle tooth of piston (258) engages in the gap in gear (254) in each case (**Fig.47**).

Screw in hexagon screw (252) with washers (251) (tightening torque: 500 Nm).

Turn steering through from end to end and then back to the straight-ahead position.

Check that the installed value equals 60.7 ± 0.2 mm for both pistons (258).

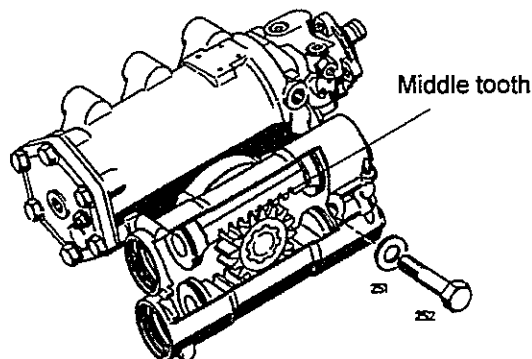


Fig.47

Place O-ring (260) in radial groove of cylinder bore and press cylinder cover (259) in until the retaining rings (261) can be fitted (*see Fig.45*).

Fit retaining rings (261).

Install pipes (207) and (208).

Tightening torques:

Pipe union (205):	50 Nm
Pipe union (206):	39 Nm
Screw plugs for both pipe unions (205 and 206):	59 Nm

Tighten Torx screw (250.1) with tool [23] (tightening torque: 5 Nm).

17 Preassembly and installation of bevel box

17.1 Versions with cross disc (348)

17.1.1 Fit intermediate flange (335)

Slip O-ring (341) onto intermediate flange (335). Press cross disc (348) and ball bearing (343) onto intermediate flange (335) (**Fig.48**). Use tool [28] for this purpose.

Secure intermediate flange (335) with cap screws (334) as marked during disassembly (tightening torque: 140 Nm).

Slip shim plate (330) onto intermediate flange (335).

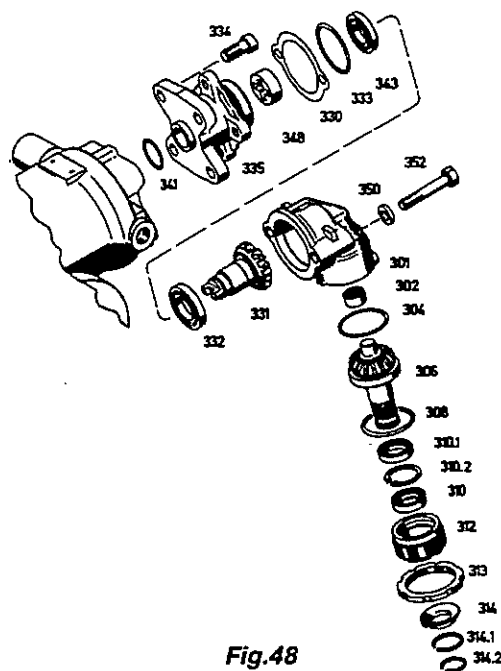


Fig.48

17.1.2 Preassemble bevel box

Press needle sleeve (302) into housing (301) as far as possible with tool [29] (**Fig.48**).



Press ball bearing (332) onto bevel gear (331) with tool [30].

Place 0.35 mm thick washers (304) or the washers (304) removed during disassembly into the housing bore. Slide bevel gear (306) as far as possible into housing (301).

Screw adjusting screw (312) into housing (301) without shaft seals (310 and 310.1), using tool [25] (tightening torque: 50 Nm).

Set bevel box to straight-ahead position. Align notch in steering shaft of bevel box with the mark on the housing.

In this position, mark one tooth on bevel gear (306) in the housing and two opposing teeth on bevel gear (331) in intermediate flange (335) with chalk so that the marked teeth engage when the bevel box is mounted.

17.1.3 Installation of bevel box

Slip on bevel box.

Uniformly screw in screws (352) with fitted washers (350), while simultaneously and constantly turning the steering shaft, until bevel gears (306 and 331) engage without backlash.

Screws (352) must not be turned further if bevel gears (306 and 331) engage before the flange of the bevel box comes to rest.

The remaining gap must be compensated with shim plates (330) in this case.

A thinner shim plate (330) must be used if zero backlash cannot be obtained.

The bevel gear must be precision adjusted when zero backlash has been obtained. Both the shim plates (330) and the washers (304) on bevel gear (306) are used for this purpose.

The bevel gears are correctly set when they engage with virtually no backlash and without jamming (max. backlash 0.04 mm).

Note:

However, the adjustment must be made in straight-ahead position so that the backlash is absolutely zero.

If the backlash is not zero when the steering gear is set to the straight-ahead position, the tooth contact must be relocated by one or more teeth until this requirement is met.

Make a new notch marking the straight-ahead position and take the bevel box off the steering again.

Place a greased O-ring (333) in the radial groove of the intermediate flange (335).

Place the bevel box back on the steering in the position marked after fitting the chosen washers (330).

Screw in screws (352) with fitted washers (350) (tightening torque: 62 Nm).



Unscrew adjusting screw (312) from housing (301).

Place a greased O-ring (308) in the radial groove of housing (301), behind the threaded bore.

Fill space between sealing lip and dust lip of shaft seal (310 and 310.1) with grease, see note in chapter III.

Mount tool [32] on bevel gear (306).

Fit retaining ring (310.2) in adjusting screw (312).

Press inner shaft seal (310.1) in as far as possible with tool [31].

Fit outer shaft seal (310) in adjusting screw (312) flush with face end.

Screw adjusting screw (312) into housing (301) with tool [25] and a torque of 50 Nm.

Tighten slotted nut (313) to a torque of 50 Nm.

Depress cast edge of housing to secure slotted nut (313) and prevent it twisting.

Check set friction value again (required value: max. 80 Ncm).

17.2 Versions with coupling sleeve (349)

17.2.1 Preassembly of bevel box

Press needle sleeves (302) in as far as possible with tool [36]. Install bevel gear (306) (*Fig.49*).

Select a retaining ring (310.3) leaving the bevel gear (306) with a max. backlash of 0.06 mm.

Install bevel gear (331).

Choose a retaining ring (310.4) ensuring zero backlash over the largest possible angle of rotation while simultaneously allowing the bevel box to run as smoothly as possible.

Fit retaining ring (310.4).

Mount tool [38] on bevel gear (306).

Grease space between sealing lip and dust lip of shaft seal (310.1) (see note in chapter III.) and press it in, together with retaining ring (310.2), with tool [37] until they engage completely.

Press a greased shaft seal (310) - see note in chapter III. with regard to the type of grease - in as far as possible with tool [39].

Measure friction torque with tools [8], [9] and [10] (required value: max. 60 Ncm).

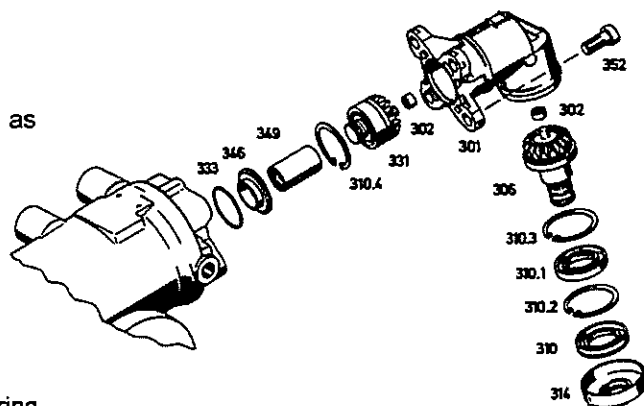


Fig.49

Assembly

Turn to find a zero-backlash area and fit protecting cap (314) with the mark pointing towards the steering gear. Remove former straight-ahead marking.

Fit O-ring (333).

Slip on centering ring (346) and coupling sleeve (349).

Note:

Coupling sleeve (349) must be fitted so that the inner chamfer points towards the steering gear.

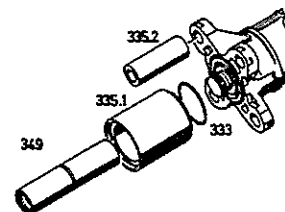


Fig.50

17.2.2 Fit pipes

Fit O-ring (333). Slip on pipes (335.1 and 335.2) (**Fig.50**).

17.2.3 Install bevel box

Secure bevel box with cap screws (352) as marked during disassembly (tightening torque: 62 Nm).

Turn steering to straight-ahead position and fit protecting cap (314) with the mark pointing towards the steering gear.

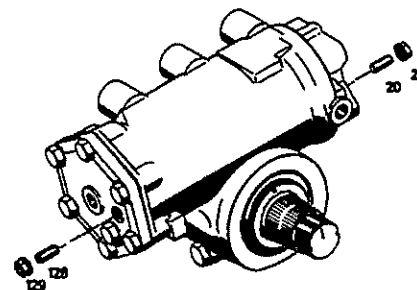


Fig.51

18 Assembly of set screw/screw (20 and 128)

18.1 Versions with collar nut (21 and 129)

Screw set screws (20 and 128) in by at least three turns and secure with collar nuts (21 and 129) (tightening torque: 20+10 Nm) (**Fig.51**).

18.2 Versions with screws (20 and 128)

Refit the screws (20 and 128) which were removed during disassembly (tightening torque: 12+3 Nm) (**Fig.52**).



Attention:

- These screws (20 and 128) may only be used for the functional tests described below.
- New screws (20 and 128) must be fitted after the functional tests (tightening torque: 12+3 Nm).
- The steering must subsequently not be turned to either limit position before being installed in the vehicle, otherwise the hydraulic steering limiter cannot be adjusted as specified.

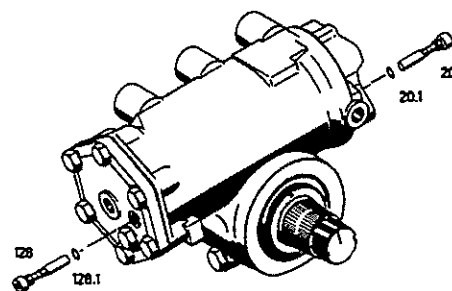


Fig.52



19 Final assembly of steering gear

Note:

The final assembly described here must not be undertaken until the setting and functional tests (chapter IV.) have been completed on the test bench.

19.1 Fit plug (52)

19.1.1 Versions with gasket (51.2)

Oil or grease the inner groove of dust seal (51), the outer circumference of gasket (51.2) and the mating face of gasket (51.2) on housing (1) (see note in chapter III. with regard to type of grease) (Fig.53).

Insert stop-ring (51.1) in the groove of dust seal (51) and place gaskets (51.2) on the inside of stop-ring (51.1) or plug (52) so that the protruding nose points away from plug (52) and stop-ring (51.1).

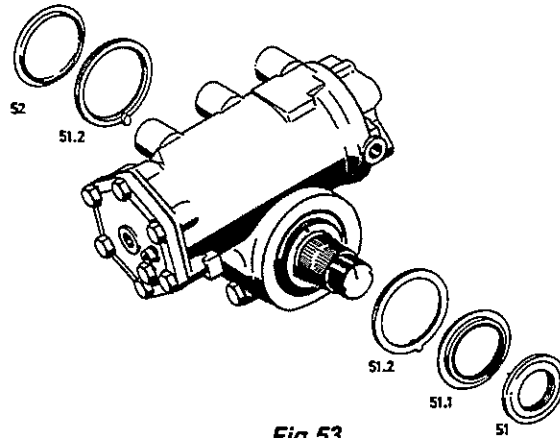


Fig.53

Slide the assembled dust seal (51) over the serration of sector shaft (80) by hand (the sector shaft must be kept as free of grease as possible) and press it into housing (1) until stop-ring (51.1) is flush with housing (1).

When fitting dust seal (51), ensure that the nose on gasket (51.2) fits exactly in the groove in housing (1).

On the opposite side of the serration on the sector shaft, press the preassembled plug (52) into housing (1) by hand until it is flush with housing (1).

When fitting plug (52), ensure that the nose on gasket (51.2) fits exactly in the groove in the housing.

Note:

Plug (52) may arch outwards due to air trapped under it during installation. For this reason, insert a small screwdriver between gasket (51.2) and housing (1) so that the trapped air can escape.

19.1.2 Versions without gasket (51.2)

Slip dust seal (51) and plug (52) onto sector shaft (80) after ensuring that the space between the dust lip and housing (1) is filled with grease (see note in chapter III. with regard to the type of grease) (*Fig.54*).

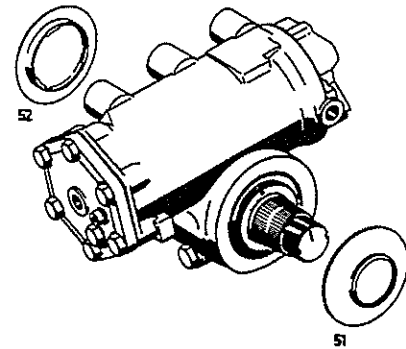


Fig.54

19.2 Fit protecting cap (53)

19.2.1 Versions with gasket (53.3)

Fit gasket (53.3) on the worm stub so that it fits exactly into the recess (*Fig.55*).

Press protecting cap (53) on as far as possible with tool [24]. Check assembly value of 5.4-0.2 mm (see illustration).

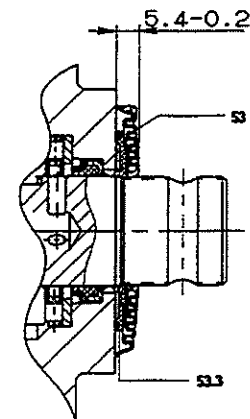


Fig.55

19.2.2 Versions without gasket (53.3)

Fit protecting cap (53) on the worm stub as far as possible with tool [24] after ensuring that the gap between dust lip and housing (1) is filled with grease (see note in chapter III. with regard to the type of grease).

19.2.3 Versions with retaining ring (53.1)

Slip protecting cap (53) onto the worm stub and fit retaining ring (53.1) (*Fig.56*).

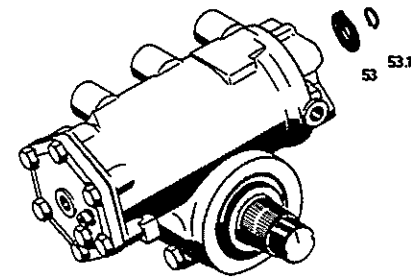


Fig.56

19.3 Fit dust seal (314)

19.3.1 Bevel box versions with cross disc (348)

Fit dust seal (314) on bevel gear (306) after ensuring that the gap between adjusting screw (312) and dust lip is filled with grease (see note in chapter III. with regard to the type of grease) (*see Fig.48*).

Fit snap rings (314.1 and 314.2).

19.3.2 Angular gear versions with coupling sleeve (349)

Fit dust seal (314) on bevel gear (306) (*see Fig.49*).

Assembly

- 19.3.3 Check that the markings for the straight-ahead position are present as shown in *Fig.57*.

Exception:

The markings may be in a different position in special versions. This is then indicated on the technical cover sheet of the spare parts list.

- 19.4 Versions with automatically adjusted steering limiter

Fit new screws (20 and 128) with new O-rings (20.1 and 128.1) (tightening torque: 12+3 Nm) (*Fig.58*).

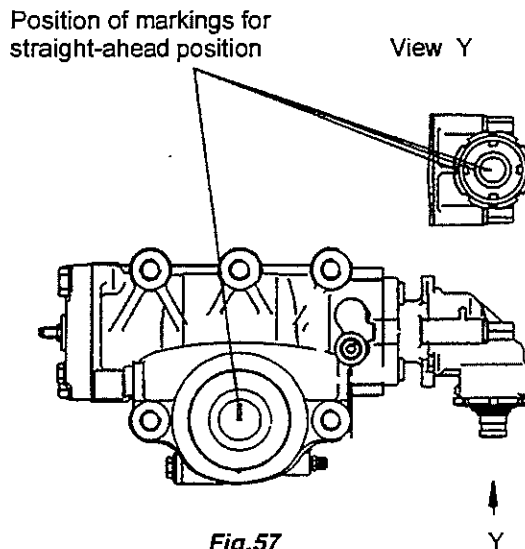


Fig.57



Attention:

The steering must not subsequently be turned to either limit position, otherwise the sliding sleeves of screws (20 and 128) are displaced into their limit position.

This then makes it impossible to adjust the hydraulic steering limiter in the vehicle as specified.

- 20 **Checking the friction torque of the completely assembled steering gear**

Mount tools [8], [9] and [10] on the steering shaft. Turn steering through from end to end and measure the friction torque outside the pressure point. Required value, see chapter VI.

The torque may vary by up to 40 Ncm when the steering is turned uniformly.

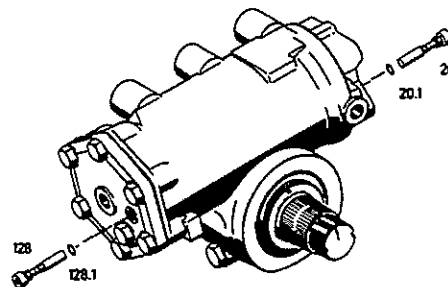


Fig.58

IV. Setting and functional test



Attention:

Every steering must undergo a setting and functional test on the test bench after being repaired in order to ensure traffic safety. The steering **must not** be installed in the vehicle without functional testing so that its correct function can subsequently be verified in a test drive.

Note:

- All the required values, tolerances etc. necessary for this functional test are specified in the spare parts list. The values mentioned below apply if nothing is specified in the spare parts list.
- The notes contained in the Instruction Manual for the test bench apply regardless of the following description.

1 Prepare steering for functional test

Set up completely assembled steering on test bench.

Connect delivery and return lines.



Attention:

Only lines and connections approved for the maximum pressure encountered may be used.

Additionally required for dual-circuit versions:

Seal ports for working cylinder with dummy plugs.

1.1 Bleed the steering:

- Versions with automatic bleeding:

These versions are fitted with automatic breather valves. It is therefore not necessary to open any breathers.

To bleed the steering, it must be turned from end to end several times. An unnecessarily high build-up of pressure must be avoided, since the breather valves are only effective in the continuous pressure range.

- Versions with breather (57):

Turn the steering so that breather (57) is positioned as near the top as possible.

Adjust the test bench to the flow rate specified below and do not turn the steering wheel.

Remove protecting cap (58) and open breather (57) by roughly one-half or a full turn.

Let air escape and reclose breather (57) when oil emerges.

Rapidly turn steering wheel from end to end several times and repeat bleeding procedure.

Torque breather (57) down to 30 Nm.

Refit protecting cap (58).



Setting and functional test

1.2 Set test bench: (Test temperature 50° C)

Note:

Test bench must be set to 20 bar above the maximum pressure specified on the rating plate for steering versions with built-in pressure limiter valve.

Pressure	Flow rate		
Type 8090:	150 bar	7 l/min	
Type 8090 N:	170 bar	8 l/min	
Type 8095:	150 bar	12 l/min	
Types 8096-8099:	150 bar	16 l/min	

2 Setting and functional test

2.1 Check absence of external leaks

The absence of external leaks must also be checked while carrying out the following tests 2.2 to 3.

2.2 Check maximum pressure

- Determine the straight-ahead position by halving the total number of turns of the steering wheel or total steering angle.
- Check or mark the middle on the steering shaft.
- Lock steering in straight-ahead position.
- Close steering valve by turning steering wheel in one direction.
- A maximum pressure corresponding to the value set on the test bench must build up when the steering valve is fully deflected (approx. 100 N manual force applied to the steering wheel).

Note:

A maximum pressure corresponding to the value specified on the rating plate (tolerance: +10%) must build up if the steering is equipped with a pressure limiting valve.

- Repeat the test for the other direction of rotation.
- If the maximum pressure is not reached, this may be due to excessive leakage oil in the steering or to a defective pressure limiting valve.
- If the maximum pressure is exceeded, the pressure limiting valve must be replaced or the setting of the pressure limiting valve on the test bench checked if the steering does not have a built-in pressure limiting valve.



Setting and functional test

2.3 Check oil leakage

2.3.1 Check oil leakage at a high flow rate

- Lock steering in straight-ahead position.
- The leakage oil draining into the return line should be measured at the following pressure when the steering valve is fully deflected (approx. 100 N manual force applied to the steering wheel):

Steering systems with built-in pressure limiting valve:
20 bar below the maximum pressure specified on the rating plate.

Steering systems without pressure limiting valve:
150 bar

Maximum permissible oil leakage:

Type 8090:	1.5 l/min
Types 8095-8099:	2.0 l/min

2.3.2 Check oil leakage at reduced flow rate

- Set test bench to a flow rate of 2-3 l/min.
- Check oil leakage as described above. The oil leakage established in section 2.3.1 must not be exceeded.

2.4 Check hydraulic centre

2.4.1 Steering not locked

- Slowly turn steering through to the end in both directions with tools [8], [9] and [10], letting it go several times in the process.

The steering must not move in either direction of its own accord.

2.4.2 Steering locked in straight-ahead position

- Turn steering shaft to lock steering valve in one direction until the pressure on the pressure gauge has risen 3 bar above the continuous pressure.
- Read off the value on tools [9] and [10].
- Repeat the measurement in the opposite direction.

The difference in torques when steering to the right or left must not exceed 30% referred to the higher value.



Setting and functional test

2.5 Valve reset

- Lock steering in straight-ahead position.
- Set test bench to previous values.
- Turn steering wheel to close steering valve, thus building up the maximum pressure.

Slowly release the steering wheel and adjust to a pump pressure 10 bar above the continuous pressure.

The valve must then return to the neutral position, i.e. the oil pressure must drop to the continuous pressure within one second.

- Check steering hitch:

There must not be any perceptible hitch when alternately turning the steering wheel in the other direction three times in succession at approx. 50 bar (hydraulic steering hitch).

2.6 Set hydraulic steering limiter

- Set counterforce on test bench.

2.6.1 Versions with manually adjusted steering limiter (identified through collar nuts (21 and 129))

- Turn the steering until the steering drop arm is deflected 47° and the hydraulic steering limiter is tripped.

Note:

Steering systems for which a different special switching range of 35 - 42°, for example, is specified in the spare parts list must be set to the explicitly specified maximum value, e.g. 42°.

- Turn set screw (20 or 128) until the oil pressure drops to 40 - 50 bar and a considerably greater effort is required to turn the steering outwards.



Attention:

In all cases, ensure that the set screws (20 and 128) are screwed in by at least three turns, otherwise they may be forced out when the maximum pressure is applied.

- Tighten the collar nut (21 or 129) down to 20+10 Nm.
- Repeat adjustment for other side.

2.6.2 Versions with automatically adjusted steering limiter (identified through screws (20 and 128))

Note:

The screws (20 and 128) originally fitted are merely used to check whether the steering limiter valve opens, but without adjusting the switching range.

Setting and functional test



Attention:

The steering limiter may only be adjusted after installation and with new screws (20 and 128) in the case of these versions.

- Turn steering in one direction and check that the pressure drops to 40 - 50 bar when the steering limiter valve opens.
- Repeat test for other side.

3 Additionally required for dual-circuit versions

3.1 Check the maximum pressure, the hydraulic centre and valve reset for the second circuit as described in section 2.

3.2 Check oil leakage

3.2.1 Check oil leakage for circuit II

- Connect delivery and return lines to circuit II.
- Seal ports for working cylinder of circuit II with dummy plugs.
- Check oil leakage as described in section 2.3.

Maximum permissible oil leakage for circuit II: 2 l/min

3.2.2 Measure oil leakage for sealing elements (164, 164.1, 172 and 173) separating circuits I and II.

- Lock steering in straight-ahead position.
- Then remove the screw plug (55) in the bottom of the housing or screw plug (55) in cylinder cover (125) if the former is not installed or unscrew the corresponding return line and drain off the oil
- Drain the oil until the oil level in the housing reaches the drainage hole and the flow of oil ceases.
- Seal the two working cylinder ports in circuit II with dummy plugs. Apply a pressure set to 3 bar above the continuous pressure on the test bench to the delivery line of circuit II. Collect the oil leaking from the housing bore or return line port of circuit I in a beaker for precisely one minute.

Max. permissible oil leakage: 0.001 dm³/min (1 cm³/min).

- This test must be performed statically with the control valve not deflected.
- Check oil leakage again dynamically at a pressure of 30 bar (set on the test bench), steering valve fully deflected once to the right and left.

3.3 Set hydraulic steering limiter

3.3.1 Steering limiter in piston

Set as described in section 2.6.



Setting and functional test / Troubleshooting

3.3.2 Steering limiter in housing cover

Turn steering in one direction until the steering drop arm is deflected as specified in the spare parts list for steering circuit II to trip the hydraulic steering limiter.

Turn valves (36) until the oil pressure drops to 30 - 40 bar and a considerably greater effort is required to turn the steering further outwards.

Torque hex nuts (38) down to 25 - 35 Nm.

4 Remove steering from test bench

Drain off the test oil by turning the steering shaft several times in both directions.

Remove steering from test bench.

Versions with automatically adjusted steering limiter

→ Affix note on settings, order number 7012 782 115, to the steering.

Versions with manually adjusted steering limiter

→ Affix note on settings, order number 7012 782 116, to the steering.

5 Check friction torque of completely assembled steering

Mount tools [8], [9] and [10] on steering shaft.

Turn steering through from end to end and measure friction torque within and beyond the pressure point.

Required values, see chapter VI.

The torque may deviate by up to max. 40 Ncm outside the pressure point when the steering is turned uniformly.

6 Affix repair code number

7 Carry out final assembly as described in chapter III. section 19.

V. Troubleshooting

Notes:

→ The ZF Servocom hydraulic steering has been built for heavy loads. It is designed in such a way that faults cannot develop if it is serviced correctly and operated normally.

→ If faults do develop, however, the following sections will help to locate and eliminate them. → Before attempting to locate individual faults in the steering, the oil level must be checked with the engine running.

→ At the same time, attention is explicitly drawn to the fact that faults can occur when using oil with a strong tendency to foam, since such oil releases very little or none of the air entrained into the steering system.



Fault	Cause	Remedy
-------	-------	--------

Moves stiffly in both directions

- Sealing elements (116, 117, 119, 169, 170) defective → Replace
- Internal fault → Repair
- Internal fault → Replace
- Valve insert (22) defective → Replace

For dual-circuit versions also:

- Working cylinder defective → Repair
- Working cylinder defective → Replace
- Sealing elements (159/164) defective → Replace

Moves stiffly in one direction

- Valve insert (109) defective → Replace
- Sealing element (123) defective → Replace
- Internal fault → Repair
- Internal fault → Replace

For dual-circuit versions also:

- Valves (36) defective/ wrongly set → Repair
- Valves (36) defective/ wrongly set → Replace
- Valves (36) defective/ wrongly set → Adjust
- Sealing element (164) defective → Replace

Steering hitch

- Air in oil → Bleed



Fault	Cause	Remedy
Obstructed return travel	→ Excessive friction torque in steering	→ Check friction torque - see chapter IV.
Imprecise straight-ahead travel	→ Wrong friction torque	→ Check friction torque - see chapter IV.
Steering wheel knocks	→ Backlash in recirculating ball element or wrong friction torque	→ Check - see chapter III.
	→ Excessive backlash in worm bearing	→ Check - see chapter III.
	→ Centre engagement piston - sector shaft	→ Check - see chapter III.
Backlash in steering wheel	→ Backlash in recirculating ball element or wrong torque	→ Check - see chapter III.
	→ Excessive backlash in worm bearing	→ Check - see chapter III.
	→ Centre engagement piston - sector shaft	→ Check - see chapter III.
Steering drifts	→ Hydraulic centre not OK	→ Replace piston/ worm assembly
Loss of oil	Sealing elements (2, 5, 8, 124, 310 and 310.1) defective	→ Replace - see chapter III.
	→ Leak in lines or connections	→ Repair [1]
Noises	→ Worm defective	→ Repair → Replace
	→ Valve insert (22) and(32) defective	→ Repair → Replace
	→ Air in oil	→ Bleed
	→ Loose connections	→ Retighten

[1] See vehicle manufacturer's manual

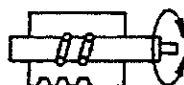


VI. Friction torques, adjustment values and tightening torques

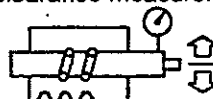
Friction torques:

Recirculating ball element:

Friction torque measurement



Tilting clearance measurement



New parts	Disassembled parts
In middle area: Type 8090: 5-20 Ncm Types 8095-8099: 5-30 Ncm	In middle area: max. 0.1 mm Tilting clearance or for type 8090: max. 20 Ncm for types 8095-8099: max. 30 Ncm
Outside the middle area: Additional increase of max. 15 Ncm	Outside the middle area: Max. increase to for type 8090: 35 Ncm for types 8095-8099: 60 Ncm

Increase in friction torque at the pressure point:

Type 8090:	20-60 Ncm
Types 8095/8096:	20-80 Ncm
Types 8097-8099:	20-100 Ncm

Completely assembled steering outside the pressure point:

Type Transmission constant (e.g. $i_1, i_2 \dots$) and variable (e.g. $iv_1, iv_2 \dots$)	Friction torque [Ncm]	
	without bevel box	with bevel box
8090		
$i_1 = 15.2 : 1$	max. 160	max. 240
$iv_1 = 16.6 : 1 / 14.0 : 1$		
$i_2 = 18.0 : 1$	max. 140	max. 220
$iv_2 = 19.6 : 1 / 16.6 : 1$		



		8095			
i_1	=	17.0	: 1	max. 180	max. 260
iv_1	=	18.5	: 1 / 15.6 :1	max. 160	max. 240
i_2	=	19.6	: 1	max. 140	max. 220
iv_2	=	21.3	: 1 / 18.1 :1		
i_3	=	23.1	: 1		
iv_3	=	25.2	: 1 / 21.3 :1		
		8097			
i_1	=	16.6	: 1	max. 200	max. 280
iv_1	=	18.2	: 1 / 15.4 :1	max. 180	max. 260
i_2	=	18.9	: 1	max. 160	max. 240
iv_2	=	20.6	: 1 / 17.4 :1	max. 140	max. 220
i_3	=	21.8	: 1		
iv_3	=	23.7	: 1 / 20.1 :1		
i_4	=	25.7	: 1		
iv_4	=	28.1	: 1 / 23.8 :1		
		8098			
i_1	=	18.3	: 1	max. 220	max. 300
iv_1	=	20.1	: 1 / 17.0 :1	max. 200	max. 280
i_2	=	20.7	: 1	max. 180	max. 260
iv_2	=	22.6	: 1 / 19.2 :1		
i_3	=	23.9	: 1		
iv_3	=	26.1	: 1 / 22.1 :1		

Type Transmission constant (e.g. $i_1, i_2 \dots$) and variable (e.g. $iv_1, iv_2 \dots$)		Friction torque [Ncm]			
		without bevel box - add-on cylinder	+ add-on cylinder	with bevel box - add-on cylinder	+ add-on cylinder
8096					
i_1	=	17.0 : 1	max. 210	-	max. 290
iv_1	=	18.5 : 1 / 15.6:1	max. 190	-	max. 270
i_2	=	19.6 : 1	max. 170	-	max. 250
iv_2	=	21.3 : 1 / 18.1:1			
i_3	=	23.1 : 1			
iv_3	=	25.2 : 1 / 21.3:1			
8099					
i_1	=	18.3 : 1	max. 250	max. 320	max. 330
iv_1	=	20.1 : 1 / 17.0:1	max. 230	max. 300	max. 310
i_2	=	20.7 : 1	max. 210	max. 280	max. 290
iv_2	=	22.6 : 1 / 19.2:1			
i_3	=	23.9 : 1			
iv_3	=	26.1 : 1 / 22.2:1			



Adjustment values:

Protecting cap (53) - Fitting value			5.4 - 0.2 mm
Plug (112) - Radial clearance	Type	8090:	max. 0.1 mm
	Types	8095-8099:	max. 0.5 mm
	Type	8099 with add-on cylinder:	max. 0.2 mm
Needle cage (120) - Axial clearance (at room temperature)	Type	8090:	0.005 - 0.025 mm
	Types	8095/8096:	0.010 - 0.030 mm
	Type	8097:	0.015 - 0.035 mm
	Types	8098/8099:	0.020 - 0.040 mm
Sliding tube (156) - Axial clearance			max.0.1 mm
Piston (258) - Installed value			60.7±0.2 mm

Tightening torques:

Screw (20)			12+3 Nm
Collar nut (21)			20+10 Nm
Valve insert (22)			30+10 Nm
Valve insert (22.1)			30+10 Nm
Screw (30)			30+10 Nm
Hex nut (38)			25-35 Nm
Screw plug (55)	M16:		40 Nm
	M18:		50 Nm
Breather (57)			30 Nm
Valve insert (109)			15±1 Nm
Hexagon screws (127)	Type	8090 (M12x1.5):	135 Nm
	Types	8095/8096/8097 (M16x1.5):	285 Nm
	Types	8098/8099 (M14x1.5):	189 Nm
Screw (128)			12+3 Nm



Collar nut (129)		20+10 Nm
Cap screws (204)		140 Nm
Pipe union (205)		50 Nm
Pipe union (206)		50 Nm
Screw plug for pipe unions (205) and (206)		59 Nm
Union screws (211)		20±2 Nm
Switch (222)		50 Nm
Cap screw (223)	Type 8096 (M8):	37 Nm
	Type 8098 (M6) (version with switch):	5.5 Nm
Pipes (225)	Type 8096:	12+2 Nm
	Type 8099:	18+2 Nm
Pipes (226)	Type 8096:	12+2 Nm
	Type 8099:	18+2 Nm
Torx screw (250.1)		5 Nm
Hexagon screw (252)		500 Nm
Adjusting screw (312)		50 Nm
Slotted nut (313)		50 Nm
Cap screw (334)		140 Nm
Hexagon screw (352)		62 Nm



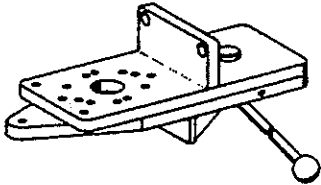
VII. Special tools

Note:

The special tools listed below refer to the standard version and the design version on the basis of which the entire manual has been compiled. Other tools may consequently be required for the particular unit in question.

Tool [1]

Assembly vice



Tool [2]

Insert for screw-out and screw-in the valve insert (109)



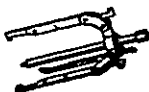
Tool [3]

Sleeve for pressing the housing covers (4)



Tool [4]

Puller for housing cover (4)



8090	8095	8096	8097	8098	8099
7418 798 654					
8098 798 151					
8090 798 006	8095 798 002	8097 798 002	8098 798 002		
8090 798 201					

Special tools



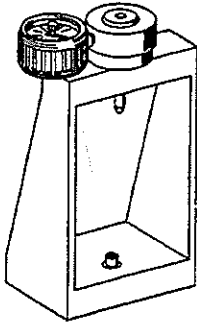
Tool [5]

Guide bush for housing cover (4)



Tool [6]

Peening fixture for valve insert (109)



Tool [7]

Punch for screwed valve insert (109)



Tool [8]

Insert for tool [9]



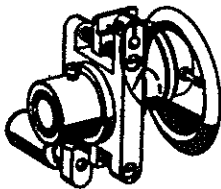
8090	8095	8096	8097	8098	8099
	8043 798 001				
8090 798 655					
8098 798 654					
serration					
1x54	7/8"x48	1x79	1x75	7/8x48	1x79
8052 798 552	8043 798 551	7419 798 551	7418 798 553	8043 798 551	7419 798 551
serration					
	1x79	A6x23x26	1x79	1x79	A6x23x26
	7419 798 551	8065 798 552	7419 798 551	7419 798 551	8065 798 552



8090	8095	8096	8097	8098	8099
			Valve slide		
			ø25	ø25,99	
			7421 798 551	8097 798 554	
			Valve slide serration		
			ø25,99	24/48x22	
			8097 798 554	8038 798 551	
7470 798 703					
7470 798 706					
8090 798 004		8090 798 001			
		8090 798 005		8090 798 005	

Tool [9]

Torque measuring device



Tool [10]

Dial gauge: Graduation 0.01 mm



Tool [11]

Guide bush for sealing rings (164)



for dual-circuit version



Tool [12]

Pliers for pressing on the sealing rings (164)



Tool [13]

Sleeve for mounting the O-ring (172) and the sealing ring (173)



Tool [14]

Mandrel for shaft seal (8)



Tool [15]

Guide bush for shaft seal (8)



	8090	8095	8096	8097	8098	8099
8090 798 652	8090 798 651					
			8096 798 001			8096 798 001
8090 798 052	8090 798 051					
8090 798 002	8090 798 003					



Tool [16]

Dial gauge holder for adjustment of axial play-worm



8090	8095	8096	8097	8098	8099
serration					
1x54	7/8"x48	1x79	1x75	7/8x48	1x79
8090 798 101	8095 798 102	8095 798 101	8097 798 101	8095 798 102	8095 798 101
serration					
	1x79	A6x23x26	1x79	1x79	A6x23x26
	8095 798 101	8097 798 102	8095 798 101	8095 798 101	8097 798 102
Valve slide					
			ø25	serration 24/48x22	
			8095 798 101	8097 798 101	
Valve slide					
			ø25,99		
			8097 798 102		
7016 798 704					

Tool [17]

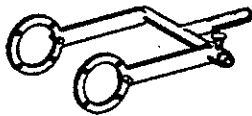
Dial gauge graduation 0.001 mm for tool [16]





Tool [18]

Adjusting device for pressure point setting



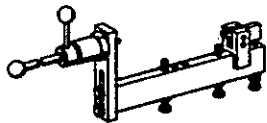
Tool [19]

Insert for tool [18]
(2 pieces are required)



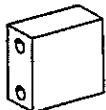
Tool [20]

Assembly tool for prying over of housing covers (4)



Tool [21]

Extension for tool [20]
for steerings with C-mass >137 mm

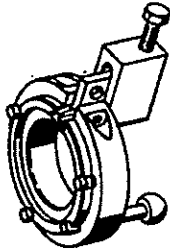


8090	8095	8096	8097	8098	8099
8090 798 151					
8090 798 551	8095 798 551		8097 798 551	8098 798 551	
8090 798 654					
				8090 798 656	



Tool [22]

Assembly tool for threefold prying



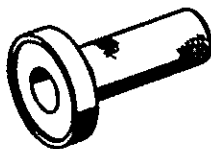
Tool [23]

Insert for torx screw (250.1)



Tool [24]

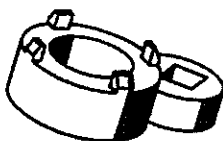
Mandrel for pressing the protecting cap (53)



Bevel box with cross disc (348)

Tool [25]

Grooved nut wrench for adjusting screw (312)



8090	8095	8096	8097	8098	8099
		8096 798 651		8098 798 651	
					7016 798 152
8090 798 053	8095 798 051				

8096	8097	8098	8099
1249 898 151			



Tool [26]

Puller for needle sleeve (302)



Tool [27]

Counter for tool [26]
and [34]



Tool [28]

Mandrel for ball bearing (343)



Tool [29]

Mandrel for needle sleeve (302)



Tool [30]

Press-in sleeve for
ball bearing (332)



8096	8097	8098	8099
7421 798 201			
7421 798 351			
7421 798 051			
7677 798 051			
7330 798 053			



Tool [31]

Mandrel for shaft seal
(310 and 310.1)



Tool [32]

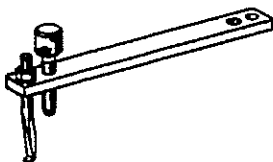
Guide bush for shaft seal
(310 und 310.1)



Bevel box with coupling sleeve (349)

Tool [33]

Puller for shaft seal (310)



Tool [34]

Puller for needle sleeve (302)



Tool [35]

Extension for tool [34]



8096	8097	8098	8099
7418 798 051			
8090 798 003			
8052 798 201			
8098 798 201			
8098 798 202			



Tool [36]

Mandrel for needle sleeve (302)



Tool [37]

Sleeve for shaft seal (310.1)



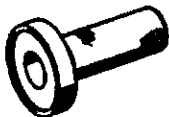
Tool [38]

Guide bush for shaft seal (310)



Tool [39]

Mandrel for shaft seal (310)



8096	8097	8098	8099
8098 798 052			
8090 798 006			
8098 798 003			
8098 798 051			



VIII. Key to numbers in figures, sectional drawings and exploded drawings

1.0	Housing	58.0	Protecting cap
2.0	O-ring	63.0	Stick-on label
3.0	Washer	80.0	Sector shaft
4.0	Housing cover	100.0	Piston
5.0	Gasket	101.0	Piston
6.0	Support ring	109.0	Valve insert
7.0	Retaining ring	110.0	Ball set
8.0	Shaft seal	111.0	Recirculating half tube
9.0	Axial-, washer	112.0	Gasket/Plug
10.0	Needle cage	113.0	Gasket
11.0	Type plate	113.1	Compensating plate
12.0	Grooved stud	113.2	Pin
14.0	Holding segment	114.0	O-ring
20.0	Set screw / Adjusting screw / Screw	115.0	Sealing ring
20.1	O-ring	116.0	Sealing ring
21.0	Collar nut	117.0	Sealing ring
22.0	Valve insert	118.0	O-ring
22.1	Valve insert	119.0	Gasket
23.0	O-ring	120.0	Needle cage
30.0	Screw	121.0	Washer
31.0	O-ring	122.0	O-ring
32.0	Valve insert	123.0	Sealing ring
34.0	O-ring	124.0	O-ring
35.0	O-ring	125.0	Cylinder cover
36.0	Valve	126.0	Washer
37.0	Washer	127.0	Hexagon screw
38.0	Hex nut	127.1	Screw
50.0	Locking nut	128.0	Set screw / Screw
51.0	Dust seal	128.1	O-ring
51.1	Stop-ring	129.0	Collar nut
51.2	Gasket	150.0	Worm
51.9	Dust seal	151.0	Worm
52.0	Plug	155.0	Snap ring
53.0	Protecting cap	156.0	Sliding tube
53.1	Retaining ring	157.0	Bush
53.3	Gasket	158.0	O-ring
54.0	Sealing ring	159.0	Sealing ring
55.0	Screw plug	160.0	Pin
56.0	Protecting sleeve	161.0	Worm
57.0	Breather	162.0	Pin

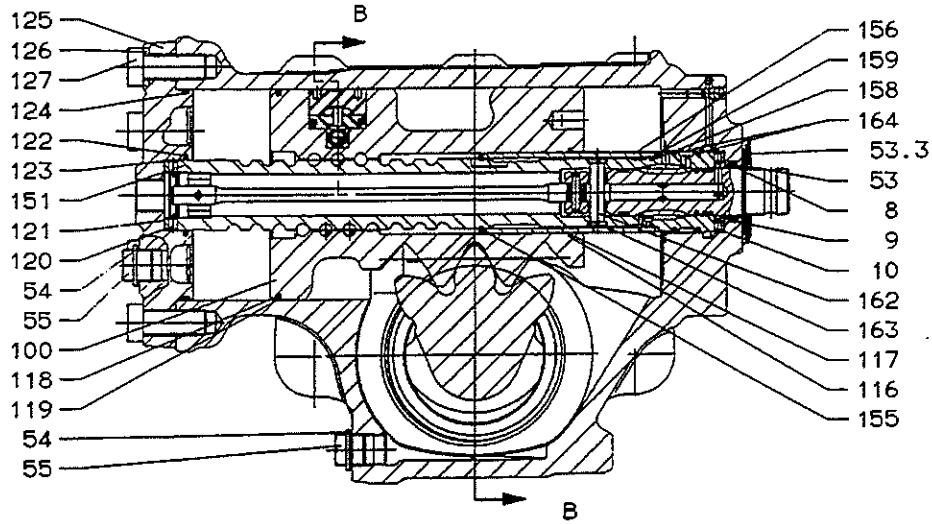


163.0	Plug	253.0	Bush
164.0	Sealing ring	254.0	Gear
164.1	O-ring	255.0	O-ring
165.0	Torsion bar	256.0	O-ring
166.0	Needle cage	257.0	Gasket
166.1	Snap ring	258.0	Piston
167.0	Pin	259.0	Cylinder cover
168.0	Valve slide	260.0	O-ring
169.0	O-ring	261.0	Retaining ring
170.0	Sealing ring	301.0	Housing
171.0	Needle cage	302.0	Needle sleeve
172.0	O-ring	304.0	Washer
173.0	Sealing ring	306.0	Bevel gear
174.0	Control sleeve	308.0	O-ring
200.0	Ball cage	310.0	Shaft seal
201.0	Bearing ring	310.1	Shaft seal
202.0	O-ring	310.2	Retaining ring
203.0	Valve housing	310.3	Retaining ring
204.0	Cap screw	310.4	Retaining ring
205.0	Pipe union	312.0	Adjusting screw
206.0	Pipe union	313.0	Slotted nut
207.0	Pipe	314.0	Dust seal / Protecting cap
208.0	Pipe	314.1	Snap ring
209.0	O-ring	314.2	Snap ring
210.0	O-ring	330.0	Shim plate
211.0	Union screw	331.0	Bevel gear
212.0	Pipe	332.0	Ball bearing
220.0	O-ring	333.0	O-ring
221.0	Housing cover / Cover	334.0	Cap screw
222.0	Steering limiter kit / Switch	335.0	Intermediate flange
222.1	Washer	335.1	Pipe
223.0	Cap screw	335.2	Pipe
224.0	O-ring	341.0	O-ring
225.0	Pipe	343.0	Ball bearing
226.0	Pipe	346.0	Centering ring
227.0	Cam disc	348.0	Cross disc
228.0	Retaining ring	349.0	Coupling sleeve
250.0	Add-on cylinder	350.0	Washer
250.1	Torx screw	352.0	Hexagon screw/Screw/ Cap screw
251.0	Washer		
252.0	Hexagon screw		

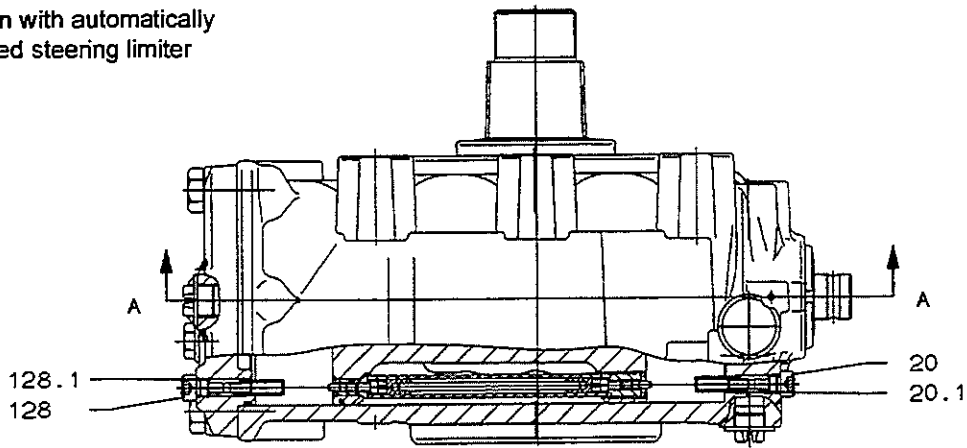


Types 8090 - 8099

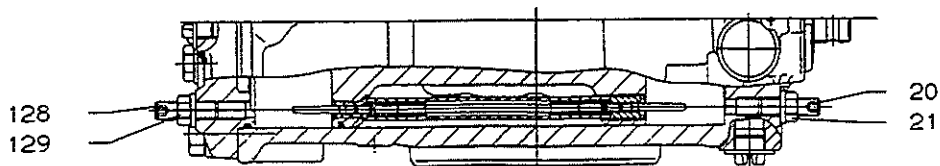
Section A-A

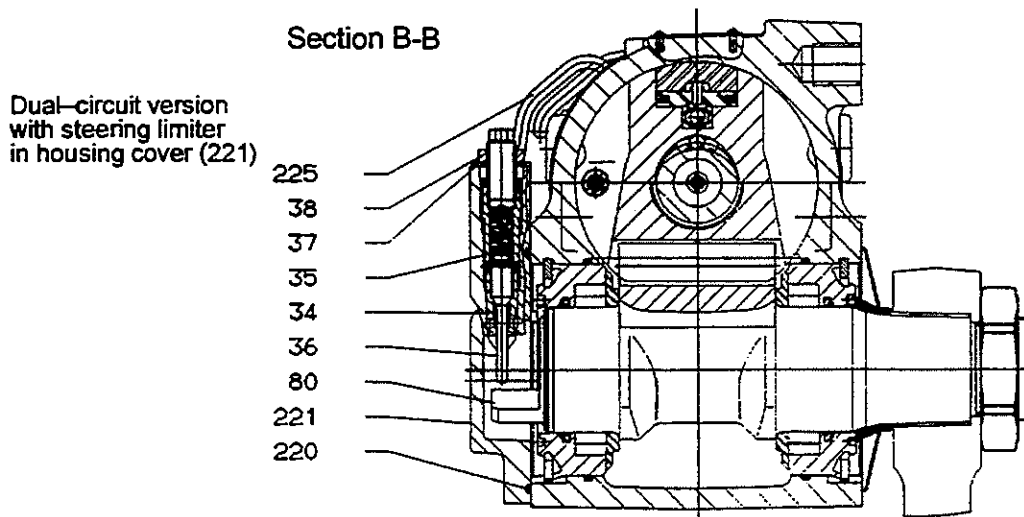
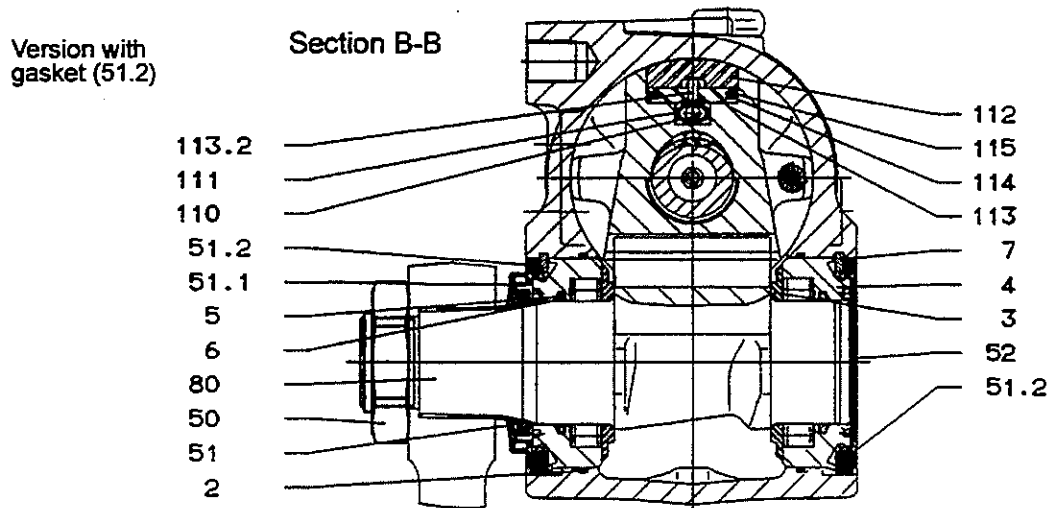
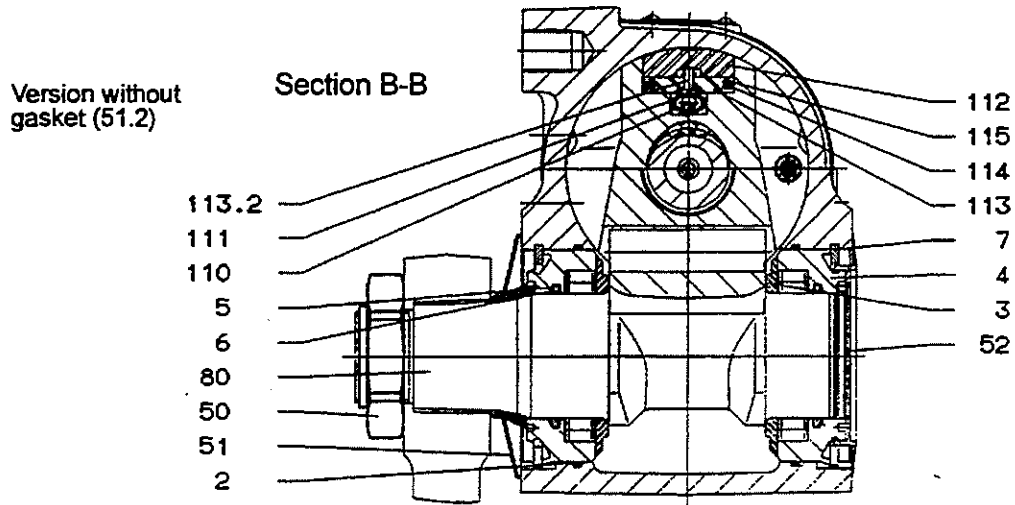


Version with automatically adjusted steering limiter



Version with manually adjusted steering limiter

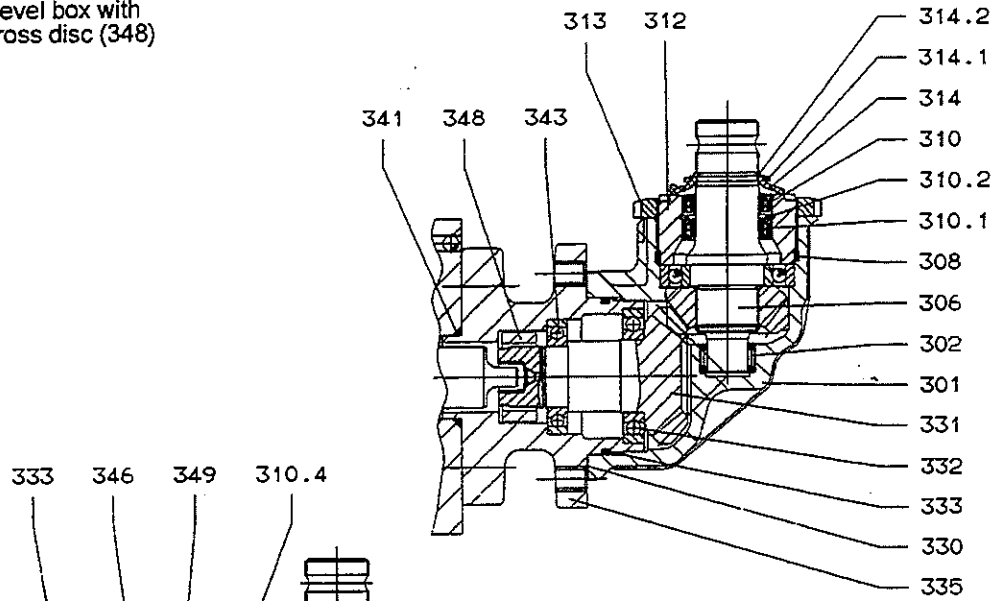




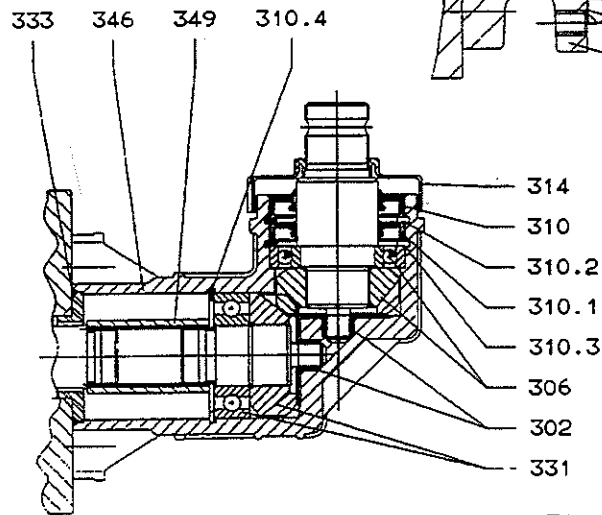


Key to numbers in figures, sectional drawings and exploded drawings

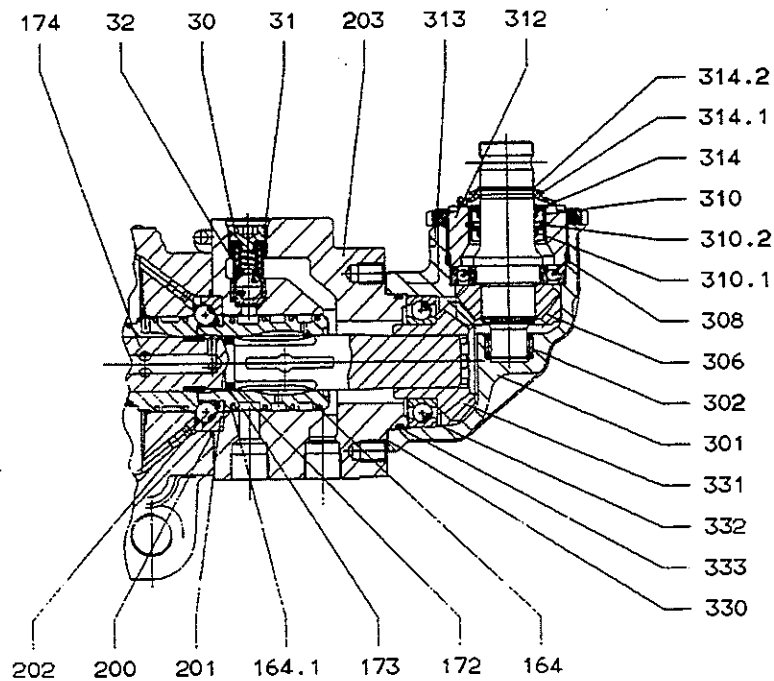
Bevel box with cross disc (348)

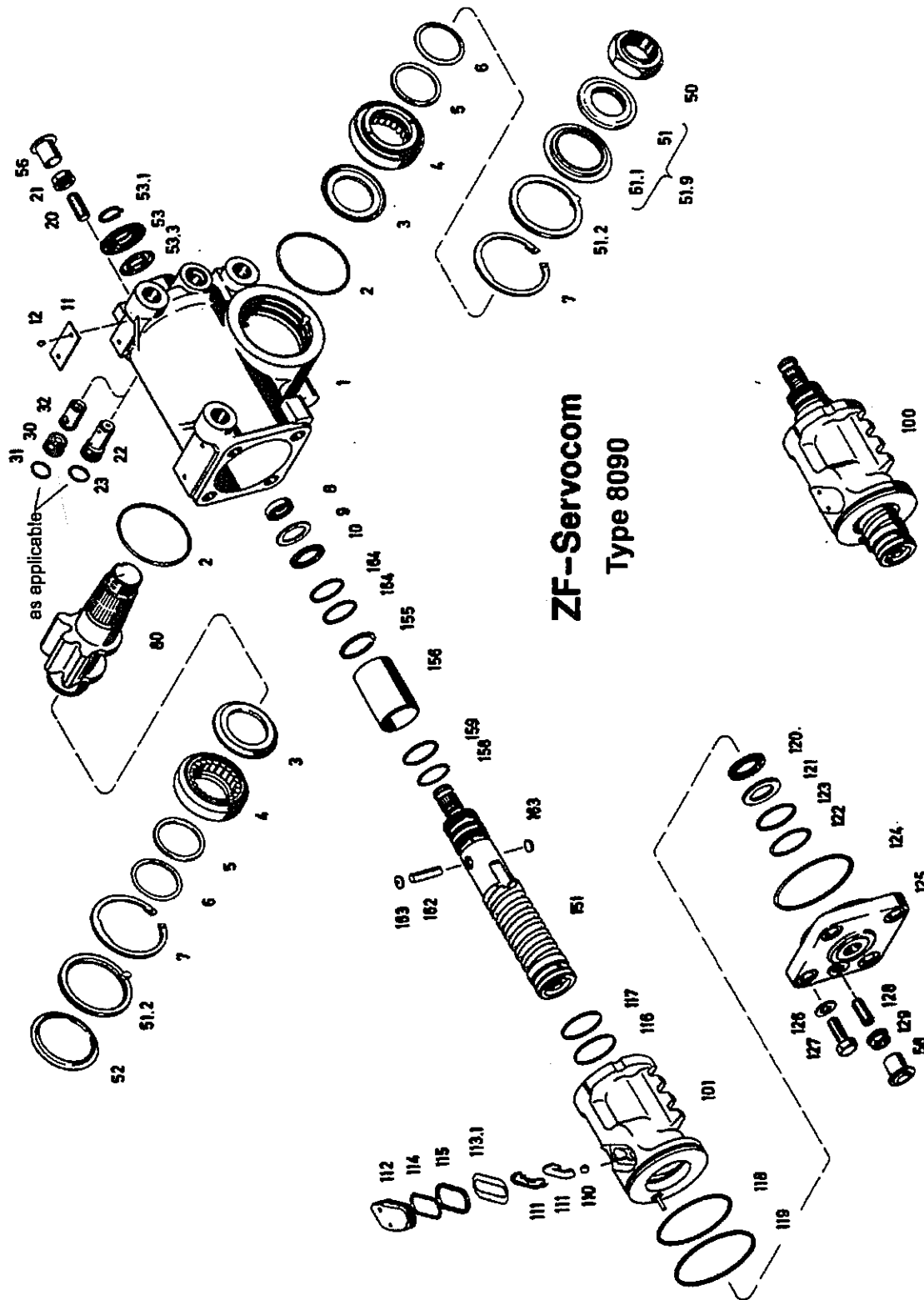


Bevel box with coupling sleeve (349)

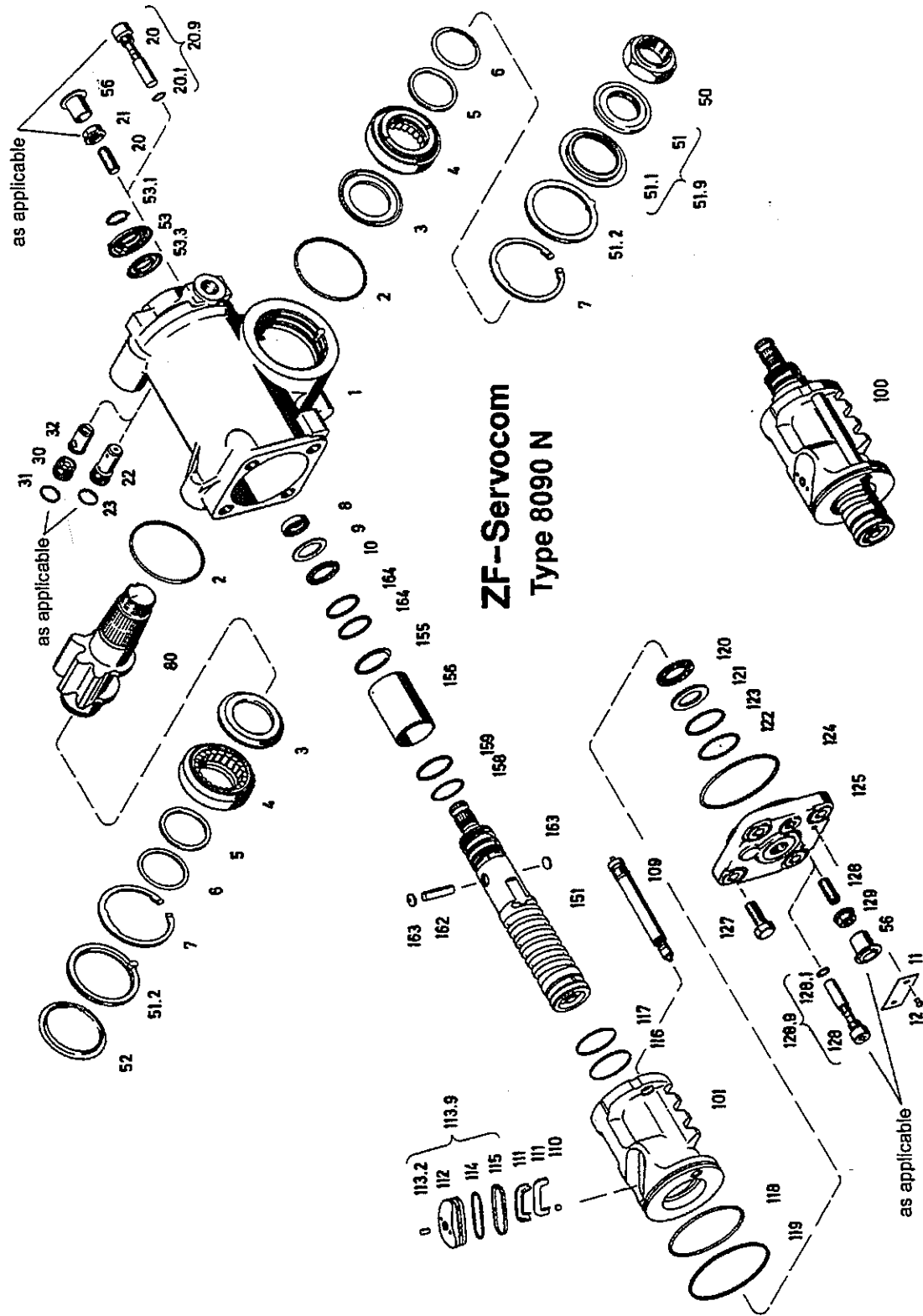


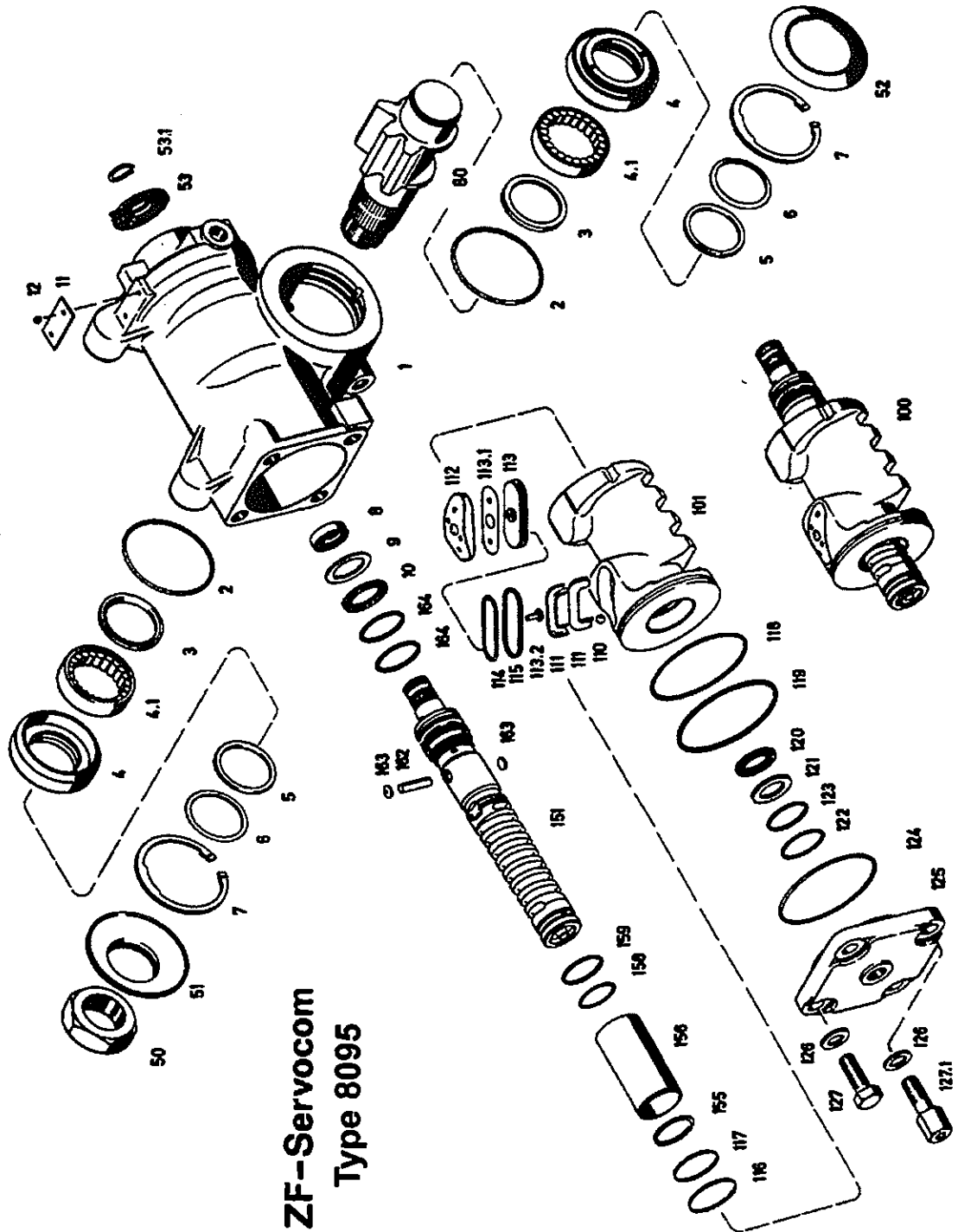
Dual-circuit version with bevel box



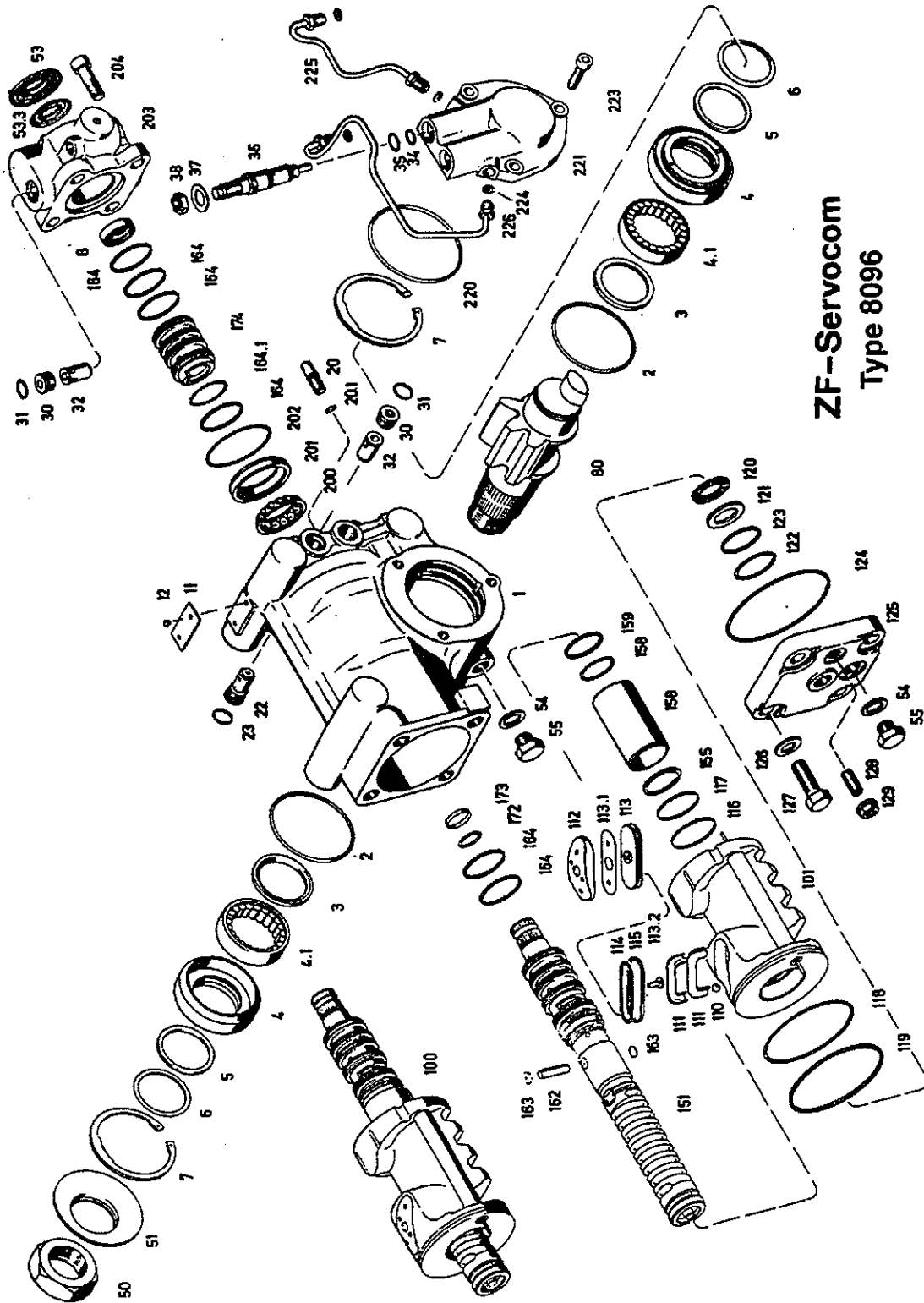


**ZF-Servocom
Type 8090**

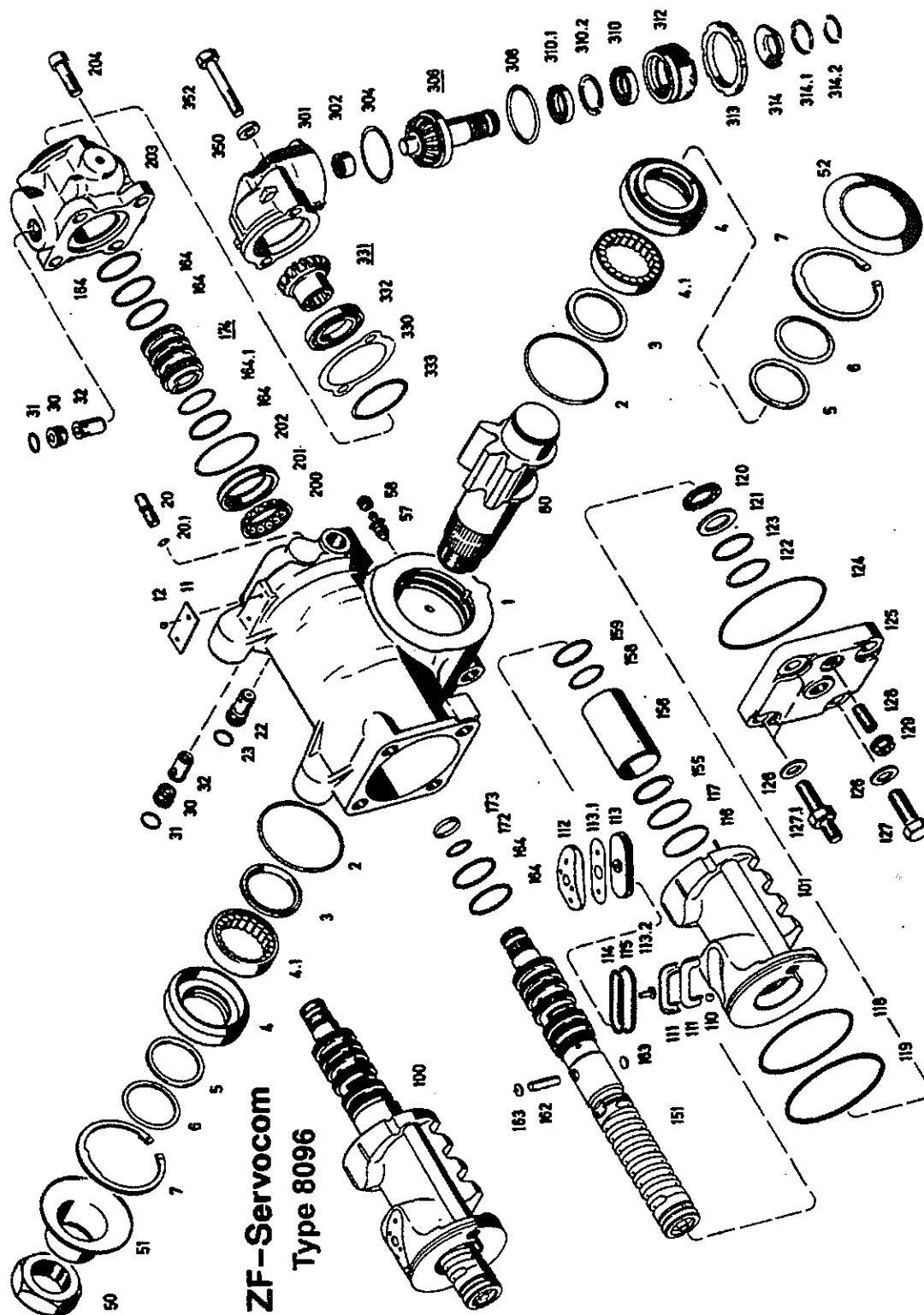




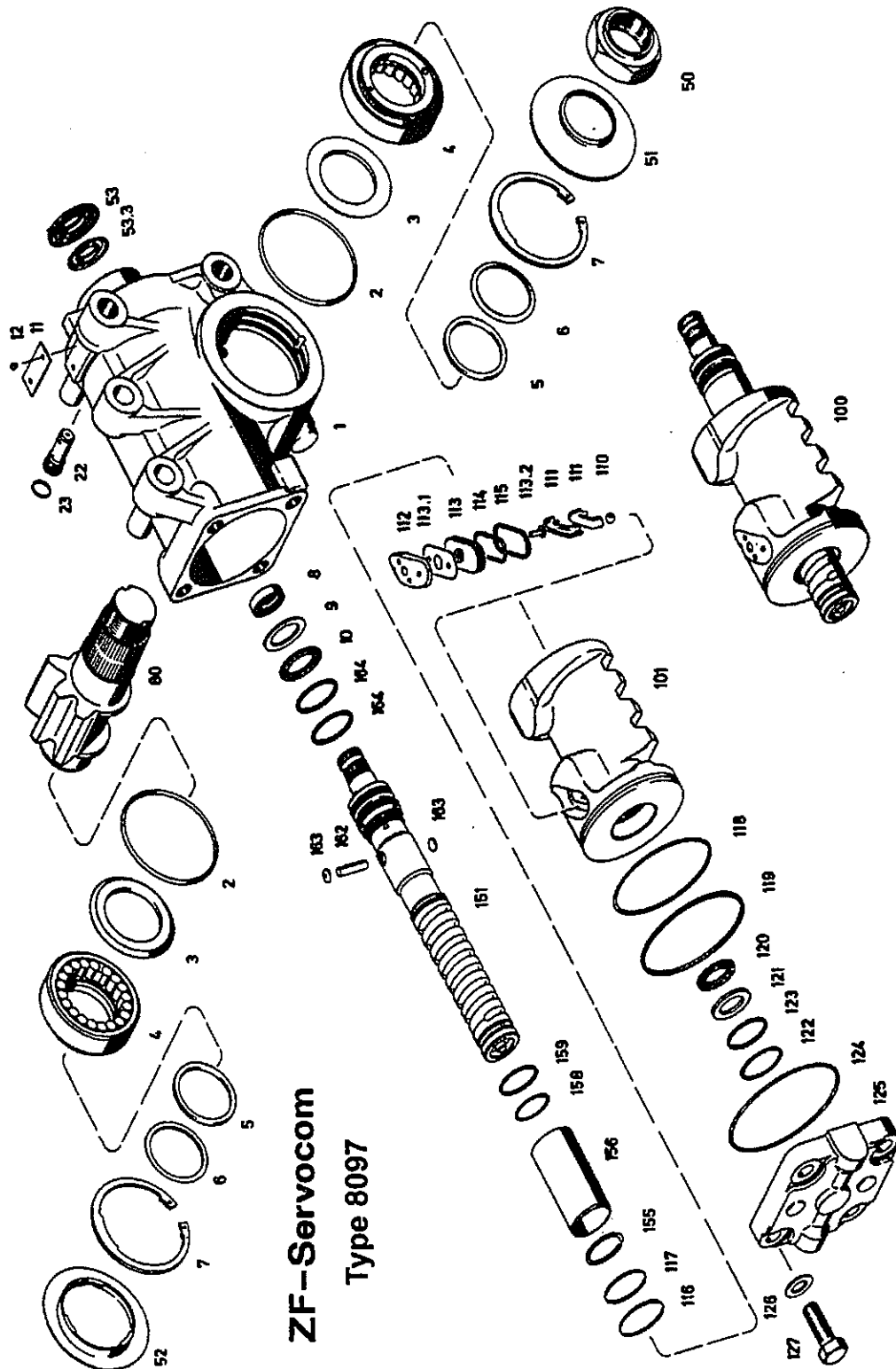
ZF-Servocom
Type 8095



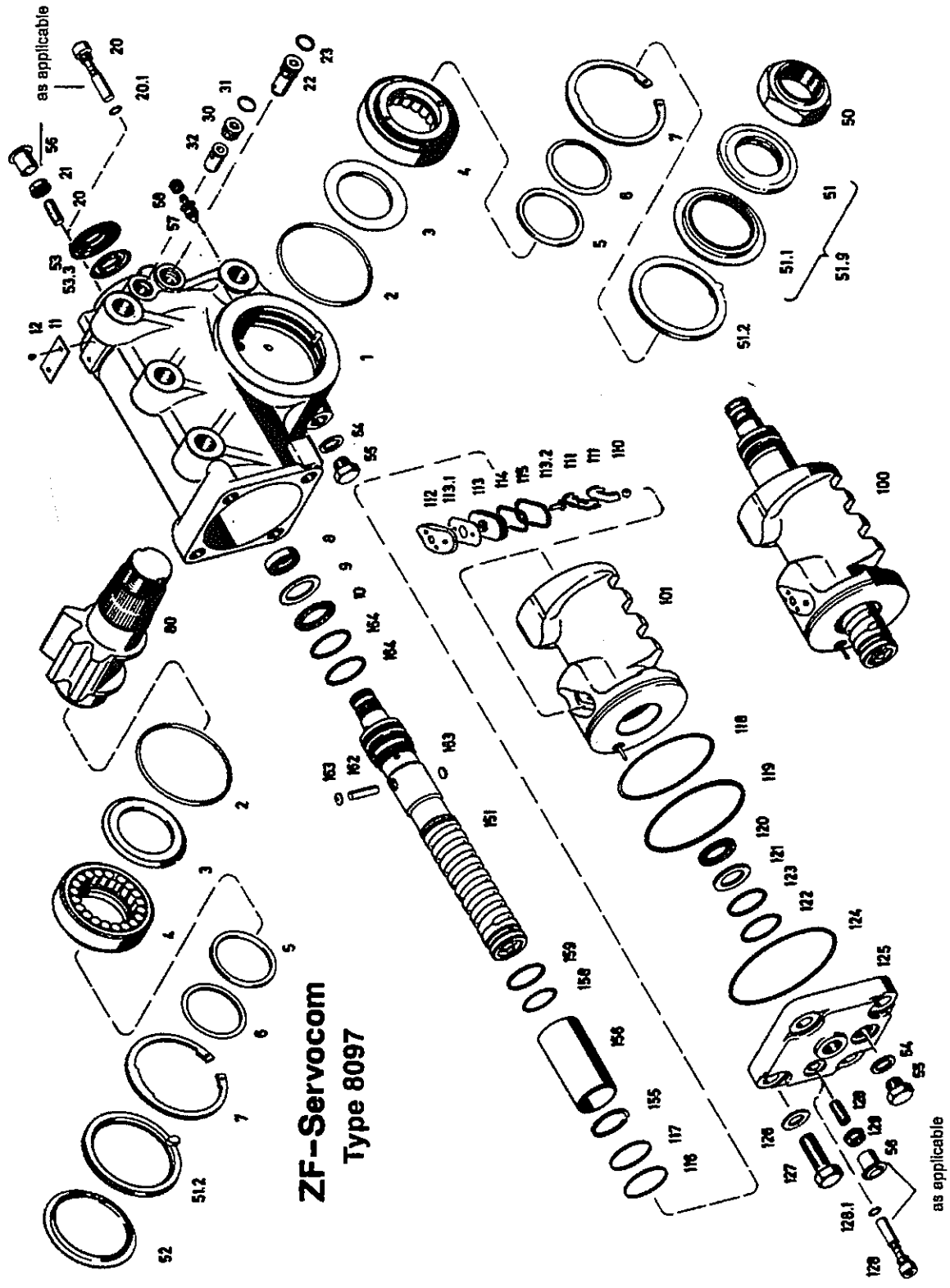
ZF-Servocom
Type 8096



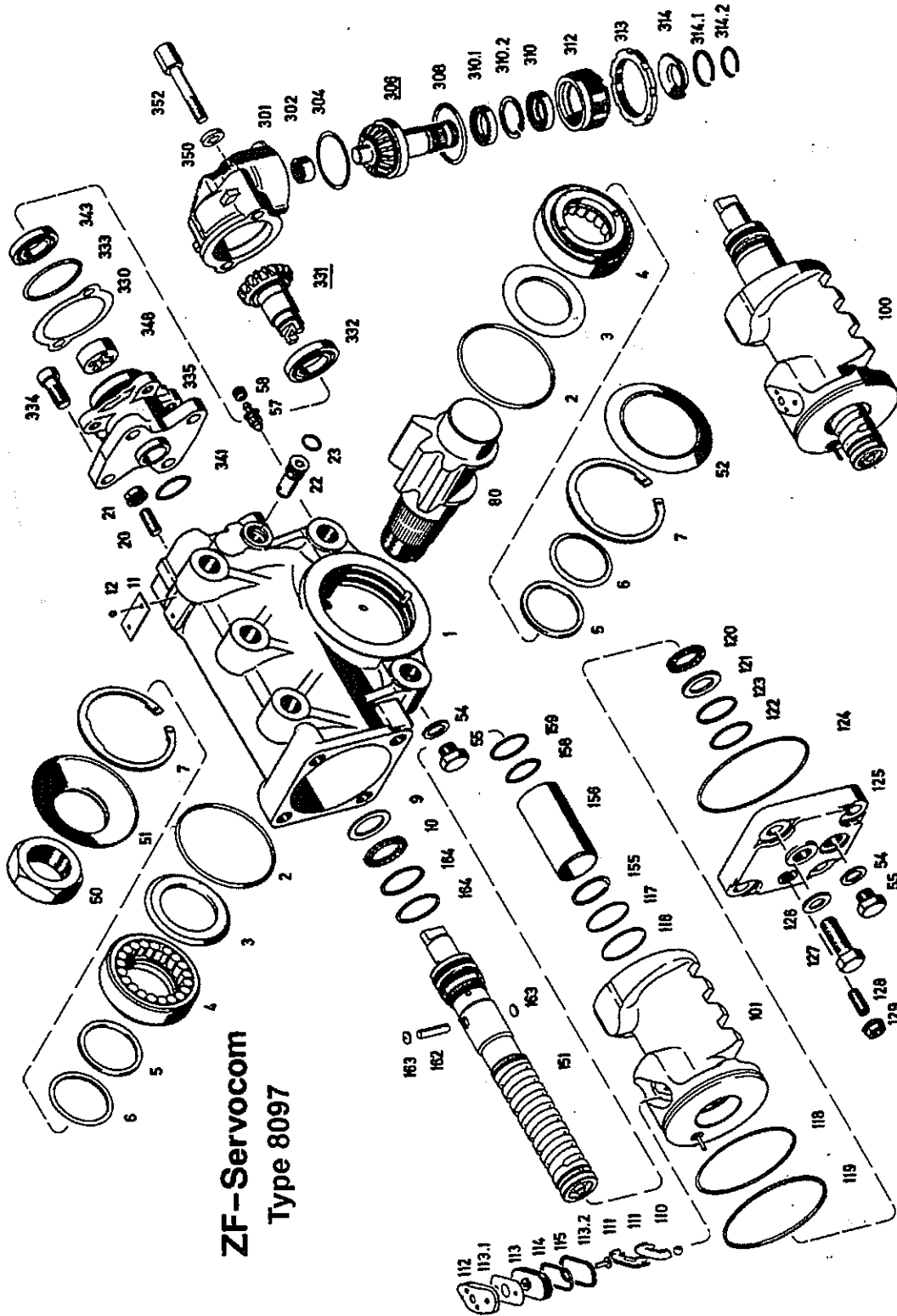
ZF-Servocom
Type 8096



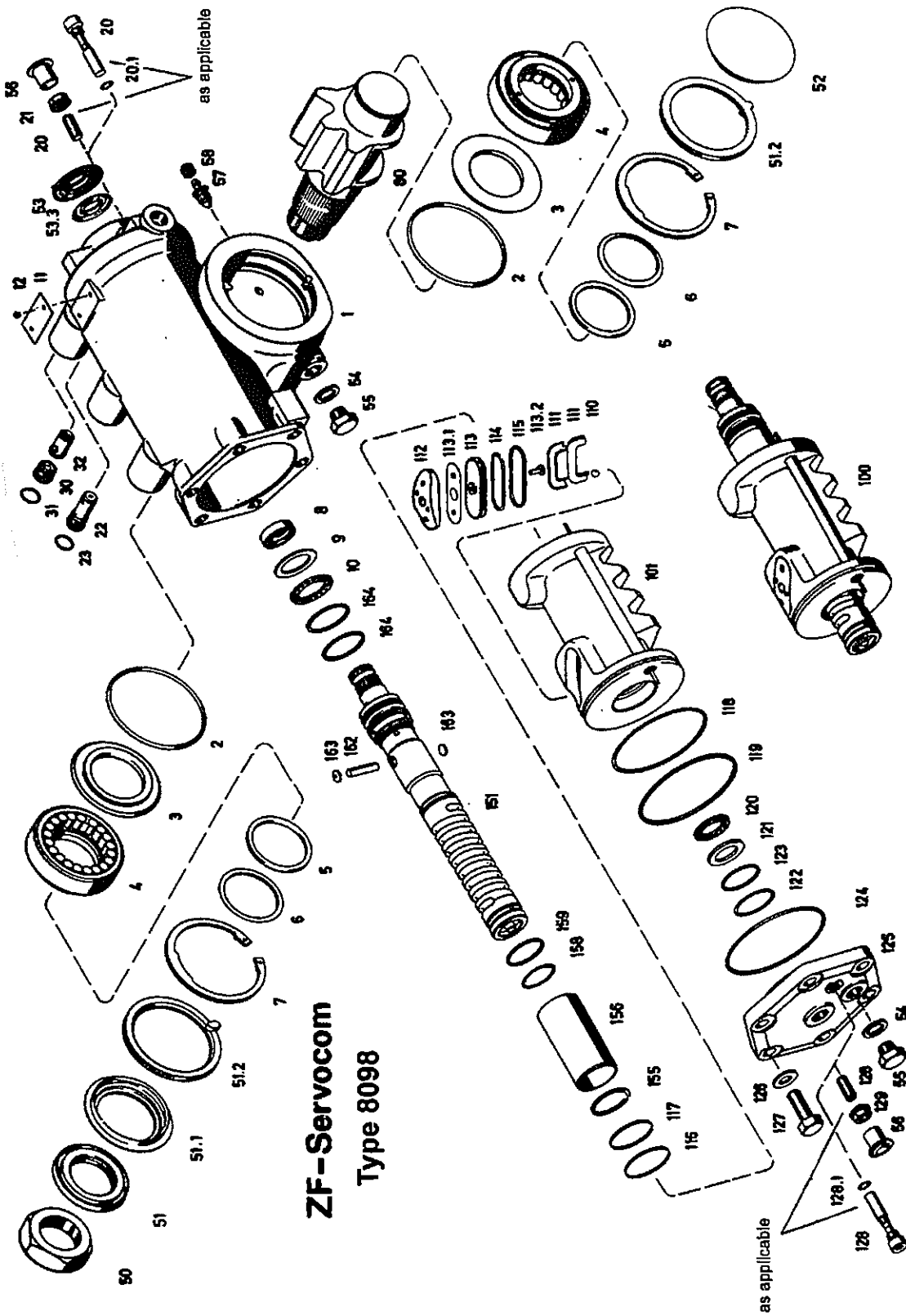
ZF-Servocom
Type 8097

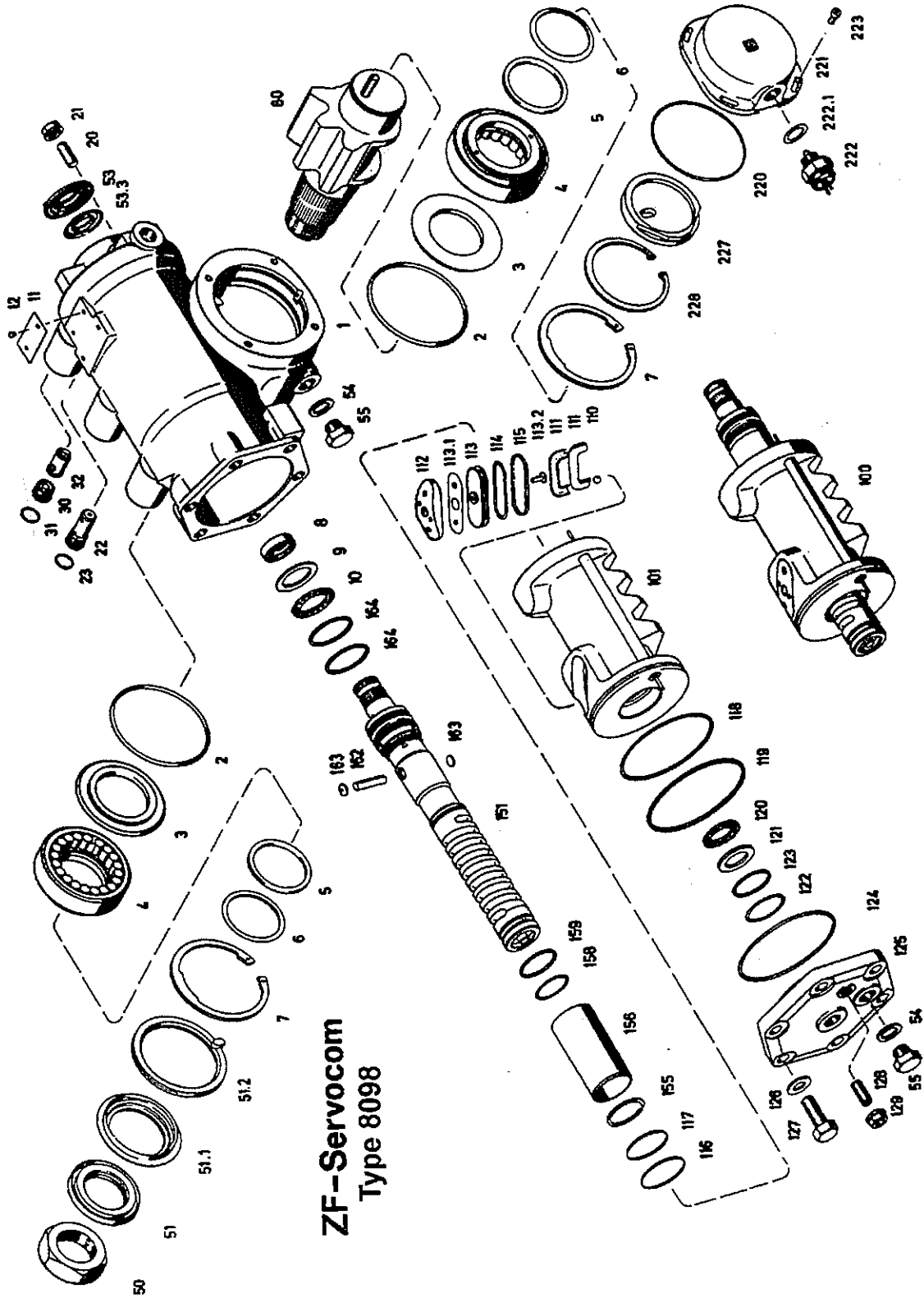


**ZF-Servocom
Type 8097**

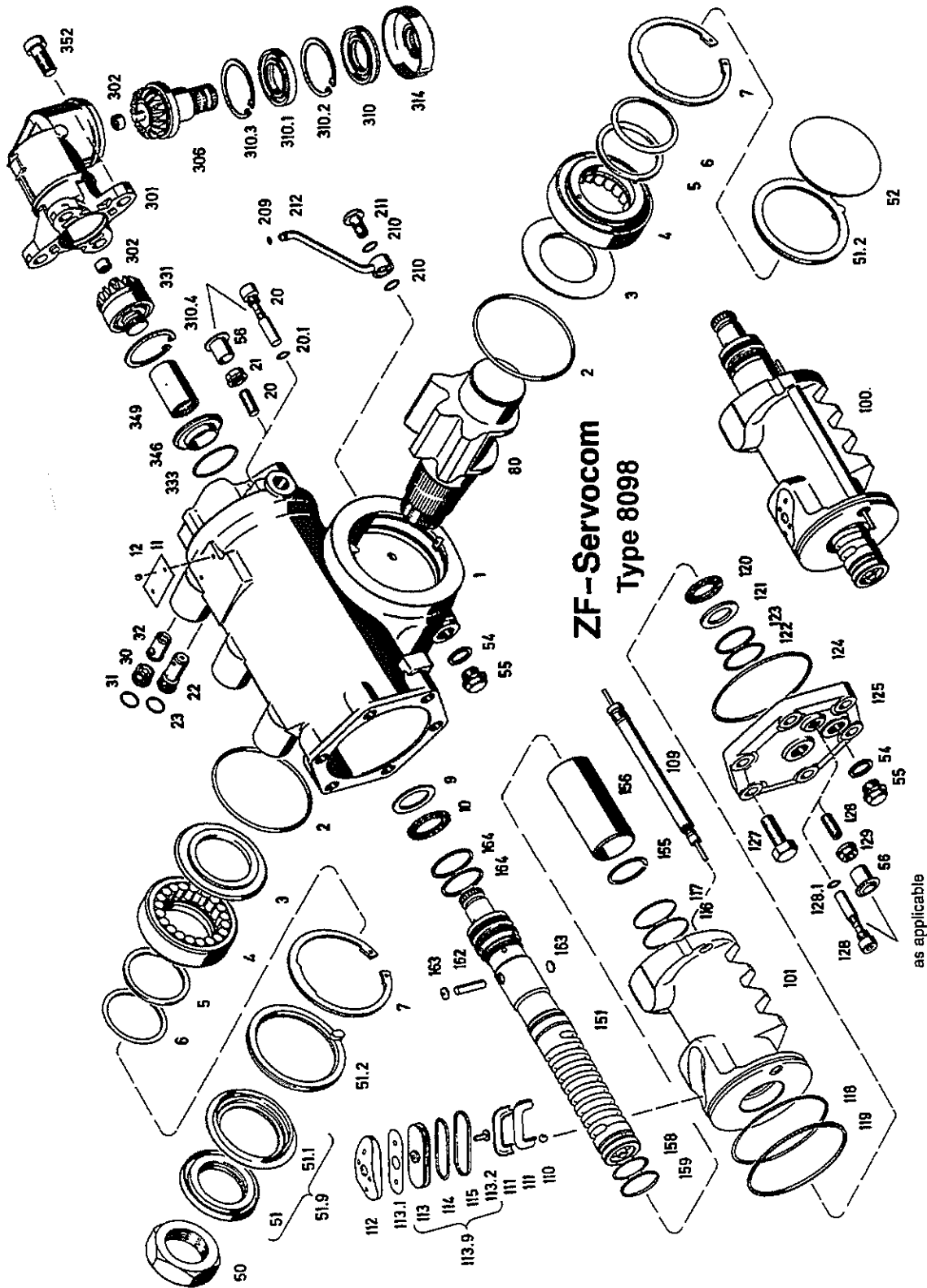


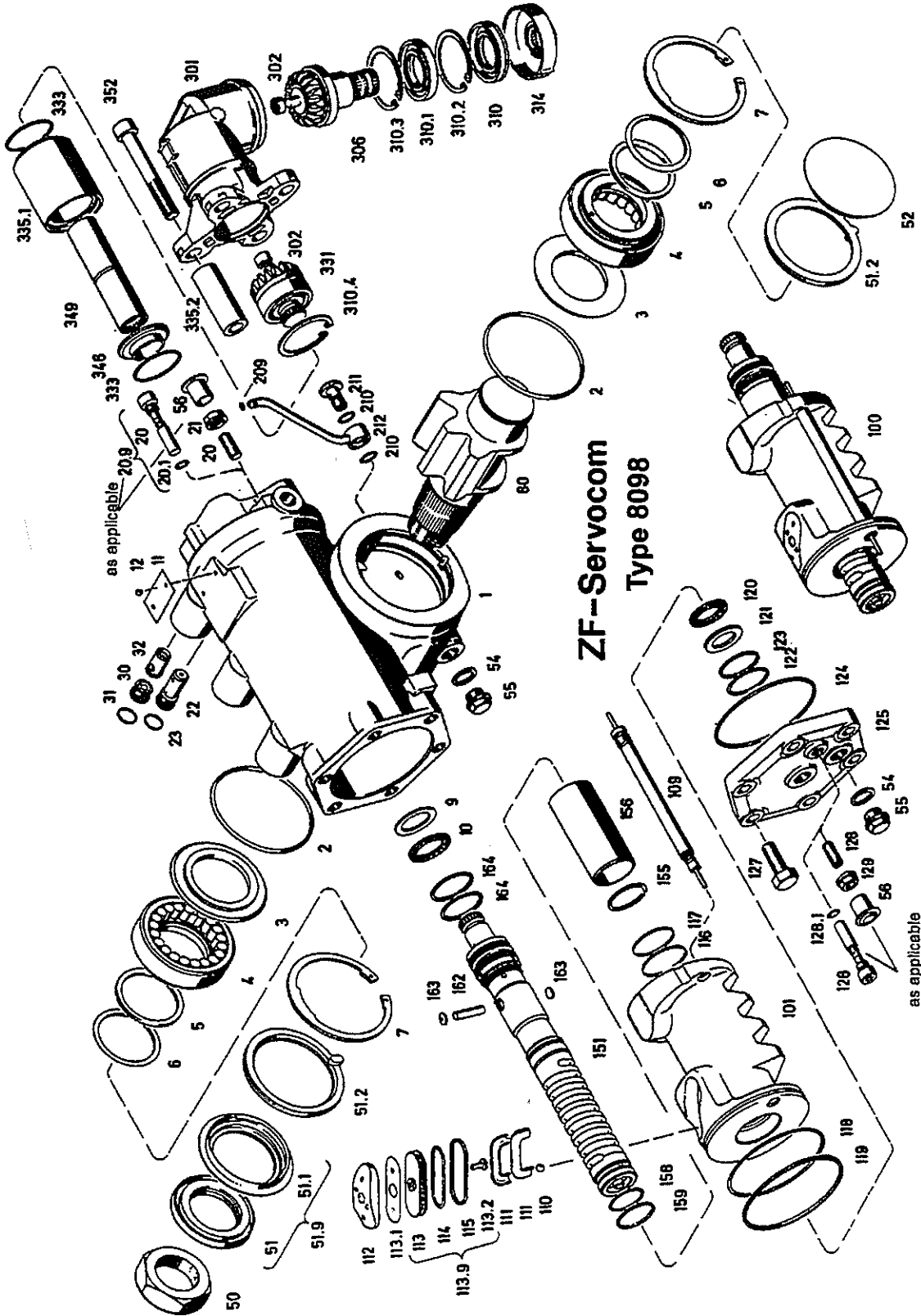
ZF-Servocom
Type 8097

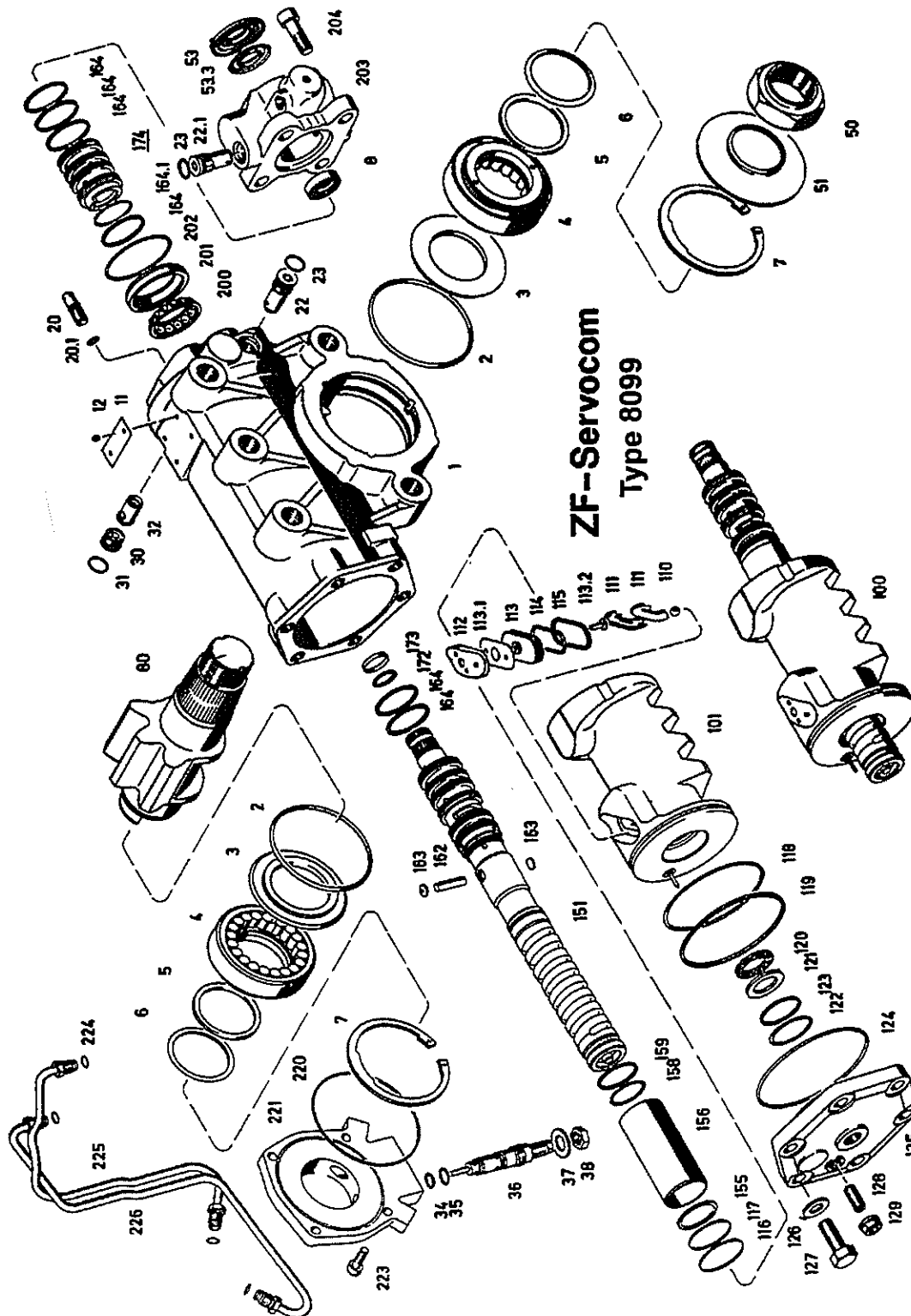


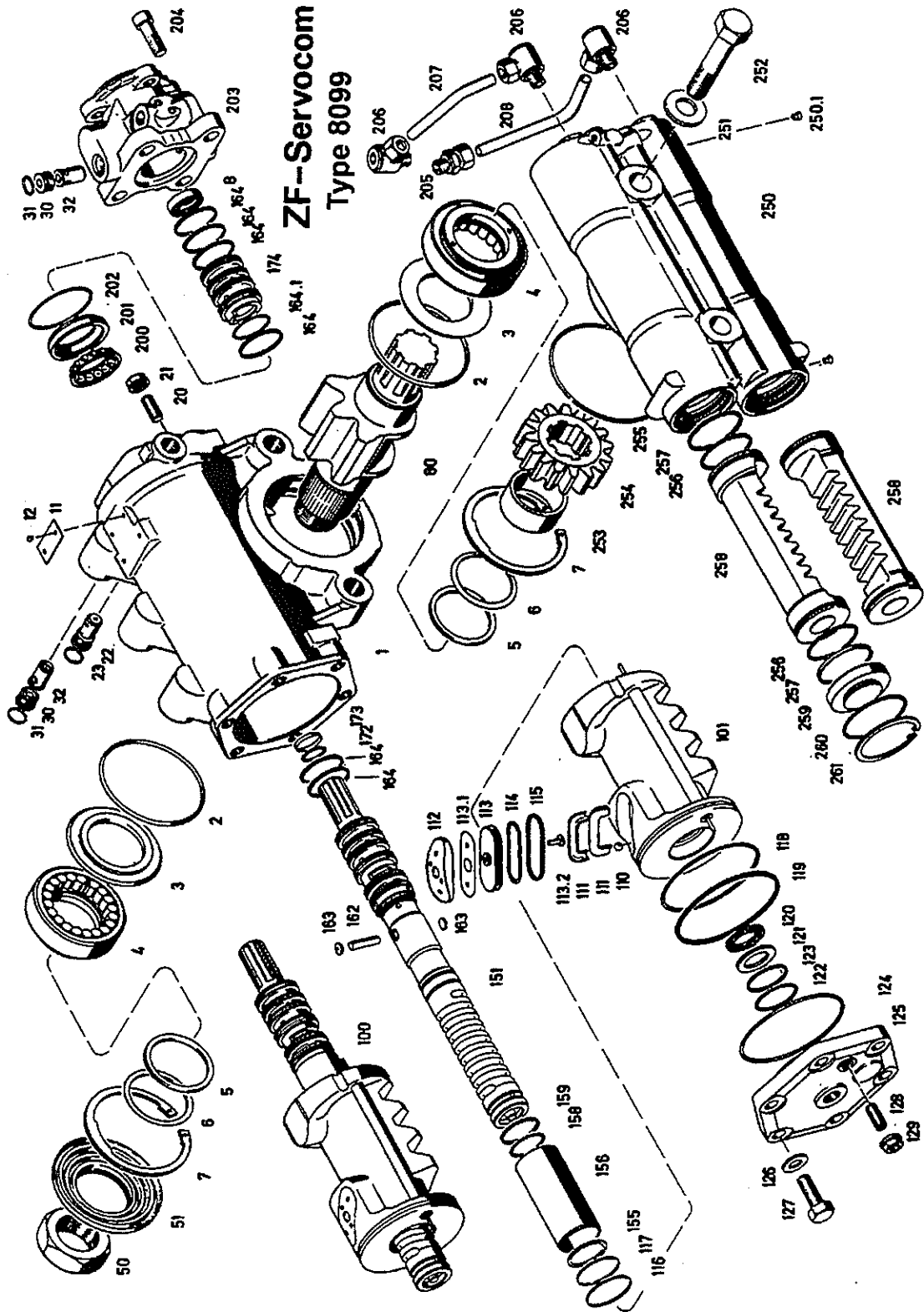


**ZF-Servocom
Type 8098**















ZF-Servocomtronic[®]

Supplement to the Repair Manual ZF-Servocom

**ZF FRIEDRICHSHAFEN AG
GESCHÄFTSBEREICH LENKUNGSTECHNIK**

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Telephone: (07171) 31-0

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Important general information



- The present Manual aims to help the user properly to execute the necessary maintenance and repair work on the ZF product.
- Read the Manual before starting any inspection and repair work.
- On completion of the maintenance and repair work, the specialist personnel must make certain that the product is once more operating flawlessly.

→ ***Please note that the ZF product must be repaired only in workshops that***

- ☞ ***employ trained personnel***
- ☞ ***have the prescribed equipment, including a test rig, crack detector and special tools***
- ☞ ***use ZF genuine spare parts.***

- This Manual is only for foremen and fitters who have undergone practical and theoretical training in our Customer Service School. Together with service information bulletins, it is intended to supplement their knowledge.
- All work carried out on ZF products must be executed with extreme care and diligence. This applies in particular to products and transmission components from vehicles damaged in accidents.
- The manufacturer does not, of course, accept any liability for damage and its consequences arising from incorrectly or inexpertly executed repairs.
- This Manual draws attention to notes on safety as follows:

Note: Where incorrect and careless work can cause damage to the product.



Attention: Where incorrect and careless work can lead to personal injury and endanger life.

- This Manual is not part of the updating service.
 - The contents of the additional service information bulletins must also be observed.
-



	Page
I. Disassembly	2
II. Examining the individual parts	4
III. Assembly	4
IV. Setting and functional test	6
V. Troubleshooting	8
VI. Special tools	12
VII. Key to numbers in figures and exploded drawing	12

Notes:

- The processes necessary for the repair of a ZF-Servocomtronic have mostly been described in the Repair Manual ZF-Servocom.
- Any deviating or additional process will be described in the following.



I. Disassembly

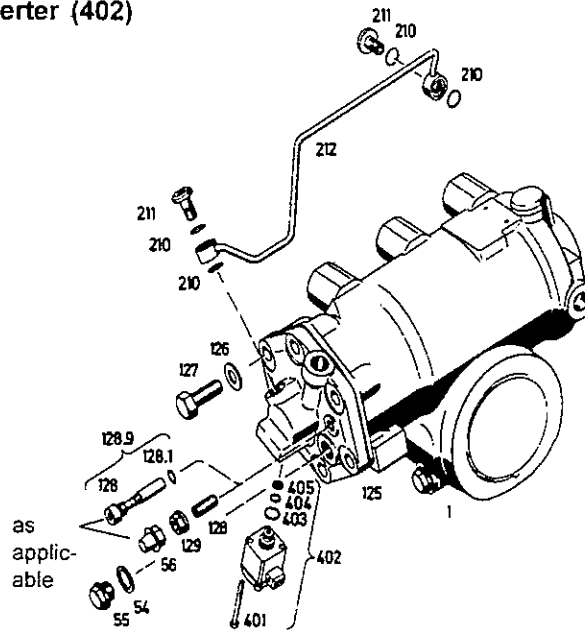
1 Removal of pipe (212) and converter (402)

Screw out union screws (211) and remove pipe (212) with O-rings (210).

Mark position of converter (402).

Turn out two cap screws (401) provided with an internal hexagon.

Remove converter (402) and dismantle O-rings (403 and 404) as well as oil screen (405).



Unscrew hexagon screws (127) with washers (126).

Drive piston (101) back towards bottom of housing so that the valve tappet of valve insert (109) is not damaged when turning the cylinder cover (125).

Remove screw (128) with O-ring (128.1) and set them aside for later use (required for functional tests, chapter IV.).

or:

Remove set screw (128) and collar nut (129).

Unscrew screw plug (55) with sealing ring (54).

Put steering drop arm onto sector shaft (80).



Disassembly

Turn worm (151) or steering drop arm to lift off cylinder cover (125).

Remove needle cage (120) and washer (121).

Remove sealing elements (122, 123 and 124).

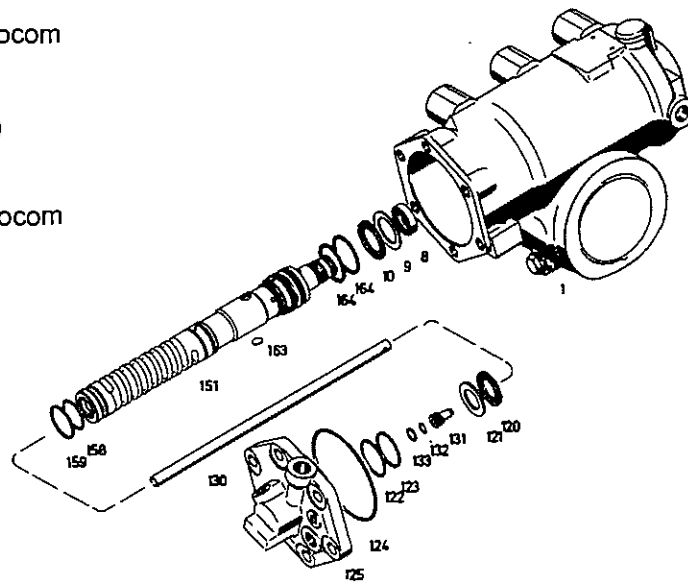
Pull pipe (130) together with reaction piston (131) out of worm (151).

2 Removal of piston (100) and worm (151)

See Repair Manual ZF-Servocom

3 Disassembly of worm (151)

See Repair Manual ZF-Servocom



Pull reaction piston (131) out of pipe (130).

Remove sealing ring (133) and O-ring (132) from reaction piston (131).

4 Removal of sector shaft (80) and disassembly of housing (1)

See Repair Manual ZF-Servocom



II. Examining the individual parts

See Repair Manual ZF-Servocom

1 Cylinder cover (125), reaction piston (131) and converter (402)

→ Tidiness of the bores

2 Reaction piston (131)

→ Free play in cylinder cover (125)

III. Assembly

1 Preassembly of housing (1) and housing cover (4) and installation of sector shaft (80)

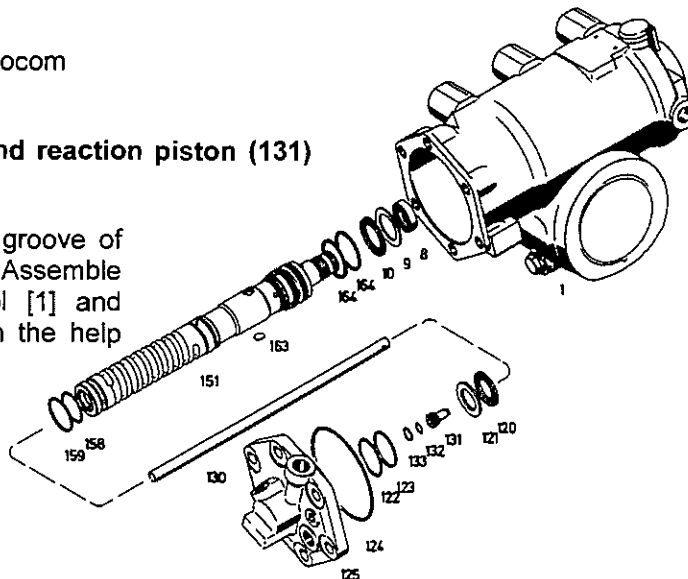
See Repair Manual ZF-Servocom

2 Preassembly of worm (151) and piston (100), installation of piston (100) and worm (151)

See Repair Manual ZF-Servocom

3 Installation of pipe (130) and reaction piston (131)

Insert O-ring (132) into the groove of the reaction piston (131). Assemble sealing ring (133) with tool [1] and press it into the groove with the help of a mounting ring.



Insert pipe (130) and reaction piston (131) in cylinder cover (125).



4 Installation of cylinder cover (125)

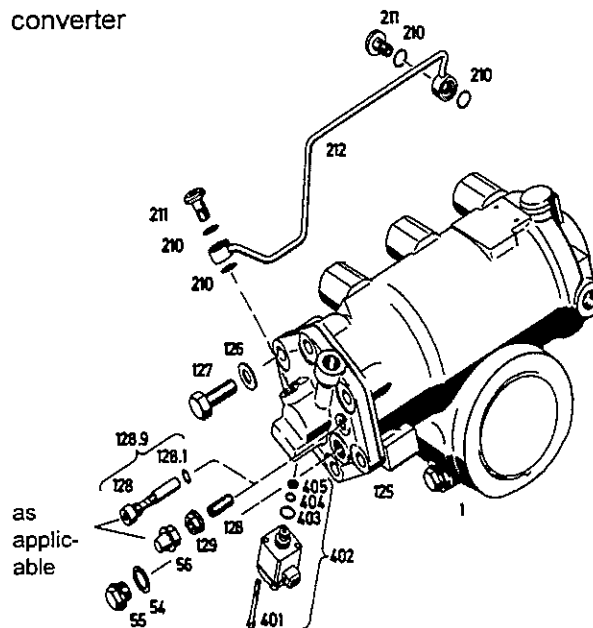
See Repair Manual ZF-Servocom

5 Completing assembly of cylinder cover (125)

Place oil screen (405) in cylinder cover (125).

Place O-rings (404 and 403) in converter (402).

Mount converter (402) as marked upon disassembly with cap screws (401) (tightening torque: 2.9 Nm).



6 Mounting of pipe (212)

Mount pipe (212) with union screws (211) and O-rings (210) (tightening torque: 20 ± 2 Nm).



IV. Setting and functional test

1 See Repair Manual ZF-Servocom

Note:

The checking for oil leakage described in the Repair Manual ZF-Servocom must be performed while the converter is closed. To do so, tool [2] (Servotronicstest) must expose the converter to a current that produces a scale reading of 0.65...0.85. Please observe the following description.

2 Functional test of the converter and of the control unit

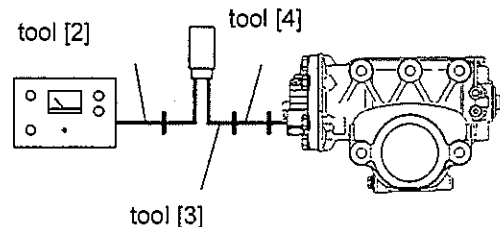
Note:

Before using the Servotronicstest unit, you should read the corresponding operating instructions.

The following functional test refers to the separate checking of the converter and of the control unit. The joint checking of both units is described in the above-mentioned operating instructions.

2.1 Functional test of the converter

- Set up the steering gear on the test bench. Adjust oil flow, pressure, and oil temperature as required for the hydraulic checking on the test bench (see Repair Manual ZF-Servocom). Lock the steering gear in central position.
- Connect the Servotronicstest (tool [2]) to a 220V mains supply with the help of a power supply unit. Now the ready-to-operate tell-tale lamp must light up.
- Connect the tools [2, 3, and 4] to the steering gear as described below.



- Set switch 8 of the Servotronicstest to position "0" .
- Note on the Servotronicstest unit:
By slowly turning the control knob 4 (converter) any driving speed can be simulated.



Turning the control knob to the right end position produces a large deflection of the pointer.
A scale reading of 0.65...0.85 means parking, i.e. low actuation force.

Turning the control knob to the left end position produces a smaller deflection of the pointer.
A scale reading 0...0.1 means maximum speed, i.e. high actuation force.

→ Testing in the parking mode

Put switch 8 of the Servotronic test in position "Wandler/converter" and turn control knob 4 (converter) to the right until the scale reading 0.65...0.85 is attained.

With the test bench switched on, turn the steering wheel to either direction until a pressure of 50 bar is built up at the test bench.

If the Servocomtronic and the converter function correctly the actuation momentum at the torque meter should be between 3.5...5.5 Nm, for example.

For the exact value, please refer to the technical data sheet of the spare parts list or the Service Information circulars.

→ Testing in the high speed mode

Turn control knob 4 (converter) of the Servotronic test to the left until the scale reading 0...0.1 is attained.

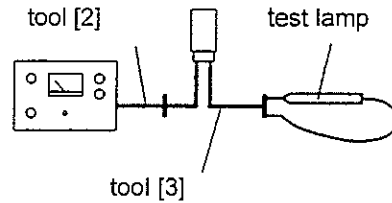
With the test bench switched on, turn the steering wheel to either direction until a pressure of 50 bar is built up at the test bench.

If the Servocomtronic and the converter function correctly the actuation momentum at the torque meter should be between 9...11 Nm, for example.

For the exact value, please refer to the technical data sheet of the spare parts list or the Service Information circulars.

2.2 Functional test of the control unit:

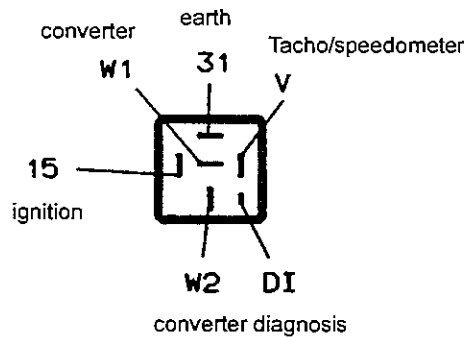
- Connect the Servotronic test to a 220V mains supply with the help of a power supply unit. Now the ready-to-operate tell-tale lamp must light up.
- Set switch 8 of the Servotronic test to position "0".
- Connect tool [3] to Servotronic test (tool [2]).
- Connect the test lamp directly to the control unit or to the cable leading to the converter as accessibility allows.



- Set switch 8 of the Servotronic test to position "Tacho/speedometer".
- Turn control knob 5 (Tacho/speedometer).
 When the control knob is turned to the right end position, the test lamp must light up.
 When the control knob is turned to the left end position, the test lamp must go out.
 During this test, the scale reading indicated on the Servotronic test rises to max. 0.25.

V. Troubleshooting

Pin layout at the socket of the control unit (plug location):



Trouble	Cause	Remedy
Heavy when steering with the vehicle stationary	→ no on-board voltage	→ check and replace, if necessary – remove the control unit – measure at the socket [2] with the help of a multimeter connecting pin 15 to 31 nom. value: 10...16 V

[2] **Attention!** Any measurement between V and 31 must be performed only with a voltmeter. Otherwise the speed signal sensor will be destroyed.



Trouble	Cause	Remedy
	→ wrong control unit	→ check → replace
	→ control unit placed at the wrong plug location	→ check
	→ defective cable connection from control unit to the steering gear	→ check and repair, if necessary – remove control unit – measure at the socket ² with the help of a multimeter connecting pin W1 to W2 nom. value: 5...9 Ω (at 20 ° 7,5 Ω)
	→ converter plug not engaged	→ check and repair, if necessary
	→ earth contact of converter cable	→ check → replace
	→ earth contact of converter	→ check → replace
	→ defective control unit	→ check → replace
	→ wrong speedometer signal before switching off ignition at a speed > 20 km/h	→ check speed signal sensor ¹ ²
	→ converter does not close	→ disassemble blow through clean
	→ defective pump	→ check → replace
	→ excessive internal oil leakage	→ check → replace

¹ see vehicle manufacturer's manual

² **Attention!** Any measurement between V and 31 must be performed only with a voltmeter. Otherwise the speed signal sensor will be destroyed.



Trouble	Cause	Abhilfe
Heavy steering when driving, o.k. when vehicle stationary	→ converter opens at too low speed	→ check control unit → replace control unit
	→ wrong control unit	→ check → replace
	→ wrong speedometer signal	→ check speedometer signal ①
		→ replace speedometer signal ①
Steering too easy when driving, o.k. when vehicle stationary	→ defective control unit	→ check → replace
	→ dirt in converter	→ disassemble clean blow through
	→ wrong speedometer signal at speed < 20 km/h	→ check speed signal sensor ①
	→ cable connection to converter in contact with on-board voltage	→ check and replace, if necessary –remove control unit –measure at the socket ② voltage from pin W1 to 31 nom. value: 0V resistance from pin W2 to 31 nom. value: $\infty \Omega$ i.e. no connection

① see vehicle manufacturer's manual

② **Attention!** Any measurement between V and 31 must be performed only with a voltmeter. Otherwise the speed signal sensor will be destroyed.

Troubleshooting



Trouble	Cause	Remedy
	→ wrong control unit	→ check → replace
	→ defect in cable tree	→ check ¹ → replace
Alternate heavy and easy steering during travelling	→ wrong speedometer signal	→ check speedometer signal ¹ → replace speed signal sensor ¹
	→ defective cable connections	→ check
	→ wrong control unit	→ replace
	→ defective control unit	→ check → replace
Pulsating steering-momentum (tingle at steering wheel) at any driving speed	→ defective control unit	→ check → replace

¹ see vehicle manufacturer's manual

² **Attention!** Any measurement between V and 31 must be performed only with a voltmeter. Otherwise the speed signal sensor will be destroyed.



VI. Special tools

Note:

The special tools listed below refer to the standard version and the design state of the ZF-Servocontronic on the basis of which the entire manual has been compiled.

Other tools may consequently be required for the particular ZF-Servocontronic unit to be repaired.

Tool [1].

Guide bush



Part-No.

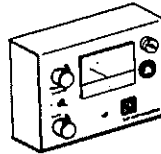
8098 798 004

Mounting ring

8098 798 655

Tool [2]

Servotronic test



7418 798 545

Power supply unit

7418 798 546

Tool [3]

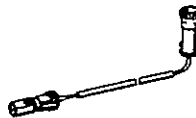
Adapter



7038 340 201

Tool [4]

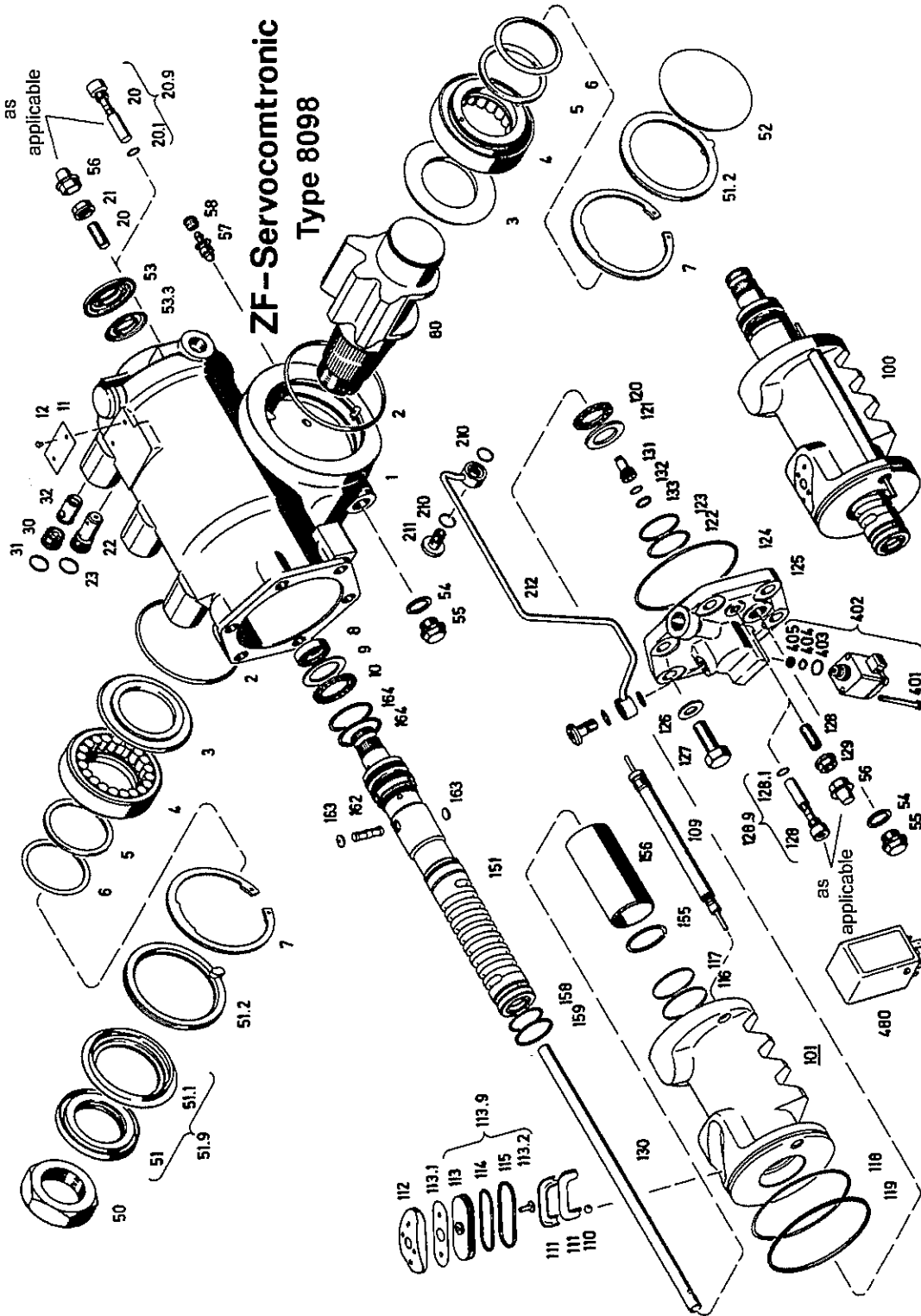
Adapter cable



7418 798 543

VII. Key to numbers in figures and exploded drawing

- 130.0 pipe
- 131.0 reaction piston
- 132.0 O-ring
- 133.0 sealing ring
- 401.0 cap screw
- 402.0 converter
- 403.0 O-ring
- 404.0 O-ring
- 405.0 oil screen





Notes

A series of 20 horizontal dotted lines providing space for notes.



Notes

A series of horizontal dotted lines for taking notes.

Notes



A series of horizontal dotted lines for taking notes.

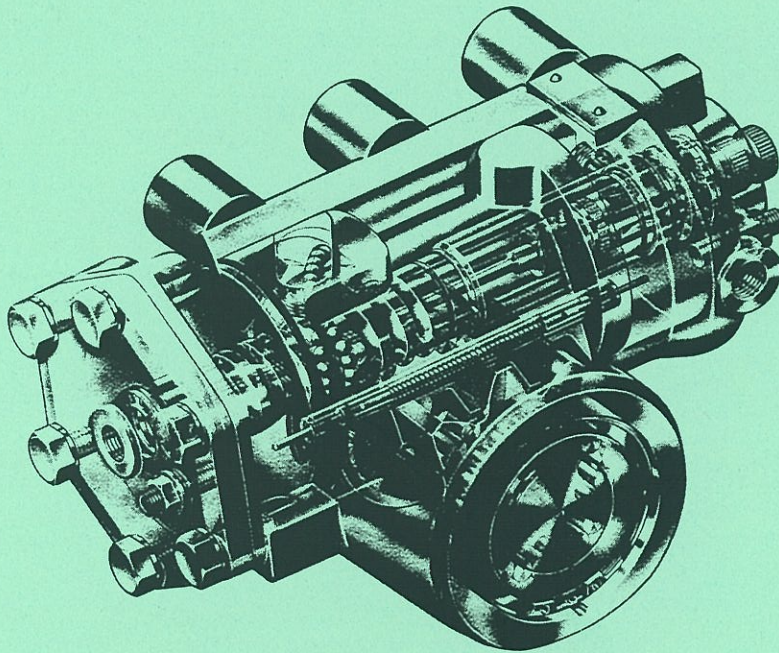






ZF-Servocom[®] **and ZF Recirculating ball power steering (CV)**

Operating, servicing/maintenance and inspection instructions



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Telefax: (07171)31-4396



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- Read the Manual before starting any inspection and repair work.
- On completion of the maintenance and repair work, the specialist personnel must make certain that the product is once more operating flawlessly.

→ ***Please note that the ZF product must be repaired only in workshops that***

- ☞ ***employ trained personnel***
- ☞ ***have the prescribed equipment, including a test rig, crack detector and special tools***
- ☞ ***use ZF genuine spare parts.***

- This Manual is only for foremen and fitters who have undergone practical and theoretical training in our Customer Service School. Together with service information bulletins, it is intended to supplement their knowledge.
- All work carried out on ZF products must be executed with extreme care and diligence. This applies in particular to products and transmission components from vehicles damaged in accidents.
- The manufacturer does not, of course, accept any liability for damage and its consequences arising from incorrectly or inexpertly executed repairs.
- This Manual draws attention to notes on safety as follows:

Note: Where incorrect and careless work can cause damage to the product.



Attention: Where incorrect and careless work can lead to personal injury and endanger life.

- This Manual is not part of the updating service.
 - The contents of the additional service information bulletins must also be observed.
-



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I. Operation



Attention: important safety information for the driver and workshop personnel

If correctly installed, properly maintained and free of accidents, ZF hydraulic power steering can have a long service life. To ensure complete operativeness, we recommend that the mechanical steering parts are checked (visual examination of all parts, check for cracks in parts under stress) and the seals replaced at the 3rd inspection (does not apply for Servocom steering manufactured after 01.94) (see Section VIII).

The size of the steering and the mechanical steering transmission are selected in consultation with the vehicle manufacturer in such a way that in the event of failure of the hydraulic steering booster, the actuating force to be applied to the steering wheel does not exceed the maximum considered to be reasonable by the law.

Under ECE-R79, this force, which depends on the permissible total weight of the vehicle, is max. 450 N on the steering wheel turn when the vehicle is steered from straight-ahead driving into a circle of radius 20 m. The speed in this case is approx. 10 km/h and the steering action must take no more than 6 seconds.

The driver should know that if the hydraulic power steering suddenly fails, e.g. through failure of the pump drive, his vehicle can still be steered but will require a considerably greater force to be applied for steering. Since such a situation occurs extremely rarely, and then usually completely unexpectedly, the driver may jump to the mistaken conclusion that the steering system is locked. However, this is not the case. The driver must simply apply the necessary force to carry out the steering action.

In order to avoid damage in the steering gear and steering column, the operating force on the steering wheel (diameter 500 mm) when steering while stationary without hydraulic assistance must not exceed 1000 N (approx. 100 kg).

This important safety information is given for the purpose of clarifying the context and preventing the driver making an incorrect diagnosis.



II. Construction and functioning

1 ZF Servocom, Type 8090-98

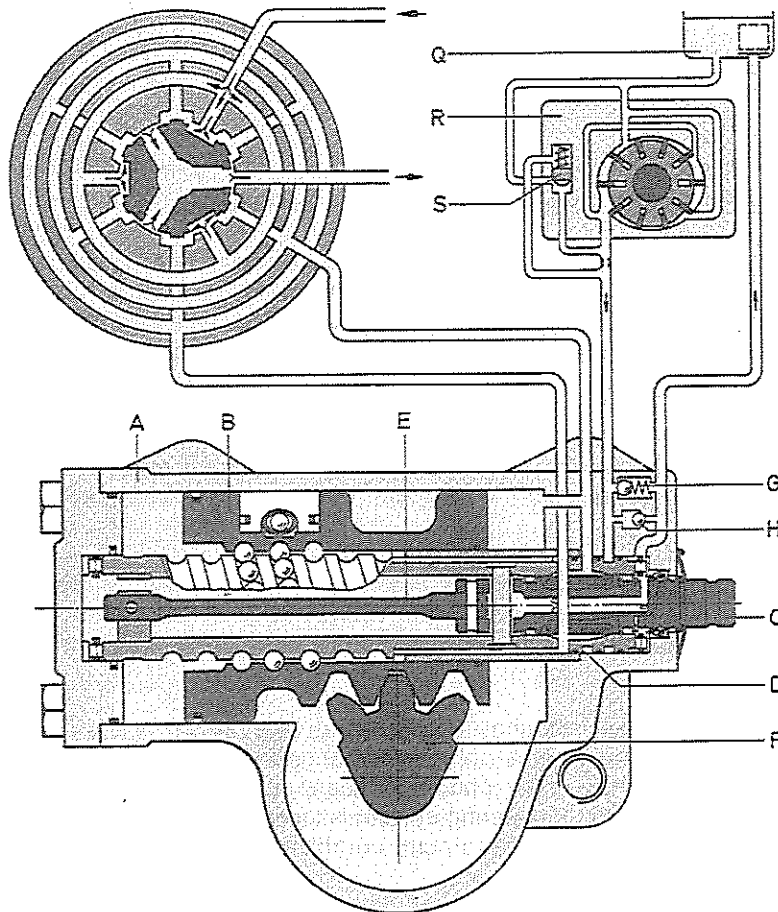
1.1 Construction

The housing of the ZF Servocom contains a control valve, working cylinder and a complete mechanical steering gear.

The pressure oil for the steering is delivered by a motor-driven oil pump which is supplied with oil from an oil tank.

The housing (A) – see also *Illus. 1* – is designed as a cylinder for the piston (B), which converts the rotation of the steering shaft (C) and the worm (D) into an axial movement and transfers this to the steering worm sector shaft (F). The toothings of the sector shaft and piston are straight-cut with a high surface quality in such a way that it is only possible to set a unique setting without play on installation in the straight-ahead driving area by means of the two eccentrically designed lateral housing covers.

The piston (B) and worm (C) are connected via a ball chain. When the worm is turned, the balls are collected by a circulating pipe at one end of the chain and fed in again at the other end, thus producing an endless ball chain.



Illus. 1 Valve slide in neutral position

- A Housing
- B Piston
- C Valve slide / steering shaft
- D Control sleeve / worm
- E Torsion bar
- F Steering worm sector shaft
- G Pressure relief valve
- H Replenishing valve
- J Induction port
- K Induction port
- L Return port
- M Return port
- N Axial groove
- O Axial groove
- P Return groove
- Q Oil tank
- R Wing pump
- S Flow control valve

The control valve consists of the valve slide (C) in a needle bearing in the worm, with six control grooves on the circumstance and the control sleeve (D) on the worm, which also has six control grooves. The valve slide, designed with steering shaft connection, turns together with the worm as the steering wheel is turned.



A torsion bar (E), which is pinned with the valve slide (C) and the worm (D), keeps the control valve in the neutral position as long as no opposing force is applied to the steering wheel.

The steering housing contains a pressure relief valve (G) which limits the discharge pressure of the oil pump to the maximum value required. A replenishing valve (H) can also be used, through which oil is sucked from the return if steering is not hydraulically boosted.

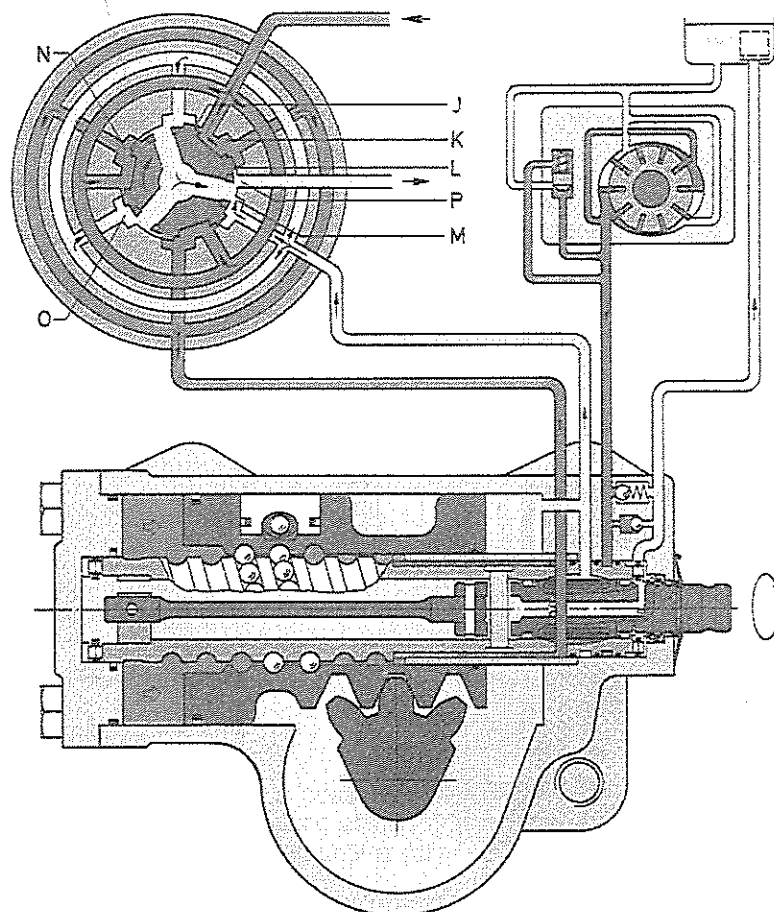
Compared with constant transmission, steering versions with variable transmission are more directly designed in the centre area than outside the centre area. The resulting smaller steering corrections benefit steering behaviour in straight-ahead driving. At the same time, the indirect transmission means that there is a higher hydraulic torque available at the steering arm in parking movement.

If the hydraulic assistance fails, the operating forces on the steering wheel are correspondingly lower in this area. This is achieved through a piston/steering worm sector shaft toothing with differing modulus and angle of pressure.

1.2 Function

Upon transfer of a torque from the steering shaft to the worm, or vice versa, the torsion bar is deformed in the elastic area so that there is torsion between the valve slide and the control sleeve. The control grooves of the valve slide are thereby displaced from the central (neutral) position compared with the control grooves of the control sleeve.

When the steering wheel is released, the torsion bar ensures that the valve is returned to the neutral position.



Illus. 2
Valve slide in working position
Steering wheel turned in clockwise direction

■ operating pressure
▨ return flow pressure

J Induction port
K Induction port
L Return port
M Return port
N Axial groove
O Axial groove
P Return groove

The 3 functional diagrams of *Illus. 1* to *3* show valve and oil flow in a simplified way for ease of comprehension. These diagrams also show the valve in cross-section so that the connections from the control valve to the cylinder compartments and the functioning of the valve can be shown schematically.



The pressure oil flows into the ring-shaped groove of the control sleeve. It is fed to the arch-shaped control grooves of the internal valve slide through three symmetrically arranged radial holes. The position of the control grooves in the valve slide and control sleeve is set in such a way that if the valve is in a neutral position, the pressure oil can run into the axial grooves (N and O) of the control sleeve, which are also arch-shaped, through the induction ports (J and K). From there the oil is released to each side of the working cylinder via radial holes. As long as the steering valve is in the neutral position, the oil can run into both sides of the working cylinder and to the three return grooves (P) in the valve slide, from where it returns to the oil tank.

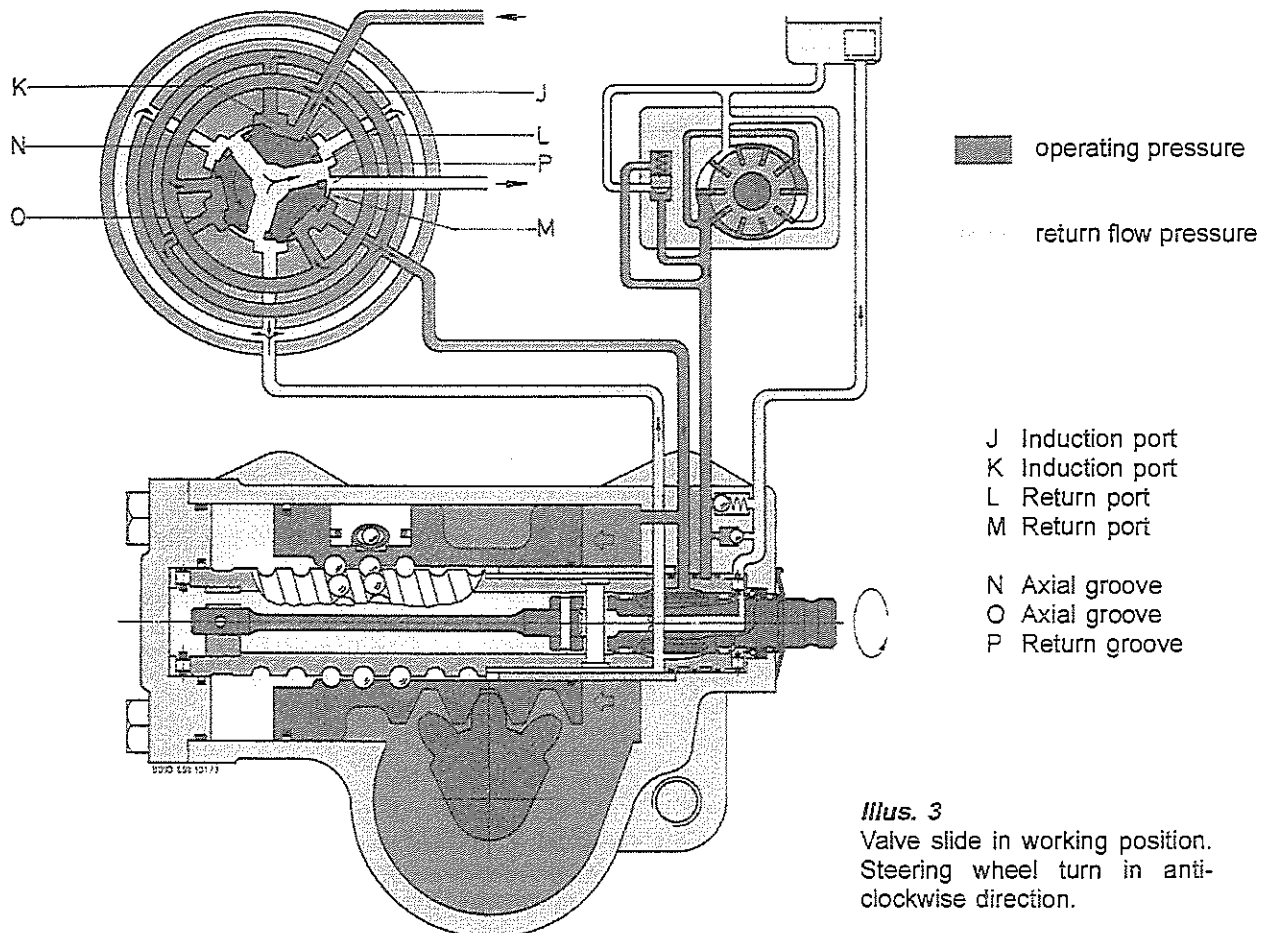
When the steering wheel is turned in a clockwise direction, the piston with a right-handed thread is pushed to the right (*Illus. 2*). Since the movement of the piston is to be assisted through pressure oil, the oil must now be directed to the left cylinder side.

The control grooves of the valve slide are pushed in a clockwise direction and the induction ports (K) are opened further for the pressure oil supply. However, the induction ports (J) close and block the supply of pressure oil to the axial grooves (O) and the control sleeves.

In the position of the valve described in *Illus. 2*, the pressure oil flows through the induction ports (K) into the axial grooves (N) of the control sleeve and from there reaches the left cylinder via the planetary thread, so that piston movement is ensured for the hydraulic assistance. The closed induction ports (J) prevent the oil flowing to the oil tank.

The oil from the right cylinder side is compressed. It flows via the opened return ports (M) to the return grooves (P) of the valve slide. From here constant return to the oil tank is ensured through the centrally positioned oil hole in the valve slide.

If the steering wheel is turned in the opposing direction (*Illus. 3*), the piston of the working cylinder moves to the left and should be assisted through pressure oil in the right cylinder. The control grooves of the valve slide are pushed in an anticlockwise direction and let the pressure oil flow through the opened induction ports (J) into the axial grooves (O), from where connection to the right cylinder is established. The oil from the left cylinder flows via the planetary thread and the opened return ports (L) to the return grooves (P) of the valve slide. Access to the oil tank is open via the centrally positioned oil hole in the valve slide.

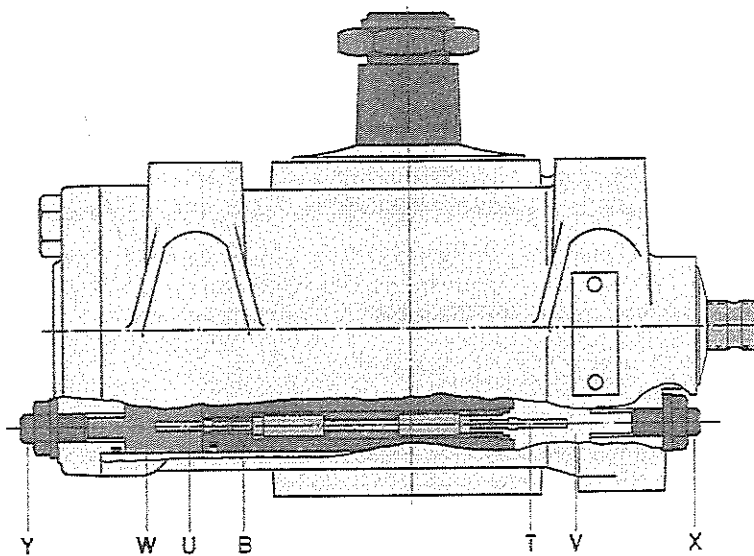


1.3 Functioning of the hydraulic steering limiter

The hydraulic steering limiter prevents steering to the wheel locks at full hydraulic pressure. It serves to protect the pump and steering linkage and prevents high oil temperatures.

A double-acting steering limiter valve with spring-weighted valve pins (T and U) extending beyond the right and left piston faces is located in the piston (B) along its longitudinal axis (*Illus. 4*).

Illus. 4 Steering limiter valves closed



T right valve pin of steering limiter valve

U left valve pin of steering limiter valve

V right cylinder compartment

W left cylinder compartment

X right setting screw

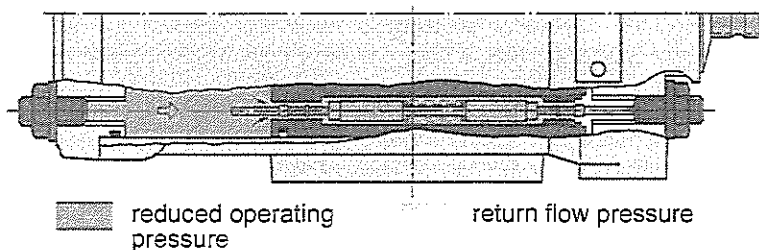
Y left setting screw

When the piston is pushed to the right or left towards the final stop, the valve pins (T and U) are actuated by the setting screws (X and Y) fixed in the housing and cylinder cover. The steering limiter valve remains closed until a valve pin contacts the setting screw.

When the piston moves to the right, for example (*Illus. 5*), the right valve pin (T) contacts the setting screw (X) before the piston limit position is reached. The valve pin (U) is thereby pushed by the pressure oil, whereby the oil flows from working cylinder compartment (W) into working cylinder compartment (V) and can reach the return. If the piston moves to the left, the process is reversed.



Illus. 5 Piston moves to the right. Right valve pin opened. Oil pressure greatly reduced.



When the steering limiter valve is opened, the steering can continue to be turned with increased force and greatly reduced hydraulic assistance up to the wheel lock or the stop in the steering.

1.4 Setting the mechanically adjustable hydraulic steering limiter, type 8090-98

Note:

In principle, the hydraulic steering limiter is first set by the manufacturer in the test bay according to the engineering instructions of the vehicle companies.

Further setting is carried out after the steering has been installed in the vehicle and in the prescribed inspections by means of a manometer. Adhere to the setting instructions of the vehicle manufacturer.

Setting the hydraulic steering limiter in vehicles using a manometer:

A manometer (pressure range up to 250 bar or hydraulic steering tester) is screwed into the pressure line between the pump and the steering system (*Illus. 6*) and the steering axle, if designed as a rigid axle, is relieved through jacking-up.

Attach jack to axle. If the vehicle has independent suspension, the steered wheels must stand on rotary tables for setting of the hydraulic steering limiter; in any case, the steering axle must be loaded in order to compensate approximately for possible deflection errors in measurement.

Turn steering up to wheel lock with engine running at idle speed, oil temperature of steering system above 50°C or 30°C, without exerting great force.

Once the wheel lock has been reached, a brief (max. 5 seconds) continued turning of the steering wheel will overcome the self-aligning force of the steering valve until a fixed steering wheel lock is achieved.

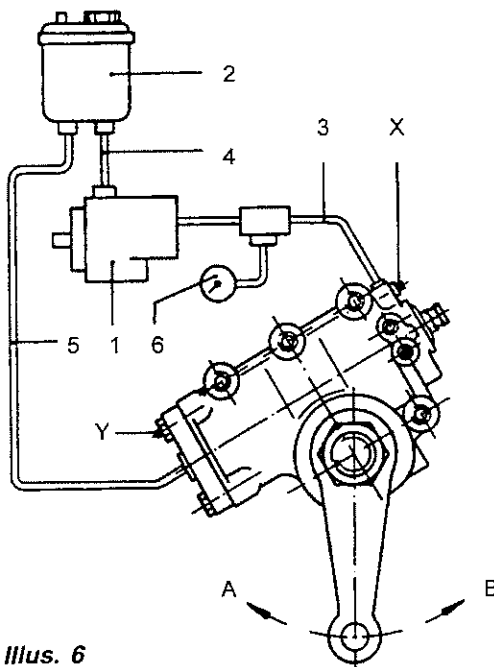
An actuating force on the steering wheel of 100 – 200 N is required to do this.

If the steering limiter is set correctly and the flow rate while the engine is at idle speed does not exceed 16 dm³/min, e.g. with steering systems with an additional working cylinder, the manometer must now show an oil pressure of

40 to 45 bar at an oil temperature of 50°C, or
45 to 50 bar at an oil temperature of 30°C.

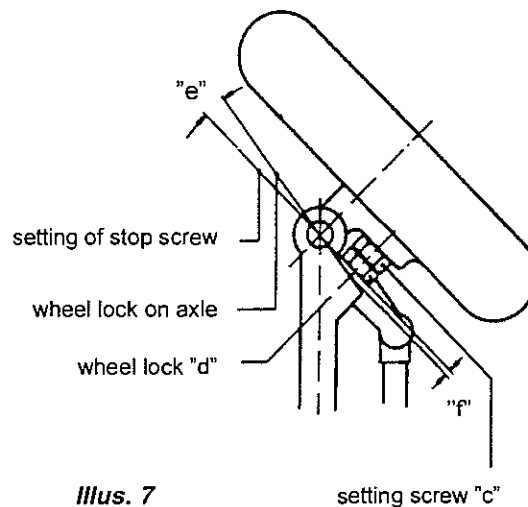
The vehicle manufacturer may prescribe a mode of setting that differs from the abovedescribed (e. g. insertion of a spacer), see *Illus. 26*.

Setting the steering limiter



Illus. 6

- X Setting screw of hydraulic steering limiter for steering arm deflection in direction "A"
- Y Setting screw of hydraulic steering limiter for steering arm deflection in direction "B"



Illus. 7

Illus. 7 shows the distance "f" which should exist between the wheel lock parts upon response of the hydraulic steering limiter, provided that the vehicle manufacturer prescribes a distance

- 1 Pump
- 2 Oil pump
- 3 Pressure line
- 4 Suction line
- 5 Return line
- 6 Manometer

If the above examination shows that the desired pressure drop has not been achieved, the reason may be that the flow rate is too great (above 16 dm³/min) or the oil temperature too low. In this case the flow rate of the pump with the engine at idle speed must be measured or the oil temperature increased. For steering systems with higher flow rates, the following setting values apply:

above 16 dm ³ /min:	50 to 55 bar at 50°C
	55 to 60 bar at 30°C
above 20 dm ³ /min:	70 to 75 bar at 50°C
	75 to 80 bar at 30°C

To make corrections, release the corresponding lock nut and screw the setting screw (X or Y) in or out (**Illus. 6**). Release the steering wheel at the same time, so that only the flow pressure builds up during this operation. Then tighten lock nut with 30 Nm.



Attention:

During the setting as soon as in the installed condition it must be secured that the setting screws (x and y) are at least screwed in 3 pitches. Otherwise the caution is present that the screws will be exploded out in the case of maximum pressure.

The second wheel lock is set in a similar fashion.

The setting screw (X) in **Illus. 6** must be adjusted if the steering column is moved towards "A" according to **Illus. 6**. In the same way, setting screw (Y) is adjusted if the steering column turns towards "B".

After this setting, the hydraulic assistance should be active until the wheel lock is reached. To check the setting appropriately, turn the steering wheel, while driving the vehicle slowly and under normal load, until the hydraulic assistance is disconnected.

Setting the steering limiter



If the pressure falls too early or too late when the steering column is turned towards "A" or "B", the setting screws (X or Y) must be twisted as described below.

If a higher pressure is measured, the corresponding setting screw must be **screwed in** again (clockwise).

If a lower pressure is measured, the corresponding setting screw must be **screwed out** again (anticlockwise).

Check:

To check this setting appropriately, turn the steering wheel, while driving the vehicle slowly and under normal load, until the hydraulic assistance is disconnected.

1.5 Automatically adjustable hydraulic steering limiter, type 8090-98 (visible externally by hexagon instead of lock nut)

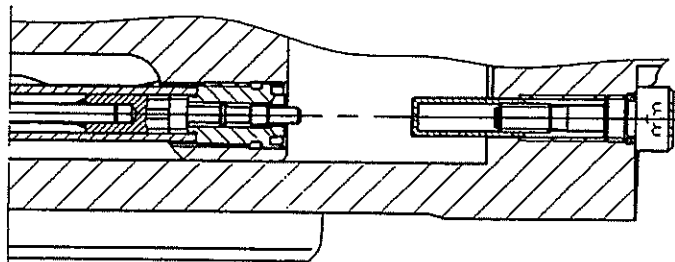


Attention:

Steering systems with automatically adjustable steering limiters must not be mechanically turned to the limit positions if the steering linkage has been removed or the system dismantled. The sliding sleeves would then be pushed into the maximum possible cut-off position and automatic setting in the vehicle would only be possible with new sliding sleeve assemblies (X or Y) (*Illus. 8*). If necessary, fit new sliding sleeve assemblies.

Sliding sleeve assemblies and normal setting screws are not interchangeable.

Illus. 8 Starting position of sliding sleeves not yet set



1.5.1 Functioning of automatically adjustable hydraulic steering limiter

With the automatically adjustable hydraulic steering limiter, screws (X and Y) with pressed-on sliding sleeves are located in place of setting screws.

These function in the same way as with the manually adjustable hydraulic steering limiter. In the limit positions, the valve piston tappets meet the sliding sleeves and open the steering limiter valves (U and T). The opening point is determined by the position of the sliding sleeves on the screws.

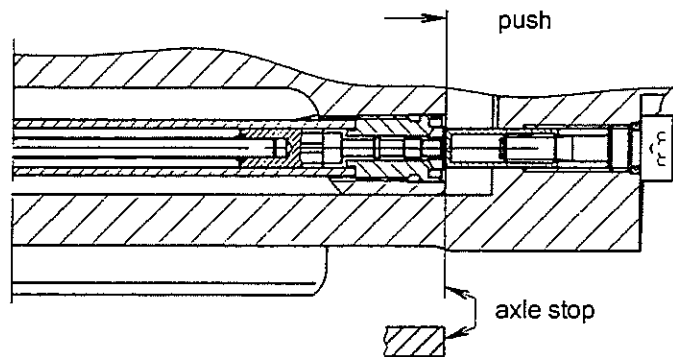
1.5.2 Setting

Note:

Setting (*Illus. 9*) is only possible after the steering system has been installed in the vehicle. The steering linkage and the axle stops must be mounted and set.

Illus. 9 Setting process

Positioning the sliding sleeves

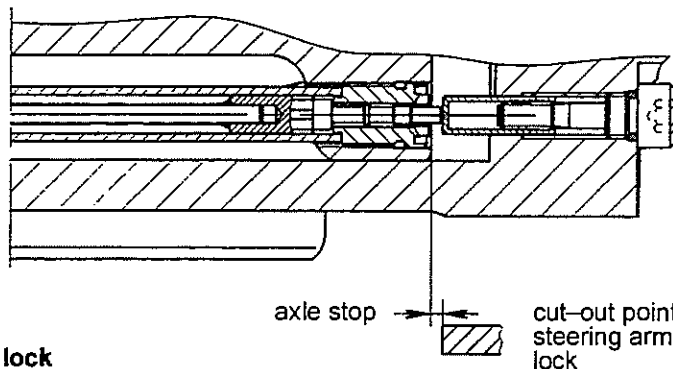


When the above conditions have been met, the steering wheel must be turned to the maximum wheel lock with or without hydraulic assistance. This causes the piston to push the sliding sleeve on the screw to the cut-out position (*Illus. 9*). The steering limiter valve is permanently open during this setting process, which is why the steering wheel can only be turned with increased force whether or not there is hydraulic assistance. In order to allow mechanical steering and roughly compensate for errors of deflection which may occur in measurement, for vehicles with independent suspension the steered wheel must be on rotary plates; if the steering axle is designed as a rigid axle, it is sufficient to support the axle with a jack. The steering axle must be loaded in any case.

This process must be carried out in both directions of rotation until a fixed stop has been reached. The sliding sleeves are automatically returned to the correct cut-out position (*Illus. 10*).

Illus. 10

Left steering limiter valve open,
oil pressure greatly reduced



1.5.3 Correcting the steering arm steering lock

To **increase the steering arm steering lock** (the space between the wheel lock parts is too great): carry out setting as described above.

To **reduce the steering arm steering lock** (the oil pressure at the axle stop does not fall to the value given in Section II Para. 1.4):

Fit new sliding sleeves assembly (20 or 128) ¹.



Attention:

It is not permitted to pull the sliding sleeve back to the press fit of the screw.

Tightening torque for sliding sleeve assembly: 15⁺³ Nm.

¹ The numbers in square brackets refer to the key to numbers in figures at the end of the instructions.



2 ZF recirculating ball power steering systems, type 8033-46

2.1 Construction:

The housing contains a control valve, working cylinder and a complete mechanical steering gear. The pressure oil for the steering is delivered by a motor-driven pressure oil pump which is supplied with oil from an oil tank. The housing (1 or A) is designed as a cylinder for the piston (2 or B) which carries out the task of converting the rotation of the steering shaft into an axial movement and transferring this to the steering worm sector shaft (5 or D). To ensure perfect power transmission, the toothing of the sector shaft is designed in such a way that when the shaft transverse to the piston is adjusted axially, any possible backlash is eliminated. This free play is adjusted using a setting screw and this can be carried out in the vehicle (see Section IV).

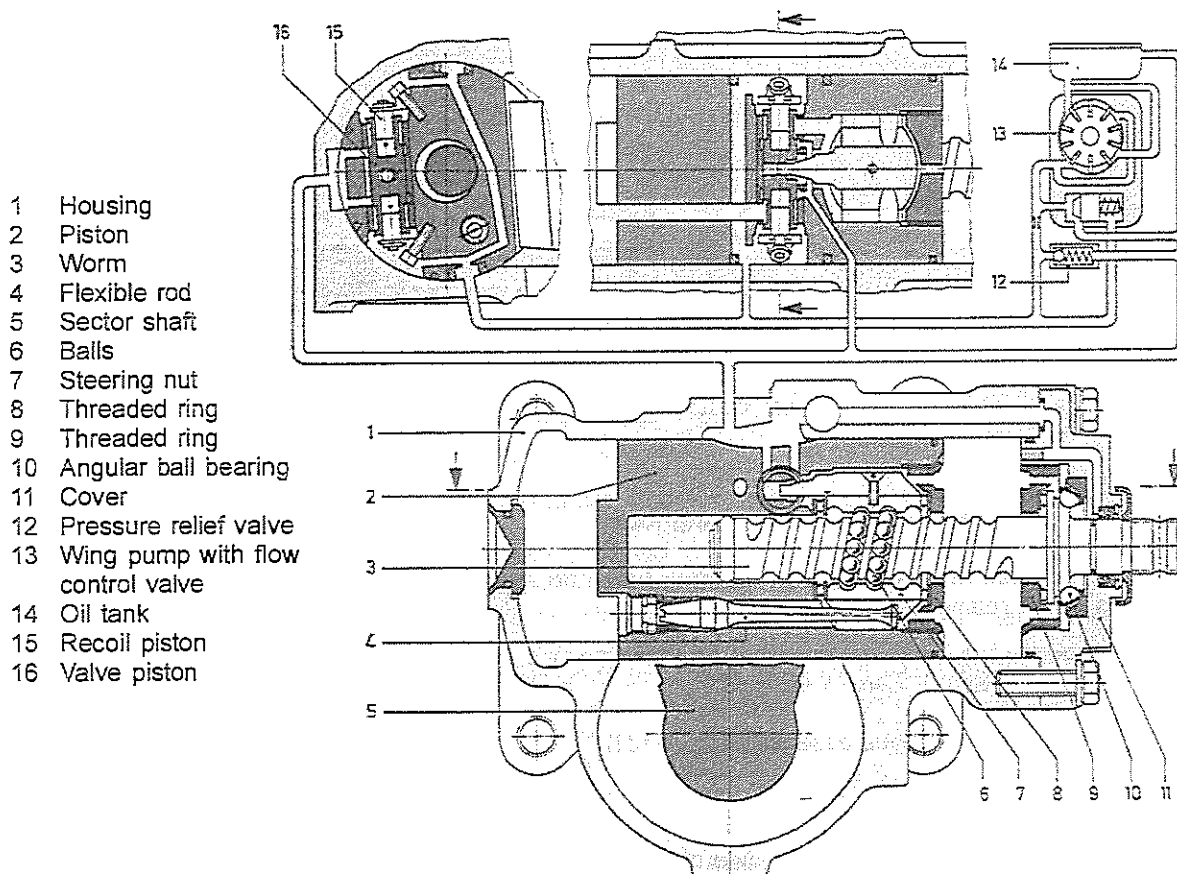
The threaded hole of the piston is connected to the worm (3 or E) via a ball chain. When the worm is turned, the balls (6 or F) on one end of the chain are taken up by a circulating pipe and fed back to the other end, thus forming an endless ball chain. The control valve is transverse to the piston. It comprises a valve piston (16) and two fixed recoil pistons (15). One finger of the steering nut (7) meshes with great accuracy into the hole of the valve piston.

2.2 Functioning:

In order to obtain hydraulic assistance while steering, which should be started when the steering wheel is turned, the valve piston must be displaced from the neutral position.

Illus. 11

Recirculating ball power steering, type 8043, steering valve centralised through flexible rod, neutral position



The valve is kept in the neutral position by means of a spring element which may, according to design, be a centralizing spring, a leaf spring or a flexible rod. For this reason force must be applied in order to overcome the pretension.



The piston, interlocked with the sector shaft and the steered wheels, resists any rotary motion. During steering, the steering nut is therefore stressed via the worm and ball chain in the circumferential direction and the elastic threshold overcome. The pressure oil flowing into the steering housing from the motor-driven pump is then directed into the cylinder from which the steering process is being hydraulically assisted.

The pressure oil flows laterally underneath the valve into a longitudinal groove of the piston. To provide a balance of pressure, it is led into an equally large longitudinal groove on the opposite side and passes through transverse holes to reach the faces of the valve piston which are separated from the cylinders by seals. With the valve in a neutral position, the oil flows towards the centre of the valve piston after flowing through feed and return leading edges and from there upwards into a recess of the piston through the corresponding holes. From here it flows out into the return (*Illus. 11*). When the valve is displaced, the pressurized side of the piston is separated from the return and the opposite side of the cylinder is connected with the return. The steering valve is fitted with 2 recoil pistons, whose function is to make it more difficult to displace the valves from the neutral position through the oil pressure. The actuating force on the steering wheel thus rises in proportion to the forces acting on the wheels. Steering systems in which a proportional rise of the actuating force is only desired up to a predetermined oil pressure are fitted with an actuating force limiting valve. The valve fitted in the recoil valve ensures that the force on the steering wheel does not rise much further after the cut-off pressure has been reached.

Action of the recoil pistons:

These have a floating bearing in the hole of the valve piston. But they are held axially and secured through connection with retaining plates. The outer faces of both pistons are constantly charged with pressure oil, whereas only one of the inner faces in the working position of the valve is charged with pressure oil. The same applies for the faces in the holes of the valve piston. This produces a force which tries to bring the valve piston back into the neutral position. This property is called "hydraulic reaction".

2.3 Functioning of the hydraulic steering limiter

2.3.1 Adjustable steering limiter

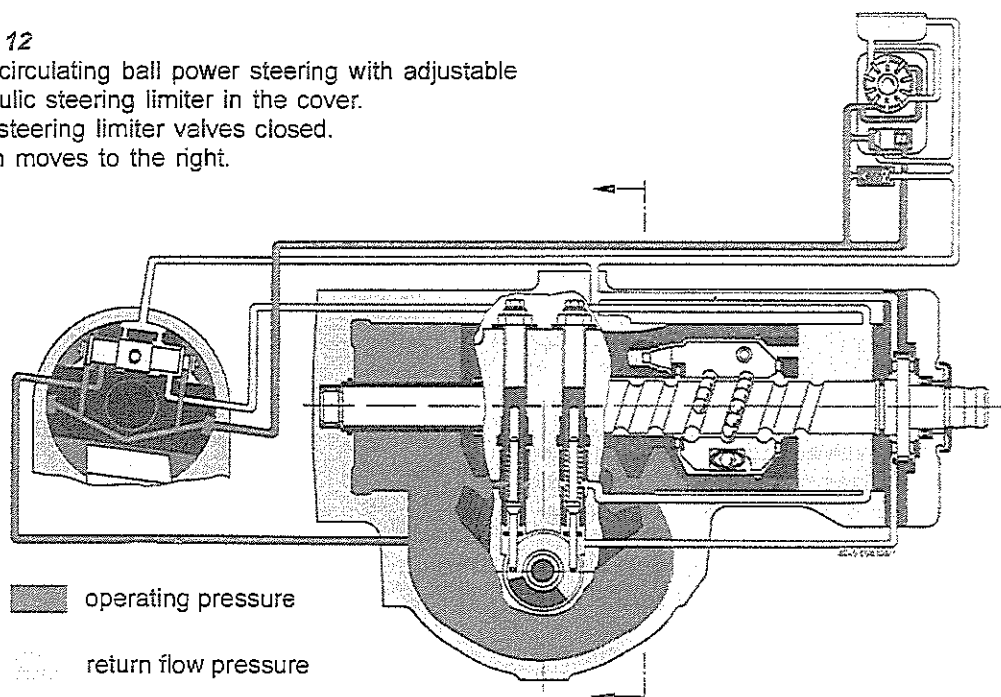
The housing cover is fitted with two valves (55), in each of which 1 valve piston is guided (*Illus. 12*). Both valve pistons are actuated by the cam located on the face of the sector shaft. When the sector shaft is turned, the valves remain closed until the cam of the sector shaft meets a valve piston, lifts it and thereby opens the valve (*Illus. 13*). The pressure oil of the left cylinder flows through a hole in the housing cover to the left valve, while the pressure oil of the right cylinder reaches the right valve through a hole in the housing.

Illus. 12

ZF recirculating ball power steering with adjustable hydraulic steering limiter in the cover.

Both steering limiter valves closed.

Piston moves to the right.



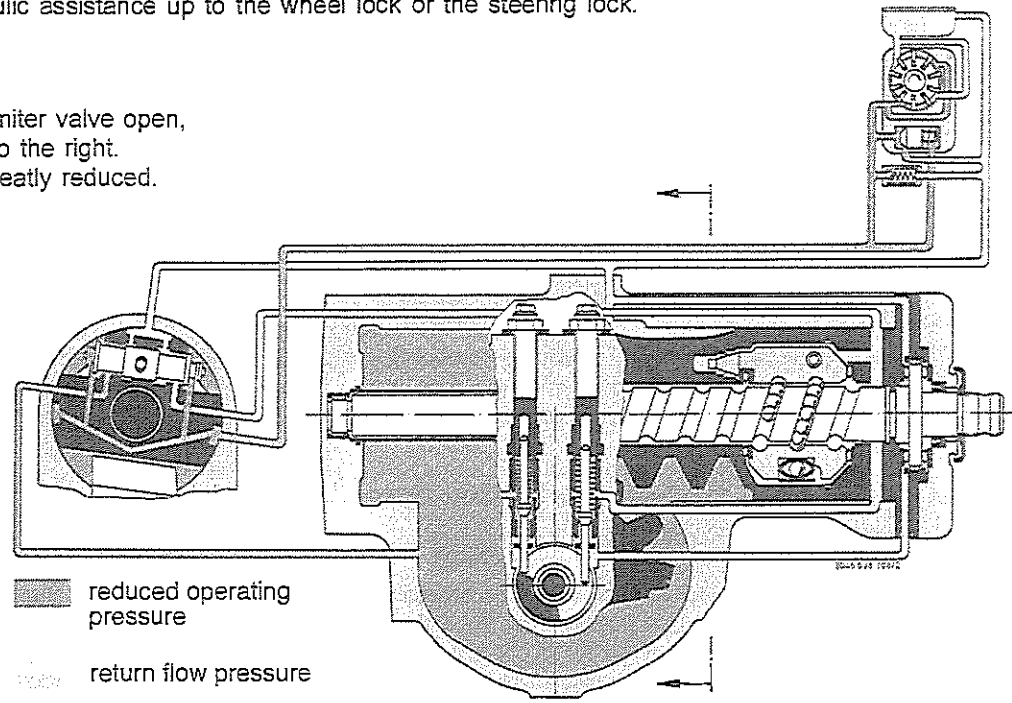


When the sector shaft is turned in a clockwise direction (see *Illus. 13*, piston moves to the right), the left valve piston is actuated according to a defined steering arm lock, which can be altered by screwing the valve in or out. The pressure oil can then flow through the valve seat from the left cylinder to the return. The position of the steering valve is not changed. The right steering limiter valve remains closed during this process.

When the sector shaft is turned in an anticlockwise direction, the right valve opens according to a predetermined path, so that the pressure oil can flow from the right cylinder to the return.

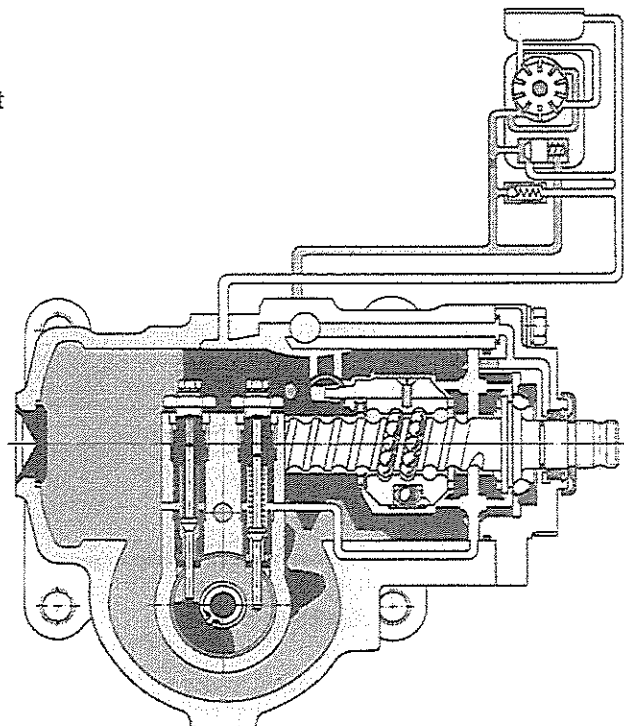
If the steering limiter valve is open, the steering can be turned further with increased force and greatly reduced hydraulic assistance up to the wheel lock or the steering lock.

Illus. 13
Left steering limiter valve open,
piston moves to the right.
Oil pressure greatly reduced.



Illus. 14
Recirculating ball power steering, type 8043.
Oil is fed to unpressurized cylinder compartment
via two steering limiter valves.

When the left valve piston is actuated, the pressure oil flows out of the left cylinder into the compartment below the steering limiter valve. The oil pressure building up there lifts the right valve piston from its seat against the spring resistance and permits access to the right cylinder compartment connected with the return.





2.3.2 Non-adjustable steering limiter

a) Steering version 8036 and 8038

The piston head is fitted with a ball valve which is always closed because of the oil pressure in the left or right working cylinder. Not until just before the piston reaches the housing on the left or the worm on the right is the valve actuated by a pin and pressure oil allowed to flow to the return.

b) Steering version 8033 and 8037

When the piston moves to the left, the pressure oil can flow into the housing return channel before the stop is reached via a piston hole located at right angles to the piston axis. When the piston moves to the right, the edge of the piston head releases the return channel in the housing.

2.4 Setting the hydraulic steering limiter, type 8033-46

Note

In principle, the hydraulic steering limiter is first set by the manufacturer in the test bay according to the engineering instructions of the vehicle companies.

Further setting is carried out after the steering is installed in the vehicle and on the prescribed inspections by means of a manometer. Adhere to the setting instructions of the vehicle manufacturer.

Setting the hydraulic steering limiter in the vehicle using a manometer:

A manometer (pressure range up to 250 bar or hydraulic steering tester) is screwed into the pressure line between the pump and the steering gear (*Illus. 15*). The steering axle, if designed as a rigid axle, is relieved through jacking. Adhere to instructions of the vehicle manufacturer. If the vehicle has independent suspension, the steered wheels must stand on rotary tables for setting of the hydraulic steering limiter; in any case, the steering axle must be loaded in order to compensate roughly for possible deflection errors in measurement. Without exerting great force, turn steering up to wheel lock with engine running at idle speed, oil temperature of steering system above 50°C.

Once the wheel lock has been reached, a brief (max. 5 seconds) continued turning of the steering wheel will overcome the resetting force of the steering valve until a fixed steering wheel lock is achieved. To reach this, and depending on the size of the hydraulic reaction, a peripheral force on the steering wheel of approx. 100 – 200 N is required. If the steering limiter is set correctly, the manometer must now show an oil pressure of between **30 and 35 bar**. To make corrections, release the lock nut (a1 or b1) and screw the corresponding valve sleeve (a2 or b2) in and out. Release steering wheel at the same time, so that only the flow pressure builds up during this work. Then tighten lock nut a1 or b1.

Tightening torque for lock nut: 25 to 35 Nm.

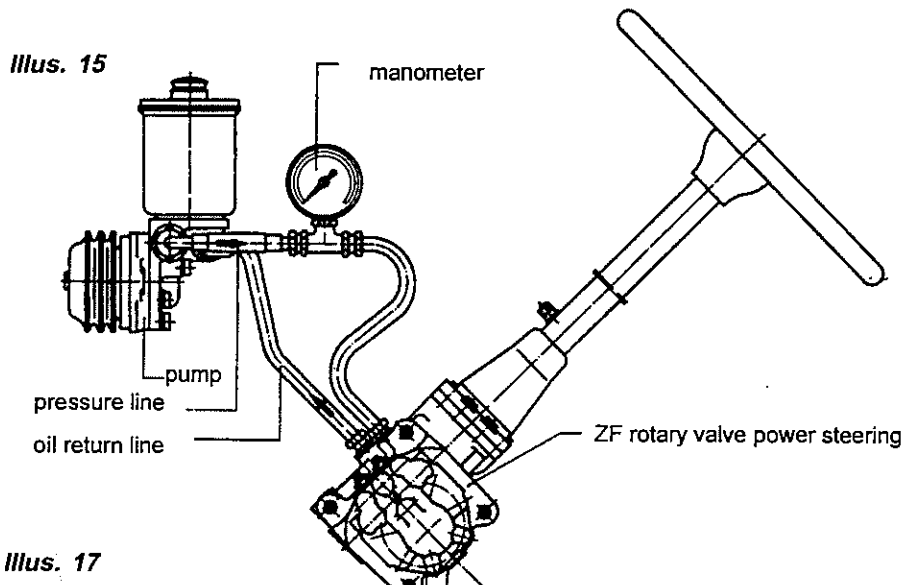
The second wheel lock is set in a similar fashion. The valve (a2) and lock nut (a1) in *Illus. 16* must be adjusted if the steering arm is moved towards "A" according to *Illus. 15*. In the same way, valve (b2) and lock nut (b1) are adjusted if the steering arm turns towards "B".

The vehicle manufacturer may prescribe a mode of setting that differs from the abovedescribed (e.g. insertion of a spacer), *see Illus. 26*.

Setting the steering limiter

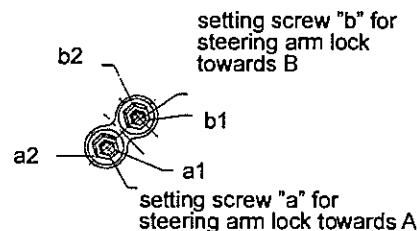
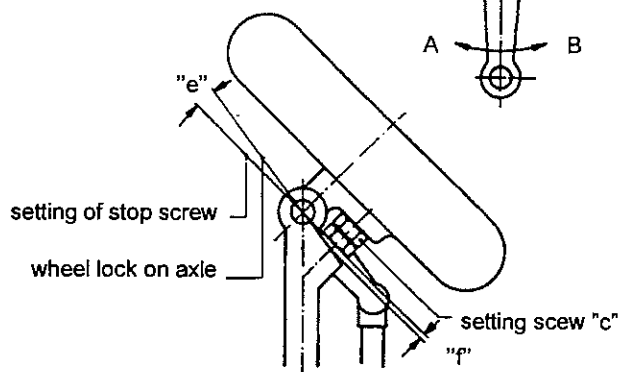


After this setting, the hydraulic assistance should be active until the wheel lock is reached. To check the setting appropriately, turn the steering wheel, while driving the vehicle slowly and under normal load, until the hydraulic assistance is disconnected.



Illus. 16

Illus. 17



Illus. 17 shows the distance "e" which should exist between the wheel lock parts upon response of the hydraulic steering limiter, provided that the vehicle manufacturer prescribes a distance.

In this position a distance should exist between the wheel lock parts (*see Illus. 17*), provided that the vehicle manufacturer prescribes a distance.

If the pressure fails too early or too late when the steering arm is turned towards "A" or "B", the valve sleeves (a2 and b2) must be twisted as described below.

If a pressure greater than 35 bar is measured, the corresponding steering limiter valve (55) must be **screwed further into** the cover (clockwise).

If a pressure lower than 30 bar is measured, the corresponding steering limiter valve (55) must be **screwed further out** (anticlockwise).

Check:

To check this setting appropriately, turn the steering wheel, while driving the vehicle slowly and under normal load, until the hydraulic assistance is disconnected.

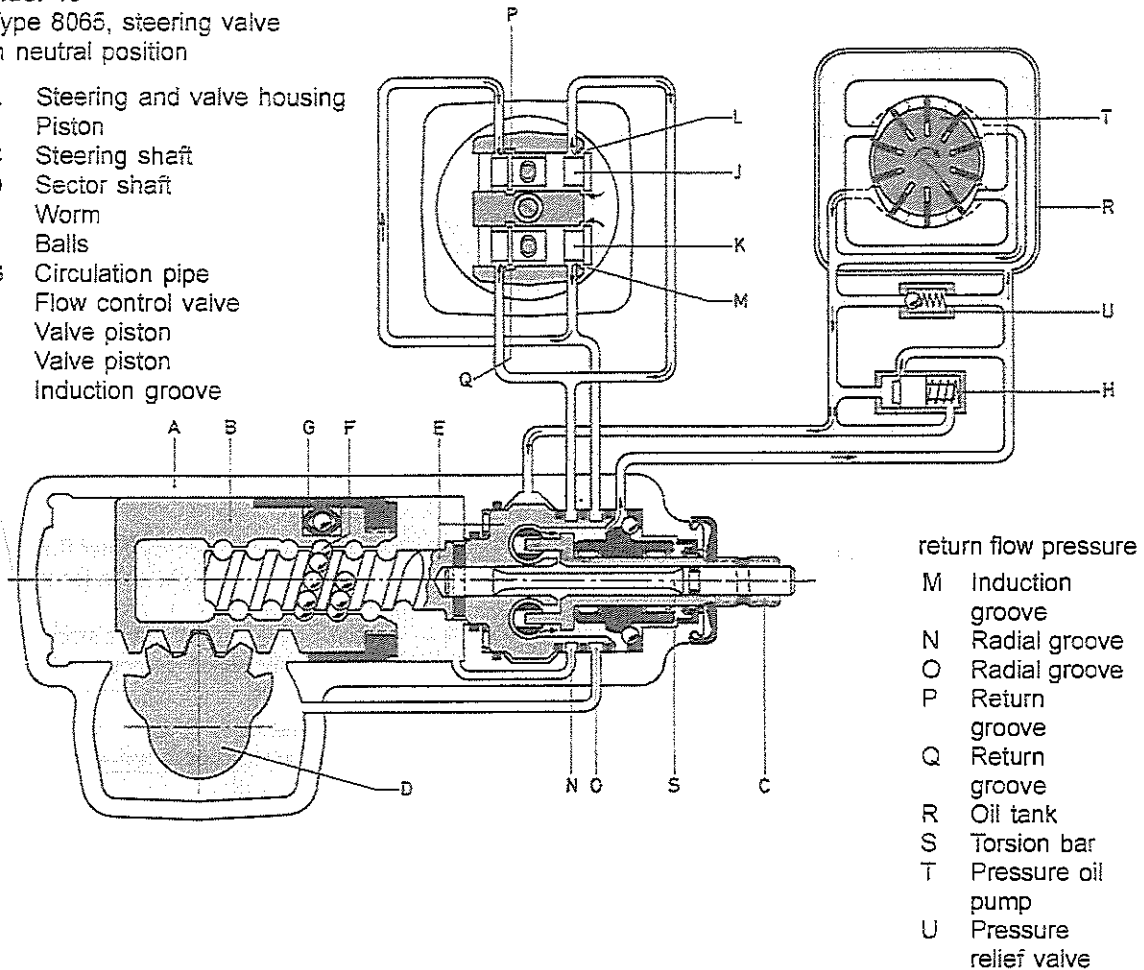


3. ZF recirculating ball power steering, type 8056-70

Illus. 18

Type 8065, steering valve in neutral position

- A Steering and valve housing
- B Piston
- C Steering shaft
- D Sector shaft
- E Worm
- F Balls
- G Circulation pipe
- H Flow control valve
- J Valve piston
- K Valve piston
- L Induction groove



3.1 Construction

Design as for steering types 8033-46, but with a different steering valve. The worm head accommodates two valve pistons (J and K) lying transverse to the worm axis, and these rotate together with the worm and the steering shaft in the valve housing of the steering system when the steering wheel is turned. The valve pistons have a cross hole in the centre in which two arms of the steering shaft (C) engage. There is therefore a connection without play between the valve pistons and the steering shaft, which is also connected to the worm via a torsion bar.

3.2 Functioning

When the steering wheel is turned in a clockwise direction, the piston with left-handed thread is pushed to the right. Since the movement of the piston is to be assisted by pressure oil, the oil must now be fed to the right cylinder side. The upper valve piston (J) is pushed to the right and the induction port (L) for the pressure oil supply opened further. By contrast, the lower valve piston (K) moves to the left and the pressure oil supply is interrupted by the closing of the induction groove (M). The return grooves (P and Q) can be seen in the upper valve representation for both valve pistons on the left of the valve piston centre. The pressure oil line of the upper valve piston is connected to the left radial groove (N) in the head of the worm and to the return groove of the lower valve piston (Q). Likewise, the pressure oil line of the lower valve piston is connected to the right radial groove (O) of the worm and the return groove (P) of the upper valve piston.



The pressure oil flows through the induction groove (L) of the upper valve piston to the left radial groove (N) and from there into the right cylinder, so that the piston movement is hydraulically assisted. However, at the same time the pressure oil reaches the return groove (Q) of the lower valve piston, but this is closed and blocks the return of this oil. The oil from the left cylinder is compressed. It flows via the radial groove (O) in the worm to the induction groove (M) of the lower valve piston. This is closed. However, at the same time the oil flows further to the return groove (P) of the upper valve piston, which is open, thus allowing the oil to reach the valve piston centre. From here constant return to the oil tank is guaranteed, as the diagram of the steering system (*Illus. 18*) shows.

If the steering wheel is turned in the opposite direction, the piston moves to the right (*Illus. 19*) and should be hydraulically assisted through pressure oil in the left cylinder. The lower valve piston is pushed to the right and allows the pressure oil to reach the right radial groove (O) in the worm, from where connection to the left cylinder is established. The pressure oil is also allowed to flow to the return groove (P) of the upper valve piston, but this is closed and prevents the oil flowing out to the valve piston centre. The oil from the right cylinder flows via the left radial groove (N) in the worm to the return groove (Q) of the lower valve piston, which is open, thus permitting access to the valve piston centre and from there to the oil tank.

3.3 Functioning of the hydraulic steering limiter

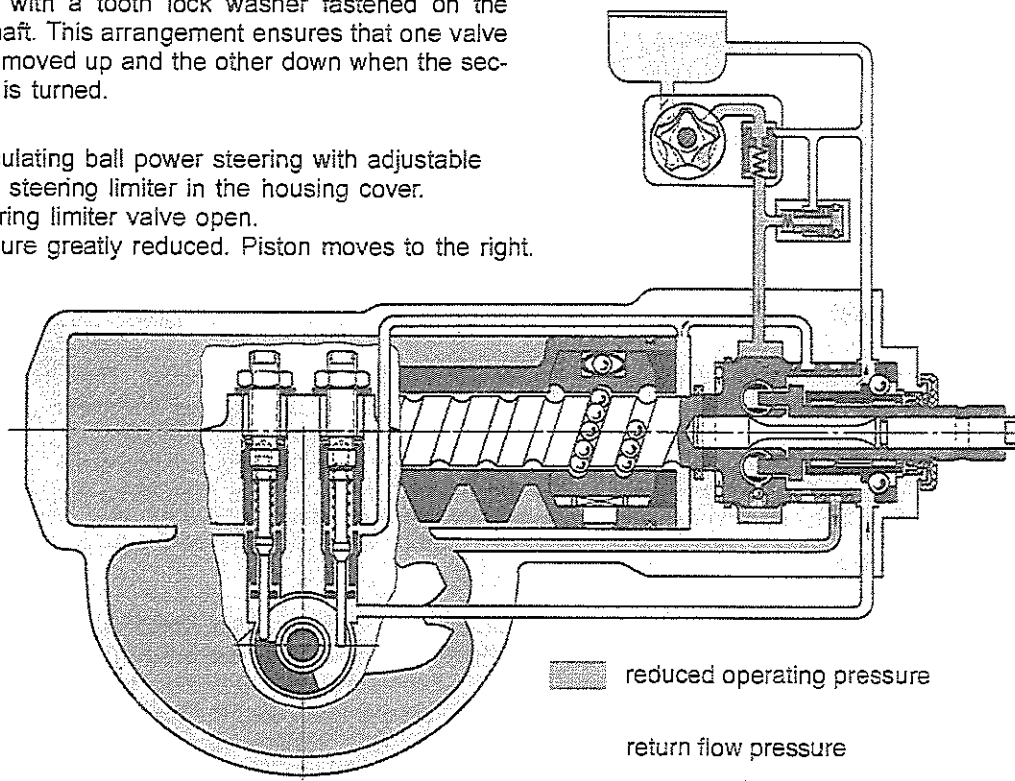
The housing cover is fitted with two valves, in each of which 1 valve piston is guided. Both valve pistons are actuated by the cam located on the face of the sector shaft (60). When the sector shaft is turned, the valves remain closed until the cam of the sector shaft meets a valve piston, lifts it and thereby opens the valve (*Illus. 19*).

The valves are connected to the return by holes. The pressure oil of the left cylinder flows through a hole in the housing cover to the left valve, while the pressure oil of the right cylinder reaches the right valve through a hole in the housing.

If the steering limiter valves are located in the housing – see *Illus. 20* – the valve pistons in the two valve sleeves are connected to a toothed quadrant by means of connecting elements. The toothed quadrant is swivel mounted in the housing cover and engages with a tooth lock washer fastened on the sector shaft. This arrangement ensures that one valve piston is moved up and the other down when the sector shaft is turned.

Illus. 19

ZF recirculating ball power steering with adjustable hydraulic steering limiter in the housing cover.
Left steering limiter valve open.
Oil pressure greatly reduced. Piston moves to the right.



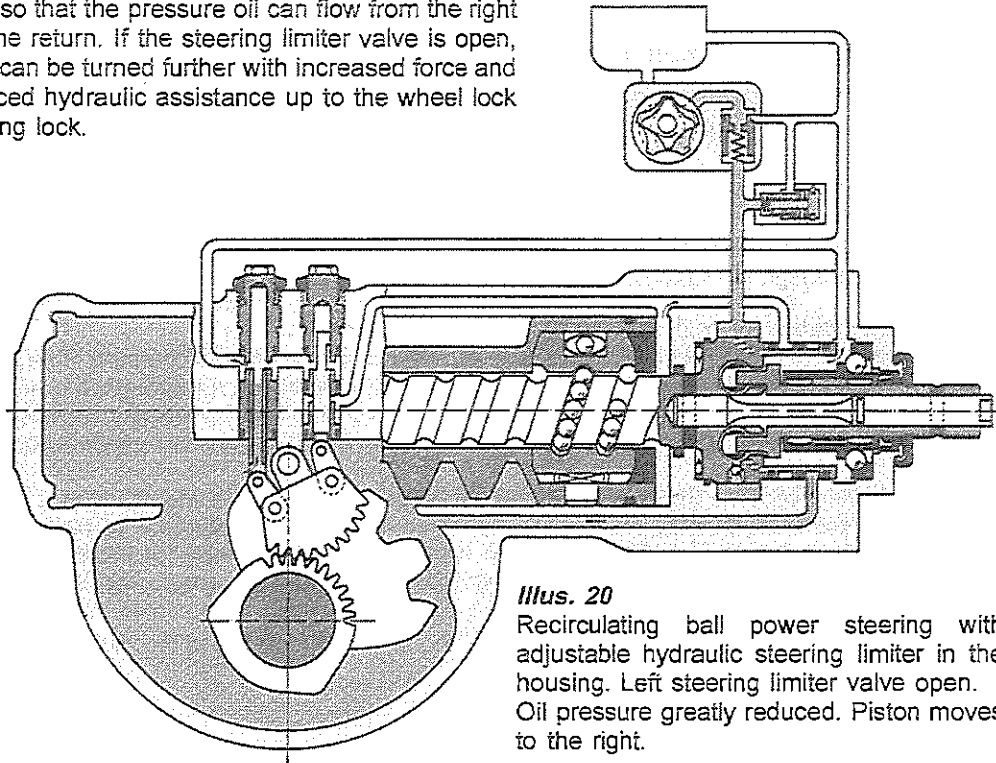
When the sector shaft is turned in an anticlockwise direction (see *Illus. 19*, piston moves to the right), the left valve piston is actuated according to a defined steering arm lock, which can be altered by screwing the valve in or out. The pressure oil can then flow through the valve seat from the left cylinder

Setting the steering limiter



compartment to the return. The position of the steering valve is not changed. The right steering limiter valve remains closed during this process.

If the sector shaft is turned in an anticlockwise direction, the right valve opens according to a predetermined path, so that the pressure oil can flow from the right cylinder to the return. If the steering limiter valve is open, the steering can be turned further with increased force and greatly reduced hydraulic assistance up to the wheel lock or the steering lock.



Illus. 20

Recirculating ball power steering with adjustable hydraulic steering limiter in the housing. Left steering limiter valve open. Oil pressure greatly reduced. Piston moves to the right.

3.4 Setting the hydraulic steering limiter, type 8056-70

Install manometer (pressure range up to 250 bar or hydraulic steering tester) as described under Section 2 for ZF rotary valve power steering (*Illus. 15 to 17*) and carry out setting.

If the pressure falls too early or too late when the steering arm is turned towards "A" or "B", the valve sleeves (a2 and b2) must be twisted as described below.

a) For steering systems in which the steering limiter valves are installed in the housing cover (*Illus. 19*): If a pressure greater than 35 bar is measured, the corresponding steering limiter valve (36) must be screwed further into the cover (clockwise).

If a pressure lower than 30 bar is measured, the corresponding steering limiter valve (36) must be screwed further out (anticlockwise).

b) For steering systems in which the steering limiter valves are installed in the housing (*Illus. 20*):

If a pressure greater than 35 bar is measured, the corresponding valve sleeve (36) must be screwed further out (anticlockwise).

If a pressure lower than 30 bar is measured, the corresponding valve sleeve must be screwed further into the housing (clockwise).

Tighten lock nut a1 or b1 with 25 to 35 Nm.

Illus. 17 shows the distance "f" which should exist between the wheel lock parts and be approx. 2mm upon response of the hydraulic steering limiter, provided that the vehicle manufacturer prescribes a setting with spacer.

Check:

To check this setting appropriately, turn the steering wheel, while driving the vehicle slowly and under normal load, until the hydraulic assistance is disconnected.



III. Maintenance, oil change and ventilation

Note:

When the steering system is being filled with hydraulic fluid, there is a danger that particles of dirt will get into the steering oil circuit. In order to avoid malfunctions caused by foreign bodies in the system, the utmost cleanliness must be ensured both on first filling and on refilling.

Before removing the oil tank cover, thoroughly clean the tank and its immediate surroundings so that no dirt can get into the hydraulic fluid.

When cleaning the vehicle with steam-cleaning devices:

Do not direct the steam cleaner straight onto exposed sealing parts of the aggregates belonging to the steering system. Water penetrating protecting caps, shaft seals or seals of universal joints can cause corrosion damage.

Recommendation for cold starts:

For vehicles with long hydraulic pipes, e.g. buses, an increased flow pressure is required for cold starts under 0°C ambient temperature. In order not to damage the pump through too great a pressure, the engine and with it the pump should be run for a few minutes without any movement of the steering wheel. This brings heated oil into circulation and the flow pressure will then normalize.

The following sections show the intervals for inspections of ZF power steering systems in kilometres per hour and in working hours. The figures in km/h must be applied for road vehicles, the figures in working hours for off-road vehicles. With vehicles having neither a tachometer nor a working hour meter, a fuel flow volume corresponding to the intervals should be taken as a guideline (Section VIII, Instructions for inspection).

For single-circuit hydraulic steering systems, the sections referring to the mobility-dependent pump are omitted.

1. Inspection

The general customer service for the respective vehicle encompasses checking all screwed connections and pipes of the power steering system, pumps (depends on engine and mobility), valves and working cylinders for tightness. A thin film of oil can be applied to the piston rods of the working cylinder, but no drops should be allowed to form.

If the steering system is installed subsequently, the installing workshop should carry out this inspection after the first 1000 kilometres or 25 hours of operation.

2. Oil grades

A suitable hydraulic fluid is required for the perfect functioning of the steering system and the pump. The hydraulic fluid also lubricates the steering gear and the pump; only one oil is therefore required for the whole system.

ATF oils, with a viscosity of approx. 26 mm²/s at 50°C, setting point under -35°C and low frothing inclination, are suitable for filling. Oils with higher viscosity can lead to the ventilating pressure in the suction being too great, producing noises in the pump. For permissible oil grades see list of lubricants TE-ML 09.

3. Oil volume

The hydraulic power steering is supplied from the factory without oil. The volume of oil required for the steering gear, without pipes, oil tank and pump, for the individual steering sizes is:

Type 8033:	0.5 dm ³	Type 8056:	0.8 dm ³	Type 8090:	0.6 dm ³
Type 8036/37:	0.7 dm ³	Type 8058:	1.0 dm ³	Type 8095:	1.5 dm ³
Type 8038:	0.9 dm ³	Type 8060:	1.2 dm ³	Type 8096:	1.7 dm ³
Type 8042:	1.5 dm ³	Type 8062:	1.4 dm ³	Type 8097:	1.9 dm ³
Type 8043/44:	1.4 dm ³	Type 8065:	1.7 dm ³	Type 8098:	2.4 dm ³
Type 8045:	1.9 dm ³	Type 8066:	1.5 dm ³		
Type 8046:	1.6 dm ³	Type 8070/72:	2.6 dm ³		



4. Oil change



Attention

An oil change is only recommended if the steering gear or pump or both have to be repaired or replaced. When doing so, the filters in the oil tanks should also be replaced and the pipes cleaned. An oil change is also required if other oils are used instead of the prescribed ATF oils (see Para. 2, Oil grades), e.g. engine oils or hydraulic fluids.

Before removing the cover of the oil tank, thoroughly clean the tank and its immediate surroundings so that no dirt can get into the hydraulic fluid.

Do not reuse oil that has been drained. Avoid mixing oils.

The oil can be drained as follows:

ZF Servocom:

Jack up steering axle as instructed by the vehicle manufacturer. Unscrew pressure and return pipes. If necessary, remove plug screws (55) from cylinder cover or housing. Then start engine briefly, no more than 10 seconds, until oil is drained from pump and tank. To check, switch engine off and turn steering once more from lock to lock until no more oil runs out. There should be a sizeable residual volume of oil in the steering system. Depending on the degree of contamination of the oil, e.g. scuff from the abrasion of internal parts of the pump, the steering system may need to be evacuated completely. The steering must then be dismantled and opened by a ZF service agency.

ZF recirculating ball power steering with oil drain screw:

Jack up steering axle as instructed by vehicle manufacturer. Unscrew oil drain screw on underside of housing.

ZF recirculating ball power steering without oil drain screw:

Undo the plug screw located on the side of the housing cover. Turn steering until the piston is pushed up to the stop. Then start engine briefly, no more than 10 seconds, until oil is drained from pump and tank.

It is possible that a rather large volume of oil will remain in the steering system. If necessary, we recommend that an oil change is followed by another rinse, i.e. that a second oil change is carried out.

To check, switch engine off and turn steering once more from lock to lock until no more oil runs out. Screw in oil drain screw or plug screw M 12x1.5 and tighten with 40 to 45 Nm.

Avoid mixing oils.

5. Filter change

The filter cartridges in single or multi-chamber oil tanks should be replaced at the same time as the inspection ^[2].



Attention

Before removing the cover of the oil tank, thoroughly clean the tank and its immediate surroundings so that no dirt can get into the hydraulic fluid.

When removing the used filter cartridges, ensure by closing the lower hole that dirty oil does not run from the filter cartridges back into the oil tank or into the oil circuit. Lubricate filter holders before use. If oil tanks are plastic, remove suction and return pipe. Disassemble oil tank, evacuate, clean and use new filter cartridges.

[2] Slight deviations are permissible if desired by the vehicle manufacturer in order to be able to record the intervals in the vehicle log.



6. Oil filling and ventilation

6.1 Oil filling



Attention:

When the steering system is being filled with hydraulic fluid, there is a danger that particles of dirt will get into the steering oil circuit. In order to avoid malfunctions caused by foreign bodies in the system, the utmost cleanliness must be ensured both on first filling and on refilling.

The steering system and the pump are filled through the filler necks on single and multi-chamber oil tanks. On first filling and oil changes, it is expedient to remove the tank cover (possible for sheet metal oil tanks) and fill hydraulic fluid up to the neck of the tank.

Start the engine at low speed and allow to work at idle speed (for vehicles with mobility-dependent emergency steering pump: drive axle with gear engaged for mobility-dependent drive axle jacked up) in order to fill the complete hydraulic system with oil. During this process, the oil level in the tank falls rapidly. The oil tank must therefore be constantly refilled to avoid the intake of air. We recommend that one mechanic runs the engine while a second pours in as much oil as is drained by the pump.

At a higher engine speed or strong suction flow, smallish air bubbles would be sucked into the pump again and be broken down into tiny bubbles by the working of the pump; this can lead to frothing and prolong the ventilation process accordingly.

When the steering system must be filled for the first time or after repairs, oil must be poured in before the suction pipe is fastened in the pump connection in order to prevent dry running in the start-up phase. Ensure particularly careful ventilation of the suction pipe. In cases where free suction of the radial piston pump is hampered, it is recommended that the suction pipe is first filled with oil.

6.2 Ventilation

When the steering system has been filled so that the oil level no longer falls below the upper marking on the dipstick, run the engine for some time (2–3 minutes) at low speed (for vehicles with mobility-dependent emergency steering pump: drive axle with gear engaged for mobility-dependent drive axle jacked up). The majority of the air will escape from the cylinder compartments. The oil level should be observed during this process. If it falls still further, top up with oil immediately. To accelerate the ventilation process, it is recommended that the steering wheel is turned several times from lock to lock. At the limit positions, do not pull on the steering wheel any more than is necessary to turn the steering. Top up with oil if necessary until the oil remains constant at the upper mark of the dipstick and no air bubbles rise in the oil tank when the steering wheel is turned.

In vehicles with an additional working cylinder, the pipe connections must point up so that the air in the cylinders and pipes can escape. Undo or remove working cylinder if necessary.

For steering versions with automatic ventilation:

Steering versions with automatic ventilation no longer have vent screws. These steering systems automatically force out the air remaining in the housing after the above ventilation process. Automatic bleeder valves only operate in the flow pressure area, which is why unnecessary pressure build-up is to be avoided.



For steering versions with vent screw:

Note:

Do not turn the steering wheel during the ventilation process and run the engine at low speed. Remove plug cap on vent screw. Then open vent screw 1/2–1 revolutions so that air remaining in this part of the housing can escape. As soon as it is only oil that runs out of the hole of the vent screw, close this again and top up with oil. Then turn steering wheel several times by jerks from lock to lock and repeat ventilation process. Top up with oil. Tighten vent screw with 5 Nm. Replace plug cap.

With Servocom steering systems without automatic ventilation (horizontal fitting position of steering shaft bottom), the upper steering limiting screw (20 or 128) provides the ventilation. The lock nut must be loosened for this purpose. The hydraulic steering limiter must be inspected after the ventilation process.

If the above instructions were observed, the oil level in the oil tank must not rise more than 1 to 2 cm when the engine is stopped, depending on the size of the steering system. The residual air still remaining in the housing is not noticeable when driving. It is absorbed and expelled by the oil during driving operation.

Turn engine off and lower steering axle or drive axle.

7. Checking the oil level

The oil level should be checked at intervals of 5000–6000 kilometres or 100–120 hours of operation. Before removing the oil tank cover, thoroughly clean the tank and its immediate surroundings so that no dirt can get into the hydraulic fluid.



Attention:

Too low an oil level can lead to malfunctions causing partial or complete failure of the steering system. If oil has been lost, it is essential that the point of leakage is located and the damage repaired. Repairs to the steering gear should only be carried out in our ZF service agencies.

For vehicles with ZF Servocom RAS (rear axle steering system):

If the oil level is above the upper mark, there may be a leak in the master cylinder of the ZF Servocom RAS. This leads to oil being forced from the ZF Servocom RAS into the front axle steering system.

7.1 Checking oil level with engine stationary

To ensure that no air is sucked in when the engine is started, determine first whether there is any loss of oil with the engine stationary (vehicles for mobility–dependent emergency steering pump: drive axle for mobility–dependent pump not driven). The tank must be topped up with enough oil so that the oil level is approx. 1 to 2 cm above the upper mark of the dipstick.

7.2 Checking oil level with engine running

With the engine running (vehicles with mobility–dependent emergency steering pump: gear engaged and drive axle for the mobility–dependent pump jacked up as instructed by the vehicle manufacturer), the oil level falls a little because the oil requires a pressure of 2 to 4 bar as a result of the flow resistances in order to flow through the steering gear.

Now enough oil is poured in for the oil level to be constantly at the upper mark. The engine can then be stopped again. The oil level must rise max. 1 to 2 cm. If this is exceeded, it shows that air is still trapped in the oil.

Irksome noises may be produced in the steering system if:

1. A filter cartridge is contaminated, replace with new one.
2. Screwed connections on suction side are not sufficiently tightened, so that air is sucked in. Tighten connections, apply varnish paint if necessary.
3. There is too little oil in the system. Top up with oil.

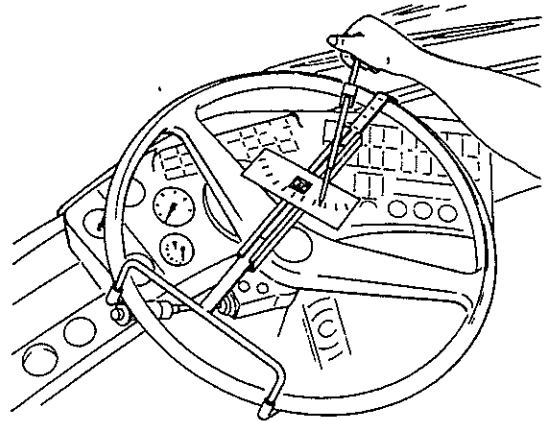


IV. Adjustments to the steering system installed in the vehicle, types 8033–46 and 8056–70

Note:

The measuring and setting tools used must be inspected regularly for accuracy.

1. Eliminating steering free play in straight-ahead driving (setting pressure point)
 - a) Jack up steering axle.
 - b) Turn steering into centre position (roughly found by halving the total number of revolutions of the steering wheel) and remove eccentric rod of steering arm (Section IX).
 - c) Undo sealing nut (50 or 27) on housing cover.
 - d) Turn steering into limit position and measure the moment of friction required to turn the steering out of straight-ahead driving (approx. 1/2 revolution before end lock). To turn the steering, the tool [6] should be used and this is placed and clamped to the rim of the steering wheel (*Illus. 21*).
 - e) Then measure moment of friction of steering in pressure point area (centre position). To do this, make 1/2 revolution on tool [6] to left and to right across straight-ahead driving and tighten the adjusting screw (31 or 62) until an increase in moment of friction of 40–60 Ncm is measured over the value measured under Para. d).
 - f) Tighten sealing nut (50 or 27) with a torque of 90 Nm (for lock nut without seal, 70 Nm), while holding the adjusting screw tight. Check set torque again.



Illus. 21

It will not improve steering property and the contact ratio in any way if the moment of friction in the straight-ahead driving area is set to be greater than 60 Ncm. Instead, it will produce too great a pressure on the adjacent parts and thereby unnecessary abrasion.

Mount and secure eccentric rod (adhere to tightening torques of vehicle manufacturer).

2. For setting of steering limiter, see Section II.

Free play in the hydraulic power steering with pump stationary and operating

In normal driving, i.e. when the oil pump discharges pressure oil, the torsion bar is twisted and the steering valve offset when the steering wheel is turned or there is a bump. This causes the hydraulic booster to engage. Only a very slight turn of the steering wheel or the sector shaft is required for this control process, so that a perceptible assistance becomes effective.

It is different if the power steering is actuated while the pump is stationary, e.g. when towing. With greater steering forces the whole lift of the control valve up to the stop must be overcome before the rotary movement of the steering wheel is transmitted to the sector shaft. There is then a perceptible free play when steering without hydraulic assistance on the steering wheel.



V. Instructions for eliminating external leaks



Attention:

To guarantee safe functioning of the steering system, ensure the utmost cleanliness when carrying out installation. Under no circumstances must force be used when assembling. The resulting damage could lead to the partial or complete failure of the steering function.

The measuring and adjusting tools used for repair must be subjected to a regular inspection for accuracy.

Note:

The numbers in brackets, e.g. (22), refer to the numbers in exploded views and the list of replacement parts.

Grades of oil used: Spectron FO 20 from DEA or equivalent calcium complex grease of consistency class 2.

1. Replacing the shaft seal on the steering arm, type 8033-46

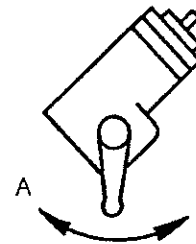
- 1.1 Mark position of universal joint, arrow of protecting cap and steering arm stump to each other and/or check agreement of marking stroke on steering arm stump with clamping slot of universal joint. Remove lower fastening screw on universal joint and pull universal joint from serration of lower steering column. Remove protecting cap (70).

1.1.1 For steering version with intermediate cover



Attention:

When carrying out the following operation, ensure that the worm is not screwed out of the thread of the piston, as there is otherwise the possibility that balls from the planetary thread will fall into the piston hole, which may lead to the steering being locked. This is best prevented if the steering wheel is turned to the full lock at which the piston is in the upper position or the steering arm swings forwards in direction "A" (*Illus. 22*). At the same time, the intermediate cover remains on the housing.



Illus. 22

- a) Unscrew fastening screws (132). Remove cover (128). Press out shaft seal (129).
- b) Use tool [8] to press new shaft seal (129) into cover (128) with sealing lip pointing into housing. Fill cavity between sealing lip and dust lip with grease (see note).
- c) Place tool [9] on lower steering arm and fit cover (128). Screw in fastening screws (132) and tighten.

Tightening torques:	M 10:	62 Nm
	M 12x1.5:	115 Nm
	M 14x1.5:	190 Nm

1.2 For steering versions with ring nut in cover or short radius

- a) Disconnect retaining ring (130). Remove shaft seal (129) using a suitable hook. Do not damage seal seat while doing so.
- b) Place tool [9] on steering arm. Use tool [8] to press new shaft seal (129) into cover (128) with sealing lip pointing into housing. Only insert seal far enough to just guarantee that the retaining ring (130) is in the correct groove and that the vent groove is not covered.

Fill cavity between sealing and dust lip with grease (see note).



- 1.2 Apply grease to shaft seal (see note) and fit protecting cap (70). Protecting caps of new design on the housing must be pretensioned. Push universal joint on serration in such a way that the slot of the lower yoke aligns with the marking on the steering arm.

Put hexagon screw through hole of yoke; ensure that hole and free rotation of steering arm stump are congruent. Tighten nut.

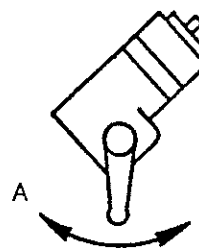
Tightening torques: M 8: 24 Nm
M 10 x 1.25: 48 Nm

2. Replacing the shaft seal on the steering arm, type 8056-70



Attention:

When carrying out the following operation, ensure that the worm is not screwed out of the thread of the piston, as there is otherwise the possibility that balls from the planetary thread will fall into the piston hole, which may lead to the steering being locked. This is best prevented if the steering wheel is turned to the full lock at which the piston is in the upper position or the steering arm swings forwards in direction "A" (illus. 23). At the same time, the intermediate cover remains on the housing.



illus. 23

- Mark position of universal joint, arrow of protecting cap and steering arm stump to each other and/or check agreement of marking stroke on steering arm stump with clamping slot of universal joint. Remove lower fastening screw on universal joint and pull universal joint from serration of lower steering arm. Remove protecting cap (160).
- Disconnect pressure and return line from steering system.
- Unscrew fastening screws (95 and 134). Remove valve housing. Press out shaft seal (131) from outside in.
- Use tool [12] to press new shaft seal (131) into valve housing with sealing lip pointing into housing. Fill cavity between sealing lip and dust lip with grease (see note).
- Place tool [13] on lower steering arm and then fit valve housing carefully. Screw in fastening screws (95 and 134).

Tightening torques: M 8 x 1- 8.8: 25 Nm
M 8 x 1- 10.9: 35 Nm
M 12 x 1.5: 115 Nm
M 14 x 1.5: 206 Nm

- Apply grease to shaft seal (see note) and fit protecting cap (160). Push universal joint onto serration in such a way that the slot of the lower yoke aligns with the marking on the steering column.
- Put hexagon screw through hole of yoke; ensure that hole and free rotation of steering arm stump are congruent. Tighten nut.

Tightening torques: M 8: 24 Nm
M10 x1.25: 48 Nm



3. Replacing the shaft ring on the drive bevel gear for versions with angle gear, type 8090–98 and 8056–70

- a) Remove lower fastening screw on universal joint. Pull universal joint from serration of bevel gear. Remove protecting cap (314).
- b) Undo slotted nut (313) and remove setting screw (312) from housing (301).
- c) Press shaft seals (310 and 310.1) from setting screw. Pull o-ring (308) from housing slot.



Attention:

The bevel gear should only be extracted from the housing if absolutely necessary, e.g. for polishing the seal surface, as otherwise the meshing, which must have no free play when the steering gear is in straight-ahead driving position, will no longer be true. In this case, first turn the steering into straight-ahead driving position and then bring the notch on the steering arm congruent with the housing marking.

- d) Fit o-ring (308) into radial slot of the housing, behind the tapped hole. Press the two shaft rings (310 and 310.1) into the setting screw (312) (the dust lips seal first) with the sealing lips pointing into the housing. Fill the cavities between the sealing lips with grease (see note).
- e) To protect the sealing lips of the shaft seals, place tool [13] on the serration of the bevel gear. Push setting screw (312) on and screw in. Only tighten setting screw until the bevel gear is free of axial play. (The moment of friction of the bearing setting when the angle gear is dismantled must be 40 to 70 Ncm). Fit slotted nut (313) and tighten with 50 Nm, while holding setting screw firmly. Apply grease to shaft seal (see note), slide on protecting cap (314 and 70 or 160).
- f) Push universal joint on serration in such a way that the slot in the lower yoke and the marking notch on the bevel gear agree.
- g) Put hexagon screw through hole of yoke. Tighten nut.
Tightening torques: M 8: 24 Nm and M 10x1.25: 48 Nm

4. Replacing the shaft seal on the steering shaft, type 8033–46 and 8056–70

Note:

The following operation only applies to steering versions in which the steering shaft is sealed by means of shaft seals (4 or 6) instead of oval seals together with back-up rings, e.g. types 8043 and 8066. If the oval seals are not tight, the steering system must be disassembled. This should only be carried out by ZF service agencies.

- a) Remove mounting of steering arm and remove steering arm using tool [7].



Attention:

Under no circumstances should the steering arm be removed by heating or driving in a wedge between the neck of the housing and the steering arm or by hammering, as this causes damage within the steering gear and material changes to the steering arm.



- b) Disconnect retaining ring (7 or 3) on housing neck.
- c) Remove shaft seal (6 or 4) from the housing neck using a suitable screwdriver or hook.
- d) Push tool [10] or [13] onto steering shaft. Push shaft seal with sealing lip to housing and with grease (see note) between sealing lip and dust lip over the sleeve and press into housing neck using tool [11] or [15].
- e) Replace retaining ring (3 or 7). Push dust seal (1.1) with grease (see note) between dust seal and housing up to location on the sector shaft.
- f) Push steering arm onto steering shaft; the marks on the steering arm and the shaft must agree. Tighten and secure hexagon nut with torques given in Section X.

VI. Removing and installing pressure relief valve and replenishing valve

1. Pressure relief valve – ZF Servocom and ZF recirculating ball power steering, type 8033–46

- a) Unscrew valve core (22 or 23) from housing. The valve core cannot be disassembled. In the event of wear or pressure deviation, the complete valve must be replaced.
- b) Fit greased o-ring (23 or 22) into slot of valve core (22 or 23). Screw in valve core.
- c) Tightening torque: 30 Nm.

2. Replenishing valve – ZF Servocom, type 8090–98

- a) Unscrew screw (30) and valve core (32).
- b) Insert valve core (32) into housing hole. Screw in screw (30) with fitted and greased o-ring (21).
- c) Tightening torque: 30 Nm.



Attention:

With the exception of the work given under Sections IV, V and VI, no other repairs necessitating disassembly of the power steering should be carried out. Repairs going beyond the work described above should be carried out by a ZF service agency.



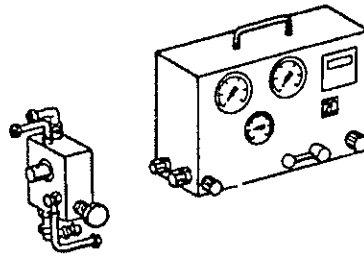
VII. Special tools

a) Tools for inspection

Tool [1]

a) Servotest 550 hydraulic steering tester

b) Sep. flow control valve 2 dm³/min
- Servocom only



Tool number

7418 798 550

7418 798 539

Tool [2]

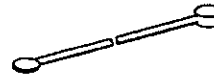
Dial with pointer for checking free play on steering wheel



7418 798 452

Tool [3]

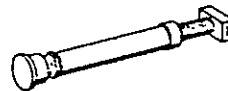
Thrust piece for limiting wheel turn
(use special tool prescribed by vehicle manufacturer)



7418 798 556

Tool [4]

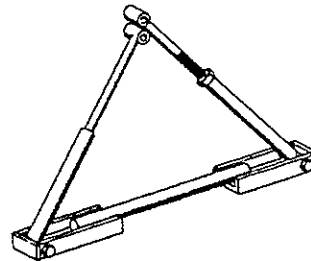
1 pair spreaders
(use special tool prescribed by vehicle manufacturer)



7418 798 653

Tool [5]

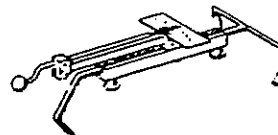
Locking device for steering arm
(use special tool prescribed by vehicle manufacturer)



7418 798 652

Tool [6]

Torque meter for setting pressure point

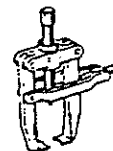


7418 798 703

Tool [7]

Extracting device for steering arm

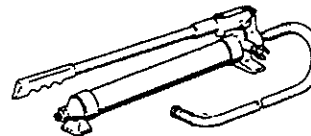
a) Extracting device



7418 798 202

b) Hydr. extracting device consisting of:
Hand pump

Cylinder



7016 798 201

0646 121 048

Bell

for steering shaft diameters up to 45 mm

for steering shaft diameters from 55 mm,
useful width 102 mm



418 798 214

for steering shaft diameters from 55 mm,
useful width 120 mm



7418 798 213

7418 798 216

Special tools



b) Tools for repair, type 8033-46

Tool [8]

Inserting sleeve or mandrel for shaft seal (129) – steering arm



a) for version with intermediate cover (122)

b) for version with ring nut in cover (128) or short radius



Tool [9]

Sleeve for protecting shaft seal (129) on lower steering arm



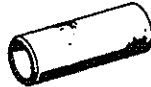
Tool [10]

Guide sleeve for protecting shaft seal (6) on sector shaft



Tool [11]

Guide sleeve or inserting sleeve for shaft seal (6) in housing neck

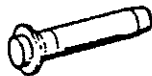


8033	8036	8037	8038	8042	8043 8044	8045	8046
	8052 798 056		7418 798 051			7418 798 051	
8033 798 001		8037 798 002	7404 798 001				
7832 798 001	8052 798 003	7359 798 001	7418 798 006				
	7409 798 001		7425 798 002	8065 798 001		7438 798 002	
	7419 798 003		7425 798 002	8065 798 002		7438 798 003	

c) Tools for repair, type 8056-70

Tool [12]

Mandrel for shaft seal (131) in valve housing



Tool [13]

Guide sleeve for protecting shaft seal (131) on lower steering arm



Tool [14]

Guide sleeve for protecting shaft seal (4) on sector shaft



Tool [15]

Inserting sleeve for shaft seal (4) in housing neck



8056	8058	8060 8062	8065	8066	8070
8052 798 051		7418 798 051			
8052 798 003		7418 798 006			
8056 798 001	7409 798 001	7425 798 002	8065 798 001		7438 798 002
8056 798 002	7419 798 003	7425 798 003	8065 798 002		7438 798 003



VIII. Instructions for inspection

Vehicles with ZF hydraulic power steering should be taken to the workshops of the vehicle manufacturer or the ZF service agencies for inspection of the ZF steering systems and ZF oil pumps according to the following mileages and operating hours.

The inspection intervals given below depend on the type of use of the vehicle. For vehicles fitted with neither a tachometer nor an operating hours counter, a fuel flow volume corresponding to the intervals should be used as a guideline.

- For ZF recirculating ball power steering systems, types 8033–8046, types 8056–8070 and ZF Servocom steering systems produced up to 12/93

Type of use	1st inspection Inspection in vehicle	2nd inspection Inspection in vehicle	3rd inspection
- Long-distance vehicles	100 000 km 60 000 miles	200 000 km 120 000 miles	300 000 km 180 000 miles
- Vehicles in highway and short-distance use	100 000 km 60 000 miles	175 000 km 105 000 miles	250 000 km 150 000 miles
- Construction vehicles and off-road vehicles	80 000 km 50 000 miles 2 500 op. hrs.	150 000 km 90 000 miles 4 500 op. hrs.	200 000 km 120 000 miles 6 000 op. hrs.

To increase road safety, we recommend that the steering system and pump are disassembled in the 3rd inspection, the mechanical steering parts examined (visual examination of all parts and check for cracks on parts under stress) and new sealing parts are fitted. This work should be carried out by a ZF service agency.

- For ZF Servocom steering systems produced from 1/94

Type of use	1st inspection Inspection in vehicle	Additional inspection Inspection in vehicle
- Construction vehicles - Vehicles for short-distance use - Vehicles with high load population	200 000 km 6 000 op. hrs or after no more than 5 years	every 200 000 km 6 000 op. hrs or after no more than 5 years
- Long-distance vehicles - Buses	500 000 km	after every additional 250 000 km



Carrying out the 1st and 2nd inspection

Note:

- a) In order to be able to form an idea of the condition of the vehicle and the power steering before carrying out the following inspection, and to compare the performance of the power steering before and after inspection, we recommend a test drive. This is particularly recommended if the driver has a poor opinion of the steering system. Before going on a test drive, check the oil level and ventilation of the steering system.
- b) The measuring and adjusting tools used must be subjected to regular inspection.

1. Checking the mechanical functioning of the steering



Attention:

Do not turn steering systems with automatically adjustable hydraulic steering limiter into limit positions when the steering linkage has been removed (see Section II, Para. 1.5).

1.1 Checking seat of the fastening screws

Tighten screws on steering and steering mounting with the torque prescribed by the vehicle manufacturer. Check sheet metal and splint mounting for perfect performance. By alternately turning and straightening the steering wheel while the vehicle is stationary, check whether the steering arm still has a firm seat on the serration of the sector shaft.

1.2 Checking straight-ahead driving position of steering and vehicle

Jack up steering axle as instructed by vehicle manufacturer (if the vehicle does not have a rigid steering axle, the wheels should be on rotary tables). Bring steering into centre position by halving the total number of steering wheel revolutions. Then turn further until markings on steering shaft and housing agree. The wheels steered should be in straight-ahead driving position (this can be checked roughly by placing a measuring strip on both front wheels and back wheels and noting toe-in). Correction is effected by screwing ball joint on eccentric rod in or out.



Attention:

If the steering linkage must be corrected longitudinally, the reason for this may be a previous accident-type incident. It is recommended therefore that the serration on the sector shaft (30) is examined for torsion (remove steering arm to do this), the steering shaft for distorted installation and all other transmission parts for bending or cracks and that the free play is measured according to Para. 7.7. Deformed parts must not be bent straight but should be replaced.

For versions with automatically adjustable hydraulic steering limiter ZF Servocom:
If necessary, install new valve sleeve assemblies (20 or 128) and reset steering limiter – see Section II Para. 1.5.

1.3 Checking free play between piston and sector shaft in centre position

- a) Turn steering into centre position (see 1.2) and remove eccentric rod from steering arm.
- b) Measure moment of friction when turning across the pressure point area. It should be greater by the following values than outside the pressure point:

Type 8090: 20 - 60 Ncm

Type 8095: 20 - 80 Ncm

Type 8097/8098: 20 - 100 Ncm

Type 8033-46: 40 - 60 Ncm

Type 8056-70: 40 - 60 Ncm

To set pressure point (only types 8033-46 and 8056-70), see Section IV. Adjustment of pressure point with ZF Servocom is only possible when dismantled (ZF service agencies).



1.4 Checking steering lock

Connect eccentric rod temporarily. Turn steering to the left up to lock. Disconnect eccentric rod and turn steering wheel further to ascertain whether there is still steering reserve. Repeat measurement to right. There must be steering reserve on both sides. If this is not the case, the wheel lock screws must be reset. Connect eccentric rod again.

Note:

When the steering linkage has been removed, steering systems with automatically adjustable hydraulic steering limiter (ZF Servocom) may only be turned into limit positions if there is to be a subsequent resetting with new valve sleeve assemblies (128); if necessary, remove valve sleeves and fit plugs for this inspection.

1.5 Checking free play of steering shaft support in steering column

Check whether there is free play by making lateral movements (shaking) on the steering wheel. If there is free play, replace bearing bush.

1.6 Checking circumferential backlash or sluggishness in universal joint or in flexible disk between upper steering shaft and steering gear

If there is free play (produces audible rattling on shaking) or sluggishness, fit new part.

1.7 Checking steering shaft and jacket tube for maximum permissible bend

Jack up steering axle as instructed by vehicle manufacturer. Remove steering wheel and self-aligning bearing ring or ball bearing bush from the jacket tube. Check the permissible bend of steering shaft and jacket tube in accordance with Section X.

2. Checking for external tightness

- a) Start engine.
- b) Check whether all screwed connections and lines of steering system and seals on steering and pumps are tight. Tighten screwed connections and replace seals if necessary. When fitting new seals, we recommend that you use our special tools.
- c) Check all hoses and lines for possible abrasion points and brittle cracks. Replace defective parts.



Attention:

For hose lines and externally visible damage such as cracks, fit only pressure-tested replacement parts recommended by the manufacturer. Note replacement part numbers of vehicle manufacturer.

- d) Stop engine.

3. Checking V-belt tension

Check tension of V-belts using the usual thumb tests (adhere to instructions of vehicle manufacturer). The V-belts must not overrun even under maximum pressure. Replace defective V-belts.

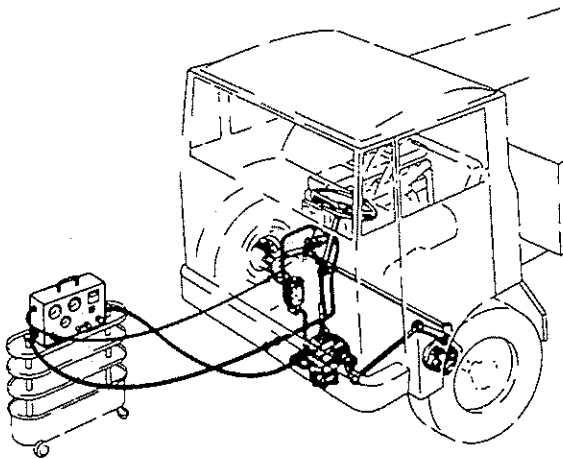
4. Fitting hydraulic steering tester

Fit Servotest 550 hydraulic steering tester in the pressure line between oil pump and ZF power steering (see *Illus. 24* and *25*) in such a way that the display instruments can be easily observed from the driver's seat. Connect pressure line from pump with connection "input 1" of tester and connection "output 2" with line to the steering (see separate operating instructions for Servotest 550). Steering systems which have a pressure relief valve positioned according to Section 7 Para. 2b) must be connected to the oil tank from connection "tank 3" of the tester.

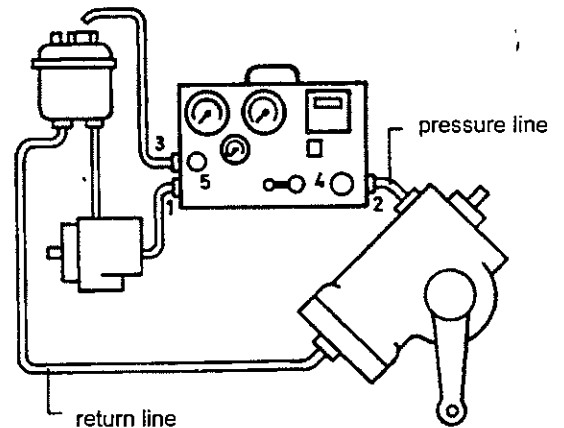


It is enough to insert the hose end into the opening of the removed tank cover. See *Illus. 25* for diagram of connections. Note oil level and top up if necessary. Ventilate steering system.

Illus. 24
Hydraulic connection diagram for hydraulic steering tester using ZF Servocom steering system as example



Illus. 25
Position of hydraulic steering tester valves after connection (idle position): pressure relief valve 120 bar, throttle valve closed, shutoff valve open.



5. **Oil filling**
See Section III (maintenance and oils).
6. **Ventilation**
See Section III (maintenance and oils).
7. **Checking hydraulic functioning of steering and pump**

Note:

To carry out the following pressure and overflow oil checks, 2 types of steering must be differentiated.

- a) Steering systems in which **the pressure relief valve is located in the pump or pressure line**. This means that the pressure is relieved before the installed tester. In these steering systems, the maximum pressure, e.g. 100 bar, is indicated on the rating plate of the pump or pressure relief valve.
- b) Steering systems in which the **pressure relief valve is installed in the steering system or separately in the pressure line between tester and steering**. The valve can thus no longer control the oil pressure if the pressure lines are blocked by the installed shutoff valve of the test device. In these steering systems, the maximum pressure is indicated on the rating plate of the steering or pressure relief valve.

7.1 Checking ZF pump for pressure

Read the maximum pressure from the rating plate of the steering or the pump or the separate pressure relief valve. Run engine until warm. Oil temperature 50°C.

- a) For steering systems with pressure relief **before** tester:

With the engine at idle speed, close shutoff valve of tester. Read pressure from manometer.

**Attention:**

Only operate maximum pressure for a short time, no more than 5 seconds, as otherwise the internal parts of the pump will be too hot, leading to premature wear. Bring shutoff valve into starting position again. The permissible deviation from nominal pressure must be no more than $\pm 10\%$.

If the difference is greater, the functioning of the pressure relief and flow control valve must be checked and the valve adjusted if necessary.

Checking the valve:

Remove pressure relief and flow control valve from ZF oil pump. Check valve piston and hole in valve housing for visible wear. The holes in the valve piston must not be clogged. The piston must be able to be moved slightly and must not stick. If necessary, a new valve must be fitted.

If the maximum pressure of the pump is still too low after this check, the internal parts of the pump must be examined for wear. In this case we recommend that the pump is exchanged.

- b) For steering systems with pressure relief **behind** tester:

**Attention:**

If the tester has been installed as described in b), ensure that the engine is only run at idle speed for the complete duration of the pressure testing. An increase in engine speed would result in an immediate, jerky rise in the oil pressure. In this case there is a danger that the pressure line will become defective or the pump will seize up.

With the engine at idle speed and while observing the manometer, close the shutoff valve of the tester slowly until the maximum pressure has been reached. Do not close valve any more (only operate maximum pressure for a short time, no more than 5 seconds, as otherwise the internal parts of the pump will be too hot, leading to premature wear). Bring shutoff valve into starting position again. If the measurement does not show nominal pressure, the functioning of the flow control valve must be checked and the valve adjusted if necessary.

Checking the valve:

Remove flow control valve from ZF oil pump. Check flow control valve piston and hole in valve housing for visible wear. The holes in the valve piston must not be clogged. The piston must be able to be moved slightly and must not stick. If necessary, a new valve must be fitted.

If the maximum pressure of the pump is still too low after this check, the internal parts of the pump must be examined for wear. In this case we recommend that the pump is exchanged.

7.2 Checking ZF oil pump for flow rate using Servotest 550 hydraulic steering tester

Note:

For setpoint values for flow rate, test pressure and test speed, see table. For descriptions and operation of hydraulic steering tester, see separate operating instructions for Servotest 550.

- a) Checking minimum flow rate

With engine at idle speed, close shutoff valve until test pressure for pump type is reached. Read off flow rate. Note conversion of engine speed to pump speed.



At a pump pressure of 50 bar (120 bar for pump type 8601), the minimum flow rate is:

for pump type	minimum flow rate dm ³ /min	speed rpm	for pump type	minimum flow rate dm ³ /min	speed rpm
7633	6.0	800	7677	8.5	500
7634	6.0	700	7681	3.1	500
7636	6.0	500	7683	4.5	500
7638	6.0	400	7684	5.9	500
7646	6.5	350	7685	7.0	500
7671	2.6	500	7686	9.4	500
7672	4.5	500	8601	2.0	1000
7673	6.1	500	8605	5.0	350
7674	7.5	500	8607	5.0	350

b) Checking the controlled flow rate

Increase speed until the capacity of the pump remains constant despite a further increase in speed, approx. 1300 rpm. The pump is now in the limiter area. The setpoint value of the capacity can be read from the respective list of replacement parts for the oil pump.

7.3 Checking the hydraulic steering limiter

a) Mechanically adjustable hydraulic steering limiter

Turn steering wheel clockwise as described under Section II, with steering axle under stress (jack up rigid axle or use rotary tables for independent suspension). Once the wheel lock has been reached, a brief (max. 5 seconds) continued turning of the steering wheel will overcome the resetting force of the steering valve until a fixed steering wheel lock is achieved. To reach this a peripheral force on the steering wheel of approx. 100–200 N is required. In this position, read off the oil pressure on the manometer; this should be no greater than indicated under Section II. For setting of the steering limiter, please refer to Section II. Para 1.4.

b) Automatically adjustable hydraulic steering limiter – ZF Servocom

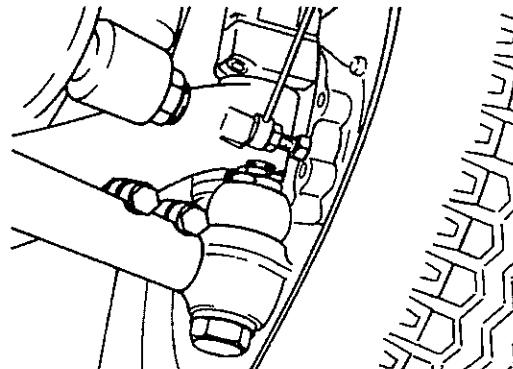
Carry out check as described under a), but with no spacers inserted. If there is no space on the wheel lock parts or the oil pressure does not fall to the value given in Section II Para. 2, fit new sliding valve assemblies (20 or 128) and reset steering limiter according to Section II Para. 1.5.

If the space on the wheel lock parts is too great and the oil pressure falls to the prescribed value, reset steering limiter according to Section II Para. 1.5.

Carry out check in the same way while steering anticlockwise.

7.4 Checking steering system for pressure

Tool [3] or thrust pieces approx. 15 mm thick (*Illus. 26*) are inserted between the wheel lock parts in such a way that the steering lock is restricted 1/2 to 3/4 of a steering wheel revolution before reaching full lock. Restriction of the steering lock should therefore be effected using these thrust pieces, but not in the hydraulic power steering through the working piston on the cylinder.



Illus. 26



Attention:

A tool under pressure may be ejected – avoid direct eye contact with the tool. If the tool locks during steering lock, it is essential that there is sufficient clearance between the wheel and the vehicle chassis for this. There is a danger of the hand being squeezed e.g. when the tool is ejected and the wheel subsequently resettles. Depending on the type of axle, use the special thrust piece specified by the vehicle manufacturer.

With engine at idle speed, turn steering wheel to the right until full lock and continue turning right for approx. 5 seconds with a force of 100–200 N on the steering wheel until the self-aligning force of the steering valve is overcome. The oil pressure is read off on the manometer. The same measurement is carried out steering to the left. If, when steering left or right or in both directions, it is discovered that the oil pressure at a steering force of 100–200 N is below the previously measured oil pressure of the pump, the steering hydraulics are not functioning properly. The cause of the pressure drop may be:

- a) Pressure relief valve in the steering system (or separate) is not working properly.
- b) There is too much overflow oil in the steering hydraulics (measure overflow oil flow).

7.5 Checking overflow oil using hydraulic steering tester

Note:

For descriptions and operation of hydraulic steering tester, see separate operating instructions for Servotest 550.

- a) For steering systems with pressure relief before tester:

Keep 15 mm thick thrust piece between the wheel lock parts. With engine at idle speed, turn steering to full lock and pull on steering wheel with approx. 100–200 N (max. 5 seconds) so that steering valve is fully closed. Read off overflow oil flow and release steering wheel. Repeat check turning in opposite direction.



Attention:

A tool under pressure may be ejected – avoid direct eye contact with the tool. Depending on the type of axle, use the special thrust piece specified by the vehicle manufacturer.

- b) For steering systems with pressure relief **behind** tester:

Close shutoff valve (4) completely and throttle valve (5) until there is back pressure 30 bar lower than the maximum pressure measured under 7.1. Open shutoff valve (4) again.



Keep 15 mm thick thrust piece between the wheel lock parts. With engine at idle speed, turn steering to full lock and pull on steering wheel with approx. 100–200 N (max. 5 seconds) so that steering valve is fully closed. Read off overflow oil flow and release steering wheel. Repeat check turning in opposite direction.

Max. permissible overflow oil values:	Type 8033 to 8037:	2.8 dm ³ /min
	Type 8038 to 8044:	3.0 dm ³ /min
	Type 8045 to 8046:	3.2 dm ³ /min
	Type 8056 to 8058:	2.0 dm ³ /min
	Type 8060 to 8070:	2.5 dm ³ /min
	Type 8090:	2.0 dm ³ /min
	Type 8095 to 8098:	2.5 dm ³ /min

For ZF–Servocom type 8090–98:

For Servocom steering systems, the functioning of the high–pressure seals must also be checked while the flow rate is low.

Set hydraulic steering tester to flow rate of 2 dm³/min. Connect separate flow control valve tool [1b] in series.

Repeat overflow oil check as described under a) or b). The overflow oil should not exceed the previously measured value. If this measurement shows a greater overflow oil value than was the case for measurement under a) or b), the cause may be that seals, especially the seals (117 and 123) in the piston or housing cover, are not in exact contact.

For ZF recirculating ball power steering, type 8033–46 and 8056–70:

Repeat overflow oil measurement with pressure of 20 to 30 bar.

The cause of excess overflow oil may be:

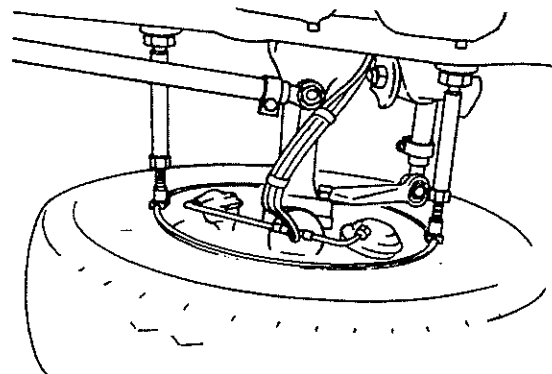
- a) Pressure relief or replenishing valve in steering not working properly – replace.
- b) Steering limiter valve switches off too early – to set, see Section II.
- c) Seals in steering are defective – dismantle steering and have repaired by ZF service agency.

7.6 Checking valve restoring force

With the steering arm locked in the centre position, close the control valve by turning the steering wheel, thereby building up the maximum pump pressure. Then slowly release the steering wheel and again set a pump pressure of 10 bar above the flow pressure. The valve must then return to its original position within 1 second, i.e. the oil pressure must fall to at least 0.5 bar above the flow pressure.

7.7 Measuring the free play on the steering wheel with engine running and vehicle stationary in straight–ahead driving position

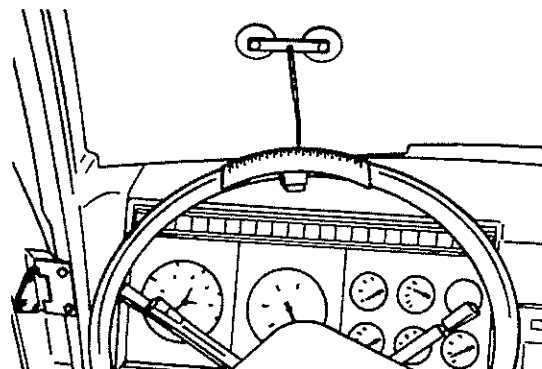
- a) Lock front left wheel (front right wheel in right–hand drive vehicles) into straight–ahead driving position by fitting two expanding devices between wheel rim (front and back) and front spring (*Illus. 27*).



Illus. 27

- b) Place dial on steering wheel and attach pointer on dashboard or windscreen (*Illus. 28*).
- c) With the engine running, begin to turn steering wheel slowly to the left while observing the manometer.

For ZF-Servocom:
higher engine speed, approx. 1000 rpm
oil temperature: 50–60°C



Illus.28

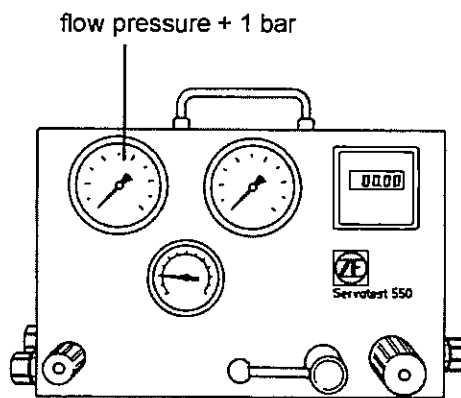
- d) When a pressure rise of 1 bar above flow pressure has been reached (*Illus. 29*), hold the steering wheel firmly and mark value on scale. Then turn steering wheel to right, again until a pressure rise of 1 bar has been reached. The total path travelled on the scale is measured.

Max. permissible travel:
Type 8090-98: 40 mm
Type 8033-46: 40 mm
Type 8056-70: 20 mm

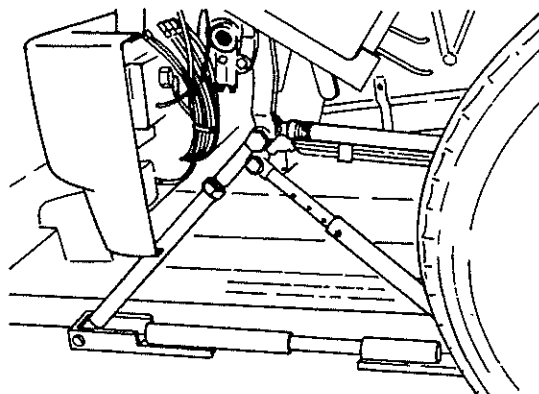
For steering versions with flange-connected or separate angle gear, the free play may be 5 mm greater.

If these conditions are not fulfilled, the measurement must be repeated with the steering arm locked (*Illus. 30*), since in the measurement carried out the free play in the ball joints of eccentric and track rods and in the other transmission parts was not eliminated. This check requires a good, play-free condition of the eccentric rod and the ball joint.

If the travel is greater than indicated even with the steering arm locked, there is mechanical play in the steering gear. This may also be the result of an accident-type impact. The steering gear should then be reconditioned or examined for accident damage by a ZF service agency (check for cracks). Switch off engine. Dismount hydraulic steering tester.



Illus.29



Illus.30

8. Filter change



Attention:

Before removing the oil tank cover, thoroughly clean the tank and its immediate surroundings so that no dirt can get into the hydraulic fluid.

- a) Unscrew plug screw from cover of oil tank and remove tank cover.



- b) Pull out used cartridge on metal collar. When removing the used filter cartridge, close the lower hole so that dirty oil does not run back into the tank.

If oil tanks are plastic, remove suction and return pipe. Disassemble oil tank, evacuate, clean and fit new filter cartridge.

- c) Grease filter holders and fit new filter cartridge with metal collar pointing up.
- d) Fill tank with oil up to neck.
- e) Start engine. The oil level will fall rapidly. To avoid the intake of air, top up tank with oil immediately. Then ventilate steering system as described in Section III.

Note:

Illus. 26, 27 and 30 show universal devices provided by ZF. Depending on the type of vehicle, special devices approved by the vehicle manufacturer may also be required.

9. Test drive

After inspection work, a test drive should be carried out to check the vehicle and steering system for perfect functioning and external tightness.

IX. Removing the steering system from the vehicle

1. Thoroughly clean steering system and the directly surrounding area, especially the line connections.
2. Discharge oil as described in Section III, Para. 4.
3. Disconnect pressure and return lines.
4. Close all oil lines to avoid contamination.
5. Pull off steering arm using tool [7].



Attention:

Under no circumstances should the steering arm be removed by heating or by driving in a wedge between the neck of the housing and the steering arm or by hammering, as this causes damage within the steering gear and material changes to the steering arm.

Do not turn steering systems with automatically adjustable hydraulic steering limiters into limit positions when the steering linkage has been removed – see Section II Para. 1.5. If necessary, fit new sliding sleeve assemblies (20 or 128).

6. Disconnect universal joint or flexible coupling between steering gear and steering column or separately installed angle gear. Do not hit the steering shaft axially when dismantling the steering wheel.
7. Remove fastening screws on housing and extract steering system.

X. Installing the steering system in the vehicle



Attention:

To guarantee safe functioning of the total steering system, ensure absolute cleanliness when fitting all aggregates belonging to the system and when connecting the lines. To avoid malfunctions due to foreign bodies or dirt in the steering oil circuit, the sealing plugs on the line connections of steering system, oil pump, working cylinder, valves etc. should only be removed when connecting the lines. If possible, do not remove protective sheaths until installation is complete. Connecting lines and screwed connections must be cleaned and deburred carefully.

Do not turn steering systems with automatically adjustable hydraulic steering limiters into limit positions when the steering linkage has been removed – see Section II Para. 1.5. If necessary, fit new sliding sleeve assemblies (20 and 128).



1. Ensure that contact surfaces of mounting eyes of bearing block and steering system are free of paint and dirt.
2. Place steering gear in bearing block and screw down. Tighten screws with corresponding torque. Depending on the type of vehicle, the steering arm may require prior mounting for reasons of space (see Para. 7).



Attention:

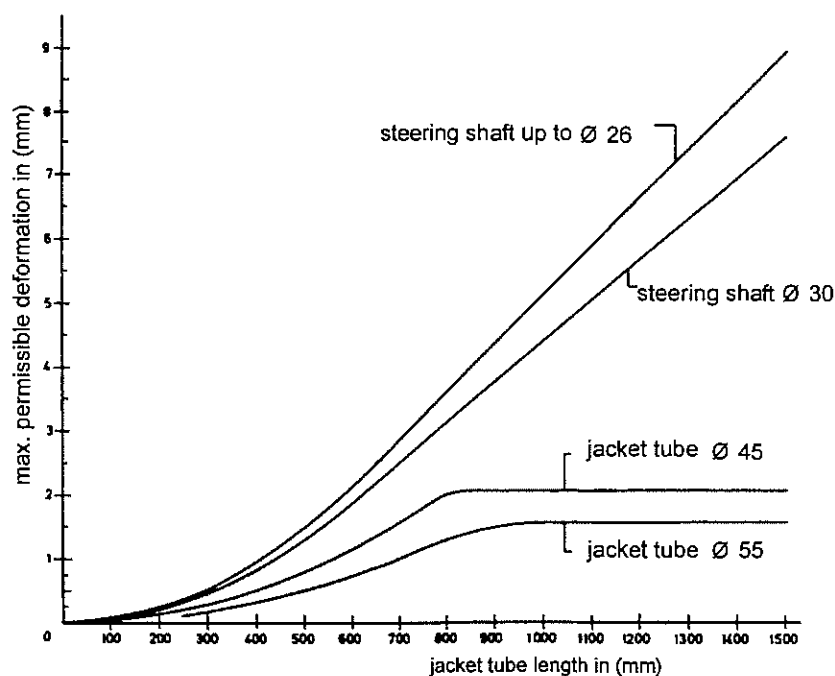
When fastening jacket tube and steering shaft, particularly in the case of a separately installed angle gear with flange-connected jacket tube, it is essential to avoid pretensions which may occur in the steering gear/bearing block due to the retaining connection to the bulkhead or dashboard.

Pretensions can be generated through bending torques, especially in the steering shaft, and depending on size and frequency can in some cases lead to permanent fractures or impair the freedom of the steering gear.

3. To check whether the steering has been correctly installed, proceed as follows:
 - 3.1 Check freedom of the steering gear or separately installed angle gear in the assembly with bearing block, steering arm and eccentric rod(s).

3.2 Checking the permissible deformation of the steering shaft

- a) Raise steering axle in accordance with the instructions of the vehicle manufacturer so that the steering system can be easily turned by hand.
- b) Remove steering wheel and dismount ball bearing sleeve or self-aligning bearing from the jacket tube of the separately installed angle gear.
- c) By turning the steering shaft at least 360 degrees, establish whether the steering shaft is deformed. The measurement can be carried out using a dial gauge or a depth gauge, although the measurement must always be taken from the same point on the periphery of the jacket tube. The radial run-out measured, divided by 2, gives the deformation of the steering shaft. The maximum permissible deformation depends on the length of the jacket tube and the diameter of the steering shaft (see *Illus. 31* and the procedure for determining the length of the jacket tube).



Maximum permissible deformation of jacket tube and steering shaft

Illus. 31



3.3 Checking the permissible deformation of the jacket tube

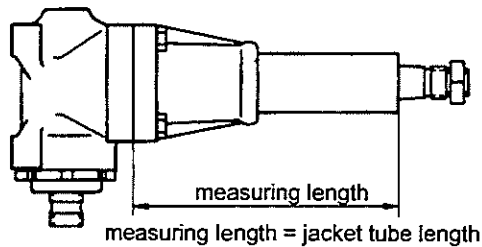
To do this, the steering shaft must be marked on one point on the periphery. Then turn the steering shaft in stages (at least 4 stages) and after each stage, use the depth gauge to measure the distance always from the external diameter of the jacket tube to the point marked on the steering shaft. Since the same steering shaft side faces the measuring point on the periphery of the jacket tube, the run-out of the steering shaft itself is not measured as well. The difference of the distance, largest measurement to smallest measurement, divided by 2, gives the deformation of the jacket tube. The maximum permissible deformation depends on the length and diameter of the jacket tube (see *Illus. 31* and the procedure for determining the length of the jacket tube).

Note:

This check must also be carried out during main inspection of the steering system and for vehicles with previous accident damage in the front area.

3.4 Determining the jacket tube length

Measure the length of the jacket tube including jacket tube flange – parting plane jacket tube flange/ housing (*Illus. 32*).



Illus. 32

4. Turn steering system into straight-ahead driving position (determined by halving the total number of steering wheel revolutions). The markings on the steering shaft and jacket tube or valve housing must agree.
5. a) Applies for separately installed angle gear with rigid steering column:

Screw in sliding contact and tighten with 5 Nm. Tightening torques for steering wheel nuts:

with cylindrical serration and cone 1:6:

M 18 x1.5:	35 - 45 Nm
M 22 x1.5:	40 - 50 Nm
M 26 x1.5:	60 - 70 Nm



Attention:

Do not hit the steering shaft axially when mounting and dismantling the steering wheel.

- b) Applies for steering systems with separate steering column:

Fit universal joint or flexible coupling between steering column and steering gear. In the straight-ahead driving position, the offset yoke part must be at a right angle to the markings on the steering shaft and jacket tube or valve housing. If two joints are used, the diffraction angle should be the same and the yokes on a plane. If such an installation is impossible, parallelity can be reached by offsetting the yokes to each other on the serration.

Installing the steering system



With aluminium universal joints, hammer blows on the yokes should be avoided as this can lead to destruction or sluggishness. Connect both by using fit bolts and tightening the nuts. Tightening torques for fit bolts:

M 8: 24 Nm
M 10 x 1.25: 48 Nm

When fitting telescopic shafts, note max. permissible lift range.

6. Bring steered wheels of vehicle into straight-ahead driving position. This is reached when the steered wheels are flush or parallel to the second pair of wheels (use measuring strip on front and rear wheel).
7. Push dust seal (1.1) with Spectron FO 20 grease from DEA or equivalent calcium complex grease of consistency class 2 into spaces on sector shaft. Then place steering arm on serration so that markings on steering arm and sector shaft agree. Provisionally tighten nut securing steering arm and turn steering to the left until full lock. Remove steering arm and continue turning steering wheel to determine if there is still steering reserve available. Repeat measurement turning to the right. Tighten nut securing steering arm with the torque listed below and secure to prescribed place by caulking (peening depth: min. 1.5 mm). Connect and tighten eccentric rod.

For versions with automatically adjustable hydraulic steering limiter:

Remove steering arm and continue turning steering wheel to determine if there is still steering reserve available. Repeat measurement turning to the right.

Screw in sliding sleeve assembly (20 and 128) (tightening torque 15+3 Nm).

Tighten nut securing steering arm with the torque listed below and secure to prescribed place by caulking (peening depth: min. 1.5 mm). Connect and tighten eccentric rod.

Do not turn steering systems with automatically adjustable steering limiter into limit positions when the steering linkage is dismantled – see Section II Para. 1.5. If necessary, fit new sliding sleeve assemblies (20 or 128).

☞ For versions with conical serration:

Thread	Gear	Tightening torques	Exception
M30x1,5	1 3/8"x36	250 Nm +10%	
M30x1,5	1 1/2"x36	300 Nm +10%	
M30x1,5	1 5/8"x36	330 Nm +10%	
M35x1,5		400 Nm +10%	
M42x1,5		500 Nm +10%	
M45x1,5		550 Nm +10%	MAN: 850 Nm+10%

☞ For cylindrical serration or binding screws:

see tightening torques prescribed by vehicle manufacturer

If the vehicle manufacturers specifies other values, these values must be applied.

8. Connect pressure and return line between pump, steering and working cylinder. If lines must be bent, this should be done when cold in order to avoid scaling.

For hose lines with externally visible damage such as cracks, only pressure-tested replacement parts released by the manufacturer should be used. Note replacement part number of vehicle manufacturer.



9. Fill system with hydraulic fluid through oil tank.
See Section III Para. 6.

10. Startup of steering system

To avoid any particles of dirt still in the steering system getting into the pressure relief valve on first startup, it is recommended that oil flows through the steering system for some minutes at different engine speeds and without the steering wheel being turned. The steering should then be turned several times in both directions, but not to full lock, at average engine speed (until operating temperature is reached).

Then ventilate steering system (see Section III).

11. Set hydraulic steering limiter.

See Section II.

12. Check oil level.

See Section III.

XI. Troubleshooting

ZF hydraulic power steering systems have been developed for heavy use. They are constructed so that no malfunctions can occur with perfect maintenance and under normal operation.

However, if this should not be the case, the following information should help locate and eliminate any problems.

Before examining the steering system for the individual faults, check the oil level with the engine running. The exact procedure for oil filling is described in detail in a separate section.

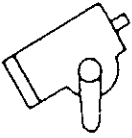

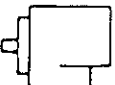
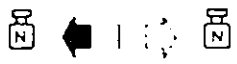
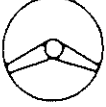
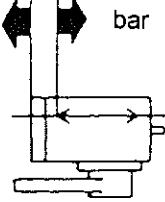
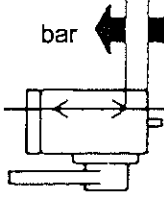
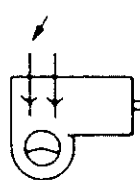
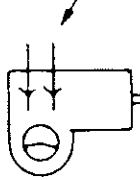
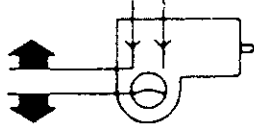
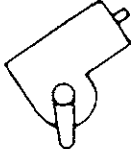



We must also point out that the use of very frothy oils can lead to faults, since such oils can only release air with difficulty, or not at all, once it has penetrated the steering system.



Fault	Cause	Remedy
		<p>eliminate leakage</p>
		<p>tension V-belt ¹</p>
<p>heavy on both sides</p>		<p>replace seals ¹</p> <p>ventilate</p>
		<p>grind off / replace ¹</p>
	<p>contaminated/ broken</p>	<p>replace, clean control valve, suction line</p>
		<p>replace, clean control valve, suction line</p>

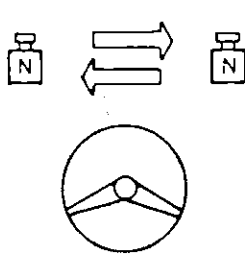
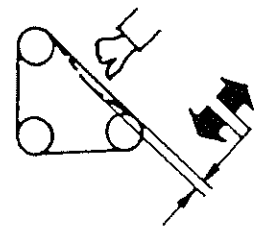
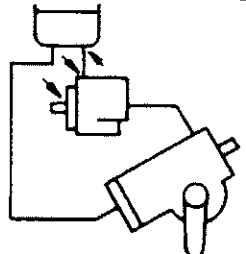
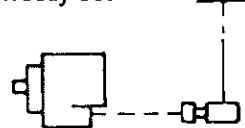

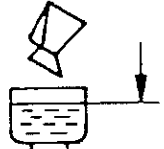
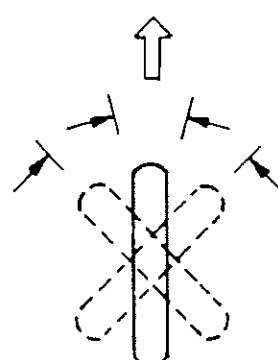
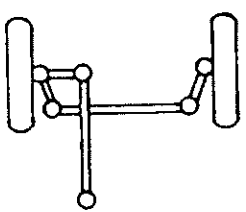
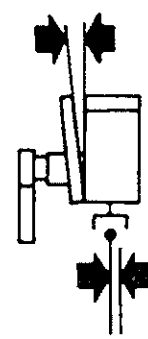
¹ refer to instruction of vehicle manufacturer



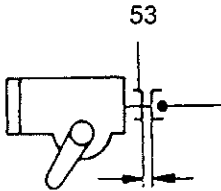
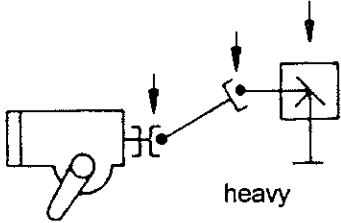
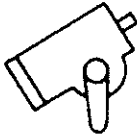
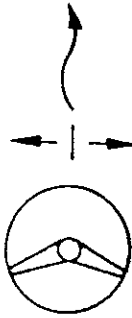
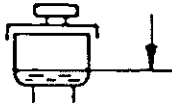
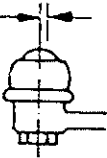

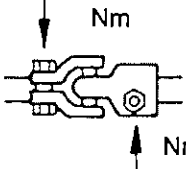
Fault	Cause	Remedy
	<p>internal fault</p>  <p>does not close – incorrectly set</p>  <p>729</p> <p>internal fault</p> 	<p>exchange steering ¹</p> <p>clean</p> <p>replace</p> <p>exchange pump ¹</p>
<p>heavy on one side</p>  	<p>Servocom</p>  <p>bar</p>  <p>bar</p> <p>Recirculating ball power steering</p> <p>not tight</p>   <p>bar</p>  <p>bar</p> <p>internal fault</p> 	<p>set section II</p> <p>53</p>  <p>54</p>  <p>55</p>  <p>replace</p> <p>set section II</p> <p>exchange steering ¹</p>

¹ refer to instructions of vehicle manufacturer

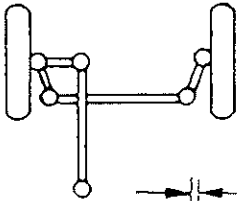
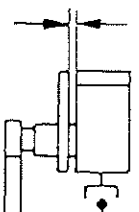
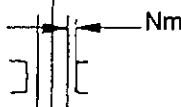
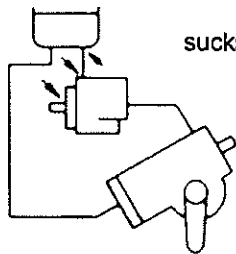
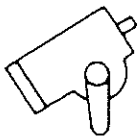
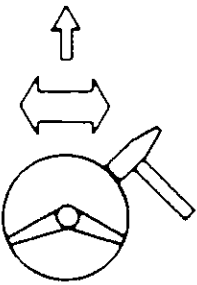


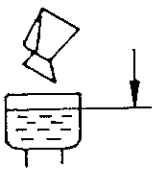


Fault	Cause	Remedy
<p>heavy on quick steering</p> 	 <p>sucks in air</p>  <p>does not close - incorrectly set</p>  <p>internal fault</p> 	<p>tension V-belt ¹</p> <p>replace seal</p>  <p>max.</p> <p>ventilate</p> <p>clean</p> <p>replace</p> <p>exchange pump ¹</p>
<p>inhibiting return V (km/h)</p> 	<p>heavy</p>  <p>distorted</p> 	<p>lubricate ¹</p> <p>loosen bracing ¹</p> <p>¹ refer to instructions of vehicle manufacturer</p>



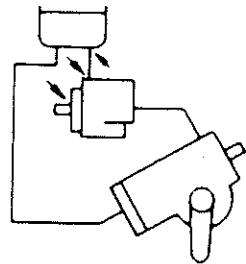
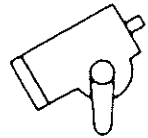
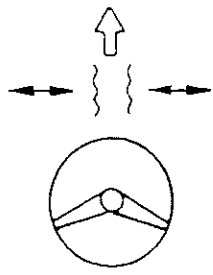
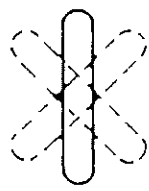
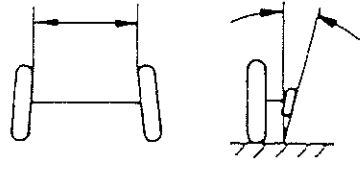
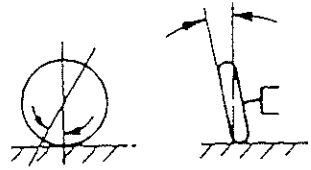
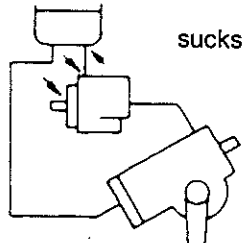
Fault	Cause	Remedy
	 <p>sticks</p>  <p>heavy</p>  <p>internal fault</p>	<p>grind off / replace 1</p> <p>lubricate / replace 1</p> <p>exchange steering 1</p>
<p>not exact V (km/h)</p> 	 <p>min.</p>  <p>max.</p>  <p>Nm</p>  <p>Nm</p> <p>Nm</p>	<p>eliminate leakage</p> <p>ventilate</p> <p>tighten / exchange 1</p> <p>1 refer to instructions of vehicle manufacturer</p>



Fault	Cause	Remedy
	 <p>heavy</p>  <p>Nm</p>  <p>Nm</p>  <p>sucks in air</p>  <p>internal fault</p>	<p>lubricate ¹</p> <p>tighten ¹</p> <p>replace seals</p> <p>ventilate</p> <p>exchange steering ¹</p>
<p>steering wheel locks</p> <p>V (km/h)</p> 	 <p>min</p>  <p>free play</p>	<p>eliminate leakage</p>  <p>max.</p> <p>replace ¹</p>

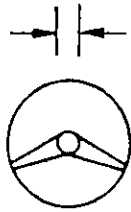
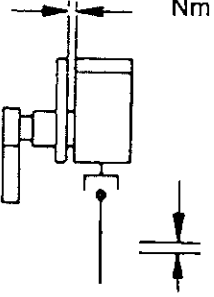
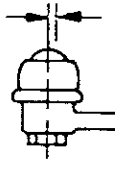
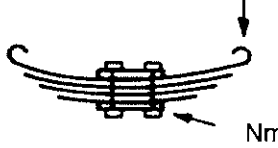
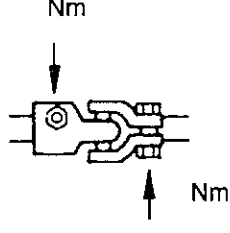
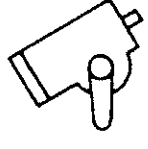
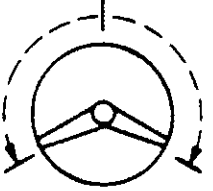
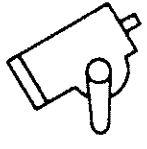
¹ refer to instructions of vehicle manufacturer



Fault	Cause	Remedy
	 <p>sucks in air</p>  <p>internal fault</p>	<p>replace seals</p> <p>ventilate</p> <p>exchange steering ¹</p>
<p>torsional vibrations V (km/h)</p> 	 <p>imbalance</p>    <p>sucks in air</p>	<p>balance ¹</p> <p>set ¹</p> <p>replace seals</p> <p>ventilate</p>


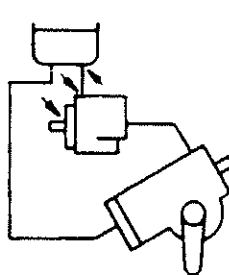

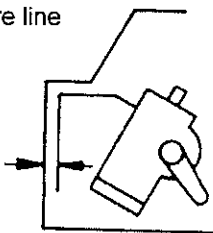
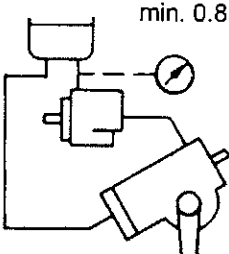




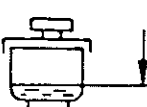
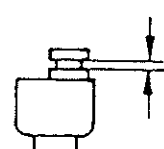
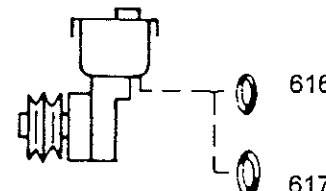
¹ refer to instructions of vehicle manufacturer



Fault	Cause	Remedy
<p>play in steering wheel</p> 	    	<p>tighten / replace ¹</p> <p>exchange steering ¹</p>
<p>runs out</p> 	 <p>internal fault</p>	<p>exchange steering ¹</p>

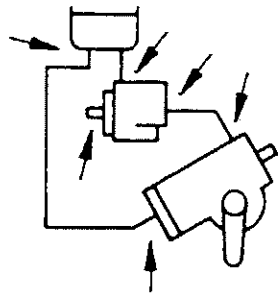
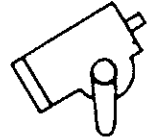
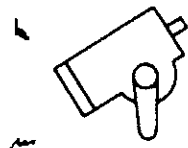
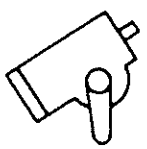
¹ refer to instructions of vehicle manufacturer



Fault	Cause	Remedy
<p>noises</p> 	<p>sucks in air</p>  <p>min.</p>  <p>pressure line</p>  <p>min. 0.85 bar</p> 	<p>replace seals</p>  <p>max.</p>  <p>ventilate</p> <p>eliminate leakage</p>  <p>max.</p>  <p>rubber retainer I</p> <p>ZF service agency</p>
<p>loss of oil</p>  <p>min.</p>	  <p>616</p> <p>617</p>	<p>close</p> <p>replace</p>

I refer to instructions of vehicle manufacturer

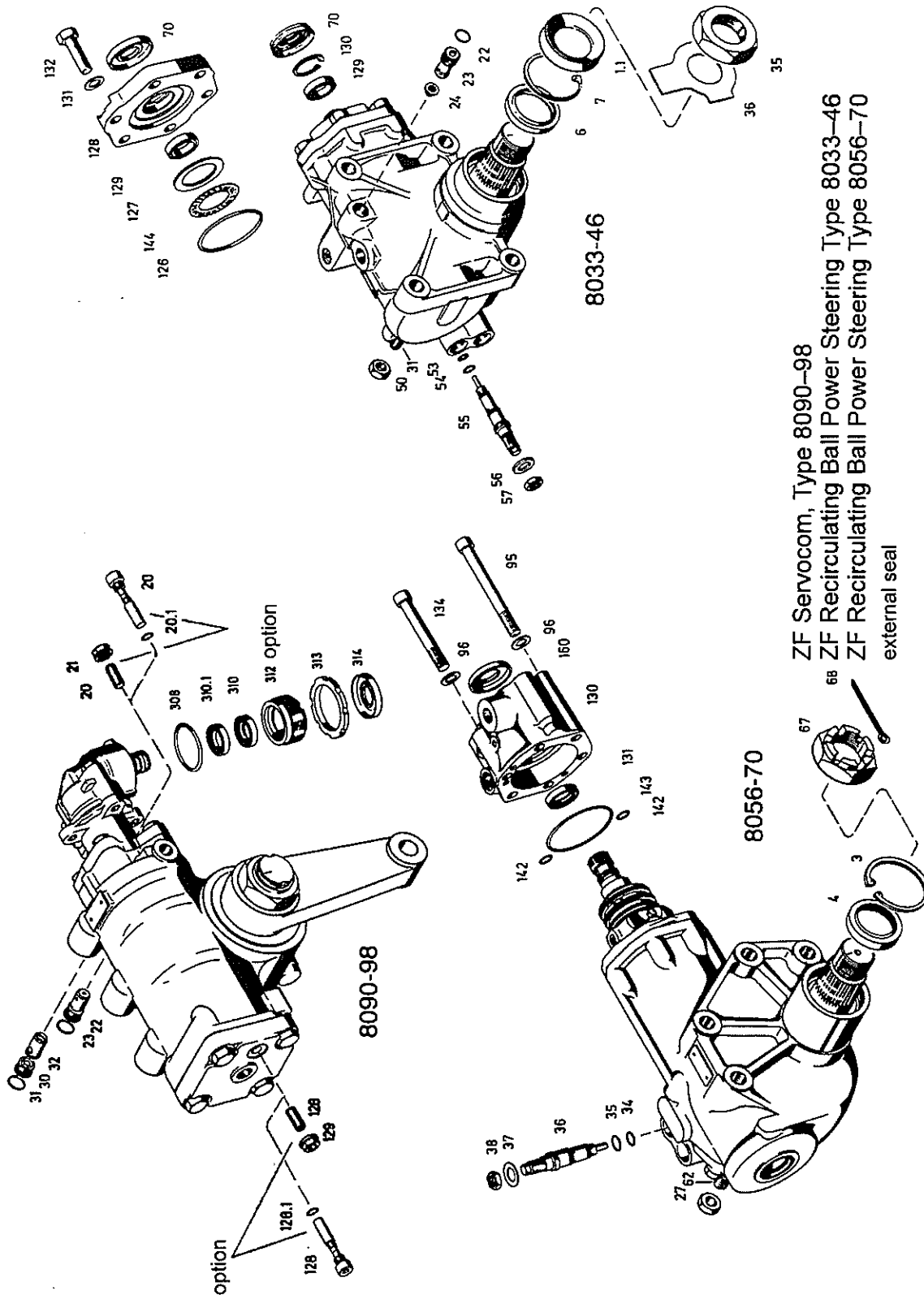


Fault	Cause	Remedy
	  <p>internal fault</p>	<p>replace seals</p> <p>tighten lines</p> <p>exchange steering ¹</p>
<p>noises</p> 	 <p>internal fault</p>	<p>exchange steering ¹</p> <p>¹ refer to instructions of vehicle manufacturer</p>



XII. Key to numbers in illustrations and exploded views

1.	Housing	96	Washer / Disk
1.1	Dust seal	122	Intermediate cover
3	Circlip / Locking ring	126	O-ring
4	Shaft seal	127	Bearing plate
6	Shaft seal	128	Stud / Cover / Screw
7	Circlip / Locking ring		
20	Stud / screw	128.1	O-ring
20.1	O-ring	129	Flanged nut / Collar nut
21	Flanged nut / Collar nut	130	Valve housing / Circlip / Locking ring
22	Pressure control valve	131	Washer / Shaft seal
23	O-ring	132	Hexagon screw
24	Screen filter	134	Cheese head screw
27	Hexagon nut	142	O-ring
30	Screw	143	O-ring
31	O-ring / Adjusting screw	144	Thrust needle cage / Axial needle cage
32	Feeder valve / Suction valve	151	Valve body
34	O-ring	152	Valve spring
35	O-ring	153	O-ring
36	Valve accessories	154	Setting plate / Adjusting plate
37	Washer / Disk	155	Valve guide
38	Hexagon nut	156	O-ring
50	Grommet nut	157	Circlip / Locking ring
51	Dust seal	158	Plug screw
53	O-ring	160	Protective cap
54	O-ring	306	Bevel gear wheel
55	Valve	308	O-ring
56	Washer / Disk	310	External shaft seal
57	Hexagon nut	310.1	Internal shaft seal
62	Adjusting screw	312	Adjusting screw
70	Protective cap	313	Slotted nut / Grooved nut
95	Cheese head screw	314	Protective cap



ZF Servocom, Type 8090-98
 ZF Recirculating Ball Power Steering Type 8033-46
 ZF Recirculating Ball Power Steering Type 8056-70
 external seal

Notes



A series of horizontal dotted lines for taking notes.

Notes



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1. DESCRIPTION

The vehicle is provided with an air suspension system. The system consists of air springs, height control valves, radius rods, sway bars, tripod and shock absorbers (Fig. 1, 2, 11, 36, 37 and 38). The system operation is fully automatic and maintains a constant vehicle height regardless of load, or load distribution.

The vehicle can also be equipped with systems such as:

- Front Kneeling (w/ Front High-Buoy);
- Front Kneeling (w/ Full High-Buoy);
- Front Kneeling (w/ Front High-Buoy) and Low-Buoy Combination;
- Front Kneeling (w/ Full High-Buoy) and Low-Buoy Combination;

2. I-BEAM AXLE FRONT SUSPENSION

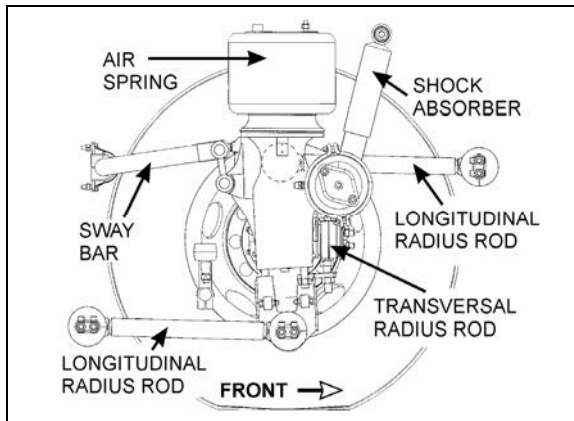


FIGURE 1: FRONT SUSPENSION COMPONENTS 16096

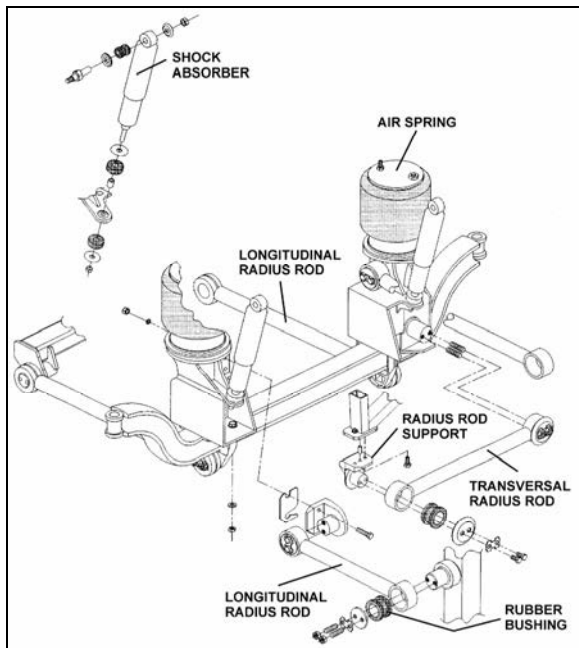


FIGURE 2: DETAILS OF FRONT SUSPENSION 16110

2.1 AIR SPRINGS

The air springs are made from a special compound rubber molded to the proper contour and dimensions. The entire vertical load of the vehicle is supported by these springs. The I-beam front axle is provided with air springs that are attached to the subframe and to the axle (Fig. 3).

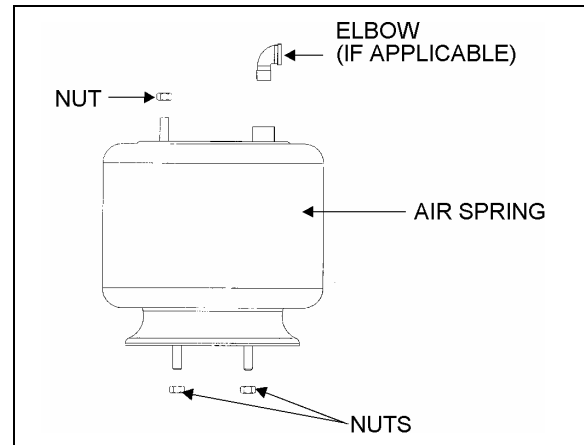


FIGURE 3: AIR SPRING 16052

2.1.1 Inspection

1. Check operation of bellows.
2. Visually inspect bellows for evidence of cracks, punctures, deterioration, or chafing. Replace the bellows if any damage is evident.
3. With the primary air system at normal operating pressure (95 - 125 psi (655 - 860 kPa)), coat all suspension air line connections and bellows mounting areas with a water and soap solution. Bubbles will indicate an air leak, and none is

Section 16: SUSPENSION

permissible. Repair or replace defective parts.

NOTE

If air spring is removed from vehicle, bellows can be lightly inflated and submerged in water to detect any leakage. If any leakage is detected, replace bellows.



WARNING

To prevent personal injury, do not apply more than 10 psi (69 kPa) of air pressure to the uninstalled air spring.

2.1.2 Removal

NOTE

Front suspension air springs can be removed without removing the entire axle assembly.

1. Safely support vehicle at the recommended body jacking points. To gain access to a given air spring, the corresponding wheel can be removed as follows.
 - a) Jack vehicle until the tire clears the ground, and place safety supports underneath body.



CAUTION

Only the recommended jacking points must be used as outlined in Section 18, "Body".

- b) Support the axle with a suitable hydraulic floor jack at the recommended jacking point.
 - c) Remove wheel.
2. Exhaust compressed air from accessory air tank by opening drain cock under reservoir.
 3. Disconnect the height control valve link and pull down the overtravel lever to ensure all air is exhausted from air springs.

NOTE

While performing this step, do not change the height control valve overtravel lever adjustment.

4. Disconnect air line from air spring, remove elbow (if applicable), and cover both the line end and fitting to prevent the entry of foreign matter.

5. Remove the air spring upper nut, and then the two lower nuts. Remove air spring.

2.1.3 Installation

1. Compress air spring as necessary, then aligning studs with their holes, position air spring between both the lower and upper supports. Thread the lower nuts and the small upper nut a few turns.

NOTE

To facilitate air spring installation, compress it manually then put a piece of tape over the air line threaded fitting. This prevents air from getting back into the bag and keeps it compressed, thus enabling to place the bag in between the mounting plates and greatly easing installation.

2. Tighten and torque the lower stud nuts, and then the upper one to 20 – 25 lbf-ft (27 – 34 Nm).
3. Thread the remaining upper nut (large nut) and tighten to 20 – 25 lbf-ft (27 – 34 Nm).
4. Install elbow (if applicable), then connect air line.
5. Connect the height control valve link.
6. Build up air pressure in system.

NOTE

To accelerate this operation, air reservoirs can be filled from an exterior air supply connected to the accessory tank fill valve or to the emergency fill valve.

7. Check operation of bellows, and with the primary air system at normal operating pressure (95 – 125 psi (655 – 860 kPa)), coat the air line connections and air spring mounting areas with a water and soap solution. Bubbles will indicate an air leak, and none is permissible. Repair or replace defective parts.
8. Reinstall wheel.
9. Remove the hydraulic floor jack from under the axle, then lower vehicle to ground.

2.2 SHOCK ABSORBERS

Double-action, telescoping-type shock absorbers ensure a smooth ride and enhance vehicle stability on the road. All shock absorbers

are eye-type mountings. The front axle is provided with two shock absorbers (Fig. 1, 2, and 4).

Shock absorbers are non-adjustable and non-repairable. Maintenance requirements involve replacement of the rubber mounting bushings, and tightening of all shock absorber pins at the proper torque of 500 - 550 lbf-ft (680 - 750 Nm) when shock absorber replacement occurs. If a shock absorber becomes inoperative, complete unit must be replaced.



CAUTION

When a shock absorber is found defective, always replace with a new set on affected axle, except if there has been a recent replacement of one unit. The following method will help in determining if both shock absorbers on the same axle have to be replaced.

2.2.1 Inspection

Loosen lower mounting of both shocks, and then carefully attempt to raise and lower the bottom portion of each shock. Note the rate of effort for distance of travel. Replace both shocks if a definite differential rate is found.

The shock must be bench checked in an upright, vertical position. If checked in any other position, air will enter the cylinder tube and make the shock absorber appear defective.

Proceed as follows to check shock absorbers:

1. With the shock absorber in a vertical position (top end up), clamp the bottom mount in a vise.



CAUTION

Do not clamp the reservoir tube or the dust tube.

2. Rotate the dust tube. Notice any binding condition (may be compared with new unit). Binding condition indicates a scored rod. Units with scored rods should be replaced.
3. Fully extend shocks and check for leaks in the seal cover area. Shock fluid is a very thin hydraulic fluid that has a characteristic odor and dark brown tint. A slight trace of shock fluid around the seal cover area is not a cause for replacement. The shock seal is

designed to permit a very slight seepage to lubricate the rod. Units that leak should be replaced.

4. Visually check shock for dents that could cause the shock to bind. Also, check for a bent rod.
5. Extend and collapse shock several times to determine that it has control (resistance) in both rebound and compression.
6. Visually inspect the shock mountings and vehicle mounting for:
 - a. Broken mounts;
 - b. Extreme bushing wear;
 - c. Shifted bushing or sleeve;
 - d. Deep cracks in bushing material (shallow surface cracks are normal);
 - e. Loose shock absorber pins;
 - f. Presence of convex washers, and their position relative to the rubber bushing.

2.2.2 Removal

1. Remove nuts and washers from shock absorbers on upper and lower mounting pins, taking care to identify the inner and outer washers to ease reinstallation. Refer to figure 4 for details.
2. Remove the shock absorber assembly from pins.
3. Remove the two inner bushings from the shock absorber and discard them.

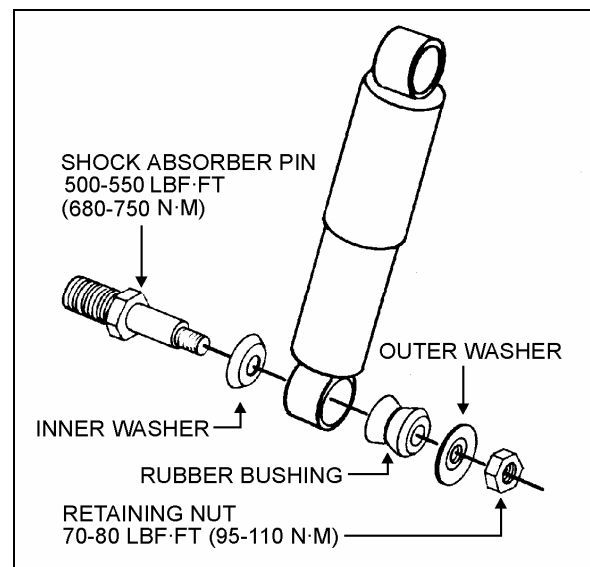


FIGURE 4: SHOCK ABSORBER

16008

Section 16: SUSPENSION

2.2.3 Installation

1. Ensure that the shock absorber mounting pins are tight and that the threads are not stripped.
2. Install new rubber mounting bushings on shock absorbers (upper and lower).
3. Place the inner washers (with washer convex side facing the shock absorber rubber bushing) on each shock absorber pin (Fig. 5).
4. Install the shock absorber eyes over the mounting pins, then the outer washers (with washer convex side facing the shock absorber rubber bushing) on each shock absorber extremity.

NOTE

If shock absorber pins are removed, they must be reinstalled using "loctite" (see "Parts Specifications" in this section).

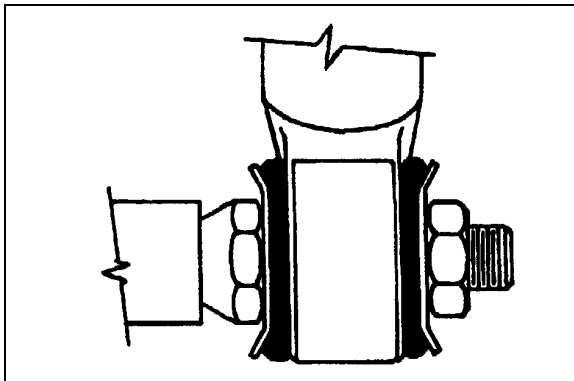


FIGURE 5: TYPICAL SHOCK ABSORBER SETUP 16009

5. Place the lower and upper mounting pin stud nuts and torque to 70 - 80 lbf-ft (95 - 110 Nm).

2.3 RADIUS RODS

Radius rods are used to secure the axles in the proper transversal and longitudinal positions. Four radius rods are provided on the front axle suspension (three longitudinal and one transversal). Refer to figures 1, 2 and 6 for details. These rods transmit both braking and driving forces from the axles to the vehicle body.

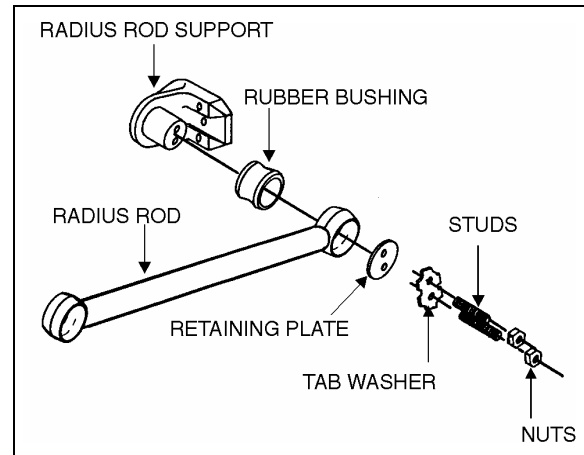


FIGURE 6: TYPICAL RADIUS ROD SETUP

16010

2.3.1 Inspection

The following instructions apply to all radius rods used on this vehicle:

1. Clean all parts thoroughly.
2. Inspect radius rods for distortion and cracks. We recommend the "Magnaflux" process to detect cracks in the radius rod. Any damaged part should be replaced with a new one.

NOTE

New bushings should be used when rods are replaced.

3. The radius rod bushings should be checked periodically for signs of shearing, deterioration, or damage. Any defective part should be replaced with a new one.

2.3.2 Removal

1. Flatten the tab washer which secures the two retaining nuts (or bolts), then unscrew the nuts (or bolts) at each extremity of the radius rod (Fig. 6).
2. Remove the tab washer and the retaining plates and radius rod ends from anchor pins, and then remove the radius rod.

2.3.3 Bushing removal

1. Safely support the radius rod as shown in figure 7.

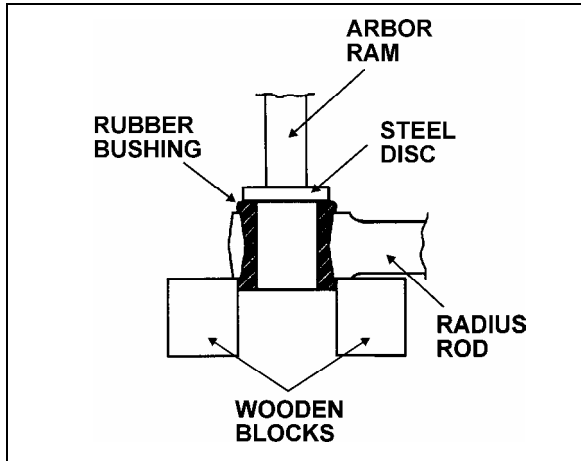


FIGURE 7: RADIUS ROD BUSHING REMOVAL 16011

2. Place a flat steel disc, slightly smaller than the outside diameter of the bushing (Fig. 7).
3. Using an arbor press or a suitable driving tool, press or drive the old bushing out of the rod and discard the bushing.

CAUTION

Make sure to prevent the steel disc from contacting the radius rod end.

2.3.4 Bushing installation

1. Lightly spray the inner and outer surfaces of radius rod bushing with water.

CAUTION

No lubricant whatsoever is to be used on the rubber bushing.

2. Safely support the radius rod, and place new bushing on top of the radius rod end (Fig. 8).
3. Place a block of wood on top of bushing and press on it manually.
4. If necessary, use an arbor press or a suitable driving tool. Press or drive the bushing into the radius rod end until it extends equally on both sides of the rod.
5. It is also possible to proceed differently. Place radius rod bushing on a plane surface. Spray a light coat of water on the inner and outer surfaces of radius rod bushing.
6. Take radius rod, align the bushing. Tap radius rod on bushing until latter is positioned correctly.

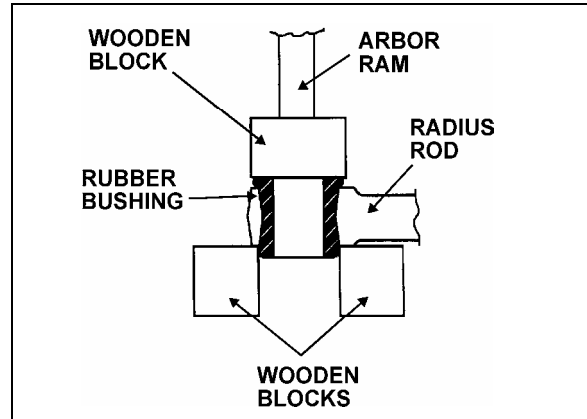


FIGURE 8: RADIUS ROD BUSHING INSTALLATION 16012

2.3.5 Installation

1. Lightly spray the radius rod support with water. Place the radius rod end over the radius rod support (Fig. 9).
2. Position the retaining plate. Install the tab washer and nuts (or bolts).

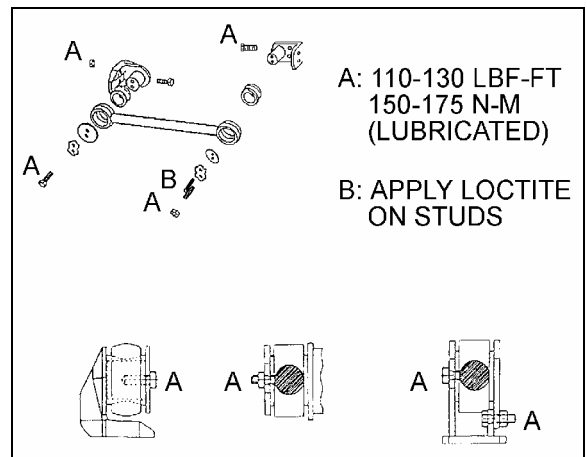


FIGURE 9: RADIUS ROD INSTALLATION 16028

CAUTION

Always use new tab washers at installation.

3. Tighten the nuts (or bolts) lightly, and repeat at the other end.
4. Refer to heading "Suspension Height Adjustment" later in this section, and set the vehicle to normal ride height.
5. With the vehicle at normal ride height, apply oil on threads and tighten all radius rod anchor pin nuts or bolts to 110 – 130 lbf-ft (150 – 175 Nm).

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CAUTION

It is extremely important upon reconnection of the rods that the proper clearance height between the axle and body be maintained. Otherwise, the rubber bushings in radius rod ends will become preloaded, thus reducing their life span.

2.4 SWAY BAR

A sway bar is provided on the front axle to increase vehicle stability. It controls lateral motion (swaying movement) of the vehicle (Fig. 10).

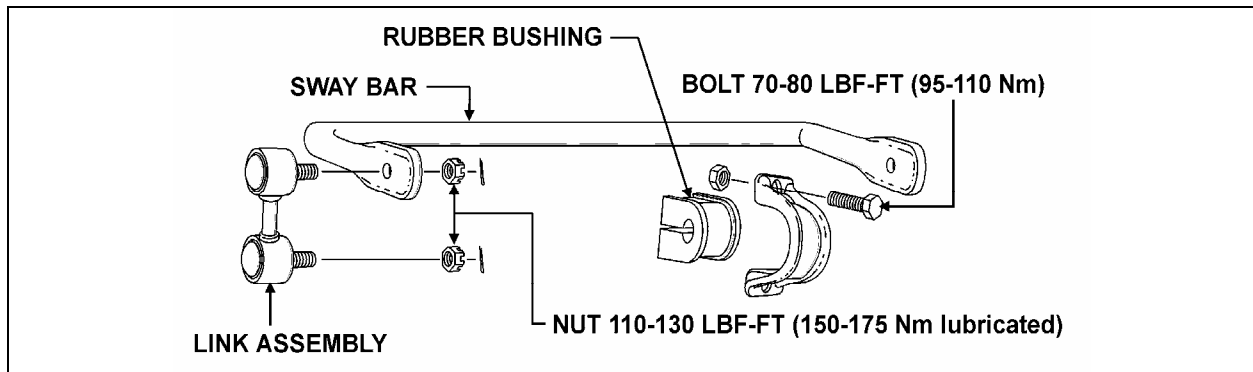


FIGURE 10: I-BEAM FRONT AXLE SWAY BAR

16099

2.4.1 Removal

1. Disconnect the two links from sway bar.
2. Safely support the sway bar. Unbolt the four bushing collars from subframe.
3. Remove sway bar.

NOTE

Sway bar bushings are slitted to ease their removal.

2.4.2 Installation

1. Loosely install the sway bar.
2. Tighten the eight bushing collar nuts to 70 - 80 lbf-ft (95 - 110 Nm) (Fig. 10).
3. Install two sway bar link upper and lower nuts and tighten to 100 - 130 lbf-ft (150 - 175 Nm) (Fig. 10).
4. Install a cotter pin on each nut and bend.

3. INDEPENDENT FRONT SUSPENSION (IFS)

3.1 STEERING LINKAGE

Turning motion of the steering wheel is transferred by the steering gear and steering linkage to the steering arms at the right and left front wheels. The steering linkage consists of tie rods connected to the bell crank and the steering arm at the left side of the coach, and to the idler arm and steering arm at the right side of the coach. The bell crank and idler arm are connected by a relay rod. A drag link connected to the bell crank and the pitman arm, which is mounted to the steering gear, transfers the turning motion of the steering wheel to the steering arms (Fig. 11).

Lower and upper A-arms are widely spaced. They are mounted on ball joints. Torque rods prevent rotation of the uprights around the lower and upper ball joints.

If the steering linkage is bent, twisted or worn, steering action of the coach will be seriously affected. Any time steering linkage components are replaced or adjusted, steering geometry and front wheel alignment must be checked as explained in this section.

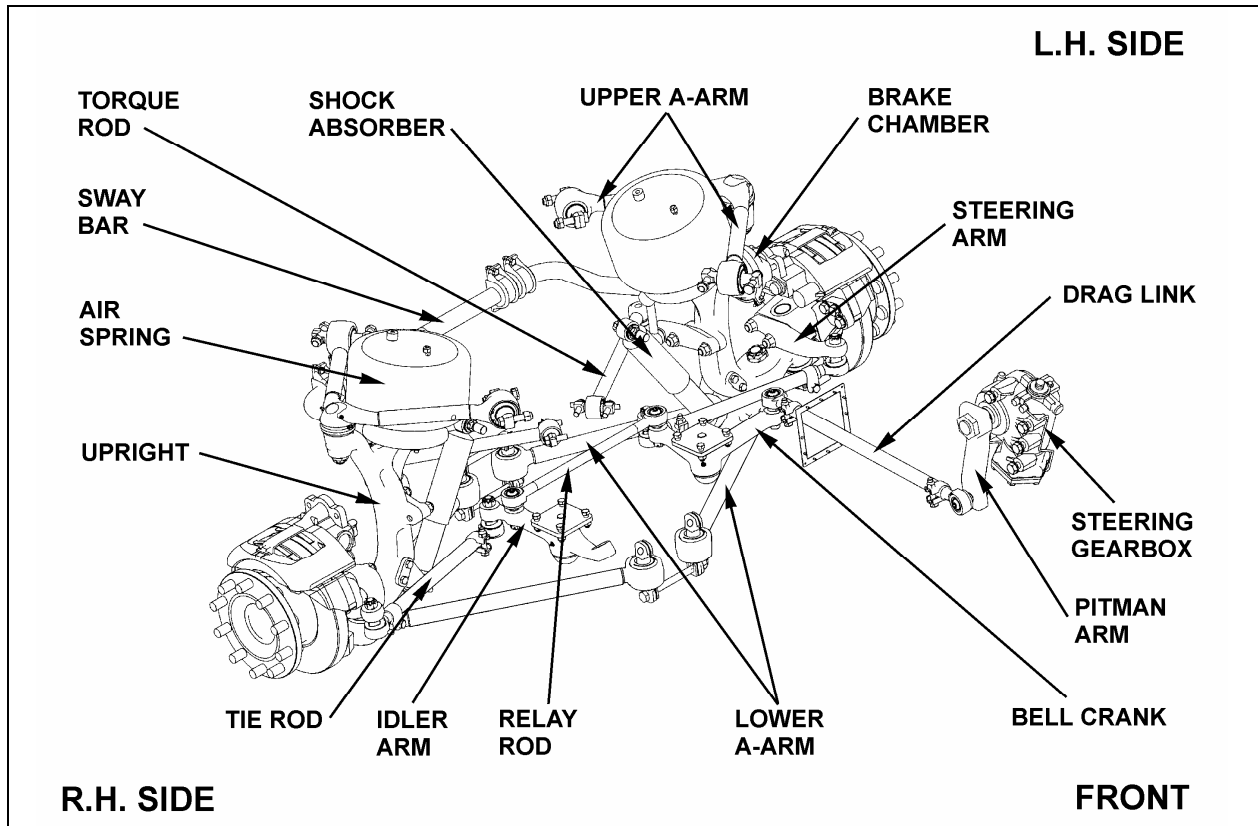


FIGURE 11: SUSPENSION AND STEERING LINKAGE

16125

Turning Angle

The maximum turning angle is set mechanically through the two steering stop screws installed on the swivel assembly. The turning angle ($58^{\circ} + 0^{\circ} - 1^{\circ}$) mechanical stop is factory adjusted to accommodate the chassis design, and therefore, does not require adjustment on new vehicles.

However, turning angle should be checked and adjusted hydraulically, if necessary, any time a component of the steering system is repaired, disassembled or adjusted.

Before checking the turning angle, be sure the front end is properly aligned as described under paragraph "3.16 Front End Alignment" in this supplement.

To check steering maximum turning angle, proceed with the following method:

1. Check if front tires rub against the frame or if the steering gear has been serviced.



CAUTION

If clamps are not correctly installed, they can interfere with other parts.

2. For a full left and right turn, check clamps' position and for interfering parts. Refer to figures 12 to 16 for location and positioning of clamps. If readjustment is required, make the proper adjustment.

NOTE

Prior to steering limiter adjustment, verify vehicle wheel alignment, and ensure that oil level is adequate and that air bleeding is done.

3. If necessary readjust steering limiter. Refer to "ZF-SERVOCOM Repair Manual" annexed to Section 14 of Maintenance Manual, "Steering", under heading: "Setting and Functional Test".

Section 16 : SUSPENSION

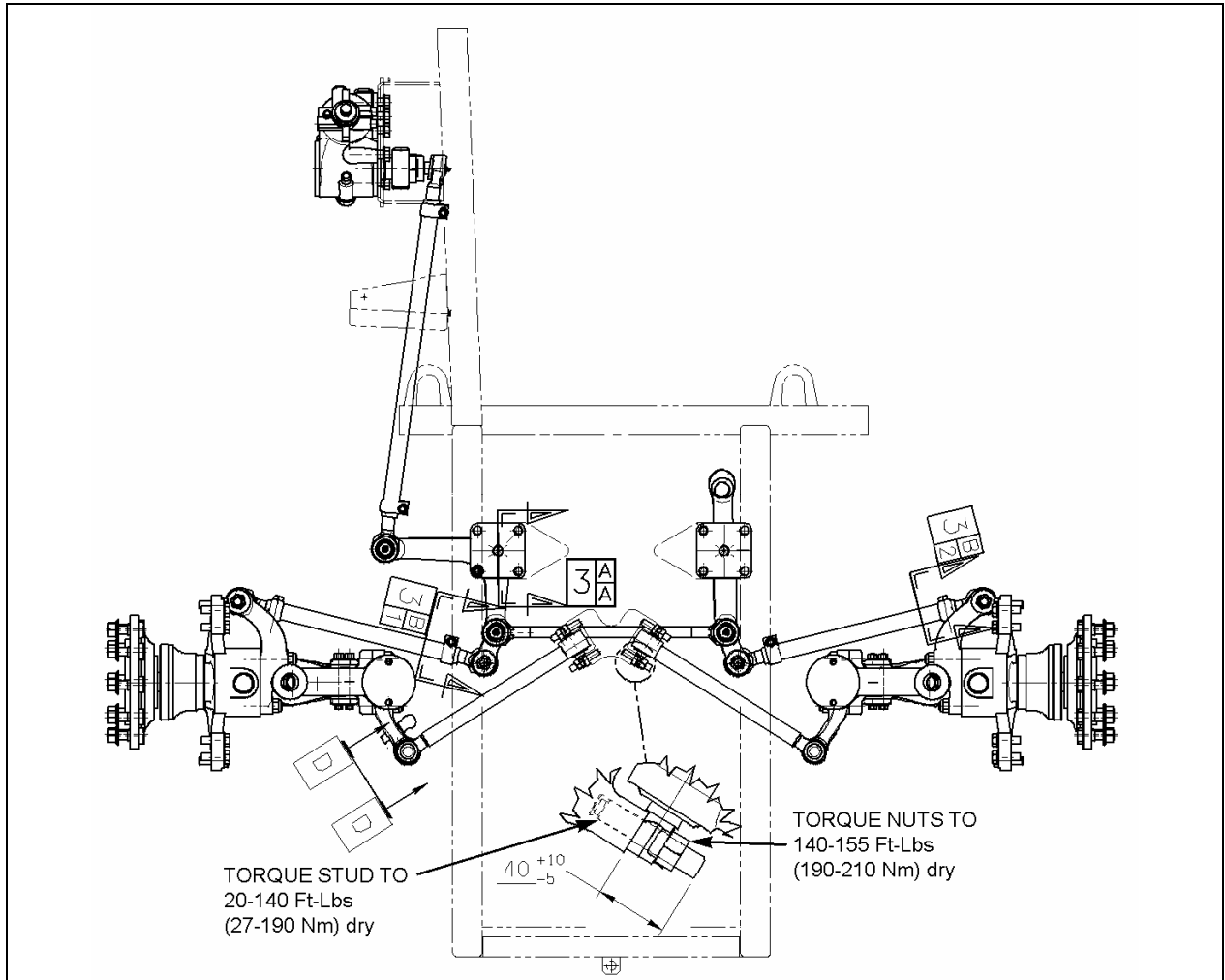


FIGURE 12: LOCATION OF CLAMPS

16168

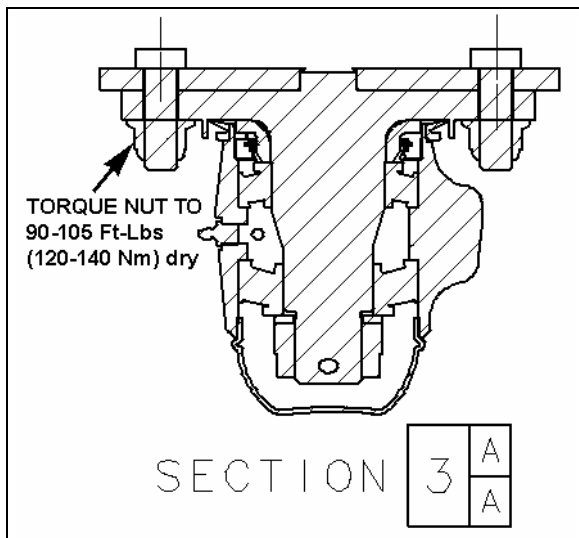


FIGURE 13: CLAMP POSITIONING

16169

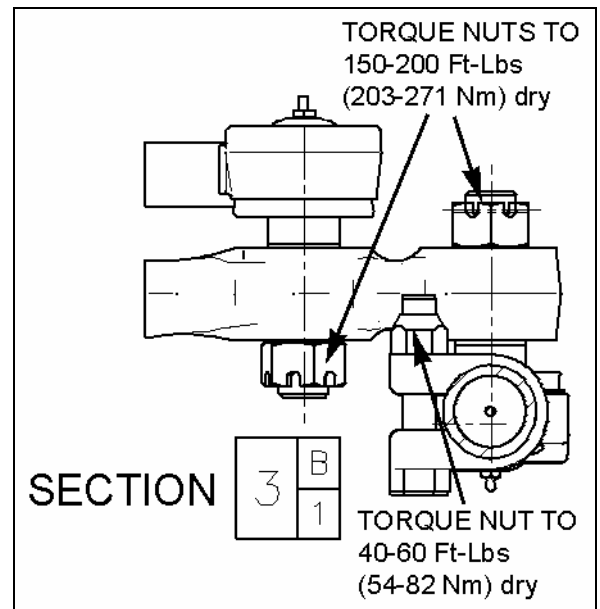


FIGURE 14: CLAMP POSITIONING

16170

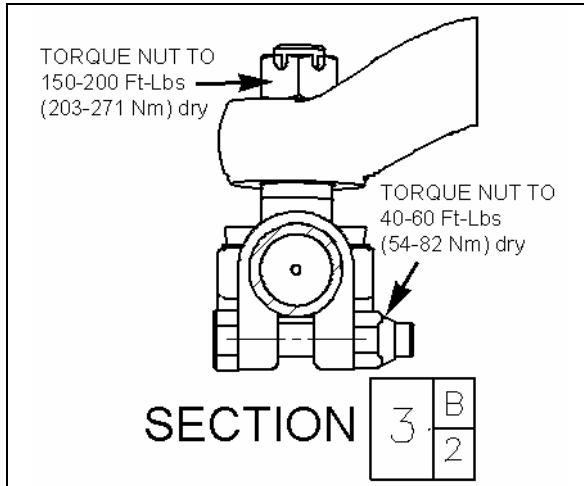


FIGURE 15: CLAMP POSITIONING 16171

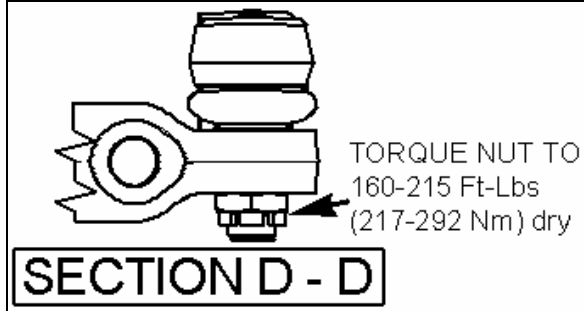


FIGURE 16: CLAMP POSITIONING 16172

3.2 POWER STEERING HYDRAULIC PUMP

Refer to the "TRW Power Steering Pump Service Manual" annexed at the end of Section 14.

3.3 STEERING LINKAGE ADJUSTMENT

NOTE

Whenever a steering linkage component has been removed and replaced, check steering geometry and front end alignment as directed in this Section. Check to insure that all stud nuts and mounting bolts and nuts have been tightened to proper torques listed under "14. Torque Specifications" at the end of this section.

1. First, align input shaft marks.
2. Afterwards, the pitman arm should be adjusted with reference mark aligned or to an angle of 90° in relation with the horizontal axis (Fig. 17).
3. Locate centerline of vehicle then install relay rod in boss at steering bell crank and idler arm. Align center of relay rod with centerline of vehicle.

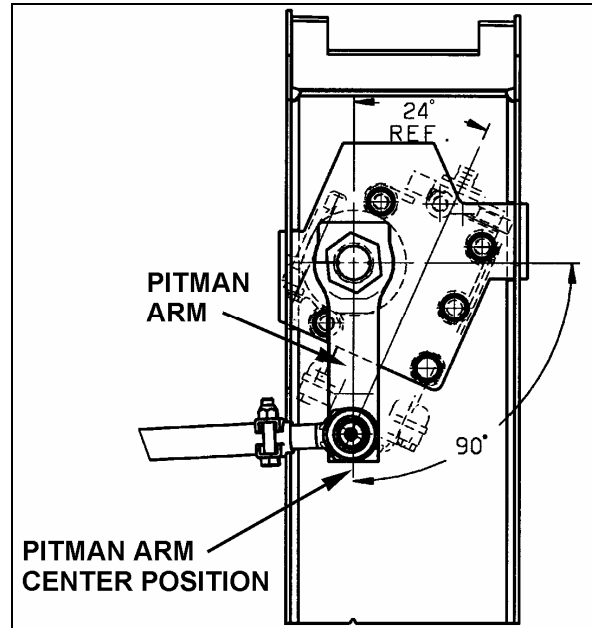


FIGURE 17: PITMAN ARM ALIGNMENT 14057

4. Install drag link to pitman arm and adjust opposite end of drag link to fit mounting stud hole in bell crank.
5. Install tie rods, and then adjust toe-in as per "Front End Alignment" in this Section.

3.4 PITMAN ARM REMOVAL

1. Remove cotter pin, nut and washer from drag link ball stud at pitman arm.
2. Disconnect drag link from pitman arm, using jaw style pullers (pressure screw type).

	WARNING
Always wear approved eye protection when operating pullers.	

	CAUTION
Do not drive pitman arm on or off pitman shaft as this can damage the steering gear.	

	CAUTION
Heating of components to aid in disassembly is not allowed because it has a detrimental effect on axle components and steering linkages.	

3. Remove pitman arm fixing nut.

Section 16 : SUSPENSION

4. Check the radial position of the pitman arm in relation to the sector shaft prior to removal of pitman arm.
5. Add reference marks to the arm and shaft if necessary to ensure correct alignment at reassembly.
6. Use a puller to remove pitman arm.

3.5 PITMAN ARM INSTALLATION

1. Position pitman arm on sector gear shaft with reference marks aligned.
2. Install fixing nut. Tighten nut to 400-450 lbf-ft (545-610 Nm).

NOTE

Use a new nut if the previously removed nut was punched.

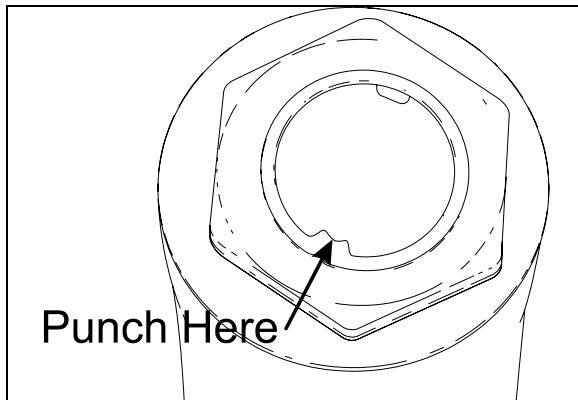


FIGURE 18: FIXING NUT PUNCH MARK 16098



CAUTION

Lock nut with sector shaft using a punch mark into the groove (Refer to figure 18).

3. Connect drag link to pitman arm. Install washers. Tighten nut to 160-215 lbf-ft (220-290 Nm). Advance nut to next alignment cotter pin slot and install a new cotter pin.

3.6 DRAG LINK

Drag link assembly consists of three parts; a drag link and two end assemblies. Both end assemblies are identical and they are retained on the drag link with a clamp bolt and nut.

Stud nuts at the pitman arm and bell crank ends of the drag link must be kept tight or hole at ball stud end of drag link and hole in pitman arm may become enlarged as a result of excessive looseness. Subsequent tightening of stud nuts

may draw studs too far into holes and dust cover parts may become damaged which can result in component failure.

Drag link end sockets are equipped with lubrication fittings and should be lubricated as directed in "Lubrication Fittings" in this section.

3.6.1 Adjustment

It should not be necessary to alter the length of the drag link except when a new link is installed or when removable end assembly has been replaced. If drag link adjustment is necessary, proceed as follows:

1. Position front wheels in straight ahead position.
2. Center steering gear as previously explained in paragraph "3.3 Steering Linkage Adjustment".
3. Remove cotter pin and stud from drag link at bell crank. Locate centerline of vehicle and center of relay rod. With center of relay rod aligned with centerline of vehicle, loosen clamp bolt at socket end (bell crank end) of drag link and adjust length of socket end assembly to fit in boss of bell crank.

NOTE

Do not change position of pitman arm.

4. Install stud nut and torque to 160 lbf-ft (220 Nm). Align nut with cotter pin slot (tighten) and install a new cotter pin.
5. Torque mounting clamp bolt nut to 40-60 lbf-ft (55-80 Nm), then test the adjustment. Front wheels should turn from right to left extremities without noticeable binding at drag link ends.

3.7 BELL CRANK AND IDLER ARM

Bell crank and idler arm are equipped with one lubrication fitting and should be lubricated as directed in paragraph "3.11 Lubrication Fittings" of this Section.

3.7.1 Bell Crank and Idler Arm Removal

NOTE

Use a piece of wire to anchor loosen end of relay rod and tie rod in order to prevent placing an excessive load on opposite socket end.

Bell crank: Disconnect drag link, tie rod and relay rod from bell crank by removing cotter pins, stud nuts and washers from ball studs. Separate socket assemblies from the bell crank.

Idler arm: Remove cotter pins, nuts and washers from ball studs connecting relay rod and tie rod to idler arm. Separate socket assemblies from idler arm.

Remove nuts and washers from bolt attaching bell crank or idler arm mounting bracket to vehicle understructure. Remove bell crank or idler arm mounting bracket.

3.7.2 Bell crank or Idler Arm Ball Joint Disassembly

1. Remove adjacent link assemblies from bell crank or idler arm as previously described.
2. Remove the cap (Fig.21).
3. Remove the cotter pin, nut and tongue washer. Remove bearings, grease seal, bearing bushing and the bell crank or idler arm from its mounting bracket stud (Fig. 21).

3.7.3 Bell Crank or Idler Arm Ball Joint Reassembly

NOTE
For bearing installation use tool Prévost # 110684.

1. Install bearing bushing on bell crank or idler arm mounting bracket stud.
2. Install bearing and grease seal in bell crank or idler arm eye (Fig. 21).

NOTE
Install grease seal according to figure 21. Grease must be able to exit the bell crank or idler arm mechanism. For grease seal installation use tool Prévost # 110683.

3. Install bell crank or idler arm on its mounting bracket stud (Fig. 21).
4. Install bearing and nut.

NOTE
Apply grease on bearing before installation.

5. Firmly tighten nut (Fig. 19).
6. Unscrew nut until bell crank or idler arm starts to turn by the application of 1 to 3 pounds load (Fig. 20).

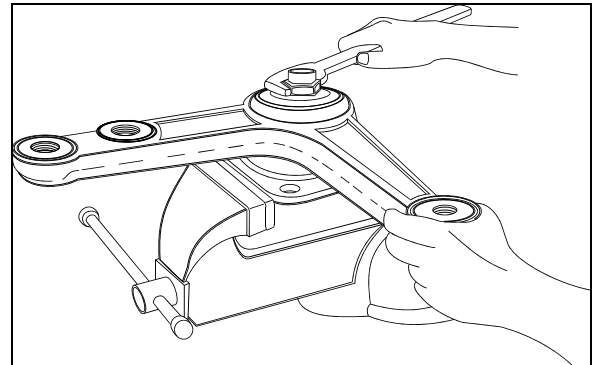


FIGURE 19: BELL CRANK 16044

7. Check for loose bearings by applying an up and down load on bell crank or idler lever (Fig. 20). The lever is not supposed to move in the vertical axis direction.

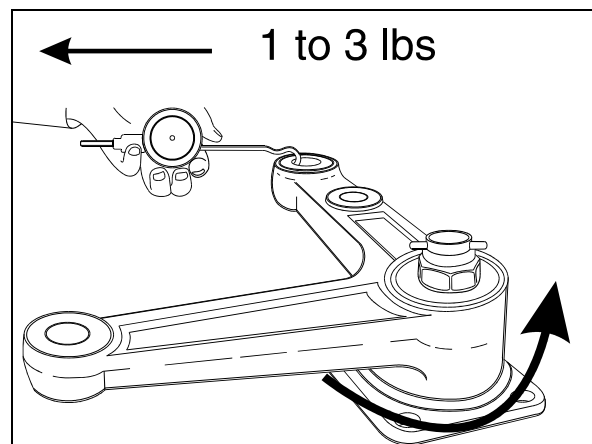


FIGURE 20: BELL CRANK 16045

8. Align nut with cotter pin slot (tighten) and install a new cotter pin.

NOTE
Bend cotter pin around the nut (Fig. 21). Do not bend the cotter pin in the direction of the cap, because it may interfere with the cap.

9. Install the cap.
10. **Bell crank:** Install drag link, tie rod and relay rod as directed herein under each specific subject.
11. **Idler arm:** Install tie rod and relay rod as directed herein under each specific subject.
12. Adjust turning angle as previously directed under paragraph "Turning Angle" and check front end alignment as specified in paragraph "3.16. Front End Alignment" of this section.

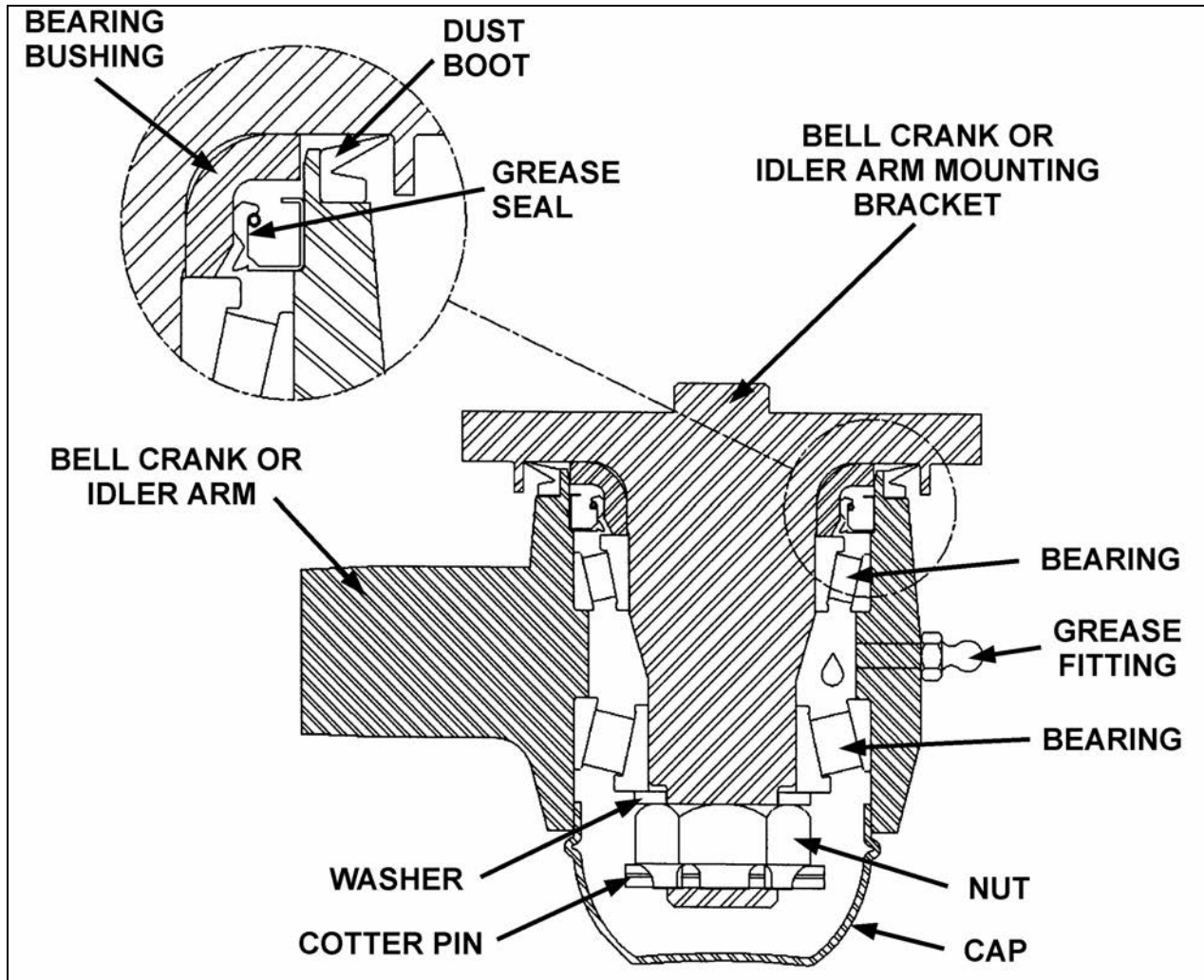


FIGURE 21: BELL CRANK AND IDLER ARM BALL JOINT

16109

3.8 RELAY ROD

Relay rod ends are equipped with lubrication fittings and should be lubricated as directed in paragraph "3.11 Lubrication Fittings" in this section.

NOTE

The relay rod is crimped in place and it is not possible to remove the ball joints.

3.8.1 Replacement

1. Remove cotter pins from bell crank and idler arm end of relay rod. Loosen nuts flush with end of studs.
2. Use a puller or place a sledge hammer behind the adjacent part to absorb shocks. Strike the studs with a brass hammer to loosen end assemblies.
3. Remove stud nuts and washers then remove studs.
4. Position relay rod studs into bell crank and idler arm then tap stud ends with a brass hammer to seat tapered surfaces.
5. Install washers and stud nuts. Tighten nuts to 160 lbf-ft (220 Nm) torque. Align cotter pin slot (tighten) and install a new cotter pin.

3.9 TIE RODS

Tie rod ends are connected to the bell crank and left steering arm, and to the idler arm and right steering arm. Each tie rod assembly consists of three parts; a tube and two socket end assemblies. The tie rod ends are threaded into the tube and secured with clamp bolts. Right and left hand threads are provided to ease toe-in adjustment. Tie rod assemblies are interchangeable from the right to the left side of the coach.

Tie rod end sockets require no maintenance other than periodic lubrication and inspection to see that ball studs are tight. Replace socket ends when there is excessive up and down motion, lost motion or end play at ball end of stud.

1. Periodically check bolt nut for tightness.
2. Inspect tie rod for bent condition and inspect tube for damaged threads. If tie rod is bent or threads are damaged, replace the assembly.
3. Lubricate tie rod end fittings as directed in paragraph "3.11 Lubrication Fittings" of this section.

3.9.1 Removal

1. Remove cotter pins and stud nuts which attach tie rod socket ends to bell crank and left steering arm (or idler arm) and right steering arm.
2. Remove tie rod ball stud by tapping on steering arm and bell crank or idler arm with hammer, while using a sledge hammer to absorb shocks.

NOTE

If tie rod end assemblies are damaged in any way, they must be replaced

3.9.2 Installation

1. Install socket end assemblies on tie rod. Be sure both ends are threaded an equal distance into the tube.
2. Make sure threads on stud and in stud nut are clean and not damaged.
3. Position ball studs (socket ends of tie rod) in holes in steering arm and bell crank or idler arm. Install a ball stud nut on each stud and tighten firmly.
4. Torque stud nuts to 160 lbf-ft (220 Nm). Align cotter pin slot (tighten) and install a new cotter pin.

NOTE

Adjust toe-in as directed in paragraph "3.16.4 Toe-In Adjustment" of this section.

5. Make sure tie rod ends are properly aligned with ball studs, then torque tie rod end clamp bolts to 40-60 lbf-ft (55-80 Nm).

NOTE

If tie rod is not properly aligned with stud, binding will result.

3.10 STEERING ARMS

The left and right wheel steering arms are secured to a swivel at one end and to a tie rod at the other end.

3.10.1 Removal

1. Remove wheel as directed in Section 13, "Wheel, Hubs and Tires" of the maintenance manual.
2. Remove cotter pin, washer and nut from stud securing tie rod to steering arm. Remove ball stud from steering arm by tapping on arm with a hammer, placing a sledge hammer underneath steering arm to absorb shocks.
3. Remove cotter pin and nut securing steering arm to swivel assembly. Remove steering arm from swivel.

3.10.2 Installation

1. Insert steering arm in swivel.
2. Torque steering arm to swivel nut to 190 lbf-ft (260 Nm). Align cotter pin slot (tighten) and install a new cotter pin.
3. Position tie rod ball stud in steering arm and tap with a brass hammer to seat ball stud in steering arm. Install washer and nut on stud. Torque nut to 160 lbf-ft (220 Nm). Tighten nut to nearest cotter pin slot and install a new cotter pin.
4. Install wheel as directed in Section 13, "Wheel, Hubs and Tires" under paragraph "2.3 Installation" of the maintenance manual.

3.11 LUBRICATION FITTINGS

All lubrication fittings must be clean before applying lubricant. Also, always be sure equipment used in applying lubricant is clean. Every precaution should be taken to prevent entry of dirt, grit, lint or other foreign matter into lubricant containers. Replace fitting when they become broken or damaged.

Intervals of application given in the following paragraphs are recommended for normal service. More frequent intervals may be applied under severe operating conditions. In selecting proper lubricants, supplier reputation must be considered. The supplier must be responsible for product quality. The diagram (Fig. 22) shows approximate location of steering lubrication fittings.

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1. **Drag Link Ends:** Lubricate at two fittings, one at each end of link, every 6,250 miles (10 000 km) with good quality lithium-base grease NLGI No. 2 (Shell Retinax LX or equivalent).
2. **Relay Rod Ends:** Lubricate at two fittings, one at each end of rod, every 6,250 miles (10 000 km) with good quality lithium-base grease NLGI No. 2 (Shell Retinax LX or equivalent).
3. **Tie Rod Ends:** Lubricate at four fittings, one at each end of both tie rods, every 6,250 miles (10 000 km) with good quality lithium-base grease NLGI No. 2 (Shell Retinax LX or equivalent).
4. **Swivel Assembly:** Refer to DANA SPICER MAINTENANCE MANUAL NDS AXLES Lubrication and Maintenance" annexed at the end of Section 10.
5. **Idler Arm and Crank bell:** Lubricate at two fittings, one on the idler arm and the other on the crank bell, every 6,250 miles (10 000 km) with good quality lithium-base grease NLGI No. 2 (Shell Retinax LX or equivalent). Apply grease gun pressure to the fitting until lubricant appears at the top seal.
6. **Upper A-Arm Central Ball Joint:** Lubricate at fitting until you see some grease on the relief valve nearby, every 6,250 miles (10 000 km) with good quality lithium-base grease NLGI No. 2 (Shell Retinax LX or equivalent).

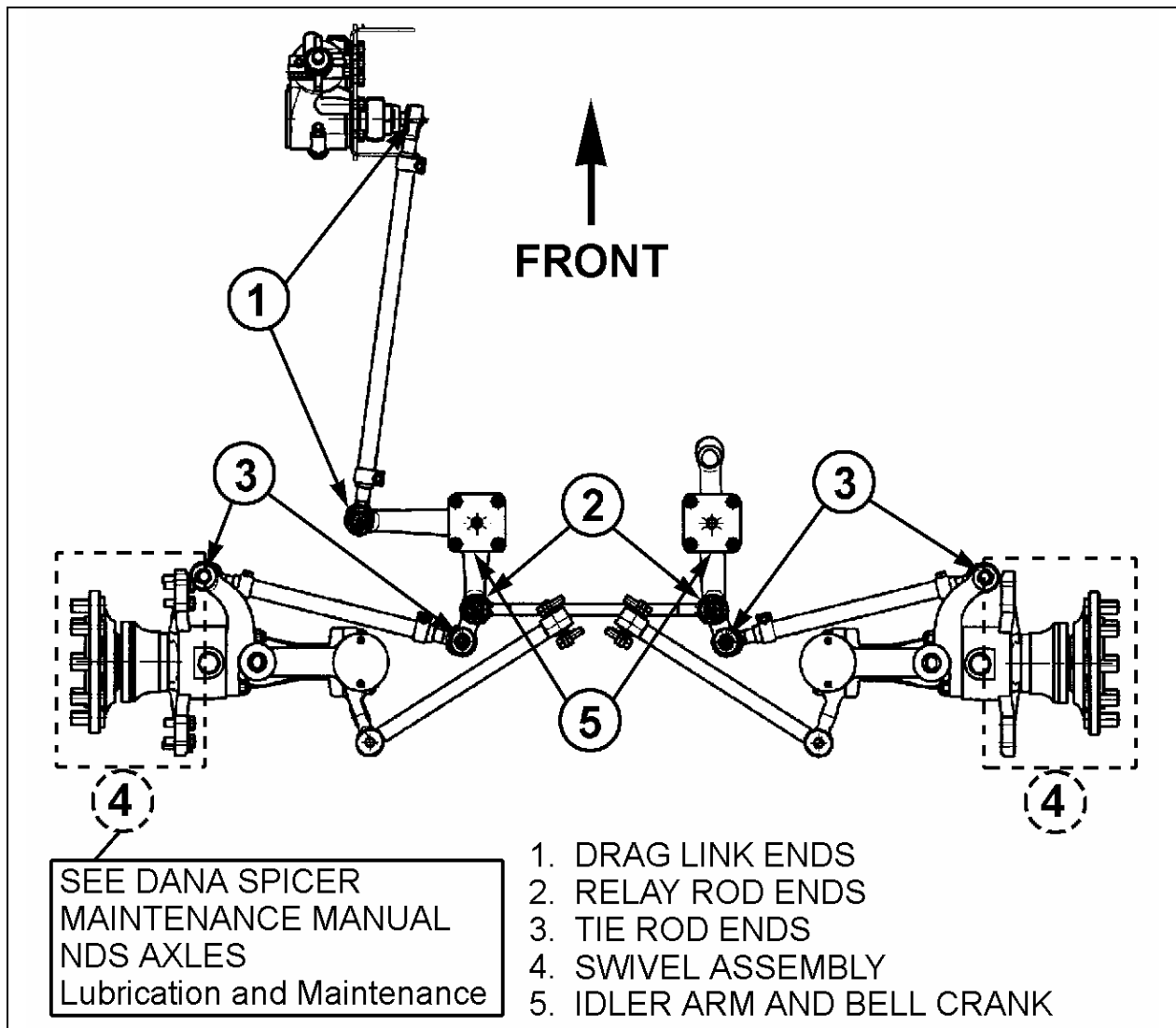


FIGURE 22: LUBRICATION FITTINGS' LOCATION DIAGRAM

16119

3.12 BALL JOINTS

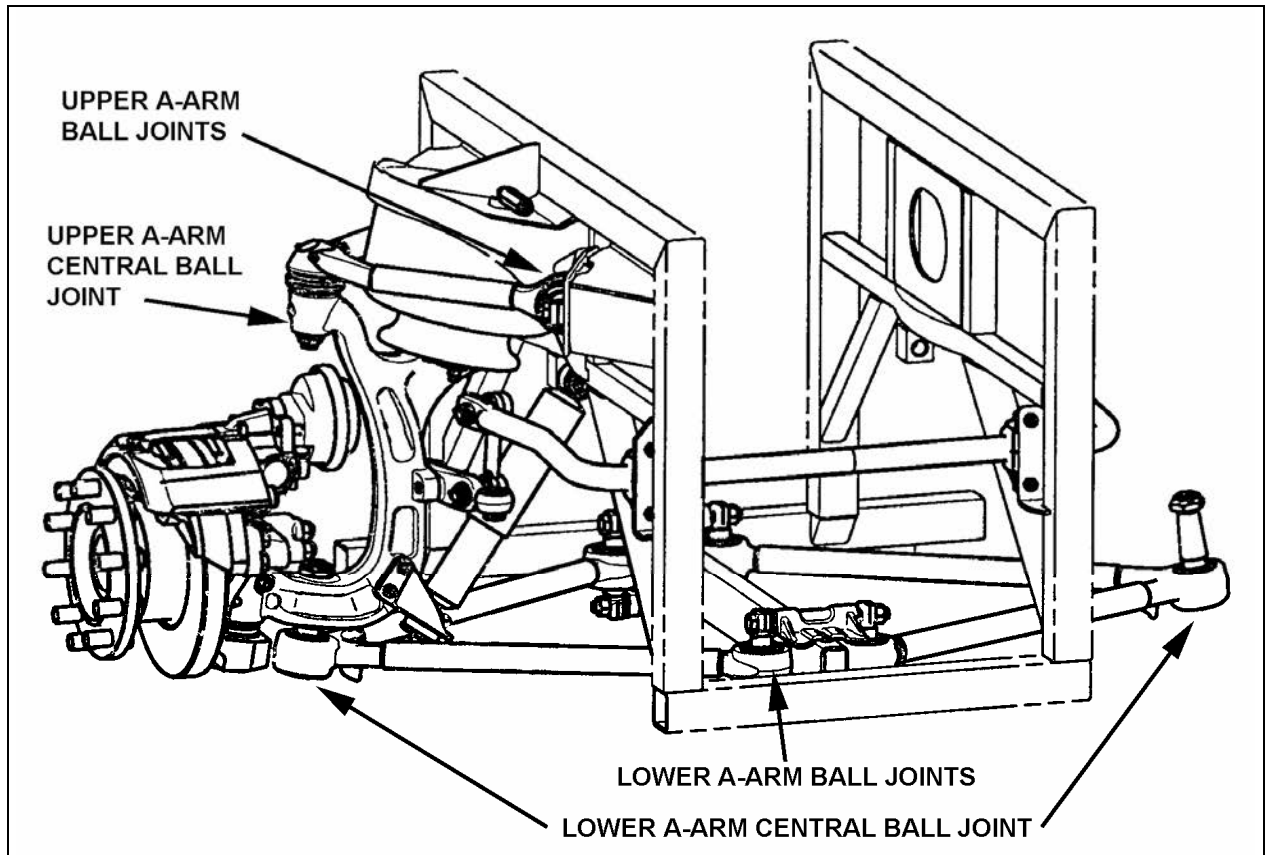


FIGURE 23: BALL JOINTS LOCATION

16137

3.13 LOWER AND UPPER A-ARM BALL JOINT

The assembly work may be done only by a recognized specialized workshop. Ensure that old and new parts do not get mixed up with each other. It is for this reason that all the old parts are to be scrapped immediately after a joint has been stripped down. A complete repair set must be used for each joint repaired, i.e. use of only part of a repair set is not permissible.

3.13.1 Inspection

Take off the load from the ball joint by lifting the front of the vehicle. Apply a load on the joint in all of the degrees of freedom in an axial, radial, etc. sense with a suitable lever tool. After the load is taken off, the joint has to spring back into its starting position. Free play is not acceptable.

Separation of rubber from ball pin or external joint shell is in accordance with "normal wear characteristics".

When the following characteristics are noted, the joint is to be changed:

- Free play;
- Radial cracking of the external sheet-metal race.

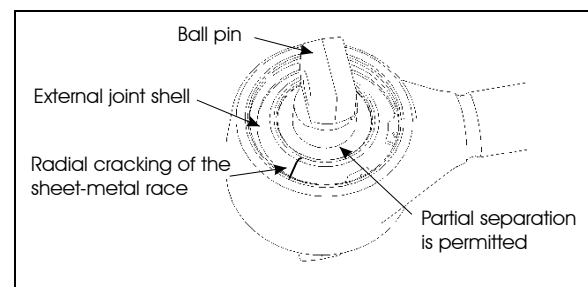


FIGURE 24: A-ARM BALL JOINTS

16173

3.13.2 Stripping Down

Strip down the defective joint through removal of retaining ring, annular spacer and ball pin/bushing, assembly and thereafter clean out housing bore and locking circlips groove.

3.13.3 Assembly

Execute assembly of the new joint parts in the following sequence:

1. Complete moistening of the contact surface between housing bore and ball pin through application of the grease.

NOTE

Apply grease, only in the case of repair kit (Prévost # 611114).

2. Insert ball pin/bushing, assembly. In case of the two-bolt type, ensure that the bolt bores are in the correct position in relation to the axis of the tube.
3. Place joint in receiving fixture and mount annular assembly tool on the housing. Then locate annular spacer and retaining ring in the housing using axial load with the aid of assembly matrix. If the ends of the annular spacer are not in contact with each other, the thus formed opening must be located at 180° to the opening of the retaining ring. Pay attention during assembly to ensure that the retaining ring eyelets are located at each side of the housing shaft axis (retaining ring eyelet lug points to tube), and that retaining ring is properly engaged in the groove of the housing.
4. When repairing defective ball pin assemblies, the necked down-bolt must regularly be replaced with a new one.

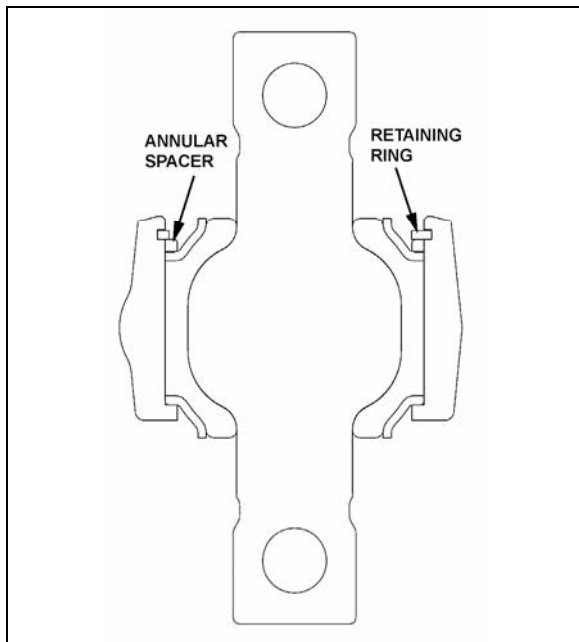


FIGURE 25: LOWER A-ARM BALL JOINTS 16114

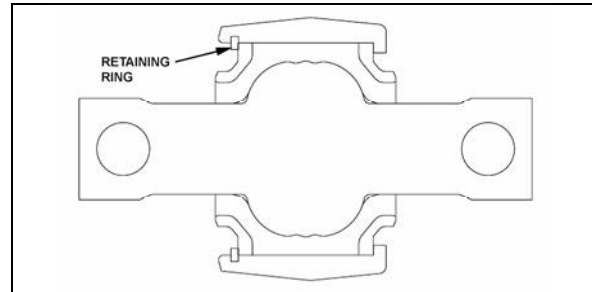


FIGURE 26: UPPER A-ARM BALL JOINTS 16115

3.14 LOWER A- ARM CENTRAL BALL JOINT

3.14.1 Inspection

Take off the load from the ball joint by lifting the front of the vehicle. Apply a load on the joint in all of the degrees of freedom in an axial, radial, etc. sense with a suitable lever tool. After the load is taken off, the joint has to spring back into its starting position. Free play is not acceptable. Separation of rubber from ball pin or external joint bushing shell is in accordance with "normal wear characteristics".

When the following characteristics are noted, the joint is to be changed:

- Free play;
- Radial cracking of the external bushing shell.

3.14.2 Stripping Down

Strip down the defective joint through removal of retaining ring, annular spacer and ball pin/bushing, assembly and thereafter clean out housing bore and locking circlips groove.

3.14.3 Assembly

Assemble the new component parts of the joint in the following sequence:

1. Complete moistening of the contact surface between housing bore and ball pin through application of the grease.
2. Place joint in receiving fixture and mount annular assembly tool on the housing. Then locate annular spacer and retaining ring in the housing using axial load with the aid of assembly matrix. If the ends of the annular spacer are not in contact with each other, the thus formed opening must be located at 180° to the opening of the retaining ring. Pay attention during assembly to ensure that the retaining ring eyelets are located at each side of the housing shaft axis (retaining ring eyelet lug points to tube), and that retaining ring is properly engaged in the groove of the housing.

- Faultlessly apply grease by mechanical means to bracket-outer core and ball-inner cone. Insert bracket outer cone in fixture with distance ring and then use press tool to apply pressure to press mount with ball-inner cone.

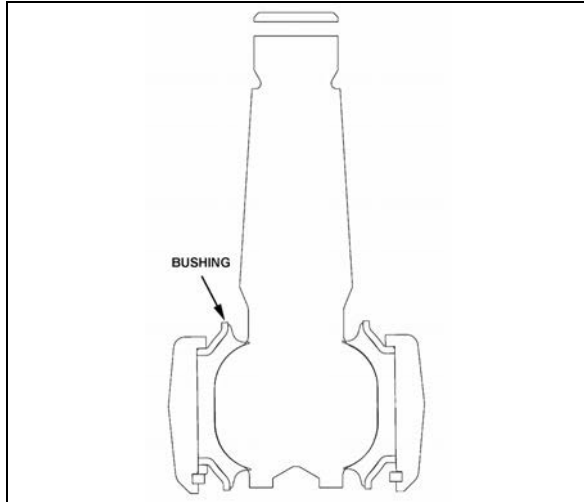


FIGURE 27: LOWER A-ARM CENTRAL BALL JOINT 16113

3.15 UPPER A-ARM CENTRAL BALL JOINT

3.15.1 Visual Inspection

Check the condition of the sealing boot, in particular:

Check if the retainer ring, which secures the sealing boot at the conical section of the ball stud, is still present.

Check if grease is present on the external surface of the sealing boots. Escaped fluid and accumulations of grease on the sealing boot may be the result of the sealing boot's rupturing. In this case, the ball joint must be systematically replaced.

3.15.2 Play Measurement

- Raise the vehicle and support through axle jacking points.
- Using a caliper, measure dimension A on figure 28.
- With a lever tool, exert sufficient force under the upper A-arm as to separate the upper A-arm from the upright in order to have the ball joint to its maximum extent. Remeasure dimension A. If the difference between the two dimensions is greater than 0.060" (1.5 mm), then the ball joint should be replaced.

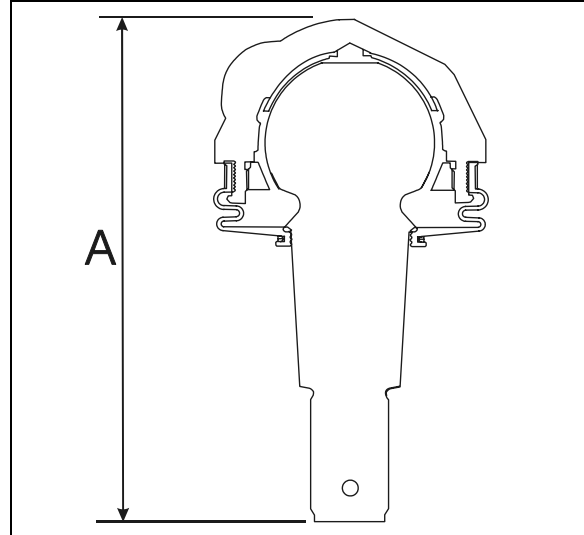


FIGURE 28: UPPER A-ARM CENTRAL BALL JOINT 16116

3.16 FRONT END ALIGNMENT

Proper front end alignment must be maintained to insure ease of steering and provide satisfactory tire life. When making front end alignment inspections, the vehicle must be level and empty with the full weight of the vehicle on the wheels.

Front end alignment inspections fall into two groups: regular service inspections performed at periodic intervals, and inspections to determine the extent of damage after a collision or severe service.

Regular service inspections concern toe-in, camber and caster.

Any variation from the specified alignment will indicate either a need for adjustment or a more thorough inspection to determine if parts replacement is required.



WARNING

During alignment, both camber and caster among other angles are adjusted. When adjusting these we install or remove shims from the lower "A" arms of the ISS suspension. After performing alignment, make sure that the following is done:

- Installing a new lock nut after all shims are finalized.
- Torque replaced nuts as per figure 32.
- Installing a longer bolt if less the 2 threads are remaining after the nut.
- Using a Torque mark on the nut for future visual inspection.

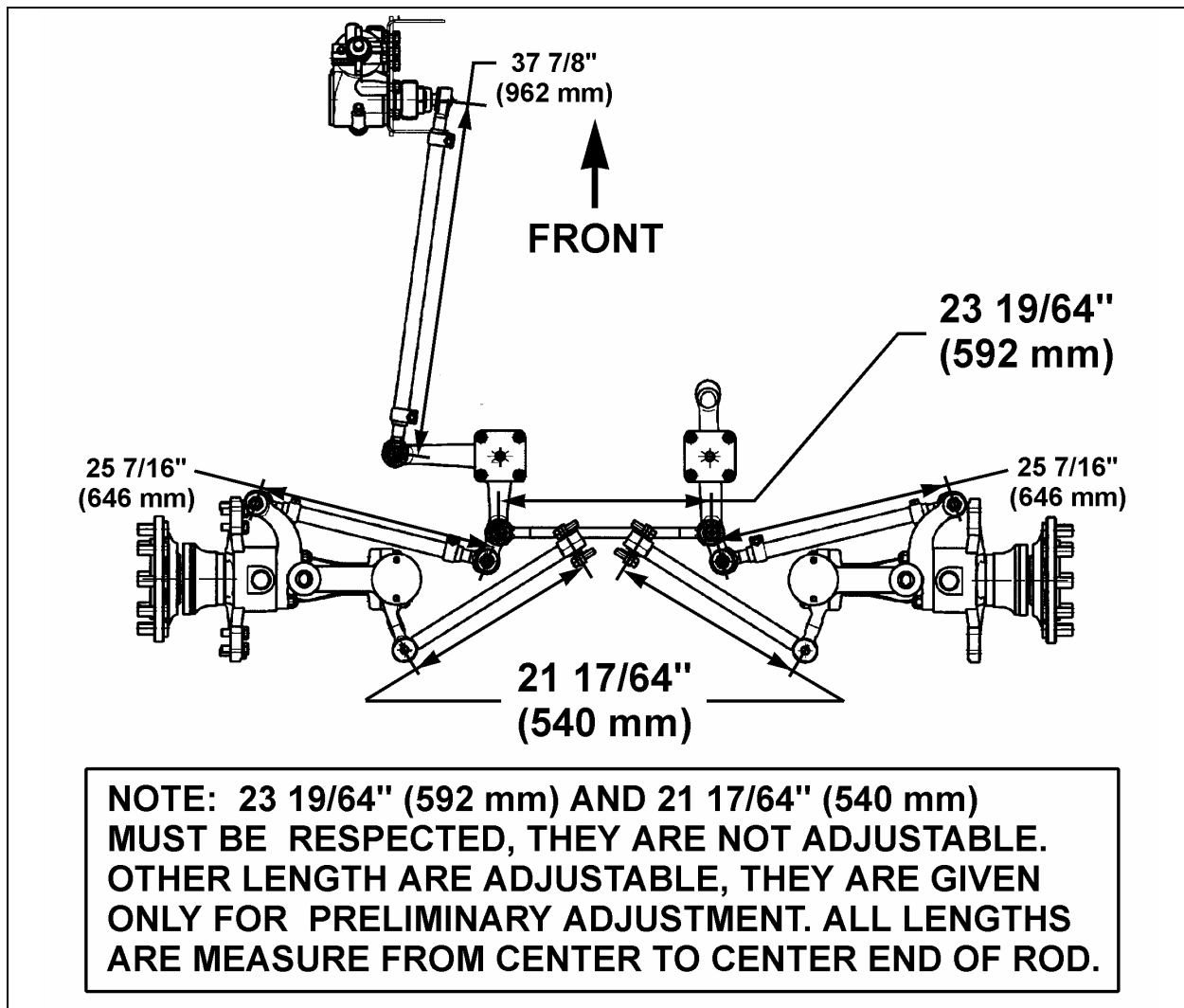


FIGURE 29: STEERING LINKAGE MEASURE

16130

3.16.1 Alignment Terminology

Wheel Camber

The amount the wheels are inclined from the vertical plane (A, Fig. 30).

Wheel Toe-In

The distance the front wheels are closer together at the front than at the rear of the tires (D minus E, Fig. 30).

King Pin Inclination

The inclination of the king pin from vertical toward the center of the vehicle at the top and outward at the bottom (B, Fig. 30).

Front Axle Caster

The inclination of the king pin from vertical in the fore and aft direction (C, Fig. 30).

3.16.2 Front End Inspection

Before checking front end alignment, make the following inspection:

1. Check that the vehicle is at normal ride height (see paragraph "5. Suspension Height Adjustment").
2. Check the tires for proper inflation.
3. Check wheel installation and run-out.
4. Check wheel bearing adjustment.
5. Check tie rods and drag link ends for looseness.
6. Check king pins for looseness.
7. Check if the length of the torque rod is 21 17/64" (540 mm) (Fig. 29). Check if the length of the relay rod is 23 19/64" (592 mm).

3.16.3 Front Wheel Camber

Positive camber is the outward inclination of the wheels at the top, negative or reverse camber is the inward inclination of the wheels at the top. Camber variations may be caused by wear at the wheel bearings, wheel spindle bushings, or bent suspension parts.

Check camber, with an accurate gauge. If camber is incorrect, check suspension parts for wear and replace worn parts. If wear is not perceptible, suspension parts may be bent or lower suspension arm may be improperly shimmed.

Check King pin inclination. If King pin inclination is incorrect, readjust the camber and check king pin inclination again.

NOTE

Camber is more important than king pin inclination, so adjust camber and verify king pin inclination.

Shim the lower suspension arm to adjust camber. If the king pin inclination is incorrect, the wheel king pin assembly may be bent and therefore should be replaced.

Excessive positive camber results in irregular wear of the tires at the outer shoulders. Negative or reverse camber causes wear at the inner shoulders.

NOTE

Shim only the lower suspension arm to adjust the front wheel camber.



CAUTION

Once the perfect shim combination is achieved, always install new stover nuts because the self locking effect is lost after tightening and loosening of the nut. It is recommended to punch marks to detect loosening of the nuts during future visual inspections.

3.16.4 Front Wheel Toe-In

Toe-in is measured from the center of the tire treads. Measurements at the front and rear of the tires must be made at the same height from the floor. Incorrect toe-in results in excessive tire wear and steering instability with a tendency to wander.

Toe-In Check

1. Check the camber adjustment and adjust if necessary.

2. Hoist the front of the vehicle and spin the wheels marking the centerline of the tire treads.
3. Place the wheels in the straight ahead position and lower the vehicle to rest on the floor.
4. Roll the vehicle ahead several feet. This removes any slack caused by looseness in the wheel bearings or steering connections.
5. Check the distance between the tire centerlines at the front and rear of the front tires. These two measurements must be made at the same height above the floor. The front measurement must be $3/32 \pm 1/32$ of an inch less than the rear measurement.

Toe-In Adjustment

1. Loosen the tie rod clamp bolts.
2. Using a pipe wrench, turn the tie rod tubes to obtain the toe-in measurement specified in step 5 under paragraph "**Toe-in Check**" of this section.
3. Tighten the tie rod clamp bolts and recheck toe-in.
4. Check that the angular relationship of the pitman arm to the steering gear is as shown in figure 17.

NOTE

Use only tie rods to adjust toe-in.

3.16.5 Front Axle Caster

Positive caster is the inclination of the top of the king pins toward the rear of the vehicle. Negative or reverse caster is the inclination of the king pins toward the front of the vehicle. This vehicle is designed with positive caster. The purpose of caster is to provide steering stability by keeping the wheels in a straight ahead position.

Caster variations may be caused by bent upper suspension arm, lower suspension arm, or king pin housing. Caster should be adjusted with shims. Precision instruments should be used to measure caster. Shim bell crank and idler arm to adjust caster.

Variations from the specified caster will affect steering stability, cause wandering, wheel shimmy, and reduce returnability when pulling out of curves.

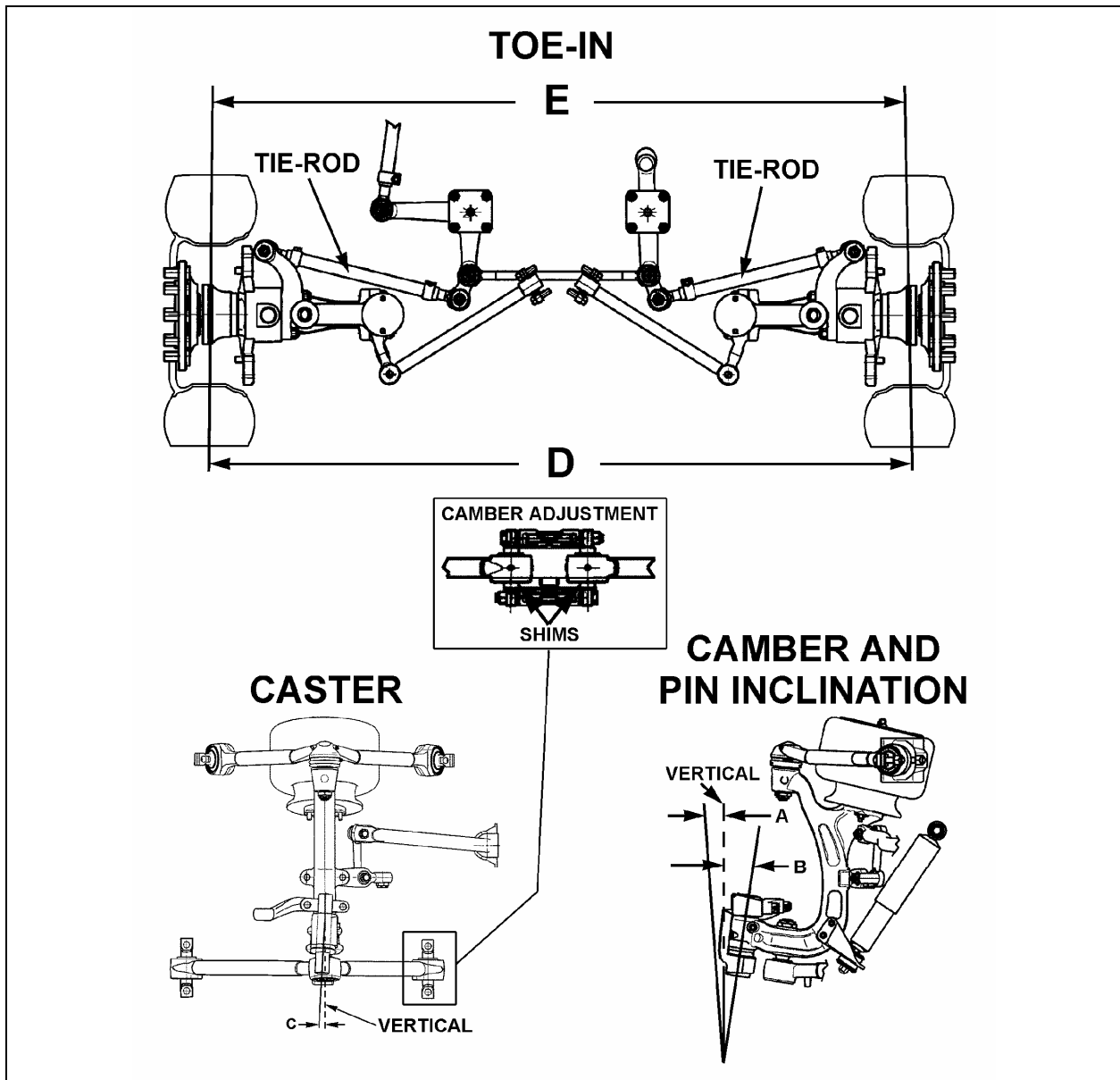


FIGURE 30: FRONT END ALIGNMENT DIAGRAM

16134

ALIGNMENT SPECS (See Figure 30)				
		Minimal	Nominal	Maximal
A	WHEEL CAMBER	0.0	0.150	0.35
B	KING PIN INCLINATION	8° (not adjustable)		
C	CASTER	2.35	2.6	2.85
D-E	TOTAL TOE	0.06	0.08	0.10

3.16.6 Major Damage

If the suspension has sustained major damage, it may be necessary to shim the bell crank and the idler arm to avoid the bump steer or roll steer. Moreover refer to paragraph "3.16: Front End Alignment".

3.17 FRONT AIR SPRINGS

Two "rolling lobe" type air springs are used with the independent front suspension, one at each wheel. These air springs are special and use the complete piston as an extra reservoir to lower the spring stiffness. Front air springs are attached to the subframe and to uprights.

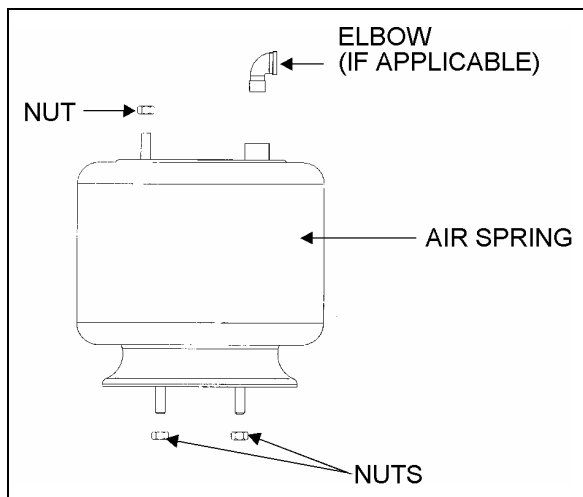


FIGURE 31: AIR SPRINGS

16052

3.17.1 Inspection

1. Check operation of bellows.
2. Visually inspect bellows for evidence of cracks, punctures, deterioration, or chafing. Replace the bellows if damage is evident.
3. With the primary air system at normal operating pressure (95 - 125 psi (655 - 860 kPa)), coat all suspension air line connections and bellow mounting areas with a water and soap solution. Bubbles will indicate an air leak, and none is permissible. Repair or replace defective parts.

NOTE

If air spring is removed from vehicle, bellows can be lightly inflated and submerged in water to detect any leakage. If leakage is detected, replace bellows.



WARNING

To prevent personal injury, do not apply more than 10 psi (69 kPa) air pressure to the unmounted air spring.

3.17.2 Removal

NOTE

Front air springs can be removed without removing the entire suspension assembly.

1. Safely support vehicle at the recommended body jacking points and jack up body understructure.
2. To gain access to a given air spring, the corresponding wheel can be removed.



CAUTION

Only the recommended jacking points must be used as outlined in Section 18, "Body" in the maintenance manual.

3. Support the assembly with a suitable jack.
4. Exhaust compressed air from accessory air tank by opening drain cock under reservoir.
5. Disconnect the height control valve link and pull down the overtravel lever to ensure all air is exhausted from air springs.

NOTE

While performing this step, do not change the height control valve overtravel lever adjustment.

6. Disconnect air line from air spring, remove elbow (if applicable), and cover both the line end and fitting to prevent the entry of foreign matter.
7. Remove the air spring upper nut, and then the two lower nuts. Remove air spring and remove the back up plate from the top of the air spring.

3.17.3 Installation

NOTE

To facilitate air spring installation, compress it manually then put a piece of tape over the air line threaded fitting. This prevents air from getting back into the bag and keeps it compressed, thus enabling to place the bag in between the mounting plates and greatly easing installation.

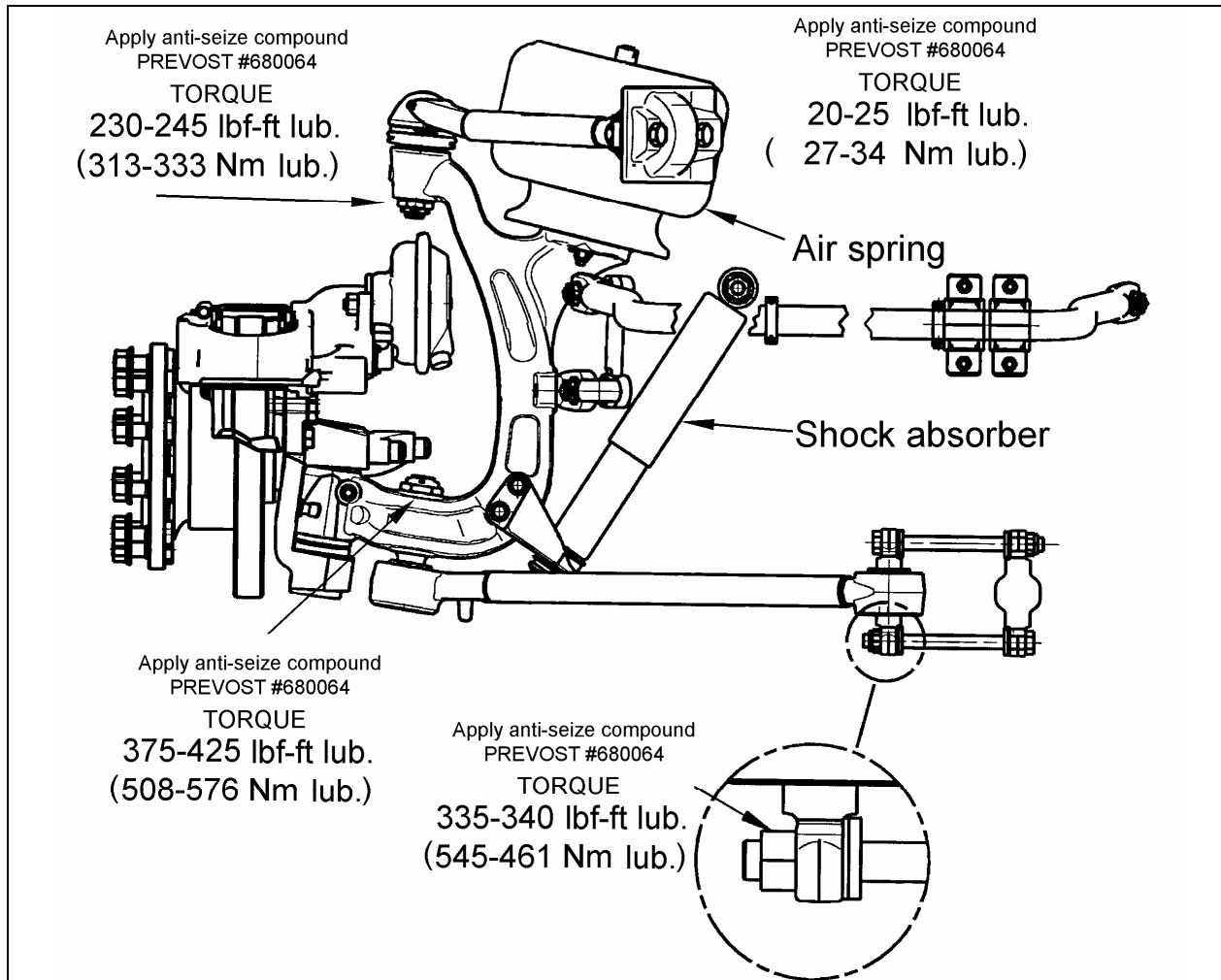


FIGURE 32: AIR SPRING AND SHOCK ABSORBER

16145

1. Compress air spring as necessary, then aligning studs with their holes, position air spring between both the lower and upper supports. Thread the lower nuts and the small upper nut a few turns.
2. Tighten and torque the lower stud nuts, and then the upper nut to 20-25 lbf-ft (27-34 Nm).
3. Install elbow (if applicable), then connect air line.
4. Connect the height control valve link.
5. Build up air pressure in system.

NOTE

To accelerate this operation, air reservoirs can be filled from an exterior air supply connected to the accessory tank fill valve or to the emergency fill valve.

6. Check operation of bellows and with the primary air system at normal operating pressure (95 - 125 psi (655 - 860 kPa), coat the air line connections and air spring mounting areas with a water and soap solution. Bubbles will indicate an air leak, and none is permissible. Repair or replace defective parts.
7. Remove the hydraulic floor jack from underneath shock absorber bracket.

3.18 SHOCK ABSORBERS

The two front shock absorbers are double-acting and telescopic type. Shock absorbers ensure a smooth ride and enhance vehicle stability on the road. Front shock absorbers have eye-type mountings on the upper side and bayonet type on lower side. Shock absorbers are non-adjustable and non-repairable.

**CAUTION**

When a shock absorber is found defective, always replace with a new set on affected axle, except if there has been a recent replacement of one unit. The following method will help in determining if both shock absorbers on the same axle have to be replaced.

3.18.1 Shock Absorber Removal

1. Remove the nut, washer and rubber joint from shock absorber mounting stud. Discard the rubber joints.
2. Remove the nut and washer from shock absorber mounting pin (upper side), taking care to identify the inner and outer washers to ease reinstallation. Refer to figure 33 for details.
3. Remove the shock absorber from the vehicle.
4. Remove inner: washers, rubber joint and bushings from the shock absorber. Discard bushings and rubber joint.

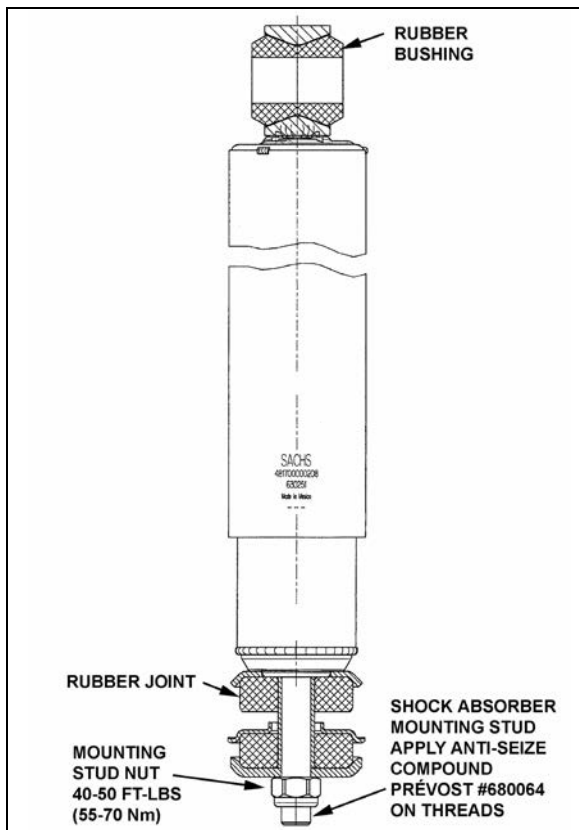


FIGURE 33: SHOCK ABSORBER

16112

3.18.2 Shock Absorber Installation

1. Check that the shock absorber mounting pin torque is proper (350-400 lbf-ft (475-545 Nm)). Ensure that the stud is clean and not stripped (upper side).
2. Install new rubber (mounting) bushing on shock absorber (upper side).
3. Place the inner washer on shock absorber pin (Fig. 33).
4. Install washer and rubber joint on shock absorber mounting stud (lower side).
5. Install the shock absorber as shown in figure 32 with the mounting stud protruding through the hole in the mounting bracket and the shock absorber eyes over the mounting pins. Install the outer washer.
6. Place a rubber joint and washer on the shock absorber mounting stud. Place the lower shock absorber mounting stud nut and torque to 40-50 lbf-ft (55-70 Nm).
7. Place the upper mounting pin stud nut and torque to 70-85 lbf-ft (95-115 Nm).

3.19 SWAY BAR

A sway bar is provided on the front and rear suspensions to increase vehicle stability. It controls lateral motion (swaying movement) of vehicle.

3.19.1 Removal

1. Disconnect the two links from sway bar.
2. Safely support the sway bar. Unbolt bushing collars from subframe.
3. Remove sway bar.

NOTE

Sway bar bushings are slit to ease their removal.

3.19.2 Installation

1. Loosely install the sway bar.
2. Torque bushing collar nuts to 60 lbf-ft (82 Nm).
3. Torque sway bar link upper nuts to 120-140 lbf-ft (163-190 Nm) on front suspension and to 100-120 lbf-ft (136-163 Nm) on rear suspension.
4. Torque sway bar link lower nuts to 120-140 lbf-ft (163-190 Nm) on front suspension and to 70-80 lbf-ft (95-110 Nm) on rear suspension.

Section 16: SUSPENSION

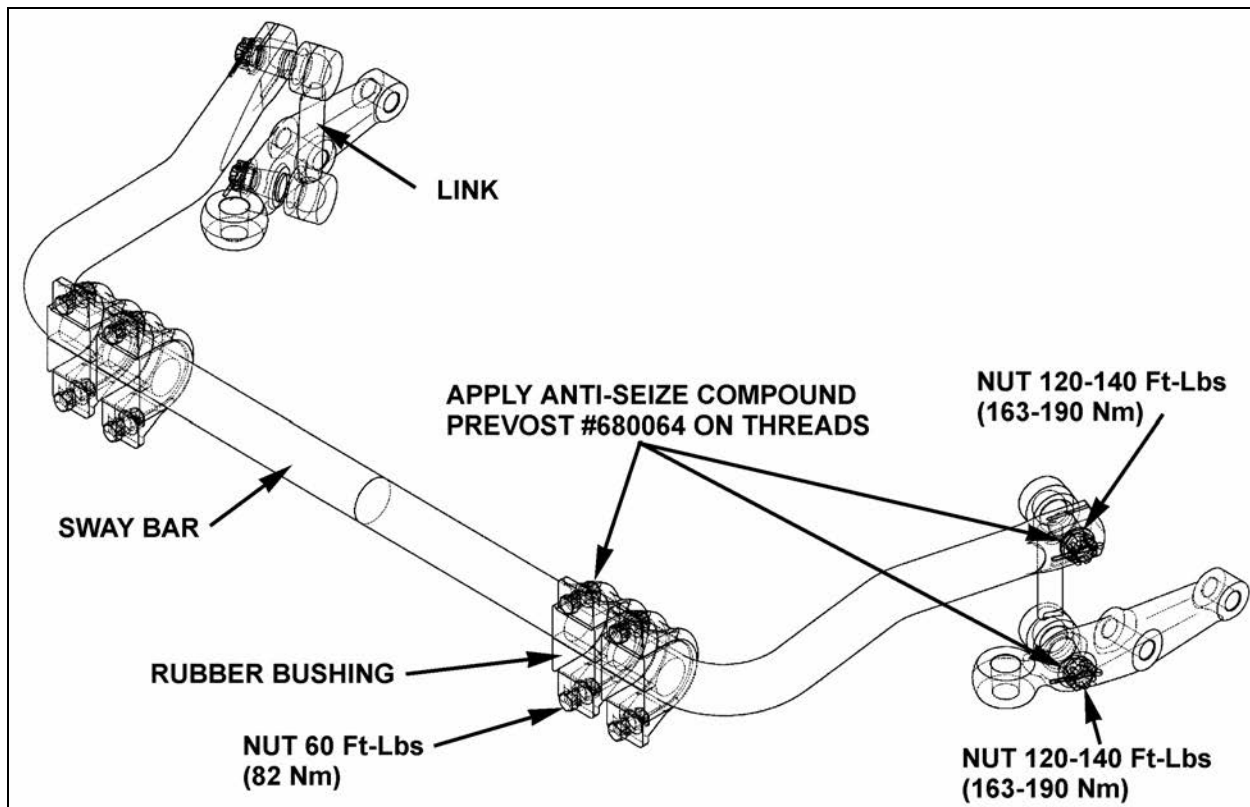


FIGURE 34: SWAY BAR (FRONT SUSPENSION)

16138B

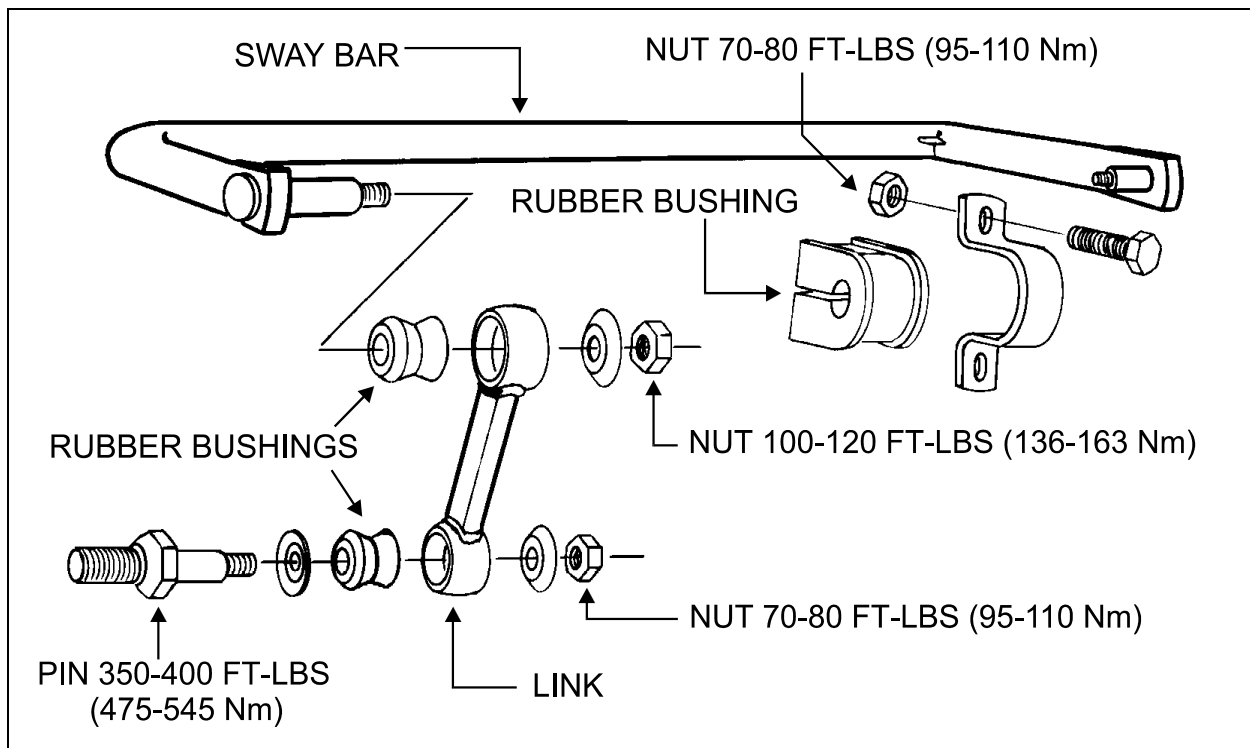


FIGURE 35: SWAY BAR (REAR SUSPENSION)

16144

4. REAR SUSPENSION

For a description of all these systems, refer to the appropriate heading in this section.

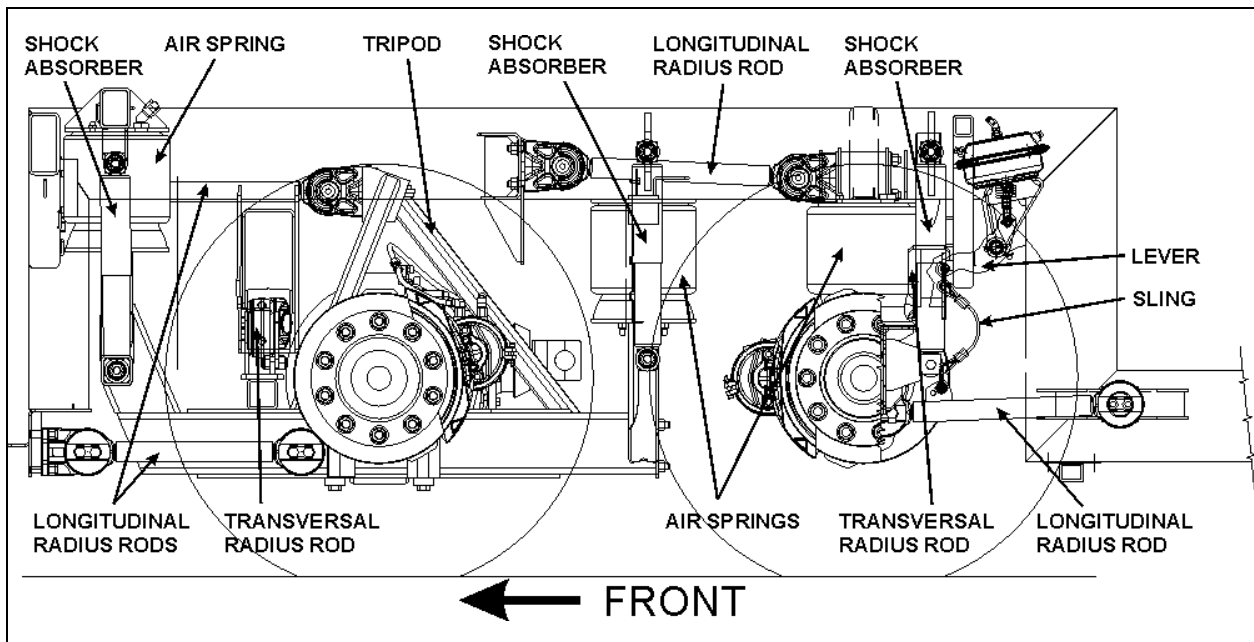


FIGURE 36: REAR SUSPENSION COMPONENTS

16167

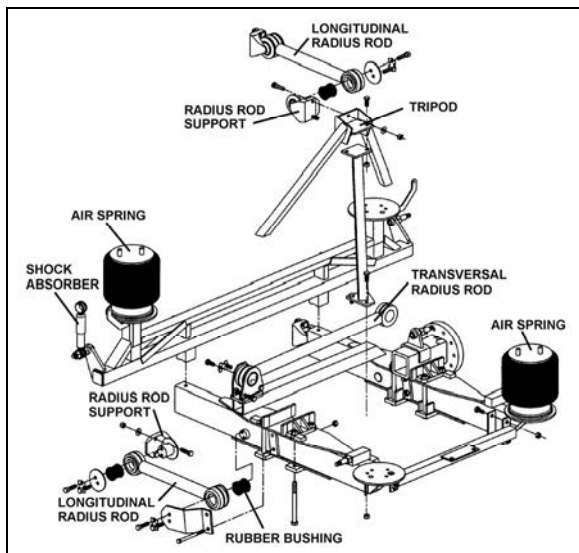


FIGURE 37: DETAILS OF REAR SUSPENSION

16106

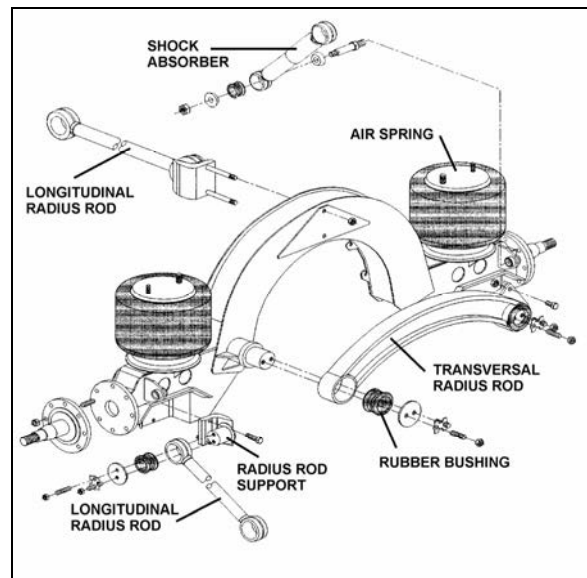


FIGURE 38: TAG AXLE SUSPENSION

16107

4.1 AIR SPRINGS

The air springs are made from a special compound rubber molded to the proper contour and dimensions. The entire vertical load of the vehicle is supported by these springs. Each of the two axles is provided with air springs that are attached to the subframe and to the axles (Fig. 39).

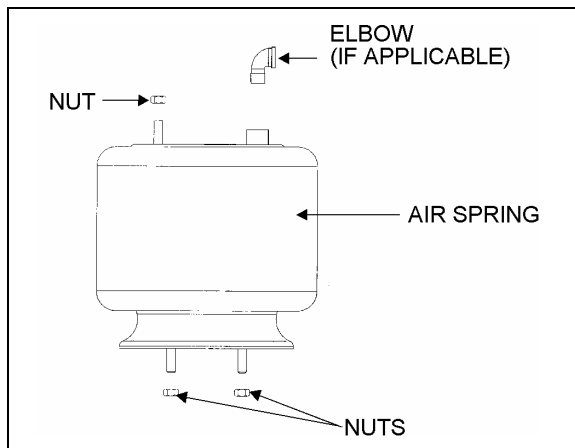


FIGURE 39: AIR SPRING

16052

4.1.1 Inspection

1. Check operation of bellows.
2. Visually inspect bellows for evidence of cracks, punctures, deterioration, or chafing. Replace the bellows if any damage is evident.
3. With the primary air system at normal operating pressure (95 - 125 psi (655 - 860 kPa)), coat all suspension air line connections and bellows mounting areas with a water and soap solution. Bubbles will indicate an air leak, and none is permissible. Repair or replace defective parts.

NOTE

If air spring is removed from vehicle, bellows can be lightly inflated and submerged in water to detect any leakage. If any leakage is detected, replace bellows.



WARNING

To prevent personal injury, do not apply more than 10 psi (69 kPa) of air pressure to the uninstalled air spring.

4.1.2 Removal

NOTE

Suspension air springs (drive and tag axles) can be removed without removing the entire axle assembly.

1. Safely support vehicle at the recommended body jacking points. To gain access to a given air spring, the corresponding wheel can be removed as follows.
 - a) Jack vehicle until the tire clears the ground, and place safety supports underneath body.



CAUTION

Only the recommended jacking points must be used as outlined in Section 18, "Body".

- b) Support the axle with a suitable hydraulic floor jack at the recommended jacking point.
 - c) Remove wheel.
2. Exhaust compressed air from accessory air tank by opening drain cock under reservoir.
 3. Disconnect the height control valve link and pull down the overtravel lever to ensure all air is exhausted from air springs.

NOTE

While performing this step, do not change the height control valve overtravel lever adjustment.

4. Disconnect air line from air spring, remove elbow (if applicable), and cover both the line end and fitting to prevent the entry of foreign matter.
5. Remove the air spring upper nut, and then the two lower nuts. Remove air spring.

4.1.3 Installation

1. Compress air spring as necessary, then aligning studs with their holes, position air spring between both the lower and upper supports. Thread the lower nuts and the small upper nut a few turns.

NOTE

To facilitate air spring installation, compress it manually then put a piece of tape over the air line threaded fitting. This prevents air from getting back into the bag and keeps it compressed, thus enabling to place the bag in between the mounting plates and greatly easing installation.

2. Tighten and torque the lower stud nuts, and then the upper one to 20 – 25 lbf-ft (27 – 34 Nm).
3. Thread the remaining upper nut (large nut) and tighten to 20 – 25 lbf-ft (27 – 34 Nm).
4. Install elbow (if applicable), then connect air line.
5. Connect the height control valve link.
6. Build up air pressure in system.

NOTE

To accelerate this operation, air reservoirs can be filled from an exterior air supply connected to the accessory tank fill valve or to the emergency fill valve.

7. Check operation of bellows, and with the primary air system at normal operating pressure (95 – 125 psi (655 – 860 kPa)), coat the air line connections and air spring mounting areas with a water and soap solution. Bubbles will indicate an air leak, and none is permissible. Repair or replace defective parts.
8. Reinstall wheel.
9. Remove the hydraulic floor jack from under the axle, then lower vehicle to ground.

4.2 SHOCK ABSORBERS

Double-action, telescoping-type shock absorbers ensure a smooth ride and enhance vehicle stability on the road. All shock absorbers are eye-type mountings. The tag axle is provided with two shock absorbers while the drive axle is provided with four of them (Fig. 36, 37 and 38).

Shock absorbers are non-adjustable and non-repairable. Maintenance requirements involve replacement of the rubber mounting bushings, and tightening of all shock absorber pins at the proper torque of 500 - 550 lbf-ft (680 - 750 Nm) when shock absorber replacement occurs. If a

shock absorber becomes inoperative, complete unit must be replaced.

**CAUTION**

When a shock absorber is found defective, always replace with a new set on affected axle, except if there has been a recent replacement of one unit. The following method will help in determining if both shock absorbers on the same axle have to be replaced.

4.2.1 Inspection

Loosen lower mounting of both shocks, and then carefully attempt to raise and lower the bottom portion of each shock. Note the rate of effort for distance of travel. Replace both shocks if a definite differential rate is found.

The shock must be bench checked in an upright, vertical position. If checked in any other position, air will enter the cylinder tube and make the shock absorber appear defective.

Proceed as follows to check shock absorbers:

1. With the shock absorber in a vertical position (top end up), clamp the bottom mount in a vise.

**CAUTION**

Do not clamp the reservoir tube or the dust tube.

2. Rotate the dust tube. Notice any binding condition (may be compared with new unit). Binding condition indicates a scored rod. Units with scored rods should be replaced.
3. Fully extend shocks and check for leaks in the seal cover area. Shock fluid is a very thin hydraulic fluid that has a characteristic odor and dark brown tint. A slight trace of shock fluid around the seal cover area is not a cause for replacement. The shock seal is designed to permit a very slight seepage to lubricate the rod. Units that leak should be replaced.
4. Visually check shock for dents that could cause the shock to bind. Also, check for a bent rod.
5. Extend and collapse shock several times to determine that it has control (resistance) in both rebound and compression.

Section 16: SUSPENSION

6. Visually inspect the shock mountings and vehicle mounting for:
 - a) Broken mounts;
 - b) Extreme bushing wear;
 - c) Shifted bushing or sleeve;
 - d) Deep cracks in bushing material (shallow surface cracks are normal);
 - e) Loose shock absorber pins;
 - f) Presence of convex washers, and their position relative to the rubber bushing.

4.2.2 Removal

1. Remove nuts and washers from shock absorbers on upper and lower mounting pins, taking care to identify the inner and outer washers to ease reinstallation. Refer to figure 40 for details.
2. Remove the shock absorber assembly from pins.
3. Remove the two inner bushings from the shock absorber and discard them.

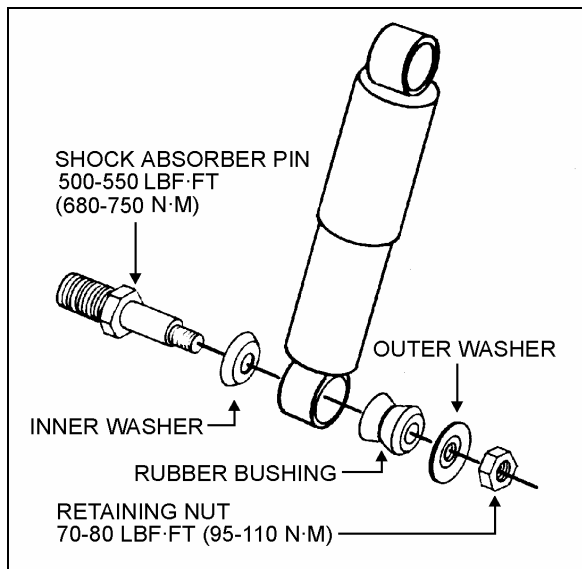


FIGURE 40: SHOCK ABSORBER

16008

4.2.3 Installation

1. Ensure that the shock absorber mounting pins are tight and that the threads are not stripped.
2. Install new rubber mounting bushings on shock absorbers (upper and lower).
3. Place the inner washers (with washer convex side facing the shock absorber rubber bushing) on each shock absorber pin (Fig. 41).

4. Install the shock absorber eyes over the mounting pins, then the outer washers (with washer convex side facing the shock absorber rubber bushing) on each shock extremity.

NOTE

If shock absorber pins are removed, they must be reinstalled using "loctite" (see "Parts Specifications" in this section).

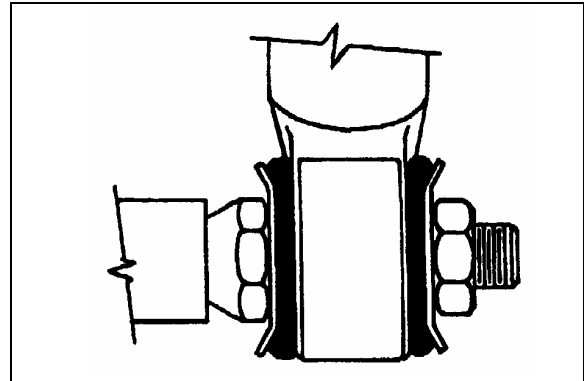


FIGURE 41: TYPICAL SHOCK ABSORBER SETUP

16009

5. Place the lower and upper mounting pin stud nuts and torque to 70 - 80 lbf-ft (95 - 110 Nm).

4.3 RADIUS RODS

Radius rods are used to secure the axles in the proper transversal and longitudinal positions. Four radius rods are provided on the drive axle suspension (three longitudinal and one transversal) and also four on the tag axle with a layout similar to the drive axle. Refer to figures 36, 37 and 38 for details. These rods transmit both braking and driving forces from the axles to the vehicle body.

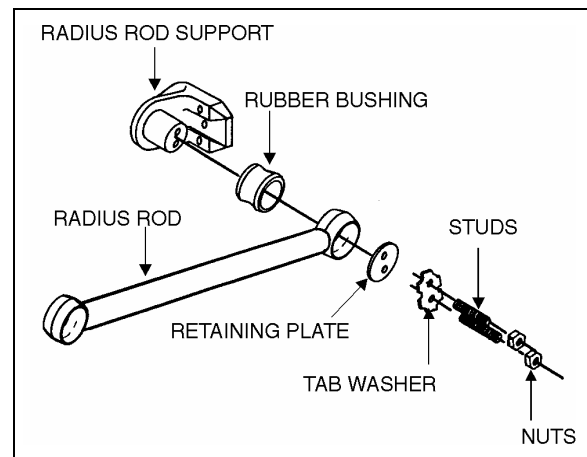


FIGURE 42: TYPICAL RADIUS ROD SETUP

16010

4.3.1 Inspection

The following instructions apply to all radius rods used on this vehicle:

1. Clean all parts thoroughly.
2. Inspect radius rods for distortion and cracks. We recommend the "Magnaflux" process to detect cracks in the radius rod. Any damaged part should be replaced with a new one.

NOTE

New bushings should be used when rods are replaced.

3. The radius rod bushings should be checked periodically for signs of shearing, deterioration, or damage. Any defective part should be replaced with a new one.

4.3.2 Removal

1. Flatten the tab washer which secures the two retaining nuts (or bolts), then unscrew the nuts (or bolts) at each extremity of the radius rod (Fig. 42).
2. Remove the tab washer and the retaining plates and radius rod ends from anchor pins, and then remove the radius rod.

4.3.3 Bushing removal

1. Safely support the radius rod as shown in figure 43.

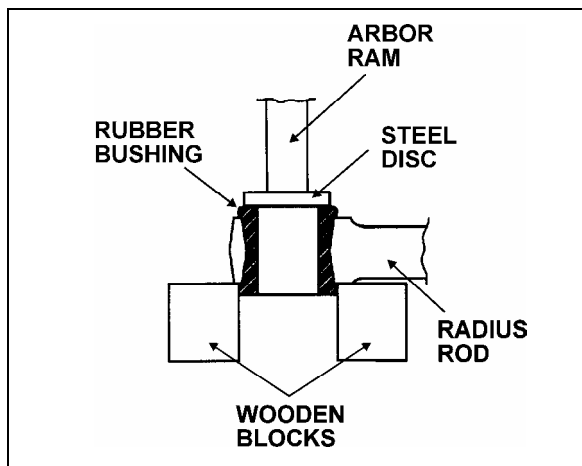


FIGURE 43: RADIUS ROD BUSHING REMOVAL 16011

2. Place a flat steel disc, slightly smaller than the outside diameter of the bushing (Fig. 43).

3. Using an arbor press or a suitable driving tool, press or drive the old bushing out of the rod and discard the bushing.



CAUTION

Make sure to prevent the steel disc from contacting the radius rod end.

4.3.4 Bushing installation

1. Lightly spray the inner and outer surfaces of radius rod bushing with water.



CAUTION

No lubricant whatsoever is to be used on the rubber bushing.

2. Safely support the radius rod, and place new bushing on top of the radius rod end (Fig. 44).
3. Place a block of wood on top of bushing and press on it manually.
4. If necessary, use an arbor press or a suitable driving tool. Press or drive the bushing into the radius rod end until it extends equally on both sides of the rod.
5. It is also possible to proceed differently. Place radius rod bushing on a plane surface. Spray a light coat of water on the inner and outer surfaces of radius rod bushing.
6. Take radius rod, align the bushing. Tap radius rod on bushing until latter is positioned correctly.

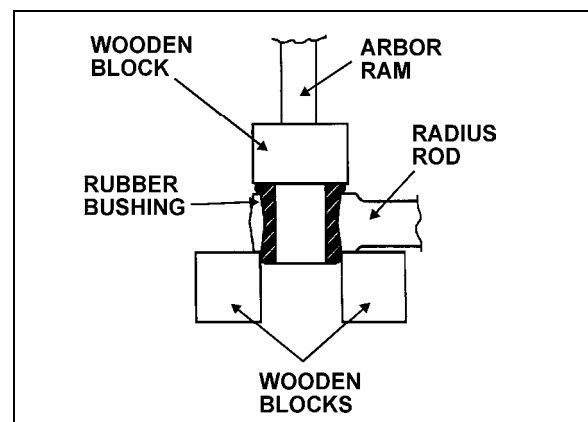


FIGURE 44: RADIUS ROD BUSHING INSTALLATION 16012

4.3.5 Installation

1. Lightly spray the radius rod support with water. Place the radius rod end over the radius rod support (Fig. 45).
2. Position the retaining plate. Install the tab washer and nuts (or bolts).

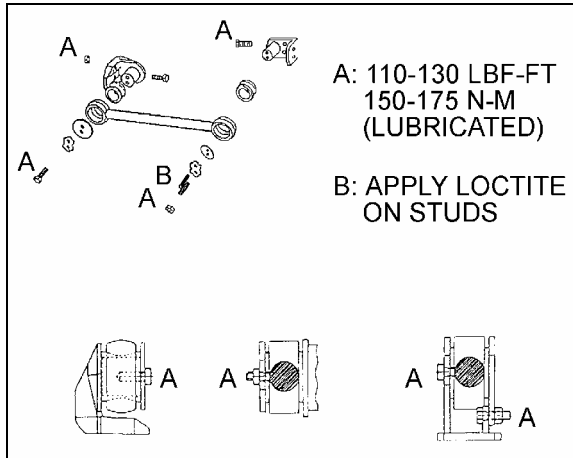


FIGURE 45: RADIUS ROD INSTALLATION 16028



CAUTION

Always use new tab washers at installation.

3. Tighten the nuts (or bolts) lightly, and repeat at the other end.
4. Refer to heading "*Suspension Height Adjustment*" later in this section, and set the vehicle to normal ride height.
5. With the vehicle at normal ride height, apply oil on threads and tighten all radius rod anchor pin nuts or bolts to 110 – 130 lbf-ft (150 – 175 Nm).



CAUTION

It is extremely important upon reconnection of the rods that the proper clearance height between the axle and body be maintained. Otherwise, the rubber bushings in radius rod ends will become preloaded, thus reducing their life span.

5. SUSPENSION HEIGHT ADJUSTMENT

The flow of pressurized air from the accessory air tank to the air springs is controlled by three height control valves. The two rear valves are mounted to the subframe and connected to the rear axles through an arm and link connection. The front valve is mounted to the subframe and

connected to the front air tank support. These connections allow the valves to apportion air pressure in the springs to the vehicle load, maintaining normal ride height.

Immediate response height control valves increase or decrease the air pressure in the suspension system as required. One height control valve is located **at center of front sway bar**, and regulates air to front suspension air springs in order to maintain the vehicle at the required height. Two are located at the drive axle, one on each inner side of rear wheelhousing.

The appropriate vehicle body height is obtained by measuring the clearance of all the air springs installed on the vehicle. The two front air springs clearance should be $11 \pm \frac{1}{4}$ " (279 \pm 6 mm). Refer to figure 46 to identify the correct area to take measurement. The rear air springs clearance should be $11 \frac{1}{2} \pm \frac{1}{4}$ " (292 \pm 6 mm).

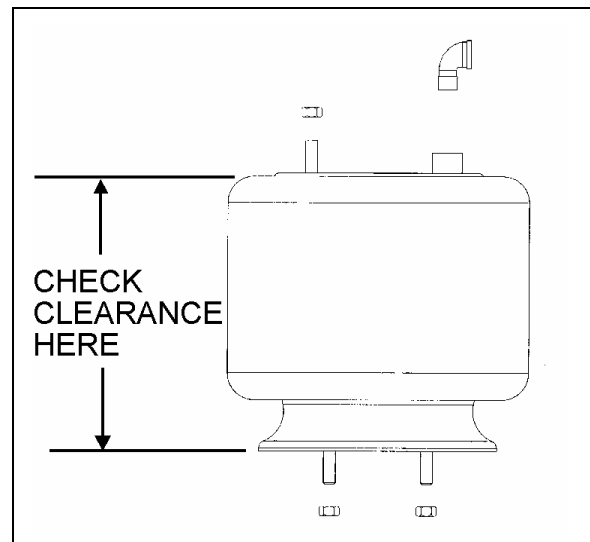


FIGURE 46: TYPICAL AIR SPRING CLEARANCE 16058

At this point, it should not be necessary to make an adjustment under normal service conditions. However, if an adjustment is required, change the position of the overtravel lever in relation to the overtravel control body. The lever should be moved up to raise vehicle height, and down to lower it. Check that main air pressure is at normal operating pressure and raise the vehicle to the specified height.



CAUTION

Always adjust on "fill cycle". If it is necessary to lower vehicle height, release sufficient air to be well below height, and adjust to height or fill cycle.

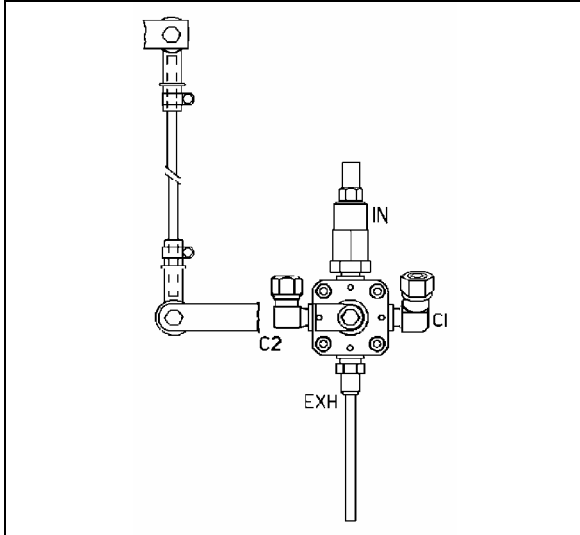


FIGURE 47: FRONT HEIGHT CONTROL VALVE 16100

The normal ride height is obtained by adjusting air spring clearance of both front and rear suspension as follows:

Front air spring clearance

1. With the vehicle at normal operating air pressure [100 - 125 psi (689 - 860 kPa)], measure air spring clearance. This clearance should be $11 \pm \frac{1}{4}$ " (279 \pm 6 mm).

NOTE

The measurement should be taken from underneath the upper air spring support on subframe to top of the lower air spring support on axle (refer to figure 46 for more details). If adjustment is required, begin with the drive axle.

2. Loosen the clamp on the height control valve rubber coupling and bring it up or down (Fig. 47).

NOTE

Allow suspension to stabilize before taking reading.

When the desired height is obtained, tighten clamp.

Rear air spring clearance

1. With the vehicle at normal operating air pressure [100 - 125 psi (689 - 860 kPa)], measure air spring clearance. This clearance should be $11 \frac{1}{2} \pm \frac{1}{4}$ " (292 \pm 6 mm).

NOTE

The measurement should be taken from underneath the upper air spring support on subframe to top of the lower air spring support on axle (refer to figure 46 for more details).

2. Loosen the clamp on the height control valve rubber coupling and bring it up or down (Fig. 48).

NOTE

Allow suspension to stabilize before taking reading.

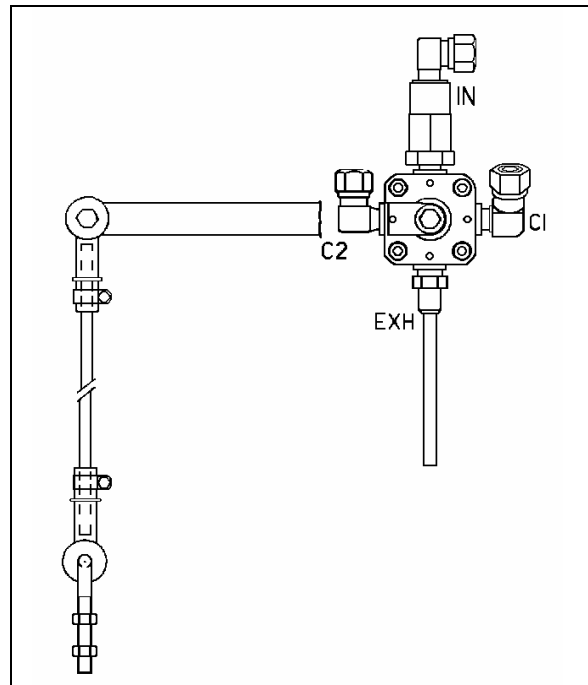


FIGURE 48: REAR HEIGHT CONTROL VALVE 16093

When the desired height is obtained, tighten clamp.

6. HEIGHT CONTROL VALVE

The height control valves automatically add air to, or release air from air springs to maintain constant suspension height regardless of load, or load distribution. Each valve adjusts independently according to the following conditions:

Loading Position

As the load increases and lowers the vehicle body, the overtravel lever commands the height control valve to add air to air springs.

Neutral Position

When vehicle body reaches the normal ride height, the height control valve overtravel lever reaches the "neutral" position and keeps both the supply and exhaust ports closed to ensure normal ride height is maintained. This condition remains static until the vehicle load is altered.

Unloading Position

As the load decreases and raises the vehicle body, the overtravel lever commands the height control valve to release air from air springs.

6.1 MAINTENANCE

The height control valve requires no periodic maintenance. Height control valve linkage operates on rubber bushings and no lubrication should be attempted at this location. Inspect the valve for loose joints, air leaks and worn bushings.

6.1.1 Removal and Installation

Before disconnecting a height control valve air line, securely support the vehicle by its jacking points on the body, and place safety supports underneath body. Refer to paragraph "16. Vehicle Jacking Points" in Section 18, "Body".

1. Exhaust air from air system by opening all air tank drain cocks. Remove height control valves.
2. Disconnect overtravel lever from link and pull down lever to exhaust remaining air from air springs.
3. Disconnect air supply and delivery lines from the height control valve. Cover line ends with tape to prevent entry of foreign matter.
4. Remove the nuts retaining the height control valve to the mounting bracket, then remove valve assembly.

Reverse removal procedure to replace height control valve. After installation, check for leakage using a soap and water solution.

7. AIR SYSTEM

The basic air system consists of an air compressor, tanks, valves, filters and interconnecting lines and hoses (refer to Section 12, "Brake and Air System" for complete information). It provides a means for braking, operating controls and accessories, and

suspension. An air system schematic diagram is annexed at the end of this section for better understanding of the system.

The air coming from the air dryer is first directed to the wet air tank, then to the primary (for the primary brake system), secondary (for the secondary brake system), and accessory (for the pneumatic accessories) air tanks (Fig. 49 and 50).

In addition, an expansion air tank may be installed in series with each air spring.

7.1 AIR TANK MAINTENANCE

Ensure that the accessories air tank is purged during pre-starting inspection. A good practice is to purge this tank at the end of every driving day by the remote air tank drain valve located in the steering compartment (Fig. 52).

Moreover, purge all tanks by their bottom drain valves at specified intervals.

7.1.1 Wet Air Tank

This tank is installed above the drive axle on the L.H. side, and is provided with a bottom drain valve. It is recommended to **purge** the wet air tank by its bottom drain valve every 12,500 miles (20 000 km), or once a year, whichever comes first.

A remote valve located in engine compartment and accessible through engine R.H. side door is used to **drain** the air dryer (Fig. 51).

7.1.2 Primary Air Tank

The primary air tank is located above the drive axle on the R.H. side.

This tank is provided with a bottom drain valve (Fig. 49 and 50). It is recommended to purge the primary air tank by its bottom drain valve every 12,500 miles (20 000 km) or once a year, whichever comes first.

7.1.3 Secondary Air Tank

This tank is located in front wheelhousing, between air springs. The tank may be installed vertically depending on type of front suspension and is provided with a bottom drain valve (Fig. 49 and 50).

It is recommended to purge the tank by its bottom drain valve, every 12,500 miles (20 000 km) or once a year, whichever comes first.

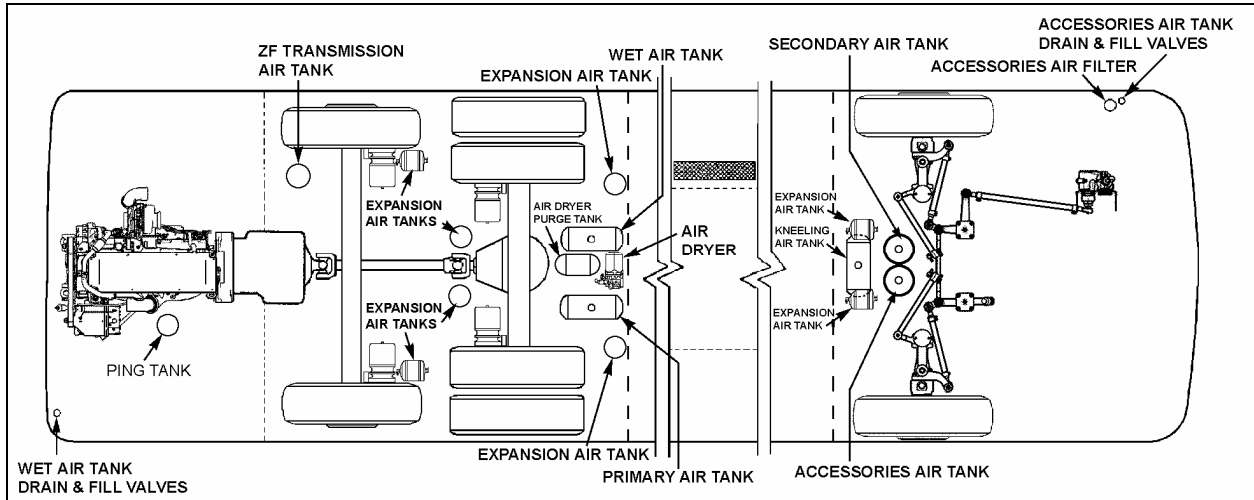


FIGURE 49: IFS AIR TANKS LOCATION

24034

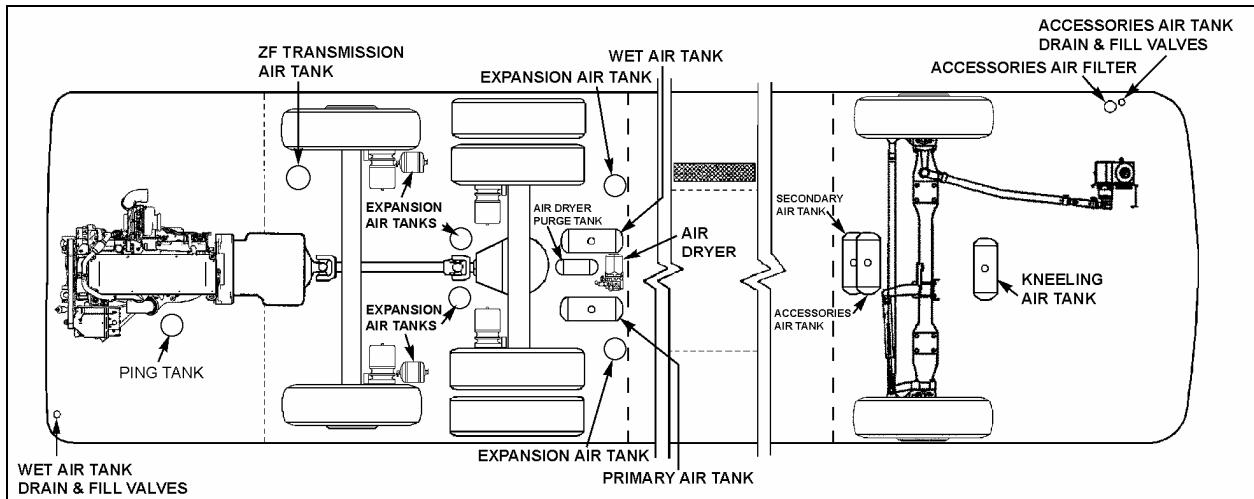


FIGURE 50: I-BEAM FRONT SUSPENSION AIR TANKS LOCATION

24035

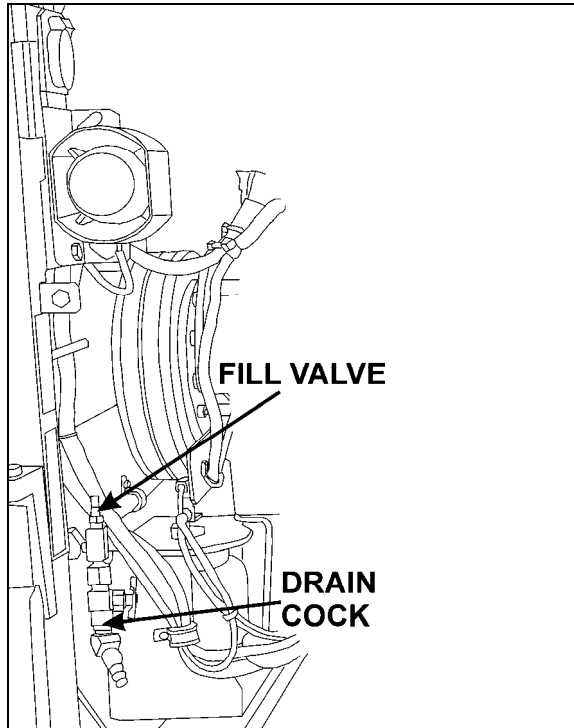


FIGURE 51: REAR VALVE LOCATION 12211

7.1.4 Accessory Air Tank

The accessory air tank is installed next to the secondary air tank. The tank may be installed vertically depending on type of front suspension and is provided with a bottom drain valve (Fig. 38).

It is recommended to purge the tank by its bottom drain valve, every 12,500 miles (20 000 km) or once a year, whichever comes first.

A remote drain valve is located in front service compartment (Fig. 52) underneath the accessory air filter. Refer to Section 12, paragraph "4. Accessory Air Filter" of the maintenance manual for daily purge procedure.

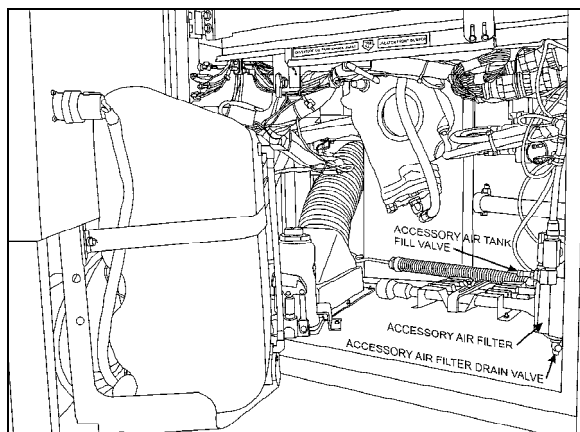


FIGURE 52: FRONT VALVE LOCATION 12210

7.1.5 Expansion Air Tank

Two expansion tanks will be installed in front wheelhousing if the IFS was chosen as an option. These air tanks are located behind secondary and accessory air tank. Also, six expansion tanks are located near rear air springs (Fig. 49 and 50). Expansion tanks are connected in series with air springs. Expansion tanks are used to lower the stiffness of the air spring. They are provided with a bottom drain valve.

It is recommended to purge them, with all other tanks, every 12,500 miles (20 000 km) or once a year, whichever comes first.

7.2 EMERGENCY FILL VALVES

The vehicle is equipped with two air system emergency fill valves to supplement the air system when air pressure is low and engine cannot be operated.

The rear valve is located in engine compartment and accessible from engine R.H. side door (Fig. 51).



CAUTION

No other point should be used to supply air system. The maximum allowable air pressure is 125 psi (860 kPa).

The front valve is located in the front service compartment close to accessory air filter (Fig. 52).

These two air valves are fitted with the same valve stems as standard tires, and can be filled by any standard external air supply line.

The rear valve will supply air for all systems (brakes, suspension and accessories) while the front valve will supply air for accessories only.



CAUTION

Air filled through these two points will pass through the standard air filtering system provided by Prévost. Do not fill air through any other points.

8. HUB UNIT AND SWIVEL ASSEMBLY

Refer to "DANA SPICER Service Manual General Information, Maintenance Manual Model NDS and Maintenance Manual NDS Axles" annexed to Section 10 of the maintenance manual.

9. FRONT KNEELING SYSTEM

The kneeling system is used to lower front of vehicle. This allows passengers to board the vehicle with greater ease. The kneeling action is achieved by exhausting air from the front air springs (bellows). This system bypasses the height control valve to provide a fast up and down movement of the front suspension. Only seven seconds are required to lower vehicle from normal level to the lowered position, and approximately the same time to raise the vehicle back to normal level. The quick response is achieved by an auxiliary air tank installed beside the secondary air reservoir (for exact position, refer to Section 12, *"Brake and Air System"*). This tank provides sufficient air supply to the kneeling system for some successive operations.

The system is provided with two safety features; first, a speed switch will enable the kneeling system to work only at less than 5 mph (8 km/h). Secondly, the parking brake is automatically applied, and a limit switch will keep it applied as long as the vehicle has not returned to a certain height where the driver will be able to manually remove the parking brake.

The purpose of the hi-buoy function in this system is to raise the front end of the vehicle to allow an extra ground clearance for particular situations. In driving condition, the height control valve is in operation and only the hi-buoy can be operated.

9.1 PRINCIPLE OF OPERATION

Refer to the air system schematic diagram annexed at the end of Section 12, *"Brake and Air System"*.

DOWN (FRONT KNEELING):

Both the bellows control and bellows exhaust solenoid valves are energized, so the air control valves release air from front air springs. The height control valve is bypassed to ensure no air is forwarded to air springs while lowering the front suspension.

UP (FRONT HIGH-BUOY):

Only the bellows control solenoid valve is energized, so the air coming from the kneeling air tank is routed through air control valves, and up to front air springs.

The height control valve is bypassed until the kneeling proximity switch signals the kneeling

module to cut off the bellows control solenoid valve, about 1" (25 mm) below normal ride height. The final height adjustment is achieved by the height control valve.

9.2 MAINTENANCE

Since the kneeling action is issued from both the air system and electrical system, refer to Section: 12, *"Brake and Air System"* and Section 06, *"Electrical System"*.

For diagnosis and understanding of the system, refer to wiring diagrams, and to the appropriate air system schematic diagram annexed to Section 12, *"Brake and Air System"*.

9.3 BELLOWS CONTROL SOLENOID VALVES

9.3.1 Removal and installation

1. On the rear side of steering compartment, locate both the bellows control and bellows exhaust solenoid valves.
2. Identify hoses and wires to ease reinstallation. Disconnect solenoid wires and the three flexible black hoses from solenoid valves.
3. Unscrew and remove the control solenoid valve and exhaust solenoid valve assembly. Place on a clean working place.

Reverse removal procedure to reinstall.



CAUTION

Any cable tie that has been cut during removal procedure should be replaced with a new one.

10. HIGH-BUOY SYSTEM

The purpose of the rear high-buoy system is to raise the entire vehicle body about 4" (100 mm) in order to increase ground clearance to board a ferryboat, to jump a curb, etc. This system can be put into service during normal vehicle operation.

10.1 PRINCIPLES OF OPERATION

The rear high-buoy system is added over the front kneeling (with front high-buoy). The front end uses the same valves as the front kneeling (with front high-buoy). A solenoid valve is added to send air to the double shuttle valves for the rear end. It uses the same dash switch as the kneeling (with front high-buoy).

UP:

The air coming from the control valve flows through double shuttle valves, to supply air springs. The double shuttle valves prevent height control valves from releasing air from air springs.

DOWN:

The control valve, on the dashboard, cuts off air supply, so the double shuttle valves allow height control valves to accomplish their function. Height control valves release air from air springs until suspension returns to its normal position.

10.2 MAINTENANCE

Refer to the air system schematic diagram "Opt. Front Kneeling With Rear High-Buoy Combination" annexed at the end of this Section.

10.3 HIGH-BUOY – PRESSURE REGULATING VALVE

The regulating valve is located in the front service compartment. This valve should be adjusted to 90 psi (621 kPa).

10.3.1 Adjustment

1. Before turning on system air pressure, release jam nut (2, Fig. 53) then turn regulator adjustment counterclockwise until all load is removed from the regulating spring.
2. Turn on system pressure.
3. Turn regulator adjustment clockwise until the desired outlet pressure is reached.
4. To avoid minor readjustment after making a change in pressure setting, always approach the desired pressure from a lower pressure. When reducing from a higher to a lower setting, first reduce the pressure at a lower pressure, and then increase it to the desired level of pressure.
5. Tighten jam nut (2, Fig. 53) to lock pressure setting.

10.3.2 Disassembly

1. Shut off inlet pressure and reduce pressure in inlet and outlet lines to zero. Turn regulator adjustment (1, Fig. 53) counterclockwise until all load is removed from regulating spring. Regulator can be disassembled without removal from air line.

2. Disassemble regulator in accordance with the item numbers on the exploded view.

10.3.3 Cleaning

1. Clean parts with warm water and soap. Dry parts and blow out internal passages in body using clean, dry compressed air.
2. Inspect parts. Replace those found to be damaged.

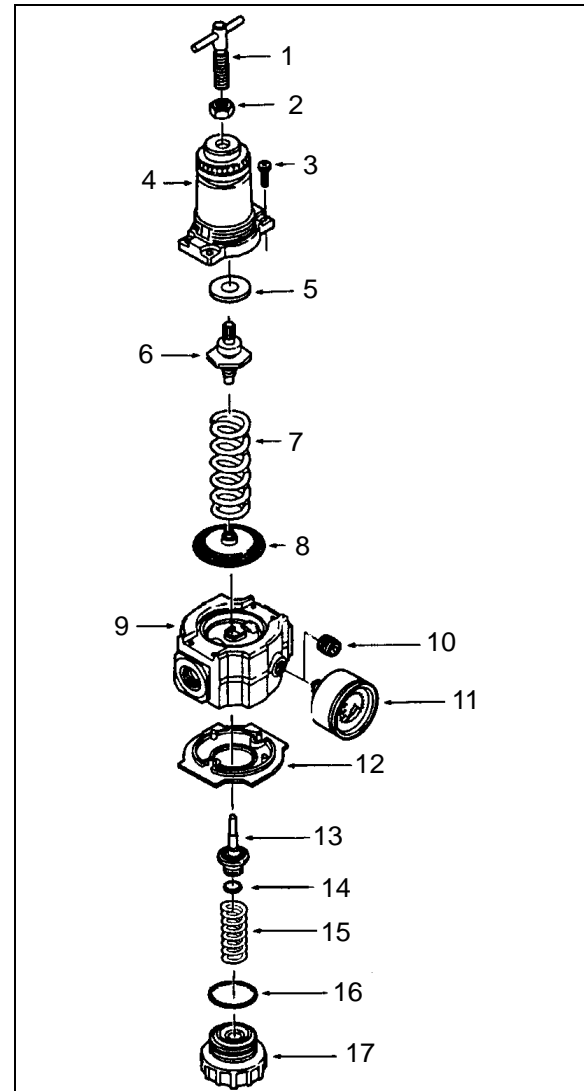


FIGURE 53: REGULATING VALVE 16035

10.3.4 Reassembly

1. Lubricate O-ring (14 and 16, Fig. 53), valve stem (13, Fig. 53), tip of adjusting screw (1, Fig. 53), and the outer circumference and both sides of the thrust washer (9, Fig. 53) with a light coat of good quality O-ring grease.

- Assemble the regulator as shown on the exploded view.

Torque Table	
Item	Torque in lbf-inch (Nm)
3 (Screw)	25-35 (2.8-3.9)
17 (Bottom plug)	20-25 (2.3-2.8)

11. LOW-BUOY SYSTEM

The purpose of the low-buoy system is to lower the whole suspension by about 4" (100 mm) in order to reduce the overall height for low clearances. This system can be put into service during normal vehicle operation.

11.1 PRINCIPLES OF OPERATION

On X3 coaches, the rear low-buoy is added over the front kneeling system. The control valve on the left console panel sends an electric signal from its pressure switch to control the front suspension as if kneeling. It also removes air from a relay valve that exhausts air supply to all leveling valves and the quick release in the rear section. Air from the rear suspension can then be depleted through the check valve-quick release assembly.

12. TROUBLESHOOTING

Condition	Cause	Correction
Bellows deflate over time	<ol style="list-style-type: none"> Defective check valve assembly. Defective exhaust valve assembly. Leak in air line and/or bellows. Defective valve cover, rubber O-rings or gasket. 	<ol style="list-style-type: none"> Replace check valve assembly. Replace exhaust valve assembly. Replace air line or bellows. Replace valve cover, O-rings or gasket.
Bellows raise to full height and fail to exhaust air pressure	<ol style="list-style-type: none"> A clogged exhaust screen in height control valve assembly. A combination clogged exhaust screen and defective air inlet valve assembly. 	<ol style="list-style-type: none"> Remove and clean screen. Clean exhaust screen and replace air inlet valve assembly.
Erratic valve action	<ol style="list-style-type: none"> Dirt or foreign matter in the air valve lever chamber. Defectives valves. 	<ol style="list-style-type: none"> Remove valve cover and blow out dirt. Install cover using new gasket. Overhaul height control valve assembly
Vehicle body fails to level to satisfactory ride height	<ol style="list-style-type: none"> Improper height control valve overtravel lever adjustment 	<ol style="list-style-type: none"> Adjust lever as directed.

Down:

The control valve, on the L.H. control panel, cuts off air supply, so air is released from air springs. A relay valve prevents height control valves from supplying air springs.

Up:

The control valve, on the L.H. control panel, supplies air to close the passage between both the delivery and supply ports. A relay valve opens and provides air springs until the suspension reaches the normal ride height.

11.2 MAINTENANCE

Refer to the air system schematic diagram "Opt. Front Kneeling With Rear Low-Buoy Combination" annexed at the end of this Section.

13. PARTS SPECIFICATIONS

Front suspension and tag axle air springs

Make..... Goodyear Tire and Rubber
Model.....1200
Type Mae West
Nominal diameter 12" (304 mm)
Supplier number.....1R12-319
Prévost number.....630125

Drive axle air springs

Make..... Goodyear Tire and Rubber
Model.....1100
Type Double Flare
Nominal diameter 11.5" (292 mm)
Supplier number.....1R11-088
Prévost number.....630104

Independent Front suspension shock absorbers

Make..... Arvin
Color.....Black
Piston Diam. 1 5/8 inch
Collapsed length 14.16 inches
Extended length 22.44 inches
Supplier number..... 680510-40J
Prévost number.....630136

I-Beam Front suspension shock absorbers

Make.....Sachs
Color.....Black
Type NUV45X230HA
Ext. Diam.....75 mm
Collapsed length 14.88" (378 mm)
Extended length23.86" (606 mm)
Supplier number..... 481700000206
Prévost number.....630254

Drive and tag axle shock absorbers

Make Sachs
Color Black
TypeN45X225HA
Ext. Diam. 75 mm
Collapsed length 15.51" (394 mm)
Extended length 24.37" (619 mm)
Supplier number481700000209
Prévost number 630253

Height control valve (Front only)

Make Barksdale
Quantity used..... 1
Supplier number 52321POAQ3-Q62
Prévost number 630157

Height control valve (Rear only)

Make Barksdale
Quantity.....2
Supplier number 52321POAQ3-Q26
Prévost number 630156

Bellows control and exhaust solenoid valve assembly

Make Norgren

Solenoid valve manifold

Supplier numberD0043B
Prévost number 641130

Coil

Voltage..... 24 V DC
Current draw29 amperes
Supplier number54932-27
Prévost number 641144

Valve (3 way, 2 positions)

Type N/C
 Supplier number 411-C-456235W
 Prévost number 641357
 Type N/O
 Supplier number 411-D-456236X
 Prévost number 641356

Radius rod bushing

Make Prévost
 Prévost number 630021

Loctite

Make Loctite
 Prévost number 680039

Sway bar bushing (Front Suspension)

Make Prévost
 Prévost number 630020

Sway bar link

Make Tennaco Automotive
 Supplier number 934400
 Prévost number 630230

Shock absorber bushings

Make Monroe
 Supplier number 45380
 Prévost number 630062

Air regulator

Make Norgren
 Recommended pressure sett. . 90 psi (621 kPa)
 Supplier number R74G-4AT-RMN
 Prévost number 641352

14. TORQUE SPECIFICATIONS

- 1- Shock absorber pin 500-550 lbf-ft (680-750 Nm)
- 2- Shock absorber pin nut 70-80 lbf-ft (95-110 Nm)
- 3- Radius rod stud 20-40 lbf-ft (27-54 Nm)
- 4- Radius rod retaining nut or bolt 110-130 lbf-ft lubricated (150-175 Nm lubricated)
- 5- Radius rod support nut 110-130 lbf-ft lubricated (150-175 Nm lubricated)
- 6- Axle attachment nut 425-475 lbf-ft (580-645 Nm)
- 7- Air spring stud nut 20-25 lbf-ft (27-34 Nm)
- 8- Sway bar link nuts 110-130 lbf-ft lubricated (150-175 Nm lubricated)
- 9- Sway bar bushing collar bolts 70-80 lbf-ft (95-110 Nm)

NOTE

During assembly, use "Loctite 242" (Prévost No 680038) with item 1 and 3. After assembly, apply "anti-seize compound" (Prévost No 680064) on all threads nuts.

Guideline to Evaluate Warranty Claims Heavy-duty Shock Absorbers

Index:

- 1) Inspection
- 2) Misting
- 3) Leakage
- 4) Noise – Rubber Bushings
- 5) Noise – Scratching Metal Dust Cover
- 6) Damping Performance

1) Inspection

It is recommended to inspect Sachs shocks visually during regular maintenance schedules, however at least:

- linehaul applications: every 100,000 miles
- vocational applications: every 50,000 miles

The visual inspection should include

- the shock itself (leakage, any irregularities)
- shock bushings
- tires (tire cupping)

The most common failures and their possible causes are compiled in this document. By understanding the cause you may be able to correct the problem, avoid future failures and ensure ride safety.

For further assistance please contact:

Sachs Automotive of America

(859) 647 – 84 47 Ivan Botello
or (248) 458 – 36 88 Jim C. King

Guideline to Evaluate Warranty Claims Heavy-duty Shock Absorbers

2) “Misting“

Appearance might be deceptive. A certain degree of vapor is normal and actually necessary for lubrication of the rod seal.

The inspection must not be conducted after drive in wet weather or a vehicle wash. Shock needs to be free from water.



“Misting“

OBSERVATION:

A precipitation of oil mist on the outside of the shock is visible.

Carefully touch shocks with dry finger. (Use caution: shocks may be hot!) If the finger remains dry, the shock is not leaking.

If in doubt, wipe shock clean and check again after a few days of operation.



CAUSE:

Oil vapor is necessary to lubricate the rod seal. At high operating temperatures this results in oil mist and precipitation.

EFFECT:

none

ACTION:

none

Guideline to Evaluate Warranty Claims Heavy-duty Shock Absorbers

3) „Leaker“

OBSERVATION

A shock is considered a „leaker“, if

- the reservoir tube (smaller diameter) is largely covered with oil
- finger gets wet, when touching shock (see „Misting“)



- after above finger test, shock exhibits a glossy film of oil and/or dirt, or an oil droplet forms on reservoir tube

- a film of oil is also visible in the upper area of the reservoir tube, after extension of the shock. If oil is only visible around the bottom, it likely stems from an outside source

CAUSE:

- worn, damaged or overheated seal



EFFECT:

- loss of oil
- loss of damping function
- loss of ride control and safety

ACTION:

replace leaking shock

Guideline to Evaluate Warranty Claims Heavy-duty Shock Absorbers

4) Noise - Rubber Bushings

Noise emitted during operation is not necessarily caused by defective shocks.

Therefore in case of noise issues:

Check all relevant suspension and axle components, e.g. rubber mounts, springs, jounce stops, bushings, steering.



Rubber bushing „worn“ or „deformed“

OBSERVATION:

- rubber bushing is visibly deformed or damaged
- eye (or „loop“) is eccentrically deformed
- sleeve is not centered within bushing

CAUSE:

- extensive use of rebound stop, incorrect ride height, shock may be too short for application
- extremely high conical angles, not suitable for this design

EFFECT:

noise, increased wear of shock and suspension

ACTION:

- verify ride height
- verify that shock is suitable for this application
- replace defective shock absorber



Guideline to Evaluate Warranty Claims Heavy-duty Shock Absorbers

5) Noise - Scratching Metal Dust Cover

Noise emitted during operation is not necessarily caused by defective shocks.

Therefore in case of noise issues:

Check all relevant suspension and axle components, e.g. rubber mounts, springs, jounce stops, bushings, steering.



„Metal dust cover scratches reservoir tube“

OBSERVATION:

- Paint scratched off reservoir tube

CAUSE:

- suspension is misaligned, shock is under unintended lateral or longitudinal preload

EFFECT:

- noise
- corrosion of reservoir tube
- subsequently wear of rod seal, leakage and loss of function

ACTION:

- check suspension, while vehicle is at design height
- replace shock only, if significant amount of paint is already scratched off or loss of oil is visible



Guideline to Evaluate Warranty Claims Heavy-duty Shock Absorbers

6) Degradation of Damping Performance

It is impossible to verify the correct damping characteristic of a shock absorber without a dynamometer. In the field, the following, more practical test can help to identify a shock, which is suspected to have failed:

- 1) Conduct test few minutes after operating the vehicle
- 2) Touch a metal element of the chassis to determine a reference temperature
- 3) Carefully touch the shock reservoir tube (lower tube, smaller diameter) on either side of the same axle to measure temperature of shock absorbers
- 4) Both shocks should be
 - warmer than the original reference point
 - similar in temperature
- 5) A cool or significantly colder shock absorber likely is a failure and needs to be replaced
- 6) After removal from the vehicle, the following may hint to the cause of failure:
 - Manually stroke shock several times in vertical position: no or delayed resistance would indicate a loss of damping force.
 - Shake shock upside down: rattling would indicate a broken internal component
- 7) A final determination can only be made by the manufacturer, using a dynamometer

Other indicators of damping force degradation include:

- a) ride deterioration
- b) deteriorated rubber attachments
- c) uneven tire wear („tire cupping“)
- d) excessive vibrations and premature wear on other vehicle components

EFFECT: Reduced ride control, comfort and safety

ACTION: Replace shock absorber

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1 VEHICLE EXTERIOR VIEW

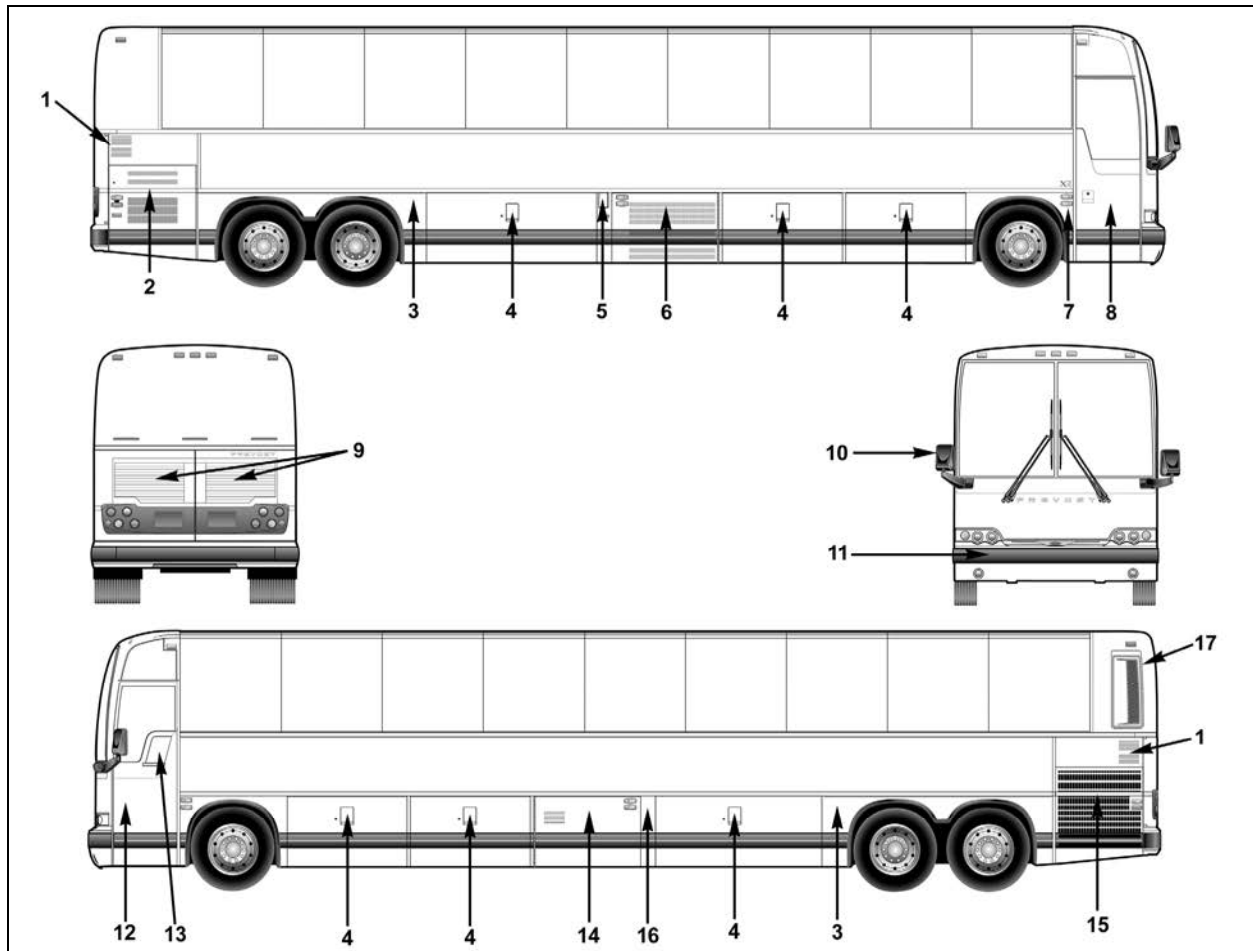


FIGURE 1: X3 COACHES EXTERIOR VIEW

18606

- | | |
|--|---|
| 1. Engine air intake | 17. Diesel Particulate Filter (DPF) compartment access door |
| 2. Engine compartment curb-side door | |
| 3. Hinged rear fender | |
| 4. Baggage compartment | |
| 5. Fuel filler door | |
| 6. Condenser compartment | |
| 7. Entrance door control switch | |
| 8. Entrance door | |
| 9. Engine compartment rear doors | |
| 10. Rear-view mirrors | |
| 11. Spare wheel compartment | |
| 12. Front electrical and service compartment | |
| 13. Driver's power window | |
| 14. Evaporator compartment | |
| 15. Radiator door | |
| 16. Rear electrical compartment | |

2 VEHICLE STRUCTURE

The body of the X3 vehicles is an integral structure made of 14, 16 and 18 gauge welded and braced high tensile steel and stainless steel members. All stainless exterior panels are glued to anti-corrosion coated members. The complete structure is protected against corrosion prior to assembly. The front and rear caps are made of molded fiberglass. The main roof is made of high tensile aluminum panels riveted to the roof structure. The floor is made of 2 layers of ½" (13 mm) thick plywood separated by a 1/8" (3 mm) insulation to reduce power train and road noises.

Welding

Since welding is a procedure that may be carried out either as specific instructions from Prévost or by an independent decision of the owner, the following information pertaining to welding should be read before beginning any welding procedure. The prohibitions and requirements outlined below must be followed during welding procedure:

1. Welding must be done only by a qualified and experienced person.
2. Adequate ground contacts and shields must be positioned as required to protect components from damage due to heat, contact by weld splatter, arcing, or other potentially damaging events associated with welding.
3. The following precautions are to be taken to protect the electronic control components. Refer to section 00, paragraph 3: "PRECAUTIONS TO BE OBSERVED BEFORE WELDING" in this manual.
4. Always wear the appropriate safety equipment.
5. Weld in clean and well ventilated area, and always have an appropriate fire extinguisher within your reach.

3 VEHICLE EXTERIOR MAINTENANCE

Regular washing to remove dust and dirt is recommended. See "*Operator's Manual*" for more details on washing and cleaning your vehicle.

3.1 CORROSION PREVENTION

Preventive maintenance is a key factor in avoiding corrosion and must be considered as part of the regular service intervals. The entire

underside of the vehicle is sprayed with a heavy application of asphalt base undercoating.

The operating environment the vehicle is subjected to will largely influence the amount of dirt and corrosion that will accumulate over a given period. Corrosion is one of the most costly factors of part failure and shortened part life. It is, however, an item that can be controlled when it is conscientiously looked after and the proper steps are taken in a timely manner.

Certain areas of the coach are more vulnerable to corrosion than others, and it is these areas that should be addressed. For example, the rear baggage compartment bulkhead in the rear wheelhousing area contains many key components and should be examined regularly for corrosion. Other areas include the front wheelhousing area and the engine compartment.

Road splash will affect undercarriage, condenser coil and engine compartment. These areas must be thoroughly cleaned to remove dirt accumulations from flanges, channels and ledges. These places accumulate dirt and salt and hold it in direct contact with steel and aluminum surfaces. Use an understructure high pressure spray as part of a regular wash. Damaged undercoating or paint should be promptly repaired before corrosion can start. Frequency of wash periods depends on operating conditions. During periods of exposure to salt, daily washing as described above is recommended. If underbody parts show evidence of rust or corrosion, treat as follows:

1. Remove dirt, grease and oil by solvent washing.
2. Remove corrosion as well as all loose coating by cleaning with a wire brush or sandblasting.



CAUTION

Sandblasting can be used for cleaning bulkheads, brackets and other structural members. It should not be used for exterior side paneling. Extreme care should be taken not to sandblast excessively.

3. Apply correct primer, paint and undercoating after removing all corrosion to prevent further damage.

3.2 PREVENTIVE MAINTENANCE SCHEDULE

NOTE

TECTYL 185 GW rust inhibitor may have been applied on your vehicle underbody as an option, if this is the case, follow this procedure thoroughly. For future application of product, refer to paragraph 3.3 in this section.

DESCRIPTION	INTERVALS		MAINTENANCE	CORRECTIVE ACTION	REFERENCE
	MONTHS	KM MILES			
BODY, EXTERNAL WINDOW FRAME	6	40 000 25 000	VISUALLY INSPECT SEALING BEADS CONDITION	REPAIR OR REPLACE SEALING BEADS IF NECESSARY	
VEHICLE UNDERBODY	12	100 000 60 000	USE A LOW PRESSURE SPRAY TO CLEAN UNDERSTRUCTURE AND VISUALLY INSPECT FOR CALCIUM DEPOSIT, CORROSION OR ANY DIRT ACCUMULATED ONTO EXPOSED SURFACES. VISUALLY INSPECT SEALING BEADS CONDITION. VISUALLY INSPECT IF UNDERFLOOR IS PEELING. VISUALLY INSPECT WHEELHOUSING COATING. MAKE SURE DISCHARGE TUBES ARE FREE FROM OBSTRUCTIONS	APPLY UNDERCOATING LOCALLY AS NECESSARY. APPLY UNDERCOATING LOCALLY AS NECESSARY REMOVE ANY OBSTRUCTION OR REPLACE DEFECTIVE TUBE	
SUSPENSION AND UNDERSTRUCTURE	12	100 000 60 000	VERIFY THE CONDITION OF ALL SUSPENSION AND UNDERSTRUCTURE FASTENERS AND CLAMPS	TIGHTEN OR REPLACE DEFECTIVE OR MISSING FASTENERS	
FLOOR COVERING	3	20 000 12 500	VISUALLY INSPECT IF FLOOR COVERING IS SHOWING SIGNS OF DETERIORATION SUCH AS CUTS, BURNS, ETC. ALSO, VISUALLY INSPECT SEALANT ALONGSIDE TRACKS. INSPECT WALL PANELS FROM BOTTOM TO WINDOWS	REPAIR OR REPLACE DEFECTIVE COVERING. MAKE SURE PROPER SEALANT IS USED.	
FLOOR CLEANING			CLEAN FLOOR COVERING AS NECESSARY		

**WARNING**



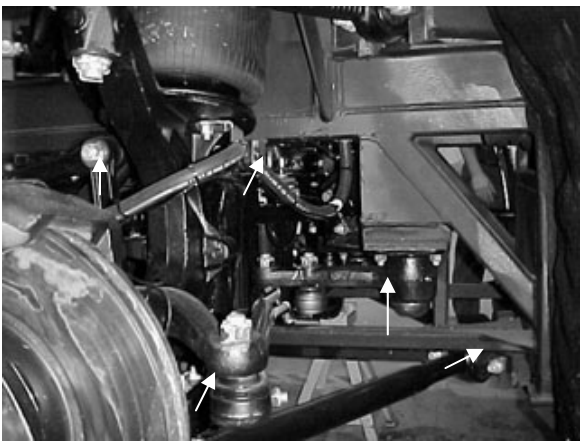
Failure to follow this preventive maintenance schedule will result in warranty void.

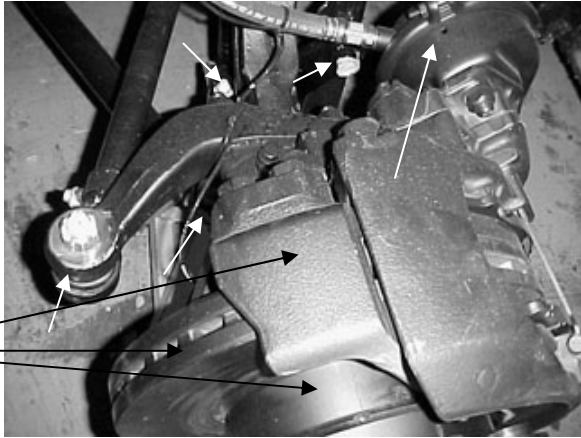
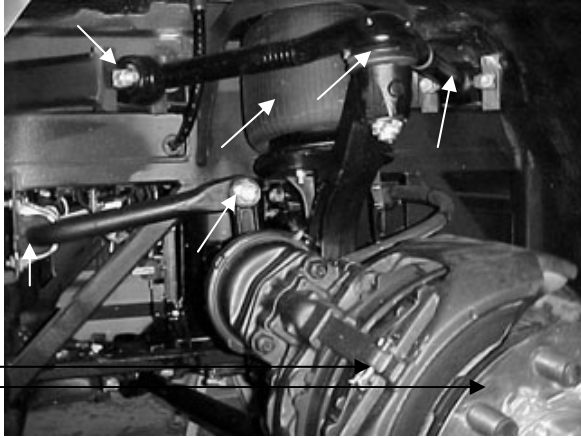
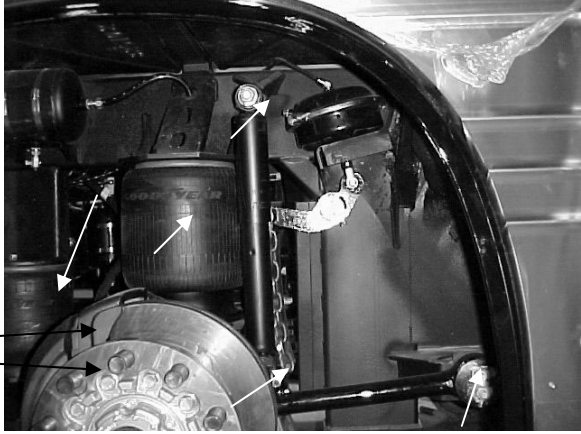
3.3 RUST INHIBITOR APPLICATION

Material: Tectyl 185 GW
R1KG21

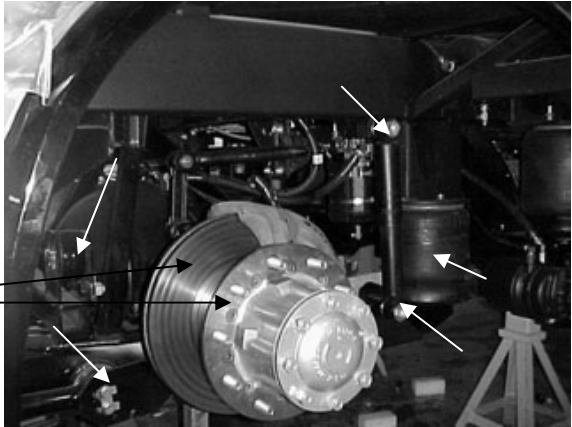
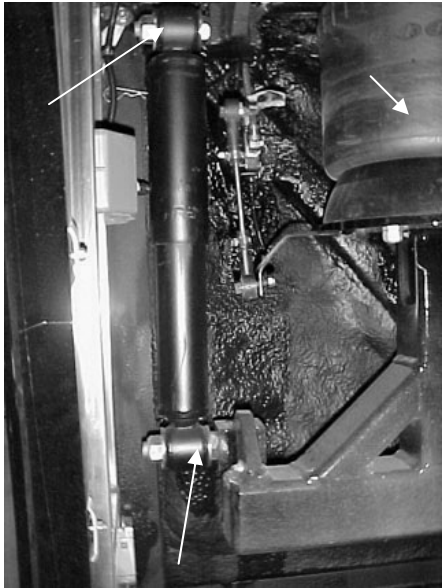
Safety Rules: Use safety glasses
Supplied air hood
Solvent-resistant rubber gloves

Section 18: BODY

<p>1.0 Wash both wheelhousing mechanical parts before masking.</p>	<p>A water-hose nozzle is recommended. Water may be hot to reduce washing time especially during winter. If parts are soiled with oil, clean using R1KG21. Avoid rubber parts.</p>
<p>2.0 Dry all water sprayed parts. Surface temperature and dew point must be respected before applying rust inhibitor.</p>	<p>Air pressure system may be used, refer to annex 1 for surface temperature and dew point.</p>
<p>3.0 Front wheelhousing a) Mask all rubber joints. Braking system must also be protected (refer to arrows). Commercial aluminum foil may be used for masking.</p>	
<p>3.1 Front wheelhousing Front view</p>	
<p>3.2 Front wheelhousing</p>	

<p>3.3 Front wheelhousing</p> <p>(Entire braking system)</p>	
<p>4.0 Rear wheelhousing</p> <p>a) Mask all rubber joints. Braking system must also be protected (refer to arrows). Commercial aluminum foil may be used for masking</p> <p>(Entire braking system)</p>	
<p>4.1 Rear wheelhousing</p> <p>(Entire braking system)</p>	

Section 18: BODY

<p>4.2 Rear wheelhousing</p> <p>(Entire braking system)</p>	
<p>4.3 Rear wheelhousing</p>	
<p>5.0 Close off wheelhousing using masking paper.</p>	<p>Prevent rust inhibitor from coming in contact with paint. To close off wheelhousing, a polythene sheet may be used.</p>
<p>6.0 Apply TECTYL 185 GW black rust inhibitor onto wheelhousing mechanical parts.</p>	<p>A spray gun and pumping system are required to apply the rust inhibitor. If the application is done inside a paint room, select high speed ventilation. Minimum required thickness is 10 mils wet or 5 mils dry.</p>
<p>7.0 Remove all masking material 30 minutes after application.</p>	

ANNEX 1

1. Check and confirm that dew point and surface temperature are in accordance with to the following criteria:
 Surface temperature > 10°C
 Surface temperature > or = to dew point + 3°C

NOTE

Use the following table to determine dew point.


2. Check and confirm that TECTYL temperature is between 10°C and 35°C.

DEW POINT

	Relative Humidity (%)									
	10	20	30	40	50	60	70	80	90	100
Temp (c)										
0	---	-16	-11	-8	-5	-3	-1	0	1	3
1	---	-15	-10	-7	-5	-3	-1	1	2	4
2	---	-14	-10	-6	-4	-1	0	2	3	5
3	---	-13	-9	-5	-3	-1	1	2	4	6
4	---	-13	-8	-5	-2	0	2	4	5	7
5	---	-11	-7	-4	-1	1	3	5	6	8
6	---	-11	-8	-3	0	2	4	6	7	9
7	-18	-10	-6	-2	0	2	5	6	8	10
8	-17	-9	-5	-1	1	4	6	7	9	11
9	-16	-9	-4	-1	2	4	6	9	10	12
10	-16	-8	-3	0	3	5	7	10	11	13
11	-15	-7	-3	1	4	6	9	10	12	14
12	-14	-6	-1	2	5	7	10	11	13	15
13	-14	-6	-1	2	6	8	10	12	14	16
14	-13	-5	0	4	6	9	11	14	15	17
15	-12	-4	1	4	7	10	12	14	16	18
16	-11	-4	1	5	9	11	13	15	17	19
17	-10	-3	2	6	9	12	14	16	18	20
18	-10	-2	3	7	10	13	15	17	19	21
19	-9	-1	4	8	11	14	16	18	20	22
20	-9	0		5	9	12	15	17	19	21 23
21	-8	0		5	10	13	16	18	20	22 24
22	-7	1		6	11	14	16	19	21	23 25
23	-6	2		7	11	15	17	20	22	24 26
24	-6	2		8	12	16	19	21	23	25 27
25	-5	3		9	13	16	20	22	24	26 28
26	-4	4		10	14	17	20	23	25	27 29
27	-4	5		11	15	19	21	24	26	28 30
28	-3	6		11	16	19	22	25	27	29 31
29	-2	6		12	17	20	23	26	28	30 32
30	-1	7		13	17	21	24	27	29	31 33
31	-1	8		14	19	22	25	27	30	32 34
32	0	9		15	20	23	26	29	31	33 35

4 COMMON FIBERGLASS REPAIR PROCEDURE

All repairs to fiberglass parts consist of filling the damaged area with fiberglass cloth and resin or strand fiberglass and resin. The repair is allowed to harden, and then finishing operations may be performed. Use of the various materials is determined by the type of repair to be made. Large holes, torn sections and separate joints require the adhesive qualities of the resin and the reinforcing qualities of the fiberglass. Small dents, scratches or pits can be repaired using resin and strand fiberglass and filler mixed into paste. Instructions for either mix are explained under their respective headings in this section. For best results when making repairs, temperature should be between 70 and 75°F (21-24°C). Some people experience a skin reaction to resins. In such cases, wipe resin off with denatured alcohol or a good thinner. Use of protective hand cream is recommended.

	WARNING
Always wear a respirator and goggles when grinding or sanding.	

Extreme care must be taken if the sander is electrically operated, as dust from some resins is combustible when subjected to sparks or open flames. The proper tool for sanding resin is a low speed, air driven disc sander with a water attachment or a dry sander having a vacuum bag. Either will eliminate flying glass and resin dust.


The following additional tools and materials will assist in making repairs: hacksaw blade, assorted files, emery paper or cloth (150 or finer), scissors or tin snips, wax paper or cellophane sheets, a 3" (75 mm) paint roller, paint brush, putty knife, acetone and one or more heat lamps.

4.1 REPAIR USING FIBERGLASS CLOTH

Where necessary, sand paint away around damaged area and scrape away undercoating, if any, and wipe clean with solvent. Grind or file the damaged area to form a "V" at the broken or cracked portion. Sides of "V" should have a shallow pitch for maximum bonding area.


NOTE
<i>Roughening the surface improves adhesion of resin.</i>

If part is warped from original shape, use clamping equipment to straighten the surface. Preheat area to be repaired with one or two heat lamps placed 18 to 24 inches (450-610 mm) from repair.

	CAUTION
Temperature should not exceed 140 °F (60 °C) during 30 minutes in order to avoid distortion.	

Cut fiberglass cloth with scissors or tin snips, 1 to 3 inches (25-75 mm) larger than area to be repaired. Build area to desired height.

Mix resin and hardener following instructions on their containers. Saturate layers of fiberglass with mixture and place laminates over damaged area. Smooth out wrinkles and make sure general contour of area is maintained. Bubbles and wrinkles can be eliminated with a roller.

	CAUTION
The pot life of the mix is approximately 15 minutes. Any accidental contamination to the skin, clothing, tools, etc. must be removed within this period. Use acetone to remove uncured resin.	

Heat resin material again by placing heat lamps 18 to 24 inches (450-610 mm) from repaired area. Allow 12 to 15 minutes for repair to cure. After repair is cured, grind, file or sand to contour. Files other than body files may be more suitable. Featheredge and finish sanding.

If small pits or irregularities appear after making repair, correct by using a liberal amount of chopped strand or filler mixed with resin to form a paste. Refer to heading "*Repair using Fiberglass Paste*" in this section.

4.2 REPAIR USING FIBERGLASS PASTE

Fiberglass paste is used for repairing small dents, scratches, and pits. Paste is made by mixing resin, hardener and fiberglass strand or filler to the consistency of putty. Where it may be necessary, sand paint away around damaged area. On underside of coach, scrape away undercoating from damaged area, and wipe clean with solvent.

Preheat the area to be repaired using heat lamps. Mix desired quantities of resin and hardener according to manufacturer's instructions. Add powdered fiberglass strand into mixture to thicken it into a putty state.

NOTE

If repair is made on a vertical surface, adding powdered filler material to mixture will reduce tendency of hot resin to flow or run.

Apply the material with a putty knife or similar object, building material up to the desired contour. For deep filling and on vertical surfaces, several layers of material may be used.

A hacksaw blade, held flat to adjacent contour and then moved in a sawing action across the repair when the resin is in a gel state, will remove excess resin from repair. Finish repair with the same procedure as when using fiberglass cloth.

4.3 TYPICAL FIBERGLASS REPAIR PROCEDURE

Remove all loose particles or damaged material using a power sander or rasp. Clean area, overlapping hole approximately 1" to 1-½" (25-40 mm) all around. Remove all dirt, grease and paint from area to ensure good bonding surface. Feather the cleaned area all around (Fig. 2).

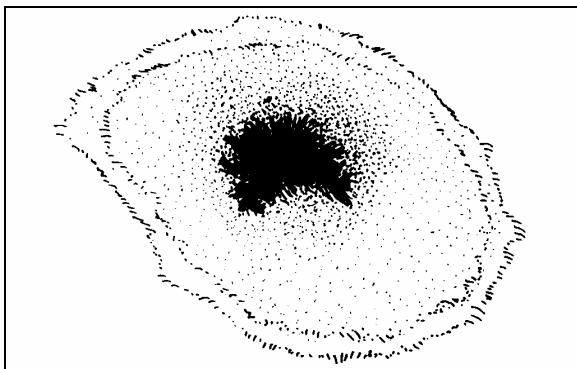


FIGURE 2: FIBERGLASS REPAIR

18089

Cut a piece of fiberglass mat slightly larger than area being repaired. Impregnate mat with general purpose polyester resin catalyzed normally. Use a clean paint brush to apply the polyester resin. Apply impregnated mat over hole and press onto surface with brush to obtain good adherence. Another coat of general purpose polyester resin can be applied at this time (Fig. 3).

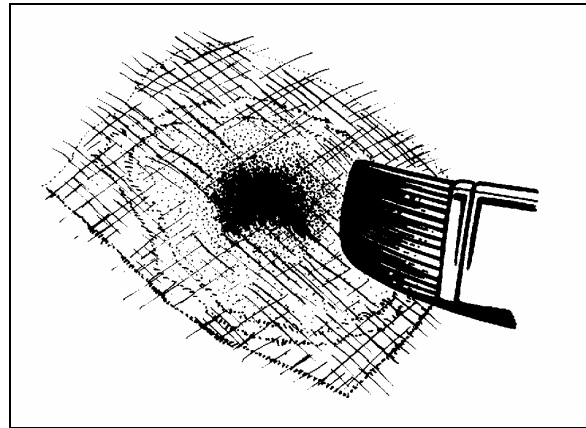


FIGURE 3: FIBERGLASS REPAIR

18090

NOTE

Remove all air between surfaces being joined. Allow area to harden and sand surface to remove any wax.

Apply another mat, followed by a cloth patch, and another mat. All layers must be thoroughly impregnated with polyester resin, brushed well and free of air. Apply more layers of mat and cloth as required until the desired strength and thickness is obtained, minimum two 1-½ oz (43 g) mats and one 9 oz (255 g) cloth (Fig. 4).

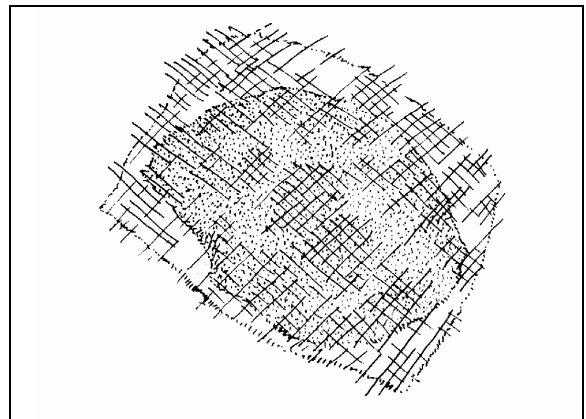


FIGURE 4: FIBERGLASS REPAIR

18091

Allow area to harden and contour the area with coarse sandpaper #100 (Fig. 5).

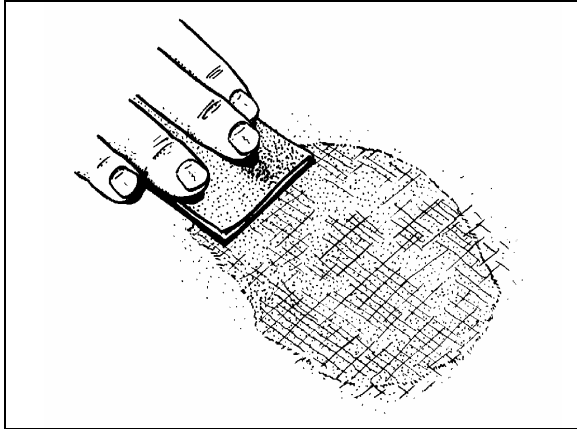


FIGURE 5: FIBERGLASS REPAIR 18092

Cover the area with a layer of resin putty and allow drying for approximately 15 to 20 minutes (Fig. 6).

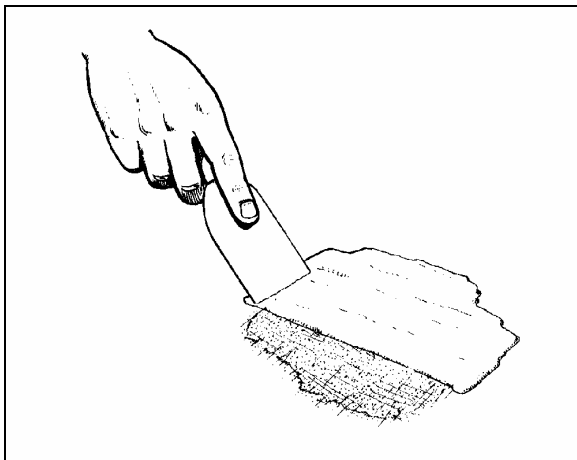


FIGURE 6: FIBERGLASS REPAIR 18093

Smooth off surface with coarse sandpaper #100 to desired shape. Further smooth surface with fine sandpaper #120 until repaired surface matches surrounding area paneling. Prime and paint the area to match surrounding paintwork.

5 COMMON PAINTING PROCEDURE

5.1 NEW PAINT CARE

Our paint supplier recommends that you follow these simple precautions the first months of your new vehicle's life.



CAUTION

Apply these recommendations after repainting vehicle.

During the first 30 days:

- Do not use a commercial bus wash. Stiff brushes or sponges could mar the finish and damage the surface. Wash the vehicle by hand only and with cool water and a very mild bus wash solution. Be careful to use only a soft cloth or sponge;
- Wash vehicle in the shade, never in direct sunlight;
- Do not "dry wipe" vehicle –always use clean water. Dry wiping could scratch the finish;
- Avoid extreme heat and cold. Park vehicle in the shade whenever possible;
- Do not park under trees which drop sap or near factories with heavy smoke fallout. Tree sap and industrial fallout may mar or spot a freshly painted surface;
- Trees are also likely to attract birds. Bird droppings are highly acidic and will damage a freshly painted surface. Bird droppings, tree sap and industrial fallout should be washed off as soon as possible;
- Do not spill oil, gasoline, antifreeze, transmission fluid or windshield solvent on new finish. IMMEDIATELY rinse off any such spill with clean water, DO NOT WIPE;
- Do not drive on gravel roads. Paint finish easily chips during the first 30 days;
- Do not scrape ice or snow from the surface. A snow scraper can act like a paint scraper if the finish is new. Brush off loose material with a soft snow brush.

During the first 90 days:

- Do not wax or polish the vehicle. This will allow the finish to dry and harden completely.


5.2 PAINT TOUCHUP

When paint touchup or partial repainting is necessary, refer to the vehicle's paint scheme for color codes and paint brand.

Prévost recommends using the original paint brand to ease color matching.

In the event you sand through to the gelcoat surface you should prime the area with Stodex "Non Stop Fill Primer (ST-11000)".

If you sand through to metal surface, first prime with Standox “Etch Primer (ST-11858)” then with Standox “Non Stop Fill Primer (ST-11000)”.

 CAUTION
Be sure to heed all paint manufacturer's recommendations, especially concerning paint dilution and application.

5.3 PAINTING

The standard paint used on the exterior of the vehicle is Standox Basislack. It is a high gloss polyurethane enamel finish designed for exposure to extreme conditions. Other types of paint may be called for as options by owner but are not dealt with in this section.

5.3.1 Safety

Care should be exercised in storing, handling, mixing, and applying paint and chemicals listed in this manual. The topcoat, primer, solvent, catalysts, accelerators, and cleaners are highly volatile and/or toxic if not properly used. Observe all safety instructions marked on the different packaging, as well as the following:

1. Do not smoke in the paint room or in adjacent area exposed to residue fumes.
2. Wear respirators approved by the governing safety and health regulations.
3. Maintain adequate ventilation at all times.
4. Dispose of any leftover paint mix properly.
5. Wear rubber gloves, rubber apron, and face shield during all phases of paint and chemical handling.

5.3.2 Surface Preparation And Paint Application

	Aluminum and / or Stainless Steel	Fiberglass	Comments
Surface Preparation	Sand using P-150 grit sandpaper. It is recommended to sandblast rivets and panel edges with OLIMAG 35-70 blast media.	Sand using P-180 or P-240 sandpaper.	Do not use paint remover over aluminum or fiberglass.
Cleaning	STANDOX silicone remover ST-11654 (68-2989)		
Priming	STANDOX Reactive Etch Primer ST-13908 * Wait 30 minutes then apply STANDOX Non-Stop Fullprimer ST-11000 (68-2973)	STANDOX Non-Stop Fullprimer ST-11000 (68-2973)	Refer to product Technical Data sheet for proper mixing
Basecoat	Refer to paint scheme or coach record for proper color code and paint brand. We recommend using the same paint brand to ease color matching.		Refer to product Technical Data sheet for proper mixing
Clearcoat	STANDOX 2K MS Rapid Clear ST-11760 (68-2979) Allow 16 hours for drying		Refer to product Technical Data sheet for proper mixing

If assistance or technical information on STANDOX products is needed, please dial: 1 (800) 551-9296

Section 18: BODY

6 GENERAL DESCRIPTION

The following procedures explain the steps to be followed for proper repair, installation and replacement for various doors, panels and windows. The paragraph divides the vehicle into zones to facilitate the search; each zone is then sub-divided into components.

Refer to the appropriate zone then component for complete procedure.

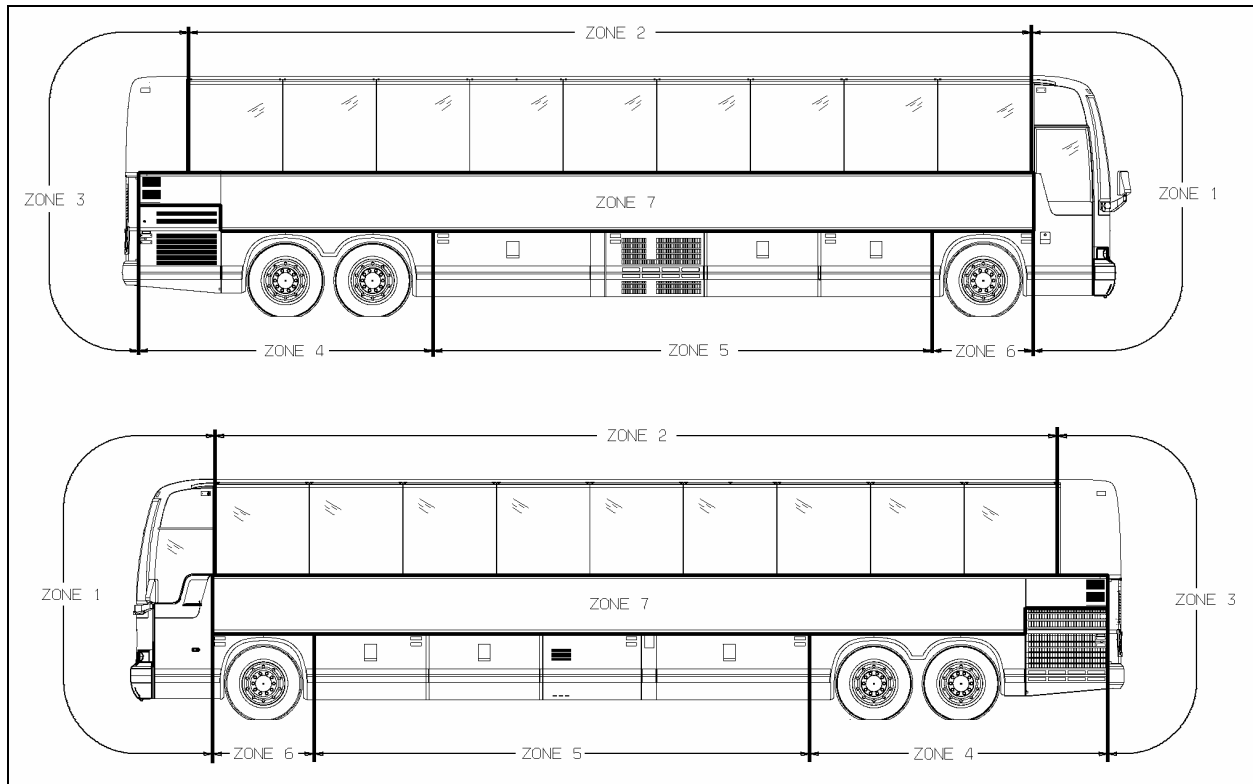


FIGURE 7: X3 COACHES ZONING

18623

7 ZONE 1

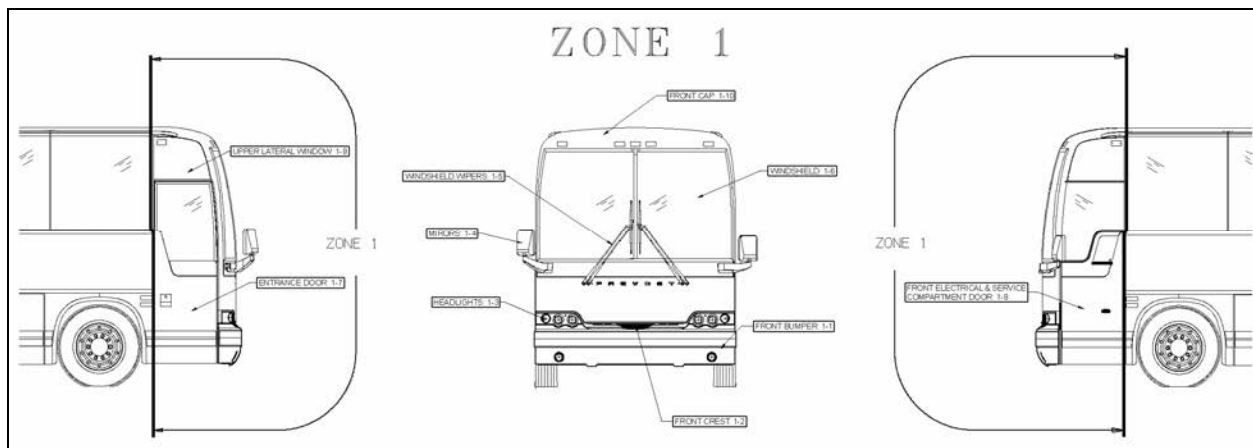


FIGURE 8: ZONE 1

18624

7.1 FRONT BUMPER

The front bumper is hinged to give access to the spare wheel and tire compartment. Pull the

handle located in the front service compartment to open the spare wheel and tire compartment. Bumper must first be tilted down before its removal. Two people are required to remove

and install the front bumper. Safely support the bumper and remove the two bolts on each bumper side to separate the bumper from the spare wheel compartment door. To install bumper, reverse the removal procedure.

WARNING

Front bumper is heavy. Use proper lifting equipment to support the bumper during the removal and installation operations to avoid personal injury.

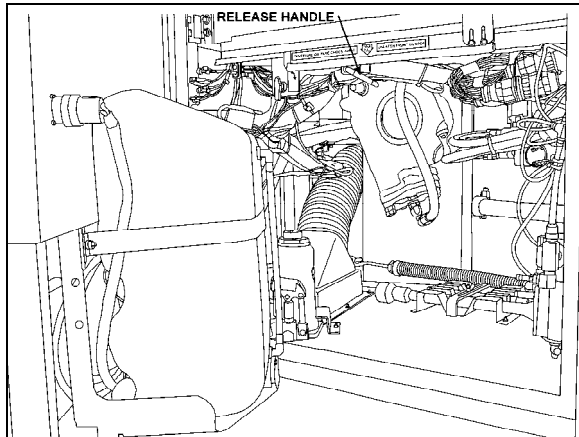


FIGURE 9: FRONT BUMPER RELEASE HANDLE 18613

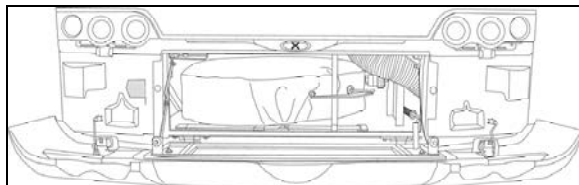


FIGURE 10: FRONT BUMPER 18614

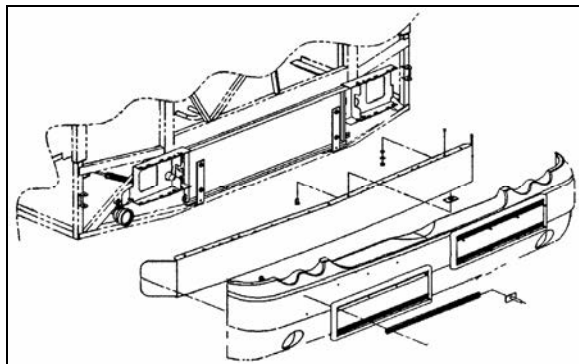


FIGURE 11: FRONT BUMPER REMOVAL 18565

7.2 FRONT CREST

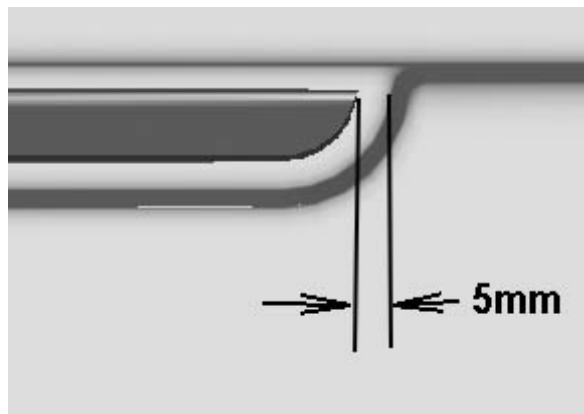
- Use a Chix cloth and anti-silicone to clean the surface where the crest will be applied.

CAUTION

Do not exceed the crest dedicated surface.



- Peel the back from the self adhesive crest side pieces.



- Peel the back from the self adhesive crest center piece. Center crest and apply.
- Compress the crest three pieces using your hands.



7.3 HEADLIGHTS

Refer to Paragraph 9.1 Headlights, included in Section 06: Electrical of the Maintenance Manual for complete information on headlights.

Section 18: BODY

7.4 REAR VIEW MIRRORS (RAMCO)

Your vehicle is equipped with two exterior mirrors.

The mirrors may be equipped with an optional electric heating system which serves to minimize ice and condensation on the mirror glass in extreme weather conditions. Integral thermostats are installed in both mirrors to avoid continuous heating. Use the appropriate switch on the dashboard to activate the defroster system on both mirrors simultaneously. The mirrors can easily be adjusted by using the remote controls located on the L.H. side control panel. The mirrors have easy to replace glass in case of breakage. Remote control motors can also be replaced.

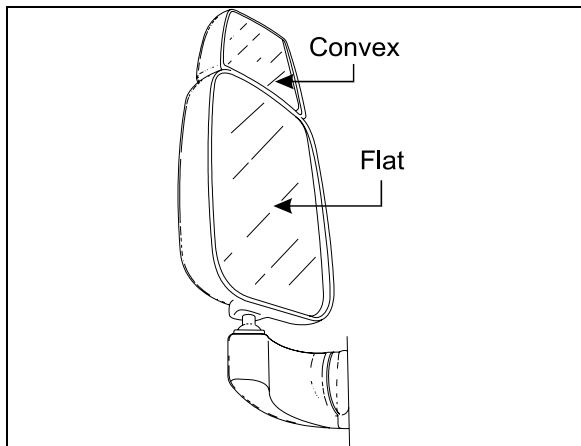


FIGURE 12: REAR VIEW MIRROR (RAMCO) 18398A

7.4.1 Adjustment

At the base of the mirror arm, loosen the mounting bolt to swing arm in or out.

To pivot the mirror head, loosen the setscrews on each side of the ball stub at the base of the mirror head to facilitate the adjustment.

7.4.2 Disassembly

At end of mirror arm, loosen the setscrews to relieve tension on the ball stem. Remove the ball stem from the arm.

Remove the four screws fastening the mirror arm base to the coach.

7.4.3 Assembly

Mount the mirror arm base to the coach. Insert the ball stem into the mirror arm and tighten the socket setscrews.

NOTE

Position the ball cup halves so the joint between them lies on the centerline of the arm. Ensure that the setscrews are not on the joint between the cup halves.

7.4.4 Replacement of Mirror Glass

Remove the broken glass.

Position new glass in mirror head and press to lock the Velcro in place.

7.4.5 Heated / Remote Controlled Rear View Mirrors

Heated/remote controlled external rear view mirrors may be provided to prevent the mirrors from frosting up in cold weather.

The remote controlled external rear view mirrors attach to support arms using a pivot collar secured by setscrews. Loosening the setscrews allows the whole head assembly to turn on the support arm for initial adjustment. A mounting bolt and washer hold the arm support to the mounting bracket. The arm support can be moved to position the mirror head into or away from the coach body.

The mirror heat switch is located to the left of the driver on the dashboard. This switch must be activated before the mirror heating element will energize. Once energized, the mirror heating element is kept at a sustained temperature (between 60-80°F) by a thermostat. Refer to wiring diagram annexed in the technical publication box.



CAUTION

Do not attach stick-on type convex mirror accessories to the heated mirror glass. This could impede uniform heat distribution on the mirror surface which could break the mirror.

Mirror Control

The remote control pointer knob(s) for the mirrors is (are) mounted on the L.H. side control panel. The harness to the mirror head runs through the arm support. The remote motor is mounted to the mirror head behind the mirror glass.

Turn pointer knob to the left for mirror head adjustments and to the right for convex mirror adjustment, then push down on either of the

button's (4) sides to adjust the selected mirror viewing angle.

Disassembly

At end of mirror arm, loosen the setscrews to relieve tension on the ball stud. Remove the ball stud. Remove the ball stud from the arm and gently pull the harness out until the connector is exposed.

Remove the four screws fastening the mirror arm base to the coach. Slide the harness free of the mirror arm base.

Assembly

Attach a stiff wire (snake) to the end of the harness and insert the wire through the mirror arm base and arm, gently pull the harness through the arm and disconnect the "snake". Connect the mirror head harness. Insert the harness connector back into the mirror arm. Insert the ball stud into the mirror arm and tighten the socket setscrews.

NOTE

Position the ball cup halves so the joint between them lies on the centerline of the arm. Ensure that the setscrews are not on the joint between the cup halves.

Convex & Flat Mirror Removal

The mirror glass assembly is mounted to the control mechanism or to mirror base with Velcro strips. Remove the mirror glass by gently pulling the lens to release the Velcro. Disconnect the heater grid at the two connectors.

Connect the connectors of the new mirror's grid to the harness. Install the lens by positioning the lens in the mirror frame and pressing to lock the Velcro in place.

7.5 WINDSHIELD WIPERS

Refer to Paragraph 23.8 Windshield Wipers and Washers, included in Section 23: Accessories of the Maintenance Manual for complete information on windshield wipers.

7.6 WINDSHIELD

For the removal or installation of windshield, you will need:

A rope,
A plastic spatula to lift the rubber seal lip,

A metal rod or screwdriver to clean the seal groove,

A filler insertion tool,

Goggles and protective gloves.

- From inside of vehicle, remove center post and interior finishing panels surrounding the windshield. In this case, we are replacing the R.H. side windshield.
- From outside of vehicle, remove filler located inside rubber seal to ease damaged windshield removal.
- From inside of vehicle, push against the top L.H. side corner of windshield for the removal of a R.H. side windshield. If the L.H. side windshield had to be removed, you would have to push against the top R. H. side corner.

NOTE

We are referring to the L.H and R.H. side as viewed from the inside of the vehicle.

- At the same time, another person gradually lifts the rubber lip from the vehicle exterior using a plastic spatula from top to bottom.
- Remove the entire damaged windshield and broken glass if applicable.
- If applicable, using a screwdriver or metal rod, remove black butyl sealant residue from rubber seal then clean with Sika 205.

7.6.1 Windshield Installation

NOTE

Rubber seal may have to be replaced if it was used on several windshield replacements.

- Spray rubber seal with soapy water to ease windshield insertion.
- Insert rope into rubber extrusion leaving enough length at each corner to make a loop. Spray soapy water onto rope and rubber extrusion (Fig. 7).
- Slide windshield into rubber seal groove starting with the bottom curved side edge. Using a plastic spatula, move the rubber seal lip aside to gradually insert the windshield into the groove.
- Spray soapy water on a regular basis to ease this operation.

Section 18: BODY

- Using the same type of plastic spatula, repeat the same operation from inside of vehicle, gradually inserting the windshield into the groove.

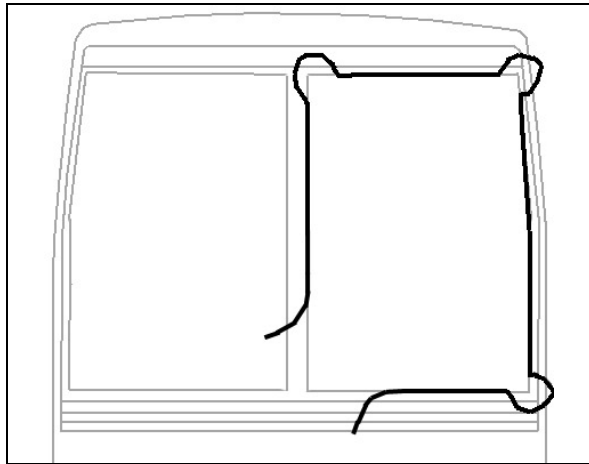


FIGURE 13: WINDSHIELD INSTALLATION USING ROPE

NOTE

Make sure windshield bottom edge is well inserted into the rubber seal groove before proceeding with the sides.

- Then, working from both sides of windshield bottom to top, gradually move the rubber seal lip aside to insert the windshield into the groove. Use also soapy water on the inside of vehicle to insert the windshield into the rubber seal groove.
- Insert the top curved corner then finish with the top of windshield.
- At the top of windshield, clean surface between fiberglass and rubber extrusion using Sika 205 (Fig. 9).
- Apply Sika 221 black between fiberglass and rubber extrusion
- Spray filler and rubber seal groove generously with soapy water.
- Using the special filler insertion tool, insert the filler into the rubber seal groove.
- Gradually insert filler into the rubber seal groove ensuring to leave a 2 inch excess length at the filler extremity.
- Every 6 inches or so, it is important to compress the filler due to its tendency to contract during drying process.
- When filler insertion is almost complete, cut filler leaving $\frac{1}{4}$ " of excess length to thwart

filler contraction over time then insert filler into groove.

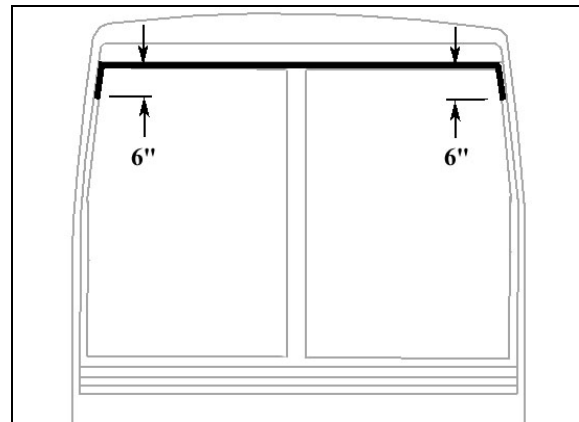


FIGURE 14: APPLICATION OF SIKA 221 BLACK

- Reinstall center post and interior finishing panels.
- Clean windshield surface of butyl residue.

7.7 ENTRANCE DOOR

An air operated "sedan type" entrance door, with an air door cylinder and damper assembly are installed under the right hand dash. The opening and closing door speed cycle is adjustable by a damper mounted in parallel with the door cylinder on the door hinge. Door activation is controlled by a panel (Fig. 15), located near the defroster and wiper motors. The accessory air reservoir supplies air to this system.

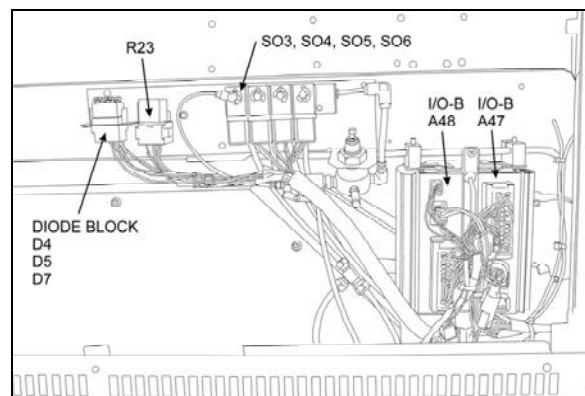


FIGURE 15: ENTRANCE DOOR & WIPER CONTROL PANEL

06619

The door is held in the closed position during coach operation by a two air cylinder locking mechanisms (Fig. 17). Air cylinders with return spring in the cylinder body are used. Air cylinders are controlled by an electrically operated solenoid valve energized by a rocker switch located under the right hand dashboard.

To open the door, initial movement of the rocker switch de-energizes the air lock solenoid valve, venting the door locking cylinders. The return locking spring pulls the door lock away from the latch, unlocking the door. Door movement starts only when pressure in the central air door lock is below 10 psi. The “air cylinder open solenoid valve” opens and allows air to flow to the door cylinder, “the air cylinder close solenoid valve” exhausts air from the rod side of the cylinder.

To close the door, initial movement of the switch energizes the “air cylinder close solenoid valve” and air flows to the cylinder by its rod side port. The “air cylinder open solenoid valve” exhausts air from cylinder. When entrance door latch is grounded with the door frame, the air lock solenoid valve is de-energized and loads the door lock cylinders. The cylinder moves the door lock in a position which engages a latch on the entrance door, holding the door positively closed.

Emergency exit valve, which opens the air valve circuit should be used only in emergencies, or when the door control system does not function properly.

Refer to the air system schematic diagram annexed at the end of section 12, “Brakes” and to page 22 of the wiring diagram.

7.7.1 Operation

The air-operated door is controlled from inside the coach by two push-button switches located on the R.H. dashboard.

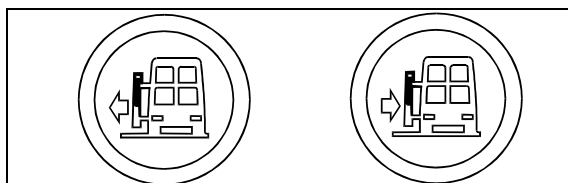


FIGURE 16: ENTRANCE DOOR OPERATING BUTTONS
06464

Opening and closing of the door from outside the coach is accomplished by a momentary toggle switch located under the front R.H. side marker light (Fig. 18).

To close the door, the switch must be pushed towards the rear of the coach and held in position until the door has completed its movement.

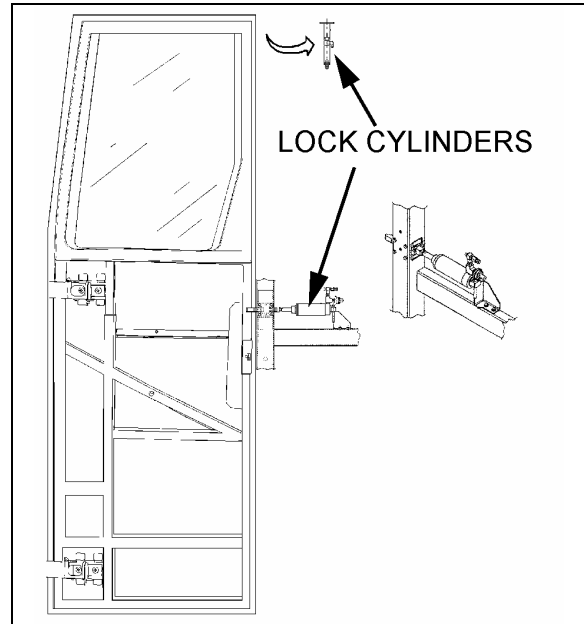


FIGURE 17: COACH ENTRANCE DOOR
18642

To open the door, the switch must be pushed towards the front of the coach and held in position. When the door reaches the fully opened position, the system will keep pressure in the cylinder locking the door in that position. The door can be stopped in any position by releasing the switch. The door is not locked in position when not fully opened or closed.

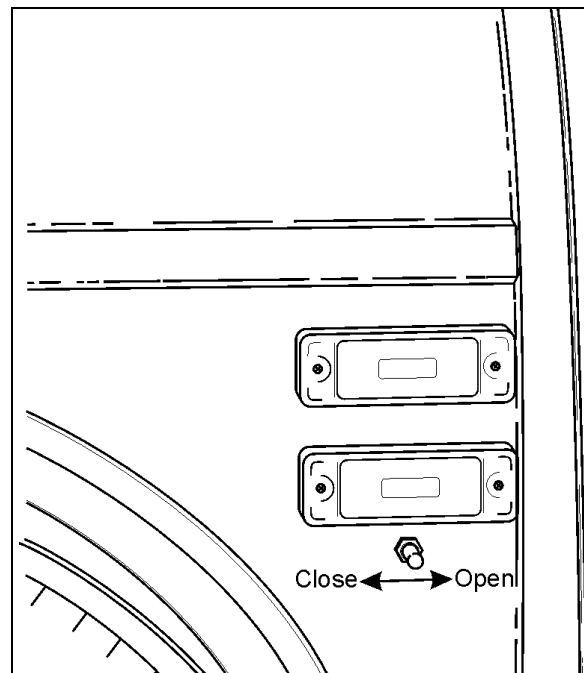


FIGURE 18: ENTRANCE DOOR CONTROL SWITCH
18599

If the door has been locked with the key, a lever on the door can be moved to unlock.

Section 18: BODY

7.7.2 Emergency Exit Valves

From inside the vehicle, an emergency exit valve located near the door on the dash panel, releases the pressure from the lock cylinder. From the exterior, an emergency exit valve located in the front service compartment, also releases the air from the lock cylinder.

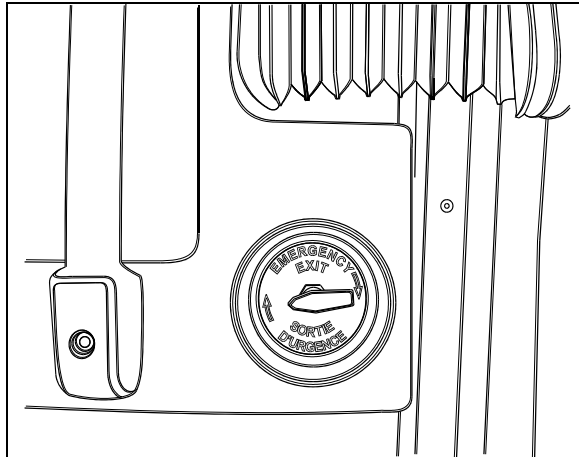


FIGURE 19: INTERIOR UNLATCH AIR VALVE 18330

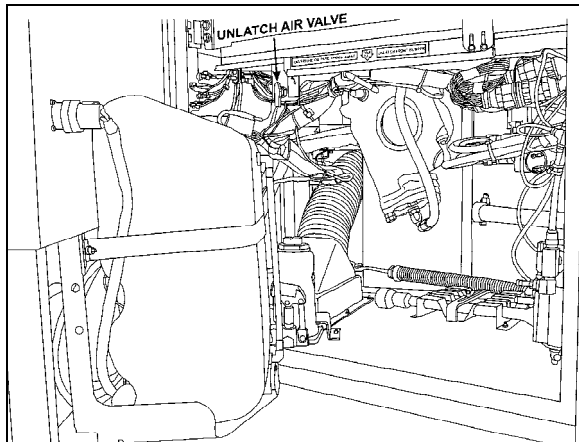


FIGURE 20: EXTERIOR UNLATCH AIR VALVE 12209

Without Air and/or Without Electricity

If the air pressure drops while the coach has or hasn't any electricity, the spring loaded cylinders will unlatch the door. In such a case, unlock the door by moving the lever on the door or by using the key, then open the door manually.

With Air but Without Electricity

From inside the vehicle, turn the emergency exit valve to the "UNLOCK" position. Move the lever. From the exterior, turn the emergency exit valve to the "UNLOCK" position. Open the door. Close it, lock with the key and reset the outside emergency exit valve to the "NORMAL" position.

7.7.3 Door Cycle Speed Adjustment

To do any adjustment, remove the two panels located next to the door hinge, as well as the door's upper hinge control.



CAUTION

It is important to make sure that damper does not reach end of stroke when door is completely closed or opened. The door cylinder must stop the door on opening. Screw or unscrew rod end to adjust if necessary.

To adjust opening and closing cycle speed on damper (Fig. 21):

1. Remove the damper from the vehicle and hold it vertically with the lower eye or pin attachment in a vice. Use clamp plates to prevent damage.
2. Fully close the damper while turning the dust cap or piston rod slowly CCW until it is felt that the cams of the adjusting nut engage in the recesses of the foot valve assembly (Fig. 21).

NOTE

In figure 21, if there is an indentation (B) in the dust cap (C) and the cover shows two holes (A), the damper is fitted with a bump rubber (D). If so, fully extend the damper and insert a round bar or screwdriver through the holes. Push the bump rubber down and remove. Remove the split plastic collar (E) (if fitted) from the piston rod.

3. The damper may have already been adjusted. Therefore check whether the damper is adjusted or not by keeping it closed and gently turning further CCW, counting at the same time the half-turns until a stop is felt. Stop turning and do not force.
4. While keeping the damper closed, make two CW half-turns. In case of prior adjustment, add the number of half-turns previously counted. The total range is about five half-turns. Pull the damper out vertically without turning for at least 3/8" (1cm) to disengage the adjusting mechanism. The dust cap or piston rod may now be turned freely.

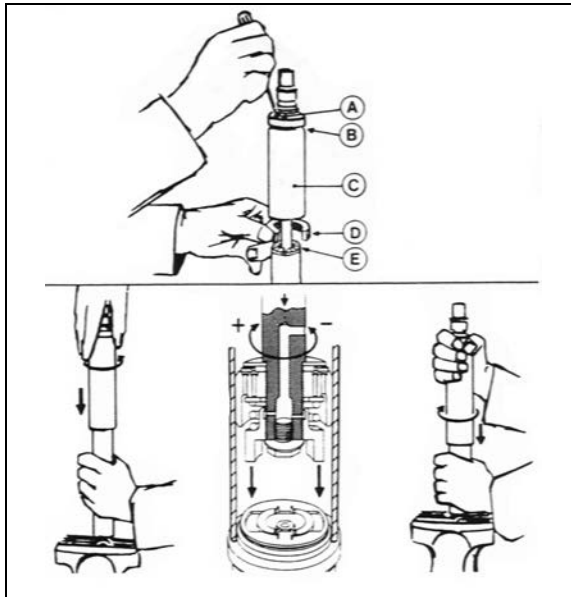


FIGURE 21: DAMPER

18643

NOTE

Where a bump rubber was installed, refit same inside the dust cap and by fully closing the damper, the rubber will seat again at top of the dust cap. Refit the split plastic collar E (Fig. 21).

5. The damper can now be refitted in the vehicle.
6. Reinstall panels and entrance door hinge cover.

7.7.4 Horizontal And Vertical Adjustment

Before attempting to correct any door operating problem by adjusting any part of the air cylinder assembly, first perform the following mechanical checks and procedure.

Check around the perimeter of the door for binding. If any binding is found, adjust as follows:

1. Remove the screws and the plastic molding covering each of the hinges.

NOTE

Ask an assistant to help you to perform the following adjustments.

2. Remove the Allen button head screw and the washer retaining the rod end with bearing to the upper hinge. See figure 22.
3. Support the door with a wooden block and a hydraulic jack.

4. Loosen the horizontal bolts retaining the door to the hinges. Adjust the door horizontally and vertically with the jack. Tighten the bolts to 30-36 Lbf-ft (40-50 Nm). Remove the jack and the wooden block.



CAUTION

Make sure the front side door does not interfere with the exterior panel.

5. Pull and fasten the rod end to the hinge with the washer and the button screw.
6. Screw the plastic moldings covering the hinges.

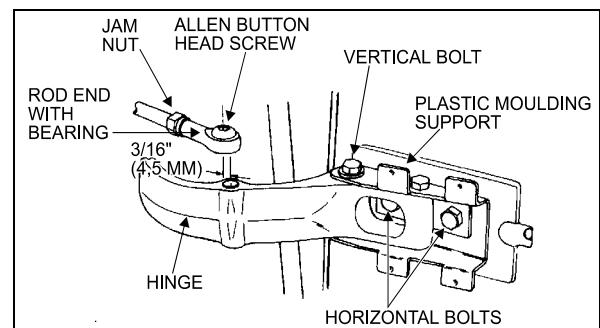


FIGURE 22: UPPER DOOR HINGE

18058

Seal Compression Adjustment

1. Turn the emergency exit valve to the "UNLOCK" position and close the door.
2. From the outside of vehicle, insert a straight edge in the gap along the door outside perimeter. Measure the distance between the door frame and the door outside surface at the door four corners (refer to figure 23).

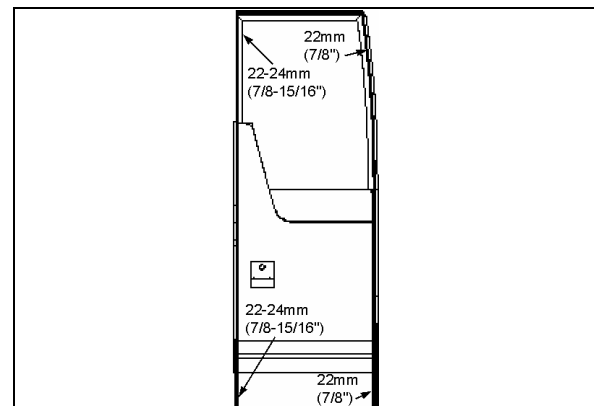


FIGURE 23: SEAL COMPRESSION ADJUSTMENT

18632

NOTE

The front measurements are the most important. If required, ask an assistant to help you to perform the following adjustments.

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- If required loosen the bolts retaining the door to the hinges. Adjust the bolts to obtain the proper seal compression.

Door Seal Replacement

- Inspect the seal; if cracked or torn, it must be replaced:
- Remove the old seal and with a sharp edge knife, scrape tape left on the fiberglass door surface.
- Sand the surface of the door where a new seal will be applied with 240 grit sandpaper.

- Clean the surface with alcohol.



WARNING

Wear rubber gloves and do not smoke when cleaning.

- Peel of protective paper from the seal. Position the seal flush with the top, sides and lower edges of the door.
- Progress slowly all around the door.
- Cut the seal and glue both ends with LOCTITE 414 glue.
- To assure bonding, press a small roller on top of the new seal.

7.7.5 Troubleshooting

SYMPTOM	PROBABLE CAUSE	REMEDY
DOOR WILL NOT OPEN FROM EXTERIOR SWITCH.	Manual door locks engaged.	Release manual door locks.
	Upper and lower solenoid locks do not disengage.	Check voltage at solenoid locks when door is open. If the voltage is 24 volts then replace solenoid #641217. Else, check circuit power.
	Relay module do not receive current.	Reset breaker "ON" or check batteries power supply.
	Opening solenoid door does not receive current.	Check voltage at opening solenoid door. If the voltage is 24 volts then replace it. Else replace control relay.
	Switch malfunction.	Replace switch.
DOOR WILL NOT CLOSE FROM EXTERIOR SWITCH.	Switch malfunction.	Replace switch.
	Solenoid failure.	Check voltage at solenoid. If the voltage is 24 volts then replace solenoid. Else replace control relay.
DOOR WILL NOT OPEN FROM INTERIOR SWITCH.	Manual door locks engaged.	Release manual door locks (open position) from vehicle exterior.
	Upper and lower solenoid locks do not disengage.	Check voltage at solenoid locks when door is open. If the voltage is 24 volts then replace solenoid #641217. Else, check circuit power and replace control relay.
	Module relay does not receive electric current.	Reset breaker "ON" or check batteries power supply.
	Door opening solenoid does not receive current.	Check voltage at door opening solenoid. If the voltage is 24 volts then replace it. Else replace control relay.
	Switch malfunction.	Replace switch.
	Upper lock stays engaged	Lubricate upper lock assembly. Check wear and replace parts if necessary.
DOOR WILL NOT CLOSE FROM INTERIOR SWITCH.	Switch malfunction.	Replace switch.
	Door closing solenoid does not receive electric current.	Check voltage at door closing solenoid. If the voltage is 24 volts then replace it. Else replace control relay.
DOOR WILL NOT OPEN AFTER DRAINING AIR FROM SYSTEM BY EMERGENCY VALVE(S).	Manual door locks engaged.	Release manual door locks (open position) from vehicle exterior.
	Damper cylinder blocks the door.	Adjust or replace damper cylinder.

SYMPTOM	PROBABLE CAUSE	REMEDY
	The upper lock blocks the door.	Adjust upper lock. Lubricate upper latch bolt. Adjust upper latch height.
DOOR LOCKS STAY ENGAGED WHEN DOOR IS OPEN.	Power supply is cut at solenoid.	Place switch in open position.
	Lock solenoid does not disengage.	Check voltage at solenoid lock when door is OPEN. If the voltage is 24 volts then replace solenoid #641217. Else, check circuit power and replace control relay.
DOOR LOCKS DO NOT LOCK WHEN DOOR IS CLOSED.	Emergency valve is open.	Close emergency valve.
	Lock solenoid stays electrified.	Check latch bolt ground on door frame. If needed clean locks for better contact. Check ground circuit.
	Lock solenoid works in reverse.	Reverse air hoses at solenoid locks.
	Relay does not function.	Replace relay.

7.7.6 Lubrication

Part	Lubricant	Frequency
Latches Upper door catch Door cylinder rod end with bearing grease fitting	Low temperature grease	Every six months
Door locking mechanism	White grease	Every six months
Key hole Damper pins Hinges	Low viscosity oil	Every six months

7.7.7 Entrance Door Body Panel and Window

Window

For the removal of entrance door window, you will need:

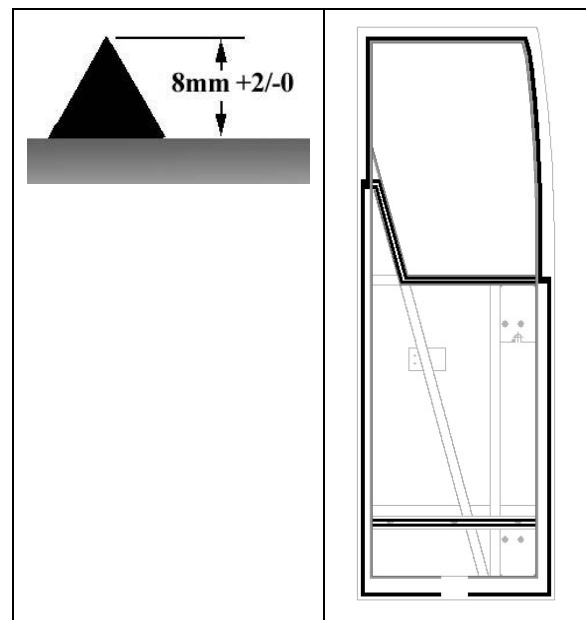
Pneumatic “Zip gun” type tool;
Razor sharp window scraper;
“Olfa” knife;
Face shield.

- Open entrance door.
- Mark the position of the entrance door window for future reference.
- Remove interior finishing panel.
- From inside of vehicle, cut Sika bead around window perimeter using a “Zip gun” while another person hold the window from the outside.

NOTE
<i>Wear ear plugs during this operation.</i>

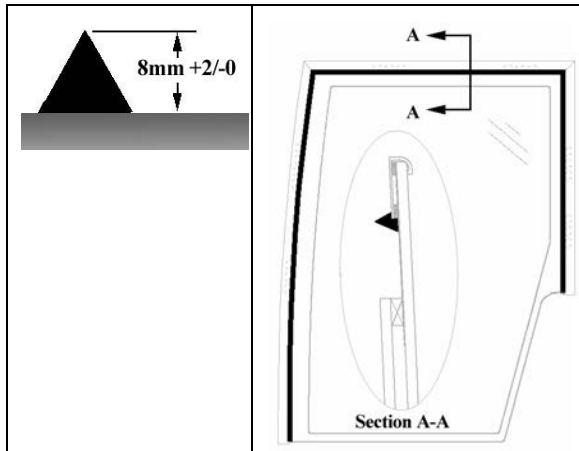
- Then, move outside of vehicle and cut Sika bead to free window while somebody else hold the window from the inside.

- Carefully remove window from frame, ask for help if needed.
- Using a razor sharp window scraper, remove from window frame Sika bead and double-face self adhesive tape residue.
- Clean window using window cleaner.
- Apply Sika Aktivator around window perimeter.
- Clean door frame using anti-silicone.
- Using a scratch pad “Scotch Brite”, scratch the perimeter of the window frame where the adhesive will be applied.
- Clean door frame again using anti-silicone.
- Apply some Sika 206 G+P onto door frame.
- Apply Sika 255 onto door frame structure.



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- Apply Sika 255 at junction of frame and window.



- Install and center window onto door frame. Using your hands, compress window.
- Discard waste according to applicable environmental regulations, use dangerous waste containers.
- Apply masking tape before applying Sika glue to protect paint and adjacent surfaces during surface treatment

Body Panel

For the removal of entrance door body panel, you will need:

Pneumatic “Zip gun” type tool;
Razor sharp window scraper;

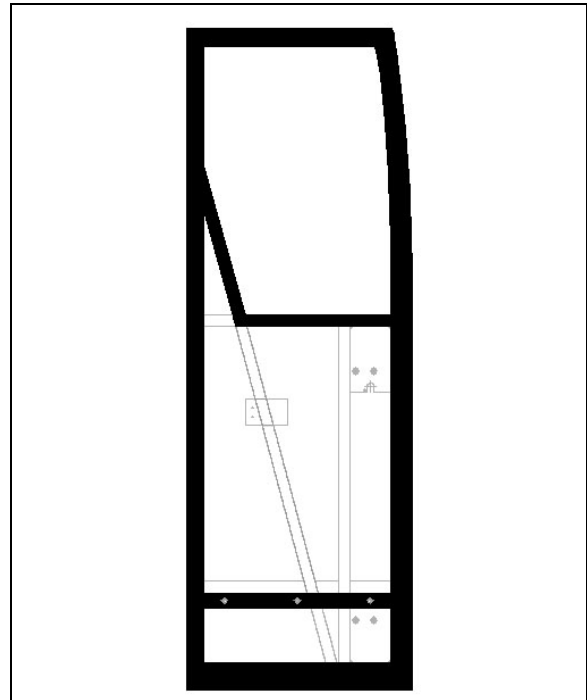
- Open entrance door.
- Remove interior finishing panels to access rub rail fixing bolts, then remove rub rail.
- Remove door lock and interior lighting.
- Using the “Zip Gun”, cut Sika bead located ¼ inch (7-8 mm) from each body panel edge.

NOTE

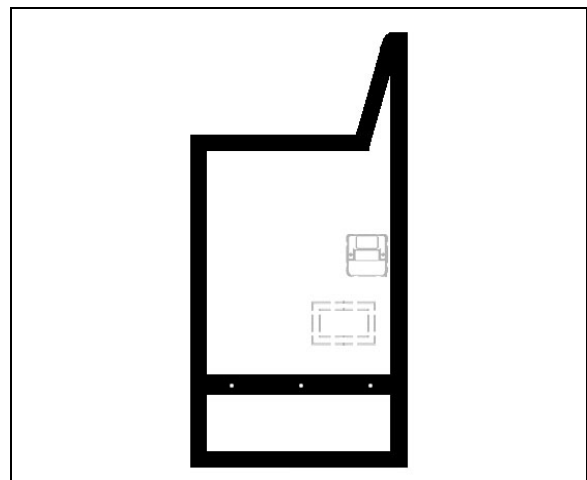
Wear ear plugs during this operation.

- Separate body panel from door.
- Using a razor sharp window scraper, remove from door frame Sika bead and double-face self adhesive tape residue.
- Using a scratch pad “Scotch Brite”, scratch the perimeter of the door frame where the adhesive will be applied.

- Clean door frame again using anti-silicone.
- Apply some Sika 206 G+P onto door frame.



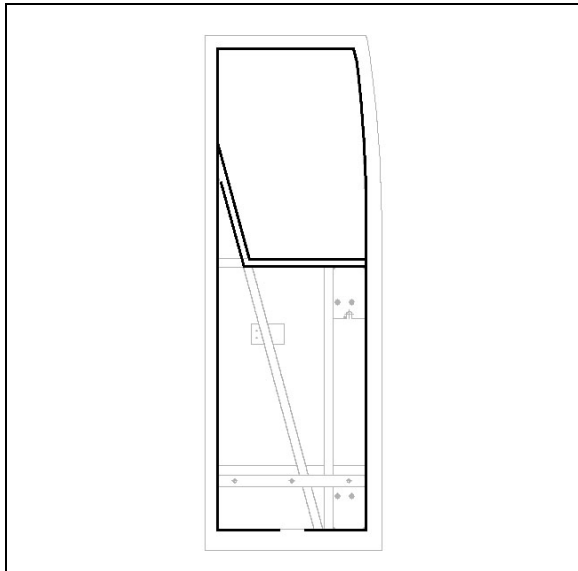
- Using a scratch pad “Scotch Brite”, scratch the perimeter of the body panel where the adhesive will be applied.
- Clean body panel using anti-silicone.
- Apply some Sika 206 G+P onto body panel.



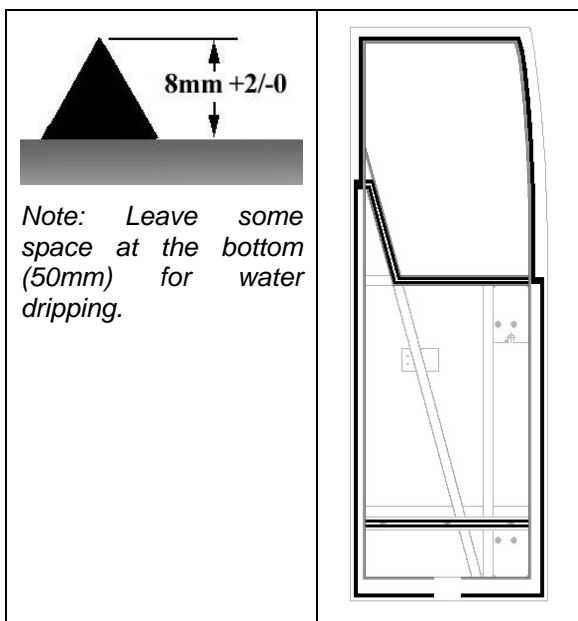
- Apply 1/8 x1/4 double face self-adhesive tape onto door frame.

NOTE

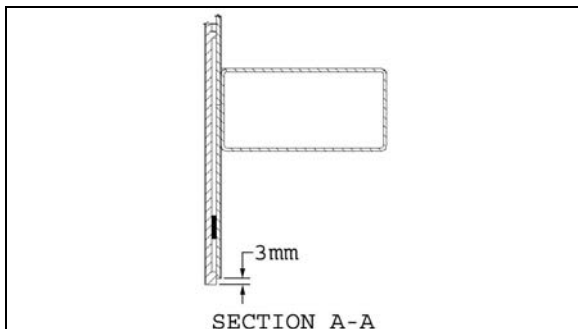
Leave some space at the bottom (50mm) for water dripping.



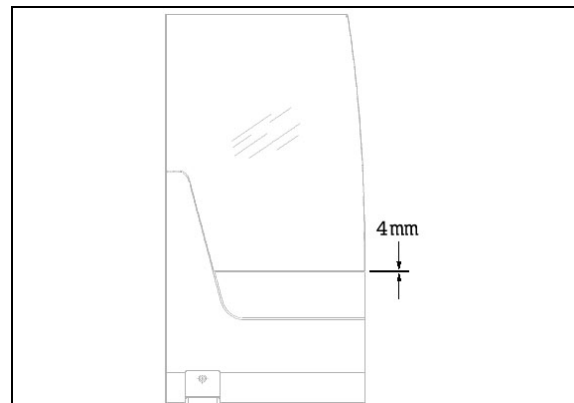
- Apply Sika 255 onto door frame structure.



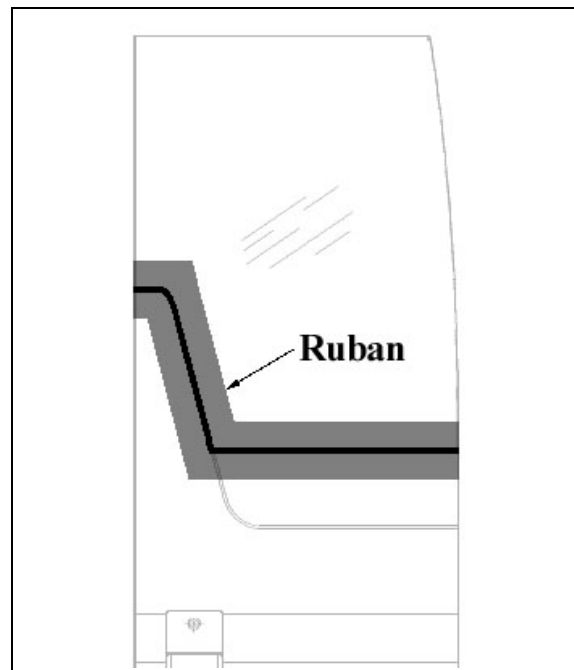
- Install and center fiber glass body panel onto door frame leaving an excess of 3mm all around the frame.



- Line-up body panel with window. There must be a gap of $4\pm 2\text{mm}$ between window and body panel.



- Apply some masking tape **1mm** from window edge and body panel.
- Fill the gap between window and body panel with Sika 255.
- Smooth down the joint with a plastic scraper then remove masking tape.
- Wet Sika joint using water to accelerate the curing process and put the finishing touch with your finger.



- Discard waste according to applicable environmental regulations, use dangerous waste containers.

Section 18: BODY

7.7.8 Front Electrical & Service Compartment Door Body Panel and Window

Door Body Panel

For the removal of front electrical & service compartment door body panel, you will need:

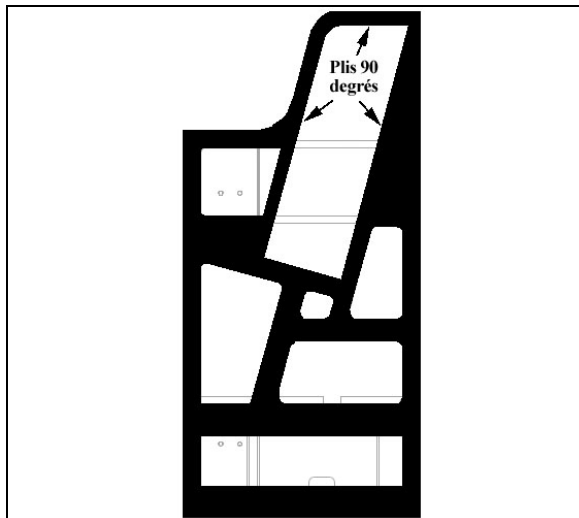
Pneumatic "Zip gun" type tool;
Razor sharp window scraper;

- Open service door.
- Remove interior finishing panels to access rub rail fixing bolts, then remove rub rail.
- Remove windshield washer reservoir, door lock and power window connector.
- Using the "Zip Gun", cut Sika bead located $\frac{1}{4}$ inch (7-8 mm) from each body panel edge.

NOTE

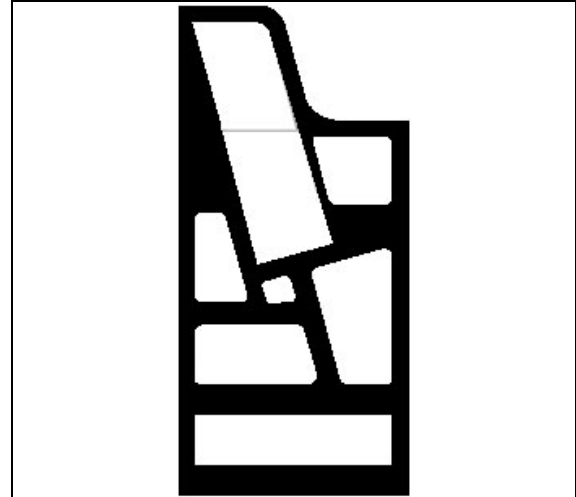
Wear ear plugs during this operation.

- Separate body panel from door.
- Using a razor sharp window scraper, remove from door frame Sika bead and double-face self adhesive tape residue.
- Clean door frame using anti-silicone.
- Using a scratch pad "Scotch Brite", scratch the perimeter of the door frame where the adhesive will be applied.
- Clean door frame again using anti-silicone.
- Apply some Sika 206 G+P onto door frame.

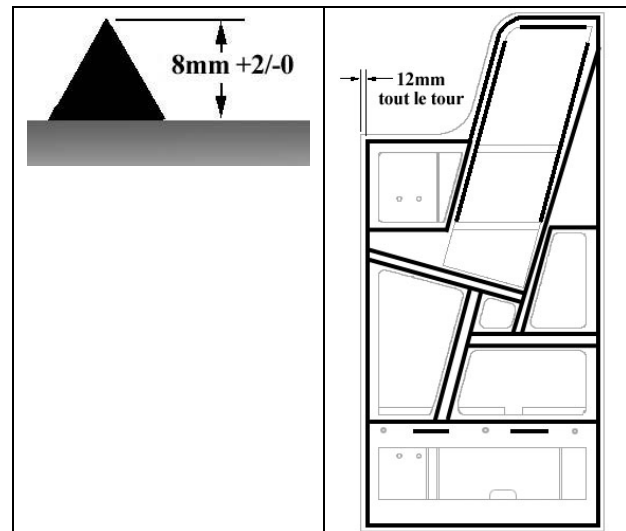


- Prepare new body panel using a scratch pad "Scotch Brite".

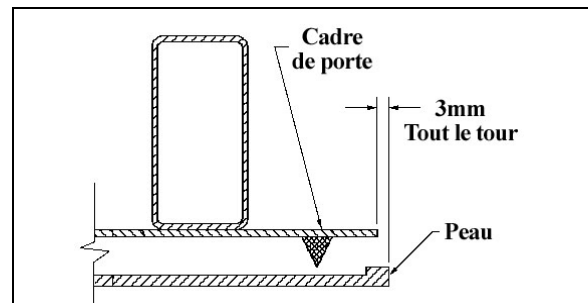
- Use a tack cloth to remove any dust or residue from the body panel surface.
- Clean body panel using anti-silicone.
- Apply some Sika 206 G+P onto body panel.



- Apply an even coat of Sika 255 onto the door frame.



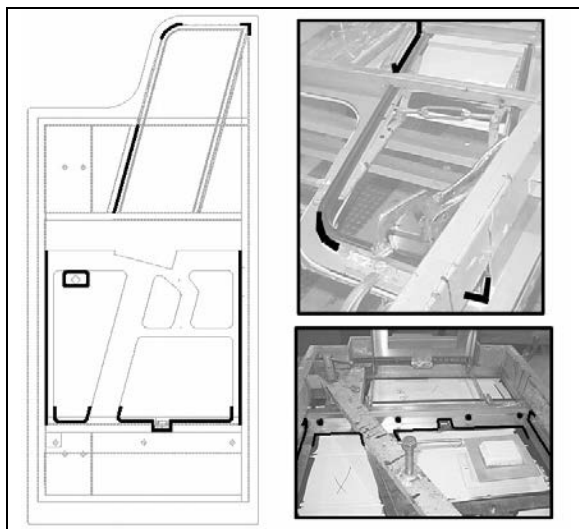
- Position body panel onto door frame and compress with your hands. Use a ruler.



- Check body panel flatness using a 2-foot ruler (must be within 2mm).



- Check proper power window sliding inside window frame.
- If applicable, remove excess of Sika adhesive all around door frame using Sika 208.
- From the inside of the door, apply some Sika 221 between door body panel and frame and on welding spots as per figure.

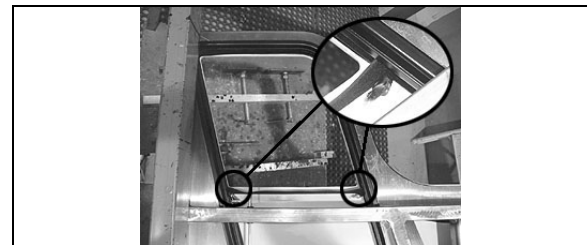


- Apply some #680066 glue inside fiber glass groove and fix power window wiper.

NOTE
Anti-friction side must be on glass side.

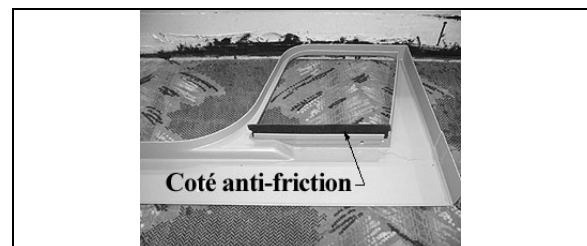


- From inside the door, apply some Sika 252 at the corners of window wiper.



- Apply some #680066 glue inside finishing panel groove and fix power window wiper.

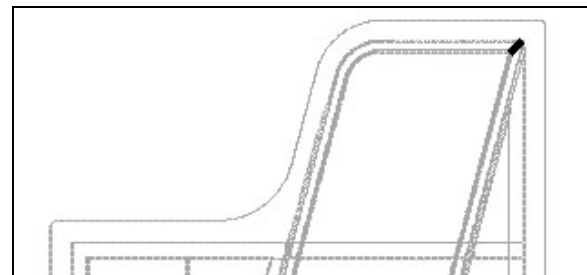
NOTE
Anti-friction side must be on glass side.



- Discard waste according to applicable environmental regulations, use dangerous waste containers.

Electrical Power Window

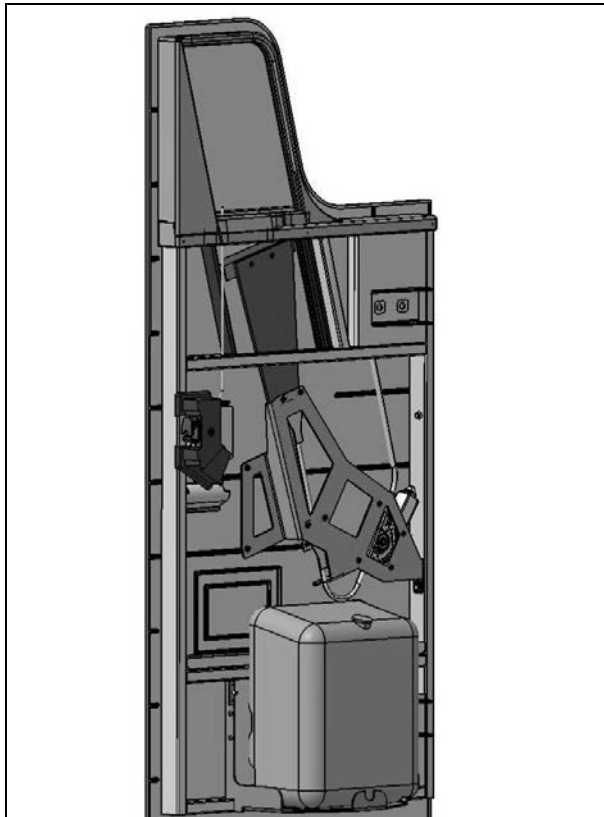
- Insert 2 seals in the window frame.
- Apply some #680066 glue at the intersection of the 2 seals and also sparingly in order to fix the seal to the window frame.



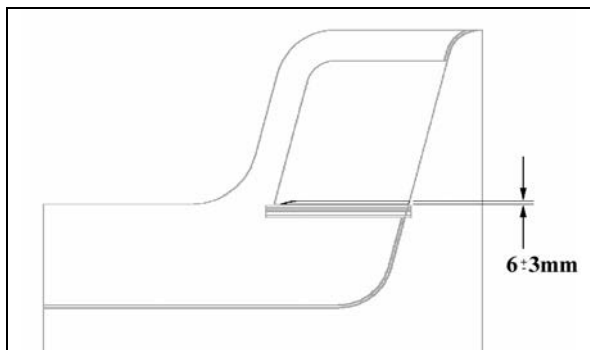
- Clean window using window cleaner.

Section 18: BODY

- Insert window into frame.
- Secure window pane to raising mechanism.



- Adjust window travel ($6\pm 3\text{mm}$ above window wiper).

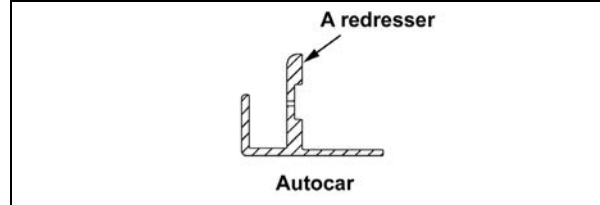


Driver's Window Gutter

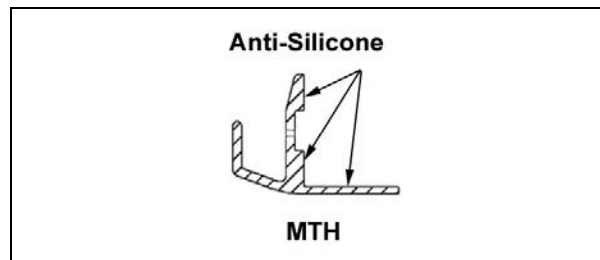
- Dry fit the gutter on the vehicle. If required, straighten up gutter using a hammer and a wooden block.



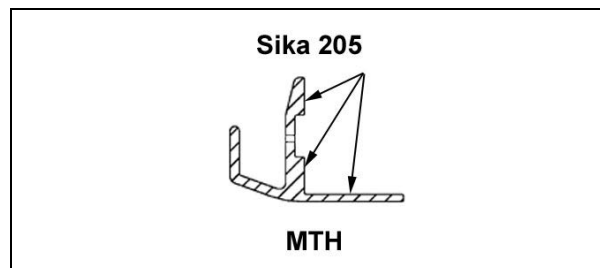
Redresser a cet endroit



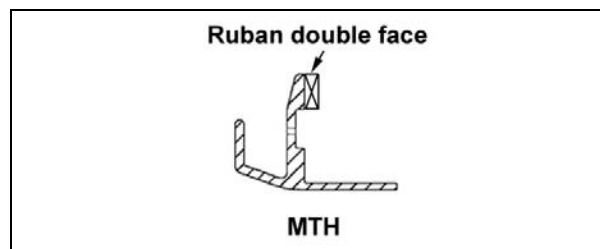
- Apply anti-silicone inside right angle.



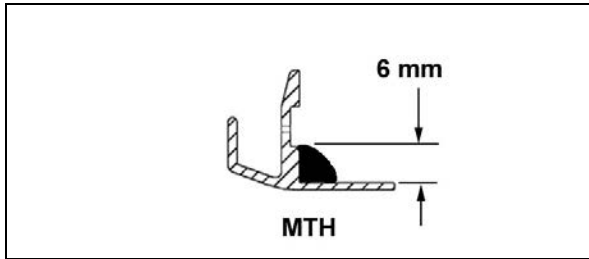
- Apply Sika 205 inside right angle.



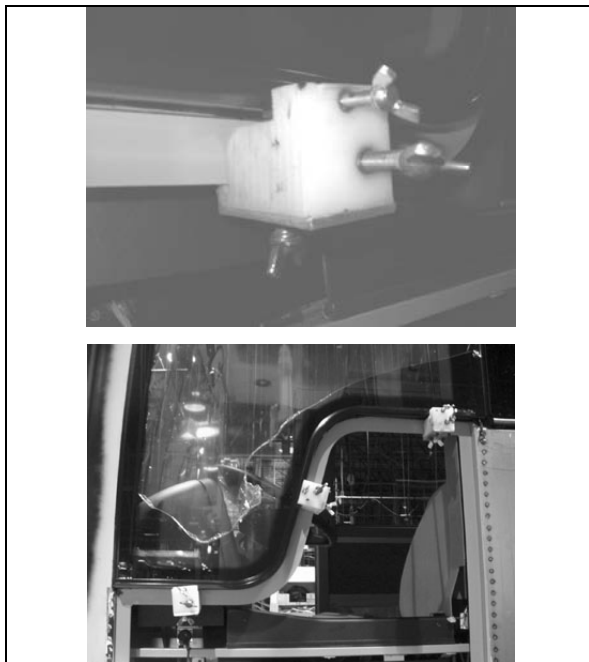
- Apply 1/16 x 1/4 double face self-adhesive tape onto gutter.



- Peel the back from double face self-adhesive tape.
- Apply Sika 252 inside right angle.



- If applicable, remove plastic film at the bottom of driver's window.
- Remove excess of Sika underneath driver's window.
- Clean bottom of driver's window using window cleaner.
- Apply Sika Aktivator at the bottom of driver's window.
- Install gutter under driver's window then compress in order to fix double face self-adhesive tape.
- Install 3 clamps and allow curing for 4 hours.



7.7.9 Upper Lateral Window

For the removal of upper lateral window, you will need:

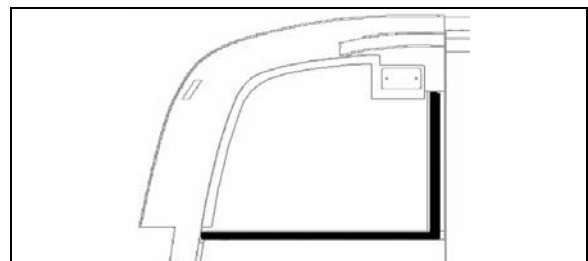
Pneumatic «Zip gun» type tool;
Razor sharp window scraper;
"Olfa" knife;
Face shield.

- From inside of vehicle, cut Sika bead around window perimeter using a "Zip gun" while another person hold the window from the outside.

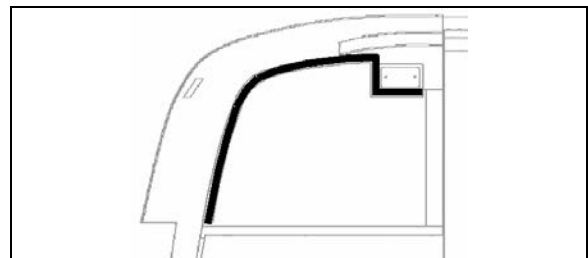
NOTE

Wear ear plugs during this operation.

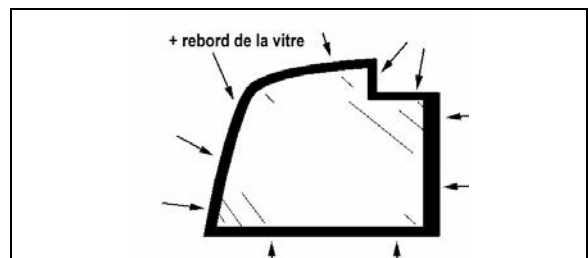
- Then, move outside of vehicle and cut Sika bead to free window while somebody else hold the window from the inside.
- Carefully remove window from frame, ask for help if needed.
- Using a razor sharp window scraper, remove from window frame Sika bead and double-face self adhesive tape residue.
- Remove clearance light
- Apply some water to vehicle structure to clean surface.



- Clean inside and outside of fiberglass using anti-silicone.
- Apply some Sika 206 G+P.

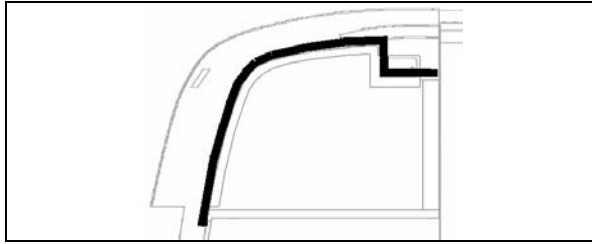


- Clean window perimeter and edges using window cleaner.
- Apply Sika Aktivator.

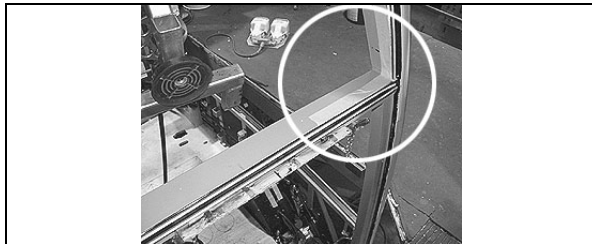


Section 18: BODY

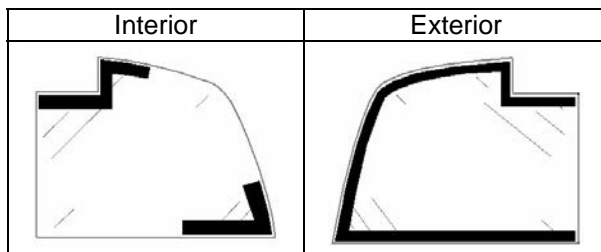
- Apply masking tape onto front face before applying Sika glue to protect paint and adjacent surfaces.



- Apply masking tape onto structure.



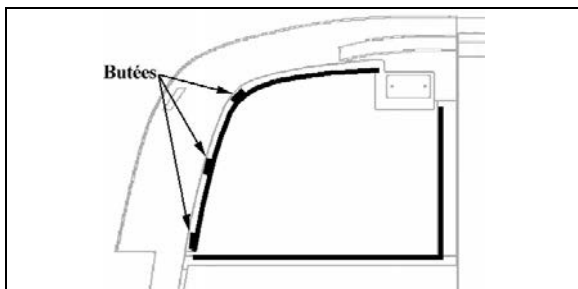
- Apply masking tape onto window.



- Affix 3 spacers #790392 onto fiberglass.
- Apply a double-face self adhesive tape 1/8 by 1/4 inch onto fiberglass perimeter (front face exterior).

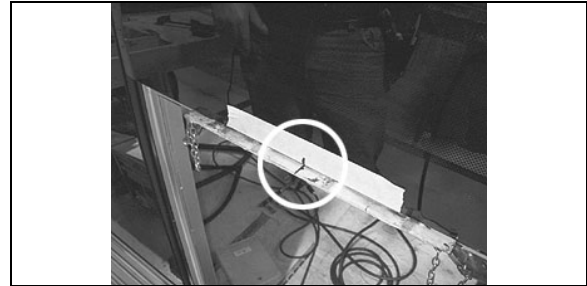
NOTE

Do not peel the back from double face self-adhesive tape at this moment.



- Install window inside the opening to check if window curve and front face are the same.

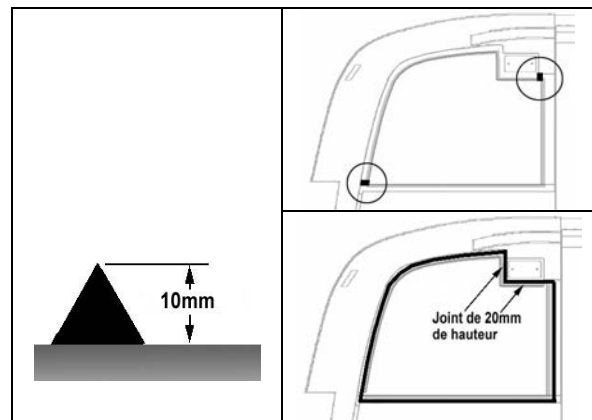
- L.H. side: Front of window must line up with front of driver's window. Use shims to adjust window height if necessary.
- R.H. side: Once the window is centered, apply some masking tape on bottom of window to mark off the position.



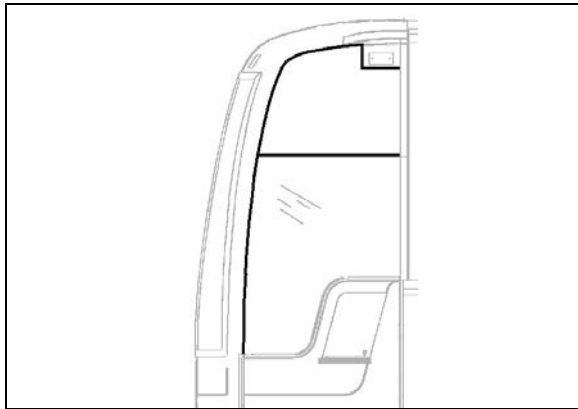
- Peel the back from double face self-adhesive tape.
- Apply some Sika 255 onto fiberglass perimeter (front face exterior).

NOTE

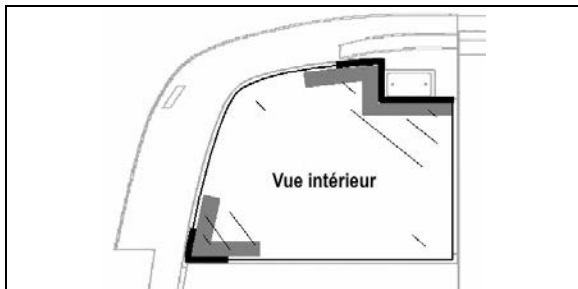
Make sure the 2 small cavities between fiberglass and structure are filled with Sika.



- Install and compress all around window perimeter to fix window to self adhesive tape.
- To support the window, position two "Quick Grip" type pliers at the base of the frame.
- Center and align the window base using the two pliers while pressing firmly the window perimeter against the frame.
- Complete a finishing joint and scrape the excess with a plastic scraper.
- Carefully remove masking tape then smooth down finishing joint with your finger. Use soapy water or Sika 208.



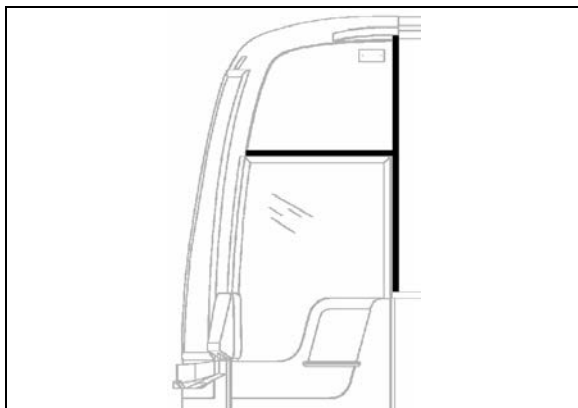
- From vehicle's interior, apply some Sika 255 and make 2 finishing joints. Smooth down the joints and remove masking tape.



- Reinstall clearance lights.
- Discard waste according to applicable environmental regulations, use dangerous waste containers.

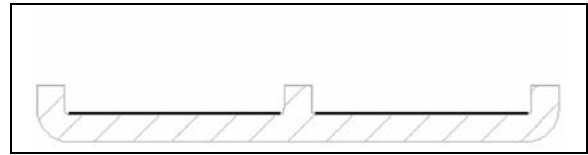
Glued Molding Installation

- Clean window gluing area using window cleaner.
- Apply Sika Aktivator onto gluing area making sure to avoid Sika adhesive if it is not cured yet.

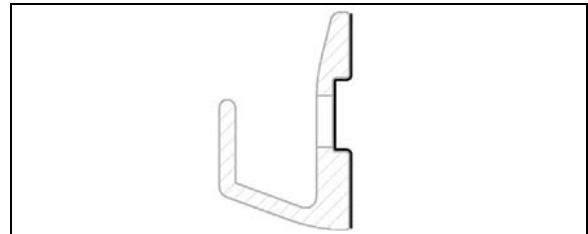


- Apply anti-silicone onto molding.

- Apply Sika 205.



- Clean gutter using anti-silicone.



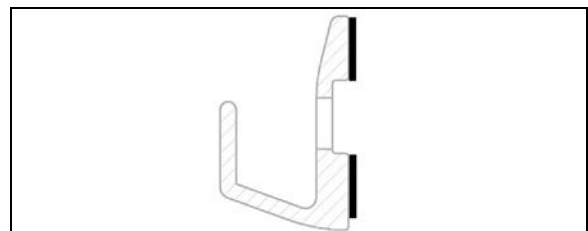
- To seal screw holes, remove screw, apply Sika 205 inside the hole then apply Sika 252.



- Apply a double-face self adhesive tape 1/8 by 1/4 inch inside the molding onto the whole length.

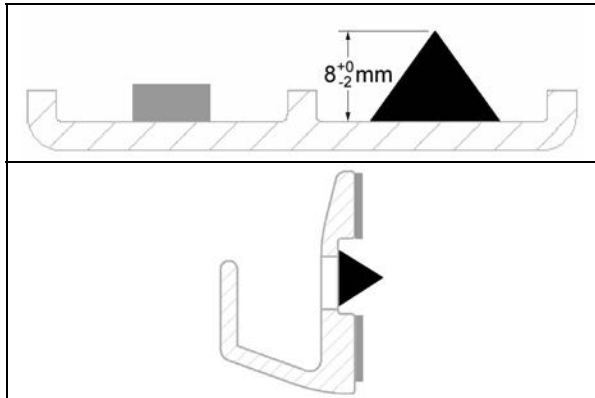


- Apply a double-face self adhesive tape 1/32 by 1/4 inch onto the whole length of the gutter.

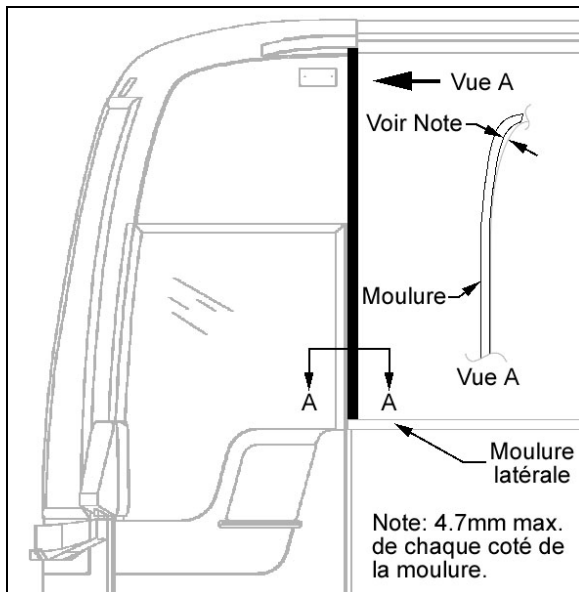


- Apply Sika 252 inside the moldings onto the whole length.

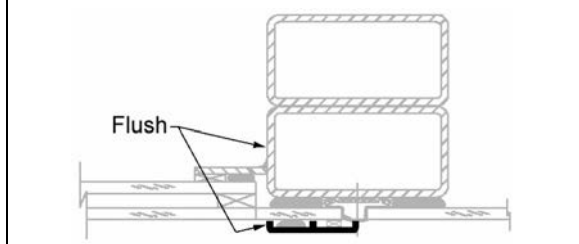
Section 18: BODY



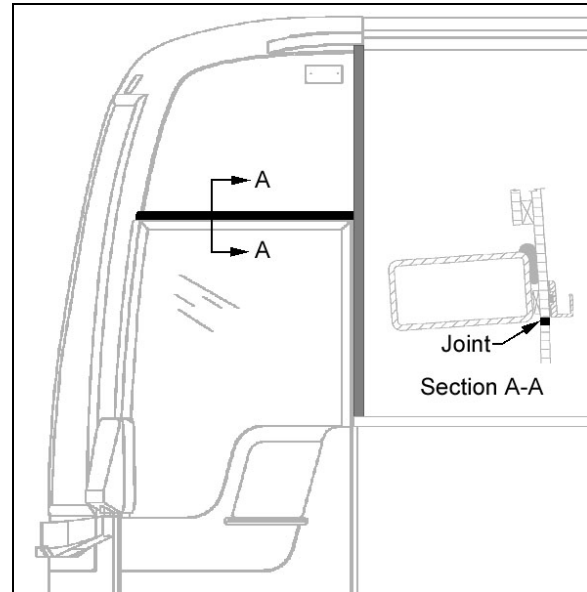
- Position and fix vertical molding. Lean vertical molding against lateral molding. Make sure vertical molding lines up with structural tubing.



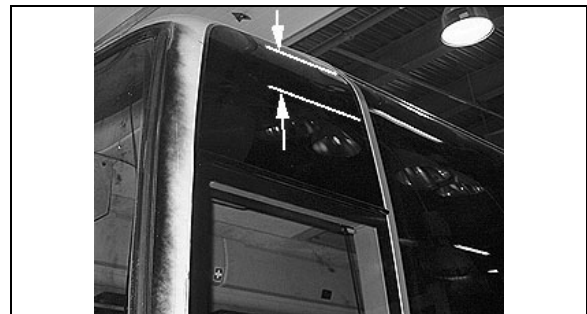
SECTION VIEW A-A



- Position and fix horizontal molding (gutter). Lean gutter against vertical molding. Position gutter just above Sika finishing joint.



- Apply masking tape on each side of vertical molding. Apply Sika 252 to fill the gap between molding and windows.
- Smooth down the joint with finger.
- If required, clean surfaces using Sika 208.



7.7.10 Front Cap

The fiberglass front cap does not need any maintenance except painting as needed. It is held in place with adhesive. If ever it has to be replaced, make an appointment at a Prévost service center near you. For minor damages, refer to section 4 "Fiberglass Repair" and section 5 "Painting".

8 ZONE 2

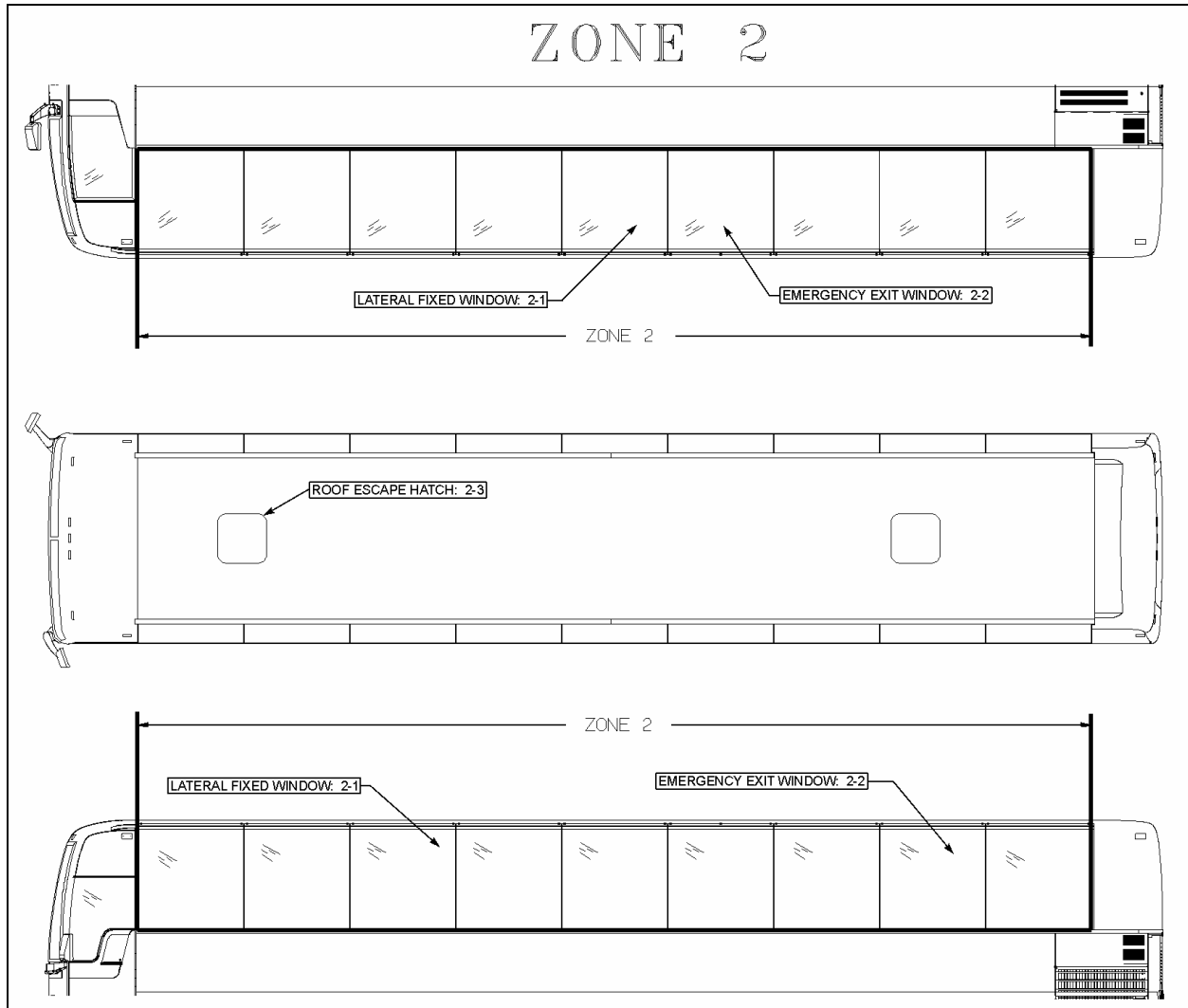


FIGURE 24: ZONE 2

18625

8.1 LATERAL FIXED WINDOW

Nine passenger side windows are provided on each side on X3-45. They are made of fixed, single or double-glazed, heat absorbing AS-3 glass. Windows are mounted in painted aluminum extrusions, which hold the glass in place from the top rail of the coach. The extrusion also serves as a hinge to allow the window to swing open when needed. The single-glazed windows are made of tinted tempered safety glass, while the double-glazed windows are made of tinted tempered safety glass outside and clear tempered glass inside.

For fixed side window removal or installation, you will need:

- * Hammer or;
- * Drill equipped with a sharp pointed rod into which a small hole was drilled;
- * Braided windshield wire and a pair of handles;
- * Gloves, goggles or face shield.

8.1.1 Fixed Window Removal

Method A

- Apply a sticky plastic film onto window outside surface (thermos) and break window. For single pane, apply a sticky plastic film on both sides of window.

Section 18: BODY

Method B

- Using a drill equipped with the special sharp pointed rod, drill through the window seal into one of the bottom corners, from a 30° angle with reference to the vehicle.
- This procedure requires accuracy and it is possible not to succeed on the first attempt. From the inside of vehicle, a second person ensures the rod passes through.
- Remove the rod, thread the wire into the small hole. Reinsert the rod and the wire into the hole far enough so that the person inside the vehicle can pull the rod using a pair of pliers.
- Attach the wire ends to the specially designed handles.
- Pull in turn from the inside and the outside of vehicle to gradually cut the Sika bead on the window perimeter.
- When you reach top corner, detach wire from the outside handle, secure it to a fish wire or rod and thread it underneath the aluminum molding behind the rivets.
- Detach wire from fish wire and continue cutting using the handle.
- Cut Sika bead until you come back to starting point, then you can remove the window by carefully pushing it out from the inside of vehicle.

8.1.2 Preparation of Structure and Installation of Window

Preparation of Structure

- Remove old Sika adhesive.
- If primer was removed at the same time than Sika, perform the following steps:
 - Clean using anti-silicone.
 - Remove from structure old primer using a sander (120-150 grit).
 - Clean again using anti-silicone.
 - Apply 206 G+P primer.
- Reactivate 206 G+P primer.

Installation of Window

- Use window cleaner around window interior perimeter and edges to remove any oily film while inspecting for damages.
- Apply Sika Aktivator.
- Using a triangular nozzle (20mm X 10mm), apply Sika Ultrafast II onto structure.

NOTE

You only have 8 minutes to install window once the SIKA ULTRAFAST II product is applied.

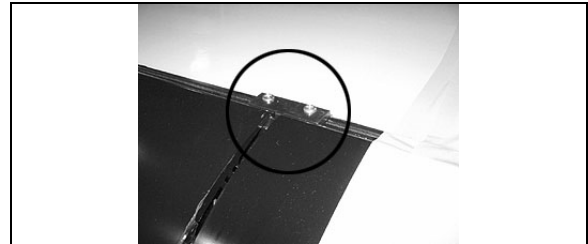
- Install window.



CAUTION

To prevent damaging the Sika joint, do not raise the window once it has touched the bead.

- Before compressing window against Sika joint, install two stops into the aluminum extrusion one inch from each window edge.



- Verify window alignment with reference to adjacent surfaces.
- Vehicle must remain stationary for 30 minutes at more than 23°C.

8.2 EMERGENCY EXIT WINDOWS

Three of the windows on curb side of the X3-45 serve as emergency exits, while there are four on driver's side. See figure 33. Except for the top window side, the three other glass sides are unprotected, which causes the workers to be exceptionally careful when manipulating or installing such windows.

In addition, when it becomes necessary to lay down the unprotected edges of the glass window, never use a steel or concrete floor support. It is recommended to use a wooden support, even better, a padded surface.

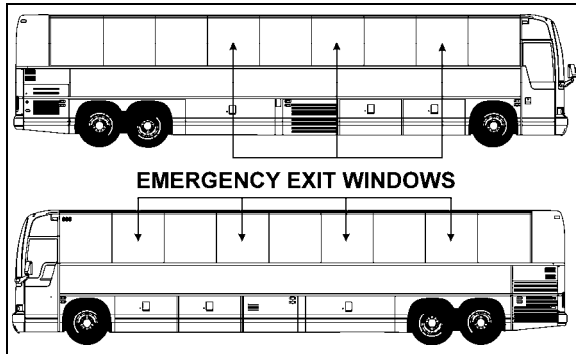


FIGURE 25: X3-45 COACH

18617

An emergency exit window can be opened by pulling the lower part of the release bar to disengage the safety latches, and then by pushing out the window frame (Fig. 32).

Emergency operating instruction decals are affixed under each emergency exit window. To close the window, pull back the window and push down the release bar.

8.2.1 Emergency Exit Release Bar

The emergency exit release bar system is generally maintenance free. It has been designed to answer the twenty pound resistance criteria for opening the emergency window. If this handle should be replaced:

1. Remove the screws and bolts securing it to the emergency exit window;
2. Install a new release bar, reverse the procedure.

NOTE

Check the legal twenty pound maximum resistance to be sure to comply with regulations.

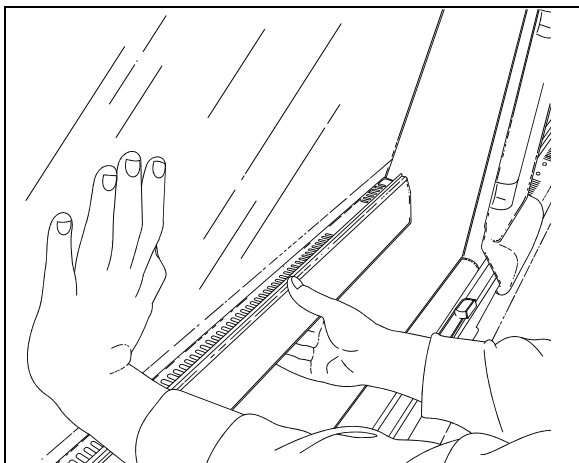


FIGURE 26: EMERGENCY EXIT WINDOW

18008

8.2.2 Emergency Exit Window Adjustment

Emergency exit windows should be checked periodically for easy opening and closing. Pulling the lower part of the release bar with both hands placed near the safety latches should disengage both locks on the window simultaneously. The tension required to release the window should not exceed twenty pounds (9 kg) of force.

The release bar mechanism itself has been designed such as no adjustments are necessary.

If too much effort is required to disengage the locks when pulling the release bar or if the window doesn't close tightly or rattles, check for interference by foreign objects or nearby parts into mechanism, such as the microswitch, rubber seal, wires, etc. Correct situation immediately.

NOTE

Tangs on the lock must be in a horizontal position.

8.2.3 Emergency Exit Window Replacement

1. Lift the bar release system;
2. Remove the stop blocks from the top exterior of the window.
3. Push the glass window out ninety degrees (90°).



WARNING

The window may fall out.

4. The window is free and can be unhooked.

Reverse the procedure to install a new emergency exit window.

8.3 ROOF ESCAPE HATCH

The vehicle can be equipped with one or two escape hatches. The escape hatch is designed to provide years of reliable service with a minimum of maintenance. All components are rust proof, and moving parts are Teflon coated to eliminate need for lubrication. Should water infiltrate the vehicle from the escape hatch, refer to the heading "Sealing" in this paragraph for procedures on how to seal this area.

Section 18: BODY



CAUTION

Use of lubricants, paints, or other coatings such as graffiti deterring sprays is not recommended.

Suggested maintenance includes periodic inspection of fasteners for evidence of loosening due to tampering, and regular cleaning with mild soap and water.

Although there are other cleaning solutions available, some contain solvents and other chemicals that can attack the high strength materials used in the production of the escape hatch.



CAUTION

Ensure that cleaning solutions are compatible with the materials used on the escape hatch.

Graffiti removing cleaners often contain acetone, ether, lacquer thinner or other solvents known to destroy the high strength properties of many plastics. Use of these cleaners must be avoided. Graffiti-resisting coatings often leave a sticky residue that interferes with smooth up/down movement of the hatch mechanism. Some of these coatings also contain solvents that will reduce the strength of certain components.



CAUTION

Use of these coatings is at considerable risk and should be avoided.

8.3.1 Repair

All components used in the production of the escape hatch are available as service parts, except for one hinge that represents a possible hazard when improperly reattached to a hidden tapping plate, itself often damaged whenever the hinge is damaged. The tapping plate is permanently laminated between the inner and outer cover assemblies, and it cannot be inspected or replaced. It is therefore necessary to replace the entire assembly following damage to the hinge. See figure 25.



CAUTION

Hinge assembly is critical and hinge should never be removed from cover assembly. Fasteners used in this assembly are special

and have critical torque requirements and tamper-resistant heads to discourage tampering.

8.3.2 Sealing

1. Open and tilt up the escape hatch cover.
2. Join the 2 ends of the rubber seal.



CAUTION

Seal joint should be toward rear of vehicle.

3. Apply rubber adhesive CA-40 (Prévost # 681285) in the gap between the seal ends.
4. Apply Sikaflex 221 sealant (Prévost # 680532) along the outline of the escape hatch on the roof of vehicle.

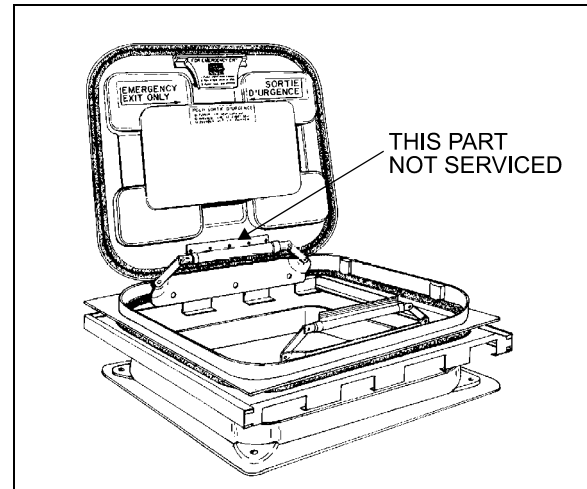


FIGURE 27: ESCAPE HATCH

18104

8.3.3 Escape Hatch Panel Assembly

The frame of the escape hatch is riveted to the roof of the vehicle. The escape hatch panel assembly can be replaced as a unit and a new panel assembly installed in the existing frame. To remove the panel assembly, remove the 4 bolts fastening the 2 hinges to the escape hatch frame and retain the 4 flat washers. Reinstall the panel assembly by fastening the 2 hinges with the 4 bolts and flat washers removed earlier.



CAUTION

When installing, roof escape hatch's hinge must be toward the front of vehicle, to prevent the hatch from being ripped out if accidentally opened while vehicle is running.

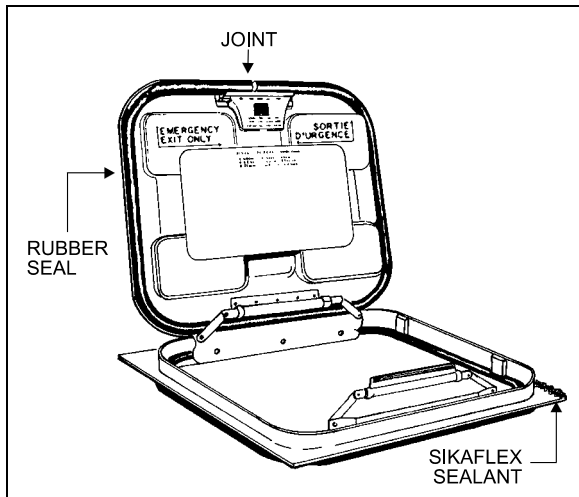


FIGURE 28: ESCAPE HATCH

18105

1. Support the frame from inside the vehicle.
2. Remove rivets.
3. Cut the rubber seal with a sharp edge knife and remove the hatch frame.
4. On vehicle top, using the knife, remove as much as possible the remaining rubber seal.
5. Drill holes (if needed) in the new metal frame.
6. Clean both vehicle top and new hatch frame with SIKA 205.
7. Apply rubber adhesive SIKA 221 under the hatch frame surface.
8. Install the frame in place and fix it with rivets.
9. Remove excess adhesive and clean all around.

8.3.4 Escape Hatch Frame

When necessary, the escape hatch frame can be removed and replaced in the following way:

9 ZONE 3

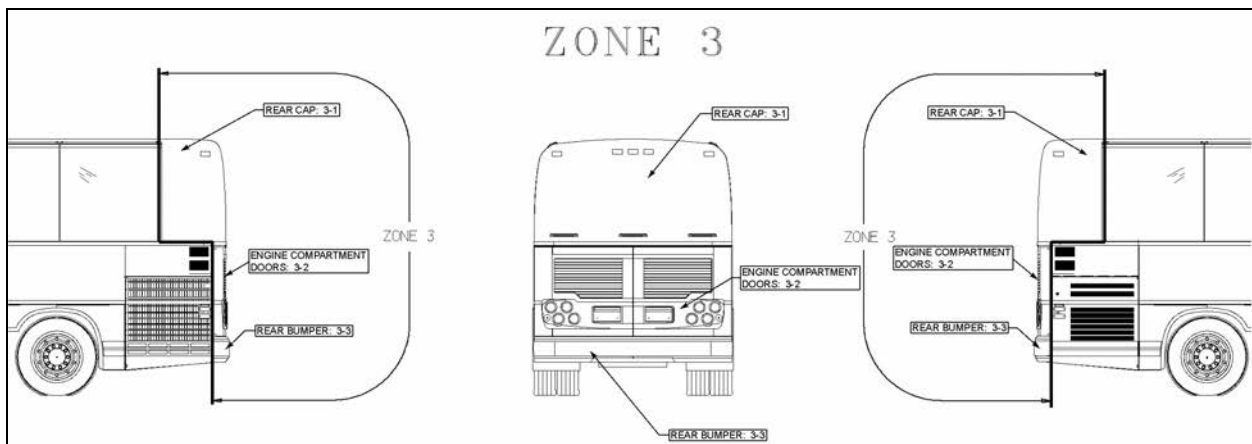


FIGURE 29: ZONE 3

18626

9.1 REAR CAP

The fiberglass rear cap does not need any maintenance except painting as needed. It is held in place with adhesive. If ever it has to be replaced, make an appointment at a Prévost service center near you. For minor damages, refer to Paragraph 4 "Common Fiberglass Repair Procedure" and Paragraph 5 "Common Painting Procedure".

9.2 ENGINE COMPARTMENT DOORS

Engine compartment doors may be adjusted for proper fit by untightening hinge bolts:

1. Loosen the bolts, (1, 2 Fig. 30) holding the hinge to the vehicle structure to shift the door "UP or DOWN".
2. Loosening the bolts (3, Fig. 30) allows the door to be shifted "LEFT or RIGHT" and "IN or OUT".
3. Adjust the doors position depending on the gap needed between exterior finishing panels.
4. Tighten the bolts.
5. Check that the doors swing freely and close properly. It may be necessary to adjust the door latch to get proper fit and operation.

Section 18: BODY

To adjust the latch mechanism (4, Fig. 30) and the striker pin:

1. Open the doors to access the striker pin.
2. Slightly loosen the striker pin.
3. Using a hammer, adjust the striker pin to center it in the door latch mechanism.
4. Tighten the striker pin.
5. Check doors fit and operation.

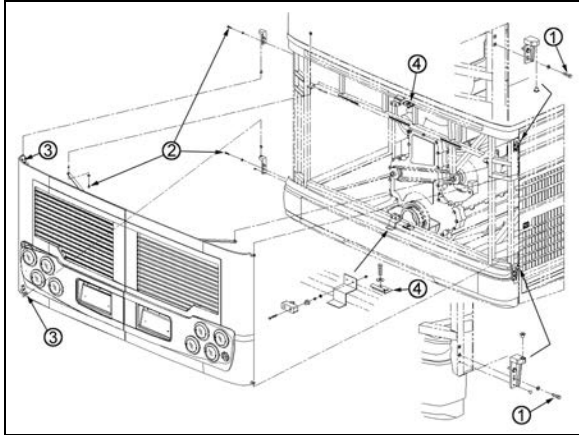


FIGURE 30: ENGINE COMPARTMENT DOORS 18633

9.3 REAR BUMPER

Remove three bolts on each side holding bumper to vehicle and remove bumper.

To install bumper, reverse the procedure.

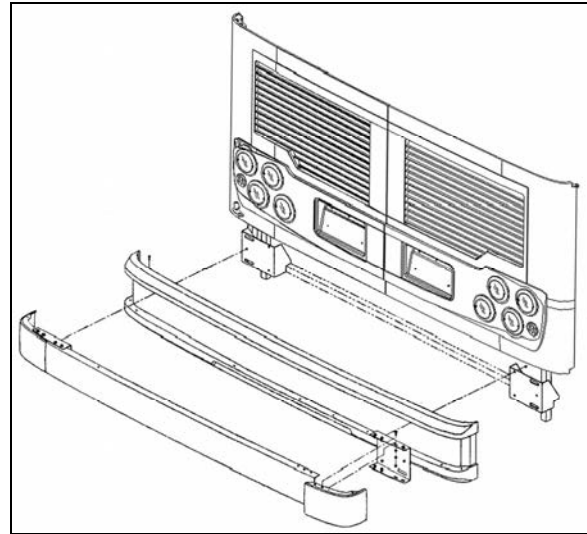


FIGURE 31: REAR BUMPER 18634

10 ZONE 4

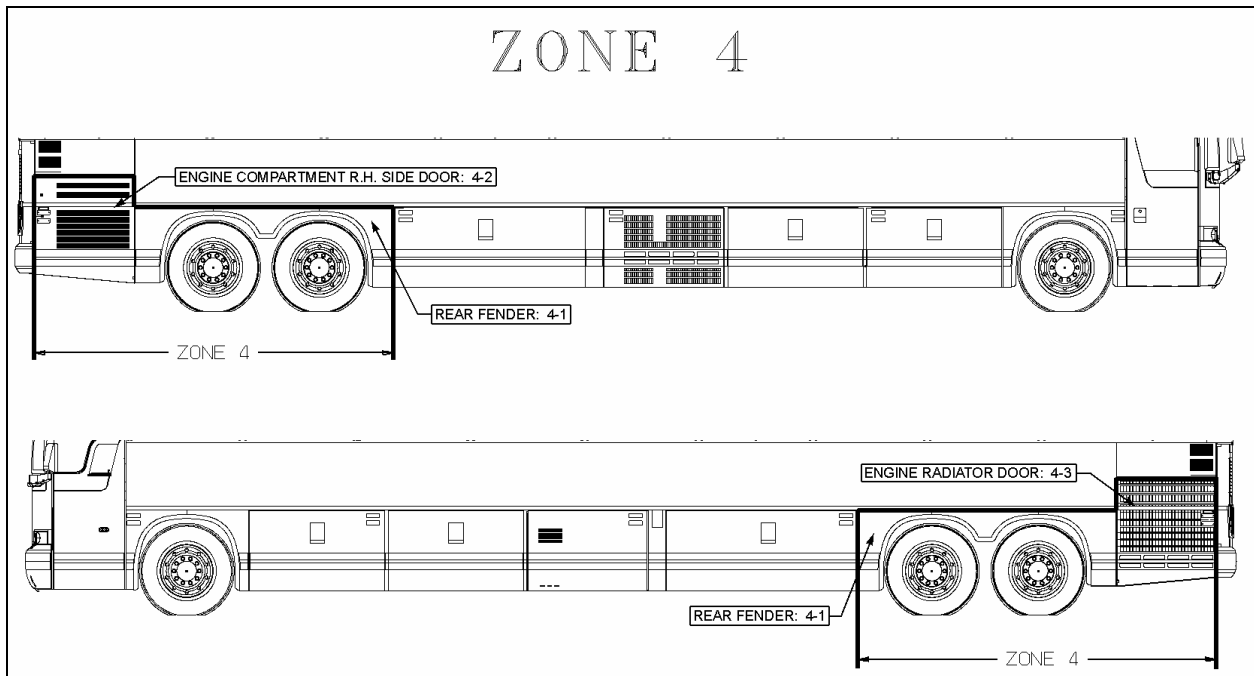


FIGURE 32: ZONE 4 18627

10.1 REAR FENDER

On the "X3" series vehicle, rear fenders are hinged for maintenance on brakes and suspension. Each rear fender panel has two mechanical spring loaded holding devices fixing it to the vehicle's structure. Push the spring type rod sideways to disengage the lock.

10.2 ENGINE COMPARTMENT R. H. SIDE DOOR

Engine compartment R. H. side door may be adjusted for proper fit by untightening hinge bolts:

1. Loosen the bolts, (1, Fig. 33) holding the hinge to the vehicle structure to shift the door "IN or OUT" and "UP or DOWN".
2. Loosening the bolts (2, Fig. 33) allows the door to be shifted "LEFT or RIGHT" and "UP or DOWN".

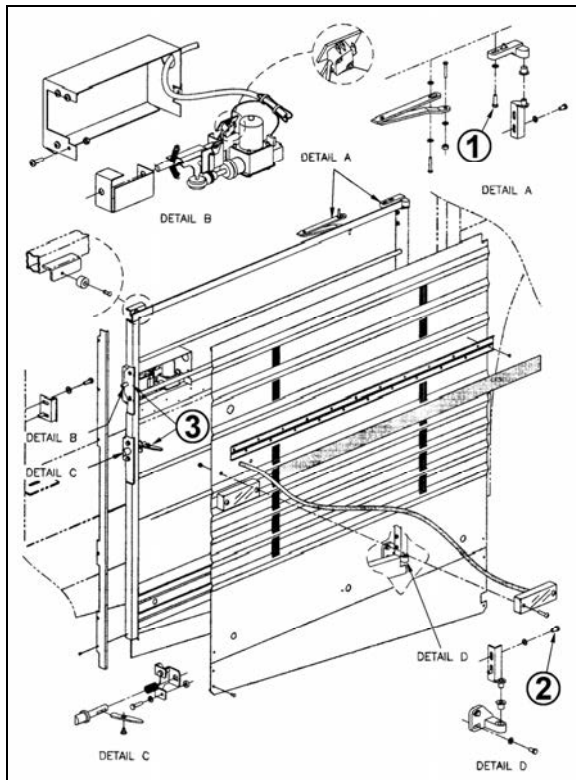


FIGURE 33: ENGINE COMPARTMENT R.H. SIDE DOOR¹⁸⁶³⁵

3. Adjust the door position depending on the gap needed between exterior finishing panels.
4. Tighten the bolts.

5. Check that the door swings freely and closes properly. It may be necessary to adjust the door latch to get proper fit and operation.

To adjust the latch mechanism (3, Fig. 33) and the striker pin:

1. Open the door to access the striker pin.
2. Slightly loosen the striker pin.
3. Using a hammer, adjust the striker pin to center it in the door latch mechanism.
4. Tighten the striker pin.
5. Check door fit and operation.

10.3 ENGINE RADIATOR DOOR

Radiator door may be adjusted for proper fit by untightening hinge bolts:

1. Loosen the bolts, (1, Fig. 34) holding the hinge to the vehicle structure to shift the door "IN or OUT" and "UP or DOWN".
2. Loosening the bolts (2, Fig. 34) allows the door to be shifted "LEFT or RIGHT" and "UP or DOWN".

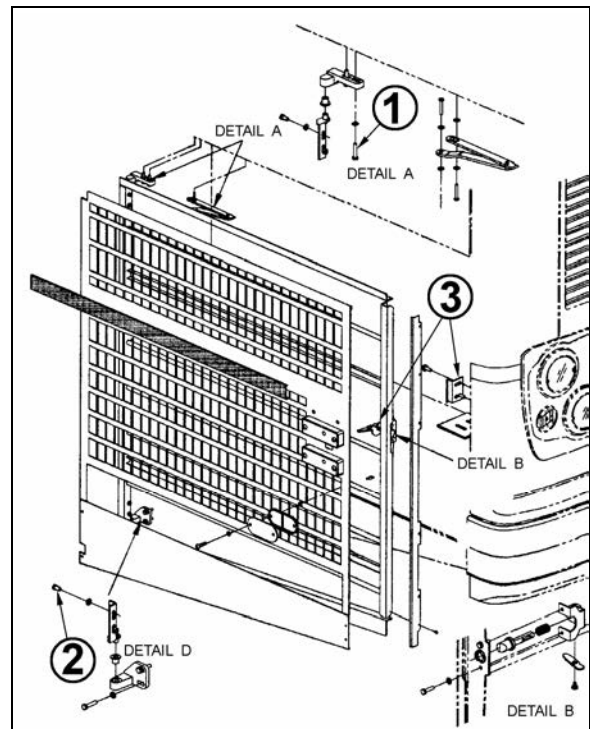


FIGURE 34: RADIATOR DOOR

18636

3. Adjust the door position depending on the gap needed between exterior finishing panels.

Section 18: BODY

4. Tighten the bolts.
5. Check that the door swings freely and closes properly. It may be necessary to adjust the door latch to get proper fit and operation.

To adjust the latch mechanism (3, Fig. 34) and the striker pin:

1. Open the door to access the striker pin.
2. Slightly loosen the striker pin.
3. Using a hammer, adjust the striker pin to center it in the door latch mechanism.
4. Tighten the striker pin.
5. Check door fit and operation.

11 ZONE 5

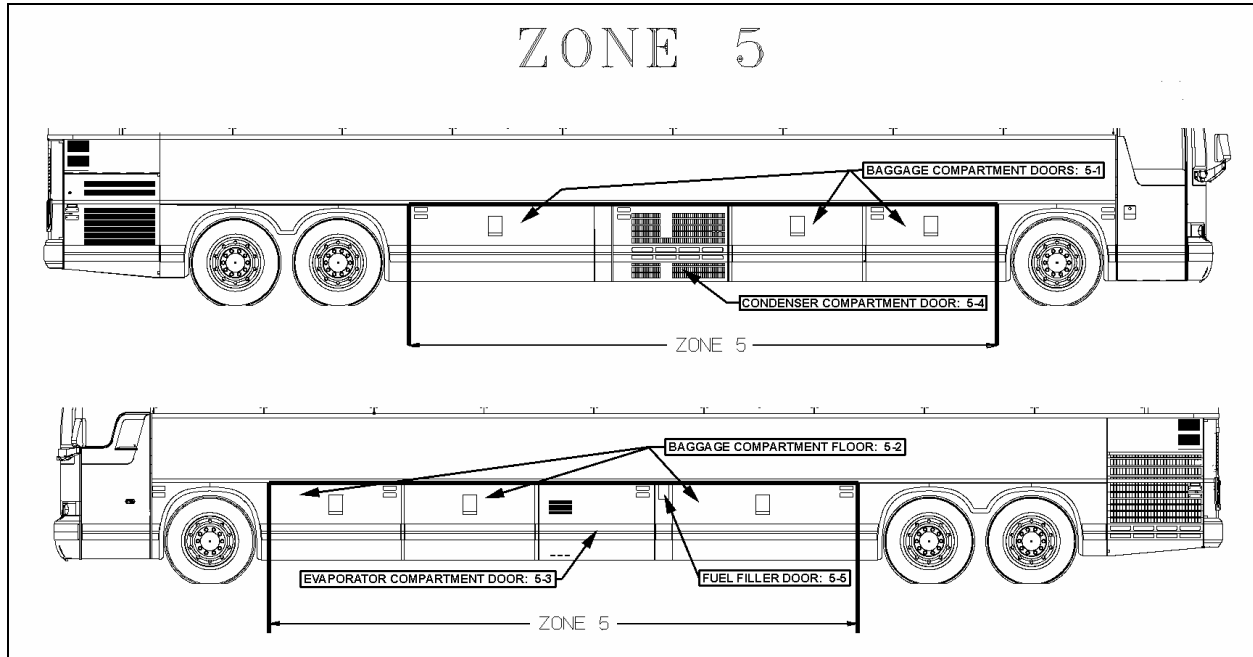


FIGURE 35: ZONE 5

18628

11.1 BAGGAGE COMPARTMENT DOORS

For the removal and installation of baggage compartment door stainless steel body panel, you will need:

A drill with drill bits;

Pneumatic “Zip gun” type tool;

Razor sharp window scraper or putty knife;

- Open damaged compartment door and unfasten rub rail fixing bolts. Remove rub rail.
- Unfasten bolts and disconnect cable if necessary in order to remove door from vehicle.
- Preferably install the door onto a work surface where it can be solidly fixed.

11.1.1 Door Lower Panel

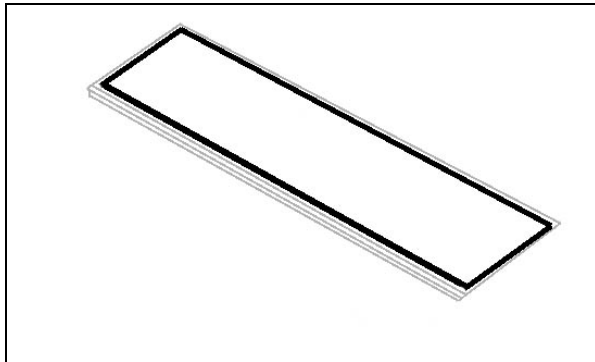
Panel Removal

- Using the “Zip Gun”, cut Sika bead located $\frac{1}{2}$ inch from the door panel perimeter edge.
- Wearing gloves, goggles and ear plugs, pry loose body panel using a “Zip gun” or lever starting from the door lower part.
- Using the window scraper, remove any Sika bead or self adhesive tape residue left on the door frame.

Lower Panel Preparation and Installation

- Use a Chix cloth and anti-silicone to remove any dust or residue from door frame.
- Prepare door frame using a scratch pad “Scotch Brite”.
- Clean door frame again using anti-silicone.

- Apply some Sika 206 G+P onto door frame.
- Clean door lower panel using anti-silicone.
- Prepare door lower panel using a scratch pad “Scotch Brite”.
- Clean door lower panel again using anti-silicone.
- Apply some Sika 206 G+P onto door lower panel.
- Using a triangular nozzle (8mm X 9mm), apply some Sika 255 onto door lower panel.



- Position and install door lower panel onto frame.
- Compress and hold for 8 hours.

11.1.2 Door Upper Panel

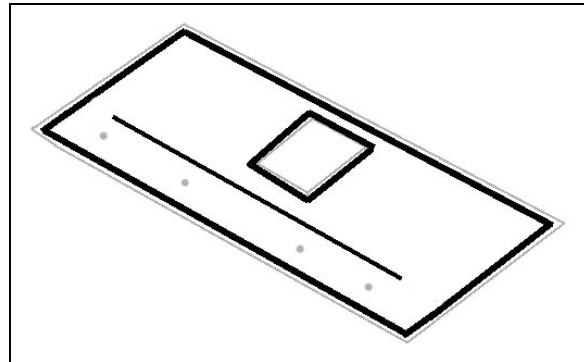
Upper Panel Removal

- From the back of the baggage compartment door, remove handle housing fixing screws (6).
- Remove lock access panel
- Wearing gloves, goggles and ear plugs, pry loose body panel using a “Zip gun” or lever starting from the door lower part.
- Cut Sika bead around handle housing.
- Using the window scraper, remove any Sika bead or self adhesive tape residue left on the door frame.

Upper Panel Preparation and Installation

- Use a Chix cloth and anti-silicone to remove any dust or residue from door frame.
- Prepare door frame using a scratch pad “Scotch Brite”.
- Clean door frame again using anti-silicone.

- Apply some Sika 206 G+P onto door frame.
- Clean door upper panel using anti-silicone.
- Prepare door upper panel using a scratch pad “Scotch Brite”.
- Clean door upper panel again using anti-silicone.
- Apply some Sika 206 G+P onto door upper panel.
- Using a triangular nozzle (8mm X 9mm), apply some Sika 255 onto door lower panel.



- Position and install door upper panel onto frame.

NOTE

Use rub rail fixing holes for upper panel proper positioning.

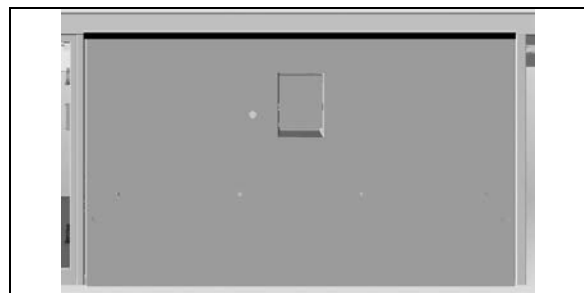
- Compress and hold for 8 hours.

Baggage Compartment Door Adjustment

- Adjust door to get a 7mm gap at the top.

NOTE

Adjustment is made using the side plates.

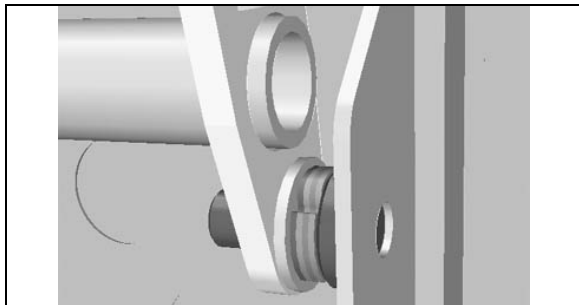


- Center door in the opening using the side plate shims.

Section 18: BODY

NOTE

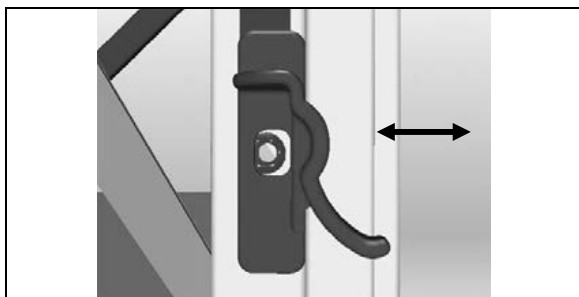
Adjustment is made using shims on the side plates. A total of 8 shims per door must be used e.g. 4 on L.H. side and 4 on R.H. side or 2 on L.H. side and 6 on R.H. side, etc.



- Adjust door position and evenness with reference to adjacent panels and doors.

NOTE

Adjustment is made by moving IN or OUT the lock plates. Adjust one corner at a time.



- Check handle adjustment. Handle must remain tight against its plastic housing.

NOTE

Adjustment is made by moving UP or DOWN the lock plates.



- Open baggage compartment door and adjust height using the catch plates.
- Tighten cylinder blocks fixing screws.

11.2 BAGGAGE COMPARTMENT FLOOR

11.2.1 Repair of Mantex Urethane Covering

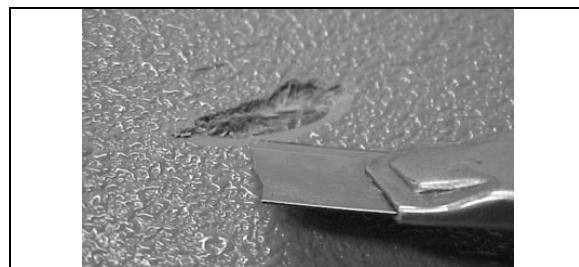
Minor Repair

Use “Dupont IMRON” paint. Apply using a paint brush or roller depending on gravity.

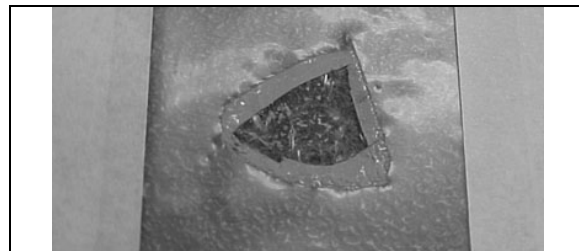
Paint Code: #J4099U

Major Repair (Hole)

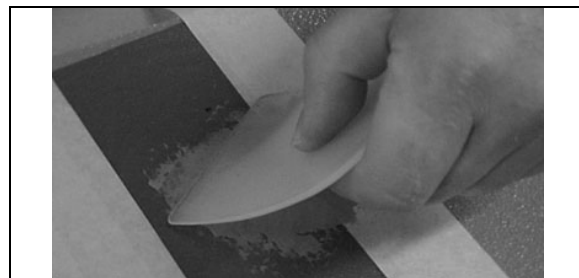
Chamfer the whole perimeter of the damaged area. If applicable, remove loose covering. Remove dust and particles.



Cover and protect damaged area surroundings.



Using a plastic spatula, apply some Sika 221 grey onto the damaged area.



Remove masking tape and protection around damaged area.

Spray pure water onto Sika. Use a floor sample to create some texture onto the adhesive.

If possible spray some more water onto the adhesive to accelerate curing.

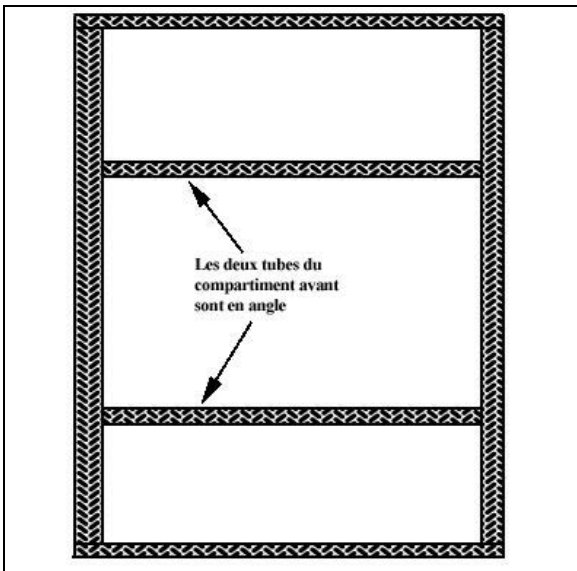


Allow drying for at least **2 hours** then repaint as per paragraph: Minor Repair.

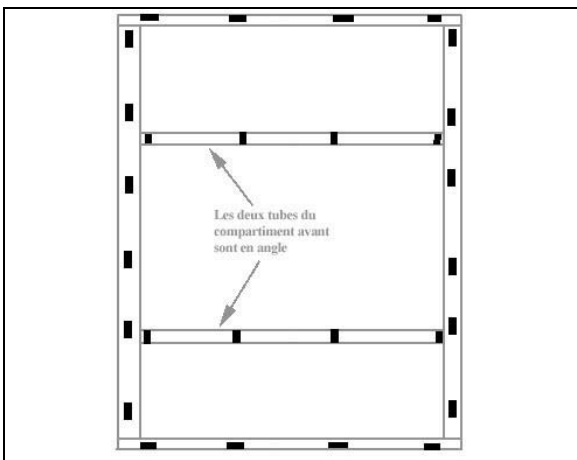
11.2.2 Baggage Compartment Floor Installation

Preparation and Installation

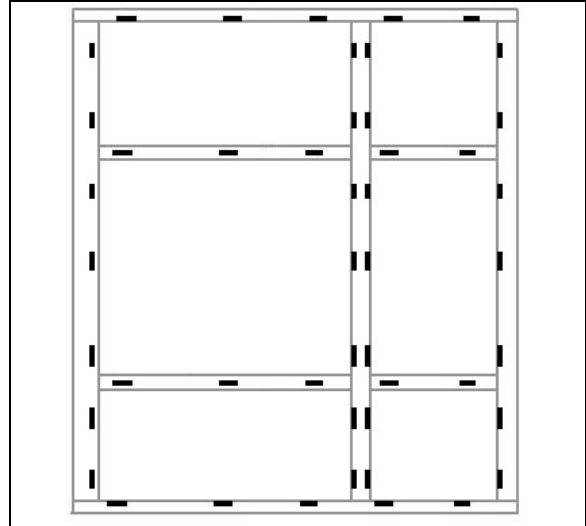
Clean baggage compartment support structure using anti-silicone.



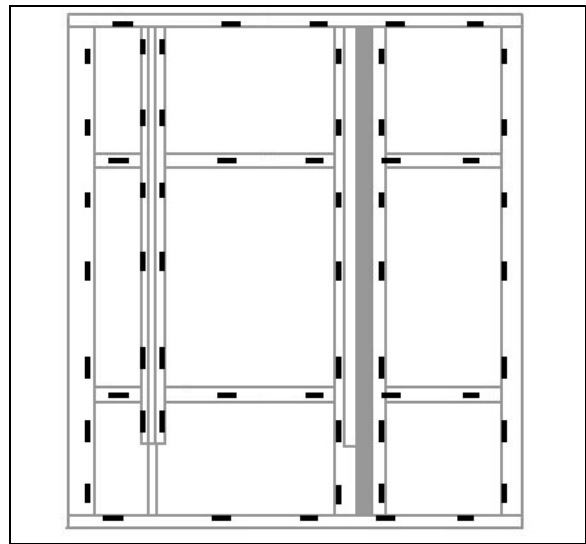
Glue spacers (790392) about 16-inch apart.



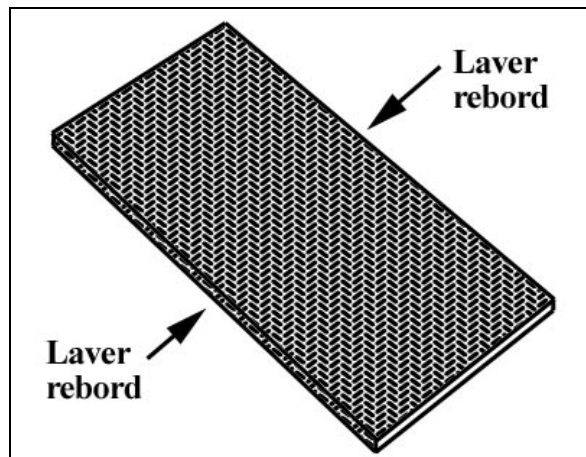
Rear baggage compartment without WCL.



Rear baggage compartment equipped with WCL

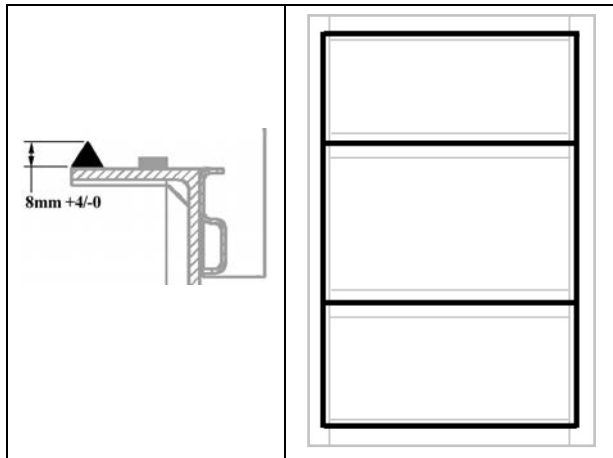


Prepare baggage compartment Mantex floor. Clean panel underside and edges.

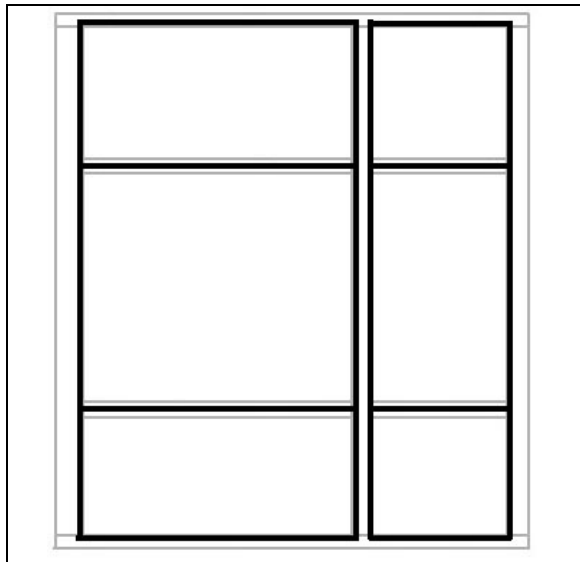


Section 18: BODY

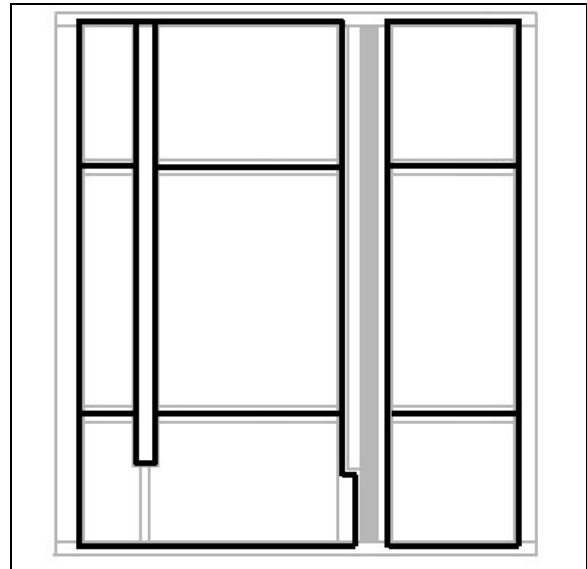
Using a triangular nozzle, apply "Simson" glue (685126) onto support structure.



Rear baggage compartment without WCL.



Rear baggage compartment equipped with WCL

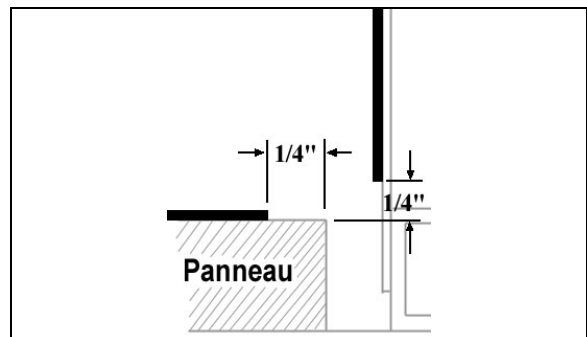


Carefully install panel onto support structure.

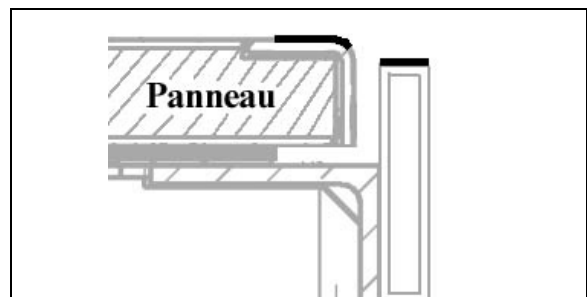
Evenly distribute and install conforming weights (6 to 8) (80 to 100 lbs **total**) onto panel for at least **4 hours**. Make sure panel does not move.

Finishing Joints

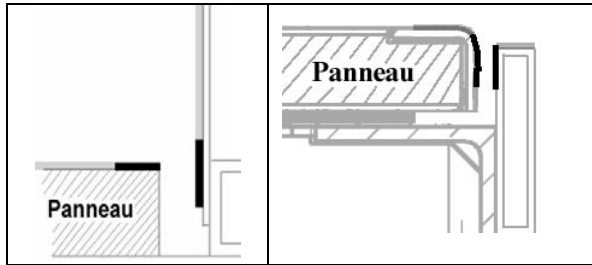
In the case of lateral finishing joint, apply some masking tape $\frac{1}{4}$ " from panel edge and $\frac{1}{4}$ " above panel.



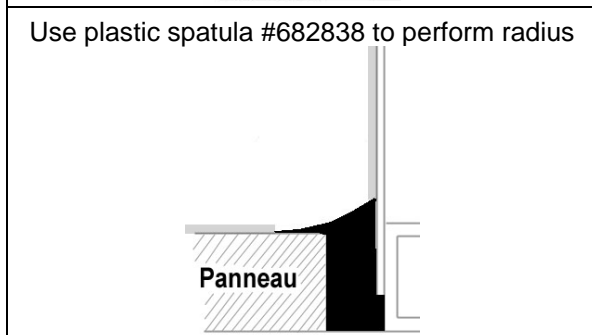
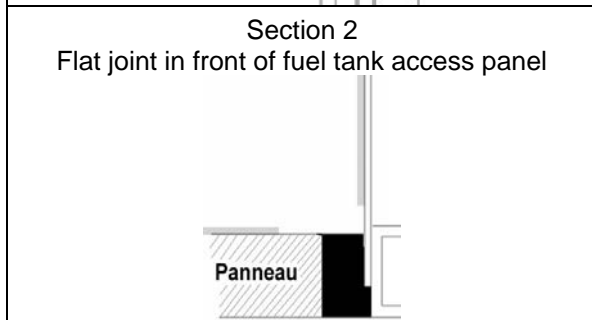
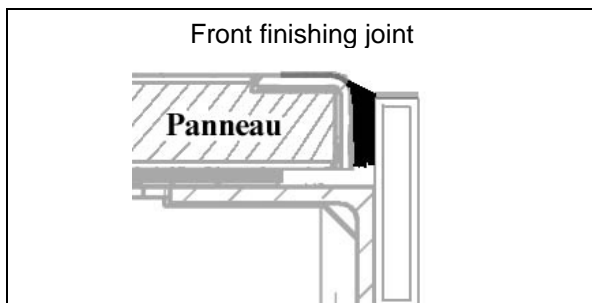
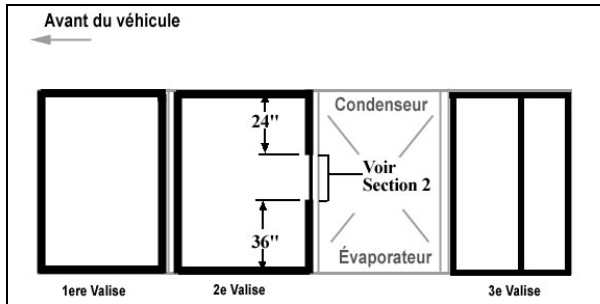
In the case of front finishing joint, apply some masking tape on each side of joint.



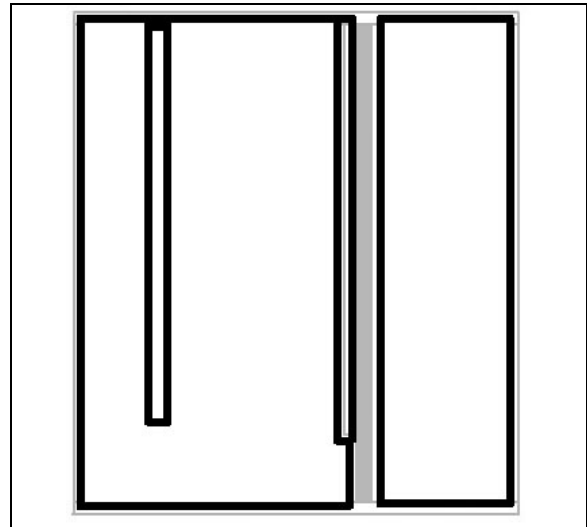
Clean with anti-silicone the area where the Simson glue will be applied.



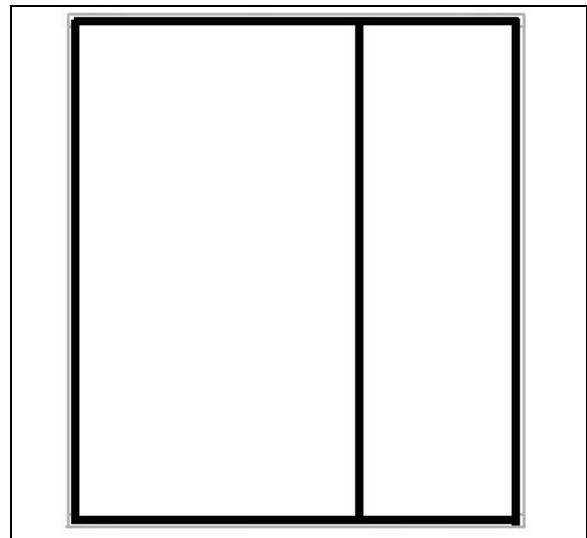
Apply some Simson glue to fill the gap.



Rear baggage compartment equipped with WCL



Rear baggage compartment without WCL.



Remove masking tape.

Smooth down joints using soapy water.

11.3 EVAPORATOR COMPARTMENT DOOR

1. Open the evaporator door.
2. Loosen the screws fixing the hinge to hinge attachment or hinge to door assembly. Loosening the screws allows the evaporator door assembly to be shifted "LEFT or RIGHT" and "UP or DOWN" or "IN and OUT".
3. Adjust evaporator door assembly position at the hinge.
4. Tighten the screws.

Section 18: BODY

5. Respect the required gap between exterior finishing panels.
6. Check that the door swings freely and closes properly. It may be necessary to adjust the door latch to get proper fit and operation.

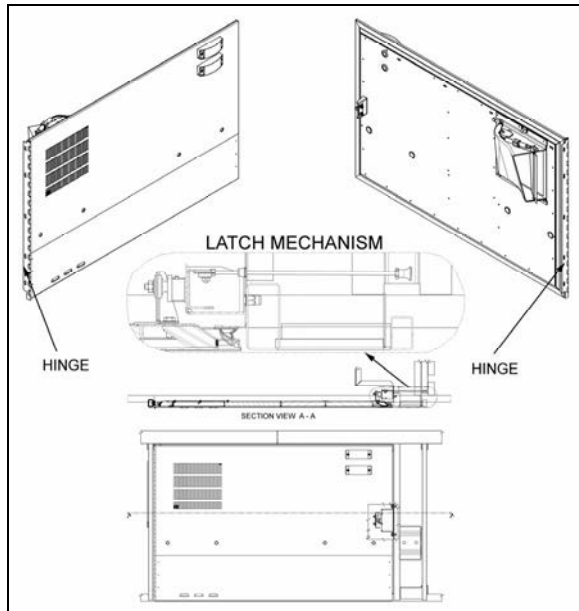


FIGURE 36: EVAPORATOR DOOR

18637

11.4 CONDENSER COMPARTMENT DOOR

1. Open the condenser door.
2. Loosen the screws fixing the hinge to hinge attachment or hinge to door assembly. Loosening the screws allows the condenser door assembly to be shifted "LEFT or RIGHT" and "UP or DOWN" or "IN and OUT".
3. Adjust condenser door assembly position at the hinge.
4. Tighten the screws.
5. Respect the required gap between exterior finishing panels.
6. Check that the door swings freely and closes properly. It may be necessary to adjust the door latch to get proper fit and operation.

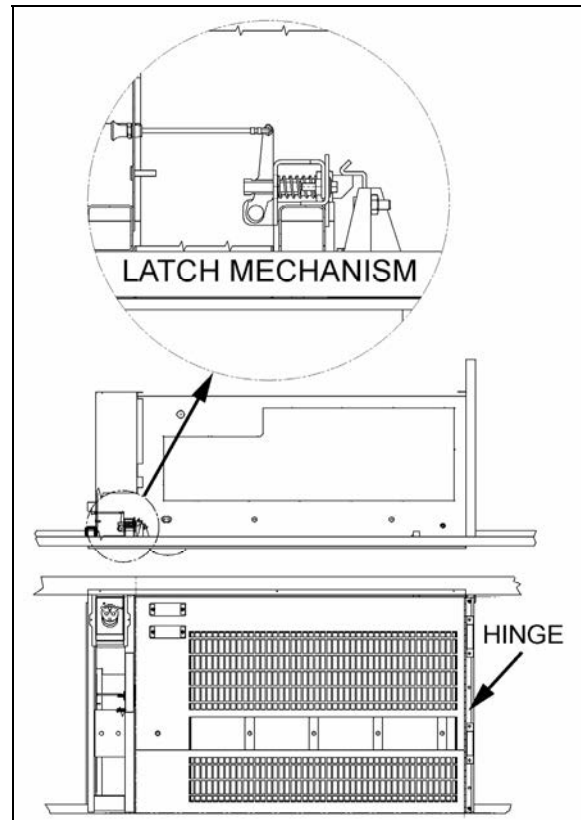


FIGURE 37: CONDENSER DOOR

18638

11.5 FUEL FILLER DOOR

1. Open the fuel filler door.
2. Loosen the screws holding the panel to hinge assembly.
3. Adjust the fuel filler door position according to distance required between exterior finishing panels.
4. Tighten the nuts.
5. Check that the door swings freely and closes properly.

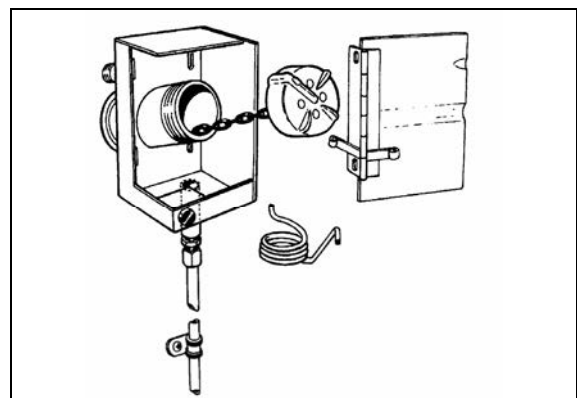


FIGURE 38: FUEL FILLER DOOR

03046

12 ZONE 6

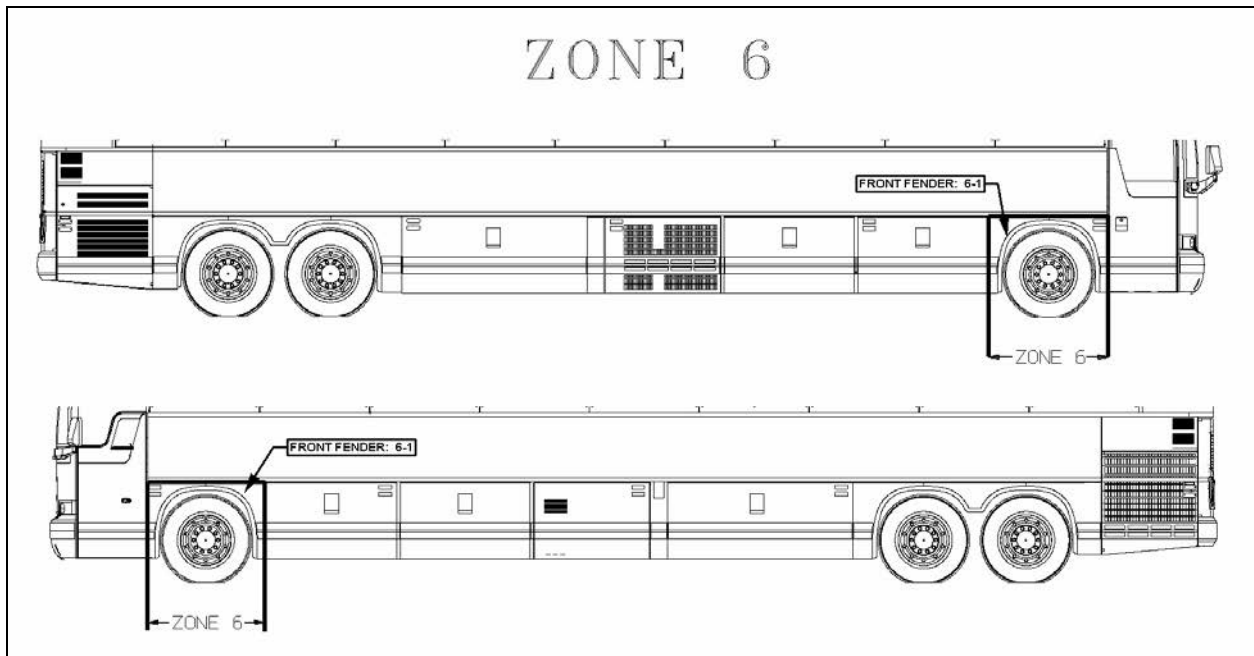


FIGURE 39: ZONE 6

18629

12.1 FRONT FENDER

Front fender may be removed using the following procedure:

Remove the nuts on the inside of the fender. Remove the fender from the vehicle. To reinstall, reverse the procedure.

13 ZONE 7

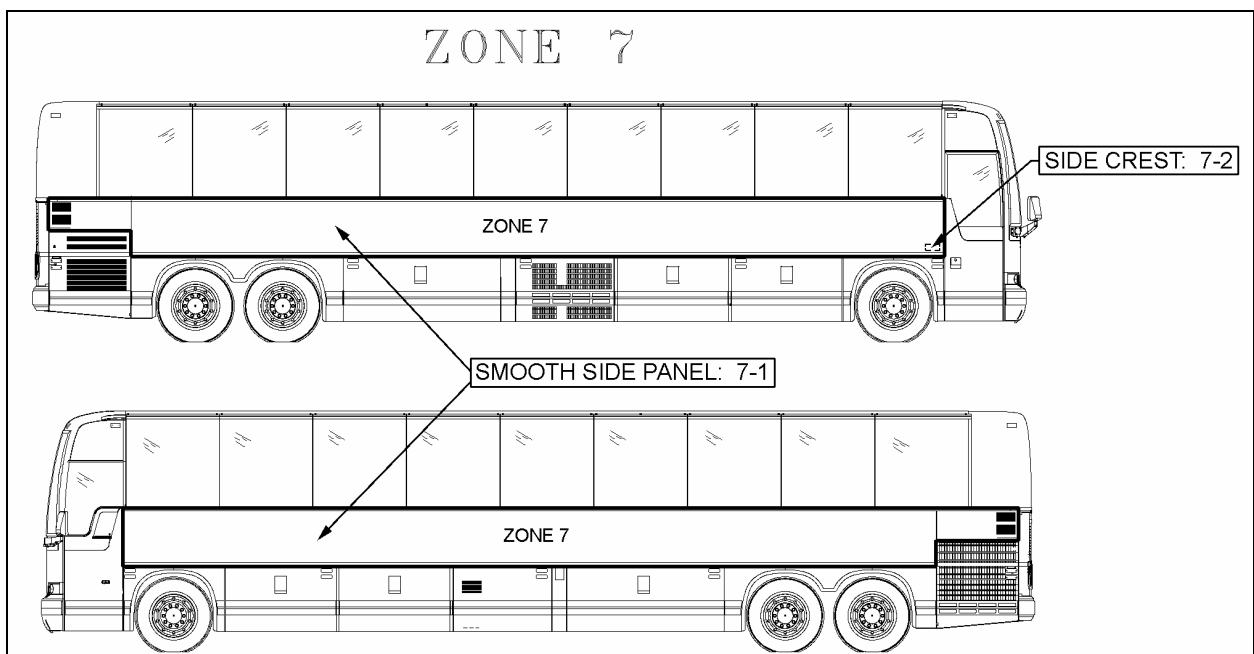


FIGURE 40: ZONE 7

18630

Section 18: BODY

13.1 X3 SMOOTH SIDE PANEL REPLACEMENT PROCEDURE

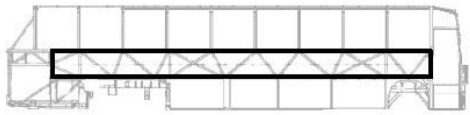
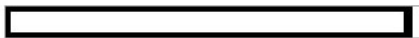
Material:

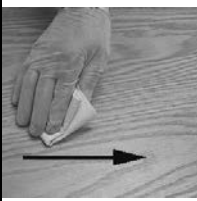
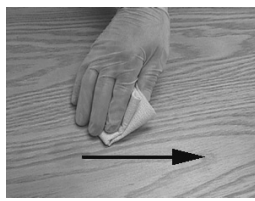
Anti-silicone (682989)	√	Scotchbrite gray (680226)	√	Sika 221 gray	√
CHIX cloth (682384)	√	Sika 205 1liter (683097)	√	Sika 252 black	√
Blue cloth (682383)	√				

Equipment:

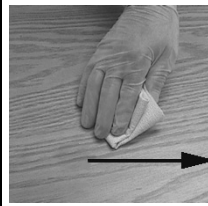
Glue gun	√	
Pencil	√	

SECTION 1 SMOOTH SIDE PANEL REMOVAL		
1.00	REMOVAL	
A)	Remove finishing molding. Insert a screwdriver into snap-on finishing molding joint. Bend finishing molding enough to be able to fix a pair of locking pliers. Using the pair of locking pliers, pull the stainless steel molding and at the same time gradually cut Sika bead with a sharp knife.	Be careful not to damage the adjacent surfaces.
B)	Using a hammer and punch, drive out rivet shanks from top and bottom and from front and rear finishing molding supports. Use a #11 titanium drill bit to remove rivet heads.	
C)	Grind tig weld spots at each end of side panel.	
D)	Safely support or temporary fix side panel.	Warning: Panel weights over 200 pounds
E)	Insert a flat screwdriver between the side panel and the vehicle chassis, in the top left and right corners. Make sure to separate side panel from structure.	Be careful not to damage the adjacent surfaces.
F)	Use the c-clamp to separate the side panel from the back structural panel and at the same time gradually cut Sika bead with a sharp knife.	Ideally, the hoist or chain block must be fastened to the floor while pulling from a 45° angle so as not to damage the vehicle structure
G)	Remove as much glue as possible from the structure using a putty knife or pneumatic knife without damaging 206 G+P primer.	Never heat SikaFlex adhesive to remove.
H)	Check panel horizontal supports for straightness using a straight edge. Take measurements with a ruler.	Tolerance : 1mm towards the outside and 1.5mm towards the inside.

SECTION 2 PREPARATION OF SURFACES			
2.00	VEHICLE SURFACE PREPARATION		
	A)	Clean using "anti-silicone" until all clothes come clean. See PR000001 section A.	
	B)	Use the belt sander (grit coarse) Use a new paper on each vehicle side.	
	C)	Clean using "anti-silicone" until all clothes come clean. See PR000001 section A.	
D)	Apply – Sika 205 See PR000001 section B.		
2.05	SIDE PANEL PREPARATION		
	A)	Clean using "anti-silicone" until all clothes come clean. See PR000001 section A.	
	B)	Use the belt sander (grit coarse) Use a new paper on each vehicle side panel.	
	C)	Clean using "anti-silicone" until all clothes come clean. See PR000001 section A.	
D)	Apply – Sika 205 See PR000001 section B.		

PR000001 Section A Alcohol or Anti-silicone	
	<p>1. Apply</p> <p>CHIX cloth</p>
	<p>2. Dry immediately</p> <p>Blue cloth</p>
3. Allow to dry	
Mandatory	Minimum time : Wait for product to evaporate
	After 2 hours: Start cleaning operation again
Before applying any other product	If surface seems dusty, greasy or with finger marks, start cleaning operation again.

Section B Sika 205



1. Apply

CHIX cloth

2. Allow drying

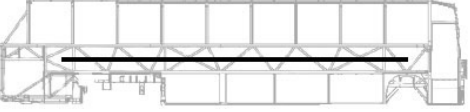
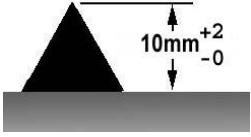
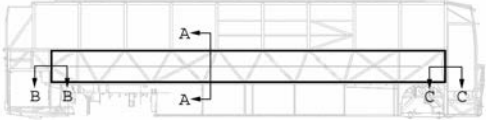
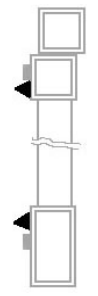

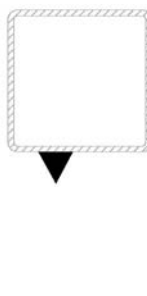
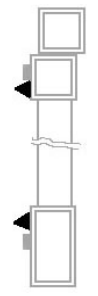

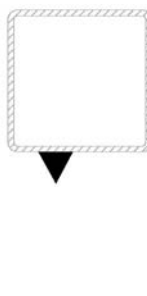
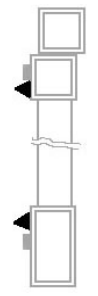

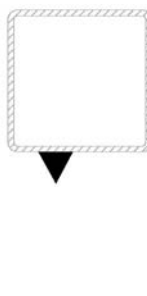
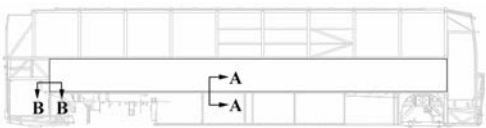
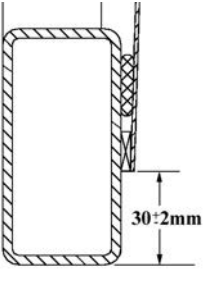
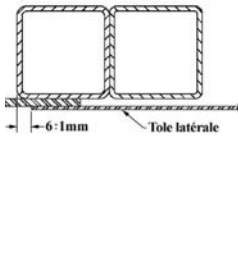
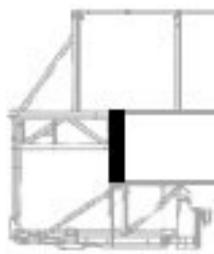
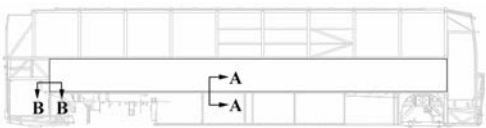
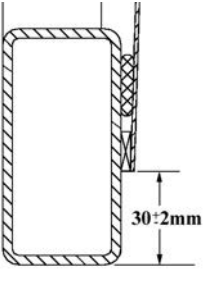
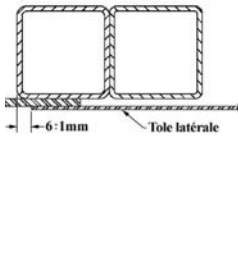
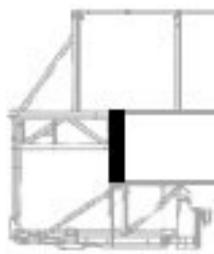
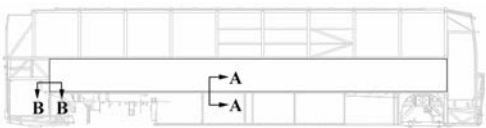
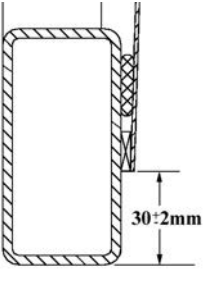
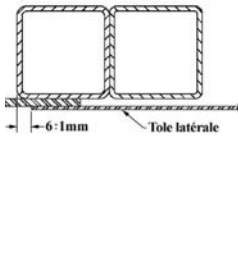
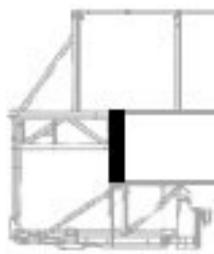
Mandatory	Minimum time	- For a smooth surface (aluminum, stainless steel, fiber glass (gelcoat side), etc.):	2 minutes
		- Pour a porous surface (fiber glass (non gelcoat side), etc.)	10 minutes

After 2 hours : Reactivate surface with Sika 205



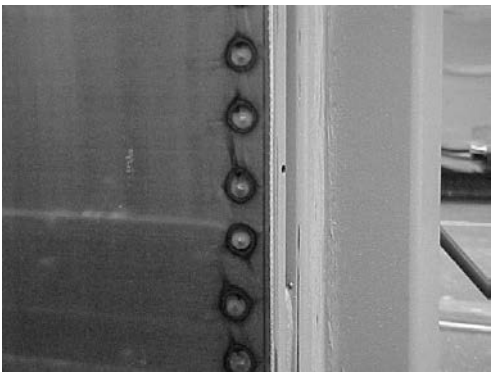
Before applying any other product If surface seems dusty, greasy or with finger marks, start operation again.

SECTION 3 SIDE PANEL INSTALLATION

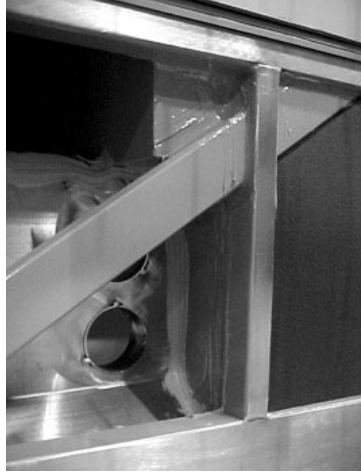
3.00	A)	Using a pencil, mark the double-face self adhesive tape position onto vehicle side.	
	B)	Apply 1/8 X 1/2" double-face tape as per marking.	
	C)	Compress tape	
	D)	Remove protective film from double-face self adhesive tape center section.	

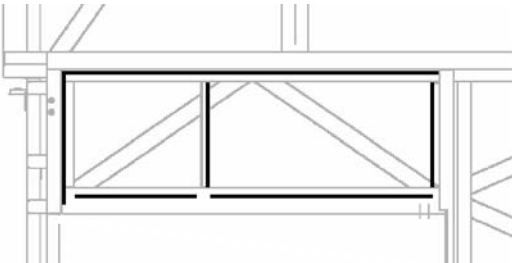

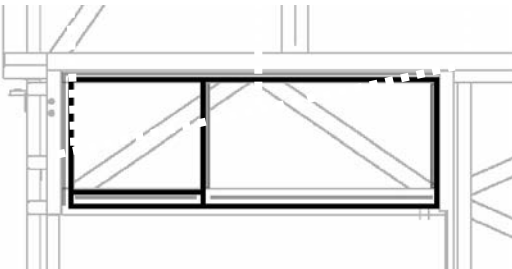
3.05	Install 1/8 X 1/2" foam tape onto middle reinforcement then compress.																						
3.10	<p>Apply Sika 252</p>  <ul style="list-style-type: none"> - Onto vehicle surface - Cut nozzle as per template - Use the guide for the application <p>Bead must be continuous for the whole perimeter.</p>	 <table border="1" data-bbox="954 546 1448 898"> <thead> <tr> <th data-bbox="954 546 1107 588">Section A-A</th> <th data-bbox="1107 546 1279 588">Section B-B</th> <th data-bbox="1279 546 1448 588">Section C-C</th> </tr> </thead> <tbody> <tr> <td data-bbox="954 588 1107 898">  </td> <td data-bbox="1107 588 1279 898">  </td> <td data-bbox="1279 588 1448 898">  </td> </tr> </tbody> </table>		Section A-A	Section B-B	Section C-C																	
Section A-A	Section B-B	Section C-C																					
																							
3.15	<table border="1" data-bbox="284 898 938 1869"> <tr> <td data-bbox="284 898 360 1056">A)</td> <td data-bbox="360 898 938 1056">Install side panel onto support jig.</td> </tr> <tr> <td data-bbox="284 1056 360 1407">B)</td> <td data-bbox="360 1056 938 1407">Position side panel in front of vehicle structure</td> </tr> <tr> <td data-bbox="284 1407 360 1539">C)</td> <td data-bbox="360 1407 938 1539">Perform final adjustment to make sure that side panel is true and square</td> </tr> <tr> <td data-bbox="284 1539 360 1806">D)</td> <td data-bbox="360 1539 938 1806">Sand rear of side panel 2" wide</td> </tr> <tr> <td data-bbox="284 1806 360 1869">E)</td> <td data-bbox="360 1806 938 1869">Perform tig spot welding (1" apart)</td> </tr> </table>	A)	Install side panel onto support jig.	B)	Position side panel in front of vehicle structure	C)	Perform final adjustment to make sure that side panel is true and square	D)	Sand rear of side panel 2" wide	E)	Perform tig spot welding (1" apart)	<table border="1" data-bbox="938 898 1448 1869"> <tr> <td colspan="2" data-bbox="938 898 1448 1056">  </td> </tr> <tr> <td data-bbox="938 1056 1193 1407"> <p>Section A-A</p>  <p>30 ± 2mm</p> </td> <td data-bbox="1193 1056 1448 1407"> <p>Section B-B</p>  <p>6 ± 1mm Toile latérale</p> </td> </tr> <tr> <td colspan="2" data-bbox="938 1407 1448 1539"> <ul style="list-style-type: none"> - 30 mm. ± 2 with reference to bottom tubing - 6 mm ± 1 with reference to vertical tubing </td> </tr> <tr> <td colspan="2" data-bbox="938 1539 1448 1806">  </td> </tr> <tr> <td colspan="2" data-bbox="938 1806 1448 1869"> <p>Quantity of "tig spot": 30 minimum.</p> </td> </tr> </table>				<p>Section A-A</p>  <p>30 ± 2mm</p>	<p>Section B-B</p>  <p>6 ± 1mm Toile latérale</p>	<ul style="list-style-type: none"> - 30 mm. ± 2 with reference to bottom tubing - 6 mm ± 1 with reference to vertical tubing 				<p>Quantity of "tig spot": 30 minimum.</p>	
A)	Install side panel onto support jig.																						
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<ul style="list-style-type: none"> - 30 mm. ± 2 with reference to bottom tubing - 6 mm ± 1 with reference to vertical tubing 																							
																							
<p>Quantity of "tig spot": 30 minimum.</p>																							

Section 18: BODY





3.20	A)	Install pulling equipment at the other end of side panel	
	B)	Make a final adjustment in height	
	C)	Sand front of side panel 2" wide	
	D)	Pull side panel so that panel moves 1/8"	Make sure the equipment pulls along the whole width of side panel
	E)	Perform tig spot welding	Quantity of "tig spot": 30 minimum.
3.30	Remove pulling equipment		
3.40	A)	Remove protective film from double-face self adhesive tape.	
	B)	Compress top and bottom section of side panel	
3.50	A)	Cut excess of side panel. Make sure that cut is parallel with tubing.	
	B)	Grind side panel end to line up with door tubing.	
3.60	To seal each panel end, apply masking tape on each side of side panel joint. Use a caulking nozzle and grey Sikaflex 221 adhesive to fill the cavity between the panel and vehicle structure. Clean using Sika 205. Allow 5 minutes minimum for drying.		

	Wear surgical gloves and smooth down the joint with your finger.	
--	--	--

SECTION 4 ENGINE AIR INTAKE PANEL INSTALLATION		
4.00	Make sure that sealing of structure has been performed properly	
4.05	Prepare vehicle surface as for side panel.	Refer to step # 2.00
4.10	Prepare air intake panel as for side panel	Refer to step # 2.05

4.15	Install foam tape 1/8" X 1/4" onto structure, as shown in picture	
4.20	Install foam tape 1/16" X 1/4" onto air intake panel pleat	
4.25	Apply a bead of 252 onto structure as per picture Important: Make sure bead is continuous Triangular bead: 10mm x 8mm	
4.30	Install panel onto structure	Use a jig to make sure that panel is lined up with engine door tubing.
4.40	Use a brush to compress Sika bead	

Section 18: BODY

5.00 *	Finition Joint		
	A)	Install a protective tape onto the tubing above welding	
	B)	Apply Sika 205 Use a plastic spatula inside a Chix cloth to ensure that Sika 205 reaches as far as the corner. See PR000001 section B.	
	C)	Apply Sika 252 black at the junction of both tubing. Smooth down the joint	
D)	Remove protective tape		

13.2 SIDE CREST

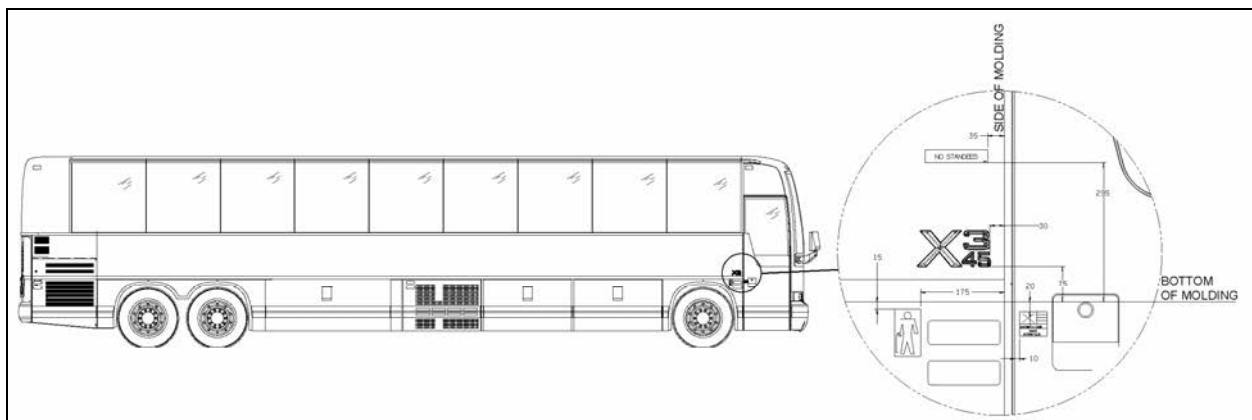


FIGURE 41: SIDE CREST POSITIONING

18639

- Clean vehicle surface using anti-silicone where the side crest and stickers will be applied.
- Using hands apply and compress side crest.
- Apply required stickers.

14 BODY PANEL AND WINDOW SPACING

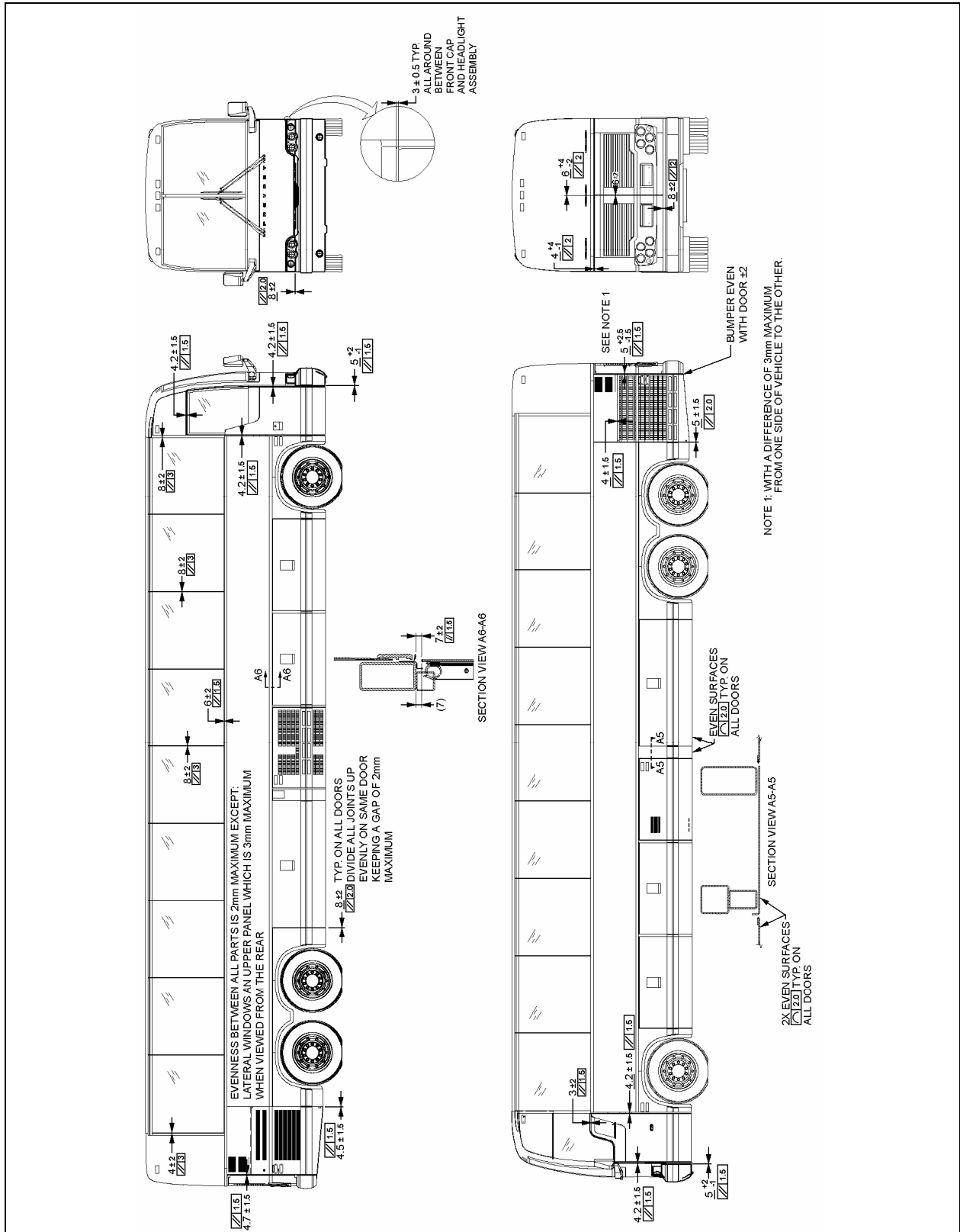


FIGURE 42: BODY PANEL AND WINDOW SPACING

18631

15 PASSENGER SEATS

X3 coaches can be equipped with any of 3 basic seat models and installed in a variety of seating arrangements:

1. The "Tourismo 2" seat is the base model and is available in heights of 40" (102 cm) and 42" (107 cm). Seating arrangement includes 2 card tables which can be folded and removed, and pivoting seats ahead of each card table. Each pair of seats is built on a welded steel frame fastened to the side wall and on a track-mounted pedestal.
2. The "Silhouette" seat is an optional model with each pair also built on a welded steel frame and mounted the same way as the "Tourismo 2" seat. Standard seating arrangement with "Silhouette" seat includes 2 card tables and 2 pivoting seats. Seating capacity is the same as with the "Tourismo 2" seat.
3. The "V.I.P." seat model is an optional seat. "V.I.P." seats are mounted on one row of paired seats built on a common frame on one side of the vehicle, and a row of single seats on the other side of the vehicle with an off-center aisle. Each "V.I.P." seat has its own set of armrests.

Each seat has a easily removable bottom cushion. Upholstery is clipped on the cushion frame for cleaning or replacement. To remove the fabric, simply unclip from the frame. The "Tourismo 2" and "Silhouette" seats have 3 armrests. The aisle and center armrests can be folded up and down manually, while the window armrest is fixed.

15.1 ROTATING SEATS

1. Remove 1 wing nut holding each seat bottom cushion from under the seat frame.
2. Lift front part of cushions and remove cushions.
3. Remove 4 wing screws fastening seat assembly to seat frame.
4. Pull seat toward aisle and rotate.
5. Align mounting holes and reinstall 4 wing screws.
6. Reinstall seat bottom cushions with wing nuts.

15.2 REMOVING FIXED SEATS

NOTE

Seats on one row are not interchangeable with seats of the other row.

To remove fixed seats, proceed as follows:

1. Remove 1 nut holding each seat bottom cushion from under the front part of the seat frame.
2. Lift front part of cushions and remove cushions.
3. Remove 4 finishing screws holding plastic cover between side wall and seat frame.
4. Remove 2 cap screws, nuts, and washers holding seat frame to side wall and retain the 2 holding brackets. See figure 43.
5. Remove 2 nuts and washers holding seat frame to pedestal rods. See figure 44.

NOTE

Bottom end of rod is coated with Locktite and threaded in a steel block which slides in the floor track. Removal of rod is possible if loosened from block. Otherwise, slide rod and block assembly to the front end of track after removing all seats located in front.

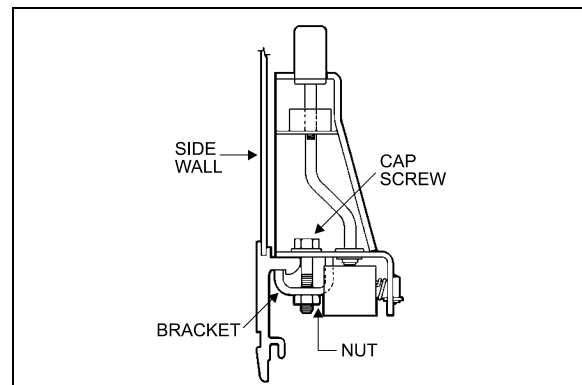


FIGURE 43: ARMREST

18106

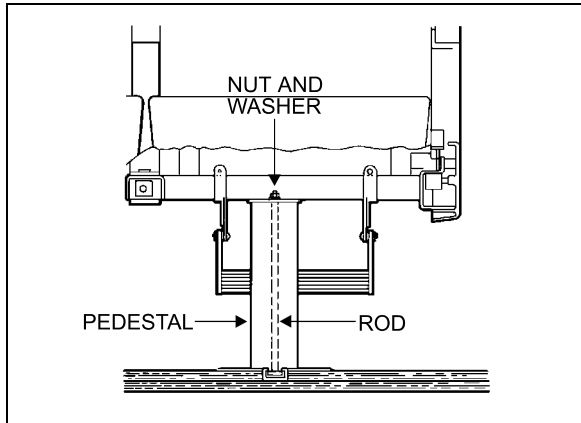


FIGURE 44: SEAT PEDESTAL ASSEMBLY 18107

6. Remove seat assembly.
7. Reverse the above procedure to install seat assembly.

NOTE

On newer vehicles, the rod consists of a carriage bolt inserted in a square plate sliding in the floor track. Removal is possible only by the front or rear end of track.

15.3 UPHOLSTERY MAINTENANCE

Coach seats are lightweight, with foam-padded backs and cushions. For both appearance and wearability, best results are obtained if upholstery is cleaned at regular intervals before dirt, dust and grit have been ground into the fabric. Seat fabric is made of 50% wool, 33% cotton, 9% nylon, and 8% acrylic.

15.3.1 Routine Cleaning

All that is required to remove the dirt is a gentle beating with the hand or the back of a brush. This will bring the dirt to the surface where it is easily removed with a vacuum or brush in the direction of the pile which can easily be recognized by running a hand lightly over the pile. If the fabric becomes excessively dirty, particles of grit will cause gradual wear, reducing the life span of the fabric.

15.3.2 Dry Cleaning

If covers are to be removed for cleaning, dry cleaning is recommended since washing might cause some shrinkage, preventing the covers from being reapplied to the seats without damage. Other than spot cleaning the covers while they are in place, dry cleaning is not

recommended, since the resulting fumes could be hazardous in the confines of the coach and the solvent could be detrimental to the foam padding of the seats.

15.3.3 Cleaning With Covers in Place

The most effective and economical method to clean the fabric seat covers is by washing with either an approved foam upholstery cleaner or with a mild household detergent.

Thoroughly vacuum the upholstery. Remove any spots or stains before the seats are washed to avoid a cleaning ring.

Dilute household detergent or liquid foam cleaner according to directions on the container. Pour a small quantity into a flat pan and work into a thick foam with a sponge or brush.

Apply only the foam to the fabric with a sponge or brush. Clean a small area of the fabric at a time with the foam. **DO NOT SOAK.** Rub vigorously. Sponge the suds from the fabric with a clean sponge or cloth moistened with water. Rinse the sponge or cloth often and change the water when it becomes dirty.

Allow the upholstery to dry completely before the coach goes back into service. To speed up drying, excess moisture can be blown off the fabric with compressed air.



CAUTION

Oil in the air line will soil the fabric. Blow the line clear and test air discharge against a plain white piece of paper. It is also effective to press the edge of a flat hardwood stick down on the cushion and slowly draw it across the fabric.

Even very soiled areas can be returned to their original appearance by a thorough cleaning, but a regular schedule of cleaning that keeps the upholstery reasonably clean at all times will greatly enhance the life span of upholstery.

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16 TARABUS FLOOR COVERING REPAIR OR REPLACEMENT

On X3 vehicles equipped with “Tarabus” covering, it is possible to replace or repair this covering. The purpose of this paragraph is to explain the steps to be followed to ensure the best results and adherence.

MATERIAL

Part No	Description	Qty
680028	Adhesive, Tarabus Floor Covering (White)	A/R
684655	Adhesive, Contact (3M)	3.8L
684654	Adhesive, Contact (3M)	18.9L
680532	Sikaflex 221 Gray	A/R

NOTE

Material can be obtained through regular channels.

1. Remove number of passenger seats required to perform repair.
2. Cut and remove damaged section of floor covering.

NOTE

It would be preferable to cut under two rows of seats so that repair is not as noticeable.

3. Clean plywood using a scraper.

NOTE

Make sure that no staples are sticking out beyond surface. Adjacent plywood sheets must be leveled.

4. Fill up holes and imperfections using MAPI PRP 110 then sand.
5. Remove dirt and adhesive residue.



CAUTION

Do not leave floor covering folded down except temporarily during installation.

6. Apply floor covering adhesive (680028) onto plywood using a serrated spreader with 1/8-inch serration. If required, apply contact adhesive (3M) (684655 or 684654) onto aluminum molding and also onto section of floor covering, which will be in contact with molding (refer to figure 45).

NOTE

Allow adhesive to dry (3 to 5 minutes).

7. Compress floor covering using a roller so as to remove any trapped air bubble.
8. Apply Sikaflex 221 gray sealant (680532) alongside passenger seat fixing tracks (refer to figure 46).

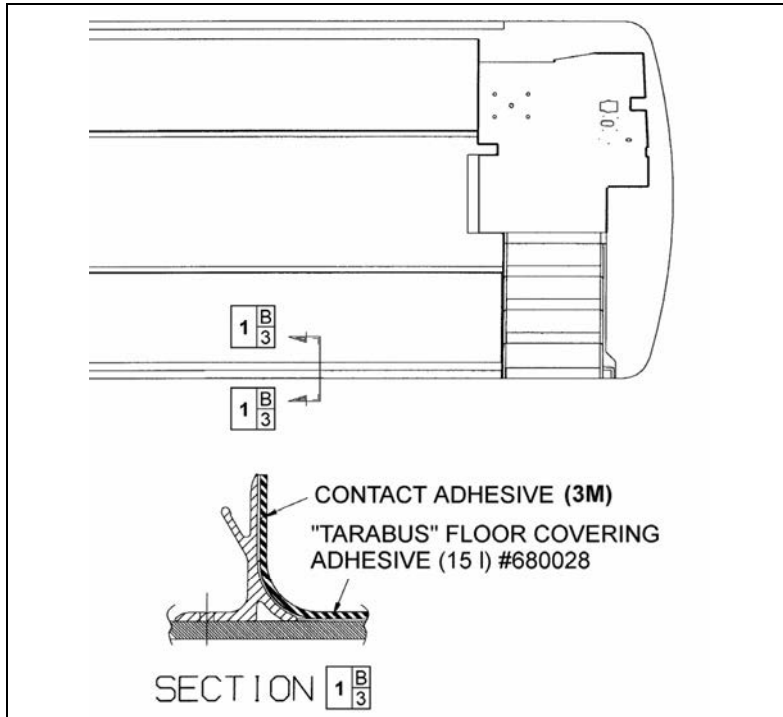


FIGURE 45: TARABUS FLOOR COVERING ADHESIVE APPLICATION 18640

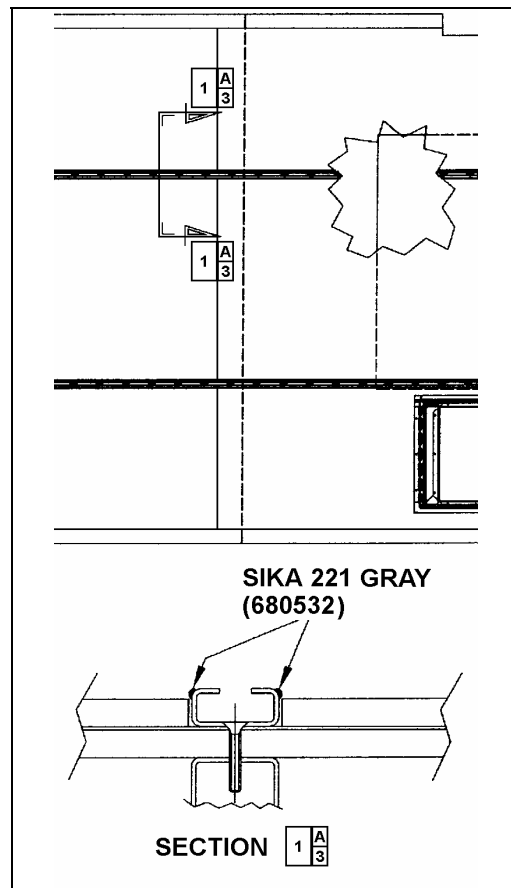


FIGURE 46: APPLICATION OF SIKA 221 GRAY 18641

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16.1 FRONT STEPS REPLACEMENT PROCEDURE

MATERIAL

Part No	Description	Qty
682989	Anti-silicone	A/R
683097	Sika 205 (1 liter)	A/R
685101	Sika Remover 208	A/R
683916	Sika 215 (1 liter)	A/R

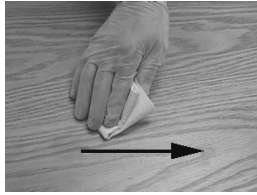
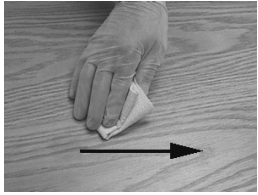
1. Cut and remove damaged step(s).
2. Remove dirt and adhesive residue.

NOTE

In wintertime, condensation and cold temperature may greatly influence bonding parameters. Working area must be at a temperature sufficient to prevent reaching condensation point. Mechanically preheat working area (heat lamp or heat gun) or wait until vehicle reaches room temperature.

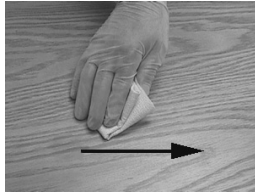
PREPARATION OF "TARABUS" FLOOR COVERING

1. Sand under step using "Scotchbrite".
2. Clean using anti-silicone (refer to Section A).

Section A Alcohol or Anti-silicone	
	<p>1. Apply</p> <p>CHIX cloth</p>
	<p>2. Dry immediately</p> <p>Blue cloth</p>
3. Allow drying	
Mandatory	Minimum time : Wait for product to evaporate
	After 2 hours: Start cleaning operation again
Before applying any other product	If surface seems dusty, greasy or with finger marks, start cleaning operation again.

3. Apply Sika Primer 215 (refer to Section D).

Section D Sika Primer 215



1. Shake bottle to mix product
2. Apply a thin layer

CHIX cloth

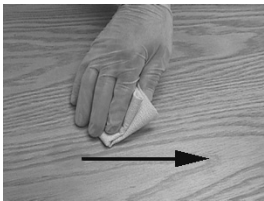
3. Allow drying

Mandatory	215	Minimum time : 20 minutes
		After 2 hours : Remove dust using damp cloth (pure water)
Before applying any other product		If surface seems dusty, dust using damp cloth.
		If surface seems greasy or with finger marks, reactivate with Aktivator.

PREPARATION OF FIBERGLASS

1. Clean using anti-silicone (refer to Section A).
2. Apply Sika 205 (refer to Section B).

Section D Sika Primer 215



1. Apply

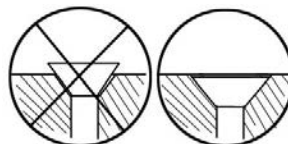
CHIX cloth

2. Allow drying

Mandatory	Minimum time	- For a smooth surface (aluminum, stainless, steel, fiberglass (gelcoat side), etc.):	2 minutes
		- For a porous surface (fiberglass (non gelcoat side), etc.)	10 minutes
		After 2 hours : Reactivate surface with Sika 205	
Before applying any other product		If surface seems dusty, greasy or with finger marks, start operation again.	

X3 VEHICLES FRONT STEPS GLUING

1. Use step nosing to measure and cut necessary length of white safety strip.
2. Use a screw to check depth of countersinking in step nosing. Screw top must not stick out beyond the aluminum surface. Countersink if needed.



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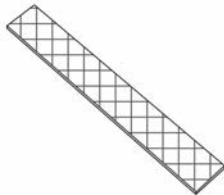
3. Apply some Sika 252 onto the step; make sure to cover the whole surface of the step. Use a serrated spreader with 1/8-inch serration to spread Sika.
4. Apply a bead of Sika 221 onto the perimeter of the step.
5. Install step and press with hands. If Sika overflows, clean with Sika 208. Repeat previous stages for each step if applicable.
6. Remove protective film from double-coated self adhesive tape located underneath step nosing, position step nosing then press. Drill and fix using screws.



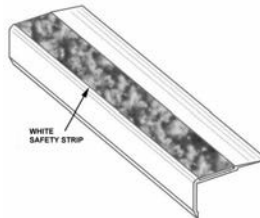
7. Clean top of step nosing using Sika 205 (refer to Section B).



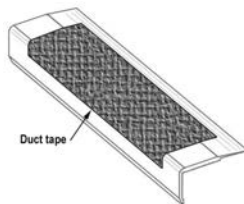
8. Apply some Sika 221 onto white safety strip, spread with a spatula to cover the whole surface.



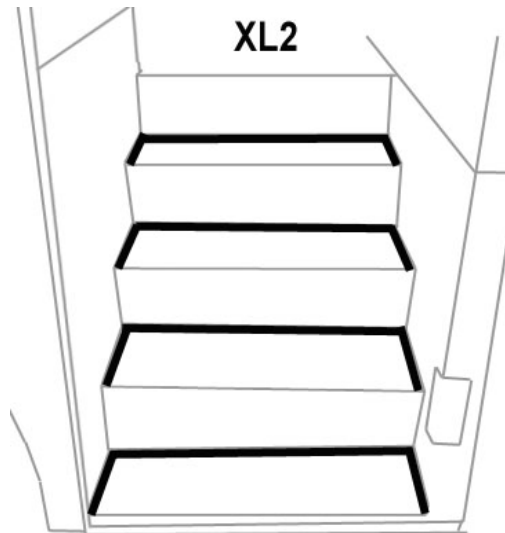
9. Position white safety strip then press using hands. If Sika overflows, clean with Sika 208.



10. Temporarily fix white safety strip with a piece of duct tape, leaving 1 to 2 inches free at each end.



11. Apply some masking tape onto the step perimeter, clean using Sika 205 (refer to Section B) then apply a bead of Sika 252 black. Smooth out the joints then remove masking tape.
12. Install weights onto the steps. Minimum waiting time: 2 hours.

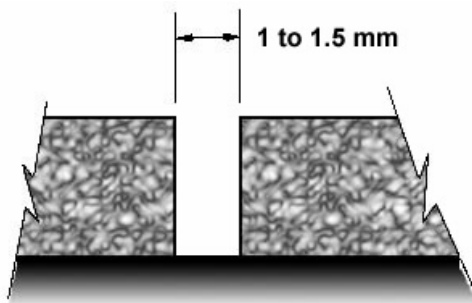


16.2 WELDING OF JOINT BETWEEN WHITE SAFETY STRIP AND "TARABUS" FLOOR COVERING

1. Pre-heat welding torch;

Set welding torch to position #4.5 (temperature of 500 °C),
Heating time: 5 minutes.

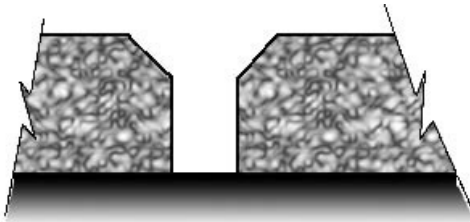
2. Before welding, visually ensure that a 1 to 1.5 mm gap exists between white safety strip and "Tarabus" floor covering. Use a knife if this is not the case.



NOTE

There should be no excess of adhesive on top of surfaces, clean if required using "All-Sol".

3. Chamfer the joint.



NOTE

The chamfer width must always be less than the filler bead diameter (between 2.5 and 3 mm).

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4. Use chamfer knife. **Be careful not to overcut or to cut to the side to prevent damaging “Tarabus” covering.**



5. Add (about 6 inches) some length to the required length of filler bead to make the joint then cut.
6. Take position with welding torch. The proper position is with a slight slope to the rear.



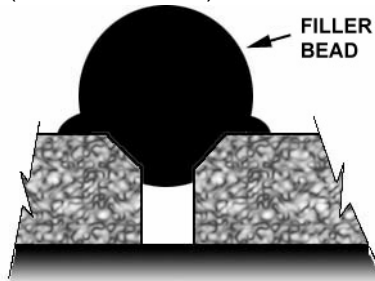
7. Once the welding torch is ready, insert the filler bead into the nozzle and immediately start welding. Move in a regular manner while pressing slightly with torch.



8. The heel of the fast nozzle must not lean against “Tarabus” covering (always parallel to the surface).



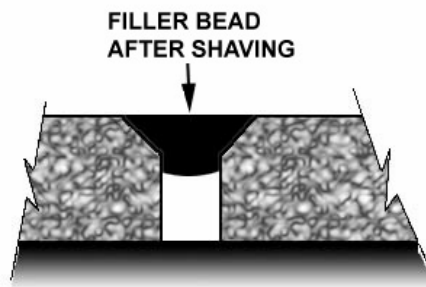
9. Allow cooling down of filler bead (about 5 minutes).



10. Shave filler bead to make it level to the floor. Use supplied knife designed for that purpose.

NOTE

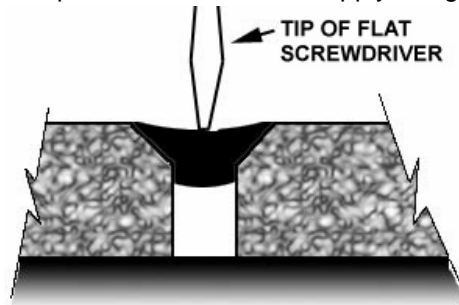
To facilitate the cut, you can spray some soapy water onto the joint.



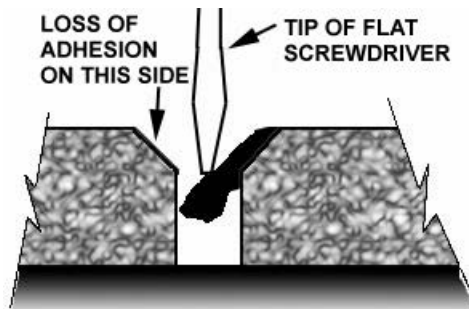
CAUTION

The procedure for turning the torch off must absolutely be followed. If this step is not taken, the element may burn.

11. Set temperature potentiometer to "0" position. Fan will evacuate residual heat. Leave the torch in operation as it is for 3 minutes.
 12. Perform adhesion test using the tip of a flat screwdriver; apply a slight pressure on the joint.



13. If welding was not performed properly, there will a loss of adhesion on one side. If this is the case, repair the joint.



Section 18: BODY

16.3 REPAIR OF A WELDED JOINT

NOTE

In wintertime, condensation and cold temperature may greatly influenced bonding parameters. Working area must be at a temperature sufficient to prevent reaching condensation point. Mechanically preheat working area (heat lamp or heat gun) or wait until vehicle reaches room temperature.

1. Using a knife, remove portion of joint to be repaired.

NOTE

Loss of adhesion may be local. If this is the case, repair may also be local.

2. Chamfer the joint again as indicated in paragraph 12.2, Section: WELDING OF JOINT BETWEEN WHITE SAFETY STRIP AND "TARABUS" FLOOR COVERING.
3. Re-weld the joint as indicated in paragraphs 6, 7 and 8. Use your thumb to hold the filler bead end.



WARNING

Nozzle is hot.



4. Always add an extra inch of filler bead at the beginning and at the end of repair.
5. Perform steps indicated in paragraphs 9, 10 and 11.

17 VEHICLE JACKING POINTS

The vehicle can be lifted by applying pressure under body jacking points or front end and drive axle jacking points. When it is necessary to lift the vehicle, care should be taken to ensure that the pressure is applied only on the specified areas. Equipment for lifting the front of the vehicle must have a combined lifting capacity of at least 20,000 lb. (9 100 kg). Equipment for lifting the rear of the vehicle must have a combined lifting capacity of at least 40,000 lb. (18 200 kg).



WARNING

DO NOT tow or jack vehicle with people on board.



WARNING

When it is necessary to raise the vehicle, care should be taken to ensure that pressure is applied only at the points indicated in figures 47 to 53.



WARNING

Extra lift capacity may be required if luggage or any other type of load are onboard the vehicle.



CAUTION

The suspension of the vehicle must be in the normal ride position before jacking.

Twelve jacking points are located on the vehicle: three are located on each side of the frame and two are located under each axle. Refer to the following illustrations for the location of jacking points.

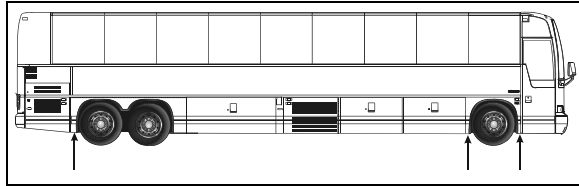


FIGURE 47: JACKING POINTS ON FRAME 18618

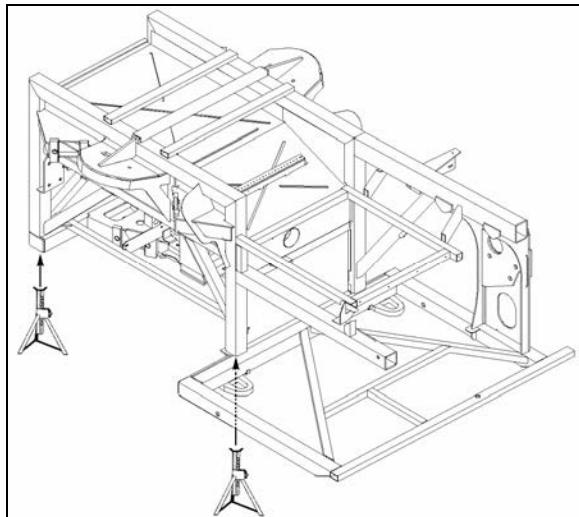


FIGURE 48: FRONT END JACKING POINTS 18592

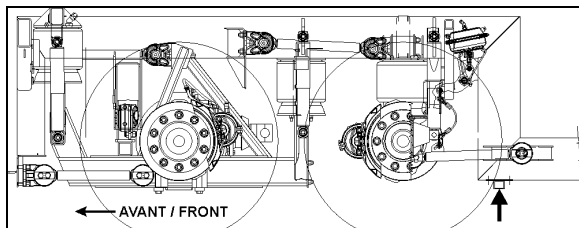


FIGURE 49: REAR END JACKING POINTS 16166

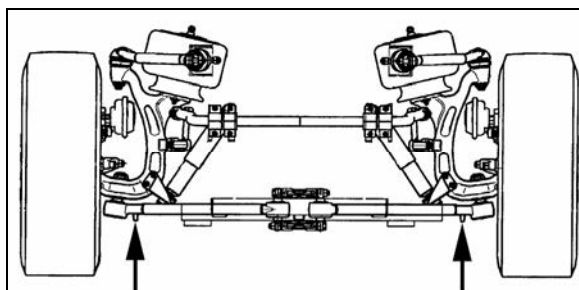


FIGURE 50: JACKING POINTS ON IND. SUSPENSION 16139

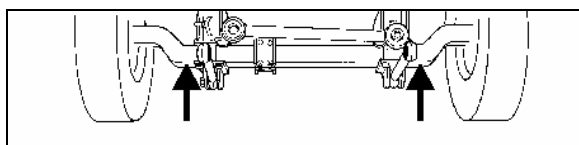


FIGURE 51: JACKING POINT ON FRONT AXLE 10005

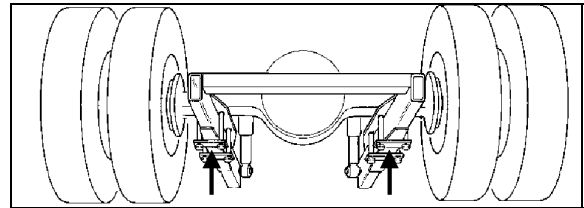


FIGURE 52: JACKING POINTS ON DRIVE AXLE 11005



CAUTION

Always unload or retract the tag axle before jacking the vehicle from the front and drive axle jacking points to prevent damage to suspension components.

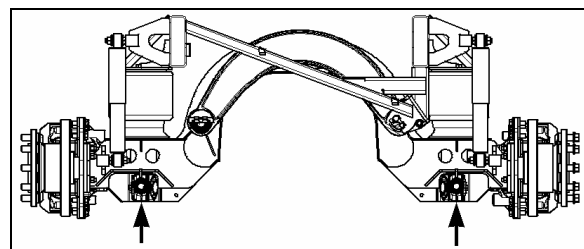


FIGURE 53: JACKING POINTS ON TAG AXLE 11029



WARNING

The jacking points on the tag axle must be used for raising the tag axle only.

Several kinds of hydraulic jacks can be used. Only jack at the specified jacking points. Jack must support the following capacities:

- Front end: 20,000 lb. (9 100 kg);
- Drive axle: 40,000 lb. (18 200 kg).

17.1 HYDRAULIC JACK

To raise: turn release valve clockwise. Insert handle in socket and raise by pumping.

To lower: remove handle and turn the release valve slowly counterclockwise.

Always keep ram and extension screw retracted when jack is not in use.

Service: Check oil level when jack fails to raise to full height. Lower ram completely with release valve open and jack in upright position, remove filler plug and refill to level of filler hole with hydraulic jack oil. Never use brake fluid.



DANGER

Jack is intended for lifting only. Do not get under the vehicle or load for any reason unless it is properly supported with safety stands and securely blocked.



DANGER

Do not overload jack above rated capacity. Prevent "side loading", make sure load is centered on ram. Do not push or tilt load off jack.

18 TOWING THE VEHICLE

The vehicle can be transported on a low bed semi-trailer of adequate gross axle weight capacity. When transporting a vehicle, apply parking brake and shut down the engine. Block all wheels and secure vehicle with tie-downs. Check that overall height will clear obstacles on the route to follow, and obtain required permits.

The vehicle can also be towed by lifting the front axle or by towing from the front with all wheels on the ground. These two methods are described below under their respective headings. Whatever the method used, the vehicle should be towed by truck operators authorized and experienced in towing highway coaches.

Observe normal precautions including, but not limited to, the ones listed below when towing the vehicle:

- Make sure the parking brake is released before towing.
- Do not allow passengers to ride onboard the towed vehicle.
- Tow the vehicle at a safe speed as dictated by road and weather conditions.
- Accelerate and decelerate slowly and cautiously.

To prevent damage to the vehicle, use the two tow eyes located under the back bumper and/or fixed to the vehicle's frame between the front axle and the front bumper. Use only a solid link tow bar and a safety chain to tow the vehicle. If required, connect an auxiliary air supply to the vehicle so brakes can be operated while towing.



CAUTION

To prevent damage to the vehicle structure, it is not recommended to tow the vehicle from the rear. In case of damage to the drive train components, use a low bed semi-trailer to support the rear end.



WARNING

During a towing operation, the driver should be alone inside the vehicle.



CAUTION

To prevent damage to the drive train components, disconnect axle shafts or driveshaft before towing. Do not attempt to push or pull-start a vehicle equipped with an automatic transmission.



CAUTION

Make sure axle shafts or driveshaft are installed correctly after towing. Tighten axle shaft and driveshaft nuts to the correct torque settings. Do not invert shafts

18.1 LIFTING AND TOWING

The towed vehicle must be lifted from under the front axle only. The tow truck must be equipped with the proper lifting equipment to reach under the front axle since no other lifting points are recommended. Lifting and towing from any other point are unauthorized as it may cause serious damage to the structure. Do not unload or raise the tag axle when lifting and towing to prevent overloading the drive axle.

1. Remove both drive axle shafts to prevent damage to the transmission. Plug axle tube to prevent oil loss. Refer to Arvin Meritor "Maintenance Manual no.5" annexed at the end of Section 11, Rear axle, in this manual for correct procedure.



CAUTION

Transmission lubrication is inadequate when towing. With automatic, semi-automatic or manual transmission, the drive axle shafts must be removed to avoid serious damage to the transmission.

- Operate the engine when towing to maintain brake system air pressure. If the engine cannot be operated, connect an external air pressure line from the tow truck to the emergency fill valve in the engine compartment.
- The emergency fill valve in the front service compartment does not supply air pressure to the brake system. The air pressure must be 75 psi (520 kPa) minimum, and the line should be attached to the air line with a clip-on chuck.

**WARNING**

Do not tow the vehicle without external air pressure applied to the emergency fill valve if the engine does not operate. Without brake system air pressure, the brakes may apply automatically if system air drops below 40 psi (275 kPa). If failure prevents releasing the parking brakes with air pressure, disengage the parking brakes mechanically.

- Lift the vehicle from under the front axle, and adequately secure the underside to the tow vehicle lifting attachment with chains.
- Observe safety precautions when towing.

18.2 TOWING WITHOUT LIFTING

**WARNING**

When towing vehicle without lifting, use only a tow truck with a solid link tow bar and related equipment. All other means of towing are unauthorized. Tow only from the front of the vehicle.

- Remove both drive axle shafts to prevent damage to the transmission. Plug axle tube to prevent oil loss. Refer to Arvin Meritor "Maintenance Manual no.5" annexed at the end of Section 11, Rear axle, in this manual for correct procedure.

**CAUTION**

Transmission lubrication is inadequate when towing. With automatic, semi-automatic or manual transmission, the drive axle shafts must be removed to avoid serious damage to the transmission.

- Operate the engine when towing to maintain brake system air pressure. If the engine cannot be operated, connect an external air pressure line from the tow truck to the emergency fill valve in the engine compartment. The emergency fill valve in the front service compartment does not supply air pressure to the brake system. The air pressure must be 75 psi (520 kPa) minimum, and the line should be attached to the air line with a clip-on chuck.

**WARNING**

Do not tow the vehicle without external air pressure applied to the emergency fill valve if the engine does not operate. Without brake system air pressure, the brakes may apply automatically if system air drops below 40 psi (275 kPa). If failure prevents releasing the parking brakes with air pressure, disengage the parking brakes mechanically.

- Position the tow truck so that the tow bar contacts the front bumper of the vehicle.
- Attach the tow truck chains only in the tow eyes of the vehicle under the bumper and take up all the slack.
- Attach safety chains as applicable.
- Observe safety precautions when towing.

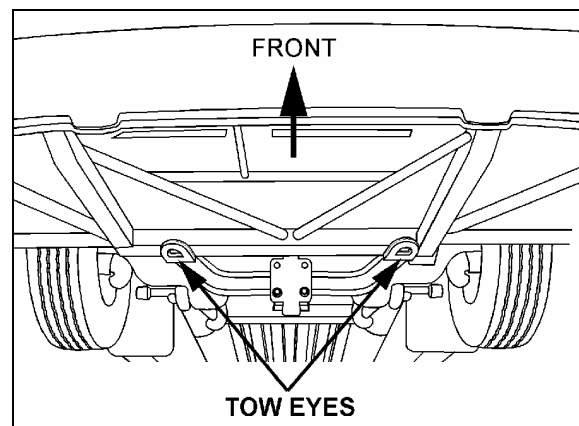


FIGURE 54: TOW EYES

18401

19 SPECIFICATIONS

Door cylinder

Manufacturer Bimba
Type Pneumatic
I.D. 1½" (mm)
Stroke..... 8" (mm)
Prévost number..... 780595

Damper

Manufacturer Koni
Prévost number..... 780565

Lock cylinder (upper)

Manufacturer Bimba
Type Air, single action, 1/8 NPT, hexagonal rod
I.D. 7/8" (22 mm)
Stroke..... 1" (25 mm)
Supplier number..... D-51127-A
Prévost number..... 641392

Lock cylinder (central)

Manufacturer Bimba
Type Air, single action, ¼ NPT
I.D. 1¾" (45 mm)
Stroke..... 1" (25 mm)
Supplier number..... 241-P
Prévost number..... 641209

Manifold solenoid

Manufacturer Norgren
Type 4 ports, 1/8 NPT
Voltage 24 VDC
Power consumption..... 6 watts
Maximum pressure..... 150 psi (1035 kPa)
Prévost number..... 641448

Solenoid valve (Latching valve)

Manufacturer Humphrey
Model 310
Operating range 0 to 125 psi (0 to 860 kPa)
Voltage 24 VDC
Voltage tolerance +10%, -15% of rated voltage
Power consumption..... 4 watts
Leak rate (max allowed) 0.245 in³/min @ 100 psi (4cc/min @ 690 kPa)
Type of operation Direct solenoid
Lubrication..... Not required (factory pre-lubed)
Filtration 40 micron recommended
Prévost number..... 641412

Pressure switch assembly

Prévost number..... 452831

Isringhausen

Seat Model 6800/338 Bus
Seat Model 6800/338 Premium LX

Service Manual



Read and understand this manual before servicing this seat.



INTRODUCTION

**MODEL 6800/338 BUS
MODEL 6800/338 PREMIUM LX**

SERVICE AND REPAIR

Proper service and repair are important to the safe, reliable operation of this seat. Service and repair should be performed only by responsible persons who have been properly instructed and authorized to do so. The procedures recommend in this manual are safe effective methods for performing service and repair operations.

We could not possibly know, evaluate, and advise the service trade of all conceivable ways in which service can be done or of the possible hazardous consequences of each way. If you use a service procedure which is not recommended, be sure that personal safety and equipment safety will not be jeopardized.

It is the responsibility of the mechanic performing the service and repair to:

- inspect for abnormal wear and damage
- choose a repair procedure that will ensure your safety, the safety of others, and the safe operation of the equipment
- fully inspect and test the equipment to ensure that the repair or service has been properly performed and the equipment will function properly.

This manual describes the correct service procedures for Model 6800/348 Premium seats. The information in this manual was current at the time of printing and is subject to change without notice or liability.

READ AND UNDERSTAND THIS MANUAL AND THE OPERATOR'S MANUAL

Learn how to service Model 6800/348 Premium seats. Failure to do so could result in personal injury or equipment damage. Consult your dealer if you do not understand the instructions in this manual and/or need additional information.

KEEP THIS MANUAL

This manual should be considered a permanent part of the seat and be available for reference when servicing the seat.

WARRANTY

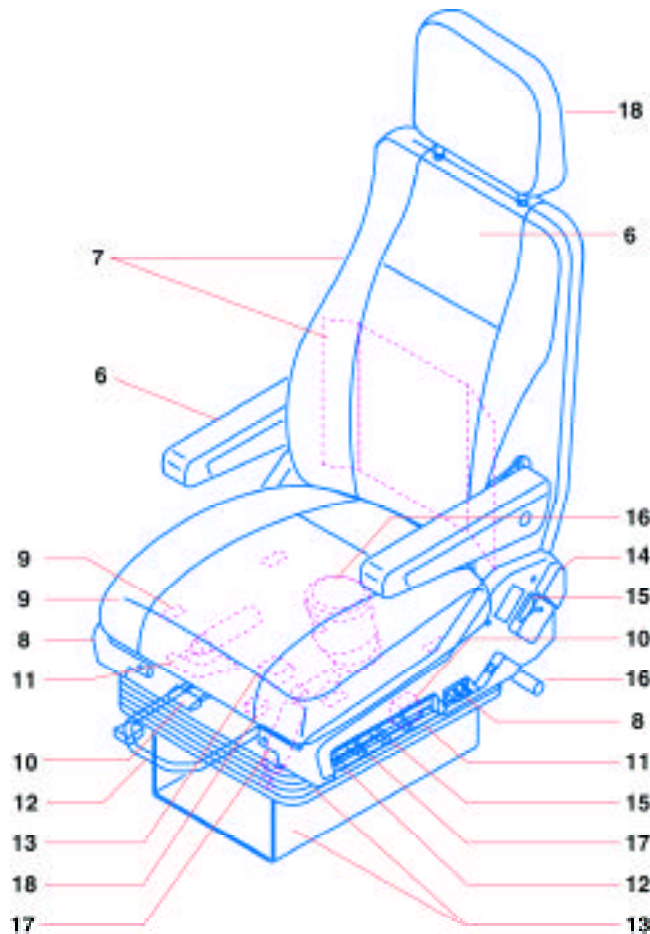
Warranty is provided as part of Isringhausen's support program for customers who operate and maintain their seat as shown in this manual. See the warranty for details.

**MODEL 6800/338 BUS
MODEL 6800/338 PREMIUM LX**

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REMOVAL AND INSTALLATION PAGE NUMBERS



GENERAL SAFETY

MODEL 6800/338 BUS
MODEL 6800/338 PREMIUM LX

In this manual safety messages will alert persons to a specific hazard, the degree or level of hazard seriousness, the probable consequences of involvement with the hazard, and how the hazard can be avoided. Safety messages will include the safety alert symbol, a signal word, and a word message.

SAFETY ALERT SYMBOL



Indicates a potential personal safety hazard.

SIGNAL WORDS

DANGER: Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

WARNING: Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION: Indicates a potentially hazardous situation which, if not avoided, may result in minor or serious injury.

WORD MESSAGE

The word message will identify the hazard, indicate how to avoid the hazard, and advise of probable consequence of not avoiding the hazard.

Problem	Cause	Solution	Page
Armrest will not stay in position.	Armrest control is defective.	Replace armrest.	6
Backrest will not adjust and/or stay adjusted.	Teeth on backrest are defective.	Replace backrest.	6
	Backrest seat latch is defective.	Replace backrest seat latch.	14
Lumbar/Bolster will not inflate.	No air supply to seat.	90 to 145 psi req'd.	5
	Air lines leak.	Replace air lines.	7
	Valve is defective.	Replace valve.	8
	Air bags leak.	Replace air bags.	7
Height will not adjust and/or stay adjusted.	Height adj. cam is defective.	Replace height adj. cam.	11
	Height adj. cylinder is defective.	Replace height adj. cylinder.	11
	Height adj. valve is defective.	Replace height adj. valve.	10
Horizontal slide will not adjust and/or stay adjusted.	Horizontal slide is defective.	Replace horizontal slide.	12
Seat pan assem. will not adjust and/or stay adjusted.	Seat pan lever is defective.	Replace seat pan lever.	10
	Seat pan glides are defective.	Replace seat pan glides.	9
Quick air release will not function.	No air supply to seat.	90 to 145 psi req'd.	5
	Valve is defective.	Replace valve.	12
Adjustable shock absorber will not adjust.	Shock absorber is defective.	Replace shock absorber.	17
	Shock absorber cable is defective.	Replace shock absorber cable.	17
Suspension will not function properly.	Suspension is defective.	Replace suspension.	13

INSPECTION

MODEL 6800/338 BUS
MODEL 6800/338 PREMIUM LX



CAUTION

Avoid the risk of injury.
Vehicle must be in a safe parked position before inspecting seat.

Visually inspect the seat. Look for damaged or worn upholstery and parts. The seat should be clean and free of dirt and debris. Check all the seat functions they should work properly and be in good condition.

1. Adjustable armrest

Should move up freely, the adjustment knob should be easy to use, the armrest must stay in the adjusted position.

2. Backrest adjustment

The control should be easy to release then the backrest should move freely. The backrest must stay in the adjusted position.

3. Backrest side bolster

The control should be easy to move to the inflate or deflate position and must return to neutral when released. Each side bolster should inflate and deflate evenly and stay at the adjusted firmness.

4. Height adjustment

Control should be easy to move and hold the seat in the adjusted position when released.

5. Horizontal adjustment

Control should be easy to move and hold the seat in the adjusted position when released.

6. Seat tilt adjustment

Control should be easy to move and hold the seat in the adjusted position when released.

7. Lower and upper lumbar support

The controls should be easy to move to the inflate or deflate position and must return to neutral when released. Each lumbar support must stay at the adjusted firmness.

8. Cushion length adjustment

Control should be easy to move and hold the seat cushion in the adjusted position when released.

9. Adjustable shock absorber

Control should be easy to move and stay in position when released.

10. Quick air release

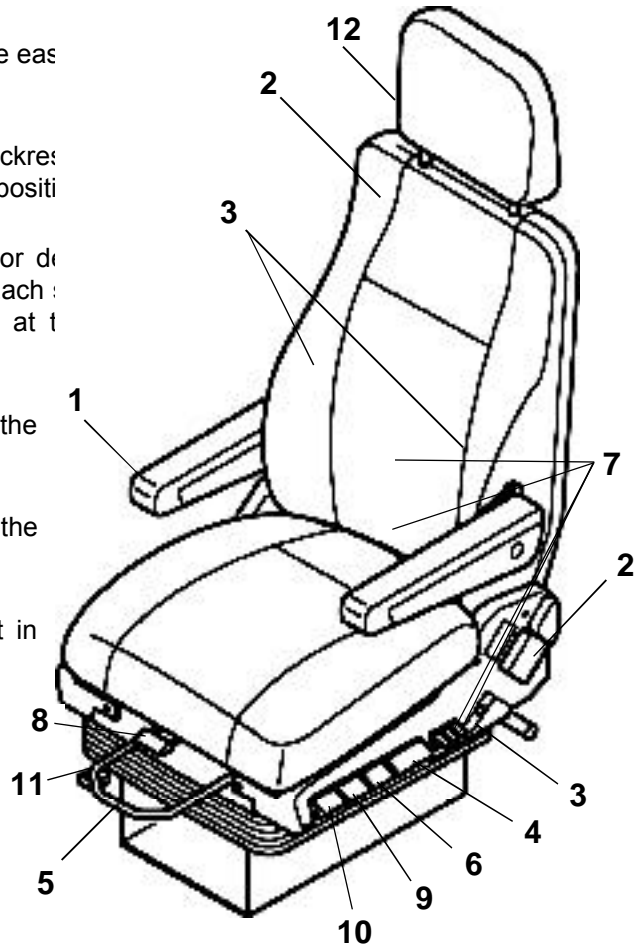
Control should be easy to move and hold seat in the adjusted position when released.

11. Horizontal isolator

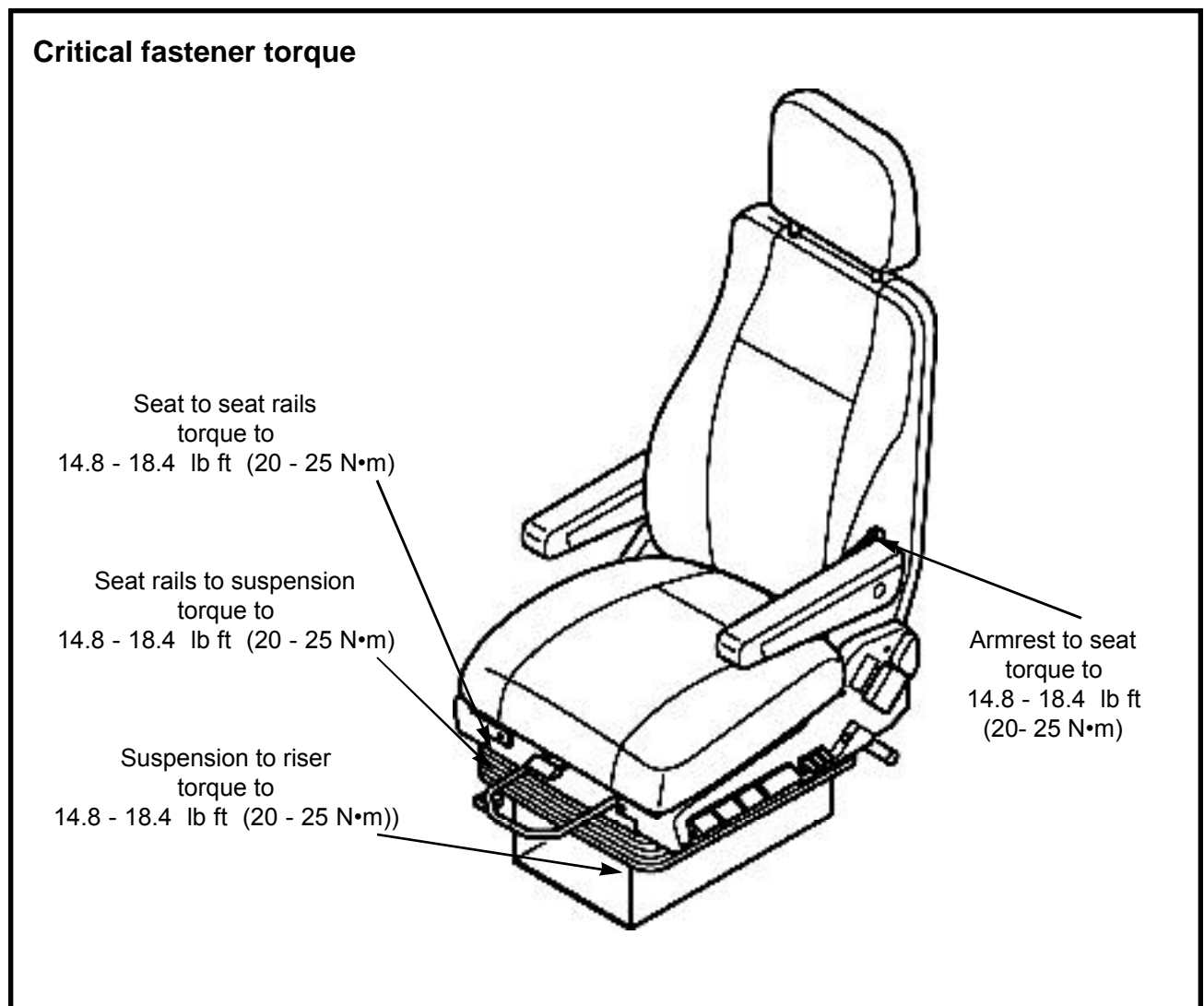
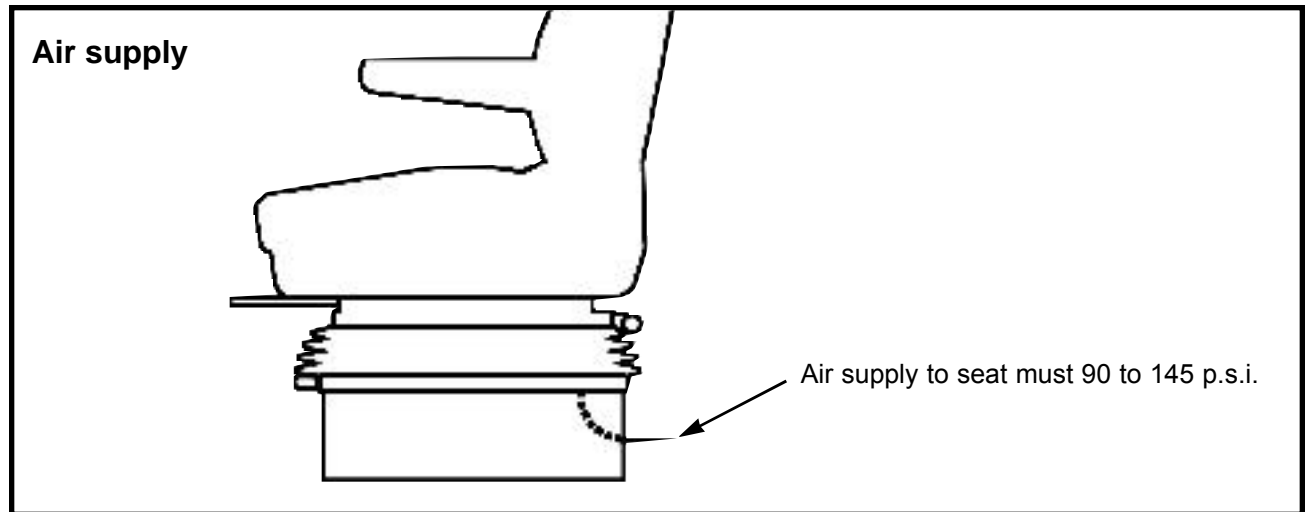
Control should be easy to move and stay in position when released.

12. Headrest

Should be easy to move up and down and stay in position. Headrest should tilt forward and backward freely.



If the seat is not functioning properly take it out of service until it can be repaired.



REMOVAL and INSTALLATION

MODEL 6800/338 BUS
MODEL 6800/338 PREMIUM LX



Avoid the risk of injury. Vehicle must be in a safe parked position before working on the seat.

NOTICE

To remove seat from vehicle follow vehicle manufacturer's instructions.

Armrest

Set up

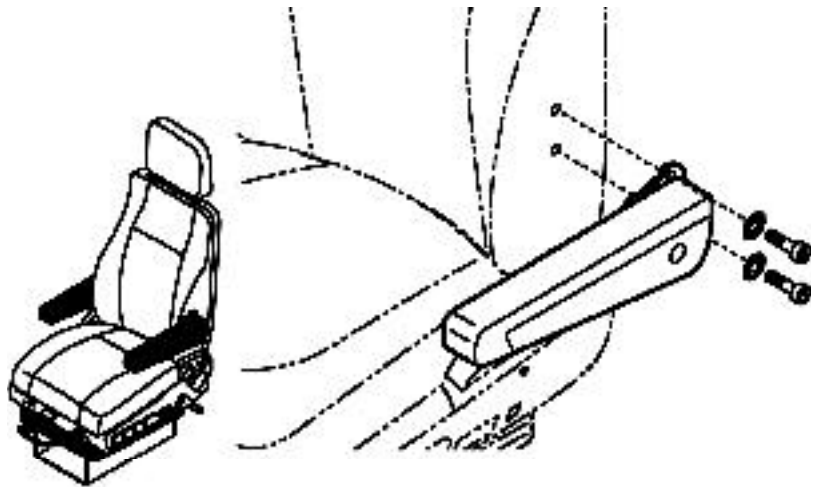
- Vehicle must be in a safe parked position or seat removed from vehicle.

Removal

- Remove fasteners
- Remove armrest

Installation

- Fasten armrest to seat with screws and lockwashers.
- Torque screws to 14.8 - 18.4 lb ft (20 - 25 N•m)



Backrest

Set up

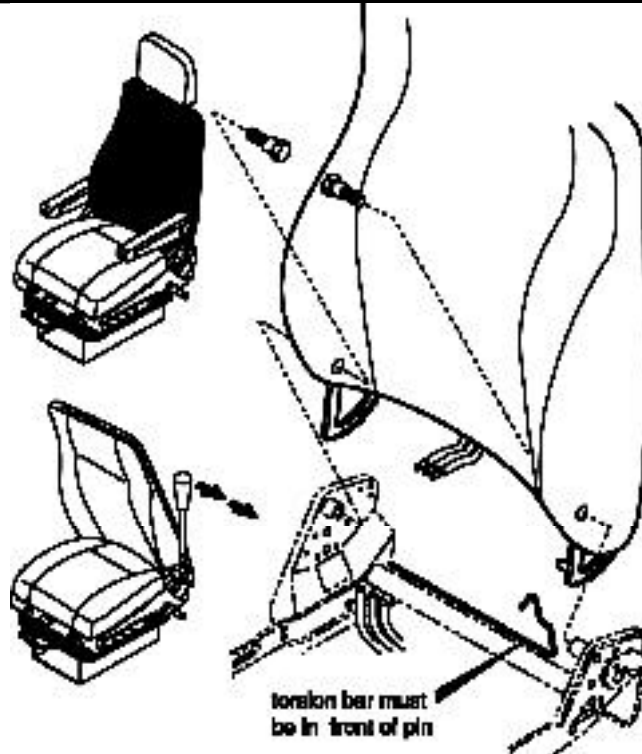
- Vehicle must be in a safe parked position or seat removed from vehicle.

Removal

- Mark and disconnect air lines
- Remove fasteners
- Pry one side of seat frame away from backrest
- Remove backrest

Installation

- Put one side of backrest in place
- Pry other side of seat frame away and put backrest in place
- Fasten backrest to seat frame with shoulder bolts
- Torque shoulder bolts to 22 - 25.5 lb ft (30 - 35 N•m)
- Connect air lines



Backrest assembly

Set up

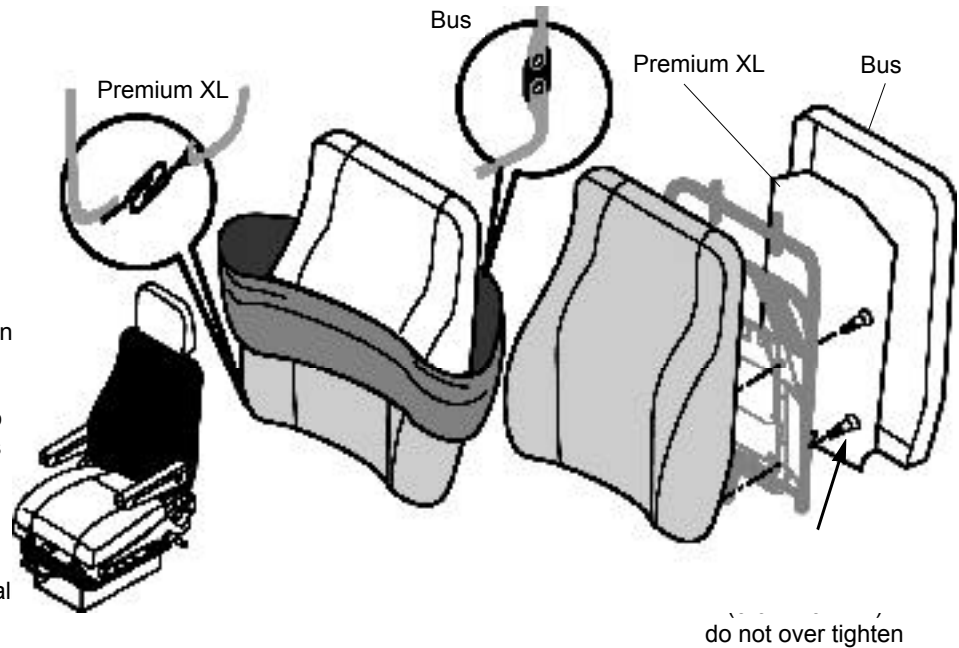
- Backrest must be removed from seat (see **Backrest**)

Removal

- Premium XL - remove upholstery and backrest liner
- Bus - remove cover, hog rings and wires.-- remove upholstery
- Remove backrest cushion fasteners -- remove cushion

Installation

- Fasten backrest cushion to backrest frame with screws
- Premium XL - install backrest liner and upholstery
- Bus - install upholstery, hog rings and wires.-- instal cover



Lumbar and bolster air bags

Set up

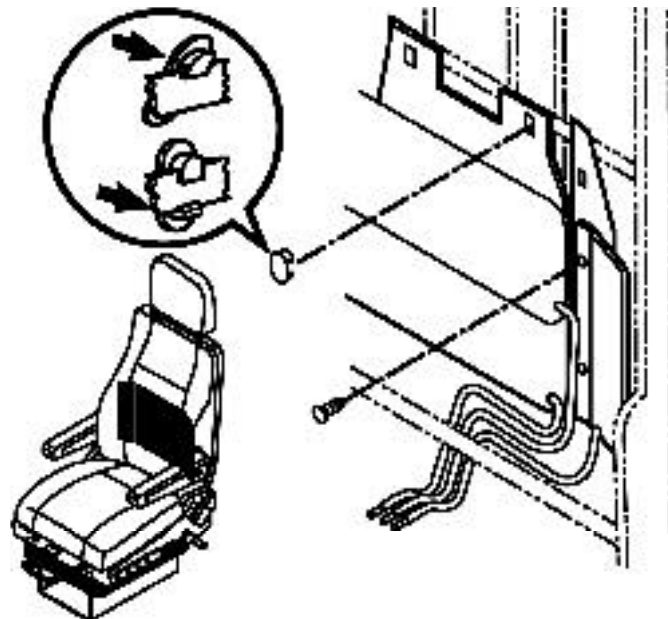
- Remove backrest components (see **Backrest assembly**)

Removal

- Remove air bag clips, push fasteners and cable ties
- Remove air bags

Installation

- Fasten air bags to backrest frame with clips - put long clip arm over bar and snap bottom of clip in place
- Install push fasteners and cable ties



REMOVAL and INSTALLATION

MODEL 6800/338 BUS
MODEL 6800/338 PREMIUM LX

Lumbar and bolster valve

Set up

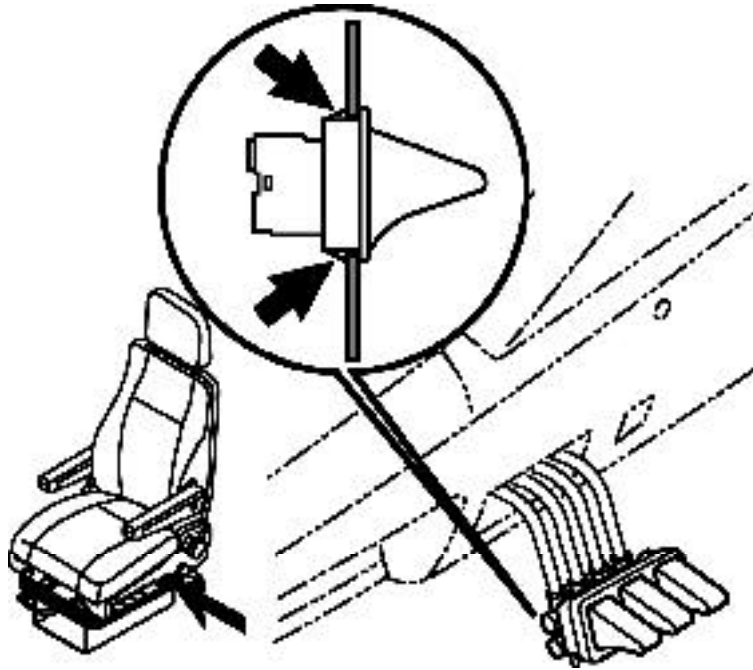
- Cover must be removed from seat (see **Covers front, LH and RH**)

Removal

- Mark air line and remove them from valve
- Press valve clips in and remove valve from cover

Installation

- Snap valve into cover
- Connect air lines



Covers, LH and RH

Set up

- Vehicle must be in a safe parked position or seat removed from vehicle.

Removal

Control cover

- Remove backrest adjustment handle
- Remove tilt adjustment handle - for fastener access
- Remove fasteners and cover

Non control cover

- Remove fasteners and cover

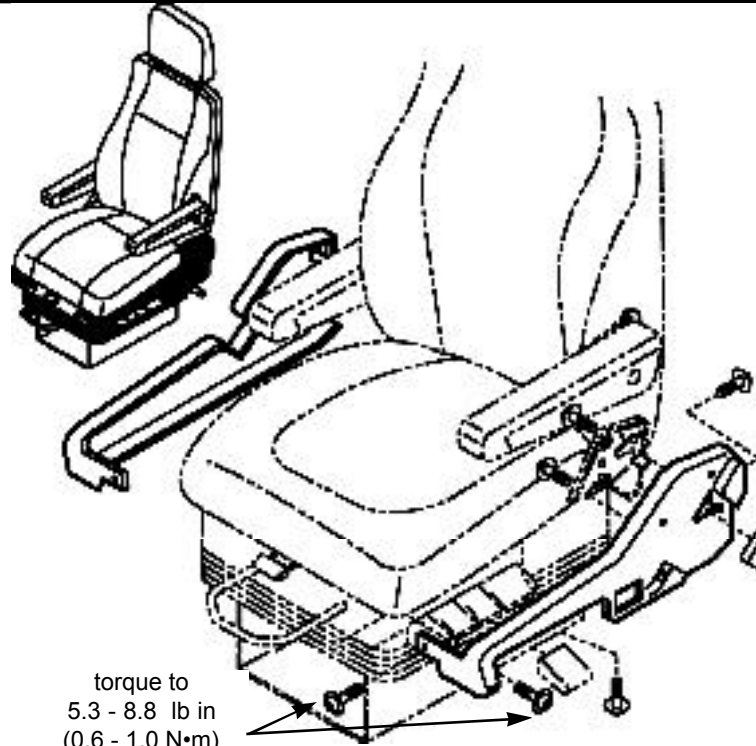
Installation

Control cover

- Fasten cover to seat frame with screws
- Install backrest adjustment handle
- Install tilt adjustment handle - removed for fastener access

Non control cover

- Fasten cover to seat frame with screws



torque to
5.3 - 8.8 lb in
(0.6 - 1.0 N•m)
do not over tighten

Seat pan assembly

Set up

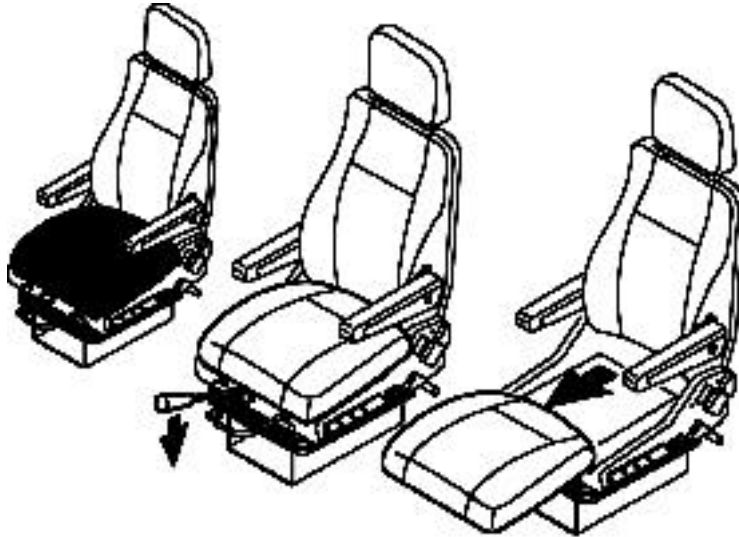
- Vehicle must be in a safe parked position or seat removed from vehicle.

Removal

- Slide cushion assembly forward
- Pry lever handle up to release cushion stop -- lift cushion off of glides

Installation

- Put seat cushion assembly on glides and slide back



Glides - seat pan

Set up

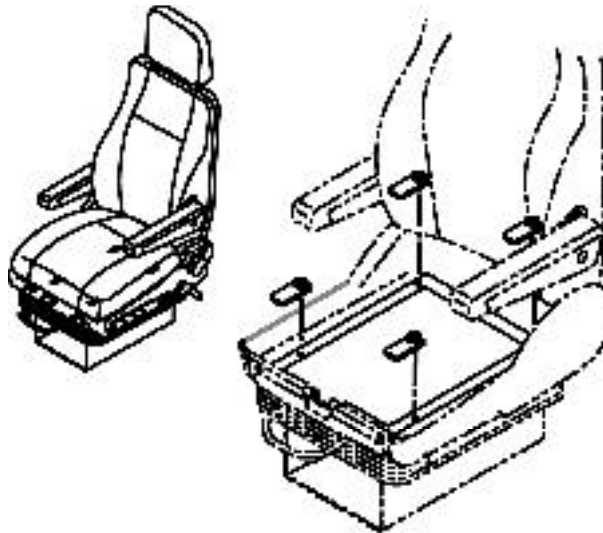
- Seat cushion must be removed from seat (see **Cushion seat pan**)

Removal

- Remove cushion glides

Installation

- Install cushion glides to seat frame



REMOVAL and INSTALLATION

MODEL 6800/338 BUS
MODEL 6800/338 PREMIUM LX

Seat pan assembly, lever and handle

Set up

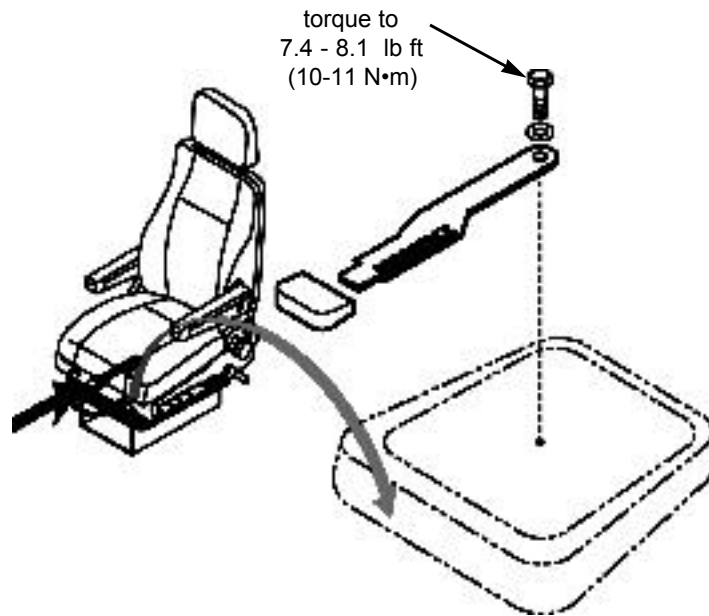
- Seat cushion must be removed from seat (see **Cushion seat pan**)

Removal

- Pull handle off
- Remove lever fasteners and remove lever

Installation

- Align locator button of lever with hole in seat pan
- Fasten lever to seat pan with screw and washer
- Push handle on



Height adjustment valve

Set up

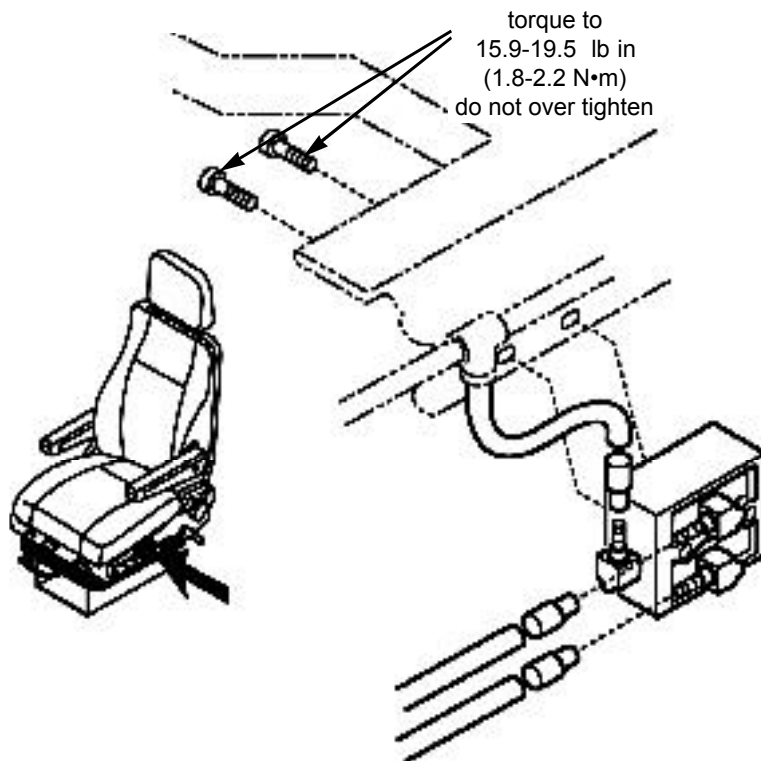
- Seat cushion must be removed from seat (see **Cushion seat pan**)

Removal

- Mark and remove air lines from valve
- Remove valve fasteners
- * Remove valve

Installation

- Fasten valve to seat frame with screw
- Connect air lines



Height adjustment handle

Set up

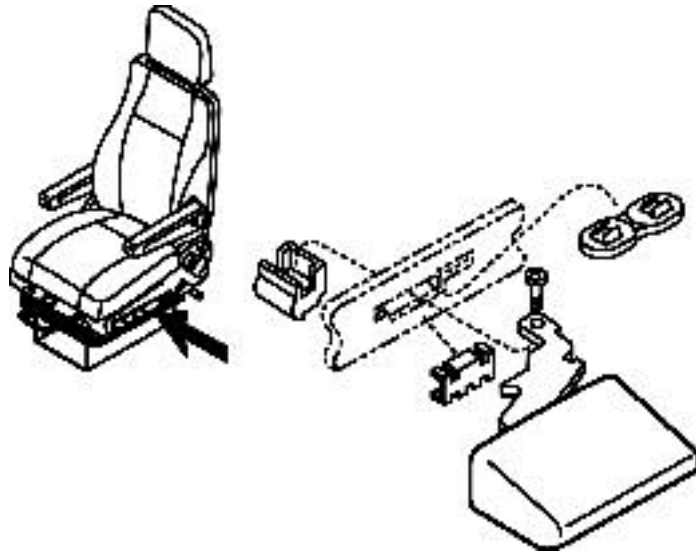
- Vehicle must be in a safe parked position or seat removed from vehicle
- Control cover must be removed (see **Covers front, LH and RH**)

Removal

- Remove screw and cam
- Pull handle and lever out
- Remove retainers

Installation

- Put upper retainers in place
- Put lever in place
- Put lower retainers in place - be sure it snaps in place
- Install cam and screw
- Install handle



Height adjustment cylinder and cam

Set up

- Vehicle must be in a safe parked position or seat removed from vehicle
- Seat cushion must be removed from seat (see **Cushion seat pan**)

Removal

Air cylinder

- Remove base end pin and retainer washer - remove rod end fastener, air line, and remove cylinder

Cam

- Remove rod end fastener
- Remove E ring and mounting pin
- Remove cam

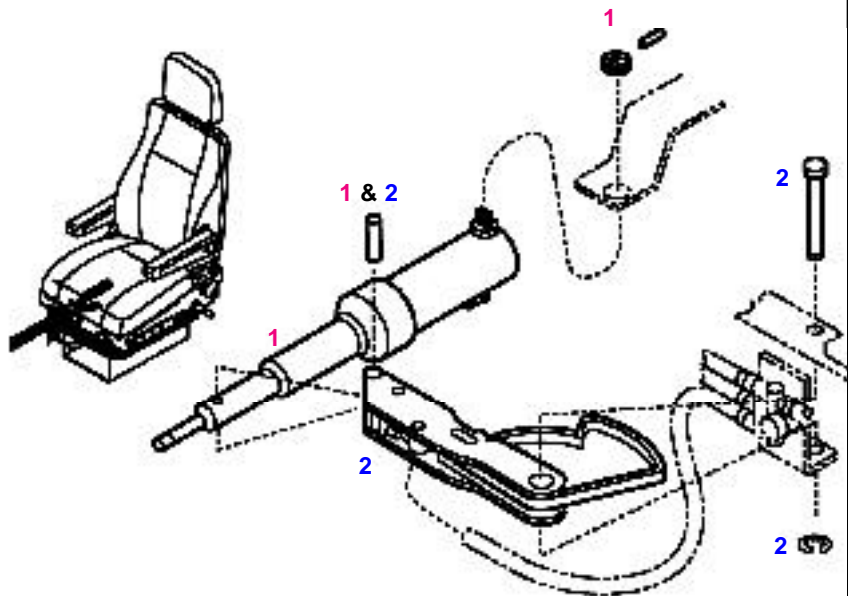
Installation

Air cylinder

- Put cylinder in place and install base end pin and retainer washer - install rod end fastener, connect air line

Cam

- Put cam in place and install pin and E ring



1 = Cylinder kit
2 = Cam kit

REMOVAL and INSTALLATION

MODEL 6800/338 BUS
MODEL 6800/338 PREMIUM LX

Horizontal adjustment slide set

Set up

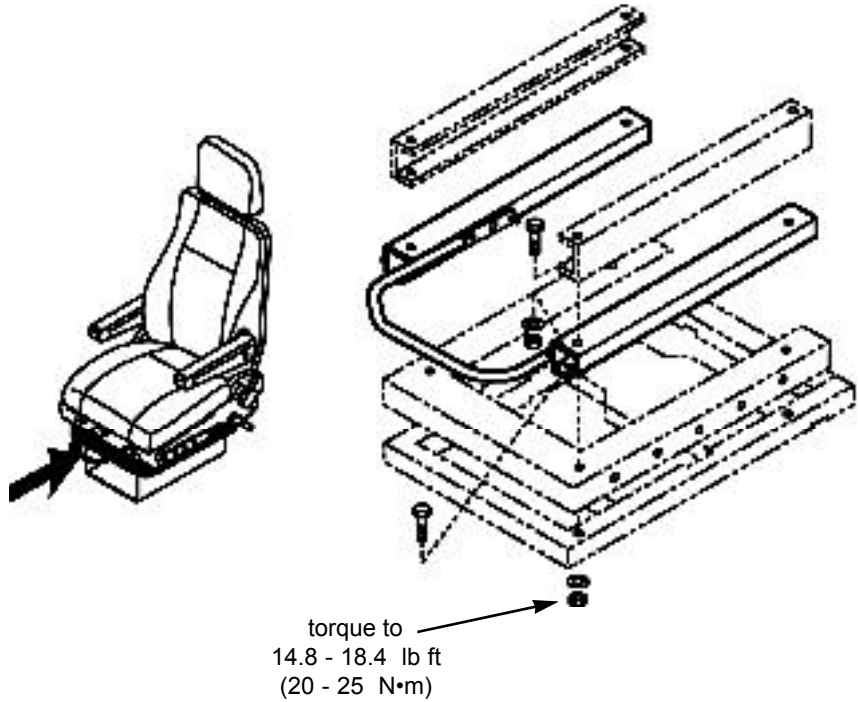
- Seat frame must be removed (see **Seat frame**)

Removal

- Move horizontal adjustment forward or back to allow access to fasteners
- Remove mounting fasteners

Installation

- Move horizontal adjustment forward or back to allow access to fasteners
- Install mounting fasteners



Quick air release - valve and handle LH and RH

Set up

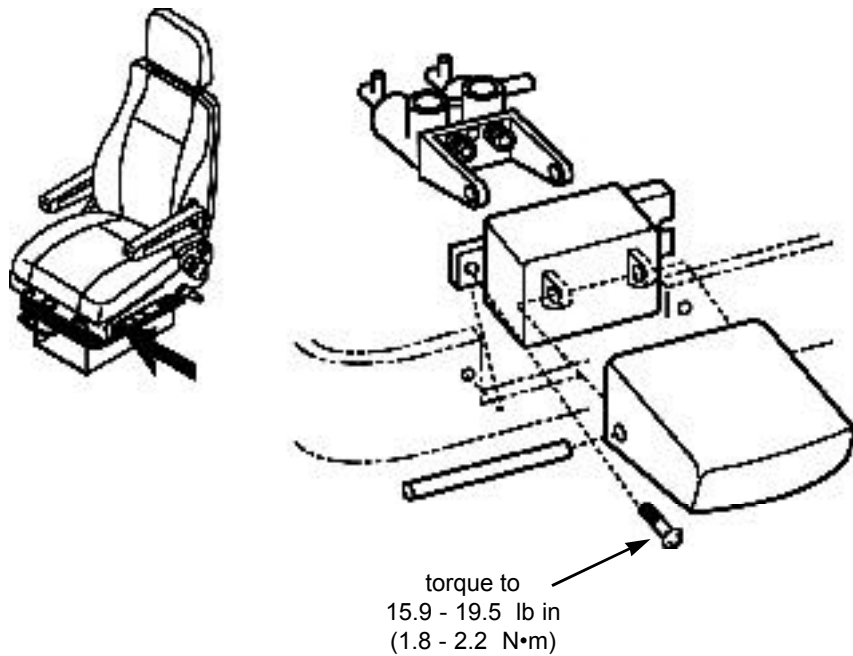
- Seat cushion must be removed from seat (see **Cushion seat pan**)

Removal

- Mark and remove air lines from valve
- Remove valve fasteners
- Remove valve
- Remove valve handle pin and valve handle

Installation

- Fasten valve handle to valve with pin
- Fasten valve to seat frame with screw
- Connect air lines



Quick air release valve - suspension

Set up

- Seat cushion must be removed from seat (see **Cushion seat pan**)

Removal

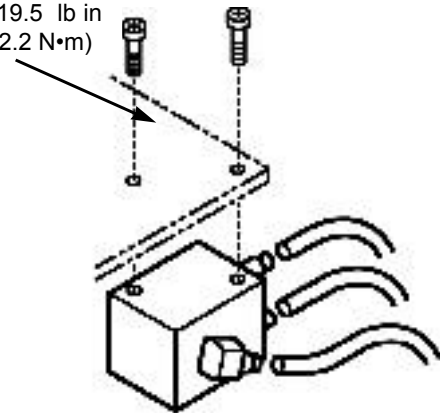
- Mark and remove air lines from valve
- Remove valve fasteners and remove valve

Installation

- Fasten valve to suspension with screws
- Connect air lines



torque to
15.9 - 19.5 lb in
(1.8 - 2.2 N•m)



Riser and Suspension

Set up - riser and suspension

- Vehicle must be in a safe parked position or seat removed from vehicle.

Set up - suspension

- Boot, Boot adapter plate, ICP bar, and tethers must be removed (see **Boot, Boot adapter plate, ICP bar, and tethers**)

Removal - suspension

- Remove air line
- Remove suspension to riser fasteners and remove suspension

Installation - suspension

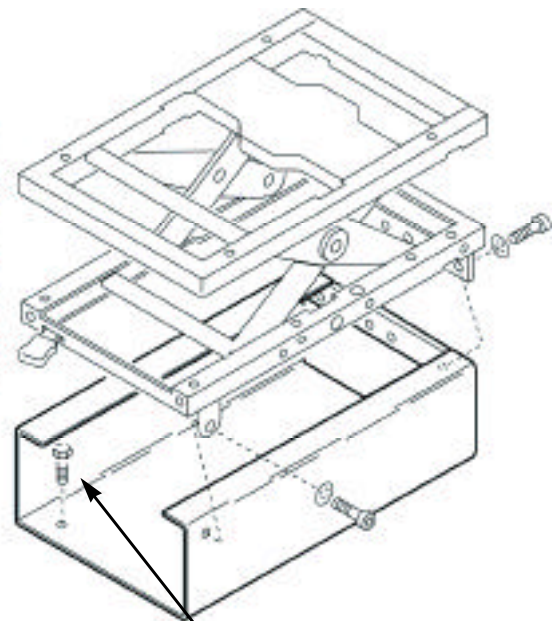
- Put suspension in place
- Install fasteners and torque to 14.8 - 18.4 lb ft (20 - 25 N•m)
- Connect air line

Removal - riser

- Remove riser to floor fasteners and remove riser

Installation - riser

- Put riser in place and install fasteners, torque to manufactures specification



torque to
manufactures
recommendation

REMOVAL and INSTALLATION

MODEL 6800/338 BUS
MODEL 6800/338 PREMIUM LX

Seat frame

Set up

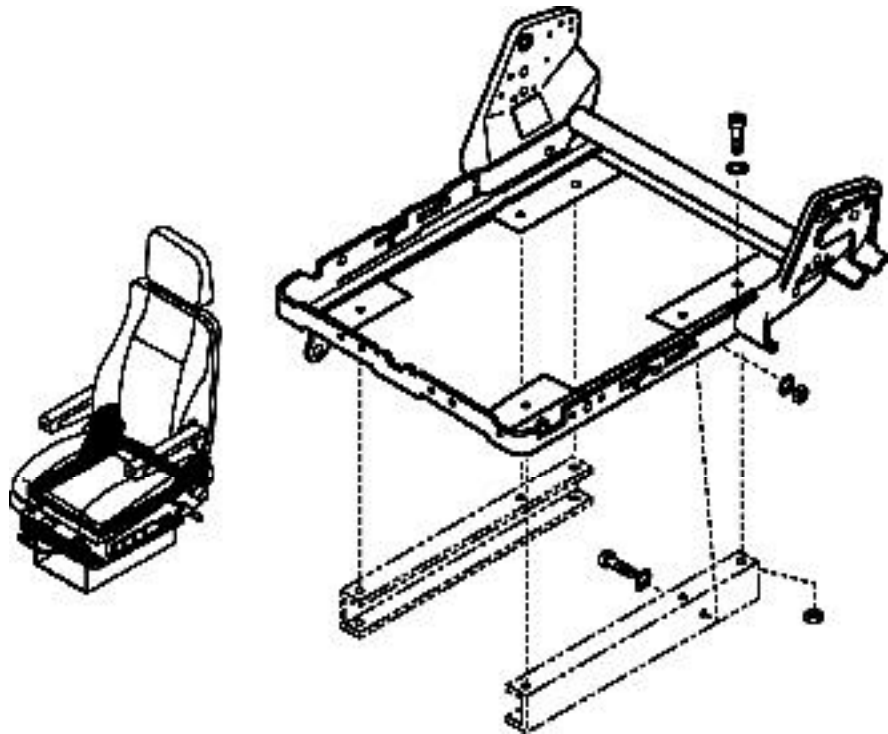
- Seat cushion and backrest must be removed from seat (see **Cushion seat pan and Backrest**)
- Shock absorber handle and cable must be removed. (see **Adjustable shock absorber handle and cable - handle end**)

Removal

- Mark and remove air lines
- Remove fasteners
- Remove seat frame

Installation

- Fasten seat frame to static spacer rails with bolts and nuts
- Torque fasteners to 14.8 - 18.4 lb ft (20 - 25 N•m)
- Connect air lines



Seat frame tooth plate

Set up

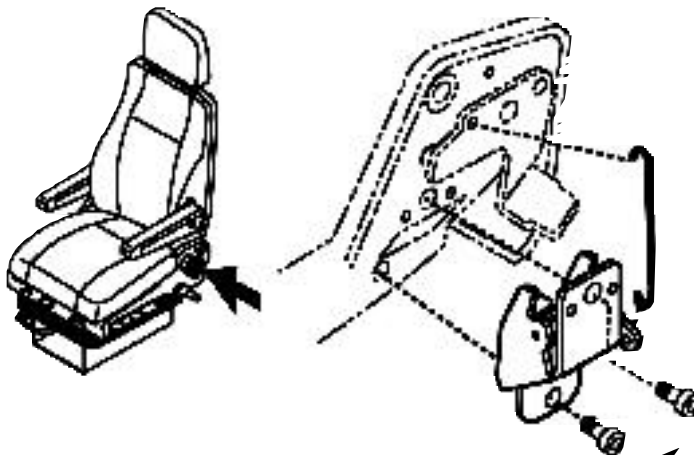
- Backrest and covers must be removed from seat (see **Backrest and Covers front, LH and RH**)

Removal

- Remove seat latch fasteners
- Remove seat latch
- Remove connecting link

Installation

- Install connecting link
- Fasten seat latch to seat frame with screws



torque to
14.8 - 18.4 lb ft
(20 - 25 N•m)

Backrest adjustment handle

Set up

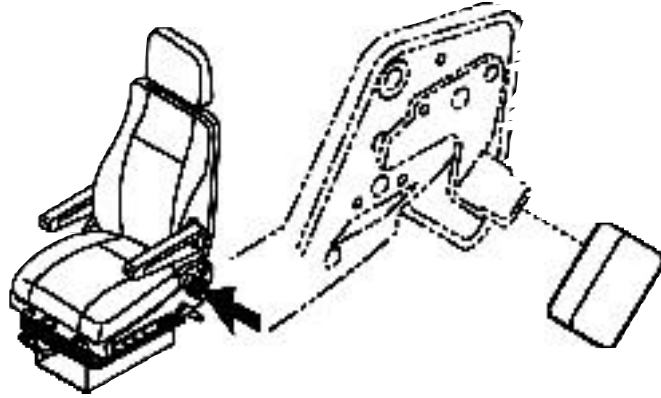
- Vehicle must be in a safe parked position or seat removed from vehicle.

Removal

- Pull handle off

Installation

- Push handle on



Tilt handle

Set up

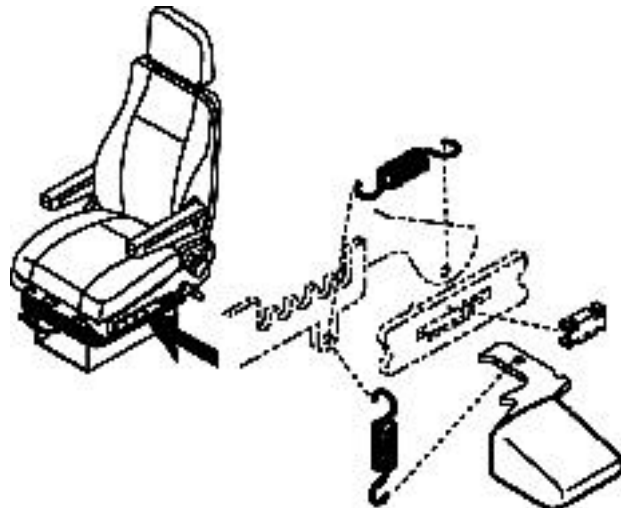
- Vehicle must be in a safe parked position or seat removed from vehicle.

Removal

- Remove springs
- Pull handle and lever out
- Remove retainer

Installation

- Put lever in place
- Install retainer, be sure it snaps in place
- Install springs
- Install handle



REMOVAL and INSTALLATION

MODEL 6800/338 BUS
MODEL 6800/338 PREMIUM LX

Air spring

Set up

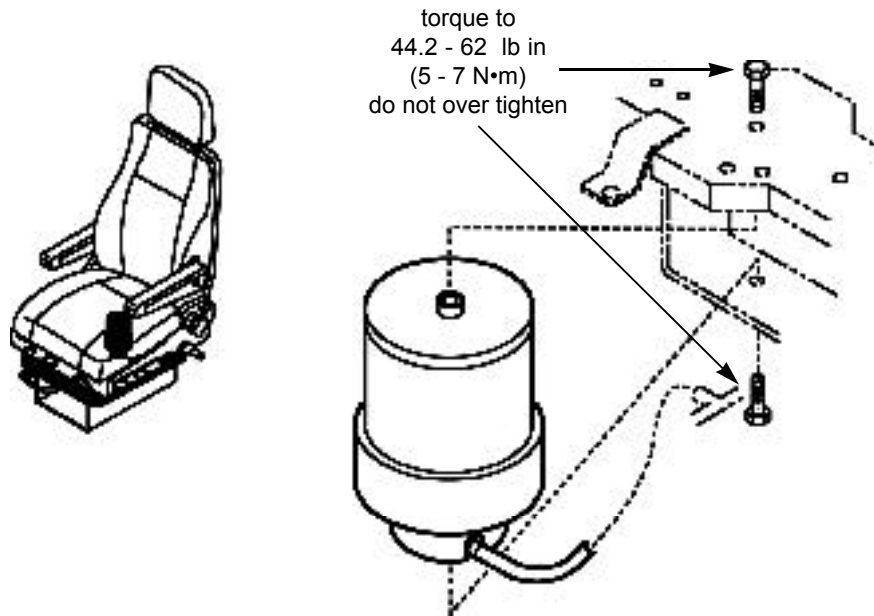
- Seat must be removed from vehicle
- Seat cushion must be removed from seat (see **Cushion seat pan**)

Removal

- Mark and disconnect air line
- Remove top and bottom mounting fasteners
- Remove air spring

Installation

- Put air spring in place
- Install top and bottom mounting fasteners
- Connect air line



Boot, Boot adapter plate ICP bar, and tethers

Set up

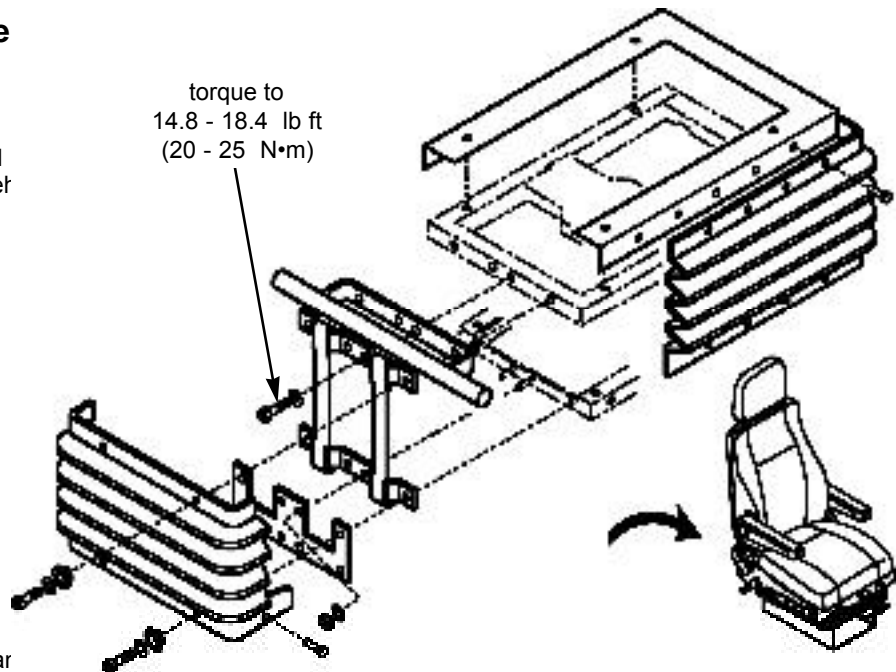
- Vehicle must be in a safe parked position or seat removed from vehicle
- Horizontal adjustment must be removed (see **Horizontal adjustment**)

Removal

- Remove belts from ICP bar
- Remove boot fasteners, remove boot, and boot adapter plate
- Remove fasteners, tether plate, tether brackets, tethers, and ICP bar

Installation

- Install fasteners, tether plate, tether brackets, tethers, and ICP bar
- Install boot adapter plate, boot, and fasteners
- Install belts to ICP bar



Adjustable shock absorber handle and cable (handle end)

Set up

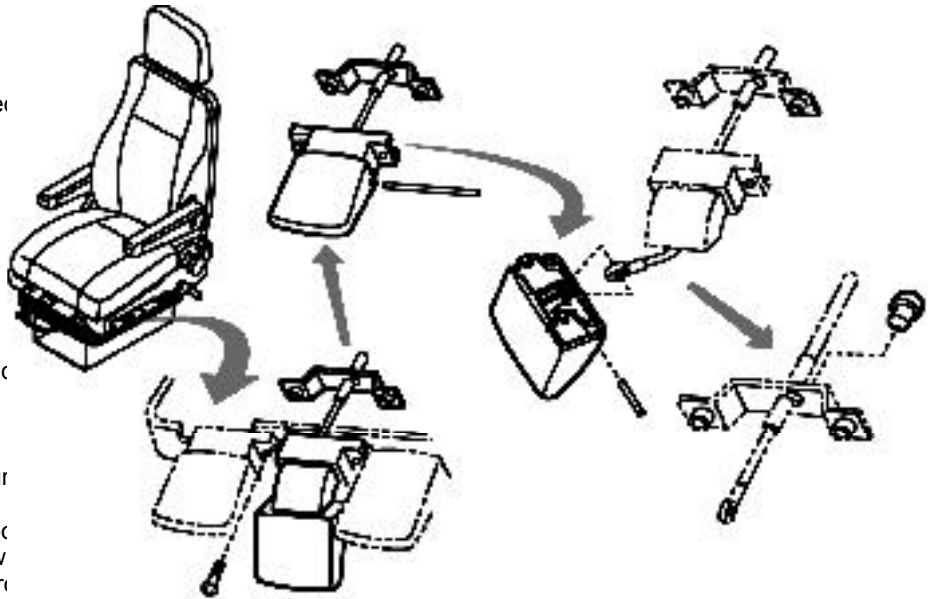
- Seat cushion must be removed from seat (see **Cushion seat pan**)

Removal

- Remove fasteners and move control, bracket, and cable up away from seat frame
- Remove control handle pin and control handle
- Remove cable pin and cable
- Remove plug from bracket and remove cable

Installation

- Put cable in bracket and secure plug
- Route cable through control bracket and fasten to control handle with pin
- Fasten control handle to control bracket with pin
- Fasten control and bracket to frame with screws



Adjustable shock absorber and cable (shock absorber end)

Set up

- Vehicle must be in a safe parked position or seat removed from vehicle
- Seat cushion must be removed from seat (see **Cushion seat pan**)

Removal

Adjustable shock absorber

- Remove retaining rings
- Remove shock absorber

Adjustable shock absorber cable

- Remove retaining ring
- Remove cable

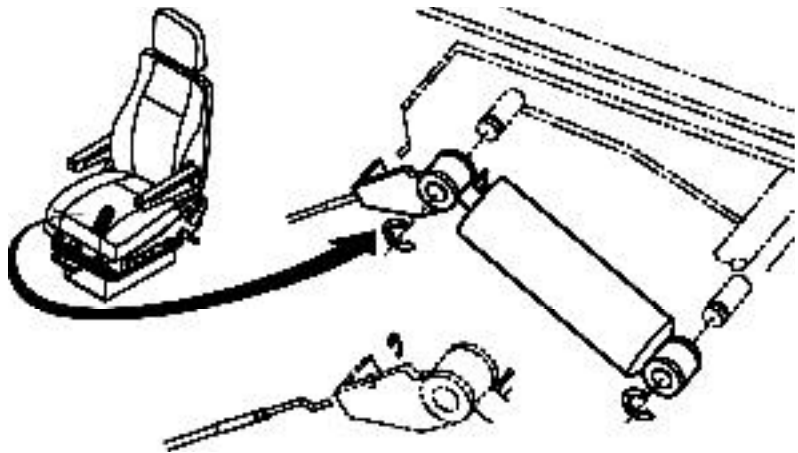
Installation

Adjustable shock absorber cable

- Put cable in place
- Install retaining ring

Adjustable shock absorber

- Put shock absorber in place
- Install retaining rings



REMOVAL and INSTALLATION

MODEL 6800/338 BUS
MODEL 6800/338 PREMIUM LX

Distribution valve

Set up

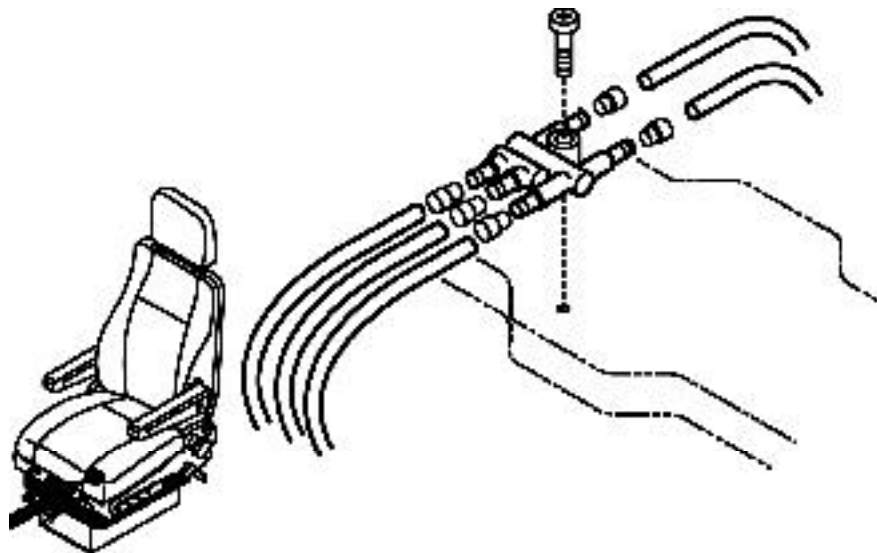
- Seat cushion must be removed from seat (see **Cushion seat pan**)

Removal

- Mark and remove air lines from valve
- Remove valve fastener and remove valve

Installation

- Fasten valve to frame with screw
- Connect air lines



Headrest

Set up

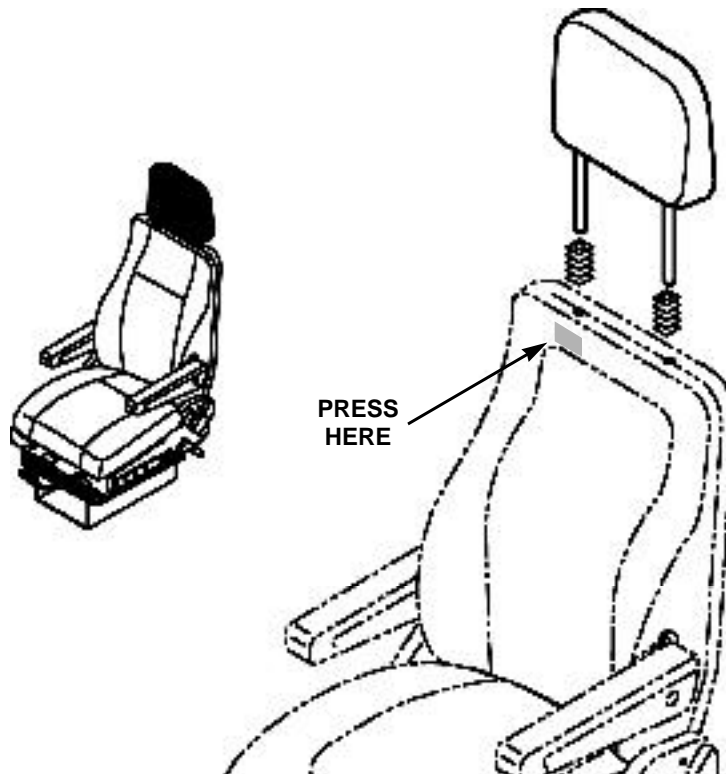
- Vehicle must be in a safe parked position or seat removed from vehicle

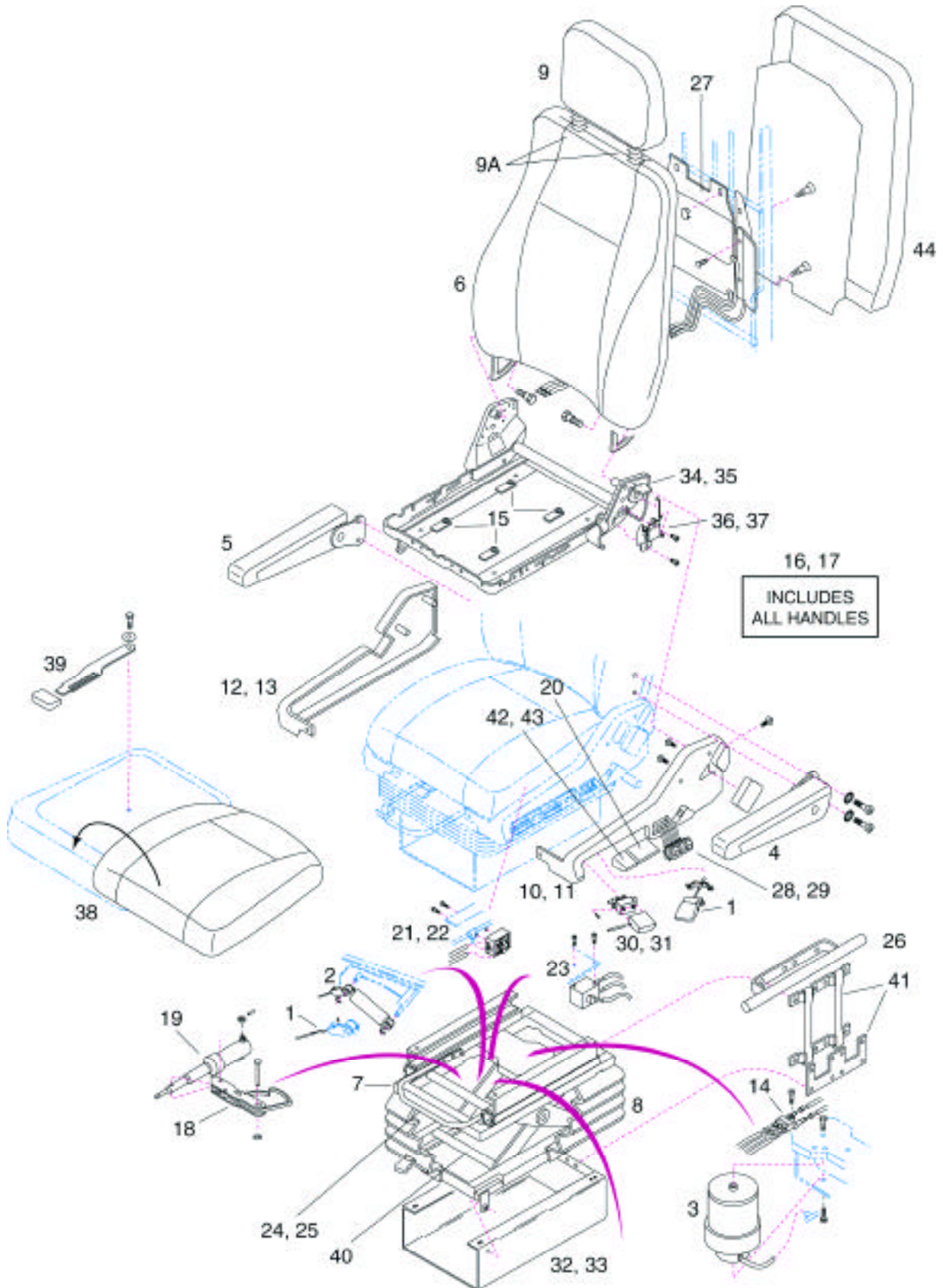
Removal

- Pull headrest to upper locking position
- Press foam, as shown, to release locking clip from detent on headrest and pull up

Installation

- Guide headrest bars into position
- Press down to engage locking clip





REMOVAL and INSTALLATION

MODEL 6800/338 BUS
MODEL 6800/338 PREMIUM LX

item	part number	description
1	910353-09	ADJUSTABLE SHOCK ABSORBER CABLE KIT
2	98889-06	ADJUSTABLE SHOCK ABSORBER KIT
3	98872-15	AIR SPRING KIT
4	924473-32	ARMREST KIT - LH
5	924474-32	ARMREST KIT - RH
6	03003-00	BACKRESTASSEMBLY - NUDE
7	111776P02	BOOTADAPTER PLATE
8	926513-01	BOOT KIT
9	110922-00	HEADRESTASSEMBLY - NUDE
9A	47541	HEADREST BOOT (2 PCS)
10	920260-04	COVER KIT CONTROL - LH
10	927399-01	COVER KIT CONTROL - LH (W/O LOGO)
11	920263-04	COVER KIT CONTROL - RH
11	927398-01	COVER KIT CONTROL - RH (W/O LOGO)
12	920262-01	COVER KIT NON-CONTROL - LH
12	927397-01	COVER KIT NON-CONTROL - LH (BELT TO FRAME W/ LOGO)
12	927397-02	COVER KIT NON-CONTROL - LH (BELT TO FRAME W/O LOGO)
13	920261-01	COVER KIT NON-CONTROL - RH
13	927396-01	COVER KIT NON-CONTROL - RH (BELT TO FRAME W/ LOGO)
13	927396-02	COVER KIT NON-CONTROL - RH (BELT TO FRAME W/O LOGO)
14	915105-03	DISTRIBUTION VALVE KIT
15	914516-04	GLIDE KIT - SEAT PAN
16	920264-03	HANDLE KIT - SEAT FRAME - LH
17	920264-04	HANDLE KIT - SEAT FRAME - RH
18	33487	HEIGHTADJUSTMENT CAM KIT
19	95486-03	HEIGHTADJUSTMENT CYLINDER KIT
20	920266-05	HEIGHTADJUSTMENT HANDLE KIT - LH
20	920266-06	HEIGHTADJUSTMENT HANDLE KIT - RH
21	98976-07	HEIGHTADJUSTMENT VALVE KIT - LH
22	98875-07	HEIGHTADJUSTMENT VALVE KIT - RH
23	98873	HEIGHTADJUSTMENT VALVE KIT - SUSPENSION
24	24569F	HORIZONTALADJUSTMENT SLIDE HANDLE
25	18755-02	HORIZONTALADJUSTMENT SLIDE SET
26	111973P02	ICP BAR - TRUCK (NOT USED W/ BELT TO FRAME)
26	111895P01	ICP BAR - BUS (FOR BELT TO ICP BAR ONLY)
27	920272-01	LUMBAR/BOLSTER KIT
28	36571-01	LUMBAR/BOLSTER VALVE - LH
29	36572-01	LUMBAR/BOLSTER VALVE - RH
30	914514-24	QUICK AIR RELEASE VALVE AND HANDLE KIT - LH
31	914514-25	QUICK AIR RELEASE VALVE AND HANDLE KIT - RH
32	03007P	RISER - 127 MM (MCI 'D-SERIES' COACH)
33	03463P	RISER - 127 MM (STD, NEOPLAN, ORION VI, NEW FLYER)
33	03013P	RISER - 156 MM (MCI 'E-SERIES' COACH)
33	03468	RISER KIT - 76 MM (PREVOST COACH)
33	111779P03	RISER - 127 MM (KW O W900 & T2000, MACK, NAVISTAR)
33	112256P02	RISER - 110 MM (PB - 379)
34	03307-01	SEAT FRAME - LH
35	03308-01	SEAT FRAME - RH
36	914500-23	SEAT FRAME TOOTH PLATE KIT - LH
37	914500-24	SEAT FRAME TOOTH PLATE KIT - RH
38	03002-00	SEAT PAN ASSEMBLY - NUDE
39	921845-02	SEAT PAN ASSEMBLY LEVER AND HANDLE KIT
40	111833-01	SUSPENSION
41	924464-01	TETHER AND TETHER PLATE KIT
42	920267-05	TILT HANDLE KIT - LH
43	920267-06	TILT HANDLE KIT - RH
44	01955-03	BACKREST PANEL (BUS ONLY)



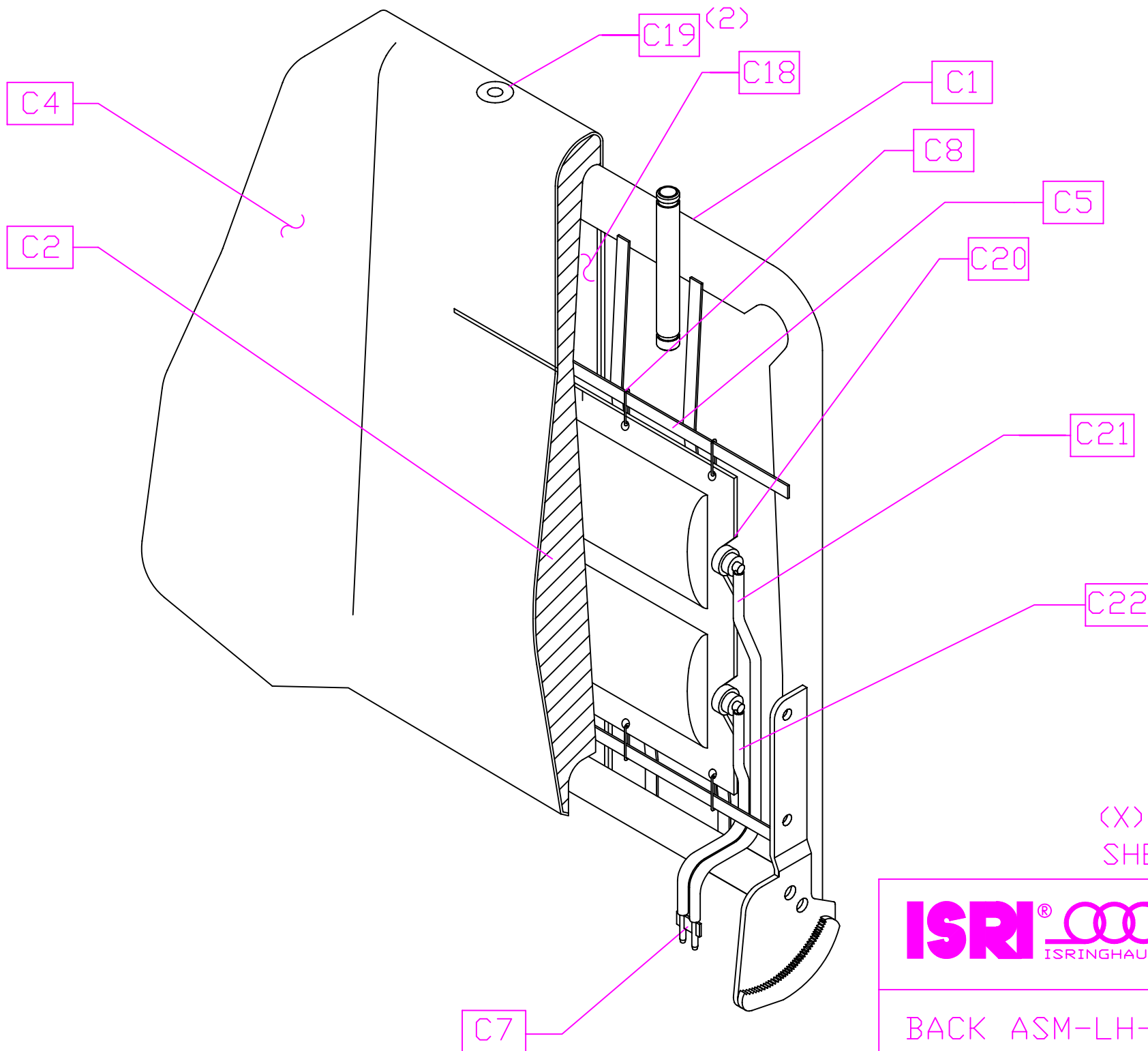
SERVICE PARTS LIST

ISRI P/N: 17518-00 Description: Backrest–517-LH-AL
 ISRI Illus. No.: C-024
 Customer: Prevost Car Customer P/N: 860739

Specification: LH controls, Air lumbar, Poly foam

ILLUS NO.	DESCRIPTION	ISRI P/N	CUSTOMER P/N
C1	Backrest Frame	17734D01	860740
C2	Backrest Foam	00849	864741
C3	Kit – Air Lumbar Bag	95622-01	860494
C4	Uph – Backrest	-----	
C5	Uph Rod – Long	See C27	
C7	Fitting	* 47278	
C8	Clip – Lumbar Bag Attach	See C3	
C18	Filler Foam – Back	13797	
C20	Air Lumbar Bag	See C24	
C21	Hose – Upper	See C24	
C22	Hose – Lower	See C24	
C23	Sew Strip	See C25	
C24	Air Lumbar Bag Asm	See C3	
C25	Uph Hdw Kit – Back – Nude	914413	
C27	Uph Hdw Kit – Back – Retro	-----	
C42	Hog Ring	See C25	
C47	Rub Strip	See C49	
C48	Screw (Rub Strip)	See C49	
C49	Rub Strip Kit	914439	

* PART OF KIT



(X) = QUANTITY
SHEET 1 OF 2

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05/92
(REV 5/22/01)

BACK ASM-LH-AL

C-024

KIT #	P/N	ITEM NO. IN KIT	ITEM
1	C3	C8, C24	AIR LUMBAR BAG – KIT
2	C24	C7, C20, C21, C22	AIR LUMBAR BAG – ASM
3	C25	C5, C18, C23	UPH HDW KIT–BACK–NUDE
4	C27	C5, C18	UPH HDW KIT–BACK–RETRO

SHEET 2 OF 2

	05/92 (REV 5/22/01)
	KIT DESCRIPTION C-024

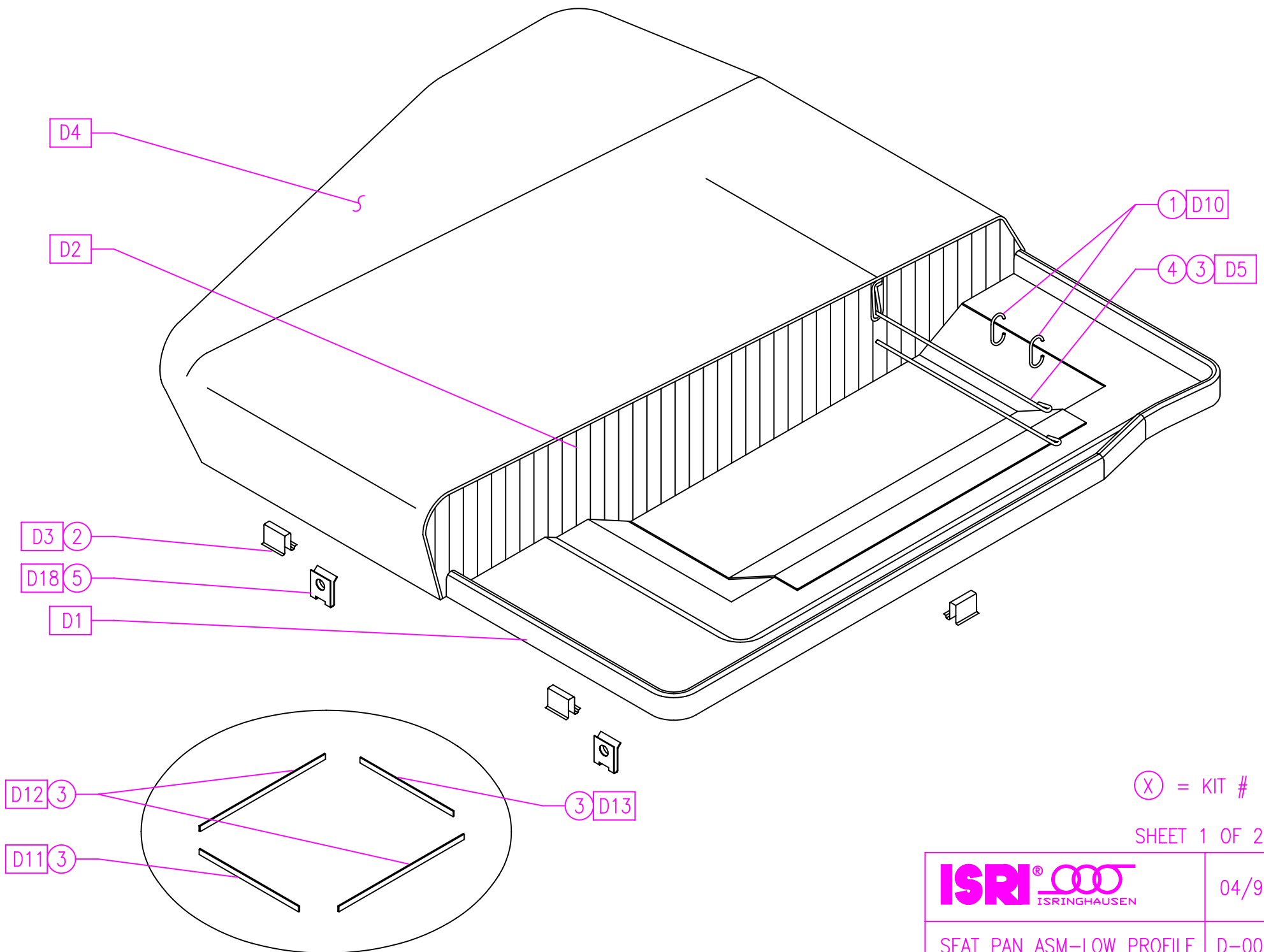


SERVICE PARTS LIST

ISRI P/N:	14663-04	Description:	Seat Pan-515
ISRI Illus. No.:	D-008		
Customer:	Prevost Car	Customer P/N:	860742
Specification:	Poly foam, w/o upholstery		

ILLUS NO.	DESCRIPTION	ISRI P/N	CUSTOMER P/N
D1	Seat Pan	17832P	860743
D2	Seat Foam	00425	860744
D3	Uph Clip	See D15	
D5	Uph Rod – Long	See D16	
D10	Hog Ring	See D16	
D11	Sew Strip – Front	See D16	
D12	Sew Strip – Side	See D16	
D13	Sew Strip – Rear	See D16	
D14	Hog Ring Kit	* 912040	
D15	Uph Clip Kit	* 912039	
D16	Uph Hdw Kit – Seat – Nude	96728	861104
D18	Nut – Clip	See D19	
D19	Hdw Kit – Nut Clip	914257	

*** PART OF KIT**



SHEET 1 OF 2

ISRI [®]  ISRINGHAUSEN	04/91
SEAT PAN ASM—LOW PROFILE	D-008

KIT #	P/N	ITEM NO. IN KIT	ITEM
1	D14	D10	HOG RING KIT
2	D15	D3	UPH CLIP KIT
3	D16	D5,D11,D12,D13,D14,D15	UPH HDW KIT – NUDE
4	D17	D5, D14, D15	UPH HDW KIT – RETRO
5	D19	D18	SEAT PAN CLIP KIT

SHEET 2 OF 2

	04/91
	KIT DESCRIPTION D-008



SERVICE PARTS LIST

ISRI P/N: 02371-02 Description: Seat Frame-515-LH-AL/MV(RH)
 ISRI Illus. No.: E-059
 Customer: Prevost Car Customer P/N: 861099

Specification: LH controls, double swivel bolt, controls – black w/symbol,
 Air lumbar/Manual valve-RH (IPS 5)

ILLUS NO.	DESCRIPTION	ISRI P/N	CUSTOMER P/N
E1	Side Plate Kit	95733-03	860487
E3	Valve Kit – Air Lumbar/MV	917471-04	861096
E4	Valve Asm – Air Lumbar/MV	* 35270-01	
E5	Torsion Bar Kit	95739-01	861091
E7	Spring Kit – Height/Slope	95619-04	860755
E8	Bushing Kit – Height/Slope	95773-01	860753
E9	Bushing / Hdw Kit – H/S	95847-01	860754
E13	Tooth Plate Kit	914209-05	
E14	Swivel Bolt / Clip Kit	914204-02	860757
E50	Cover – Seat Frame – Rear	See E1	
E51	Hose–Lumbar Upper-Rubber	See E4	
E52	Cover – Side Plate – RH	See E1	
E54	Handle – H/S – Front	* 47270-02	
E55	Cap – Side Plate	See E1	
E56	Handle – Backrest	* 43537-02	
E57	Cover – Side Plate – LH	See E1	
E58	Hose-Lumbar Supply-PU3	See E4	
E59	Cap – Torsion Bar	See E5	
E60	Bar – Torsion	See E5	
E61	Lock – Torsion Bar	See E5	
E62	Pad – Felt	* 42258	
E63	Seat Frame w/o Covers	917673D	
E65	Screw – Hose Guide	See E3	
E66	Hose Guide	See E3	
E67	Hose-Lumbar Lower-Rubber	See E4	
E70	Nut – Tee	See E3	
E73	Bushing	See E8 or E9	
E74	Link-Pivot-H/S-Opp Control	See E63	
E75	Ring – Retaining	See E14	
E76	Bolt – Swivel	See E14	

*** PART OF KIT**



SERVICE PARTS LIST

ISRI P/N: 02371-02 Description: Seat Frame-515-LH-AL/MV(RH)
 ISRI Illus. No.: E-059
 Customer: Prevost Car Customer P/N: 861099

Specification: LH controls, double swivel bolt, controls – black w/symbol,
 Air lumbar/Manual valve-RH (IPS 5)

ILLUS NO.	DESCRIPTION	ISRI P/N	CUSTOMER P/N
E77	Bolt – Shoulder – M8	See E9	
E78	Bushing	See E8 or E9	
E79	Link-Pivot-H/S-Control	See E63	
E80	Lever – Backrest Adjust	41509D	
E81	Ring – Retaining	See E1	
E82	Spring – Tension – Backrest	41552D	860751
E83	Plate – Latch – H/S – Rear	35865J	
E84	Pin – Pivot – Latch	40647N	
E85	Ring – Retaining	60020	
E86	Guide – H/S	42962	
E88	Spring – Tension	See E7	
E89	Lever – H/S – Front	43012D	860588
E90	Spring – Tension	See E7	
E91	Spring – Tension	See E7	
E92	Plate – Latch – H/S – Front	47275D	860756
E93	Ring – Retaining	60020	
E94	Nut – Hex – Crimp Lock – M8	See E9	
E95	Linkage – H/S – Rear – DS	See E63	
E96	Ring – Retaining	60047	
E97	Link	See E63	
E98	Plate – Tooth – Seat Frame	See E13	
E99	Ring – Retaining	See E13	
E100	Ring – Retaining	60020	
E102	Bushing	See E8	
E103	Ring – Retaining	60020	
E104	Clip – U	60186	
E105	Linkage – H/S – Front – DS	See E63	
E138	Hose-PU3 (MV/Air Spring)	See E3	
E139	Housing – AL/MV	* 24111-02	
E140	Screw-Mtg-AL/MV Housing	See E3	
E141	Cover – Rocker – AL – Lower	* 45480-24	861094

*** PART OF KIT**



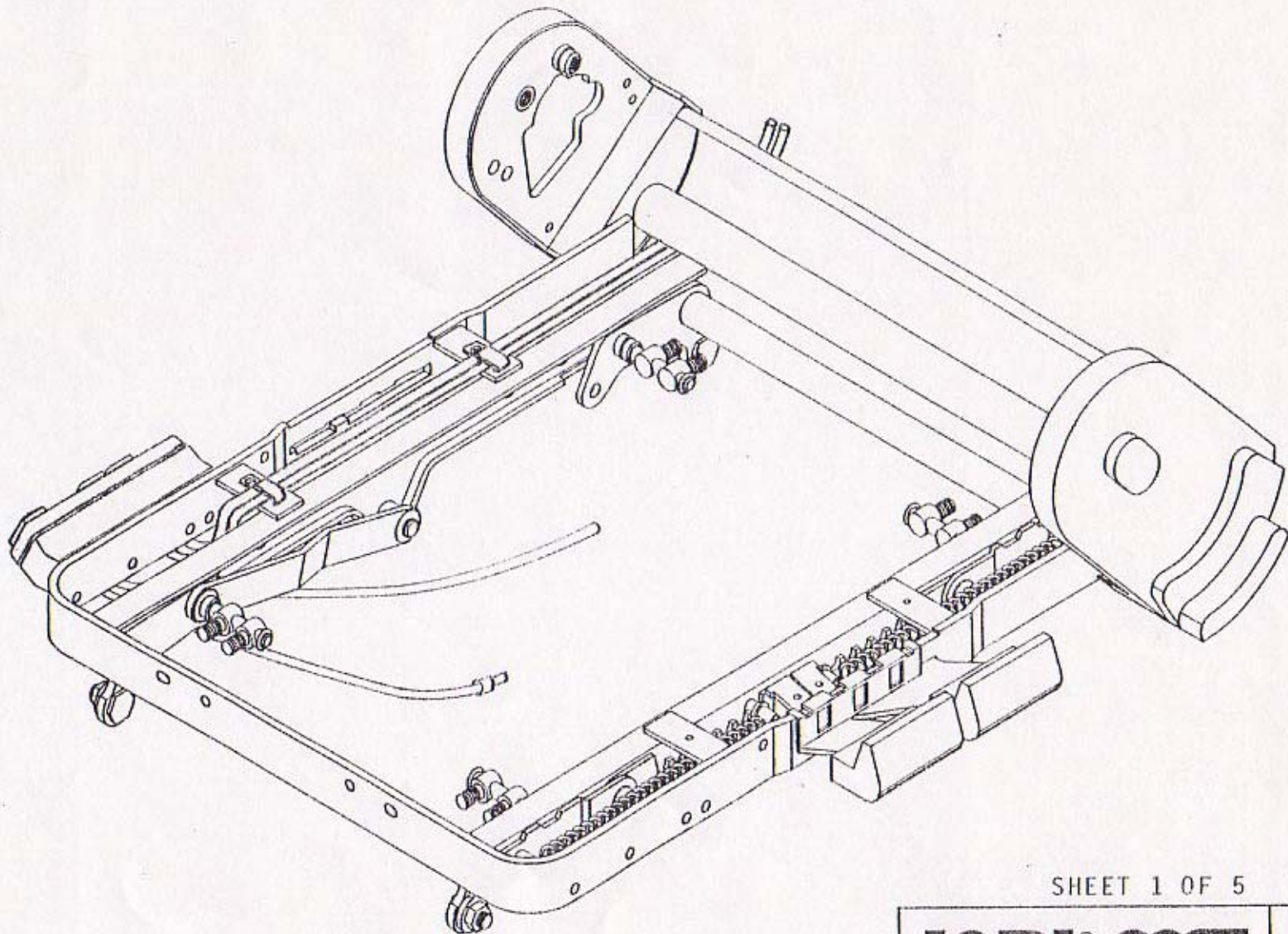
SERVICE PARTS LIST

ISRI P/N: 02371-02 Description: Seat Frame-515-LH-AL/MV(RH)
 ISRI Illus. No.: E-059
 Customer: Prevost Car Customer P/N: 861099

Specification: LH controls, double swivel bolt, controls – black w/symbol,
 Air lumbar/Manual valve-RH (IPS 5)

ILLUS NO.	DESCRIPTION	ISRI P/N	CUSTOMER P/N
E142	Washer – Flat – A8.4	See E3	
E143	Sleeve – Push On – PU4	* 46097-02	
E144	Sleeve – Push On – PU3	* 44713-02	
E145	Ring – Retaining	60045	
E147	Hose-PU3 (AL Supply)	See E3	
E149	Valve – AL/MV (IPS5)	See E4	
E150	Cover – Rocker – AL – Upper	* 45480-23	861093
E152	Cover – Rocker – MV (+/-)	* 46680-02	861097
E156	Plastic Tie	See E3	
E179	Connector - “Y” - PU4	* 44712	
E181	Connector–Inline–PU4/PU3	* 44436	
E182	Connector-Inline-PU3/PU3	* 46708	
E183	Hose-PU4 (Y/Valve Supply)	See E3	
E184	Hose-PU4 (Supply/Y)	See E3	
E185	Tag – “P” (Supply Hose)	See E3	

*** PART OF KIT**



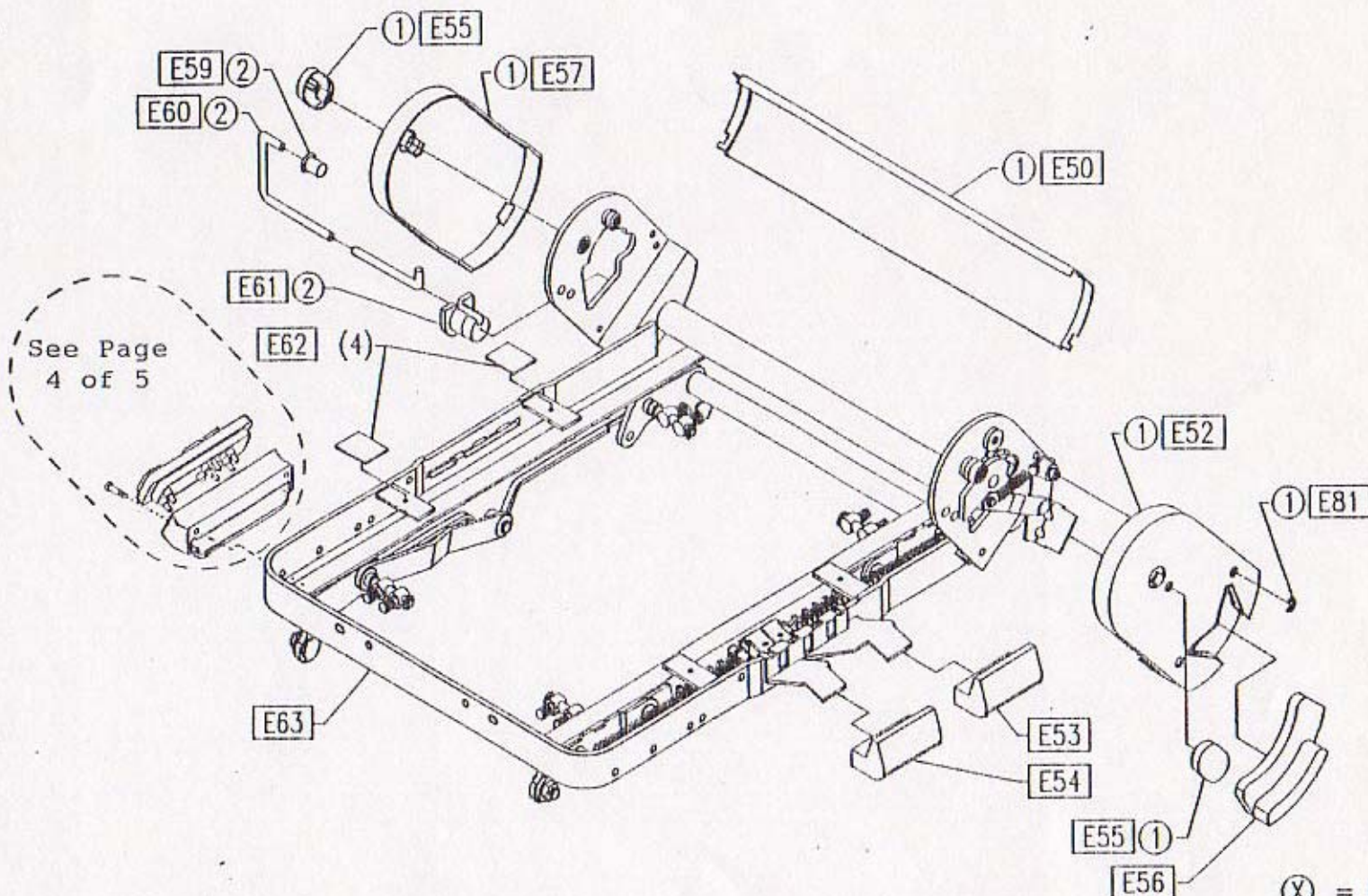
SHEET 1 OF 5

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12/95

SEAT FRAME-515-LH

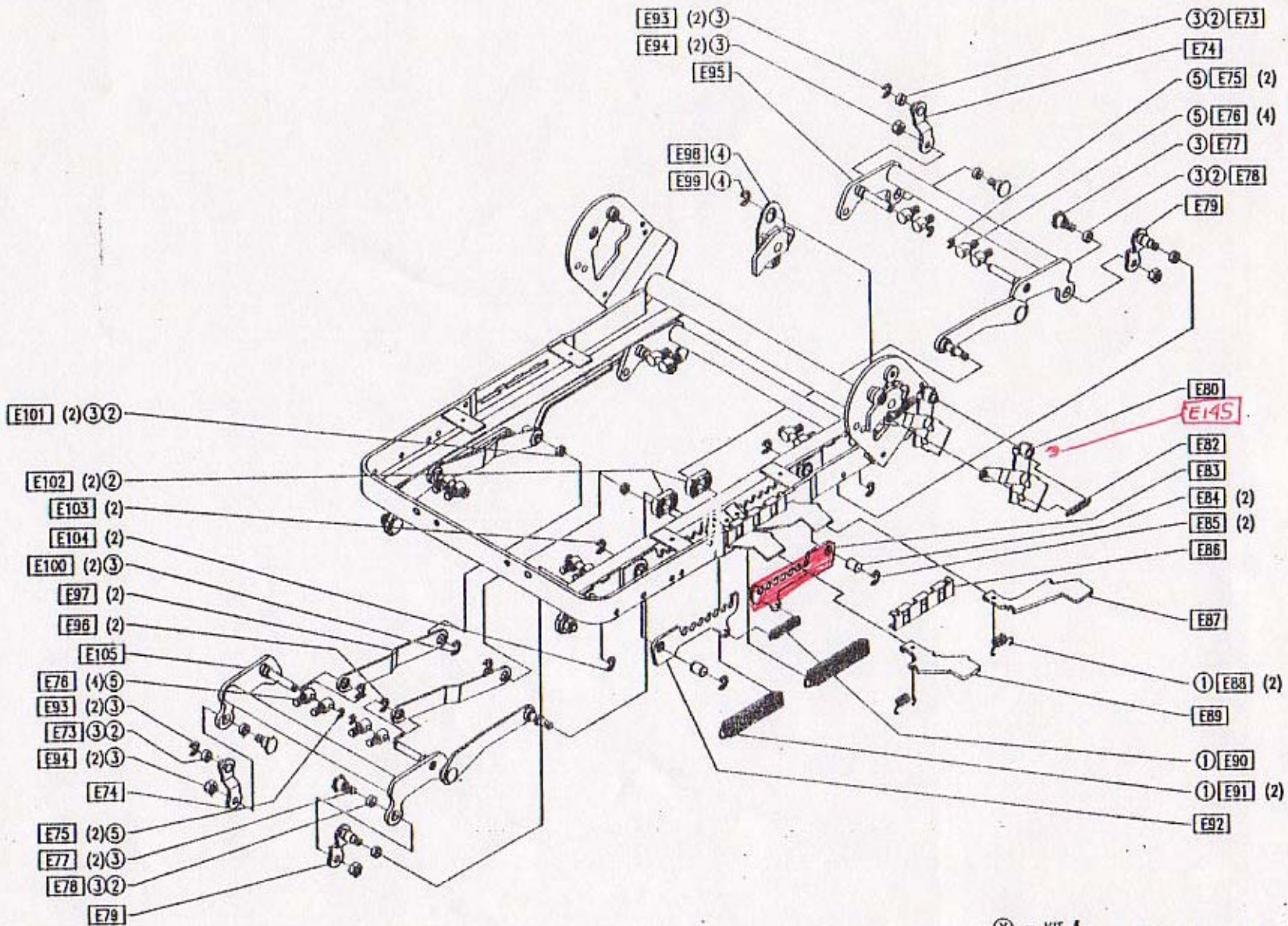
E-059



SHEET 2 OF 5

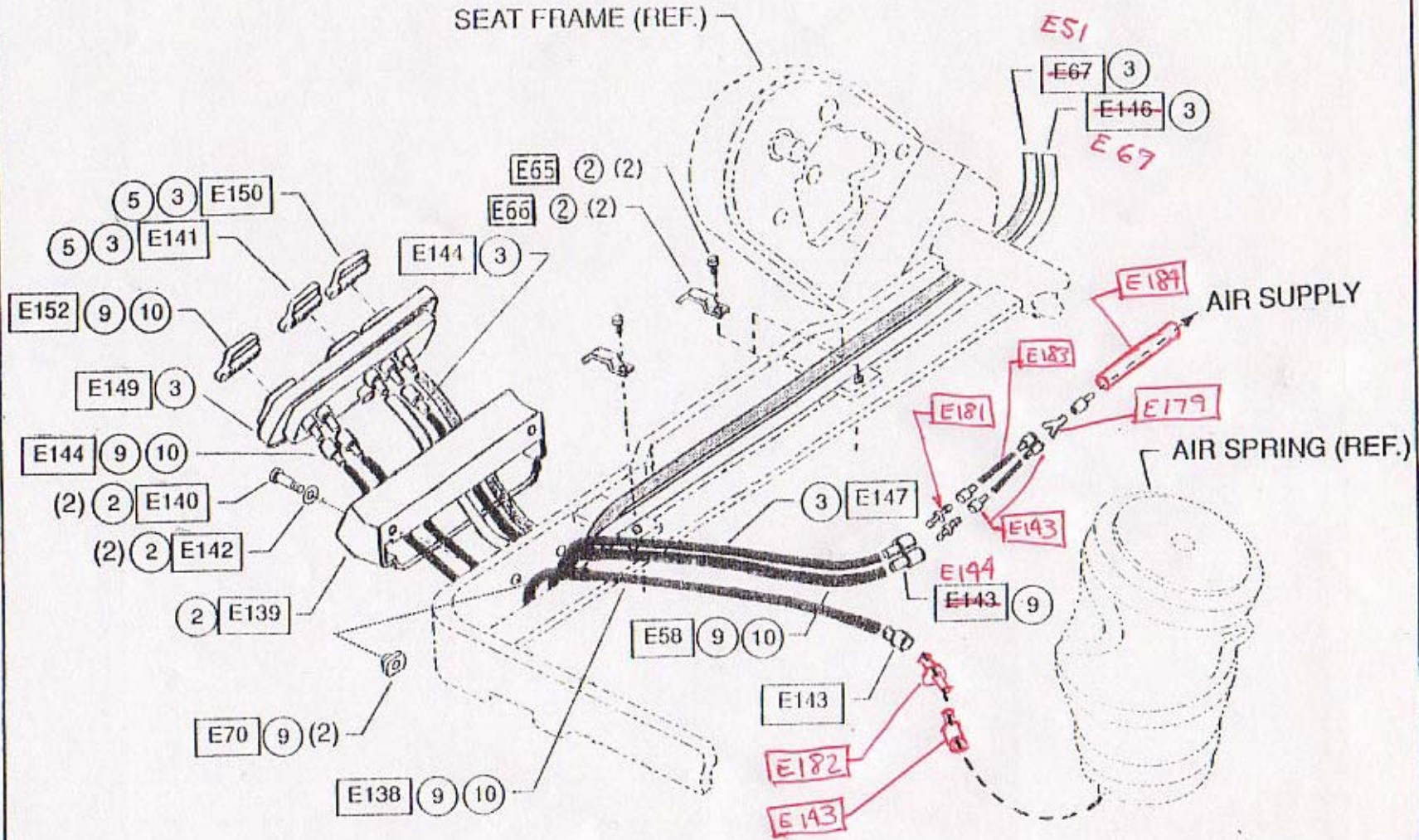
KIT #	P/N	ITEM NO. IN KIT	ITEM
1	E1	E50, E52, E55, E57, E81	SIDE PLATE KIT
2	E5	E59, E60, E61	TORSION BAR KIT

	12/95
	E-059



⊗ = KIT /
 (X) = QUANTITY SHEET 3 OF 5

SEAT FRAME (REF.)



○ = KIT #
 () = QUANTITY

KIT #	P/N	ITEM NO. IN KIT	ITEM
1	E1	E50, E52, E55, E57, E81	SIDE PLATE KIT
2	E3	E4, E70, E139, E140, E142, E143	VALVE KIT-AL/MV
3	E4	E51, E67, E141, E144, E146, E147, E149, E150	VALVE ASM-AL/MV
4	E5	E59, E60, E61	TORSION BAR KIT
5	E6	E54, E56, E141, E150, E152	HANDLE KIT-SF-AL/MV
6	E7	E88, E90, E91	SPRING KIT-H/S
7	E8	E73, E78, E102	BUSHING KIT-H/S
8	E9	E73, E77, E78, E93, E94, E100	BUSHING/HDW KIT-H/S
9	E13	E98, E99	TOOTHPLATE KIT
10	E14	E75, E76	SWIVEL BOLT/CLIP KIT

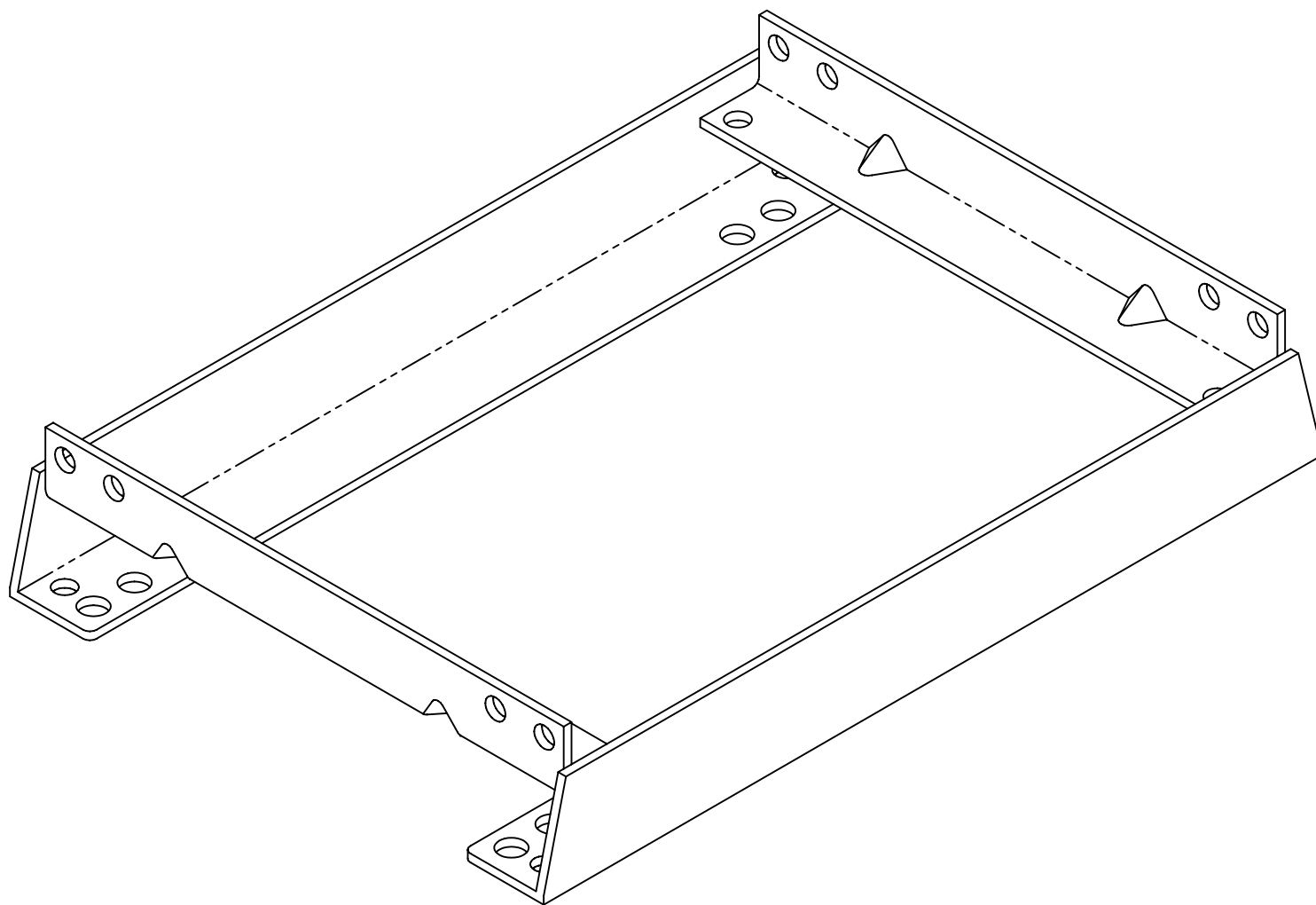
SHEET 5 OF 5

ISRI® 
ISRINGHAUSEN

12/95

KIT LIST

E-059

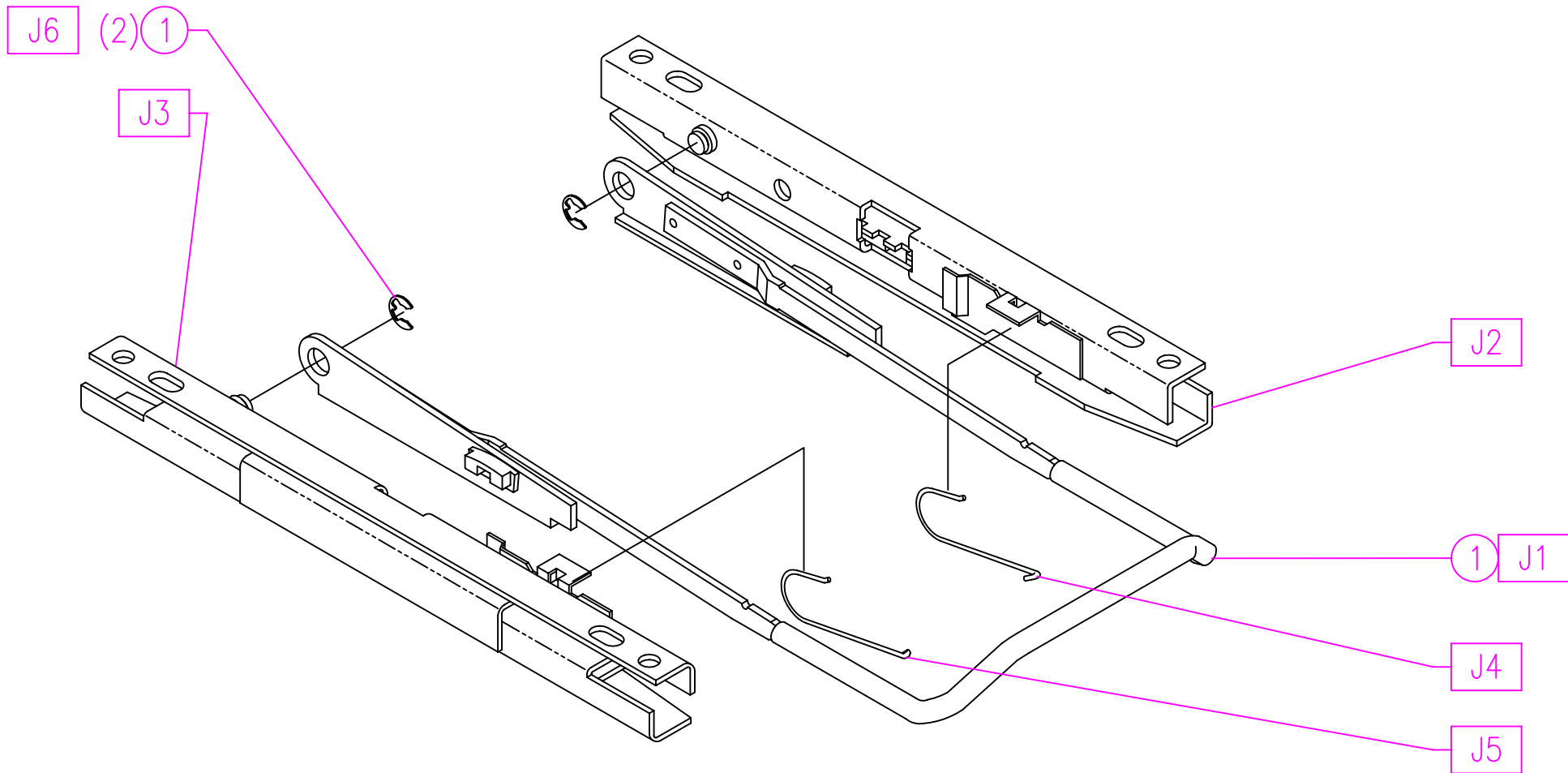




SERVICE PARTS LIST

ISRI P/N:	17491	Description: Slide Set – “B” Style
ISRI Illus. No.:	J-006	
Customer:	Prevost Car	Customer P/N: 860758
Specification:	90/60 slide stroke, double locking, bar handle up	

ILLUS NO.	DESCRIPTION	ISRI P/N	CUSTOMER P/N
J1	Handle – Slide	See J8	
J2	Slide – Slave – LH	23908	
J3	Slide – Master – RH	23907	
J4	Spring – Handle Return – LH	43284C	
J5	Spring – Handle Return – RH	43283C	
J6	Ring – Retaining	See J8	
J8	Handle/Clip Kit	914212-04	



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ISRINGHAUSEN

04/91

SLIDE SET

J-006

KIT #	P/N	ITEM NO. IN KIT	ITEM
1	J8	J1, J6	HANDLE KIT



SERVICE PARTS LIST

ISRI P/N: 17259-01 Description: Susp–Air
 ISRI Illus. No.: K-019
 Customer: Prevost Car Customer P/N:
 Specification: Manual air, 100 mm stroke, Adjustable shock

ILLUS NO.	DESCRIPTION	ISRI P/N	CUSTOMER P/N
K2	Suspension Hdw Kit	95477-03	860770
K3	Bumper / Bracket Asm	See K12	
K5	Shock Kit	914410	860766
K6	Air Spring Kit	95474-02	
K12	Bumper Kit	913934-05	860769
K19	Shock Cable Kit	914411	860767
K20	Shock Handle Kit	914412-01	861105
K50	Nut – Hex – M8	See K12	
K51	Washer – Split Lock – B8	See K12	
K53	Bumper – Cone Shape	See K12	
K56	Bushing – Flange	See K2	
K59	Nut–Hex–Crimp Lock-M10	See K2	
K61	Spring – Air	See K6	
K66	Washer – Flat – A6.4	See K6	
K67	Screw – Air Spring Mtg - Lwr	See K6	
K69	Bracket – Bumper Stop	See K3	
K70	Bumper – Up Stop	See K3	
K72	Bolt – Shock Mtg - Lower	See K5	
K73	Hose–MV / Air Spring	See K16	
K75	Bolt – Shoulder – M10	See K2	
K78	Roller	See K2	
K83	Bushing – Shock - Lower	See K5	
K84	Shock Absorber	See K5	
K106	Frame – Upper	N/A Separate	
K108	Frame – Lower	N/A Separate	
K109	Scissor – Outer	N/A Separate	
K110	Scissor – Inner	N/A Separate	
K125	Cable Tie	See K5 or K9	
K152	Spacer Block	See K2	
K153	Bearing Block	See K2	
K154	Bolt – Air Spring Mtg – Upr	See K6	

***PART OF KIT**

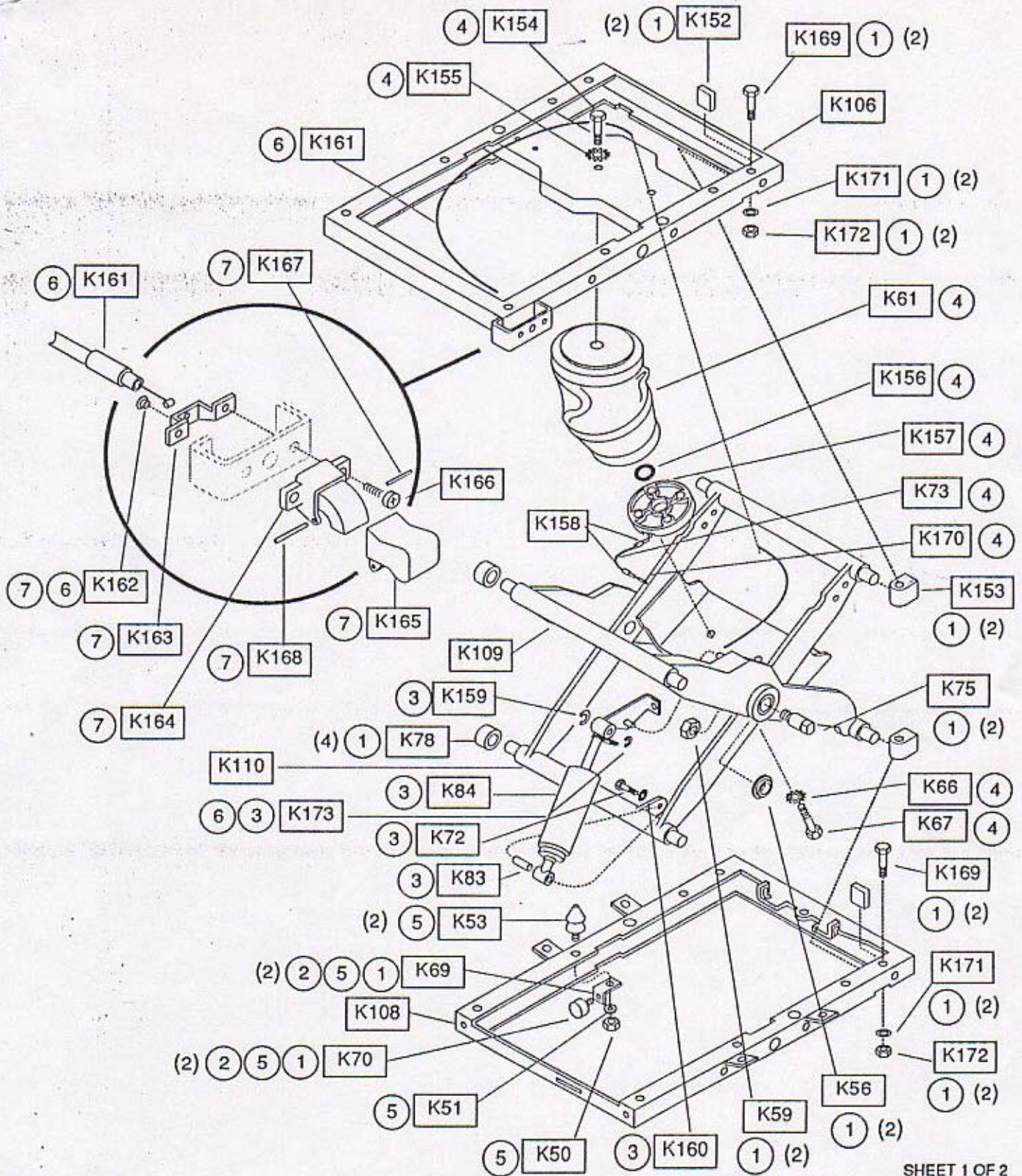


SERVICE PARTS LIST

ISRI P/N: 17259-01 Description: Susp–Air
 ISRI Illus. No.: K-019
 Customer: Prevost Car Customer P/N:
 Specification: Manual air, 100 mm stroke, Adjustable shock

ILLUS NO.	DESCRIPTION	ISRI P/N	CUSTOMER P/N
K155	Washer–Air Spring Mtg-Upr	See K6	
K156	O-Ring (Air Spring)	See K6	
K158	Sleeve – Push on – PU3	* 44713-01	
K159	Ring–Retaining–Shock-Upr	See K5	
K160	Washer-Shock-Lwr	See K5	
K161	Cable – Adjustable Shock	See K19	
K162	Plug	See K19 or K20	
K163	Bracket – Cable/Handle Mtg	See K20	
K164	Housing – Adjustable Shock	See K20	
K165	Handle – Adjustable Shock	See K20	
K166	Screw (Adj Shock Housing)	See K20	
K167	Pin-Long (Shock Hdl Pivot)	See K20	
K168	Pin-short (Shock Cable)	See K20	
K169	Bolt – Bearing Block	See K2	
K170	Conn-Reducer-PU4/PU3	* 44436	
K171	Washer-Bearing Block	See K2	
K172	Nut-Bearing Block	See K2	
K173	Ring–Retaining (Shk Cable)	See K19	

* PART OF KIT



SHEET 1 OF 2

 ISRI [®] ISRINGHAUSEN	5/92
	Susp Asm - Air K-019

○ = KIT #
 () = QUANTITY

Kit No.	P/N	Item No. In Kit	Description
1	K2	K12, K56, K59, K75, K78, K152, K153, K169, K171, K172	Susp. HDW Kit
2	K3	K69, K70	Bumper/Bracket Assembly
3	K5	K72, K83, K84, K159, K160, K173	Shock Kit
4	K6	K61, K66, K67, K73, K154, K155, K156, K157, K170	Air Spring Kit
5	K12	K50, K51, K53	Bumper Kit

SHEET 2 OF 2

ISRI® 
ISRINGHAUSEN

7/92

Susp Asm - Air

K-019

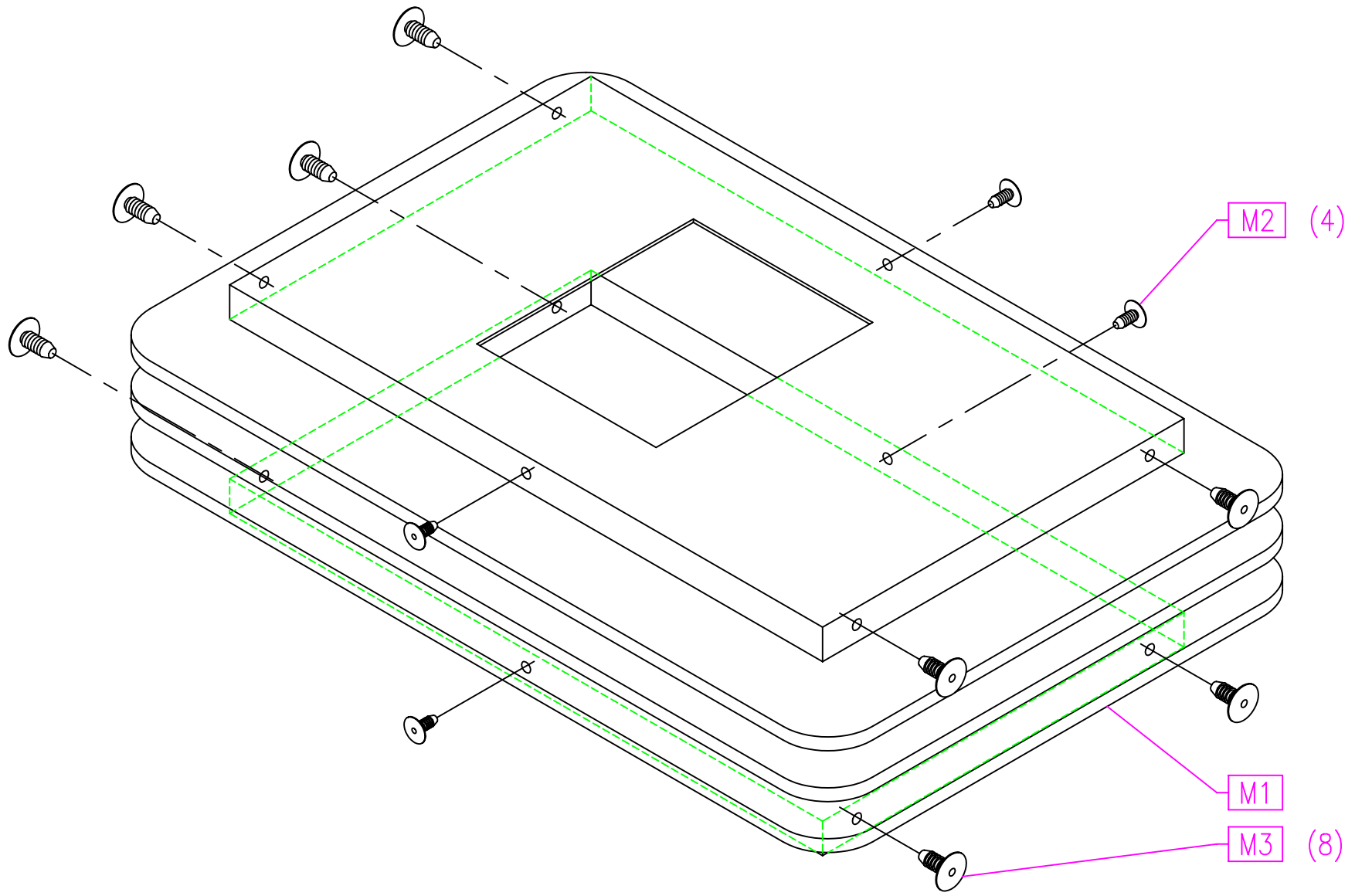


SERVICE PARTS LIST

ISRI P/N: 92625-01 Description: Boot Kit-Susp-Air-AL
 ISRI Illus. No.: M-001
 Customer: Prevost Car Customer P/N:

Specification:

ILLUS NO.	DESCRIPTION	ISRI P/N	CUSTOMER P/N
M1	Boot	00169	
M2	Boot Button – Small	See M4	
M3	Boot Button – Large	See M4	
M4	Hdw Kit – Boot Button	910507	



(X) = QUANTITY

 <p>ISRI[®] ISRINGHAUSEN</p>	<p>10/90</p>
<p>AIR SUSP BOOT KIT</p>	<p>M-001</p>



MAINTENANCE MANUAL

 **MULTINA**

ALLEGRO MAINTENANCE MANUAL VERSION 1

Prepared by Frederic Leclerc, Technical Publisher

Illustrated by Jean-Marc Bourassa

Document number: DEV02M-00EN-INTER

June 2006

HOW TO USE THIS MANUAL

The maintenance manual has been prepared to serve as a guide to personnel involved in the maintenance of the Multina Interurban Seat. The manual includes all maintenance tasks of the seats.

The maintenance manual is divided as follows:

1. **FRONT MATTER** - This section includes an explanation of How to Use the Manual, Table of Contents, and List of Effective Pages. When we send a new version of the manual to a customer, each modification will be described in the List of Effective Pages. The revision status is indicated on the previous page.

2. **CHAPTER 1 INTRODUCTION** - This chapter is divided into the following three sections:

SECTION I. GENERAL INFORMATION - This section explains the scope of the manual, and provides a list of abbreviations.

SECTION II. SEATING DESCRIPTION - This section describes and illustrates the seat components, the seat characteristics, and models.

SECTION III. PRINCIPLES AND OPERATION - This section describes and illustrates how to operate the seat, such as tray table, footrest, etc.

3. **CHAPTER 2 MAINTENANCE** - This chapter is divided into the following three sections:

SECTION I. PREVENTIVE MAINTENANCE INSPECTION SCHEDULE - This section provides preventive maintenance schedule inspection of every spare part of the seat. Also, the section provides the maintenance tasks for preventive cleaning of seat fabrics.

SECTION II. MAINTENANCE PROCEDURES - This section provides information on both removal and installation of line replaceable components. This section also provides a table of the parts and hardware needed to perform the task. The table of parts and hardware is composed as follows:

Item: The item indicates the callout on the illustration.

QTY: The Qty indicates how many parts are needed to perform the task.

Inspection: The inspection indicates the period of time (in months) Multina recommends for inspecting parts.

Description: The description contains the name of each assembly or component. Refer to IPC for more information about hardware.

Multina #: The Multina number indicates our identification number.

NOTE: Refer to Illustrated Parts Catalog for all part numbers.

SECTION III. ADJUSTMENT PROCEDURES - This section provides information on adjustment procedures.

3 CHAPTER 3 TROUBLESHOOTING - This chapter provides all the troubleshooting procedures for seat. The information is presented in a four column table, such as symptoms, possible causes, corrective actions, and references.

LIST OF EFFECTIVE PAGES

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CHAPTER 1 INTRODUCTION

SECTION I GENERAL INFORMATION

1.1.1 Scope

The maintenance manual contains all information needed to perform the overhaul of the seat, as well inside as outside the car.

NOTE: Refer to Illustrated Parts Catalog for all part numbers.

1.1.2 Abbreviations List

ADA	Americans with Disabilities Act	hdns	hardness
al	aluminum	hex	hexagonal
aly	alloy	hgt	height
anod	anodize	hlcl	helical
blk	black	id	inside diameter
brs	brass	in	inch
Brz	bronze	insr	insert
btnhd	button head	intl	internal
Cd	cadmium	IPC	Illustrated Parts Catalog
cle	closed end	knrld	knurled
conl	conical	l	long
cp	cone point	lb	pound
cptv	captive	lb	pound
Crm	chrome	lb ft	pound-force foot
cs	carbon steel	lb in	pound-force inch
cskh	countersunk head	lg	length
ctsk	countersunk	lh	left-hand
Cu	copper	lkg	locking
dia	diameter	mach	machine
duro	durometer	matl	material
ext	exterior	max	maximum
extl	external	min	minimum
filh	fillister head	nar	narrow
fl	flat	nat	natural
flg	flanged	Ni	Nickel
flh	flat head	no	number
fp	flat point	nom	nominal
ft	foot	np	nickel plated
ga	gauge	nprn	neoprene
gr	grade	nr	non rotative
grv	groove	nyl	nylon
hd	head	od	outside diameter

oe	open end	Zn	Zinc
ovh	oval head		
ovp	oval point		
phh	phillips head		
phpnh	phillips pan head		
pld	plated		
plstc	plastic		
pt	point		
qik-opng	quick-opening		
rad	radius		
rbr	rubber		
rd	round		
rdh	round head		
rh	right-hand		
rng	range		
rtng	retaining		
sch	socket head		
scr	screw		
sft	shaft		
shldr	shoulder		
skt	socket		
slflkg	self-locking		
slftpg	self tapping		
sld	slotted		
spr	spring		
sq	square		
sqh	square head		
sst	stainless steel		
stl	steel		
thd	thread (ed)		
thk(ns)	thick(ness)		
tnsn	tension		
tr	truss		
trh	truss head		
trsn	torsion		
tth	tooth		
ty	type		
typ	typical		
UNC	Unified Coarse Thread		
UNF	Unified Fine Thread		
w	wide		
w/	with		
wd	width		
wht	white		
wr	wire		
x-mas	christmas		
yel	yellow (chromated coated)		

SECTION II SEATING DESCRIPTION

1.2.1 Seats Description

There are three different types of intercity bus seats; a two-passenger seat, a two-passenger swivel seat, and a three-passenger bench seat.

1.2.1.1 Two-Passenger Seat

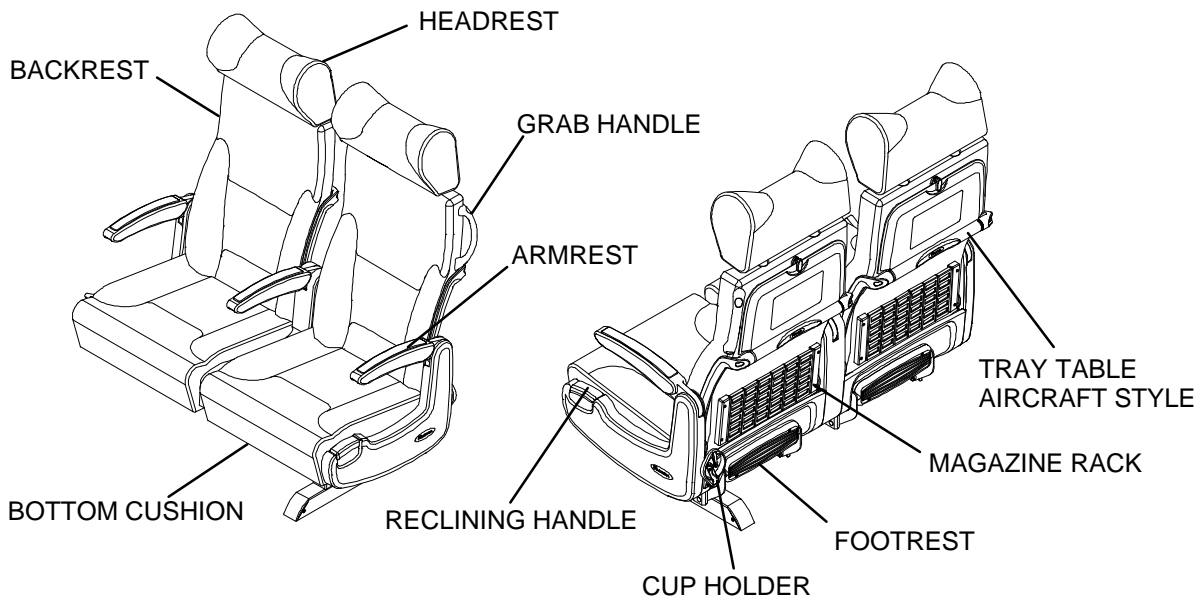


Figure 1-1 Two-Passenger Seat

(See figure 1-1). Each seat frame is made of steel tubing and aluminum casting. All shrouds are made of ABS.

The cushions are made of a metal frame (seat pan), a suspension system (bottom cushion only), and polyurethane foam. The cover can be of leather, vinyl or fabric. The headrest is located on the backrest and can be adjusted to the desired height. The hydraulic reclining mechanism is composed of the reclining handle and the gas cylinder. The backrest reclines up to 25°. Three armrests are provided; the aisle side down armrest, the center folds up armrest and on the side of the wall a fixed armrest.

The seat can be provided with different accessories; an automatic return footrest, a magazine rack (plastic or mesh), a grab handle, a tray table, and a cup holder. The cup holder can be used with plastic or foam cup and soda bin. The maximum diameter is 2 5/8 in.

Two models of tray tables are available with the seat; an aircraft style tray table and a fixed tray table installed directly to the back of the backrest. The fixed tray table is provided with a safety collapse at 25 lb to prevent breaking. The aircraft style is provided with an advertising window and this table is freelance of the backrest.

1.2.1.2 Two-Passenger Swivel Seat

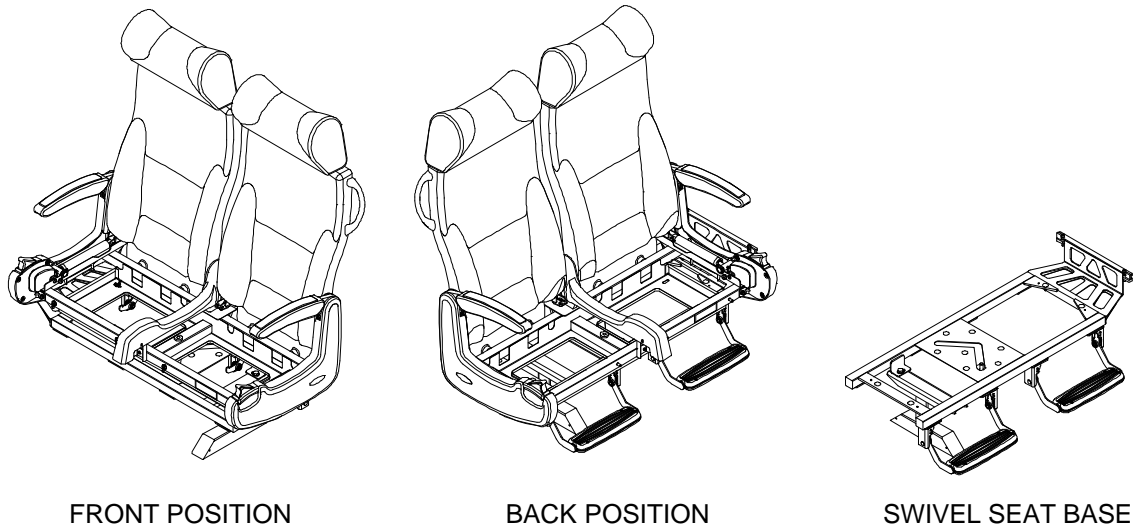


Figure 1-2 Two-Passenger Swivel Seat

(See figure 1-2). The swivel seat is similar to the fixed seat but it can be rotated in a reversed position.

A special rotating base is provided with the swivel seat. Four wing studs fasten the seat frame to special rotating base.

1.2.1.3 Three-Passenger Bench Seat

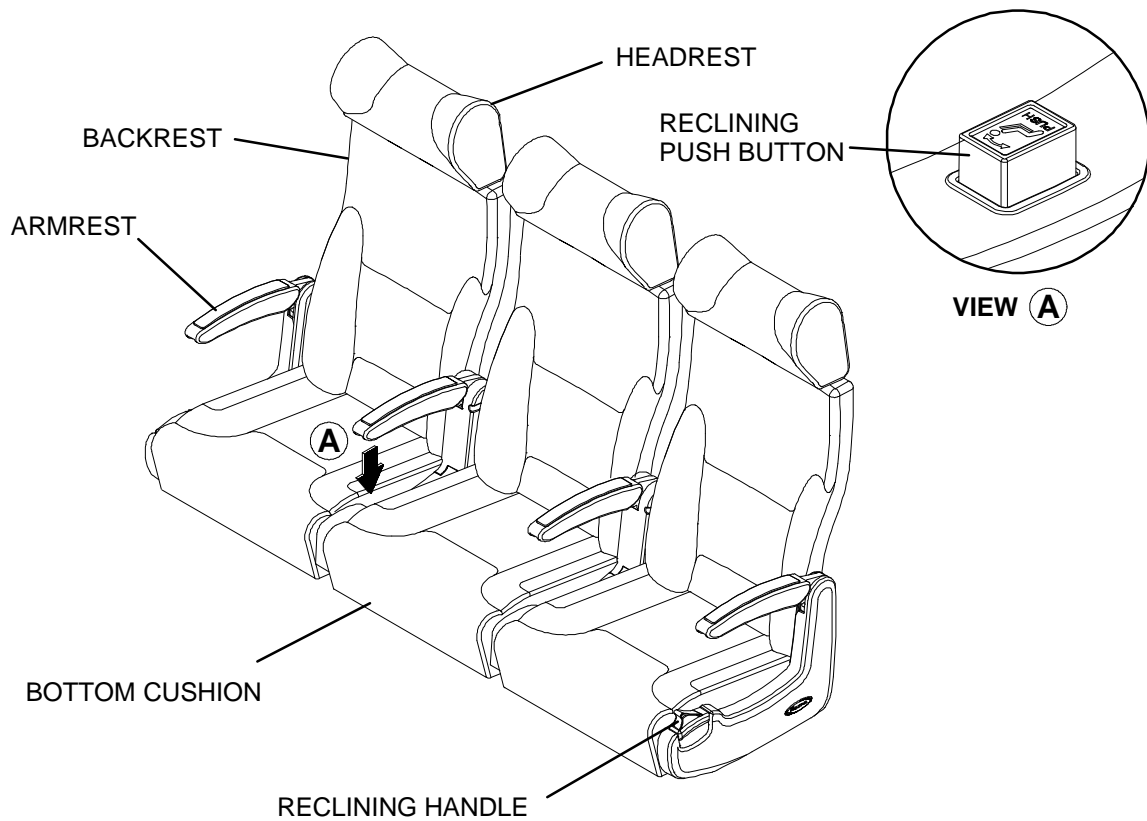


Figure 1-3 Three-Passenger Bench Seat

(See figure 1-3). The three-passenger bench seat is installed without pedestal. There are neither pedestal nor accessories (tray table, magazine net, and cup holder) installed on it. The middle backrest reclining is activated with the push button located on the front center shroud (view A).

SECTION III PRINCIPLE OF OPERATION

1.3.1 Backrest Reclining

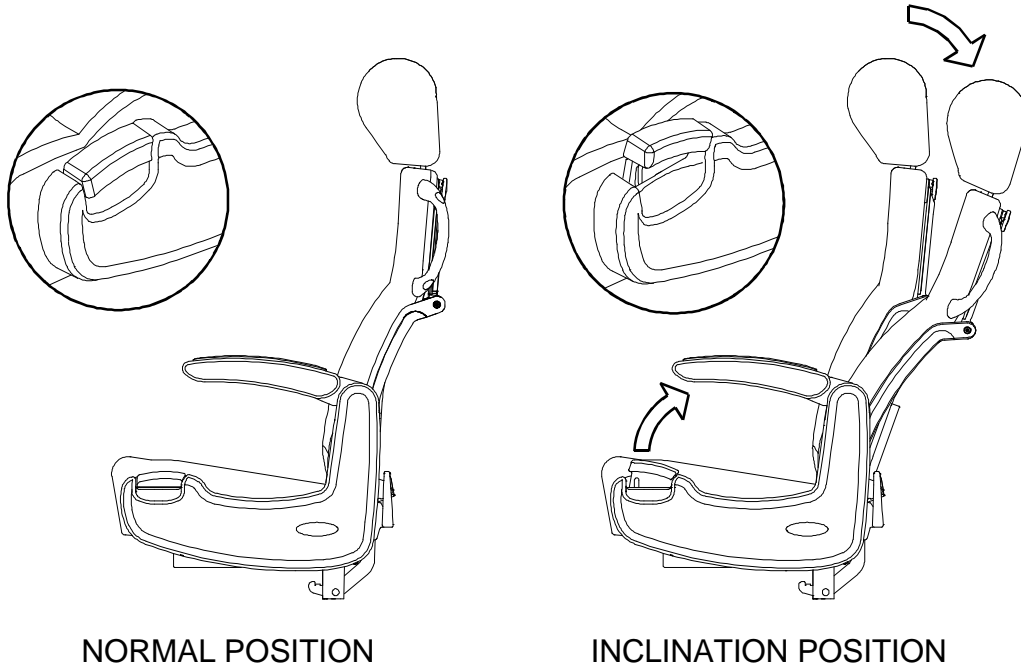


Figure 1-4 Backrest Reclining

The backrest of the seats can recline up to 25°. The reclining device is activated by a reclining handle located at the aisle side and at the wall side of each seat. At the pull of the handle, the gas cylinder is released and the passenger then presses down the backrest to the desired position.

1.3.2 Upward and Downward Armrest

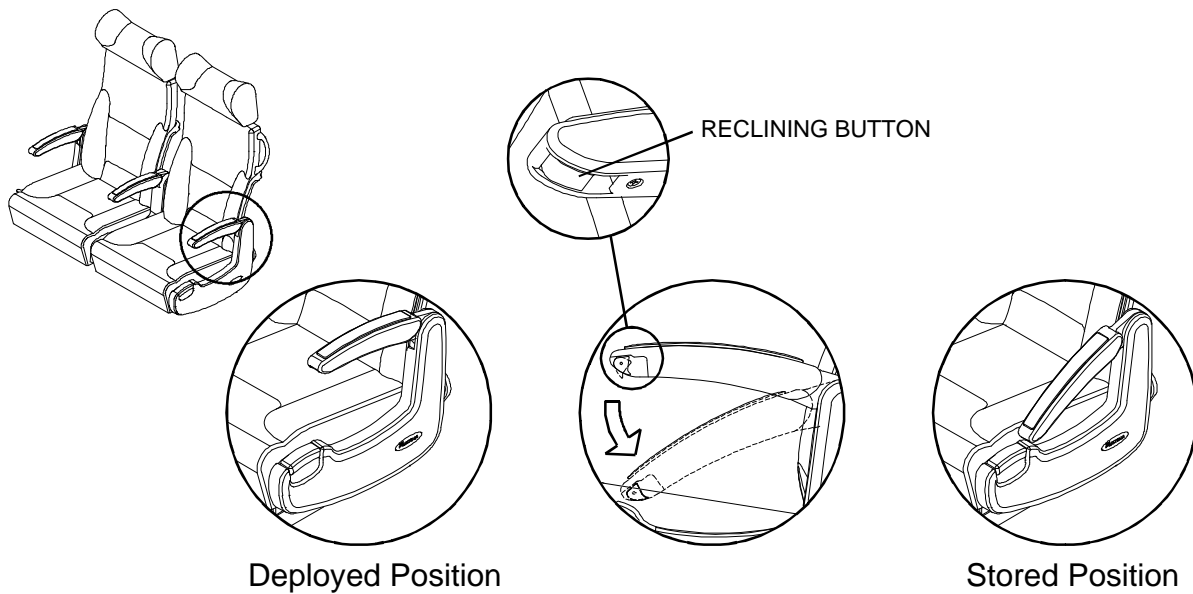


Figure 1-5 Downward Armrest

Each seat features a pivoting downward armrest and upward armrest. To stow the downward armrest, pull reclining button to unlock armrest (do not apply pressure on the armrest) and then, the armrest will be free for movement. To deploy armrest, pull upward on it until the armrests locking interlocks correctly.

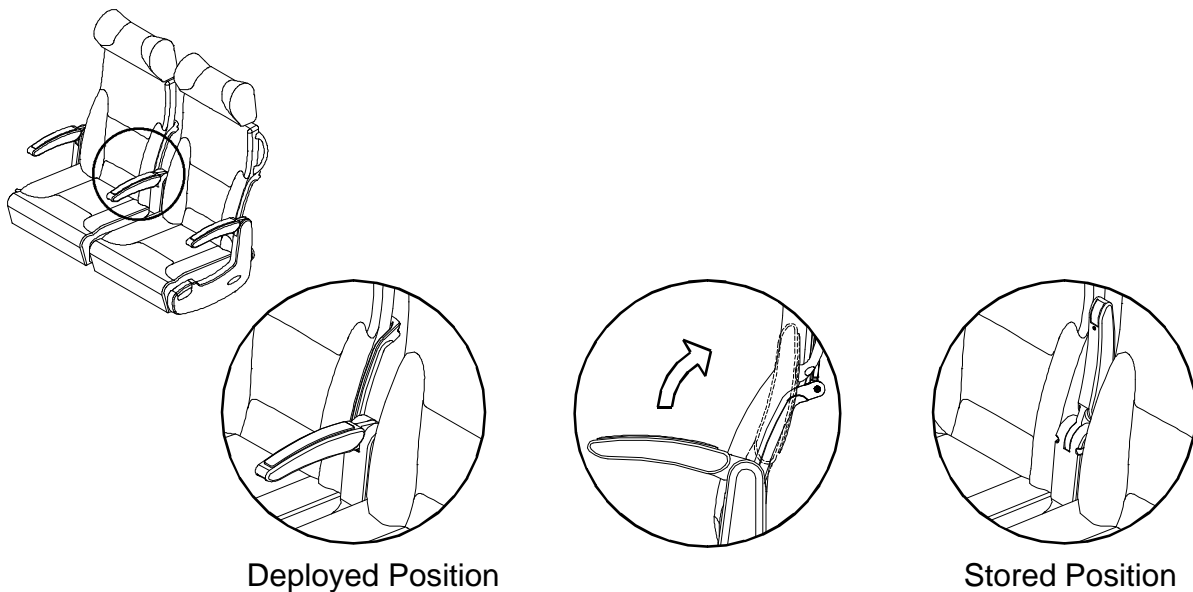


Figure 1-6 Fold-up Armrest

To deploy or to stow the fold-up armrest, press downward or pull upward on it.

1.3.3 Footrest

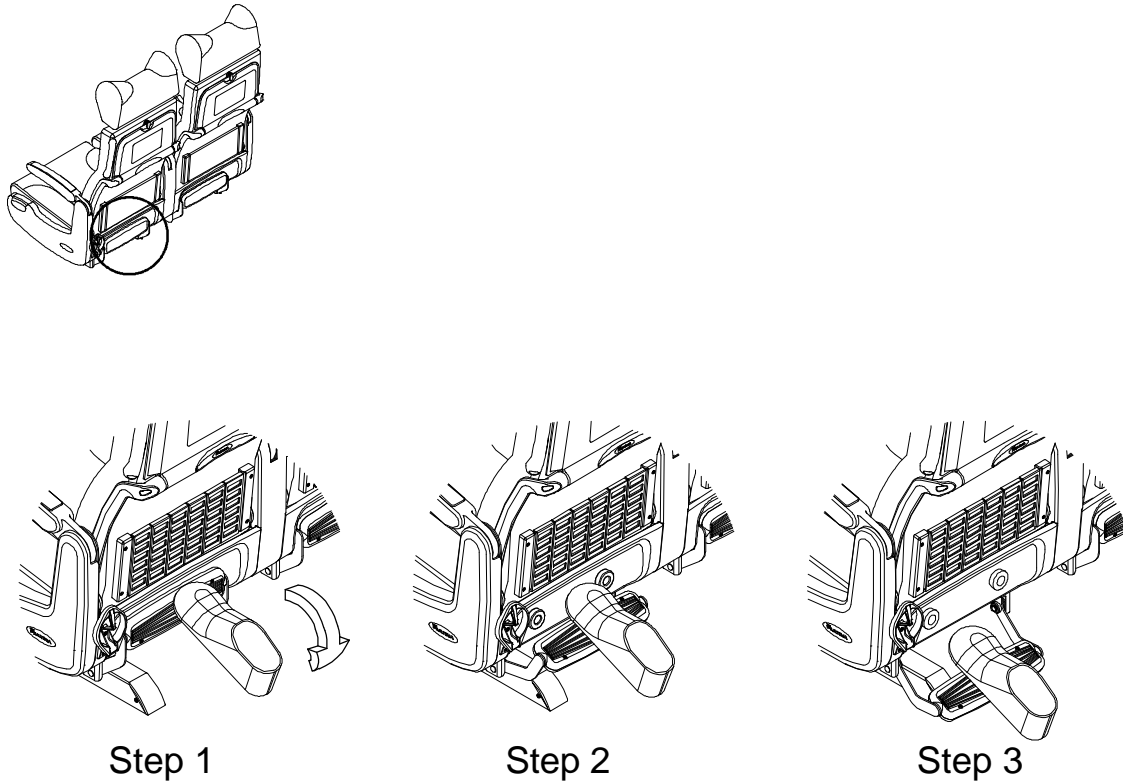


Figure 1-7 Footrest

Each seat is provided with two footrests which can be stored or deployed.

To use the footrest in the deployed position, press downward with the foot on the top of it. The footrest is self storing when feet are removed.

1.3.4 Tray Tables

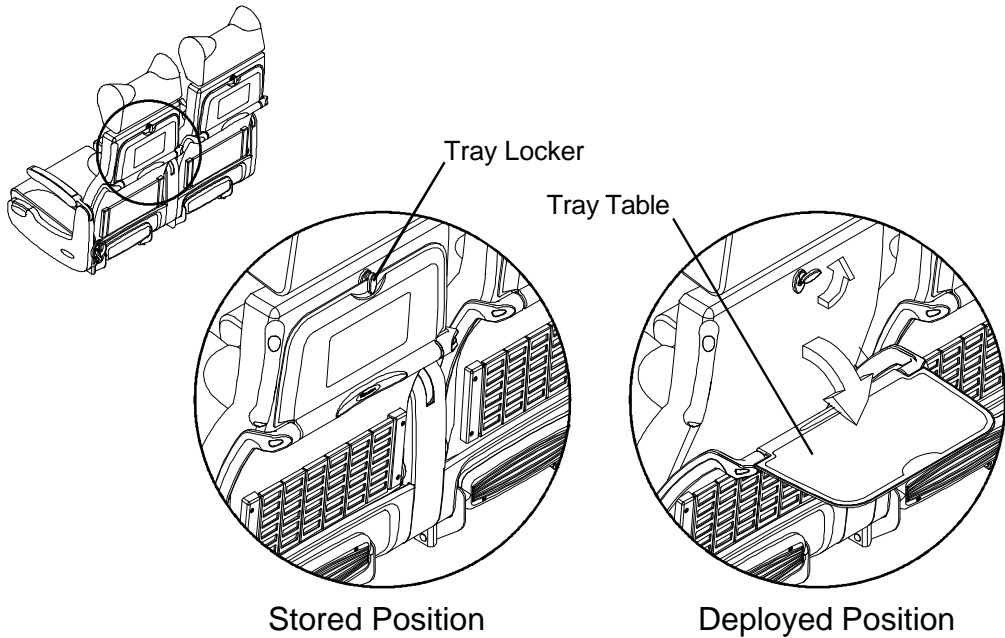


Figure 1-8 Aircraft Style Tray Table

To use the tray table, rotate the tray locker counterclockwise, and then, the tray table will be free to deploy to horizontal position. Do not exceed the 150-lbs maximum load.

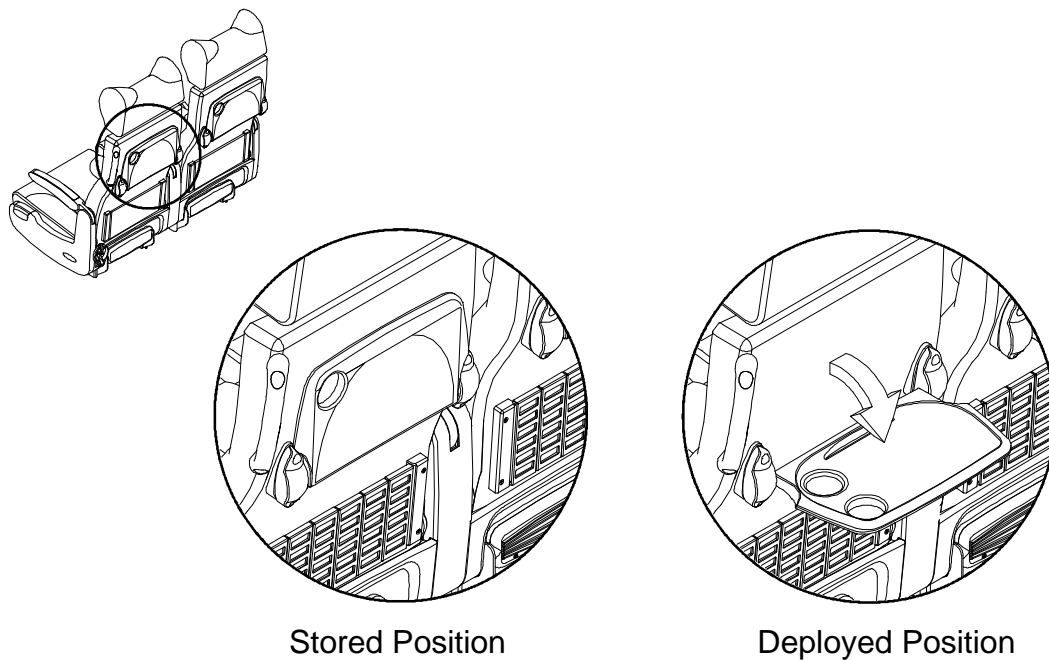
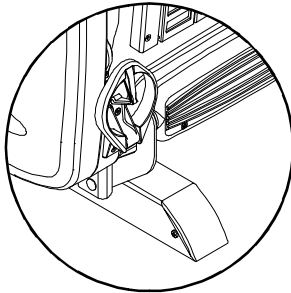
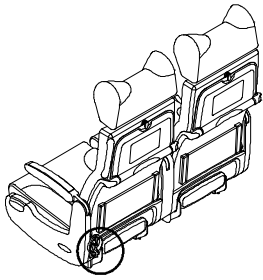


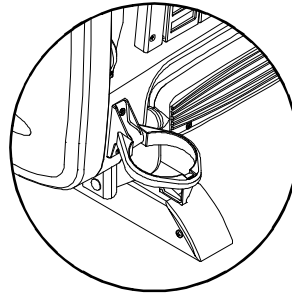
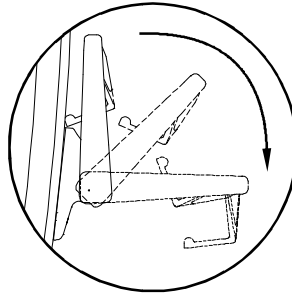
Figure 1-9 Fixed Tray Table

To use the fixed tray table, pull it and take it down to its horizontal position. When an excess load is applied to it, table stands down automatically to prevent breaking.

1.3.5 Cup Holder



Stored Position



Deployed Position

Figure 1-10 Cup Holder

To deploy the cup holder pull it and take it down to its horizontal position, then deploy cup support. Note that the maximum cup diameter is 2 5/8 in.

1.3.6 Swivel Seat Rotation

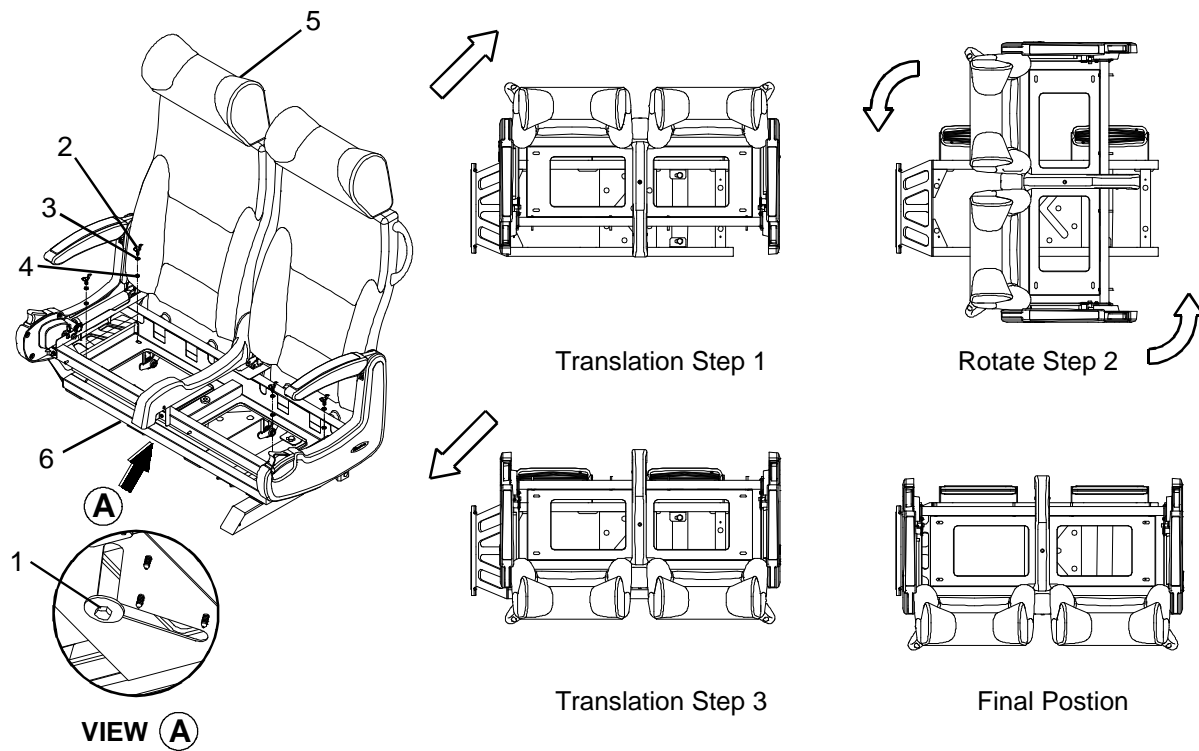


Figure 1-11 Swivel Seat

To reverse seat:

- A. Remove both bottom cushions (See [2.2.2.1.1](#) Removal).
- B. Loosen screw (1).
- C. Remove four wing studs (2), lockwashers (3), and washers (4) fastening seat frame (5) to seat base (6).
 - 1) Deploy both footrests in down position.
 - 2) Slide seat frame (5) from wall to aisle side.
 - 3) Rotate seat frame (5) 180°.
 - 4) Slide seat frame (5) from aisle side to wall.
- D. Position seat frame (5) correctly to seat base (6) and fasten with four washers (4), lockwashers (3), and wing studs (2).
- E. Tighten screw (1).
- F. Install both bottom cushions (See [2.2.2.1.2](#) Installation).

CHAPTER 2 MAINTENANCES

SECTION I PREVENTIVE MAINTENANCE INSPECTION SCHEDULE

2.1.1 Seat Inspection Schedule

COMPONENTS	TASK
Maintenance schedule, daily inspection	
Passenger Seats	Visual inspection and cleaning of cushions, tray tables and footrests to remove dust and grime. (See 2.1.2.)
Maintenance schedule, 184-day inspection (6 months)	
Cushions	Wash fabric cover.
Passenger Seats	Inspect seat reclining, armrest, tray table, and footrest mechanisms for proper operation and loose hardware.

Table 2-1 Seat Inspection Schedule

2.1.2 Leather, Vinyl, and Fabric Cover Maintenance

2.1.2.1 Leather Maintenance

Sponge the stain with a solution of soft soap (ex: Ivory) and lukewarm water. DO NOT SOAK. Follow this by rubbing with a damp cloth.

WARNING

DO NOT USE WASHING POWDER, AMMONIA, SODA, BLEACH OR ANY PRODUCTS WHICH CONTAIN THEM. Do not product such as Armor All because this kind of product will dry up and cracks could appear.

2.1.2.2 Vinyl Maintenance

Sponge the stain with a solution of soft soap (ex: Ivory) and lukewarm water. DO NOT SOAK. Follow this by rubbing with a damp cloth.

WARNING

DO NOT USE WASHING POWDER, AMMONIA, SODA, BLEACH OR ANY PRODUCTS WHICH CONTAIN THEM.

2.1.2.3 Fabric Maintenance

With proper care your upholstery will provide years of beautiful service. To help keep your upholstery looking new, certain precautions and cleaning instructions should be followed. By giving your upholstery a little extra attention, it will stay looking great for years!

According to the Environmental Protection Agency your upholstery serves as a magnet that collects a variety of pollutants and contaminants from various sources. Internal sources include air conditioners, heaters, and tobacco smoke and food particles. Outdoor sources include pollen and spores from trees, plants and other vegetation as well as exhaust fumes from cars, fireplaces and other form of pollution.

Satisfactory results are usually achieved by cleaning with non-water-based foam cleaner, provided that manufacturer's directions are carefully adhered to. Any product or technique should always be tested on an inconspicuous area before attempting overall cleaning.

2.1.2.3.1 Cleaning of Upholstery

The seat cushion and back covering may be fabricated of different materials, consisting of both synthetic and natural fabrics. Vinyl coated fabrics cannot be machine washed (laundered). For cleaning of the seat upholstery in view of the above limitations, the following procedure is suggested:

Woven Fabrics

1. Frequent and thorough vacuum cleaning.
2. Occasional steam cleaning.
3. To the cover (not removed) apply a thick layer of soap (non-alkaline) or approved foam type cleaner. Suds are to be scrubbed into fabric using a stiff bristle brush or a sponge.
4. After scrubbing sponge the suds from the fabric with a clean sponge or cloth dampened with water. Rinse sponge or cloth frequently with clean water.

5. Do not water soak fabric, as this will cause shrinkage.

Considerable thought and development work has gone into the production of our fabrics to enable them to withstand the rigorous use on public transport vehicles. We felt therefore, a few hints on the care and cleaning would help you to obtain the best possible life from your fabric.

One of the main advantages of these fabrics is their construction which allows dirt to fall to the base of the pile. This presents a relatively clean surface to your passenger which is obviously very important.

Routine Cleaning. All that is required to remove the dirt is gentle beating with the hand or the back of a brush. This will bring the dirt to the surface where it is easily removed by a vacuum cleaner or a soft brush. It is preferable to vacuum or brush in the direction of the pile which can easily be recognized by running a hand lightly over the pile. Cleaning should be carried out as often as possible. If the fabric becomes excessively dirty, then particles of grit will cause gradual wear to take place, thus reducing the life of the moquette.

Steam Cleaning. Occasional steam cleaning will breathe new life into tired upholstery. Portable steam cleaners are readily available from hire shops to rent or buy, and we have many examples showing how a vacuum and steam clean can rejuvenate a drab interior. *(The need to follow safe operating procedures when steam cleaning is vital to prevent risk of scalding.)*

METHOD 1

Apply a non-inflammable solvent (trichlorethylene) with a clean, white, absorbent material, treating small areas working from the outer edge towards the center of the stain. Blot frequently with a dry cloth to avoid rings.
OPEN WINDOWS AND DOORS TO ALLOW FUMES TO DISPERSE.

METHOD 2

Sponge the stain with a solution of household detergent and lukewarm water. DO NOT SOAK. Follow this by rubbing with a damp cloth, rinsing cloth between each treatment.

WARNING

DO NOT USE SOAP, WASHING POWDER, AMMONIA, SODA, BLEACH OR ANY PRODUCTS WHICH CONTAIN THEM.

ALCOHOLIC LIQUIDS

Sponge with water followed by Method 2.

BATTERY ACID

Saturate with a solution of sodium bicarbonate, leave for several minutes before drying out. It is important for the above treatment to be carried out immediately to avoid serious damage to the moquette.

BEVERAGE STAINS

Use Method 1. If stain persists, try methylated spirits.

BLOOD STAINS

Use Method 2.

BURNS

Scrape blackened area with a knife and treat with Method 2. Extensive burns require expert attention.

CHEWING GUM

Soften with cyclohexanone and scrape off carefully with a knife.

COSMETICS

Use Method 1, followed by Method 2.

WRITING INK

Use Method 2. If brown stain remains, treat as for rust.

COPYING INK

Treat with methylated spirits, blotting frequently to avoid ink spreading. Use cleaning Method 2 to complete the treatment.

BALLPEN INK

Treat as copying ink.

MARKING INK

(Felt-tipped pens). Treat with Methyl Ethyl Ketone (M.E.K.), followed by Method 2.

OIL, GREASE AND PAINT MARKS

Remove surplus substance with a knife or spoon, and then treat with Method 1, followed by Method 2. Should stains reappear, repeat cleaning process.

RUST

Use Method 2, followed by a warm solution of oxalic acid. Complete treatment by sponging with water.

TAR

Soften with benzene and then treat with Method 1, followed by Method 2.

URINE

Use Method 2.

VOMIT

Use Method 2.

NOTE Prompt and correct cleaning will remove most stains. Wrong treatment will only increase the damage. In cases where there is doubt, always seek expert advice. Information is to the best of our knowledge true and accurate, but all recommendations or suggestions are made without guarantee since the conditions of use are beyond our control.

TRIM MAINTENANCE

CLEANING OF TRIM PARTS

Aisle End Panel & Rear Shell

Minor stains may be removed from trim parts with good quality toilet soap. More severe cleaning problems require the use of diverse cleaning agents and polishes. Most household cleaners, automotive waxes, and polishes can be adapted to this job. Solvents and spray type household cleaners containing hydrocarbons will attack A.B.S. materials and should be used sparingly, if at all.

A cleaning solution should be applied sparingly with a clean, relatively dry cloth and wiped over the material gently. It is recommended that the cleaning be accomplished by repeated applications of the cleaner rather than one heavy application. All normal soaps and detergents may be considered safe for removing dirt and grease from A.B.S. materials.

CAUTION:

1. Never soak panels in cleaning solution or allow them to remain wet with solution for any length of time.
2. Do not use waxes which dry with a bloom as they are extremely difficult to remove after application:

SECTION II MAINTENANCE PROCEDURES

2.2.1 Seat Frame

2.2.1.1 Two-Passenger Seat Frame Removal / Installation

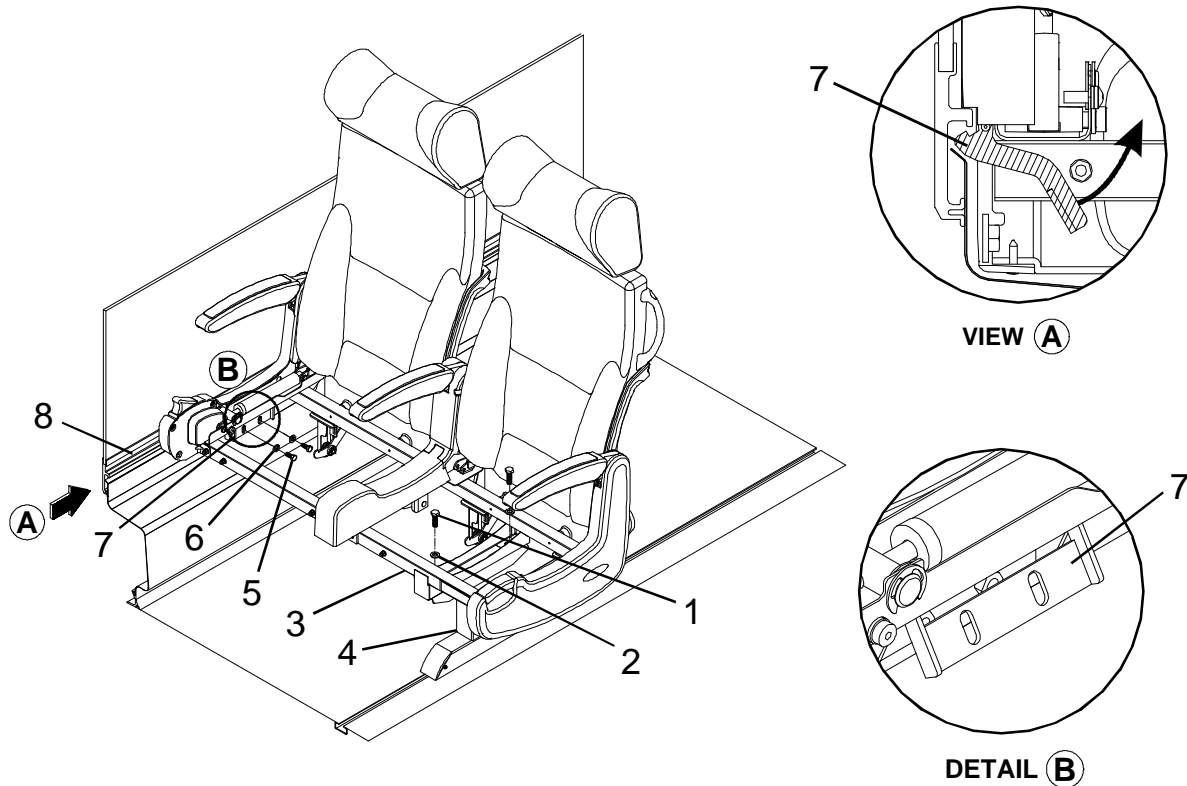


Figure 2-1 Two-Passenger Seat Frame Removal

2.2.1.1.1 Removal

1. Remove bottom cushions (See [2.2.2.1.1](#) Removal).
2. Remove two screws (1) and washers (2) fastening seat frame (3) to pedestal (4).
3. Remove two screws (5) and washers (6) fastening seat bracket clamp (7) to wall bracket (8).
4. Pull seat bracket clamp (7) to disengage it.
5. Remove seat frame (3).

2.2.1.1.2 Installation

1. Engage seat bracket clamp (7) to wall bracket (8). Push seat bracket clamp (7) to lock correctly.
2. Install two screws (5) and washers (6) to fasten seat bracket clamp (7) to wall bracket (8). Torque to 25 Nm.
3. Install two screws (1) with Loctite and washers (2) to fasten seat frame (3) to pedestal (4). Torque to 40 Nm.
4. Install bottom cushions (See [2.2.2.1.2](#) Installation).

2.2.1.2 Three-Passenger Seat Frame Removal / Installation

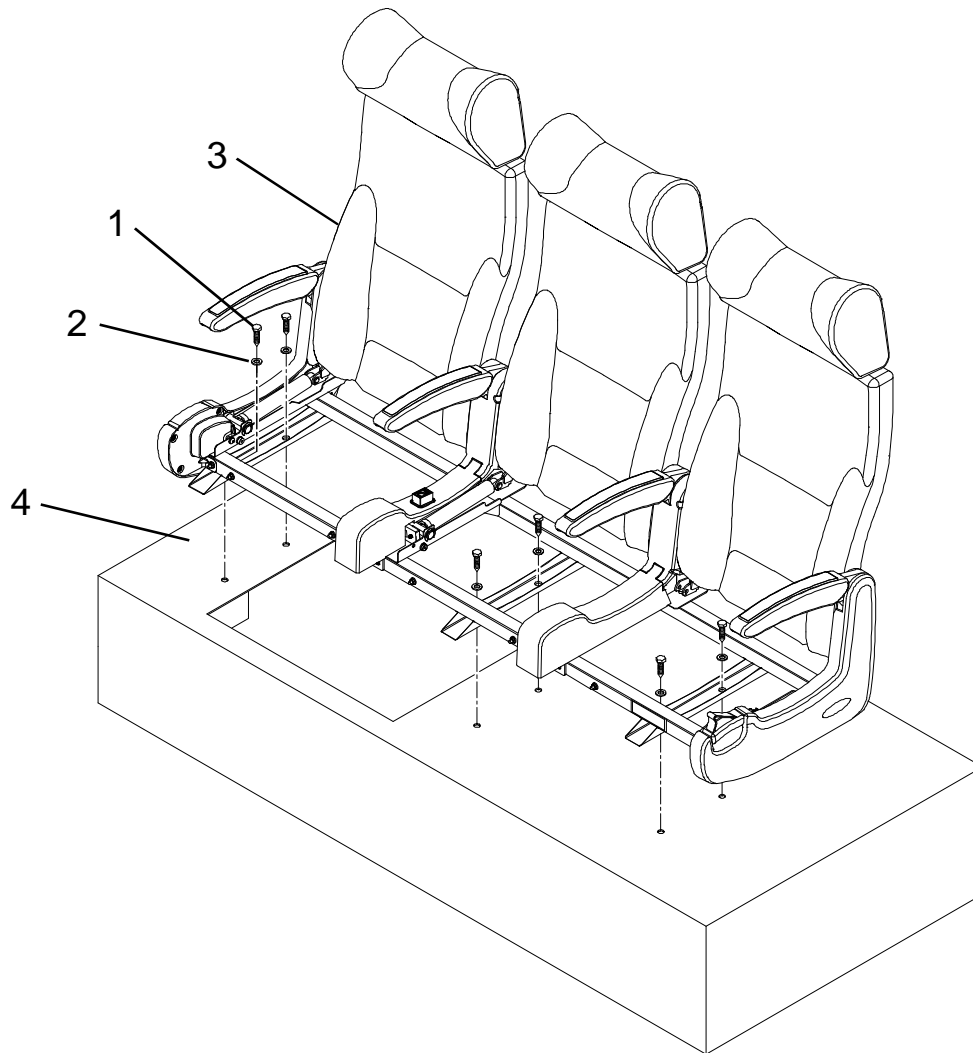


Figure 2-2 Three-Passenger Seat Frame Removal / Installation

2.2.1.2.1 Removal

1. Remove all bottom cushions (See [2.2.2.1.1](#) Removal).
2. Remove six screws (1) and washers (2) fastening seat frame (3) to base (4).
3. Remove seat frame (3).

2.2.1.2.2 Installation

1. Position seat frame (3) on base (6) and fasten with six screws (1) and washers (2).
2. Install bottom cushion (See [2.2.2.1.2](#) Installation).

2.2.1.3 Two-Passenger Swivel Seat Removal / Installation

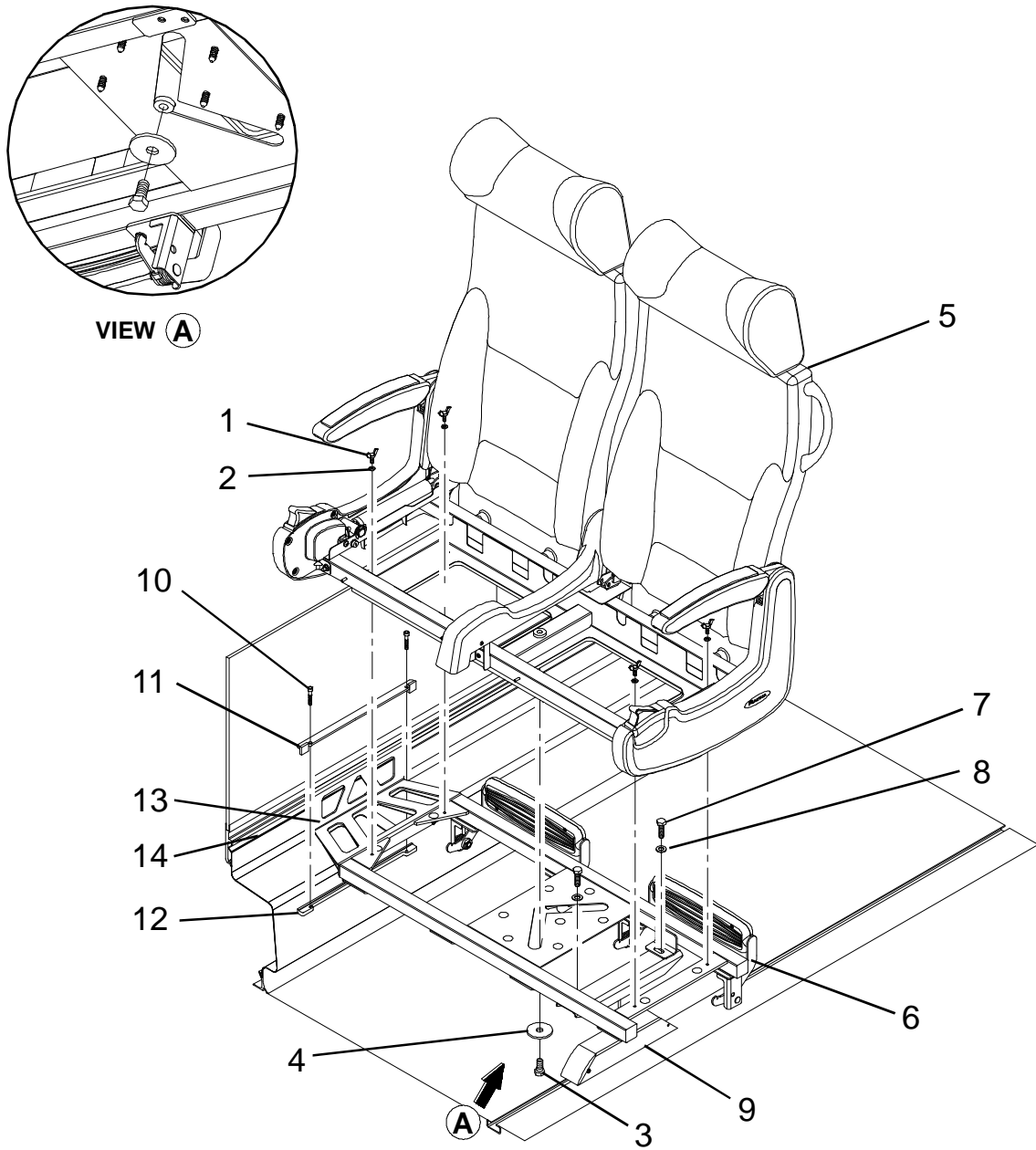


Figure 2-3 Two-Passenger Swivel Seat Removal / Installation

2.2.1.3.1 Removal

1. Remove bottom cushions (See [2.2.2.1.1 Removal](#)).
2. Remove four wing studs (1) and washers (2).
3. Remove screw (3) and washer (4) locking seat frame (5) to seat base (6).
4. Remove seat frame (5).
5. Remove two screws (7) and washers (8) fastening seat base (6) to pedestal (9).
6. Remove two screws (10) fastening upper clamps (11) and lower clamp (12) to wall bracket (13).
7. Remove seat base (6).

2.2.1.3.2 Installation

1. Position seat base (6) to pedestal (9) and to wall rail (14).
2. Install two screws (7) with Loctite and washers (8) to fasten seat base (6) to pedestal (9). Torque to 40 Nm.
3. Position upper clamps (11) and lower clamps (12) to wall bracket (13) and fasten with two screws (10). Torque to 10 Nm.
4. Position seat frame (5) to seat base (6) and fasten with four wing studs (1) and washers (2). Hand tight only.
5. Install screw (3) with Loctite and washer (4) to lock seat frame (5) to seat base (6). Torque to 40 Nm.
6. Install bottom cushions (See [2.2.2.1.2 Installation](#)).

2.2.2 Cushions

2.2.2.1 Bottom Cushion Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
2	1	Bottom Cushion (without cover)	63208001

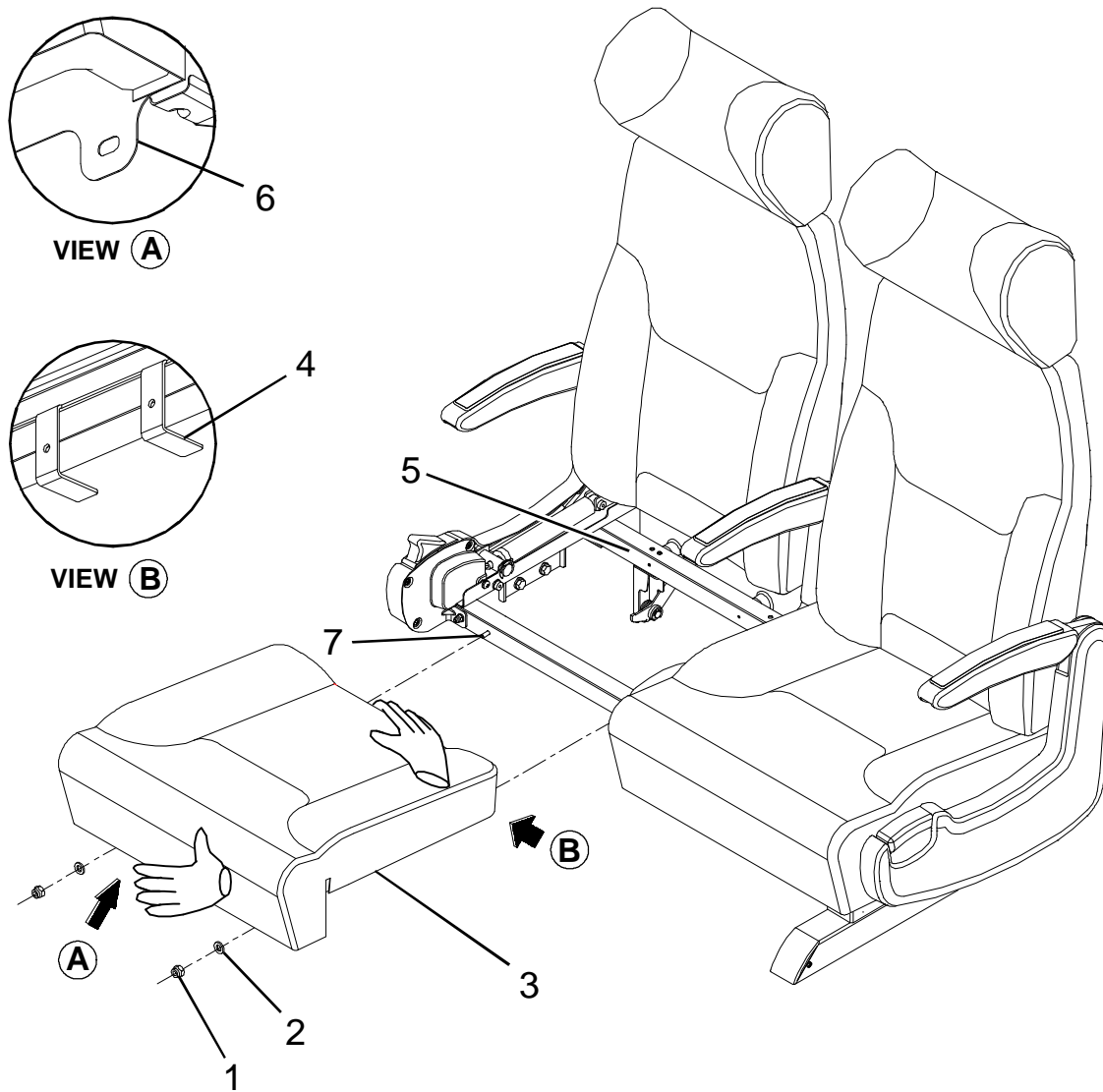


Figure 2-4 Bottom Cushion Replacement

2.2.2.1.1 Removal

1. Remove two nuts (1) and washers (2) fastening bottom cushion (3).
2. Remove and discard bottom cushion (3).

2.2.2.1.2 Installation

1. Align bottom cushion bracket (4) to seat frame rear tube (5) and bottom cushion pan hole (6) to seat frame stud (7).
2. Install two nuts (1) and washers (2) to fastening new bottom cushion (3). Torque to 10 Nm.

2.2.2.2 Bottom Cushion Cover Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
9	1	Bottom Cushion Cover	Refer to Illustrated Parts Catalog

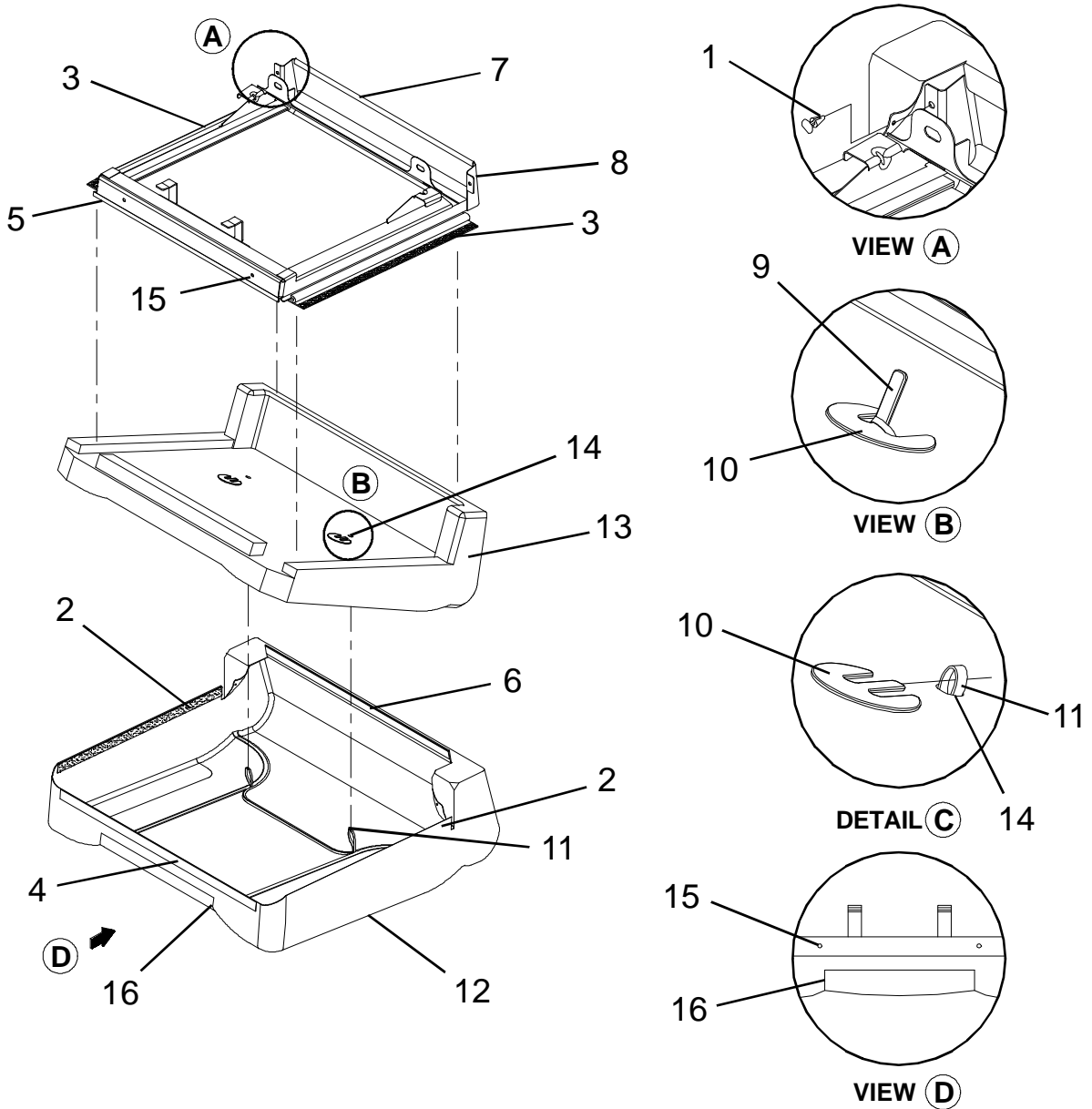


Figure 2-5 Bottom Cushion Cover Replacement

2.2.2.2.1 Removal

1. Remove bottom cushion (See [2.2.2.1.1 Removal](#)).
2. Remove two nylon darts (1).
3. Remove bottom cushion cover Velcro (2) from both sides of pan Velcro (3).
4. Remove rear plastic tongue (4) from bottom cushion pan J-hook (5).
5. Remove front plastic tongue (6) from bottom cushion pan J-hook (7).
6. Remove bottom cushion pan (8).
7. Pull up center pin (9) of ``E`` round clip (10) to release pull tab (11).
8. Remove ``E`` round clip (10).
9. Remove and discard bottom cushion cover (12) from bottom cushion foam (13).

2.2.2.2.2 Installation

1. Insert two pull tabs (11) into bottom cushion foam holes (14). Use a J-hook.
2. Install ``E`` round clip (10) to fix pull tabs (11). Fold 180° center pin (9) of ``E`` round clip to lock pull tabs.
3. Position bottom cushion foam (13) correctly into new bottom cushion cover (12).
4. Position bottom cushion pan (8) to foam and cover assembly.
5. Insert front plastic tongue (6) into bottom cushion pan J-hook (7).
6. Align two bottom cushion pan holes (15) with both cover seams (16) and insert rear cover plastic tongue (4) into bottom cushion pan J-hook (5).
7. Press both sides of bottom cushion cover Velcro (2) onto both sides of pan Velcro (3).
8. Install bottom cushion (See [2.2.2.1.2 Installation](#)).

2.2.2.3 Backrest Cushion Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
2,9	1	Backrest Cushion (without cover)	63207001
2	1	Backrest Cushion (with Handle), Right-Hand (without cover)	63207005
9	1	Backrest Cushion (with Handle), Left-Hand (without cover)	63207004

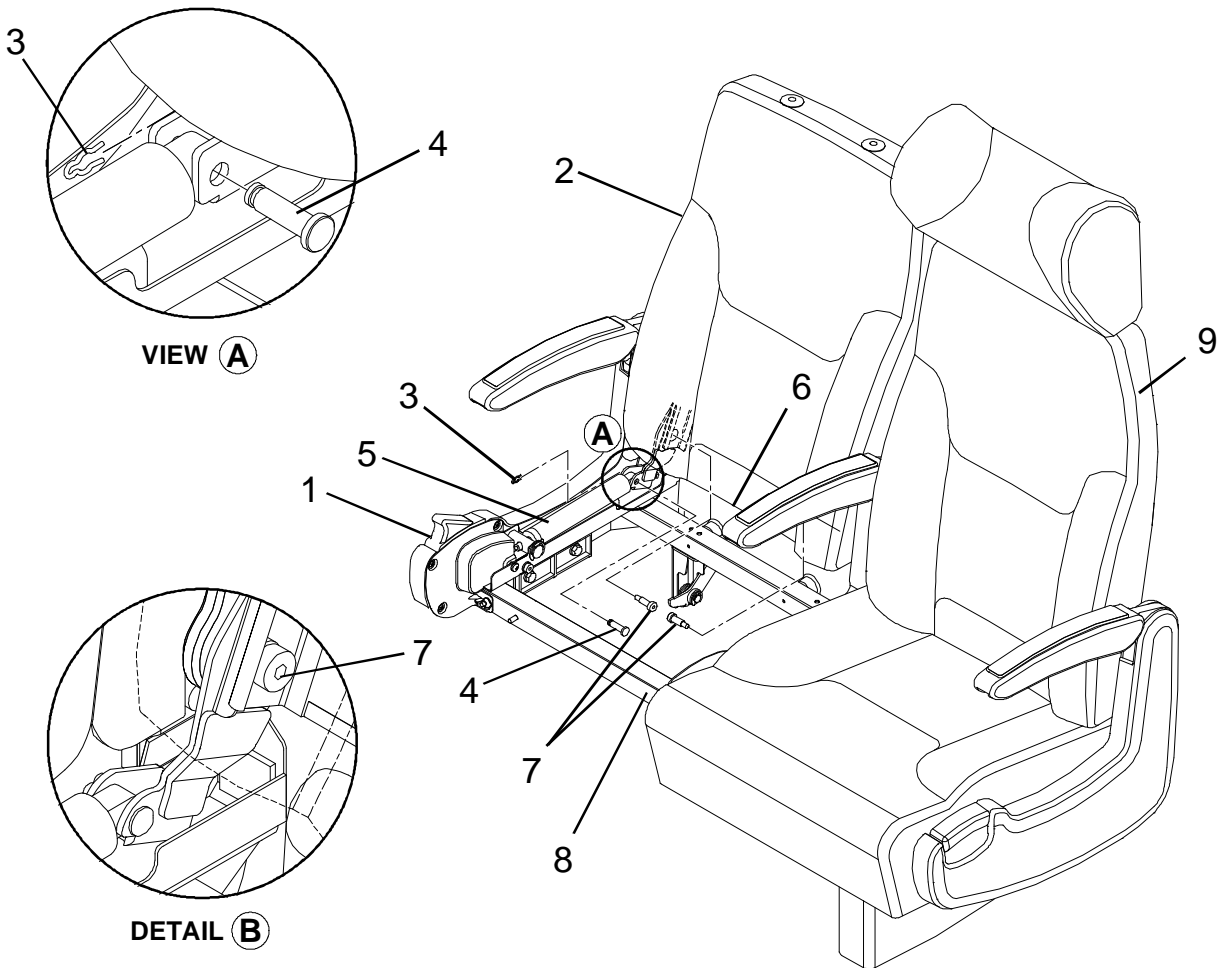


Figure 2-6 Backrest Cushion Replacement

2.2.2.3.1 Removal

1. Remove bottom cushion (See [2.2.2.1.1](#) Removal).
2. Remove aisle shroud (See [2.2.3.1.2](#) Removal).

NOTE

Multina suggests removing of the center upper and rear shrouds to prevent damaging shroud.

3. Remove rear and center upper shrouds (See [2.2.3.2.1](#) and [2.2.3.3.1](#) Removal).
4. Pull reclining handle (1) to recline backrest (2) to maximum position.
5. Remove hair pin clip (3) and clevis pin (4) fastening backrest (2) to gas cylinder (5). Discard hair pin clip.
6. Pull cover Velcro (6) from backrest (2) lower part to access to shoulder screws (7).
7. Remove two shoulder screws (7) fastening backrest to seat frame (8).
8. Remove and discard backrest cushion (2).

2.2.2.3.2 Installation

1. Position new backrest (2) to seat frame (4) and fasten with two shoulder screws (7). Torque to 40 Nm
2. Replace backrest foam and cover Velcro (6) in place.
3. Position backrest (2) and fasten with clevis pin (4) to gas cylinder (5).
4. Install new hair pin clip (3) to clevis pin (4).
5. Pull reclining handle (1) to recline backrest (2) to normal position.
6. Install rear and center upper shrouds (See [2.2.3.2.1](#) and [2.2.3.3.1](#) Installation).
7. Install aisle shroud (See [2.2.3.1.2](#) Installation).
8. Install bottom cushion (See [2.2.2.1.2](#) Installation).

2.2.2.4 Backrest Cushion Cover Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
5	1	Backrest Cushion Cover	Refer to Illustrated Parts Catalog

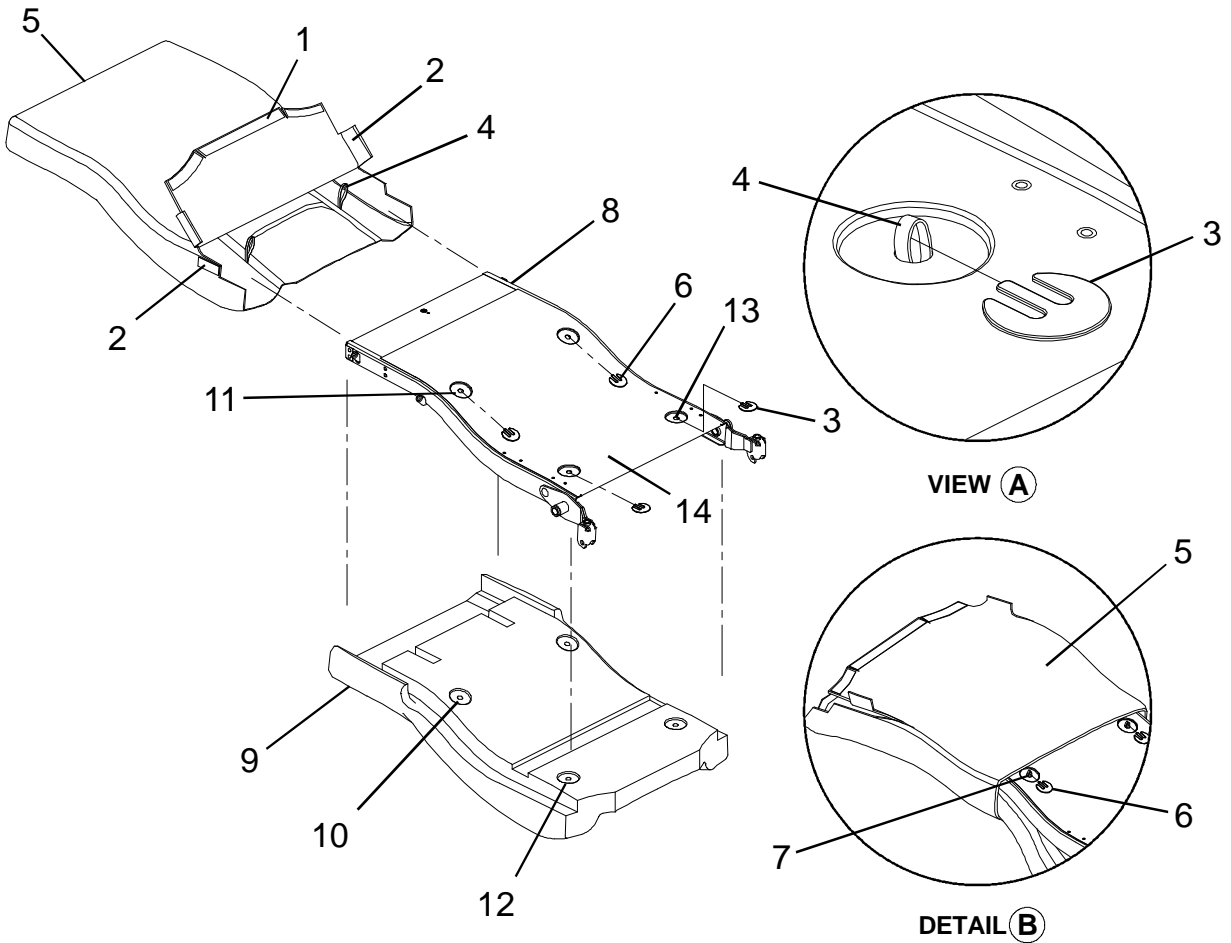


Figure 2-7 Backrest Cushion Cover Replacement

2.2.2.4.1 Removal

1. Remove bottom cushion (see [2.2.2.1.1](#)).
2. Remove backrest cushion (see [2.2.2.3.1](#)).
3. Remove headrest cushion and sliding guide (see [2.2.2.5.1](#)).
4. Remove center backrest cover Velcro (1).
5. Remove side backrest cover Velcro (2).
6. Remove two ``E`` round clips (3) to release lower pull tabs (4).
7. Turn backrest cover (5) over until upper ``E`` round clips (6) are accessible. See detail B.
8. Remove two ``E`` round clips (6) to release upper pull tabs (7).
9. Remove backrest cover (5) from backrest pan (8) and backrest foam (9). Discard backrest cover.

2.2.2.4.2 Installation

1. Position backrest foam (9) to backrest pan (8).
2. Turn new backrest cover (5) over to back until upper pull tabs (7) are accessible.
3. Position new backrest cover (5) to foam and pan assembly. See detail B.
4. Insert two upper pull tabs (7) through backrest cushion foam upper holes (10) and through backrest pan upper holes (11). Use a J-hook.
5. Install ``E`` round clip (6) to fix upper pull tabs (7).
6. Fold down backrest cover (5) and insert two lower pull tabs (4) through backrest cushion foam lower holes (12) and through backrest pan lower holes (13). Use a J-hook.
7. Install ``E`` round clip (3) to fix lower pull tabs (4).
8. Position backrest piping and backrest seams correctly.
9. Apply pink adhesive to backrest pan lower part (14) in order to stick carpet onto it.
10. Press side backrest cover Velcro (2) into place.
11. Attach center backrest cover Velcro (1) with front one.
12. Install headrest cushion and sliding guide (see [2.2.2.5.2](#)).
13. Install backrest cushion (see [2.2.2.3.2](#)).
14. Install bottom cushion (see [2.2.2.1.2](#)).

2.2.2.5 Headrest and Sliding Guide Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
2	1	Headrest Cushion (without cover)*	63204001
5	2	Sliding Guide	197704

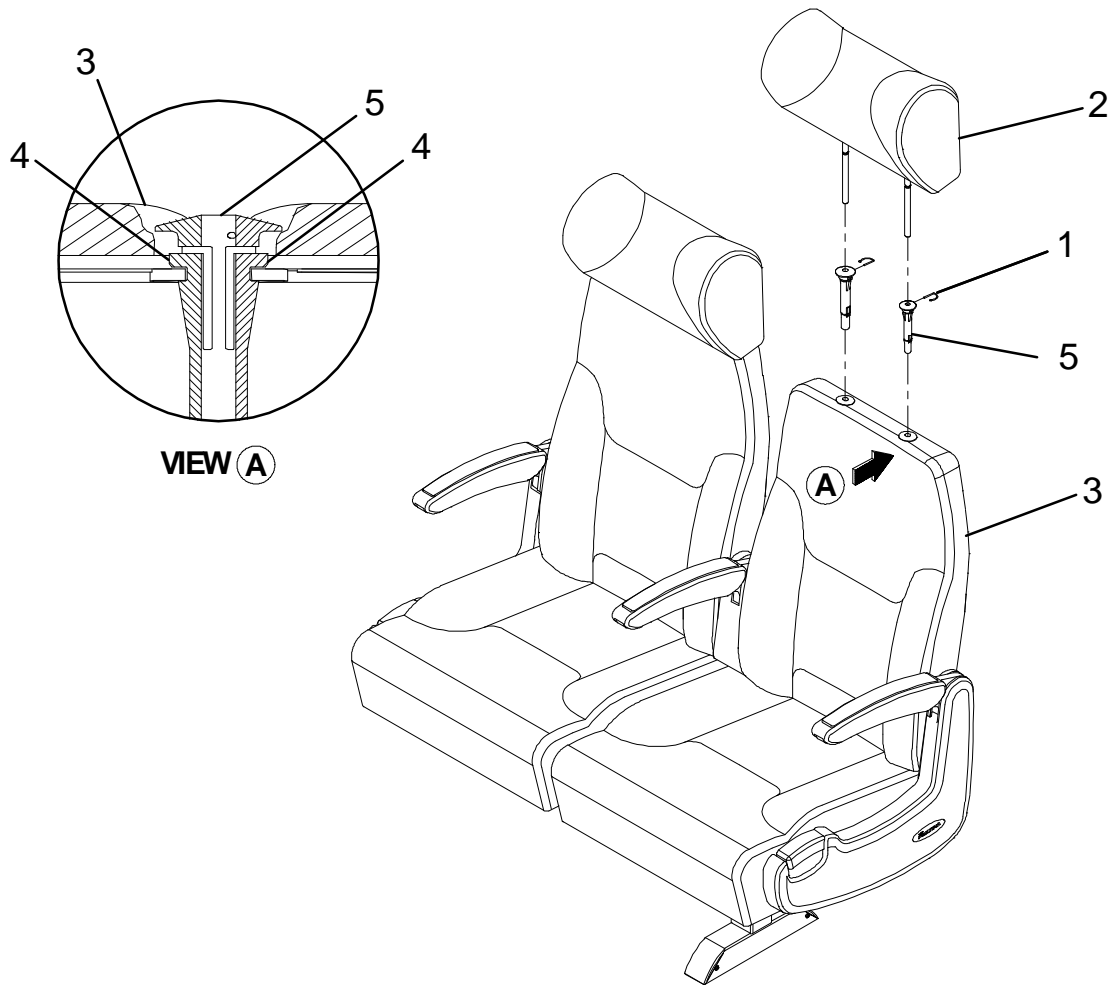


Figure 2-8 Headrest and Sliding Guide Replacement

NOTE

* Refer to illustrated Parts Catalog to get the appropriate cover part number.

NOTE

Multina suggests the replacement of entire headrest (with cover).

2.2.2.5.1 Removal

1. Remove hitch pin clip (1) with flat tip screwdriver.
2. Remove headrest (2) from backrest (3).
3. With two flat tip screwdrivers, press each sliding guide clip (4) of sliding guide (5) to unlock it.
4. Pull and discard sliding guide (5).

2.2.2.5.2 Installation

1. Position sliding guide (5). Push on sliding guide head (5) until sliding guide clip (4) interlocks correctly.
2. Position hitch pin clip (1) in sliding guide.
3. Install new headrest (2) to backrest (3).
4. Push hitch pin clip (1) to interlock correctly.

2.2.3 Shrouds

2.2.3.1 Aisle Side Shroud Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
2	1	Aisle Side Shroud, Left-Hand	210518
2	1	Aisle Side Shroud, Right-Hand	211764
5	1	Multina Label	279646

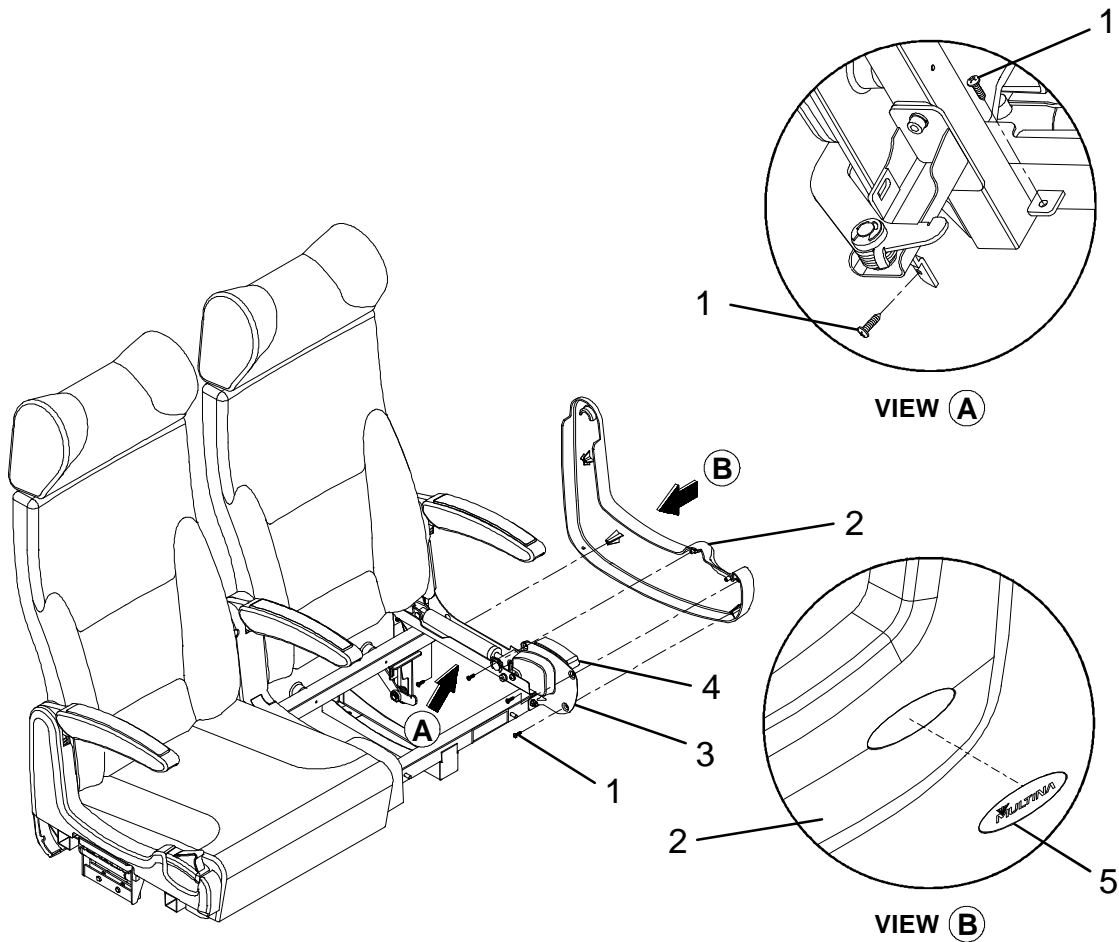


Figure 2-9 Aisle Side Shroud Replacement

2.2.3.1.1 Removal

1. Remove bottom cushion (See [2.2.2.1.1](#) Removal).
2. Remove five screws (1) fastening aisle side shroud (2) to seat frame (3).
3. Remove and discard aisle side shroud (2).

2.2.3.1.2 Installation

1. Position new aisle side shroud (2) to seat frame (3).
2. Align screw (1) with reclining handle (4) and screw it. Torque to 0.3 Nm.
3. Install four screws (1) to fastening aisle side shroud (2) Torque to 0.3 Nm.
4. Install new label (5) to aisle side shroud (2).
5. Install bottom cushions (See [2.2.2.1.2](#) Installation).

2.2.3.2 Center Rear Shroud Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
2	1	Center Rear Shroud	226608

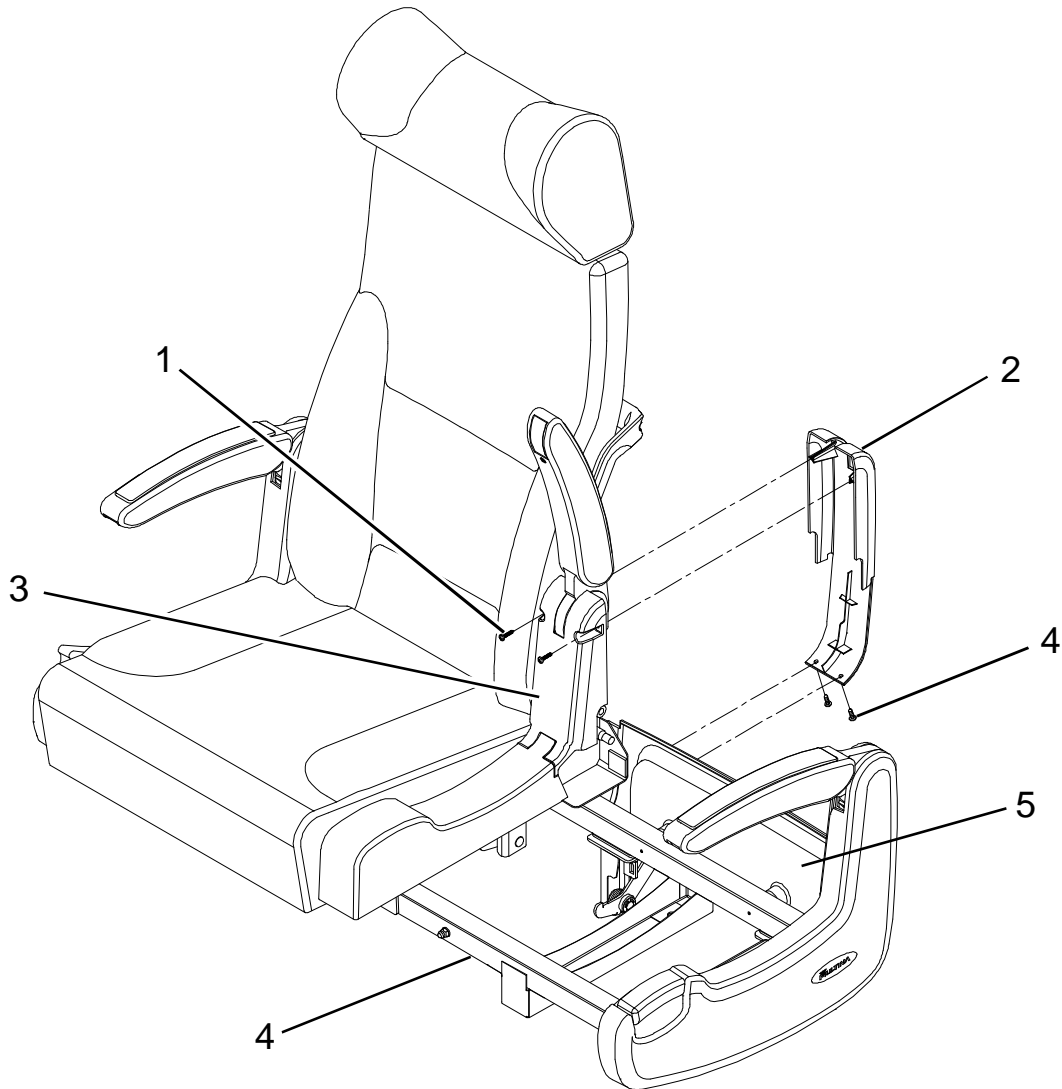


Figure 2-10 Center Rear Shroud Replacement

NOTE

Bottom cushion and backrest was removed for clarity.

2.2.3.2.1 Removal

1. Remove two screws $\frac{3}{4}$ in lg (1) fastening center rear shroud (2) to center upper shroud (3).
2. Remove two screws $\frac{5}{8}$ in lg (4) fastening center rear shroud (2) to footrest shroud (5).
3. Remove and discard center rear shroud (2).

2.2.3.2.2 Installation

1. Position new center rear shroud (2) and fasten with two screws $\frac{5}{8}$ in lg (4) to footrest shroud (5). Torque to 0.3 Nm.
2. Install two screws $\frac{3}{4}$ in lg (1) to fasten new center rear shroud (2) to center upper shroud (3). Torque to 0.3 Nm.

2.2.3.3 Center Front and Upper Shroud Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
3	1	Center Upper Shroud	227088
7	1	Center Front Shroud	226587

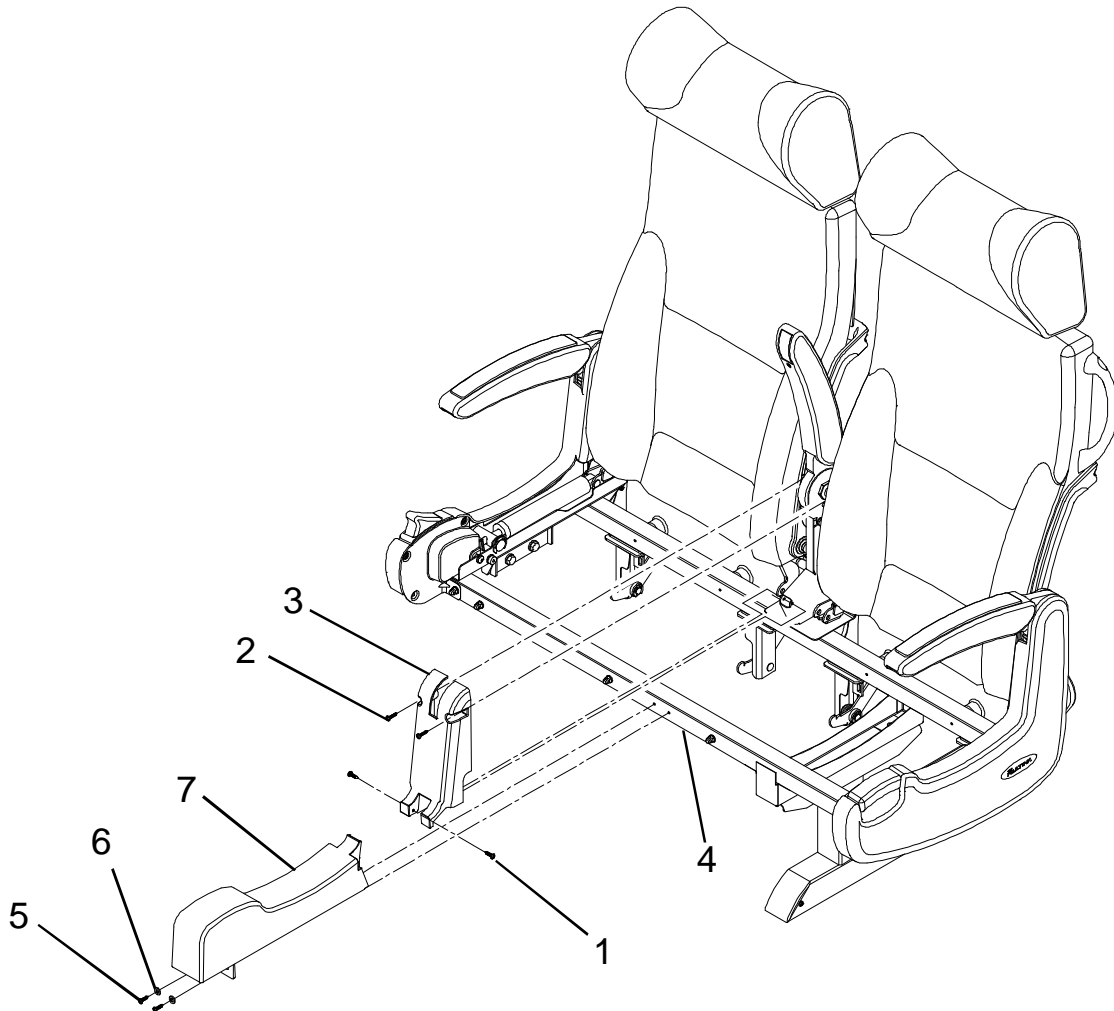


Figure 2-11 Center Front and Upper Shroud Replacement

2.2.3.3.1 Removal

1. Remove two bottom cushions (See [2.2.2.1.1](#) Removal).
2. Remove two 3/8 in lg screws (1) and two 3/4 in lg screws (2) fastening center upper shroud (3) to seat frame (4).
3. Remove and discard center upper shroud (3).
4. Remove two screws (5) and washers (6) fastening center front shroud (7) to seat frame (4).
5. Remove and discard center front shroud (7).

2.2.3.3.2 Installation

1. Position new center front shroud (7) and fasten with two screws (5) and washers (6). Torque to 0.3 Nm.
2. Position new center upper shroud (2) and fasten with two 3/4 in lg screws (2) and two 3/8 in lg screws (1). Torque to 0.3 Nm.
3. Install two bottom cushions (See [2.2.2.1.2](#) Installation).

2.2.3.4 Inside Shroud Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
2	1	Inside Shroud, Left-Hand	210526
2	1	Inside Shroud, Right-Hand	211377

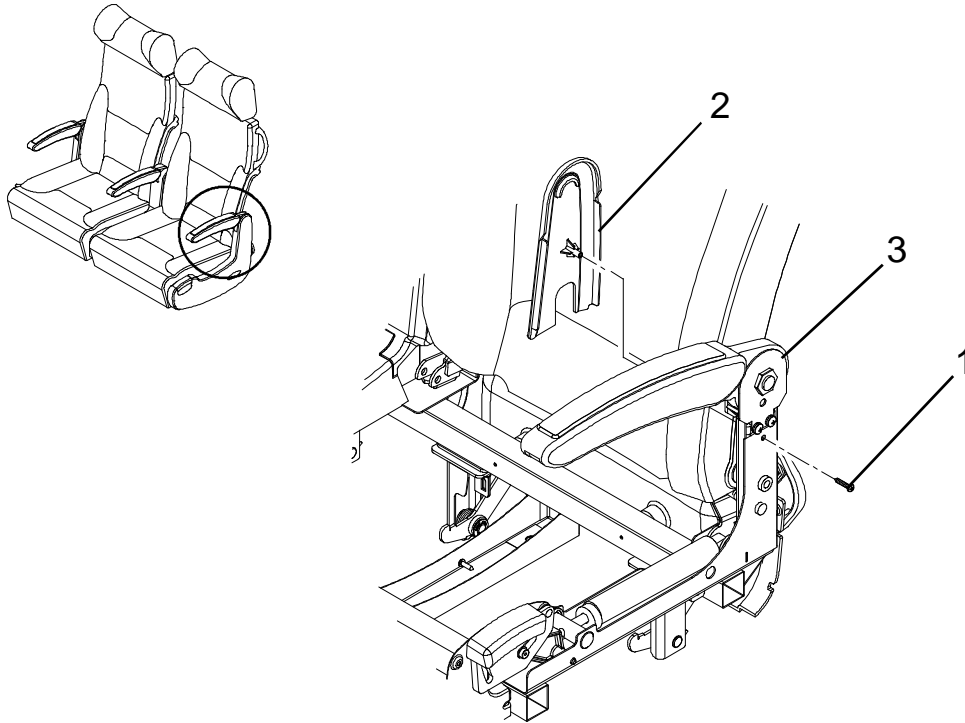


Figure 2-12 Inside Shroud Replacement

2.2.3.4.1 Removal

1. Remove bottom cushion (See [2.2.2.1.1](#) Removal).
2. Remove aisle side shroud (See [2.2.3.1.1](#) Removal).
3. Remove screw (1) fastening aisle side shroud (2) to seat frame (3).
4. Remove and discard aisle side shroud (2).

2.2.3.4.2 Installation

1. Position new aisle side shroud (2) to seat frame (3) and fasten with screw (1). Torque to 0.3 Nm.
2. Install aisle side shroud (See [2.2.3.1.2](#) Installation).
3. Install bottom cushion (See [2.2.2.1.2](#) Installation).

2.2.3.5 Footrest Bumper and Footrest Shroud Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
3	1	Footrest Shroud	197579
4	2	Footrest Bumper	231634

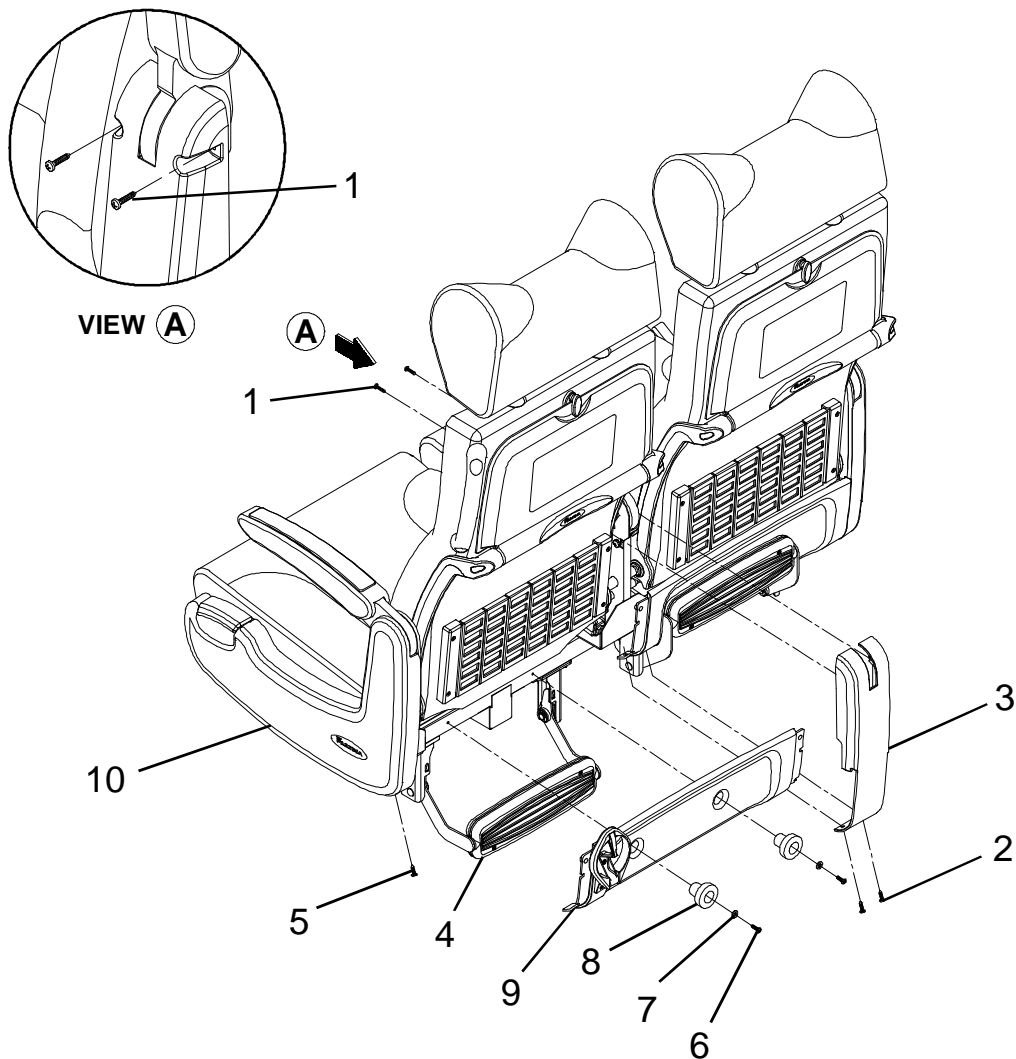


Figure 2-13 Footrest Bumper and Footrest Shroud Replacement

WARNING

BEWARE OF THE AUTOMATIC FOOTREST RAPID UPRIGHT INCLINATION. RISK OF INJURY! MAKE SURE ALL LIMBS ARE AWAY FROM MOVING PARTS.

2.2.3.5.1 Removal

NOTE

Keep footrest down to get access to shroud screws.

1. Remove cup holder (See [2.2.5.4.1](#) Removal) from aisle side only.
2. Remove two screws $\frac{3}{4}$ in lg (1) two screws $\frac{5}{8}$ in lg (2) fastening center rear shroud (3). Remove shroud.
3. Remove screw (5).
4. Place footrest (4) downward.
5. Remove two screws (6) and washers (7) fastening bumper (8) and footrest shroud (9).
6. Remove and discard footrest bumper (8) and footrest shroud (9).

2.2.3.5.2 Installation

1. Position new footrest shroud (9), new footrest bumper (8) and fasten with two screws (6) and washers (7). Torque to 0.3 Nm.
2. Release footrest (4).
3. Install screw (5).
4. Position center rear shroud (3) and fasten with two screws $\frac{3}{4}$ in lg (1) and two screws $\frac{5}{8}$ in lg (2). Torque to 0.3 Nm.
5. Install cup holder (See [2.2.5.4.2](#) Installation) to aisle side only.

2.2.4 Mechanism

2.2.4.1 Reclining Gas Cylinder Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
5	1	Reclining Gas Cylinder	214332
3	1	Hair Pin Clip	287646

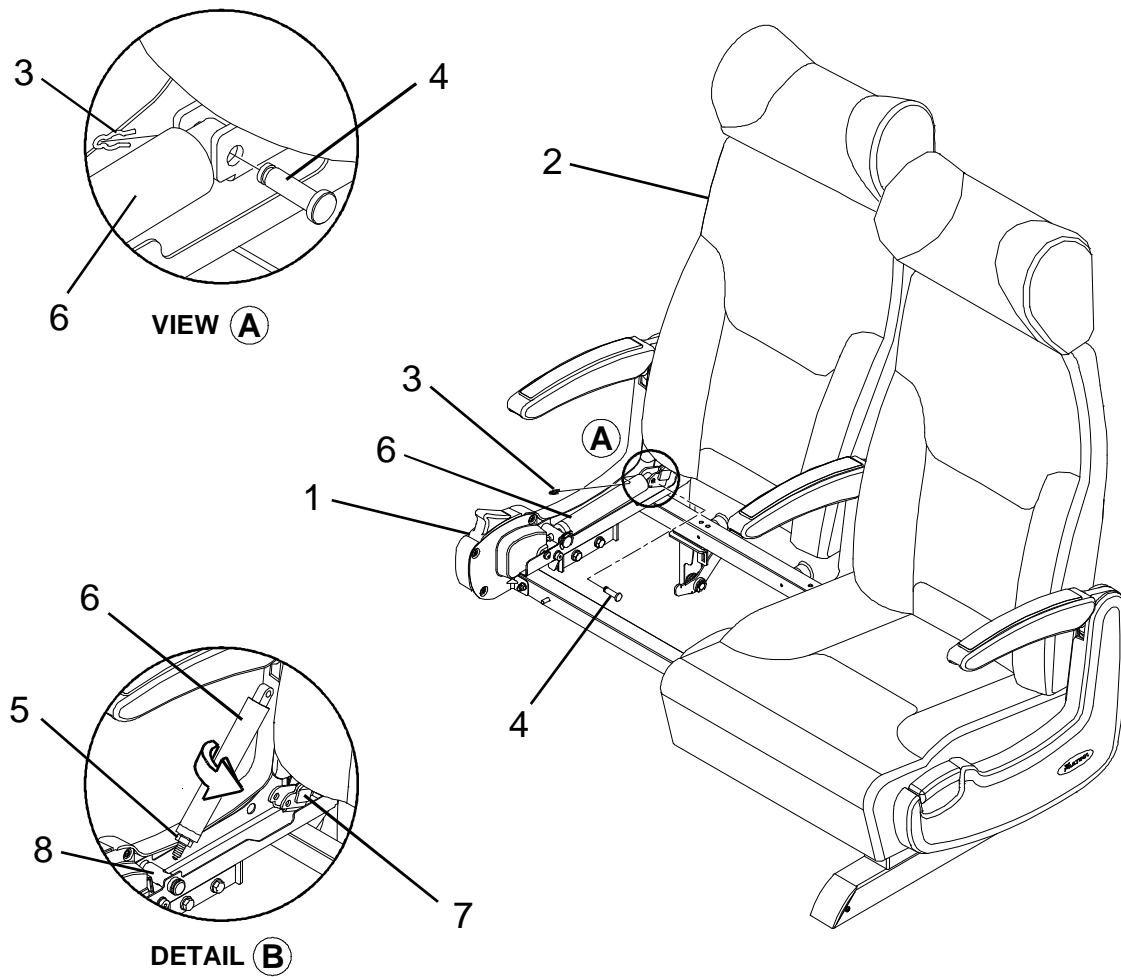


Figure 2-14 Reclining Gas Cylinder Replacement

WARNING

BEWARE OF THE AUTOMATIC BACKREST RAPID UPRIGHT INCLINATION WHEN RECLINING HANDLE IS PRESSED. RISK OF INJURY! MAKE SURE ALL LIMBS ARE AWAY FROM MOVING PARTS.

2.2.4.1.1 Removal

NOTE

- The aisle side shroud should be removed when the maintenance is done on the aisle side of the seat.
1. Remove bottom cushion (See [2.2.2.1.1](#) Removal).
 2. Remove aisle shroud (See [2.2.3.1.1](#) Removal). Aisle side maintenance task only.
 3. Pull reclining handle (1) to recline backrest (2) to maximum position.
 4. Remove hair pin clip (3) and clevis pin (4) fastening gas cylinder (5) to backrest (2). Discard hair pin clip.
 5. Swivel backrest (2) slightly to front.
 6. Loosen jam nut (5).
 7. Unscrew gas cylinder (6) from pivot cylinder (8) (See Detail B). Discard gas cylinder.

WARNING

BEWARE OF THE AUTOMATIC BACKREST RAPID UPRIGHT INCLINATION WHEN RECLINING HANDLE IS PRESSED. RISK OF INJURY! MAKE SURE ALL LIMBS ARE AWAY FROM MOVING PARTS.

2.2.4.1.2 Installation

NOTE

- Do not activate gas cylinder until installation is completed.
1. Align and screw new gas cylinder (6) thread side with pivot cylinder (8). Hand tight only.
 2. Tighten jam nut (5).
 3. Align new gas cylinder (6) whole side with backrest receptacle (7).
 4. Install clevis pin (4) and hair pin clip (3).
 5. Pull reclining handle (1) to recline backrest (2) to normal position.
 6. Install aisle shroud (See [2.2.3.1.2](#) Installation). Aisle side maintenance task only.
 7. Install bottom cushion (See [2.2.2.1.2](#) Installation).

NOTE

- Verify that the reclining system is functional by pressing the reclining handle.

2.2.4.2 Reclining Handle and Lever Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
3	1	Reclining Handle, Aisle Side, Left-Hand	210534
3	1	Reclining Handle, Aisle Side, Right-Hand	211385
	1	Reclining Handle, Wall Side, Left-Hand	231458
	1	Reclining Handle, Wall Side, Right-Hand	231466
6	1	Reclining Lever	210905

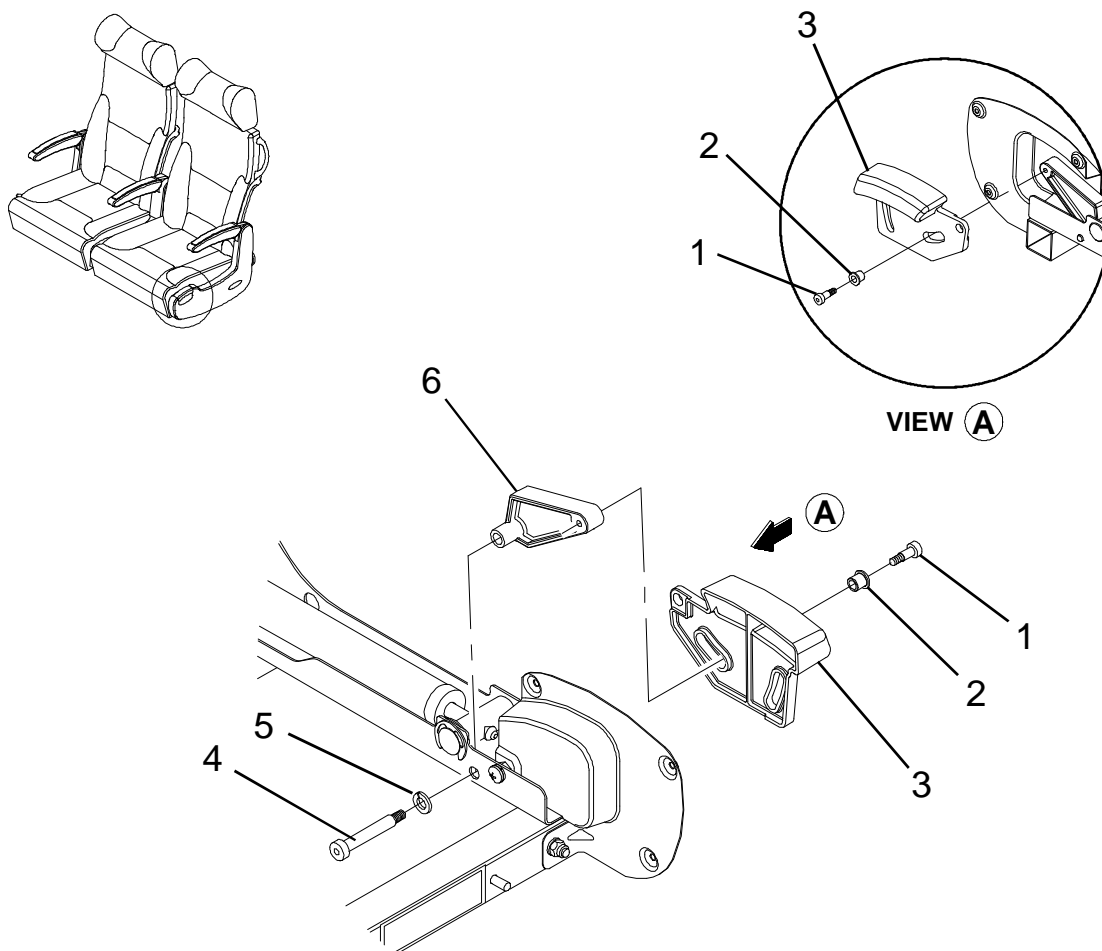


Figure 2-15 Reclining Handle and Lever Replacement

2.2.4.2.1 Removal

NOTE

- The seat should be removed when the maintenance is done on the wall side for the replacement of the wall side reclining handle.
1. Remove bottom cushion from aisle side (See [2.2.2.1.1](#) Removal).
 2. Remove aisle side shroud (See [2.2.3.4.1](#) Removal).
 3. Remove screw (1) and flanged bearing (2) fastening reclining handle (3).
 4. Remove and discard reclining handle (3).
 5. Remove screw (4) and washer (5) fastening reclining lever (6).
 6. Remove and discard reclining lever (6).

2.2.4.2.2 Installation

1. Position new reclining lever (6) and fasten with screw (4) and washer (5). Torque to 5.5 Nm.
2. Position new reclining handle (3) and flanged bearing (2) and fasten with screw (1). Torque to 0.75 Nm.
3. Install aisle side shroud (See [2.2.3.4.2](#) Installation).
4. Install bottom cushion from aisle side (See [2.2.2.1.2](#) Installation).

NOTE

- Verify that the reclining system is functional by pulling the reclining handle.

2.2.4.3 Downward Armrest Assembly Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
4	1	Downward Armrest Assembly	63203005
6	2	Nylon Washer	237770

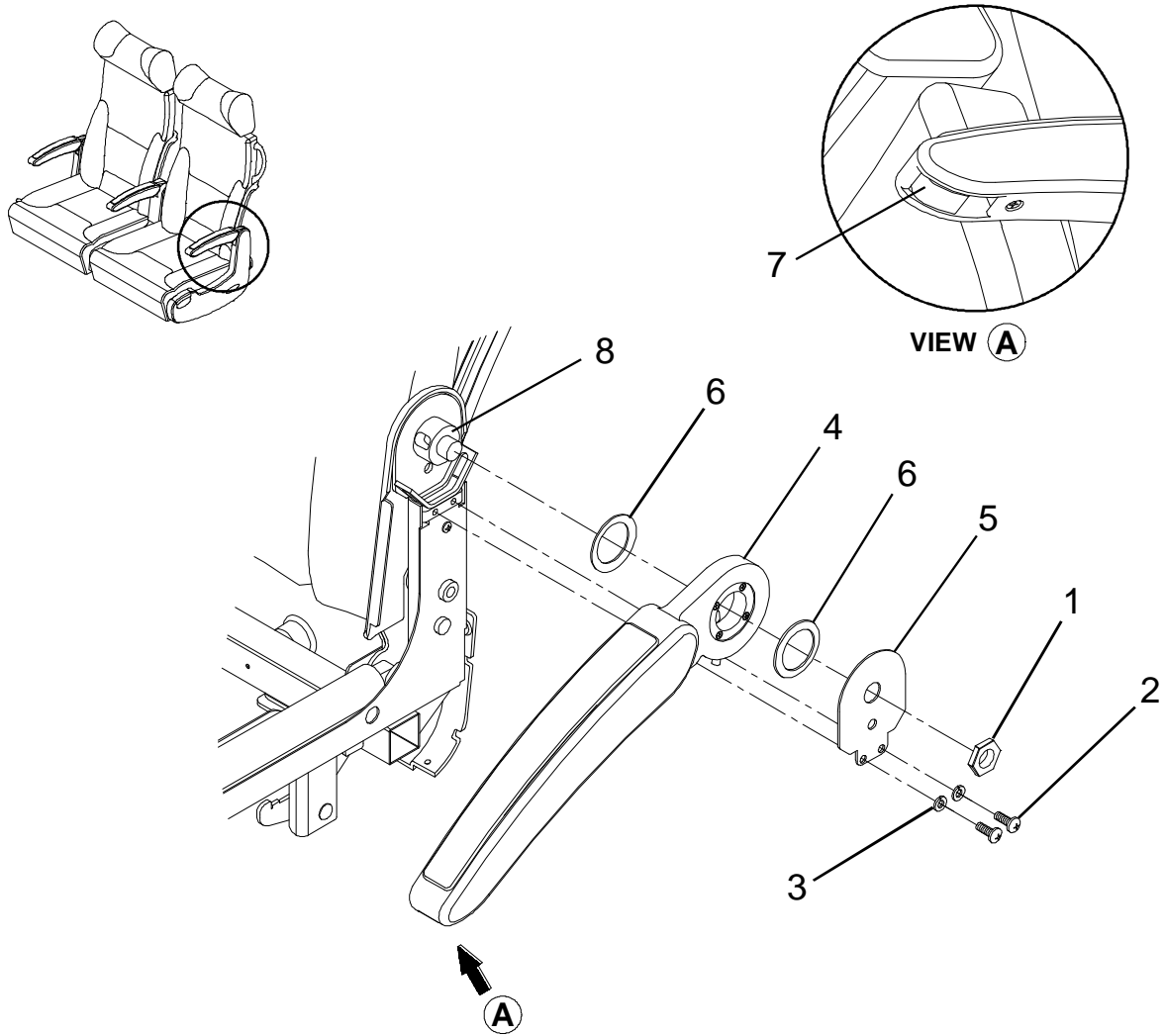


Figure 2-16 Downward Armrest Assembly Replacement

2.2.4.3.1 Removal

1. Remove bottom cushion (See [2.2.2.1.1](#) Removal).
2. Remove aisle side shroud (See [2.2.3.4.1](#) Removal)
3. Remove one nut (1), two screws (2) and washers (3) fastening armrest assembly (4).
4. Remove cover plate (5) and nylon washers (6). Discard nylon washers.
5. Press armrest button (7) to release armrest assembly to downward position.
6. Press armrest button (7) again to remove armrest assembly (8). Discard Armrest assembly.

2.2.4.3.2 Installation

1. Position new nylon washer (6).
2. Press armrest button (7) to positioning armrest assembly (8).
3. Install nylon washer (6) and cover plate (5) and fasten with two screws (2) and washers (3). Torque to 10 Nm.
4. Install nut (1). Torque to 40 Nm.
5. Install aisle shroud (See [2.2.3.4.2](#) Installation).
6. Install bottom cushion (See [2.2.2.1.2](#) Installation).

NOTE

- Verify that the reclining system is functional by pressing armrest button.

2.2.4.4 Center Upward Armrest Assembly Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
8	1	Upward Armrest Assembly	63203002
9	2	Nylon Washer	237770

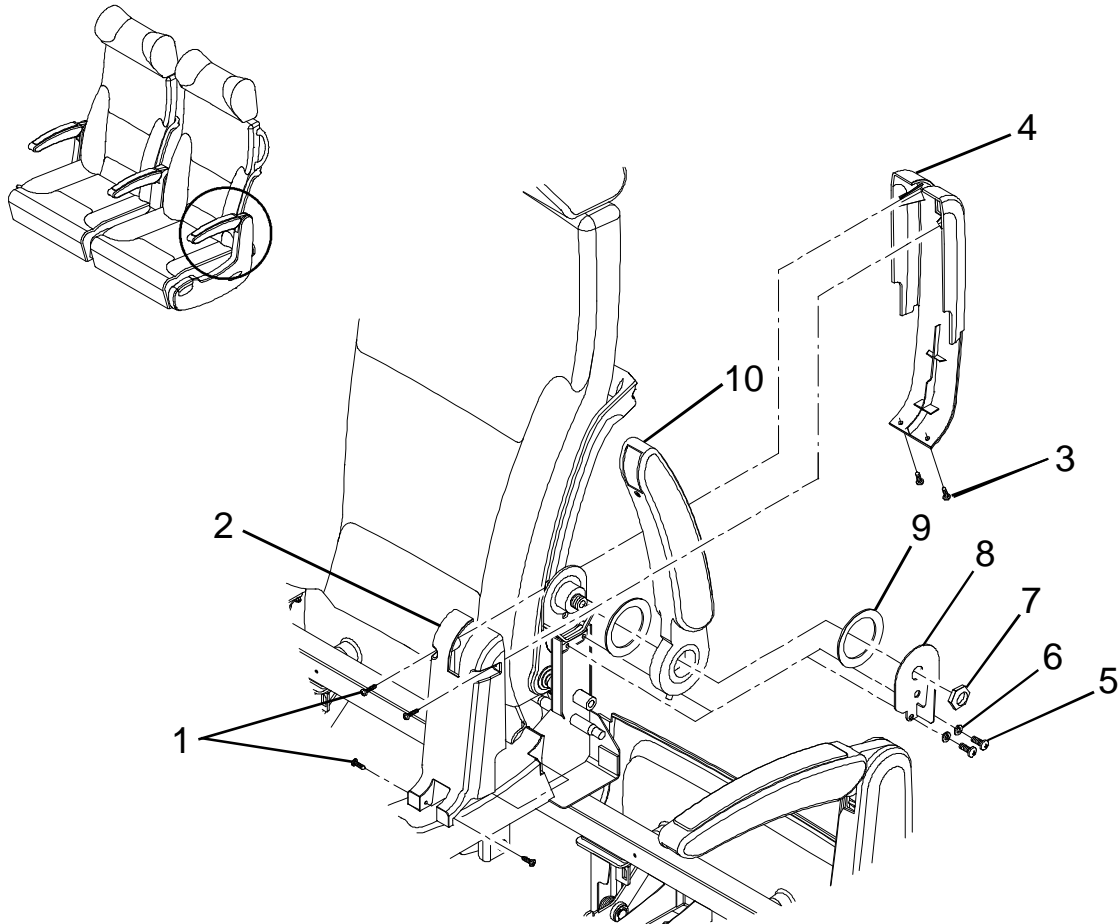


Figure 2-17 Center Upward Armrest Assembly Replacement

2.2.4.4.1 Removal

1. Remove aisle side bottom cushion (See [2.2.2.1.1](#) Removal).
2. Remove aisle side backrest cushion (See [2.2.2.3.1](#) Removal).
3. Remove four screws (1) fastening center upper shroud (2).
4. Remove center upper shroud (2).
5. Remove two screws (3) fastening center rear shroud (4).
6. Remove two screws (5), washers (6), and nut (7).
7. Remove cover plate (8) and nylon washers (9). Discard nylon washers.
8. Remove and discard center armrest (10).

2.2.4.4.2 Installation

1. Position two new nylon washers (9) and new center armrest (10).
2. Install cover plate (8) and fasten with two screws (5) and washers (6). Torque to 10 Nm.
3. Install nut (7). Torque to 40 Nm.
4. Position center rear shroud (4) and fasten with two screws (3).
5. Position center upper shroud (2) and fasten with four screws (1) Torque to 0.3 Nm.
6. Install aisle side backrest cushion (See [2.2.2.3.2](#) Installation).
7. Install aisle side bottom cushion (See [2.2.2.1.2](#) Installation).

2.2.4.5 Fixed Armrest Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
11	1	Fixed Armrest Assembly	63203004
9	2	Nylon Washer	237770

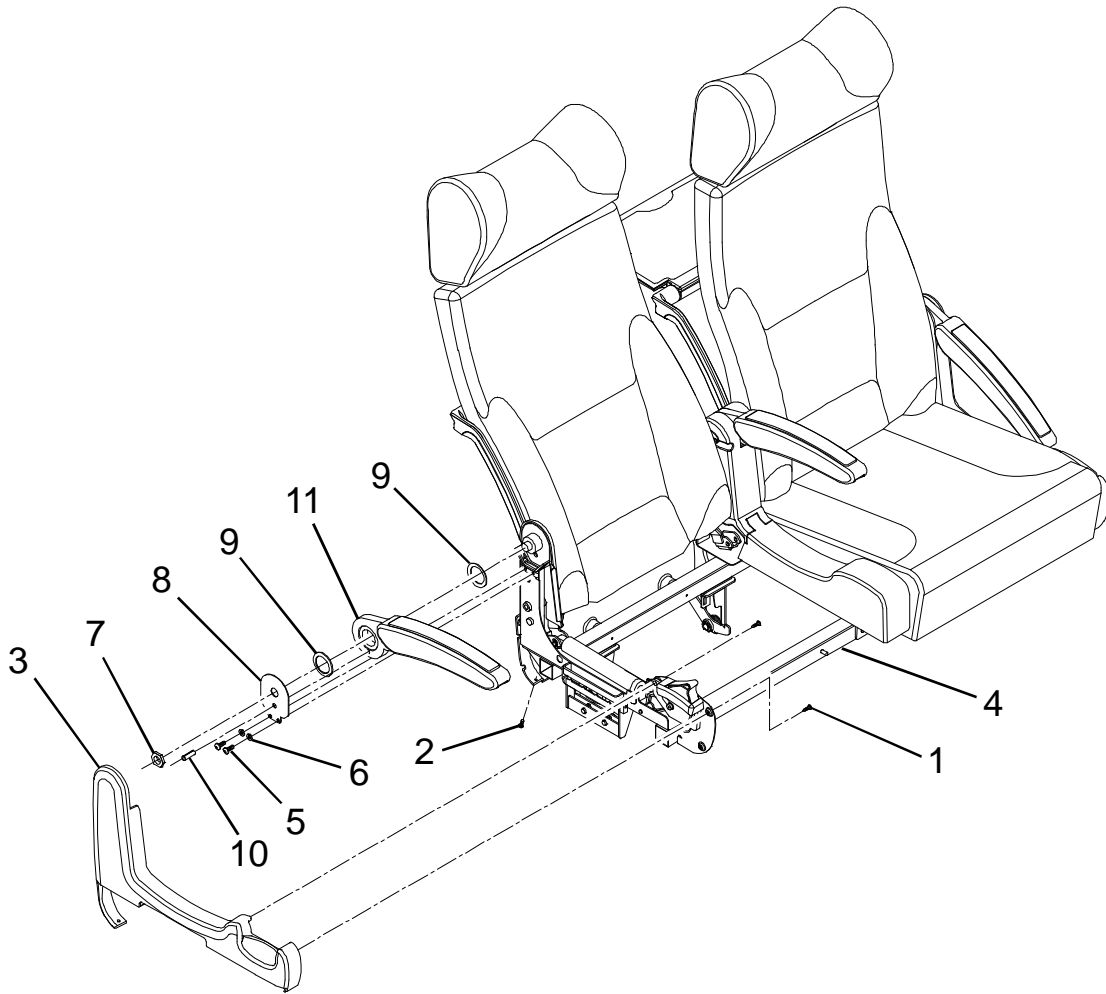


Figure 2-18 Fixed Armrest Replacement

NOTE

- The seat should be removed for this maintenance task.

2.2.4.5.1 Removal

1. Remove wall side bottom cushion (See [2.2.2.1.1](#) Removal).
2. Remove two screws (1) and one screw (2) fastening wall side shroud (3) to seat frame (4).
3. Remove two screws (5) and washers (6).
4. Remove nut (7).
5. Remove tension spring pin (10).
6. Remove cover plate (8).
7. Remove two nylon washers (9) and fixed armrest assembly (11). Discard armrest.

2.2.4.5.2 Installation

1. Position new fixed armrest assembly (11) with two new nylon washers (9).
2. Install cover plate (8).
3. Install tension spring pin (10).
4. Install nut (7). Torque to 40 Nm.
5. Install two screws (5) and washers (6). Torque to 10 Nm.
6. Position wall side shroud (3) and fasten with two screws (1) and one screw (2). Torque to 0.3 Nm.
7. Install wall side bottom cushion (See [2.2.2.1.2](#) Installation).

2.2.4.6 Armrest Cover and Foam Insert Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
3	1	Armrest Cover	225824
4	1	Armrest Foam Insert	225710

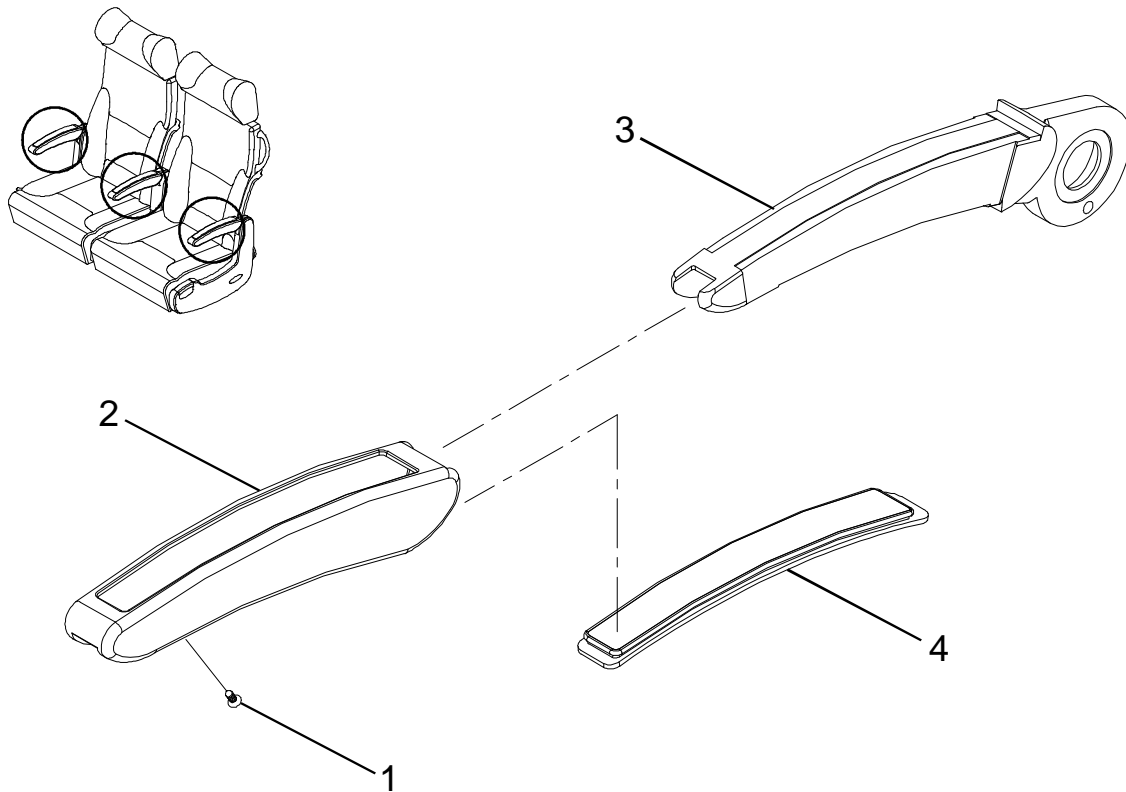


Figure 2-19 Armrest Cover and Foam Insert Replacement

2.2.4.6.1 Removal

1. Remove screw (1) fastening armrest cover assembly (2).
2. Remove and discard armrest cover (3) and/or armrest foam insert (4).

2.2.4.6.2 Installation

1. Position new armrest foam insert (4) into new armrest cover (3).
2. Position armrest cover assembly (2) to armrest frame (4) and fasten with screw (1). Torque to 1.5 Nm.

2.2.4.7 Bench Seat Reclining Button Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
5,6, 7,8	1	Reclining Button Kit	280524
8	1	Reclining Label	229649

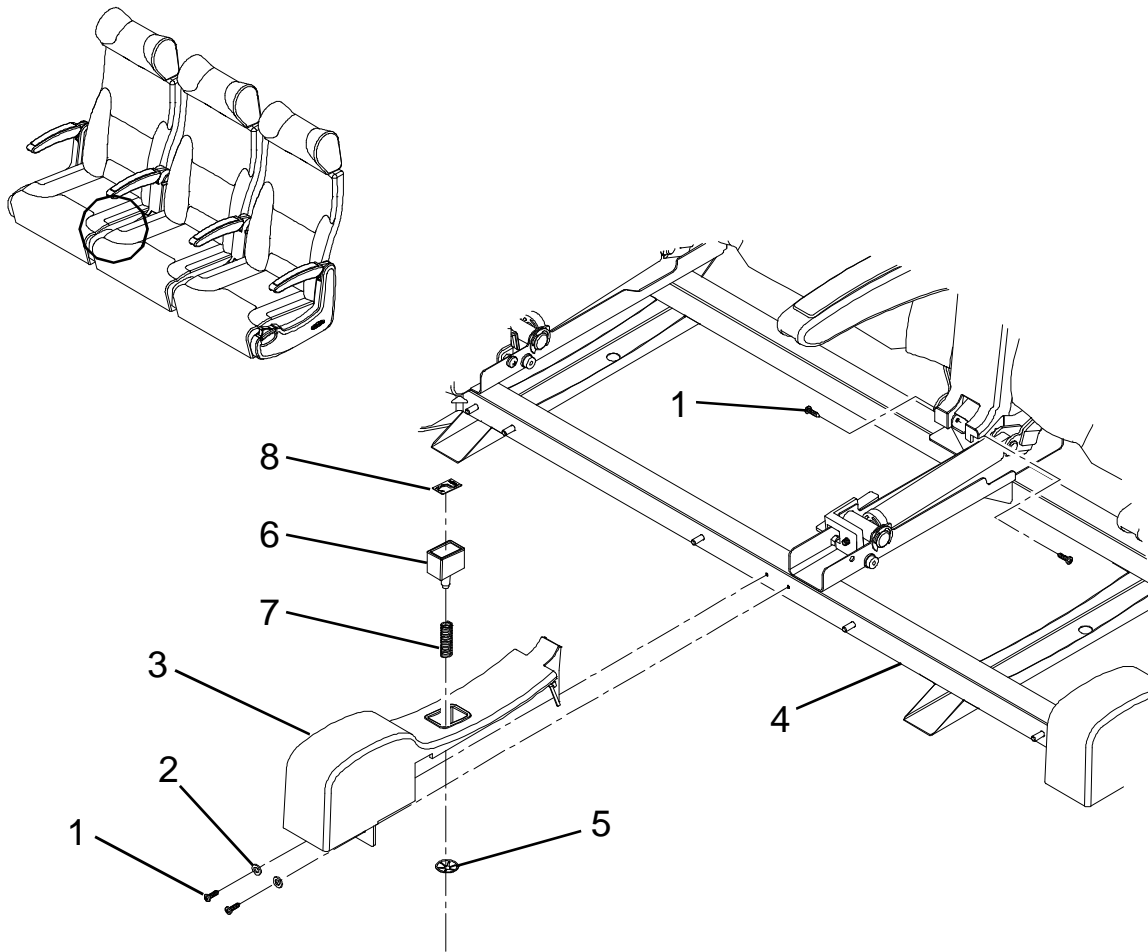


Figure 2-20 Bench Seat Reclining Button Replacement

WARNING

BEWARE OF THE AUTOMATIC BACKREST RAPID UPRIGHT INCLINATION WHEN RECLINING BUTTON IS PRESSED. RISK OF INJURY! MAKE SURE ALL LIMBS ARE AWAY FROM MOVING PARTS.

WARNING

SPRINGS ARE UNDER TENSION AND CAN BE EXPELLED AT GREAT SPEED. REPLACE WITH CARE AND WEAR PROPER EYE PROTECTION. FAILURE TO DO SO MAY LEAD TO INJURY.

2.2.4.7.1 Removal

1. Remove bottom cushion (See [2.2.2.1.1](#) Removal).
2. Remove four screws (1) and two washers (2) fastening center shroud (3) to seat frame (4).
3. Remove retaining ring (5) fastening reclining button assembly (6).
4. Remove reclining button spring (7). Discard spring.
5. Remove and discard reclining button assembly (6).

WARNING

BEWARE OF THE AUTOMATIC BACKREST RAPID UPRIGHT INCLINATION WHEN RECLINING BUTTON IS PRESSED. RISK OF INJURY! MAKE SURE ALL LIMBS ARE AWAY FROM MOVING PARTS.

WARNING

SPRINGS ARE UNDER TENSION AND CAN BE EXPELLED AT GREAT SPEED. REPLACE WITH CARE AND WEAR PROPER EYE PROTECTION. FAILURE TO DO SO MAY LEAD TO INJURY.

2.2.4.7.2 Installation

1. Position new ``PUSH`` sticker (8) to reclining button (6).
2. Position reclining button (6) and spring (7) to center shroud (3).
3. Install retaining ring (5) to fastening reclining button assembly (6).
4. Position center shroud (3) to seat frame (4) and fasten with four screws (1) and two washers (2). Torque to 0.3 Nm.
5. Install bottom cushion (See [2.2.2.1.2](#) Installation).

NOTE

- Verify that the reclining system is functional by pressing the reclining button handle.

2.2.5 Accessories

2.2.5.1 Footrest Assembly Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
3	1	Footrest Assembly	63209002

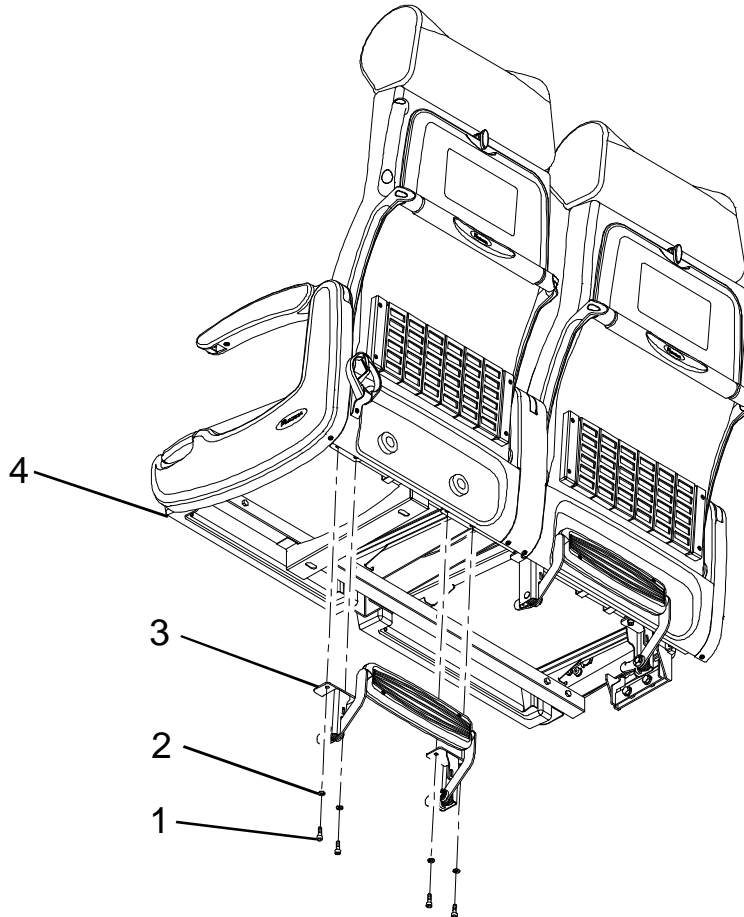


Figure 2-21 Footrest Assembly Replacement

2.2.5.1.1 Removal

1. Remove four screws (1) and washers (2) fastening footrest assembly (3) to seat frame (4).
2. Remove and discard footrest assembly (3).

2.2.5.1.2 Installation

1. Position new footrest assembly (3) and fasten with four screws (1) with Loctite and washers (2). Torque to 10 Nm.

2.2.5.2 Footrest Plastic Cap Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
2	2	Footrest Plastic Cap	214754

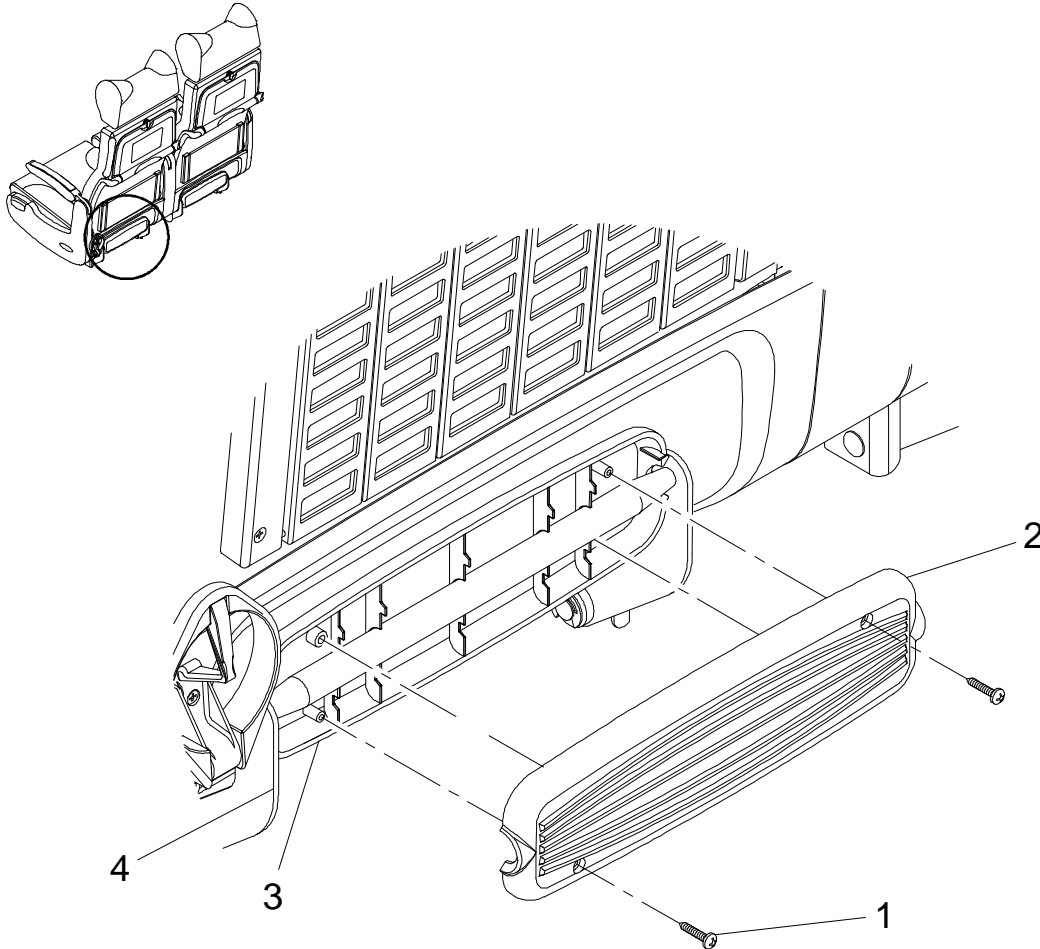


Figure 2-22 Footrest Plastic Cap Replacement

2.2.5.2.1 Removal

1. Remove four screws (1) fastening both footrest caps (2, 3).
2. Remove and discard both footrest caps (2, 3).

2.2.5.2.2 Installation

1. Position two new footrest caps (2, 3) to footrest frame (4) and fasten with four screws (1). Torque to 0.3 Nm.

2.2.5.3 Footrest Springs and/or Flanged Bearings Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
3	2	Footrest Spring	217630
5	4	Flanged Bearing	279726

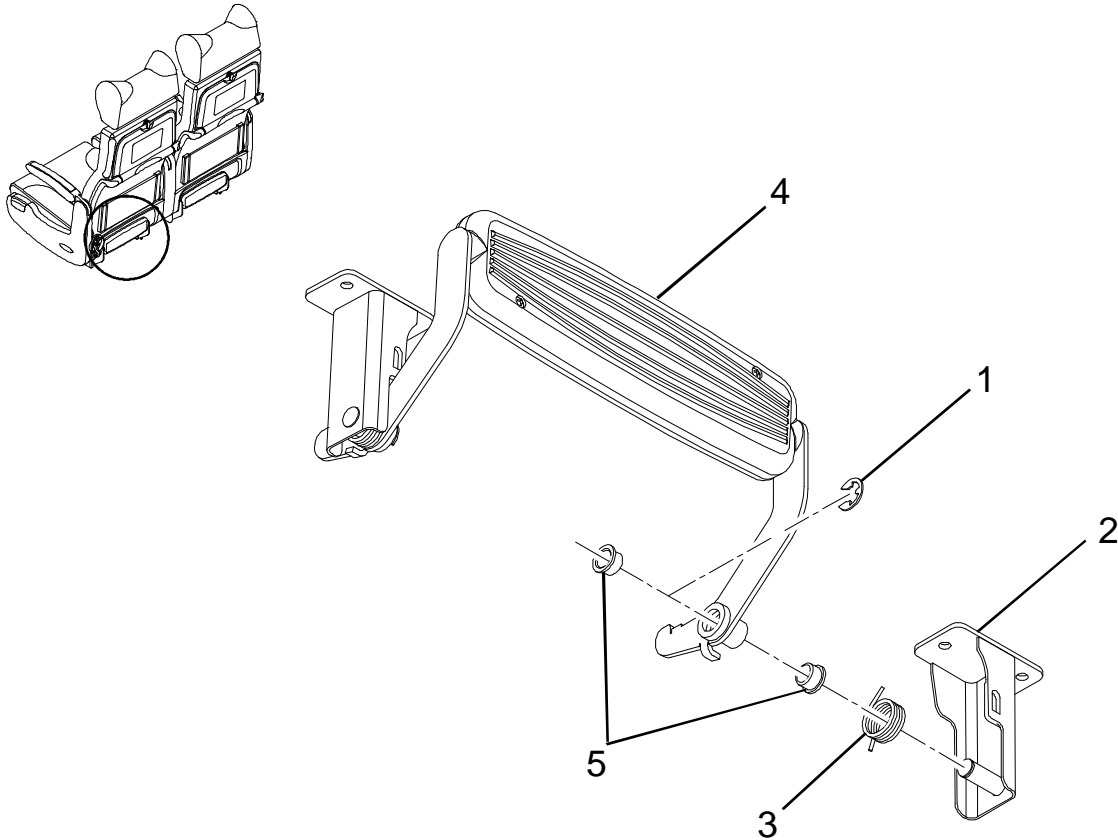


Figure 2-23 Footrest Torsion Springs and/or Flanged Bearings Replacement

WARNING

SPRINGS ARE UNDER TENSION AND CAN BE EXPELLED AT GREAT SPEED. REPLACE WITH CARE AND WEAR PROPER EYE PROTECTION. FAILURE TO DO SO MAY LEAD TO INJURY.

NOTE

- Maintenance task should be done on both sides.

2.2.5.3.1 Removal

1. Remove retaining ring (1).
2. Remove footrest bracket (2) and footrest spring (3). Discard footrest spring.
3. Remove and discard both flanged bearings (5) from footrest assembly (4).

WARNING

SPRINGS ARE UNDER TENSION AND CAN BE EXPELLED AT GREAT SPEED. REPLACE WITH CARE AND WEAR PROPER EYE PROTECTION. FAILURE TO DO SO MAY LEAD TO INJURY.

2.2.5.3.2 Installation

1. Press fit two new flanged bearings (5) to footrest assembly (4).
2. Engage new footrest spring (3) to footrest bracket (2) and install to footrest assembly (4).
3. Install retaining ring (1).

2.2.5.4 Cup Holder Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
1,2,3	1	Cup Holder Kit	63209009

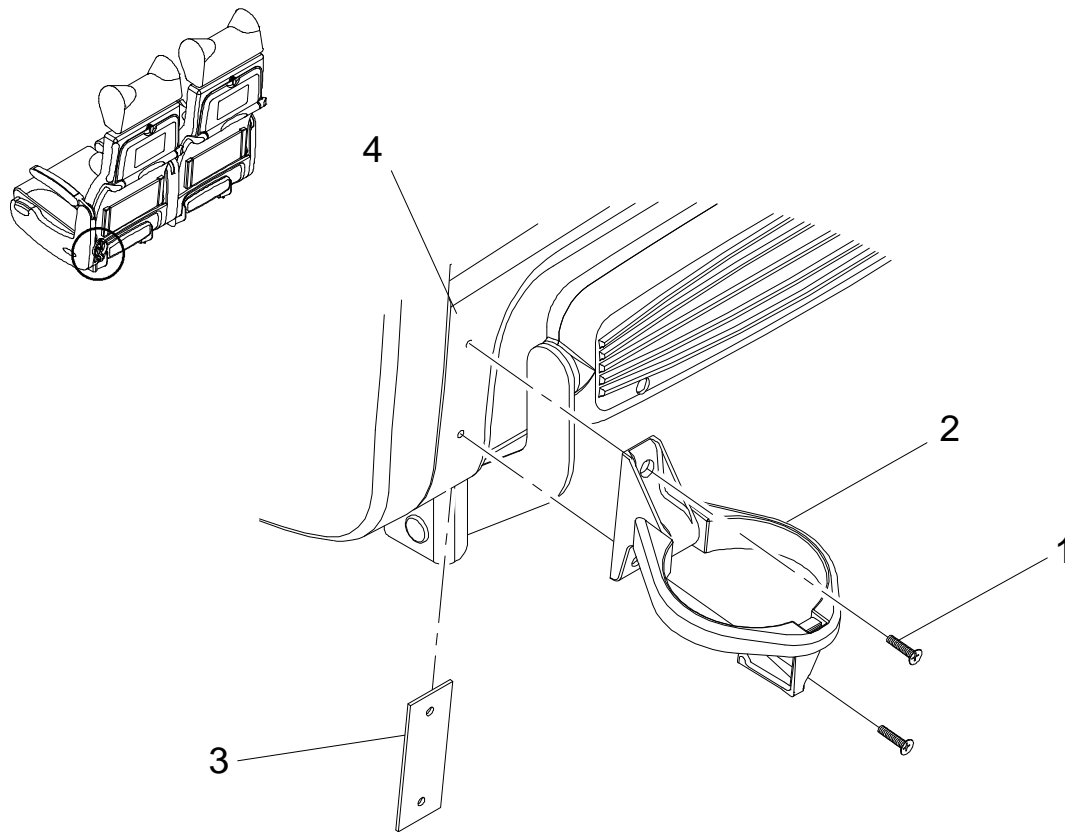


Figure 2-24 Cup Holder Replacement

2.2.5.4.1 Removal

1. Remove two screws (1) and metal plate (3) fastening cup holder (2).
2. Remove and discard cup holder (2).

2.2.5.4.2 Installation

1. Position metal plate (3) and cup holder (2) and fasten with two screws (1). Torque to 1.5 Nm.

2.2.5.5 Tray Table Aircraft Style Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
1,2, 3,4, 6	1	Tray Table Aircraft Style	63209011

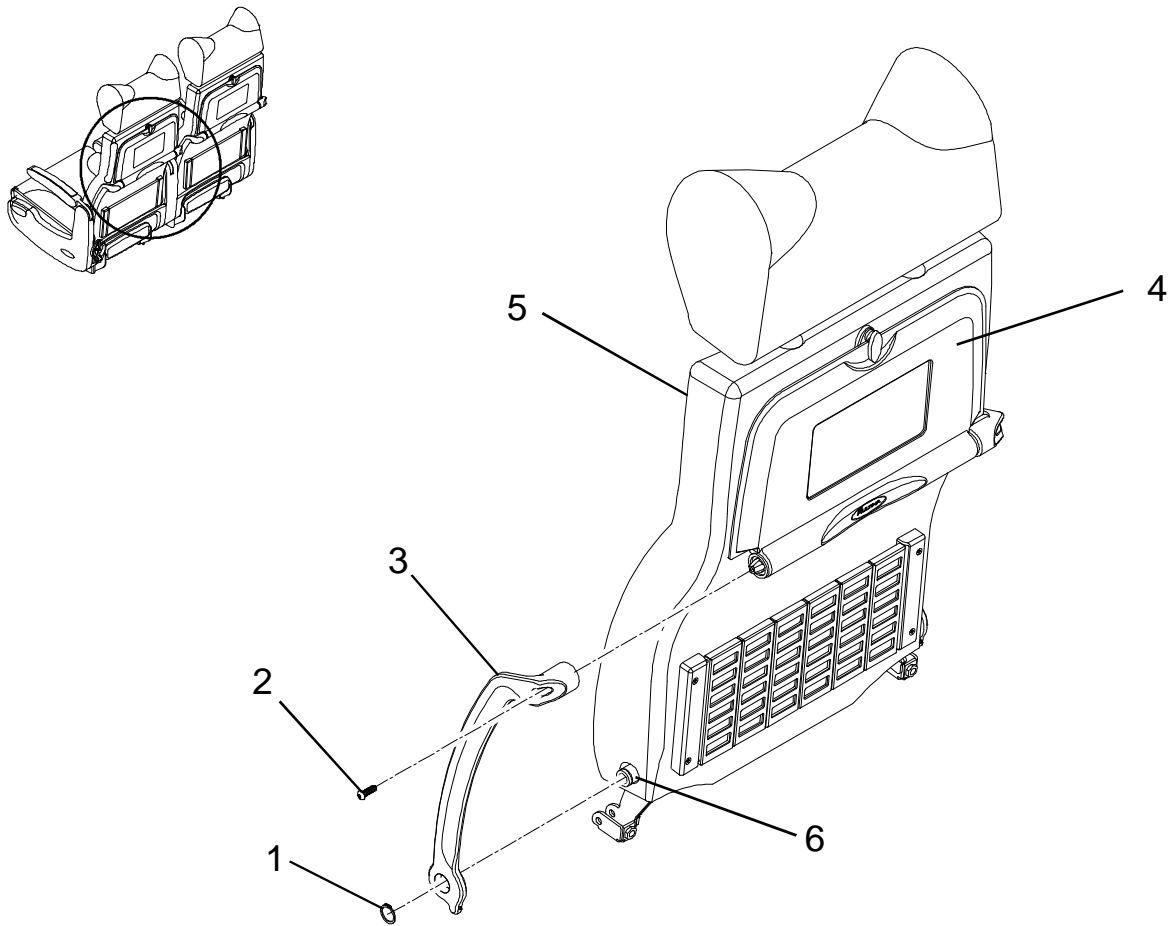


Figure 2-25 Tray Table Aircraft Style Replacement

2.2.5.5.1 Removal

1. Remove backrest cushion assembly (See [2.2.2.3.1](#) Removal).
2. Remove two retaining rings (1) from each side.
3. Remove screw (2) fastening tray table arm (3) to tray table assembly (4).
4. Remove both tray table arms (3).
5. Remove and discard tray table assembly (4) from backrest (5).

2.2.5.5.2 Installation

1. Position two new tray table arms (3) to both backrest shafts (6).
2. Position new tray table assembly (4).
3. Install two screws (2) to fastening tray table arm (3) to tray table assembly (4). Torque to 10 Nm.
4. Install two retaining rings (1) on each side to fasten assembly to backrest shafts (6).
5. Install backrest cushion assembly (See [2.2.2.3.2](#) Installation).

2.2.5.6 Tray Table Aircraft Style Top and/or Stopper Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
2	1	Tray Table Aircraft Style Top	279401
5	2	Stopper	274263

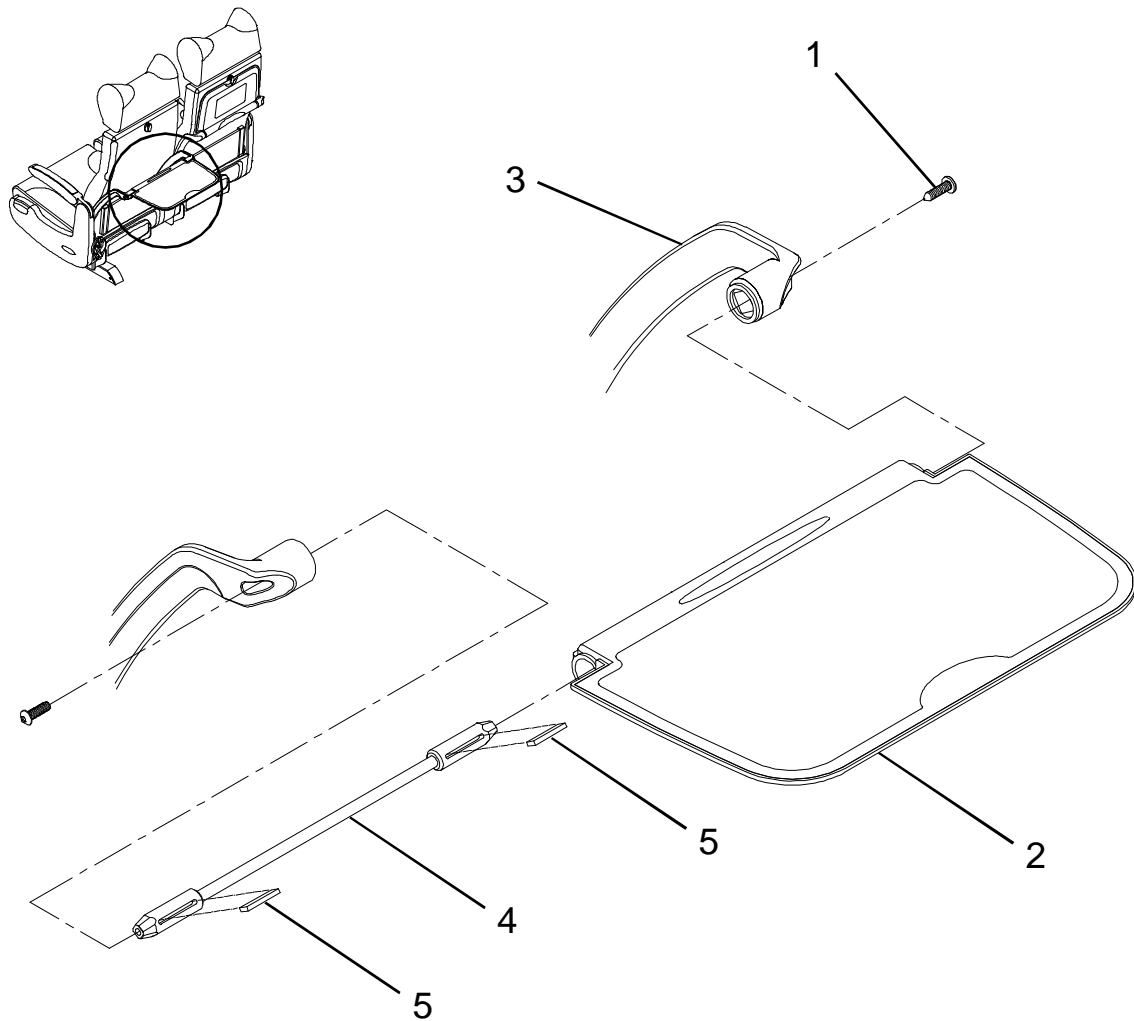


Figure 2-26 Tray Table Aircraft Style Top and/or Stopper Replacement

2.2.5.6.1 Removal

1. Remove two screws (1) fastening tray table top (2) to tray table arms (3).
2. Remove pivot shaft (4) from tray table top (2).
3. Remove and discard tray table top (2).
4. Remove and discard two stoppers (5) from pivot shaft (4).

2.2.5.6.2 Installation

1. Install two new stoppers (5) to pivot shaft (4).
2. Position pivot shaft (4) in new tray table top (2).
3. Position tray table top (2) between tray table arms (3) and fasten with two screws (1) with Loctite. Torque to 10 Nm.

2.2.5.7 Tray Table Pivoting Hook Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
2	1	Tray Table Pivoting Hook	279267

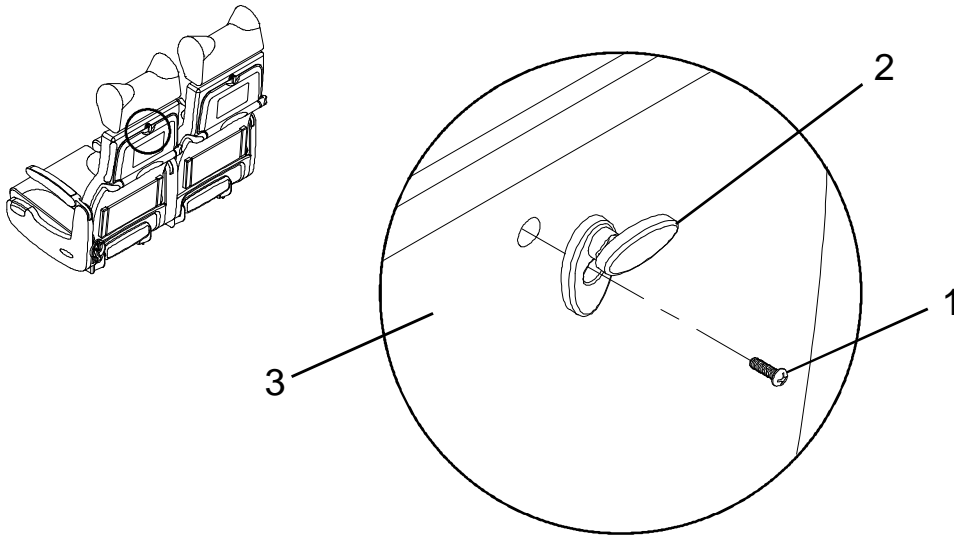


Figure 2-27 Tray Table Pivoting Hook Replacement

2.2.5.7.1 Removal

1. Rotate counterclockwise tray table pivoting hook (2).
2. Remove screw (1) fastening tray table pivoting hook (2) to backrest (3).
3. Remove and discard tray table pivoting hook (2).

2.2.5.7.2 Installation

1. Position new tray table pivoting hook (2) and fasten with screw (1) with Loctite. Torque to 4 Nm.

2.2.5.8 Fixed Tray Table Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
4	1	Fixed Tray Table	231546

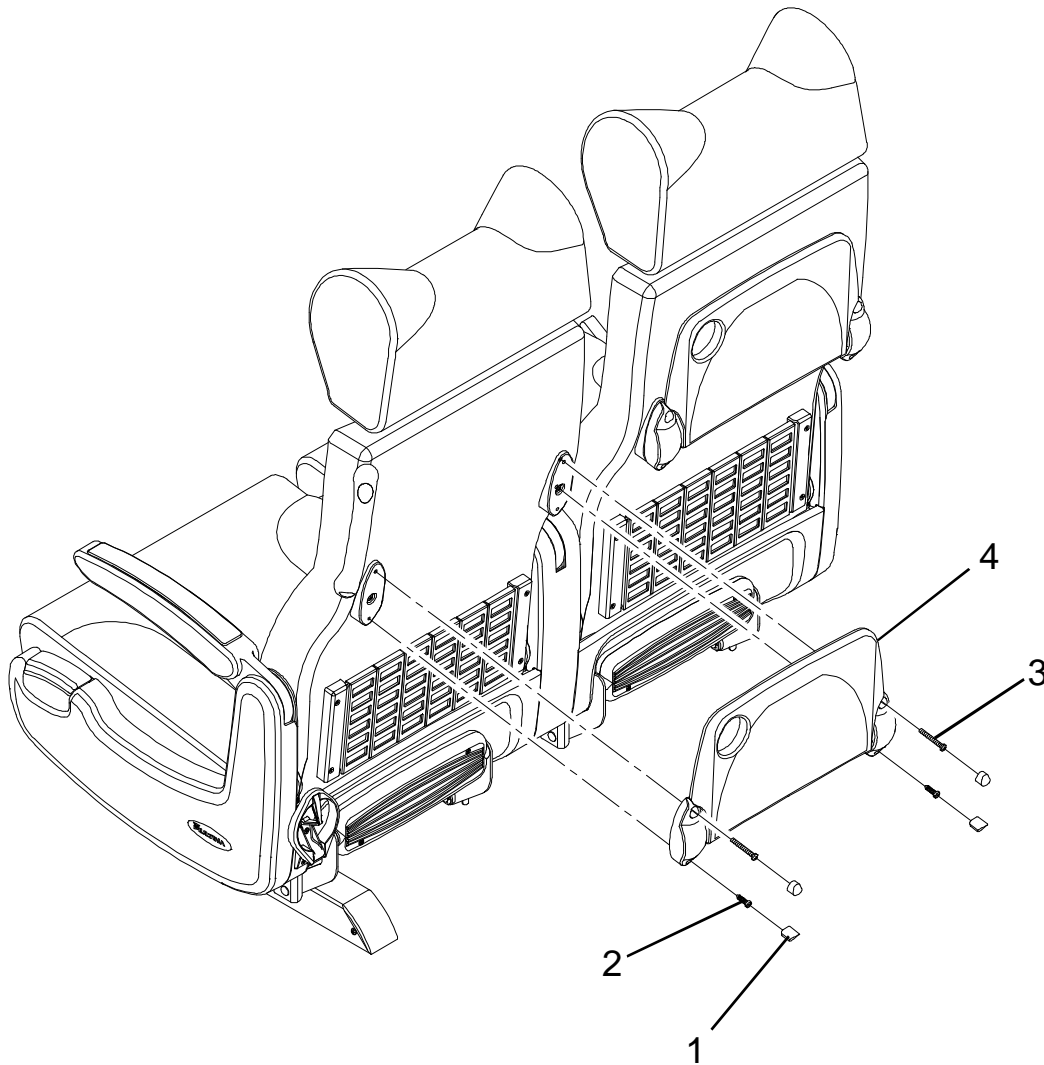


Figure 2-28 Fixed Tray Table Replacement

2.2.5.8.1 Removal

1. Remove four nylon caps (1).
2. Remove two screws $\frac{3}{4}$ in long (2) and two screws 40 mm long (3) fastening tray table (4).
3. Remove and discard tray table (4).

2.2.5.8.2 Installation

1. Position new fixed tray table (4) and fasten with two screws $\frac{3}{4}$ in long (2) with Loctite. Torque to 1 Nm.
2. Install two screws 40 mm long (3) with Loctite. Torque to 4 Nm.
3. Install four nylon caps (1).

2.2.5.9 Grab Handle Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
4	1	Grab Handle Lateral Kit	63203001

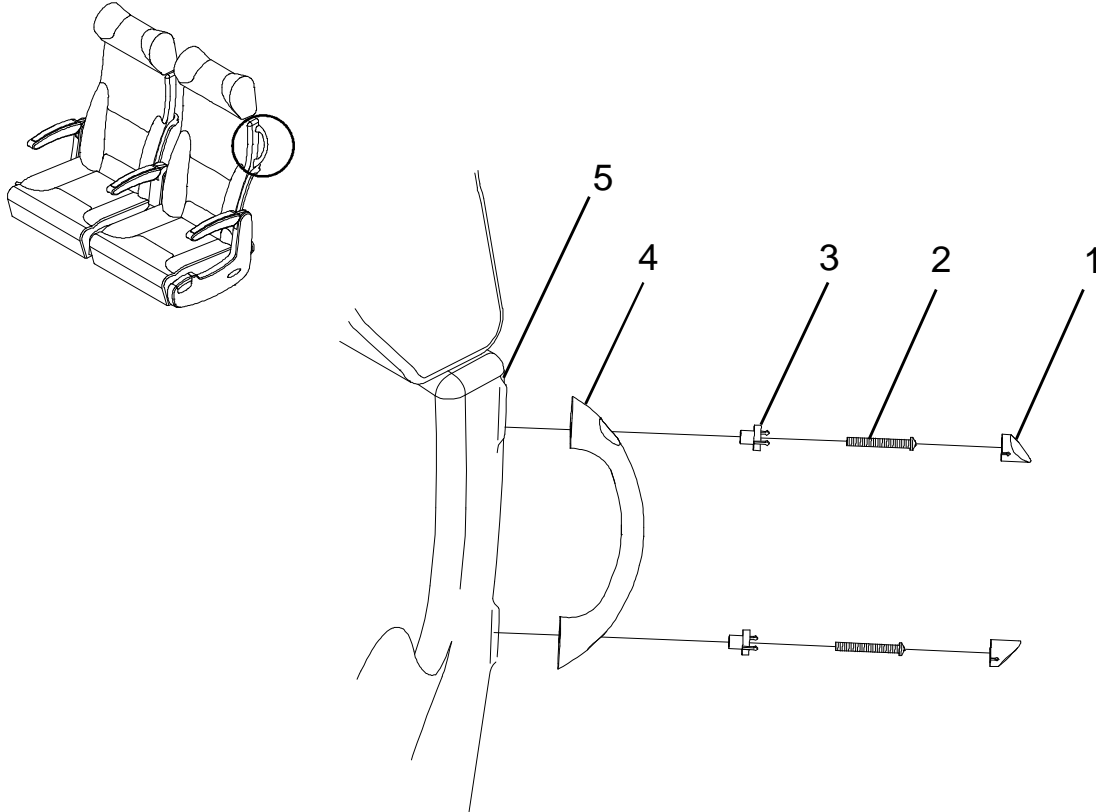


Figure 2-29 Grab Handle Replacement

2.2.5.9.1 Removal

1. Remove two grab handle caps (1) with flat tip screwdriver.
2. Remove two screws (2) fastening grab handle (4) to seat frame (5).
3. Remove and discard grab handle (4).

2.2.5.9.2 Installation

1. Position new grab handle (4) and insert cap (3) and fasten with two screws (2) with Loctite. Torque to 4 Nm.
2. Install two grab handle caps (1). Push on caps until caps interlock correctly.

2.2.5.10 Magazine Net Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
2	1	Magazine Net Kit	63209007

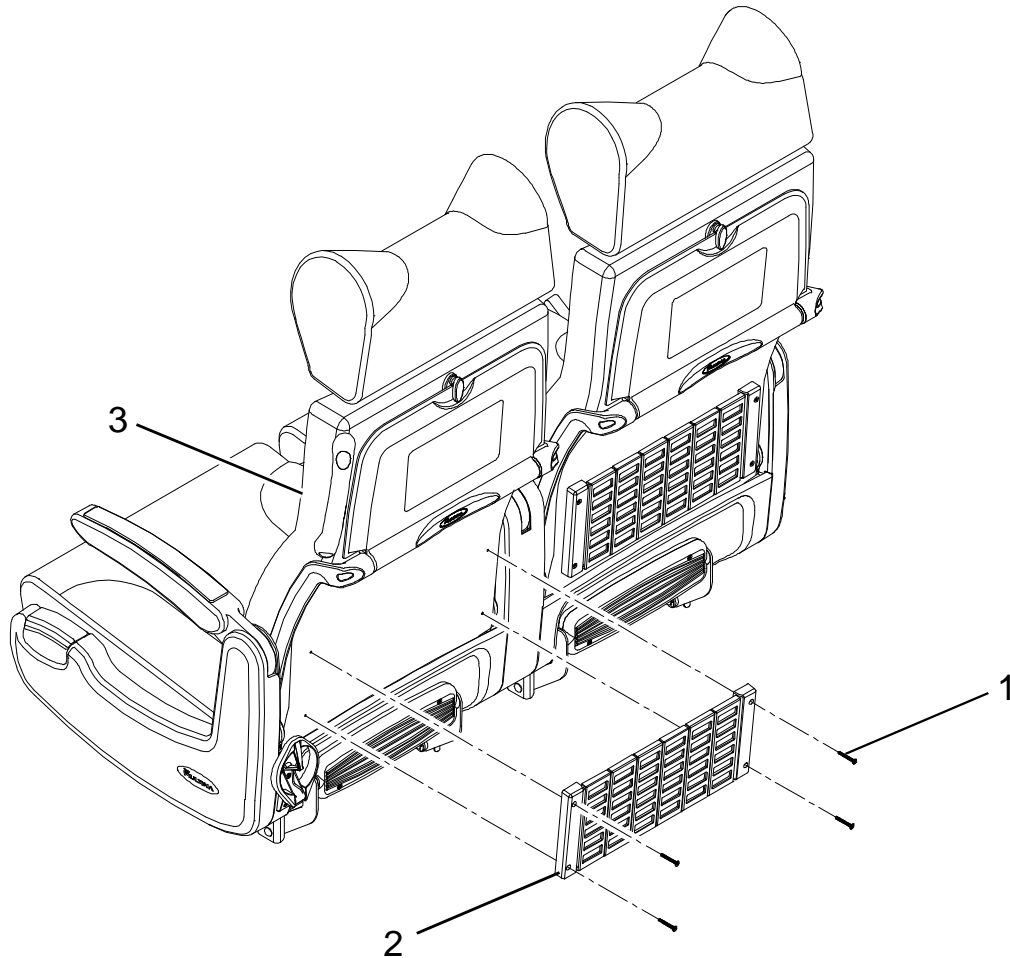


Figure 2-30 Magazine Net Replacement

2.2.5.10.1 Removal

1. Remove four screws (1) fastening magazine net (2) to backrest (3).
2. Remove and discard magazine net (2).

2.2.5.10.2 Installation

1. Position new magazine net (2) and fasten to backrest (3) with four screws (1) with Loctite. Torque 1.5 Nm.

2.2.5.11 Tray Table Advertising Window and/or Advertising Label Replacement

Parts & Hardware

Item	QTY	Description	MULTINA #
1	1	Tray Table Advertising Window	279849

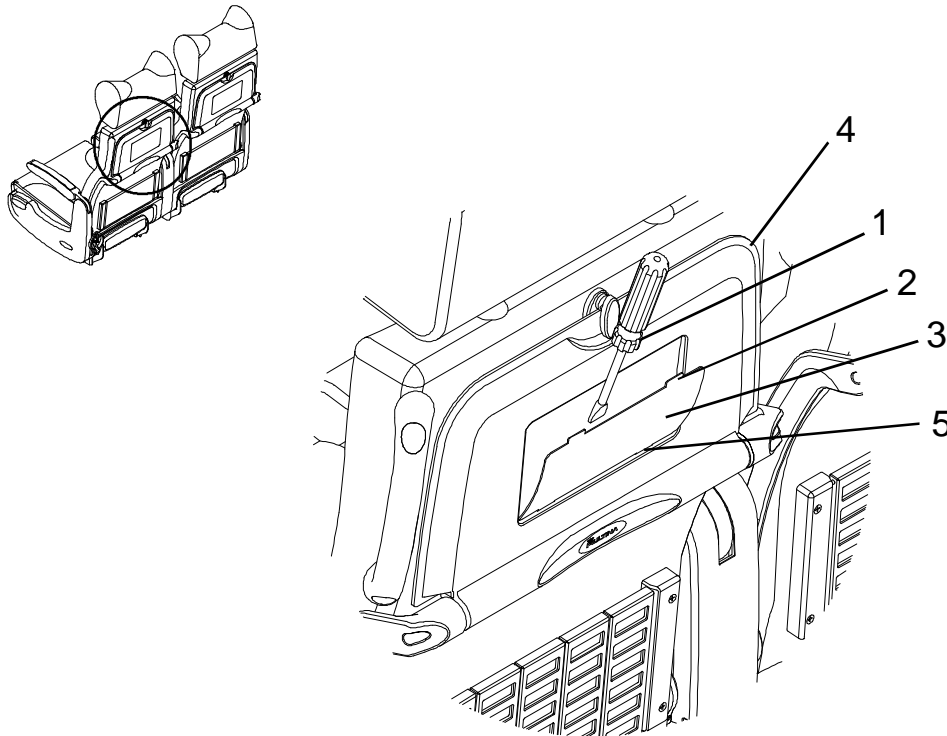


Figure 2-31 Tray Table Advertising Window and/or Advertising Label Replacement

2.2.5.11.1 Removal

1. Use a flat tip screwdriver (1) to disengage advertising plastic window upper strip (2).
2. Remove and discard advertising plastic window (3) from tray table (4).

2.2.5.11.2 Installation

1. Align advertising plastic window lower strip (5) to tray table (4).
2. Bend plastic window slightly (3) to engage upper strip (2) in tray table (4).

SECTION III ADJUSTMENT PROCEDURES

2.3.1 Tray Table Adjustment

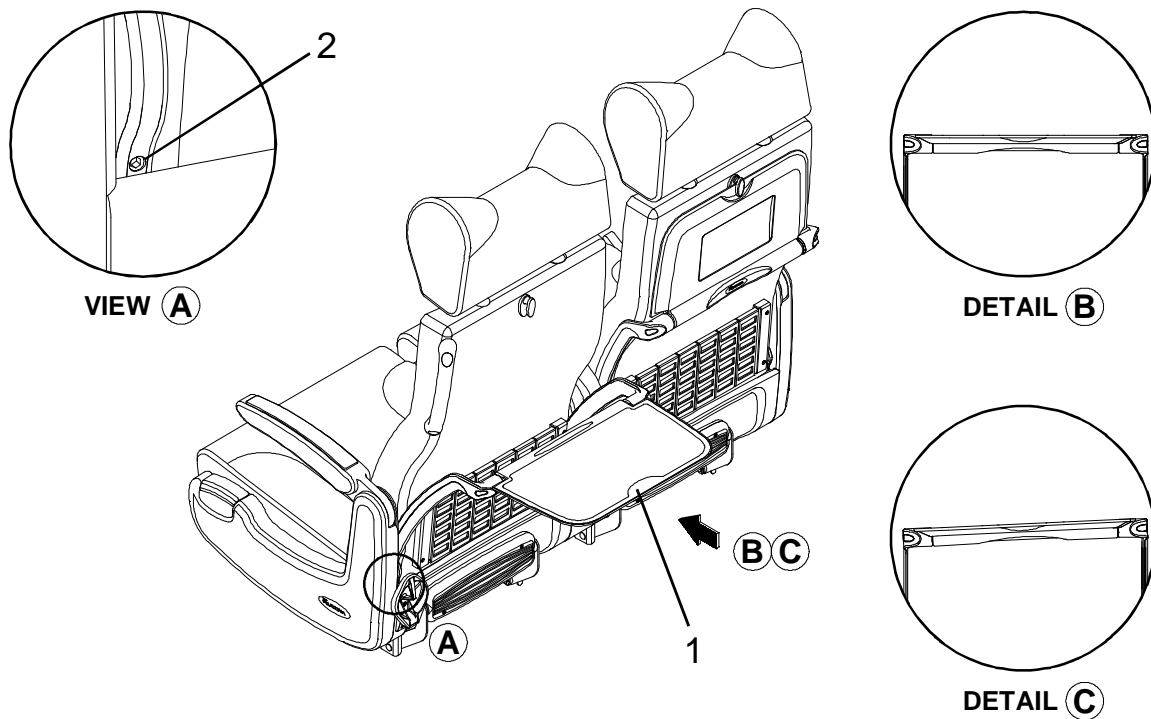


Figure 2-32 Tray Table Slant Adjustment

NOTE

- Adjust both screws at the same time.
- The adjustment angle of the tray table should be 0° to 5° max.

1. Deploy tray table (1) to its horizontal position.
2. Tighten adjustment screw (2) to reduce angle on tray table (1) to get horizontal position (detail (B)). If position is like detail (C), loosen adjustment screws (2) to increase angle on tray table (2) to get horizontal position (detail (B)).

CHAPTER 3 TROUBLESHOOTING

3.1.1 Seat Troubleshooting Table

Symptom	Reason	Corrective Action	Reference
1. Backrest reclining movement is stiff or impossible to recline.	a) Gas Cylinder is defective. b) Reclining Handle is defective.	a) Replace Gas Cylinder. b) Replace reclining handle and/or reclining lever.	a) 2.2.4.1 b) 2.2.4.2
2. Headrest height adjustment is stiff or impossible to do.	a) Headrest sliding guides are broken. b) Headrest sliding guides are dirty.	a) Replace sliding guide. b) Clean headrest rod.	a) 2.2.2.5
3. Footrest does not return automatically	a) Footrest springs are broken.	a) Replace footrest spring	a) 2.2.5.3
4. Footrest assembly is loose.	a) Flanged bearings are used.	a) Replace flanged bearings.	a) 2.2.5.3
5. Footrest is noisy when it returns automatically.	a) Footrest bumper is missing.	a) Replace footrest bumper.	a) 2.2.3.5
6. Tray table is not completely horizontal.	a) Tray table adjustment is not adequate. b) Tray table is broken.	a) Adjust tray table. b) Replace tray table.	a) 2.3.1 b) 2.2.5.5
7. Tray table doesn't stay in place.	a) Tray table pivoting hook is broken.	a) Replace pivoting hook.	a) 2.2.5.7
8. Downward Armrest doesn't work.	a) Downward Armrest mechanism is broken.	a) Downward Armrest.	a) 2.2.4.3 ,
9. Armrest is stiff or loose.	a) Nylon washers are broken or used. b) Armrest nut is loose	a) Replace nylon washers and /or add shim. b) Tighten nut.	a) 2.2.4.3 , 2.2.4.4 , 2.2.4.5

Table 3-1 Seats Troubleshooting Table

Sheffield Plastics Inc.

A  Bayer MaterialScience Company

119 Salisbury Road
Sheffield, Massachusetts 01257
TEL: 413.229.8711
FAX: 413.229.8717
www.sheffieldplastics.com

Makrolon Cleaning Instructions

The Following techniques for cleaning Makrolon polycarbonate sheet are based on standard industry practice. To ensure acceptability of the results, always test a sample of the material with the cleaner and technique to be used.

Guidelines:

Do rinse the sheet with warm water prior to cleaning process.

Don't use abrasives or high alkaline cleaners.

Don't leave cleaners on sheet for long periods, wash immediately.

Don't apply cleaners in direct sunlight or at elevated temperatures.

Don't use scrapers, squeegees or razors.

Don't clean with gasoline.

Do follow the application with a lukewarm water rinse.

Compatible Cleaners and Detergents:

Formula 409¹, Joy², Windex with Ammonia D³, Palmolive⁴, Naphtha VM&P Grade, Isopropyl Alcohol

To Minimize Fine or Hairline Scratches:

Plastic Polishes applied and removed per manufacturer instructions.

Suggested Polishes:

Mirror Glaze Clear Plastic Polish, Cleaner & Detailer (by Meguiars 800-347-5700 or Meguiars.com)

Novus Plastics Polish #1, #2 (by Novus Inc. 800-NOVUS60 or noscratch.com)

Plexus Plastic Cleaner and Polish (by BTI Chemical Co. PlexusPlasticCleaner.com)

To Remove Masking Adhesive and Glazing Compound:

Apply Naphtha VM&P grade, Kerosene or Isopropyl Alcohol with clean soft cloth. Wash immediately with soap and lukewarm water and rinse with thoroughly with clean water.

To Remove Graffiti:

Naphtha VM&P grade, Isopropyl Alcohol or Butyl Cellosolve removes paint, marker ink. (Do not use in direct sunlight).

Isopropyl Alcohol, Naphtha VM&P grade or Kerosene will help lift stickers and other adhesive backed labels. Wash immediately with soap and lukewarm water and rinse with thoroughly with clean water.

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MAK_Cleaning_5-05

SECTION 22: HEATING AND AIR CONDITIONING

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1. HEATING AND AIR CONDITIONING

The coach's interior is pressurized by its Heating, Ventilation, Air Conditioning (HVAC) units. Air flow and controls divide the vehicle in two areas: driver's area and passengers' area. The interior of vehicle should always be slightly pressurized to prevent dust and moisture from entering vehicle. Each section has its own fresh air, returning air and discharge air ducting. The exhaust is mainly done through the lavatory ventilator and through normal air-tightness losses.

2. AIR CIRCULATION

2.1 DRIVER'S AREA

Fresh air is taken from a plenum underneath the front service compartment and enters the mixing box through an ON/OFF damper. Return air is taken through the base of the dashboard panel utility compartments into the mixing box. Mixed air goes through cooling and heating coils, fans and discharge ducts.

Both right and left discharge ducts defrost one half of the windshield. The driver can also divert some air flow to the console, from which he can direct air to his knees and/or upper body with adjustable HVAC air registers and to his feet with the appropriate button (see Fig. 1 and Operator's manual). The coach is also equipped with a windshield upper section de-icing system.

One additional air register is located in the driver's area but supplied by the passengers' air ducting system. It is installed in the stepwell for step de-icing.

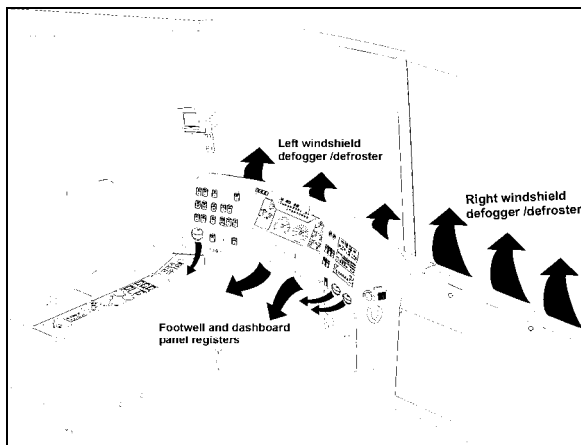


FIGURE 1: DRIVER'S AIR CIRCULATION 22307

2.2 PASSENGERS' AREA

Fresh air enters the vehicle on the L.H. side, through the recirculation damper located inside the evaporator compartment door (Fig. 2). The damper can be fully opened for normal operation or closed for extreme weather or highly polluted areas (Refer to the X3 Operator's Manual for more details). The recirculation REC button is located on the HVAC control unit. Press down the button to partially close the fresh air damper. Return air is drawn from inside the vehicle through the register duct located amidships on L.H. side of vehicle (Fig. 3).

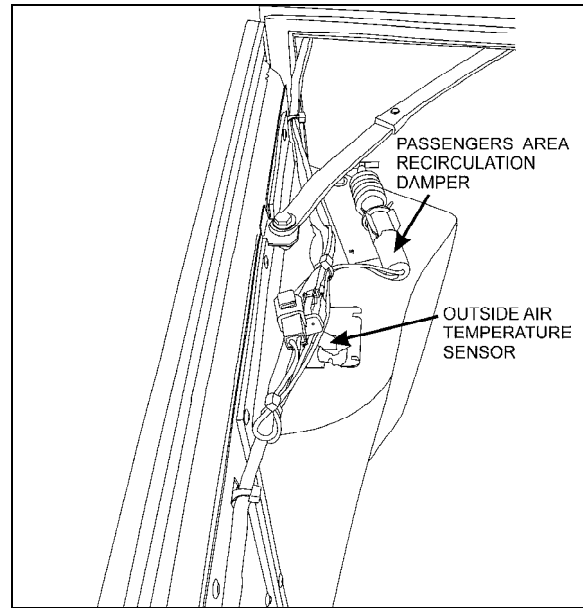



FIGURE 2: PASSENGERS' AREA RECIRCULATION DAMPER 22302

A double blower fan unit, which is activated by the evaporator motor, draws mixed air through an air filter, cooling and heating coils, then forces this air in the ventilation ducts along the walls, and finally exhausts it just below side windows.

X3 coaches are also equipped with an overhead compartment ventilation system, a three-position

rocker switch  (OFF - 1st speed - 2nd speed) located on R.H. dashboard panel controls the speed of both fans. Return air is drawn just below the middle side windows through an air filter into the overhead compartment fan; discharge air is fed to the rotating registers through the ventilation duct (Fig. 4).

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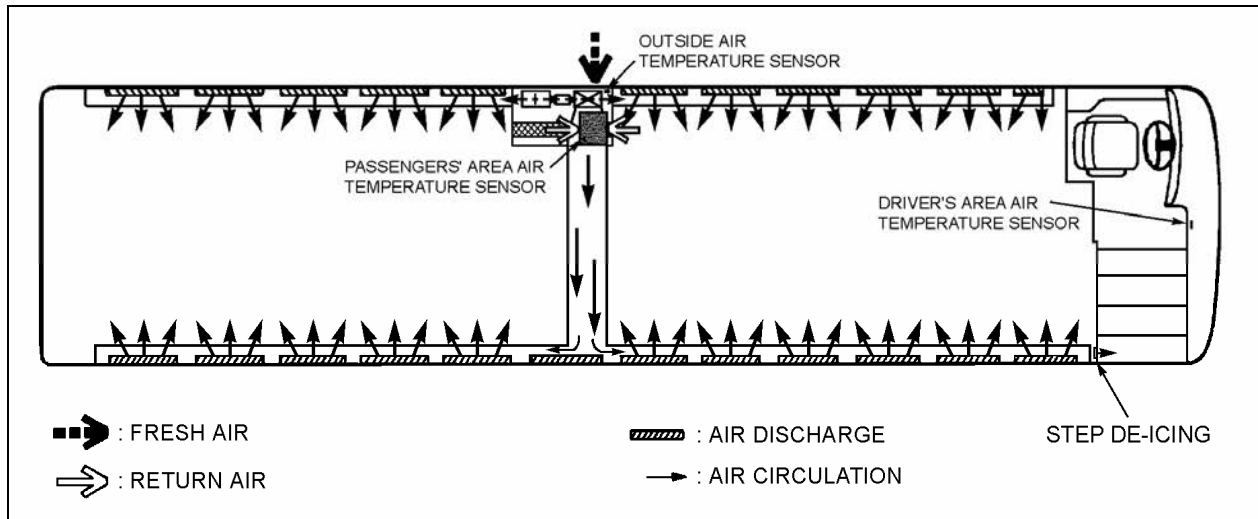


FIGURE 3: CENTRAL HVAC SYSTEM AIR CIRCULATION

22308

The overhead compartment air registers are used to control air flow for the passenger seats. One register per seat direct air flow by pointing or rotating register. Open or close register to adjust air flow.

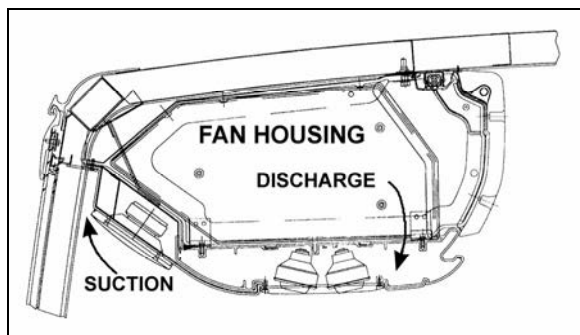


FIGURE 4: PASSENGERS OVERHEAD COMPARTMENT VENTILATION SYSTEM

22211

3. CENTRAL HVAC SYSTEM OPERATION

To operate the air conditioning system when coach is stationary, engine should run at fast idle. During operation of the air conditioning system, windows should be kept closed and door not left open longer than necessary. In order to prevent battery discharge, HVAC system will not operate if vehicle charging system is not working properly.

3.1 DRIVER'S SECTION OPERATION

The temperature control in the driver's area is provided directly by the L.H. portion of the HVAC control unit mounted on the R.H. dashboard panel (Fig. 5).


The driver's HVAC section piping is paralleled with the passengers HVAC section piping. Both sections use the same refrigerant and coolant, and are linked to the same condenser and compressor, even if they are individually controlled. It requires the passengers HVAC section to engage the A/C compressor magnetic clutch. Consequently, the driver's section cannot be operated in the A/C mode alone.

NOTE

The driver's HVAC section turns on automatically at starting of the engine and uses the settings that were kept in memory before turning off of the system.

The A/C compressor starts automatically when the two following conditions are satisfied:

1. The outside temperature is above 32°F (0°C).
2. The passenger's area temperature has reached 7°F (4°C) under the set point.

Using the Up/Down type switch  sets the fan speed and the speed chosen is illustrated on the window display.

NOTE

Upon starting, if the outside temperature is above 32°F (0°C) and then drops below 32°F (0°C), the compressor will keep running up to a temperature of 15°F (-9°C) to prevent condensation from forming on the windows.

Section 22: HEATING AND AIR CONDITIONING

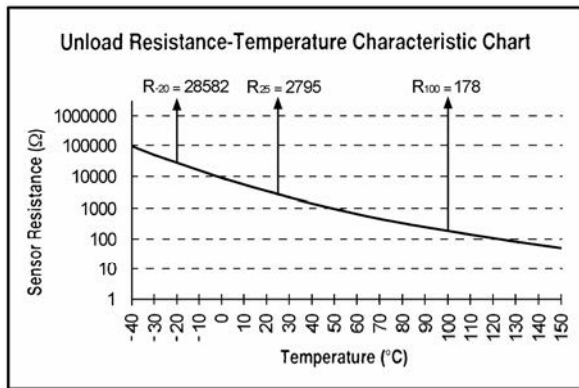
NOTE

To perform a test of the driver's section windshield defroster, it is possible to run the system without running the engine.

The following 2% error chart and table can be used to troubleshoot the driver's area air temperature sensor and the outside air temperature sensor.

NOTE

The driver's area air temperature sensor is located behind the grill of the R.H. side console (Refer to fig. 12).



Temp °C	Temp °F	Resistance Ohms
-40	-40	100865
-35	-31	72437
-30	-22	52594
-25	-13	38583
-20	-4	28582
-15	5	21371
-10	14	16120
-5	23	12261
0	32	9399
5	41	7263
10	50	5658
15	59	4441
20	68	3511
25	77	2795
30	86	2240
35	95	1806
40	104	1465
45	113	1195
50	122	980
55	131	808
60	140	670
65	149	559
70	158	468
75	167	394
80	176	333
85	185	283
90	194	241
95	203	207
100	212	178
105	221	153
110	230	133

115	239	115
120	248	100
125	257	88
130	266	77
135	275	68
140	284	60
145	293	53
150	302	47

3.2 PASSENGERS' SECTION OPERATION

The R.H. portion of the HVAC control unit enables the selection of the temperature in the passenger's area (refer to the Operator's Manual for details).



FIGURE 5: CENTRAL HVAC SYSTEM CONTROL UNIT 22296

Temperature control is provided in conjunction with a thermistor sensor inside register duct, located amidships on L.H. side of vehicle (Figs. 3 & 6).

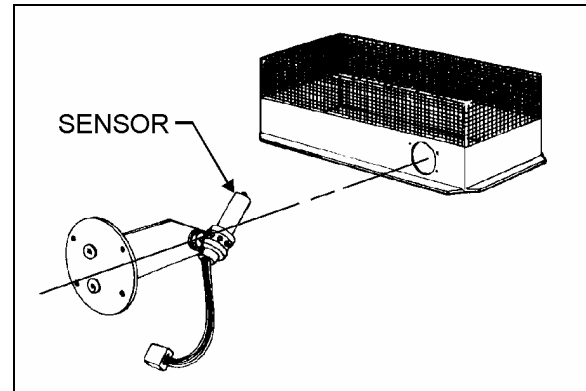


FIGURE 6: THERMISTOR SENSOR

22064

The flow of water to the vehicle's main heater core is controlled by a pneumatic water valve which varies the cycling rate depending on selected temperature. A red LED, located on HVAC control unit, illuminates when heating mode is selected. A green LED illuminates when compressor clutch is in operation.

The evaporator fan motor, located in the evaporator compartment, is protected by a 90 amps, manually-resettable (CB3) circuit breaker located on the rear junction panel of the rear electrical compartment (refer to Section 06, "Electrical System" in this manual for details).

Section 22: HEATING AND AIR CONDITIONING

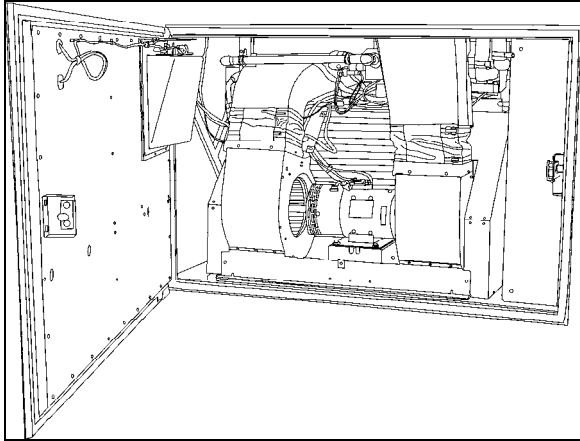


FIGURE 7: EVAPORATOR COMPARTMENT 22301

The condenser coil mounted on the opposite side of the evaporator is ventilated by four axial fans. The fan motors are protected by a manually-resettable 70 amp circuit breaker (CB 7) mounted on the rear junction panel of the rear electrical compartment.

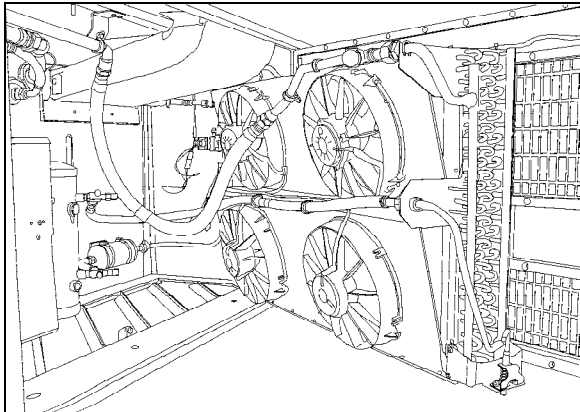


FIGURE 8: CONDENSER COMPARTMENT 22299

3.3 OVERHEAD COMPARTMENT A/C

Optional small A/C evaporator coils may be added to both overhead compartments existing air system. These auxiliary A/C system components are separate and completely independent of central system and permit a wider temperature range in the passenger's area. The three-position rocker switch used to control the fans also controls the A/C system.

4. HVAC UNIT MAINTENANCE

No special maintenance is required on the passengers, driver's and auxiliary HVAC units, with the exception of cleaning their respective coils and air filters, plus periodic inspection for broken drains, hoses and charging of system.

NOTE

Squeeze rubber hose located underneath the appropriate compartment to eliminate the accumulated water and dirt when you make routine maintenance.

4.1 COIL CLEANING

Check the external surface of the coil at regular intervals for dirt or any foreign matter.

For the driver's HVAC unit, remove the grill and the access panels and back flush the coil from inside.

For the passengers' section evaporator coil, remove the access panel and back flush the coil (Fig. 9 & 10) every 12,500 miles (20 000 km) or once a year, whichever comes first.

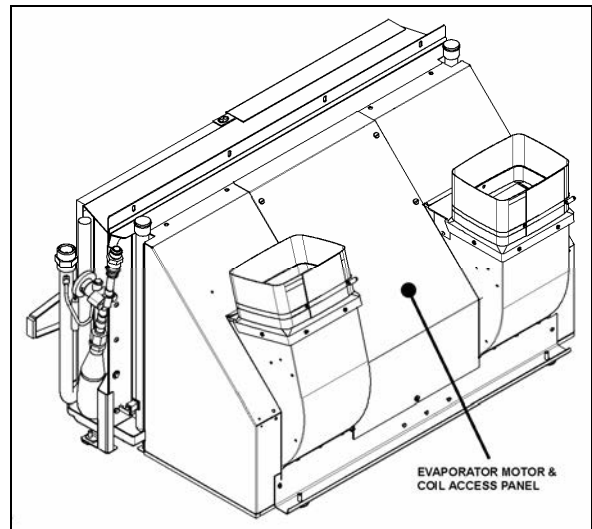


FIGURE 9: EVAPORATOR MOTOR & COIL ACCESS PANEL 22309

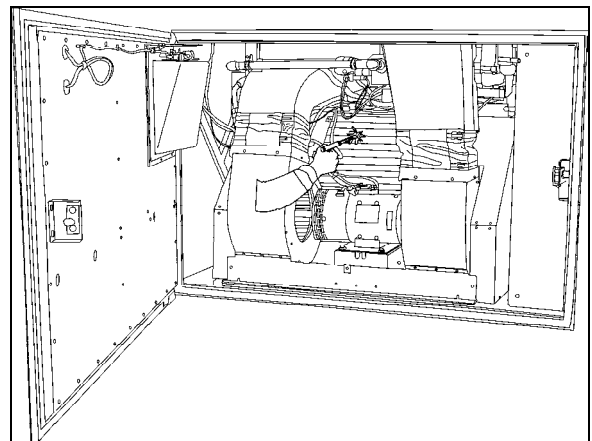




FIGURE 10: EVAPORATOR COIL CLEANING 22310

For the condenser coil, back flush the coil (Fig. 11) every 6,250 miles (10 000 km) or twice a year, whichever comes first.

	CAUTION
Use a water jet or water mixed with low air pressure to clean the coil.	

	CAUTION
Direct the pressure straight through the coil to prevent bending of fins and do not use extremely high pressure. Do not use hot water, steam or caustic soap.	

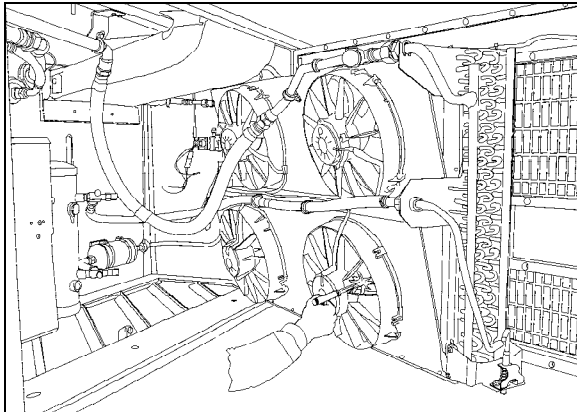


FIGURE 11: CONDENSER COIL CLEANING 22311

4.2 DRIVER'S SECTION AIR FILTERS

The driver HVAC system is located behind the dashboard's R.H. side lateral plastic panel. To gain access to the A/C filters, unscrew the R.H. lateral console's grill located at the top step of the entrance door steps. Slide out the recirculating air and fresh air filters. To clean filters back flush with water, then dry with air, every 12,500 miles (20 000 km) or once a year, which-ever comes first (Fig. 12 & 13).

<p>NOTE</p> <p><i>If the windshield is continuously fogged, check that the driver's air filter is not clogged.</i></p>

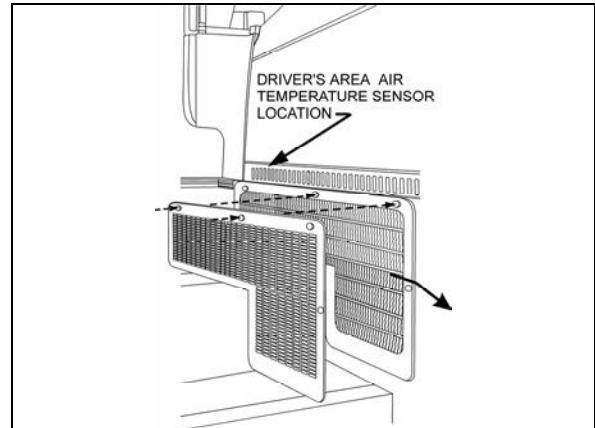


FIGURE 12: DRIVER'S SECTION ACCESS GRILL 22312

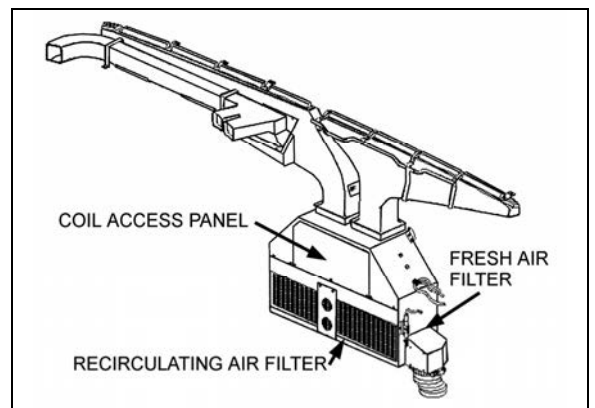


FIGURE 13: DRIVER'S SECTION AIR FILTERS 22171

4.3 PASSENGERS' SECTION AIR FILTER

The passengers' section air filter is located in the evaporator compartment. To access the filter on X3 coaches, open baggage compartment door located in front of the evaporator compartment (L.H. side). Open access panel by turning the three screws of panel ¼ of a turn, unsnap both fasteners on top of filter, and slide out filter (Fig. 14). To clean filter, back flush with water or soapy water, then dry with air every 12,500 miles (20 000 km) or once a year, whichever comes first.

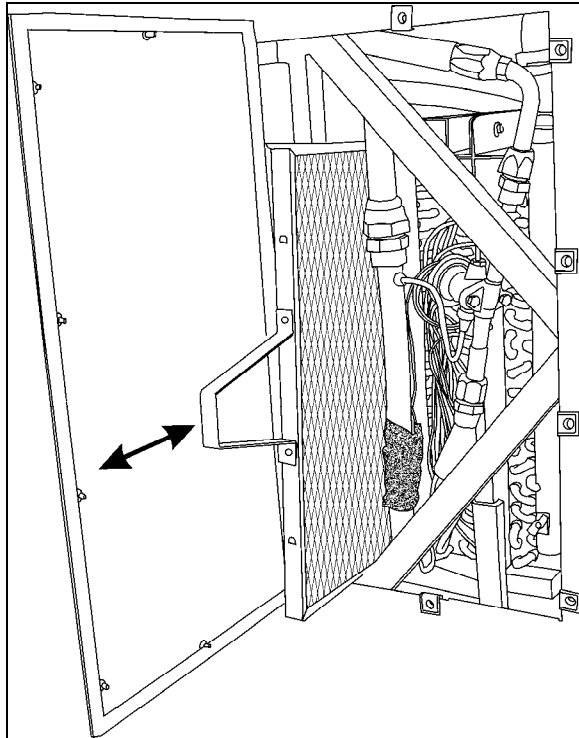


FIGURE 14: PASSENGERS' SECTION AIR FILTER 22306



CAUTION

Do not use high pressure water jet to avoid damaging filter.



CAUTION

Be sure not to reverse filter upon installation.

4.4 OVERHEAD COMPARTMENT FAN AIR FILTER

A/C evaporator coils may be installed in both overhead compartment air systems. Only the air filters are serviceable. The air filters are accessible from inside the overhead compartments. Slide out the filters, then back flush with water, dry with air and replace. This procedure should be done every 12,500 miles (20,000 km) or once a year, whichever come first.

If A/C units were installed, ball valves are added on supply and return lines in the engine compartment. They have service port to evacuate the A/C overhead compartment circuit. When work has to be done on an evaporator coil unit, it will be easier to remove it and repair it on a bench.

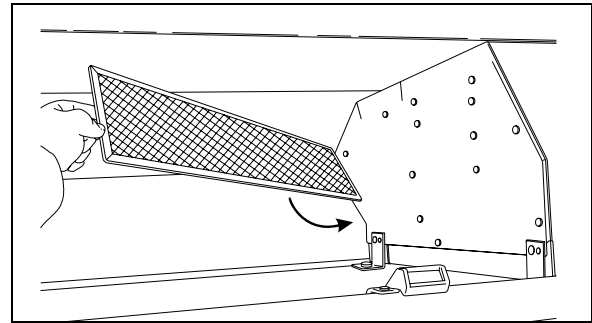


FIGURE 15: OVERHEAD COMPARTMENT FAN AIR FILTER 22201

5. HVAC SYSTEM PARTICULARITIES, TESTING AND TROUBLESHOOTING

Before undertaking any troubleshooting on the HVAC system, study the appropriate wiring diagrams to get a complete understanding of the HVAC components circuitry, read and understand section 06:ELECTRICAL of this manual under "Troubleshooting And Testing The Multiplex Vehicles" and "Test Mode For Switches And Sensors". The information included in these paragraphs is necessary for troubleshooting the HVAC system on Multiplex vehicles.

5.1 HVAC SYSTEM AND TEST MODE FOR SWITCHES AND SENSORS

When in switch/sensor test mode (see Section 06: ELECTRICAL for complete information), the A/C compressor HI and LO pressure values are displayed one after the other instead of the outside temperature in the telltale panel LCD display. This feature can be used when the vehicle is traveling to check the A/C compressor pressure values.

NOTE

When starting the A/C compressor wait 5 seconds before checking pressures in order to give the system a chance to build its pressure. During the first 5 seconds after startup, the compressor is active on 6 cylinders and the A/C valve is open regardless of the pressure readings.

In test mode, with the parking brake applied and the passenger set point set to a value higher than 64°F (18°C), the hot water circulating pump is not set to OFF as it would normally do when the outside temperature gets above 50°F (10°C). This feature allows verification of the pump when inside a garage. This is also useful

Section 22: HEATING AND AIR CONDITIONING

when working on the heating system to remove air pockets trapped in the system.

When performing an A/C cooling test and having the water pump shut off in switch/sensor test mode is required, just set the passenger set point temperature to the minimum 64°F (18°C) to shut off the pump.

5.2 HVAC SYSTEM AND TEST MODE FOR ELECTRIC MOTORS

The test mode allows testing the motors and electric contactors without the need to have the engine running (see Section 06: ELECTRICAL under "TEST MODE FOR ELECTRICAL MOTORS" for complete information).

Use this test mode for testing of the condenser motors, the A/C compressor clutch activation, left and right unloaders, evaporator motor, water pump, hot water solenoid valve and overhead compartment air register fan.

5.3 PARTICULARITIES

Conditions for engaging the 2 nd speed on the evaporator motor (cooling demand).	The 2 nd speed engages if the passenger's area temperature is 1 degree above the set point and it revert to speed 1 if the temperature gets equal or below the set point.
Conditions for hot water recirculating pump activation (heating demand).	The pump turns to OFF if the outside temperature is above 50°F (10°C), when there is less demand for heating. Note: To test a working pump, it is possible to keep it active even if the outside temperature is above 50°F (10°C). See paragraph 5.2 HVAC SYSTEM AND TEST MODE FOR ELECTRIC MOTORS.
The compressor unloaders are working based on pressure and also on the difference between the passenger's area temperature and the set point.	<p>2 left compressor cylinders:</p> <p>Stop if: Passenger's area temperature is at less than 0.4°C degree above the set point or if the compressor output is above 280 psi, or if the compressor input is below 26 psi.</p> <p>Restart if: Passenger's area temperature is 0.9°C or more above the set point and the compressor pressure output is less than 220 psi and the compressor pressure input is above 34 psi.</p> <p>2 right compressor cylinders:</p> <p>Stop if: Passenger's area temperature is at less than 0.2°C above the set point or if the compressor input falls below 23 psi.</p> <p>Restart if: Passenger's area temperature is 0.7°C or more above the set point and the compressor input pressure is above 32 psi.</p>
The A/C deactivation pressure is 320 psi.	In case of high pressure, the analog pressure sensor connected to the Multiplex module deactivates the compressor. There is also a « Pressure switch » adjusted to 350 PSI that acts to stop the compressor in the instance that the Multiplex module fails.

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5.4 HVAC SYSTEM TROUBLESHOOTING

Problem/Symptom	Probable Causes	Actions
No temperature control in the passenger area Passenger temperature display indicates two dashes "--"	Problem with the temperature sensor located in the evaporator compartment air intake or the sensor wiring	Instruct the driver to manually control the temperature by playing with the passenger set point. Set above 22°C (72°F) to heat and below 22° C (72°F) to cool
Defroster fan not functioning	Module A47 is not powered or is faulty	<ol style="list-style-type: none"> 1. Check the SYSTEM DIAGNOSTIC menu of the message center display (MCD). Select FAULT DIAGNOSTIC and ELECTRICAL SYSTEM. The message "Voltage Module A47, Value too Low, Active" confirms a power problem on the module 2. Check / reset circuit breaker CB6 3. Check / replace fuse F5 4. Use the air release valves near the entrance door and in the front service compartment to lock / unlock the door
HVAC condenser fans not functioning in speed 1	Circuit breaker CB7 was manually tripped and not reset Seized bearing Brush problem Bad wiring	Check / reset circuit breaker CB7
HVAC condenser fans not functioning in speed 1	Module A54 is not powered or is faulty	<ol style="list-style-type: none"> 1. Check the SYSTEM DIAGNOSTIC menu of the message center display (MCD). Select FAULT DIAGNOSTIC and ELECTRICAL SYSTEM. The message "Voltage Module A54, Value too Low, Active" confirms a power problem on the module 2. Check / reset circuit breaker CB5 3. Check / replace fuse F67 , F68
HVAC condenser fans not functioning in speed 2	Circuit breaker CB7 was manually tripped and not reset Seized bearing Brush problem Bad wiring	Check / reset circuit breaker CB7
Defroster fan is functioning but no heat or cooling available in the driver's area	Module A46 is not powered or is faulty Faulty speed control Bad wiring	<ol style="list-style-type: none"> 1. Check the SYSTEM DIAGNOSTIC menu of the message center display (MCD). Select FAULT DIAGNOSTIC and ELECTRICAL SYSTEM. The message "Voltage Module A46, Value too Low, Active" confirms a power problem on the module.

Problem/Symptom	Probable Causes	Actions
		2. Check / reset circuit breaker CB1 3. Check / replace fuse F12
The A/C compressor clutch does not engage	Module A52 is not powered or is faulty	1. Check the SYSTEM DIAGNOSTIC menu of the message center display (MCD). Select FAULT DIAGNOSTIC and ELECTRICAL SYSTEM. The message "Voltage Module A52, Value too Low, Active" confirms a power problem on the module 2. Check / reset circuit breaker CB5 3. Check / replace fuse F65
Evaporator fan not functioning	Circuit breaker CB3 tripped Module A54 is not powered or is faulty Brush problem	1. Check / reset circuit breaker CB3 2. Check the SYSTEM DIAGNOSTIC menu of the message center display (MCD). Select FAULT DIAGNOSTIC and ELECTRICAL SYSTEM. The message "Voltage Module A54, Value too Low, Active" confirms a power problem on the module 3. Check / reset circuit breaker CB5 4. Check / replace fuse F67 , F68

6. CENTRAL AIR CONDITIONING SYSTEM

The schematic of Figure 16 shows the central and auxiliary A/C systems and their components. The central system is equipped with a 6 cylinder, 05G Twin Port Carrier compressor with an air conditioning capacity of 7½ tons. The receiver tank and filter dryer are mounted inside the condenser compartment.

X3 Coaches may be supplied with an auxiliary A/C system (Fig. 16). Auxiliary A/C system comes with a 7 cylinder, Sanden SD7 compressor with an air conditioning capacity of 2 tons.

6.1 A/C CYCLE

Refrigeration may be defined as "the transfer of heat from a place where it is not wanted to a place where it is unobjectionable". Components required for a closed circuit refrigeration system are shown in Figure 16.

The air conditioning system used on X3 series coaches is of the "Closed" type using "R-134a".

1. The refrigerant flowing to the compressor is compressed to high pressure and reaches a temperature higher than the surrounding air. It is passed through the air-cooled fins and tubes of the condenser causing the hot,

high pressure gas to be condensed into a liquid form.

2. The liquid refrigerant flows to the receiver tank, then passes through a filter dryer where moisture, acids and dirt are removed and then through a moisture indicator which indicates if any moisture is present in the system.
3. By its own pressure, the liquid refrigerant flows through a thermal expansion valve where the pressure drop causes the refrigerant to vaporize in a vapor-liquid state at a low temperature pressure.
4. The cold low pressure refrigerant passes through the passengers and the driver's evaporator coils which absorbs heat from the air passing over the fins and tubes, and changes into gas. In this form, the refrigerant is drawn into the compressor to repeat the air conditioning cycle.
5. The success of the air conditioning system depends on retaining the conditioned air within the vehicle. All windows and intake vents should be closed. An opening of approximately 8 in² (5162 mm²) could easily neutralize the total capacity of the system.

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6. Other causes of inadequate cooling are dirty coils or filter. Dirt acts as insulation and is also serves as a restriction to the air flow.
7. The refrigeration load is not constant and varies. It is also affected by outside temperature, relative humidity, passenger load, compressor speed, the number of stops, etc.
8. The compressor will load or unload depending on operating conditions.

6.2 REFRIGERANT

The A/C system of this vehicle has been designed to use Refrigerant 134a as a medium. Regardless of the brand, only R-134a must be used in this system. The chemical name for this refrigerant is Ethane, 1, 1, 1, 2-Tetrafluoro.



DANGER

Refrigerant in itself is nonflammable, but if it comes in contact with an open flame, it will decompose.

6.2.1 Procurement

Refrigerant is shipped and stored in 30 and 100 pound (13,6 and 45 kg) metal cylinders. Approximately 24 pounds (10,9 kg) are used in the central system. If vehicle is equipped with an auxiliary A/C system, then approximately 5.5 lbs (2,5 kg) will be needed.

It will be impossible to draw the entire refrigerant out of the cylinder. However, the use of warm water when charging the system will assure the extraction of a maximum amount of refrigerant from the cylinder.

6.2.2 Precautions in Handling Refrigerant

1. Do not leave refrigerant cylinder uncapped.
2. Do not subject cylinder to high temperatures, do not weld or steam clean near system or cylinder.
3. Do not fill cylinder completely.
4. Do not discharge vapor into an area where a flame is exposed.
5. Do not expose the eyes to liquid refrigerant.

All refrigerant cylinders are shipped with a heavy metal screw cap. The purpose of the cap is to protect the valve and safety plug from damage. It is a good practice to replace the cap after each use of the cylinder for the same reason. If the cylinder is exposed to the sun's radiant heat pressure increase resulting may cause release of the safety plug or the cylinder may burst.

For the same reason, the refrigerant cylinder should never be subjected to excessive temperature when charging a system. The refrigerant cylinder should be heated for charging purposes by placing it in 125°F (52°C) water. Never heat above 125°F (52°C) or use a blowtorch, radiator, or stove to heat the cylinder. Welding or steam cleaning on or near any refrigerant line or components of the A/C system could build up dangerous and damaging pressures in the system.

If a small cylinder is ever filled from a large one, never fill the cylinder completely. Space should always be allowed above the liquid for expansion. Weighing cylinders before and during the transfer will determine the fullness of the cylinders.



WARNING

One of the most important precautions when handling refrigerant consists in protecting the eyes. Any liquid refrigerant which may accidentally escape is approximately -40°F (-40°C). If refrigerant comes in contact with the eyes, serious injury could result. Always wear goggles to protect the eyes when opening refrigerant connections.

6.2.3 Treatment in Case of Injury

If liquid refrigerant comes in contact with the skin, treat the injury as if the skin was frost-bitten or frozen. If liquid refrigerant comes in contact with the eyes, consult an eye specialist or doctor immediately. Give the following first aid treatment:

1. Do not rub the eyes. Splash eyes with cold water to gradually bring the temperature above the freezing point.
2. Apply drops of sterile mineral oil (obtainable at any drugstore) in the eyes to reduce the possibility of infection. The mineral oil will also help in absorbing the refrigerant.

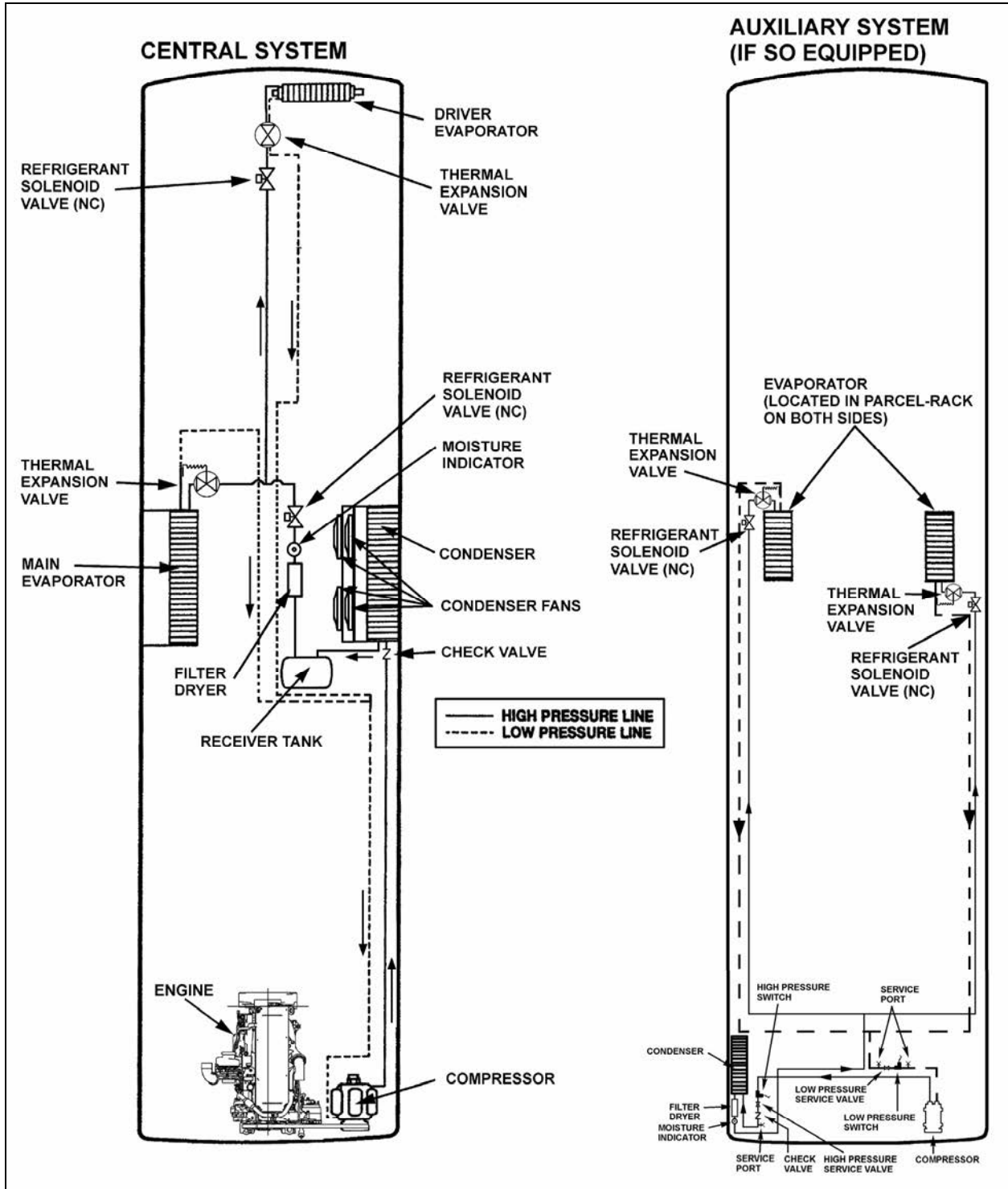


FIGURE 16: REFRIGERANT CIRCUIT (CENTRAL AND AUXILIARY SYSTEMS)

22313_1

Section 22: HEATING AND AIR CONDITIONING

6.2.4 Precautions in Handling Refrigerant Lines

1. All metal tubing lines should be free of kinks, because of the resulting restrictions on the flow of refrigerant. A single kink can greatly reduce the refrigeration capacity of the entire system.
2. The flexible hose lines should never be allowed to come within a distance of 2-½" (6,3 cm) from the exhaust manifold.
3. Use only sealed lines from parts stock.
4. When disconnecting any fitting in the refrigeration system, the system must first be discharged of all refrigerant. However, proceed very cautiously, regardless of gauge readings. If there happens to be liquid refrigerant in the line, disconnect fittings very slowly, keeping face and hands away so that no injury can occur. If pressure is noticed when fitting is loosened, allow it to bleed off very slowly.



WARNING

Always wear safety goggles when opening refrigerant lines.

5. In the event that any line is opened to the atmosphere, it should be immediately capped to prevent entrance of moisture and dirt.
6. The use of the proper wrenches when making connections on O-ring fittings is important. The use of improper wrenches may damage the connection. The opposing fitting should always be backed up with a wrench to prevent distortion of connection lines or components. When connecting the flexible hose connections, it is important that the swaged fitting and the flare nut, as well as the coupling to which it is attached, be held at the same time using three different wrenches to prevent turning the fitting and damaging the ground seat.
7. The O-rings and seats must be in perfect condition. The slightest burr or piece of dirt may cause a leak.
8. O-rings should be coated with refrigeration oil and installed on the line before the line is inserted into the fitting to prevent damaging the O-ring. If leaks are encountered at the couplings or connectors, no attempt should

be made to correct the leaks by tightening the connections beyond the recommended torque. The O-rings are designed to seal at the specified torque and overtightening the connection does not result in a satisfactory and permanently sealed connection. The connection must be disassembled and the cause of the leak (damaged O-ring, defective lines, etc.) corrected. Use new O-ring.

6.2.5 Auxiliary System Refrigerant Lines

1. From the inside of the coach, remove the mirror located inside the lavatory to access the Y connector separating the system two sides. Also a small access panel located in front of the lavatory entrance door, near the ceiling enables to reach the R.H. side supply and return line fittings.
2. The L.H. side supply and return line fittings are accessible by removing the rearmost overhead storage compartment separator.

6.3 PUMPING DOWN

This procedure is intended to reduce refrigerant loss, on central system only, by isolating it in the compressor and the receiver tank, as well as in their connecting line, in order to carry out repairs on other sections of the air conditioning system (lines and components).

NOTE

Before attempting any repair between compressor and receiver tank, use a recovery unit to remove refrigerant from the system.

NOTE

On vehicles equipped with an auxiliary A/C system, refer to "Sanden SD7 Service Manual".



WARNING

To prevent any injury, when air conditioning system must be opened, refer to previous paragraph "PRECAUTIONS IN HANDLING REFRIGERANT".



CAUTION


The filter dryer must be changed each time a line in the system is opened.

Procedure

1. Energize passengers 'section liquid solenoid valve.
2. Run the system for 10 minutes, shut it OFF, then close the receiver tank outlet valve by turning it clockwise, backseat the suction service valve on the compressor, install an appropriate pressure gauge set, and turn the valve forward ¼ turn to enable a visual check of the suction pressure.
3. Disconnect the "Low Pressure Switch" connector (mounted near the A/C compressor, and install a jumper wire.

NOTE

This jumper wire will allow the clutch to remain engaged after pressure drops below 15 psi (103,5 kPa).

4. Start the engine, press the "Passenger ON/OFF" switch then adjust (lower) temperature control  to maximum A/C.
5. Run the compressor until pressure reaches 1-2 psi (7-14 kPa).

NOTE

During this operation, care must be taken not to fill the receiver tank over the upper sight glass. If so, stop process immediately. Always allow refrigerant piping and units to warm up to the ambient air temperature before opening system or sweating will take place inside the lines.

6. Stop engine, and close compressor outlet valve by turning it clockwise until valve is properly seated.
7. Close compressor suction valve by turning it clockwise until it is properly seated.
8. Wait until pressure gauge reaches 1 to 2 psi (7 to 14 kPa). To accelerate procedure, lightly open compressor suction valve until pressure reaches this value.

6.4 ADDING REFRIGERANT (VAPOR STATE)

Use the suction service valve on the compressor to add a small quantity of refrigerant to the system. Backseat the valve and connect a charging line from the refrigerant cylinder to the valve. Tighten connection at level of refrigerant cylinder and open tank end slightly to purge air from the charging line. Tighten the charging line at the compressor. Screw in the stem of suction valve approximately two turns. Start the engine and run at fast idle. Add sufficient refrigerant to bring the level in lower sight glass of receiver tank to mid-point. Always charge the system with the cylinder upright and the valve on top to avoid drawing liquid out of the cylinder.

6.5 EVACUATING SYSTEM

1. Open both receiver valves by turning "out" (normal position).
2. Remove the caps from the two 90° adapters on the suction, discharge valves and connect two hoses to the vacuum.
3. Place the two compressor valves, suction and discharge, in neutral position by turning each one 3 to 4 turns "in" from the "out" position.
4. Open the solenoid valve by energizing or manually bypass.
5. Start the vacuum pump. Open the large (suction) shutoff valve and close the small vacuum gauge valve.
6. The pressure will drop to approximately 29 inches vacuum (14.2 psi or 97,9 kPa) (the dial gauge only gives a general idea of the absolute system pressure).
7. Backseat the compressor valves by turning "out" all the way.
8. Shut down the vacuum pump.
9. Remove the hoses.
10. Reinstall the caps at the suction valve take-off points.

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6.5.1 Double Sweep Evacuation Procedure

1. Remove any remaining refrigerant from the system using a refrigerant recovery machine.
2. Connect the evacuation manifold, vacuum pump, hoses and micron gauge to the unit.
3. With the unit service valves closed (back seated) and the vacuum pump and the thermistor valves open, start the pump and draw the manifold and hoses into a very deep vacuum. Shut the vacuum pump off and see if the vacuum holds. This is to check the setup for leaks.
4. Midseat the system service valves.
5. Open the vacuum pump and the thermistor valves. Start the pump and evacuate to a system pressure of 2000 microns.
6. Close the vacuum pump and the thermistor valves, turn off the vacuum pump (closing the thermistor valve protect the valve from damage).
7. Break the vacuum with clean refrigerant (or dry nitrogen) and raise the pressure to approximately 2 PSIG. Monitor the pressure with the compound gauge.
8. Remove the refrigerant with the recovery machine.
9. Repeat steps #5 – 8 one time.

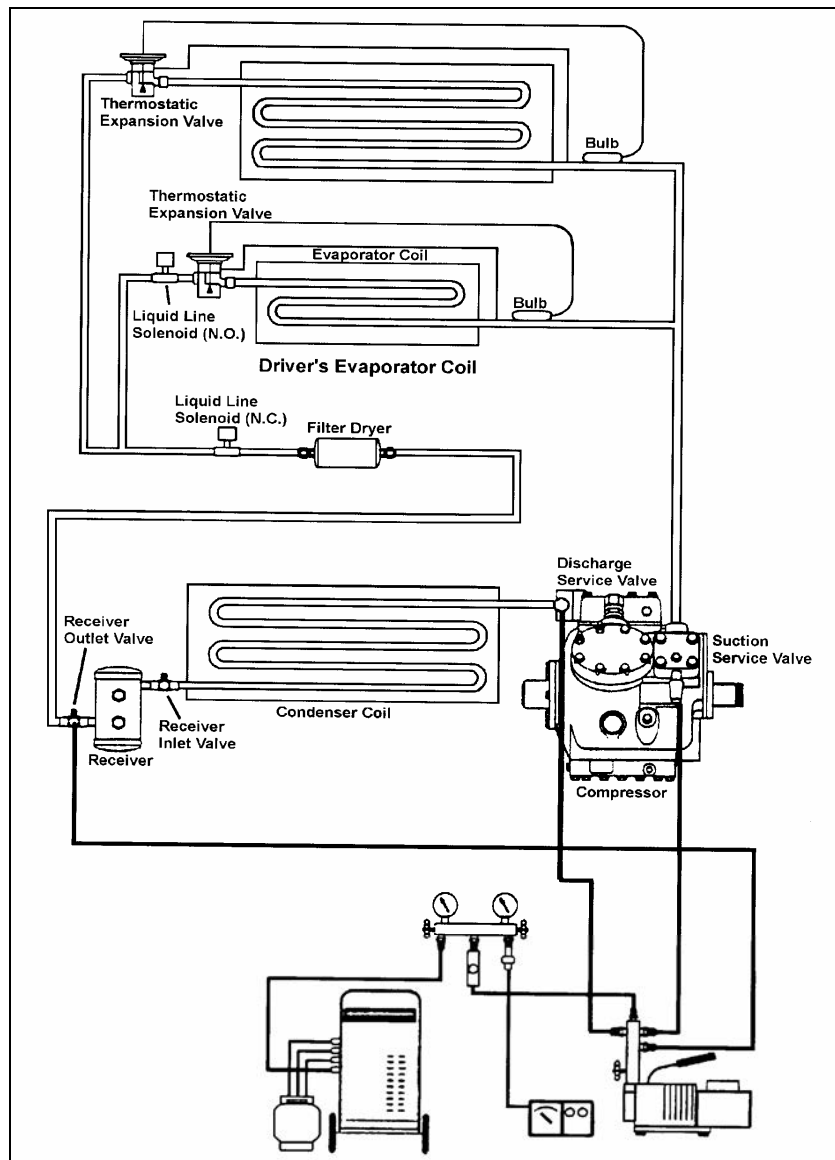


FIGURE 17: DOUBLE SWEEP EVACUATION SET-UP

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10. After the second "sweep", change the filter drier (if you have not done so) and evacuate to 500 microns.
11. Evacuating the system below 500 microns on systems using the Carrier 05G compressor may risk drawing air into the system past the carbon shaft seal.
12. Check to insure that vacuum holds. (If the pressure continues to rise, it indicates a leak or moisture in the system).
13. Charge the system with the proper amount of refrigerant using recommended charging procedures.

NOTE

This method will aid in preventing unnecessary system failures by ensuring that the refrigeration system is free of contaminants.

6.6 CHARGING SYSTEM

When a system has been opened or if there are any questions about the air or moisture in the system, evacuate the system. Charging of an evacuated system may be accomplished by forcing liquid R-134a directly into the receiver tank. This may be accomplished by placing the refrigerant cylinder upside down on a scale with the valves at the bottom. This ensures that only liquid will enter the receiver tank.

When charging an empty system, weigh the amount of refrigerant put into the system. This will eliminate any possibility of overfilling. A nominal charge requires 24 pounds (10,9 kg). If the vehicle is equipped with an auxiliary system, a full charge requires 5.6 lbs (2,6 kg).

1. Backseat the two compressor shutoff valves ("out").
2. Install the test gauges at the shutoff valves noting that the 400 psi (2758 kPa) gauge is connected to the discharge.
3. Turn in the two shutoff valves 3 to 4 turns.
4. Open the lower receiver valve by turning "out" all the way.
5. Backseat the upper receiver valve by turning out all the way.
6. Remove the cover cap from the service fitting in the top receiver valve.

7. Attach a charging hose to the R-134a tank. Open the tank valve slightly permitting R-134a to escape thus purging the hose of air.
8. Connect the charging hose to the service fitting.
9. Open the R-134a tank valve.
10. To build up pressure in the receiver tank, heat the receiver tank with a heating blanket.
11. Turn in the upper receiver valve several turns. The R-134a will now enter the system.
12. The proper charge of R-134a is 24 lbs (10.89 kg). When the scale indicates this amount of charge, backseat the receiver valve and close the R-134a tank valve.
13. Disconnect the charging hose. Replace the cover caps.
14. The system is now ready for operation.



CAUTION

The evacuation of the system must be made by authorized and qualified personnel only. Refer to local laws for R-134a recuperation.

6.7 REFRIGERANT SYSTEM CLEAN-OUT AFTER COMPRESSOR FAILURE

Although the vast majority of reciprocating refrigerant compressors manufactured today are extremely reliable, a small percentage do fail. These failures usually result in minor or extensive system contamination depending on the severity of the failure. When an open type compressor becomes damaged internally, this provokes small particles of bearings, steel, brass, copper, and aluminum and, in severe cases, carbonized oil, which could contaminate the system. To prevent repeated failures, the problem which caused the failure should be corrected, and depending upon the severity of the failure, the system should be thoroughly cleaned out using one of the clean-out procedures mentioned.

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6.7.1 Determining Severity of Failure

The severity of compressor failure can be categorized as minor or major. A failure is considered minor when the contamination is limited to the compressor with little or no system contamination. A major failure, or burnout, results in extensive system contamination as well as compressor damage. Extensive system contamination can be determined by withdrawing a small sample of compressor oil and checking its color, odor and acidity. A Virginia Chemical "TKO" one step acid test kit is one of several compressor oil test kits that may be used. A high acid content would indicate a major failure or burnout. A small amount of refrigerant gas may be discharged. A characteristic burned odor would also indicate severe system contamination.

6.7.2 Clean-out after Minor Compressor Failure

1. Be sure to correct the problem which caused the failure.
2. Change liquid line filter dryer.
3. Run the unit for 2 hours on high speed cool only.
4. Check compressor oil level to ensure compressor is not overcharged with oil. Sometimes a significant amount of oil is pumped out of the compressor to other parts of the system when a compressor fails. This oil will return to the replacement compressor when it is started, causing an overcharge of oil in the sump of the replacement compressor. In this case, it is important that the oil level be adjusted to the proper level.
5. Withdraw a sample of the compressor oil and check its color, odor, and acidity, using instructions supplied above. If the oil is contaminated, change the oil and filter dryer, and repeat the procedure until the system is clean.

6.7.3 Clean-out After Major Compressor Failure


1. Reclaim the refrigerant into a refrigerant bottle through a filter dryer to filter out contaminants.
2. Remove the failed compressor and repair it if possible.

3. Install new or repaired compressor.
4. Change the filter dryer.
5. Circulate clean R-134a or nitrogen with the reclaimer to clean out many of the contaminants collected in the coil valves, TXV (Thermal Expansion Valve), solenoid valves, check valves, and any other mechanical component that may have collected contaminants.
6. Evacuate and charge the system normally.
7. Run the unit for 8 hours and monitor the pressure drop across the filter dryer. Also check the liquid line dryer for signs of restriction. If the pressure drop across the filter dryer exceeds 12 to 14 psig (82,75 to 96,5 kPa) with a 40°F (5°C) evaporator coil temperature, stop the unit and change the liquid line and suction line filter dryer. After 4 or 5 hours of operation, stop the unit and replace the filter dryer.
8. After 8 hours of operation, stop the unit and remove a sample of the compressor oil and check its color, odor, and acidity, using instructions supplied above. If the oil is contaminated, replace the oil and repeat step 7. If the oil is not contaminated, change the filter dryer again and replace the moisture-liquid indicator.
9. After approximately 7 days of operation, recheck the compressor oil for cleanliness and acidity.

7. CENTRAL A/C SYSTEM COMPONENTS

7.1 COMPRESSOR (CENTRAL SYSTEM)

7.1.1 Belt Replacement

**DANGER**

Set the battery master switch to the "Off" position. For greater safety, set the engine starter selector switch in engine compartment to the "Off" position.

1. Open engine compartment rear doors and locate the belt tensioner pressure releasing valve (Fig. 18), mounted above the engine R.H. side door next to the air pressure regulator, then turn handle clockwise in

order to release pressure and tension on belts.

2. Remove the radiator fan driving mechanism belt (Refer to Section 05: Cooling).
3. Slip the old A/C compressor belts off and the new ones on.
4. Reset belt tensioner pressure releasing valve (Fig. 18) to 50 psi (345 kPa) to apply tension on the new belts as explained in Section 12.

NOTE

Both belts must always be replaced simultaneously to ensure an equal distribution of load on each of them.

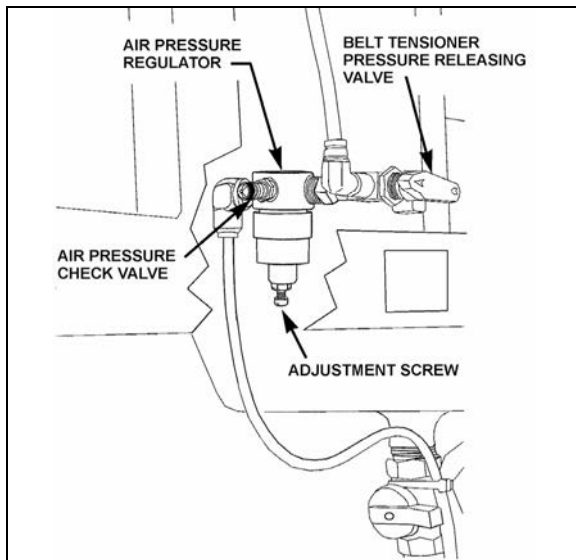


FIGURE 18: AIR PRESSURE REGULATOR 12200

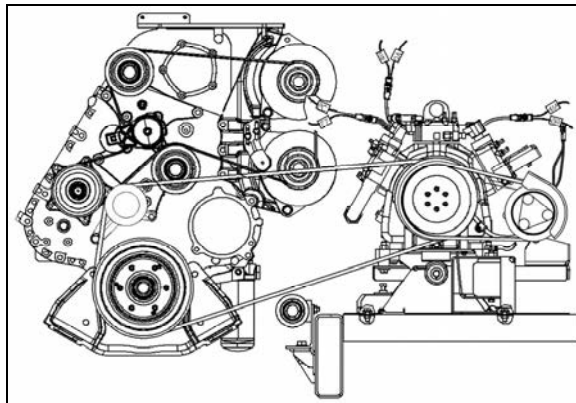


FIGURE 19: BELTS ARRANGEMENT (DDC S60 ENGINE) 22347

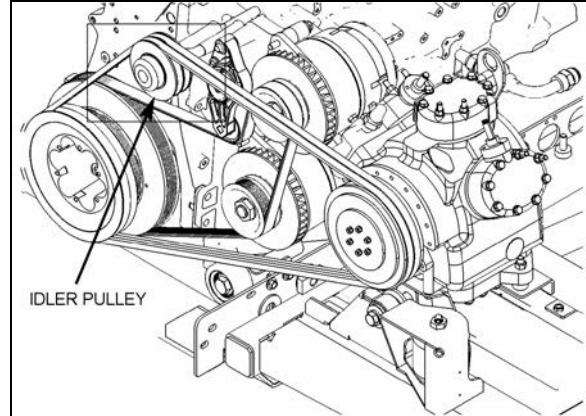


FIGURE 20: BELTS ARRANGEMENT (VOLVO D13 ENGINE)

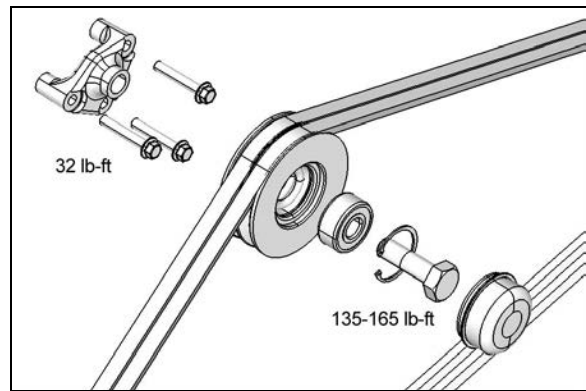


FIGURE 21: IDLER PULLEY INSTALLATION ON VOLVO D13 ENGINE

7.1.2 Belt Play

After belt replacement or during normal maintenance, belt play between pulleys and belt must be checked to ensure proper operation. Refer to figure 22 for proper plays.

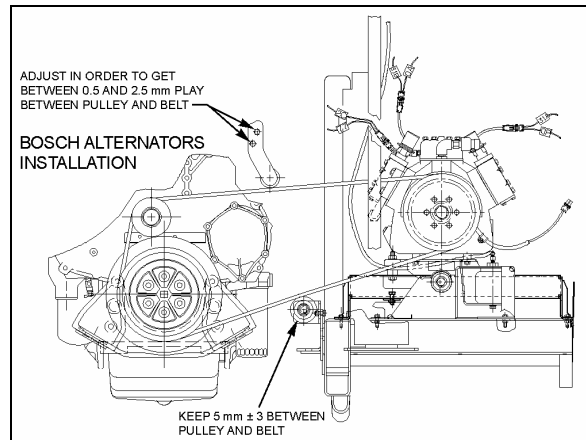


FIGURE 22: BELT PLAY 22288

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7.1.3 Pulley Alignment

In order to avoid skipping, disengagement and a premature wear of compressor belt, it is necessary to align compressor pulley with the crankshaft pulley. Before performing the following procedure, release air from belt tensioner bellows by means of the air pressure releasing valve. After completing these procedures reset belt tensioner air pressure regulator to 50 psi (345 kPa).

7.1.4 Longitudinal Compressor Alignment

1. Rest an extremity of a straight edge of approximately 46 inches (117 cm) against the upper part of the outer face of crankshaft pulley, positioning the other end close to the compressor clutch pulley (Figs. 23 & 24).
2. Check the distance between each extremity of straight edge (1. Fig. 23) and the first drive belt. If they are different, loosen the compressor support bolts and with a hammer, knock support to slide it in order to obtain the same distance; then tighten bolts.

7.1.5 Horizontal Compressor Alignment

1. Rest an extremity of the straight edge against the upper part of the outer face of compressor pulley, positioning the other end close to the crankshaft pulley.
2. Check the distance between each extremity of straight edge (1, Fig. 24) and drive belt. If they are different, loosen the pillow block compressor bolts and with a hammer, knock compressor pillow block to slide it, in order to obtain the same distance; then tighten bolts.

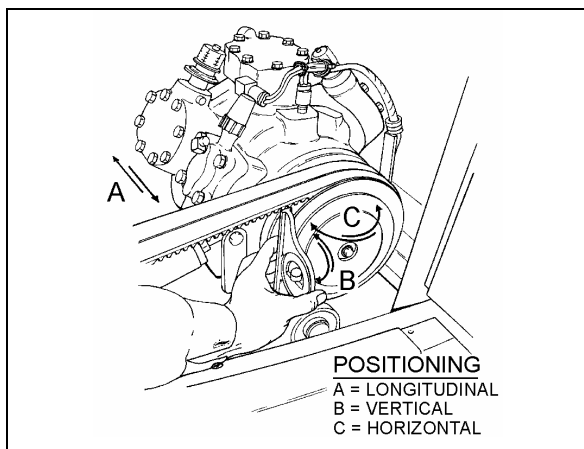


FIGURE 23: COMPRESSOR ALIGNMENT

22072

7.1.6 Vertical Compressor Alignment

Rest a short "angle and level indicator" on the outer side face of the crankshaft pulley, adjust the level indicator inclination at 0° and check if the compressor pulley is at same angle (Fig. 23). If it is not the same, shim under the appropriate pillow block in order to obtain the correct angle.

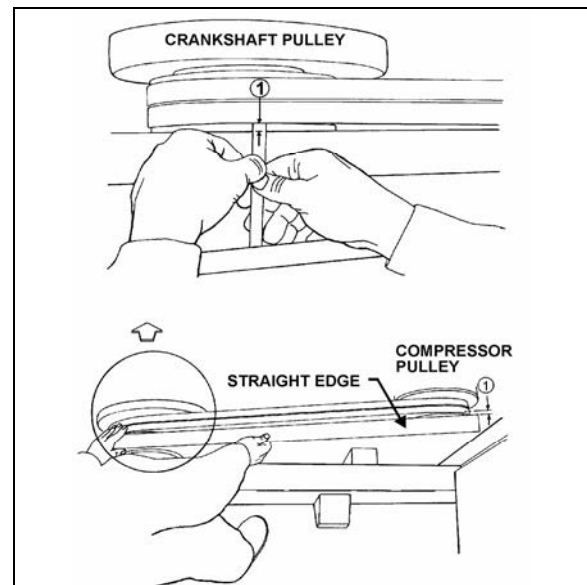


FIGURE 24: COMPRESSOR ALIGNMENT

22040

7.1.7 Compressor Maintenance

For the maintenance of the A/C compressor, see the *Carrier Compressor "WORKSHOP MANUAL" for MODEL 05G TWIN PORT COMPRESSOR* included at the end of this section.



CAUTION

Use only Castrol SW 68 (POE) oils with refrigerant 134a.

7.1.8 Troubleshooting Guide

A preliminary check may be made by simply feeling the cylinder heads with the unit in operation at ambient temperatures of 35°F (2°C) and over. The cylinder heads are internally divided into suction and discharge valves. The lower half of the cylinder head is the suction side, and it should be relatively cool to the touch, as opposed to the hot upper discharge side. If a valve plate or head gasket is blown, or a compressor unloader is stuck open, partially

compressed refrigerant vapor will be circulated between the suction and discharge sides of the head. The affected cylinder head will then have a relatively even temperature across its surface and be neither as hot as the normal discharge temperature nor as cool as the normal suction temperature.

Blown Head Gaskets

Symptom:

- * Loss of unit capacity at low temperature.
- * Even cylinder head temperature.

Cause:

- * Improperly torqued cylinder head bolts.
- * Improperly positioned gasket at assembly.
- * Warped cylinder head.
- * Severe liquid refrigerant floodback.

Blown Valve Plate Gaskets

Symptom:

- * Loss of unit capacity at medium and low temperatures.
- * Very hot cylinder head surface.
- * Higher than normal suction pressure.

Cause:

- * Improperly torqued cylinder head bolts.
- * Severe liquid refrigerant floodback.
- * Oil slugging caused by an overcharge of oil or flood starts.
- * Discharge valves not seated properly (liquid drainback during shutdown).

Broken Suction Valves

Symptom:

- * Loss of unit capacity at all temperatures.
- * Compressor unable to pull extremely low vacuum with suction service valve frontseated.

Cause:

- * Repeated liquid refrigerant floodback.
- * Flooded starts.

- * Overcharge of oil.
- * Discharge valves not seated properly (liquid drainback during shutdown).
- * Expansion valve not controlling properly.

Unloader Valve Stuck Open

Symptom:

- * Loss of unit capacity at all temperatures.
- * Higher than normal suction pressure.
- * Even cylinder head temperature.

Cause:

- * Unloader body stem bent.
- * Foreign material binding unloader piston or plunger.

7.2 MAGNETIC CLUTCH

Refer to Carrier service information entitled "Housing-Mounted Electric Clutch" at the end of this section for the description and maintenance of the magnetic clutch.

7.3 EVAPORATOR MOTOR

The evaporator motor is installed in the evaporator compartment (L.H. side of vehicle) (Fig. 25). It is a 27.5 volt, 2 HP (1.5 kW) motor which activates a double blower fan unit.

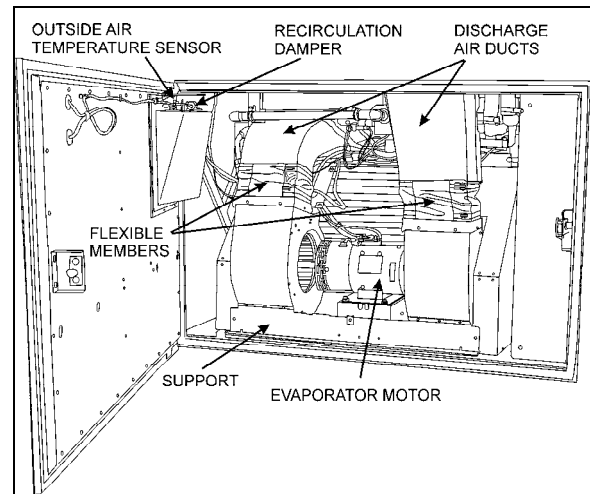


FIGURE 25: EVAPORATOR COMPARTMENT

22314

7.3.1 Removal

1. Set the battery master switch (master cut-out) to the "OFF" position.

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2. Open the last L.H. side baggage compartment door. Pull the black release button located on the L.H. side in order to unlock and open the evaporator compartment door.
3. Remove the evaporator motor and coil access panel.
4. Identify the L.H. side discharge duct inside compartment and remove the Phillips head screws retaining the flexible member to duct.
5. Repeat step 4 for the R.H. side air duct.
6. Disconnect the electrical motor speed control connections on the motor plate.
7. From under the vehicle, remove the eight bolts retaining the evaporator fan motor support. Remove the complete unit from the evaporator compartment (Fig. 26 & 27).

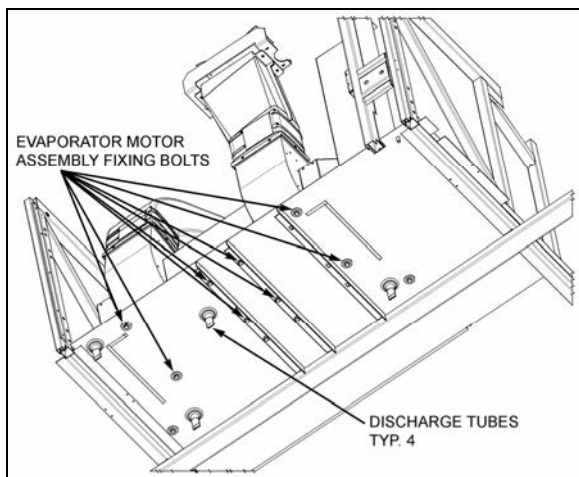


FIGURE 26: EVAPORATOR MOTOR ASSY FIXING BOLTS 22315



CAUTION

Never support evaporator motor by its output shafts while moving it.

8. On a work bench, unscrew the fan square head set screws, the Phillips head screws retaining cages to support and slide out the assemblies from the evaporator motor output shaft.

7.3.2 Installation

To reinstall the evaporator motor, reverse "Evaporator Motor Removal" procedure.

7.3.3 Checking Operation of Brush in Holder

Lift brush slightly 1/8 inch (3 mm) and release it. Brush must produce a dry noise.

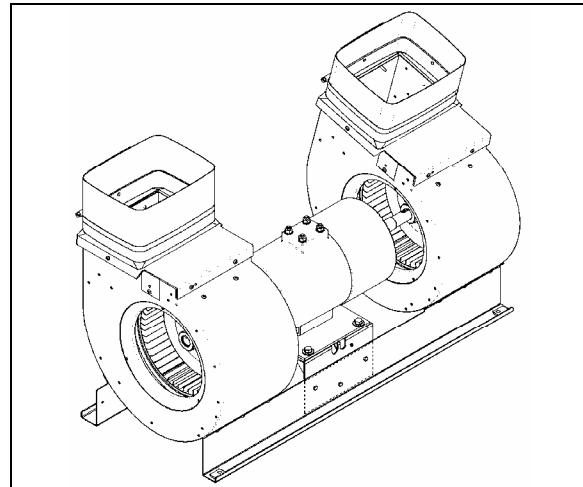


FIGURE 27: EVAPORATOR MOTOR ASSEMBLY 22316

7.3.4 Brush Wear Inspection and Replacement



CAUTION

Only use replacement brushes recommended by the manufacturer. Not doing so will void warranty.

Replace the brushes if less than 3/4 inch (19 mm). New brush length is 1-1/4 inch.

To replace brushes, proceed as follows:

1. Set battery master switch to the "OFF" position.
2. Remove the protective screen band from the motor housing by pulling down the spring loaded fastener.
3. Lift the spring, remove and replace brushes as per the following procedure: "SEATING BRUSHES".
4. Reverse installation procedure.

7.3.5 Seating Brushes

Grinding consists in giving to the seating face of a new brush the exact curve of the commutator or ring so that good mechanical and electric contact of the brush is ensured upon startup.

For best results, remove oil and grease from commutator before applying brush seater.

NOTE

The new motor brushes are provided with preformed seating face, i.e. with curved face machined with the required radius. This curve is only approximate and does not exempt further grinding. The advantage of preforming is to appreciably shorten the time required for grinding.

Grinding is generally done on the machine itself, in accordance with various processes' and conformably to the importance and the type of machines:

- a) Grinding with abrasive cloth medium grit (sandpaper) (grit 60) applied to a part of the commutator by hand. The new brushes installed in their brush holder and pressing against the cloth, one makes oscillate the rotor until complete grinding of the seating faces (Refer to figure 28). It is necessary to avoid raising the cloth under the brushes otherwise it would result, after grinding, to reduce and badly definite surfaces (Refer to figure 29).

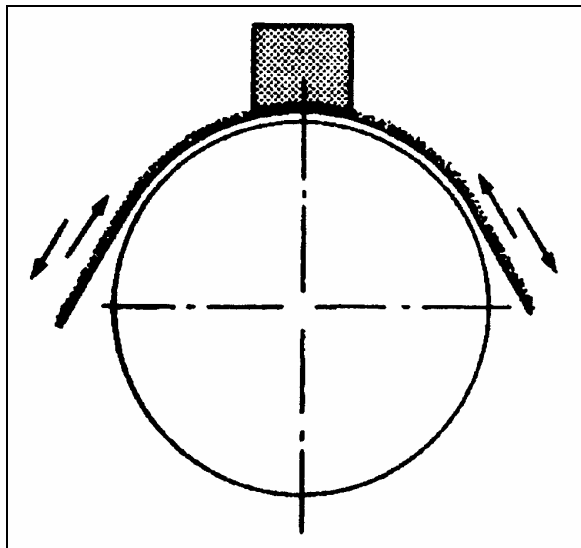


FIGURE 28: PROPER GRINDING TECHNIQUE 22317

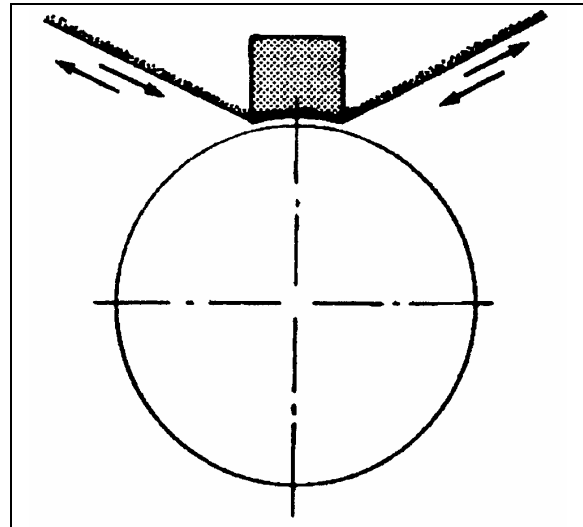


FIGURE 29: IMPROPER GRINDING TECHNIQUE 22318



CAUTION

If grinding with a honing stone, you must disconnect the time delay in order to keep the motor in 1st speed. If you prefer, you may also install a jumper on the evaporator motor between terminal E2 and A1 to bypass relay R60 and keep the motor in 1st speed as well.

- b) Grinding with the honing stone is always done under no or much reduced voltage. Dust particles act like abrasive and wear down the brushes exactly with the profile of the commutator. **Do not misuse this method because grinding removes some metal from the commutator. It is applicable only to grinding requiring only reduced wear of the brushes.**

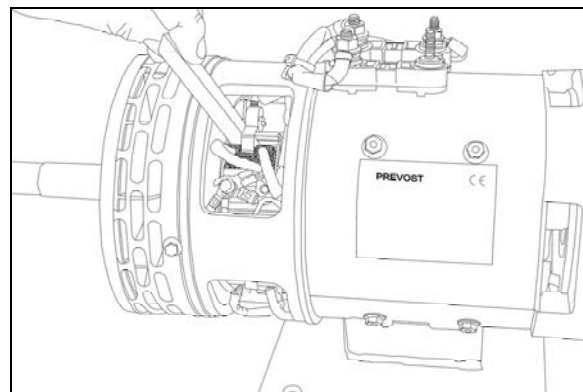


FIGURE 30: GRINDING WITH THE BRUSH SEATER STONE 22319

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Repeat method a or b until brushes are fully seated. **Seating surface of the brush must be no less than 80% of the face (Refer to figure 31).**

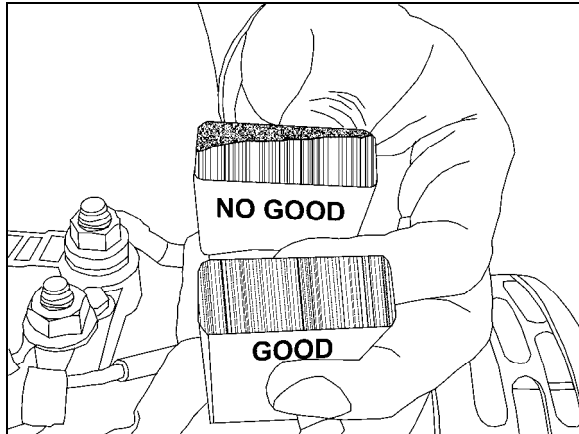


FIGURE 31: SEATING SURFACE OF THE BRUSH 22320



CAUTION

After grinding with the sandpaper or the honing stone, it is necessary to remove the brushes from the brush holders and vigorously clean with an air gun the commutator and the seating faces of the brushes to eliminate abrasive dust and dust from brushes.



DANGER

Use a dust mask to prevent inhalation of dust particles. Protect against electrical shock when working on energized equipment. Protect against falling or slipping when working on rotating equipment.



CAUTION

If grinding is not carried out or is carried out in an incorrect way, the brush may seat against a restricted zone only, which will support the entire load. The consequences risk to be serious for the commutator as for the brush and to seriously damage the motor.

After grinding is completed, it is necessary to check the evaporator motor amperage in 1st speed and in 2nd speed. **Make sure that the evaporator compartment door is closed and that the reading is 30 A ± 3 in 1st speed. Confirm that the reading is 64 A ± 4 (MAX 68 A) in 2nd speed.**

7.3.6 Brush Holder Adjustment

NOTE

The brush holders are mounted on a support that can rotate. Rotating that rocker ring will move all the brush holders at the same time.

1. Remove the screws securing the grid and remove the grid. Locate the 2 bolts fixing the mechanism permitting the rotation of the brush rocker ring.
2. Loosen (do not remove) the bolts just enough to release the mechanism.
3. Move gently the exposed brush holder in order to have **30 A ± 3 in 1st speed and 64 A ± 4 in 2nd speed when the door is closed** and a maximum distance of 10 mm (3/8 inch) between the brush face and a reference line passing through the center of the 2 bolts on the motor housing.



CAUTION

If rotating the rocker ring is necessary, it is preferable to mark off the angular position of the rocker ring before unfastening the bolts fixing the mechanism in order to get back to the factory setting at the end of the operation.

NOTE

Take a final reading in 1st and in 2nd speed after tightening the brush holder bolts. The amperage may have changed.

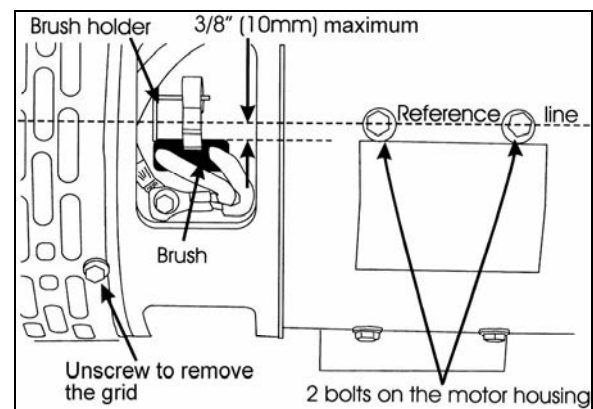


FIGURE 32: EVAPORATOR MOTOR

22321

**CAUTION**

To avoid damaging the motor, make sure all vehicle doors are closed when taking the readings.

7.3.7 Checking Commutator

The surface must be polished. A brown-black colored surface is normal and indicates a good switching. Ensure there is no evidence of arcing or metal chips.

7.4 CONDENSER

The central A/C system condenser coil is hinge mounted on the R.H. side of the vehicle on the A/C condenser door (Fig. 34). The condenser coil for vehicles equipped with an auxiliary A/C system is mounted on the outer face of engine radiator. Since condenser's purpose is to dissipate heat from the hot refrigerant, it is important to keep the cooling coils and fins clean. A clogged coil will cause high discharge pressure and insufficient cooling.

7.4.1 Condenser Fan Motors

Four brushless fan motors (Fig. 33), 28.5 V - (0.6 HP - 0.42 kW) are installed in the condenser compartment on R.H. side of vehicle in order to ventilate the condenser coil. They are mounted on a support, fastened to the door. The fans pull outside air through the condenser coil and discharge it through an opening at bottom of compartment. When temperature drops inside condenser, the pressure in the refrigerant line also drops and it is, therefore, no longer required to cool condenser. Consequently, when pressure drops to 130 psi, the motors will run at low speed and if the pressure continues to drop to 90 psi, a pressure switch stops the motors so that fans do not operate needlessly. When pressure rises to 120 psi, the pressure switch reactivates the motors. If the pressure rises to 170 psi, the motors will switch to high speed.

For details about electrical wiring, refer to "A/C and Heat system" in the master wiring diagram.

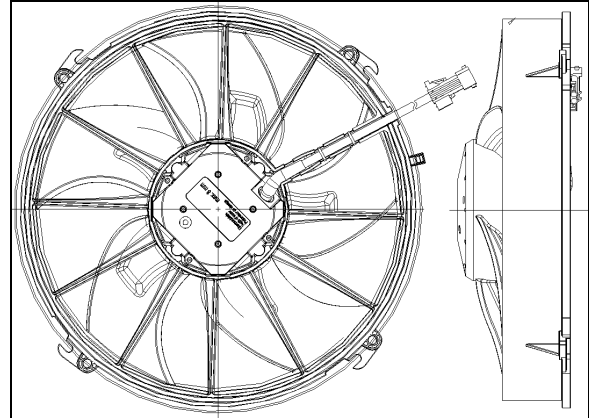


FIGURE 33: CONDENSER FAN MOTOR

22322

7.4.2 Condenser Fan Motor Removal

1. Set the battery master switch to the "Off" position.
2. Disconnect wiring from terminals on motor. Tag each wire to aid in identification at time of reconnection.
3. Remove the four "Phillips" head screws retaining the fan motor assembly to the mounting support.
4. Remove the motor.

7.5 RECEIVER TANK

The receiver tank is located in the condenser compartment (Fig. 34). The function of the receiver tank is to store the liquid refrigerant. During normal operation, the level of the refrigerant should be approximately at the mid-point of the lower sight glass.

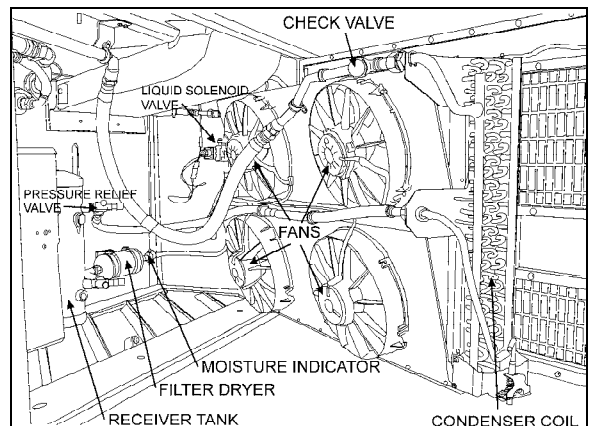


FIGURE 34: A/C CONDENSER COMPARTMENT

22323

In case of extreme pressure there will be a rise in the liquid receiver tank. A pressure relief valve will break at 450 psi (3103 kPa) and relieve the receiver tank pressure.

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The receiver tank incorporates an inlet valve on the inlet side (upper section) which allows the tank to be isolated or serviced. An outlet valve on the outlet side (lower section) permits complete isolation from the rest of the system.

7.6 FILTER DRYER

A filter dryer, also located in the condenser compartment, is installed on the liquid refrigerant line after the receiver tank. It is used to absorb moisture and foreign matter from refrigerant before it reaches the expansion valves.


The filter should be replaced if the system has been opened or after a prolonged exposure, when the moisture indicator sight glass turns to pink.


A filter dryer, located close to the engine compartment L.H. side rear door, is installed on vehicles equipped with an auxiliary A/C system. Its function is similar to that of filter used on main systems. Replace only when system is opened or a problem occurs.

7.6.1 Replacement

The filter is of the disposable type. When replacement is required, remove and discard the complete unit and replace with a new unit of the same type according to this procedure:

1. Isolate the refrigerant in the receiver tank by following the "Pumping Down" procedure explained in this section
2. Change the filter dryer as a unit.
3. Add a small quantity of refrigerant R-134a to the low side of the system. Check for leaks. Return the system to normal operation.

	CAUTION
<p>Do not use carbon tetrachloride or similar solvents to clean parts. Do not use steam guns. Use mineral spirits or naphtha. All parts should be thoroughly cleaned. Use a stiff brush to wash dirt from grooves, holes, etc.</p>	

	DANGER
<p>Cleaning products are flammable and may explode under certain conditions. Always handle in a well ventilated area.</p>	

7.6.2 Moisture Indicator

The moisture sensitive element consists of a color changing ring which is reversible from pink to blue and vice versa as the moisture content in the refrigerant changes. Pink indicates a wet refrigerant, light violet (caution) and blue indicates a dry refrigerant.

Since temperature changes affect the solubility, color change will also vary with the refrigerant temperature. The above table shows the color change for R-134a at various moisture levels and liquid line refrigerant temperatures.

COLOR INDICATOR			
TEMPERATURE	BLUE (ppm)	LIGHT VIOLET (ppm)	PINK (ppm)
75°F (24°C)	Below 5	5-15	Above 15
100°F (38°C)	Below 10	10-30	Above 30
125°F (52°C)	Below 15	15-45	Above 45
p.p.m.= parts per million (moisture content)			

A moisture level of less than 15 p.p.m. for R-134a indicated in the blue color range of the above table is generally considered dry and safe. A color indication of light blue to light violet indicates the caution range of moisture level. For positive protection, the drying of the system should be continued until the color of the element turns to deep blue.

The liquid refrigerant is readily visible through the center opening of the moisture element where the presence of bubbles indicates a shortage of refrigerant or restriction in line.

Moisture is one of the main causes of chemical instability or contamination in air conditioning systems. If moisture is present, it can corrode the valves, condenser and evaporator coils, compressor and other components causing a malfunction and eventual failure of the system. Uncontrolled moisture in the system can result in very expensive multiple component replacements if not corrected at an early stage. The moisture indicator permits an early detection of moisture in the system and when corrected by a desiccant charge, system contamination is greatly minimized.

7.7 LIQUID REFRIGERANT SOLENOID VALVE

The flow of liquid refrigerant to the driver's and main evaporators is controlled by a normally-closed solenoid valve. The driver's liquid solenoid valve is located on the ceiling of the spare wheel and tire compartment and is accessible through the reclining bumper.

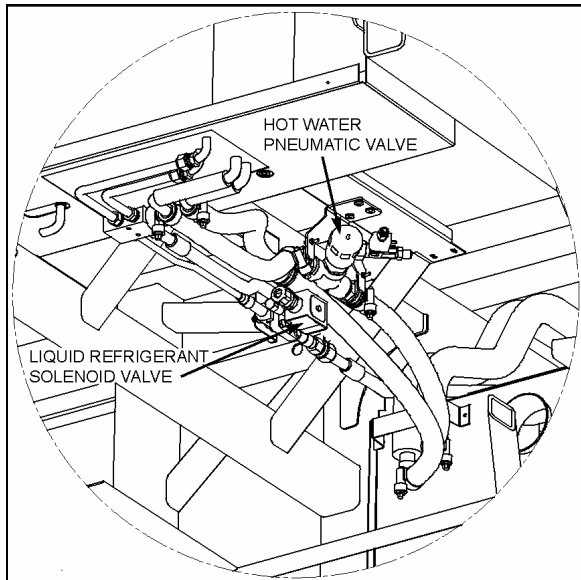


FIGURE 35: DRIVER'S EVAPORATOR LIQUID SOLENOID VALVE 22324

NOTE

An identical refrigerant solenoid valve is used on the auxiliary A/C system and is located near the auxiliary A/C unit.

7.7.1 Manual Bypass

This type of solenoid valve is equipped with a manual operating stem. The 3/16" square stem located on the bonnet is exposed when the seal cap is removed. To manually open valve, turn stem 1/2 turn counterclockwise. To manually close valve, turn stem clockwise until tight against seat. Manual stem must be in closed position for automatic electric operation.

7.7.2 Coil Replacement

1. Disconnect connector from the coil connector.
2. Take out the retaining screw at the top of the coil housing. The entire coil assembly can then be lifted off the enclosing tube.

3. Place the new coil and yoke assembly on the enclosing tube. Lay data identification plate in place.
4. Insert the coil retaining screw, rotate housing to proper position and tighten screw securely.
5. Connect connector from coil connector.

7.7.3 Valve Disassembly

1. Remove the coil as stated previously.
2. Pump down the system as stated earlier in this section.
3. Remove the four socket head screws which hold the body and bonnet together (Fig. 36).
4. Carefully lift off the bonnet assembly (upper part of the valve) so that plunger will not fall out. The diaphragm can now be lifted out.

NOTE

The above procedure must be followed before brazing solder-type bodies into the line.



CAUTION

Be careful not to damage the machined faces while the valve is apart.

7.7.4 Valve Reassembly

1. Place the diaphragm in the body with the pilot port extension up.
2. Hold the plunger with the synthetic seat against the pilot port.
3. Make sure the bonnet O-rings are in place. Lower the bonnet assembly over the plunger, making sure that the locating sleeve in the bonnet enters the mating hole in the body.

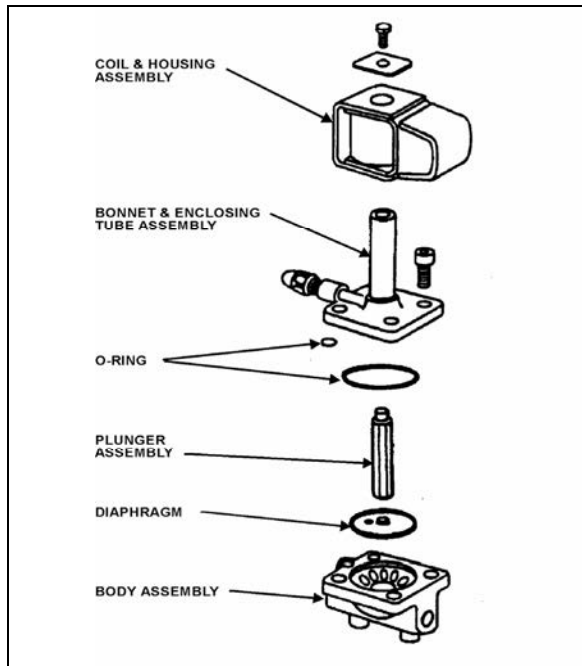


FIGURE 36: REFRIGERANT SOLENOID VALVE 22044

4. Insert the four socket head screws and tighten evenly.
5. Replace the coil as stated previously.
6. Add a small quantity of refrigerant R-134a to the low side of the system. Check for leaks. Return the system to normal operation.

7.8 EXPANSION VALVE

The expansion valve for the central system is a thermo-sensitive valve with a remote control bulb head attached to the evaporator outlet line and is accessible by the evaporator coil access door (Fig. 14 & 37). The valve regulates the flow of refrigerant liquid into the evaporator coils and is controlled by the suction gas temperature leaving the evaporator. The bulb head senses the refrigerant gas temperature as it leaves the evaporator. High temperature will cause expansion and pressure on the power head and spring. Such action causes the assembly valve to open, allowing a flow of refrigerant liquid into the evaporator.

The remote bulb and power assembly is a closed system. The pressure within the remote bulb and power assembly corresponds to the saturation pressure of the refrigerant temperature leaving the evaporator and moves the valve pin in the opening direction. Opposed to this force, on the under side of the diaphragm and acting in the closing direction, is the force exerted by the superheat spring. As the

temperature of the refrigerant gas at the evaporator outlet increases above the saturation temperature corresponding to the evaporator pressure, it becomes superheated. The pressure thus generated in the remote bulb and power assembly surpasses the combined pressures of the evaporator pressure and the superheat spring, causing the valve pin to move in the opening direction. Conversely, as the temperature of the **refrigerant** gas leaving the evaporator decreases, the pressure in the remote bulb and power assembly also decreases and the combined evaporator and spring pressures cause the valve pin to move in the closing position.

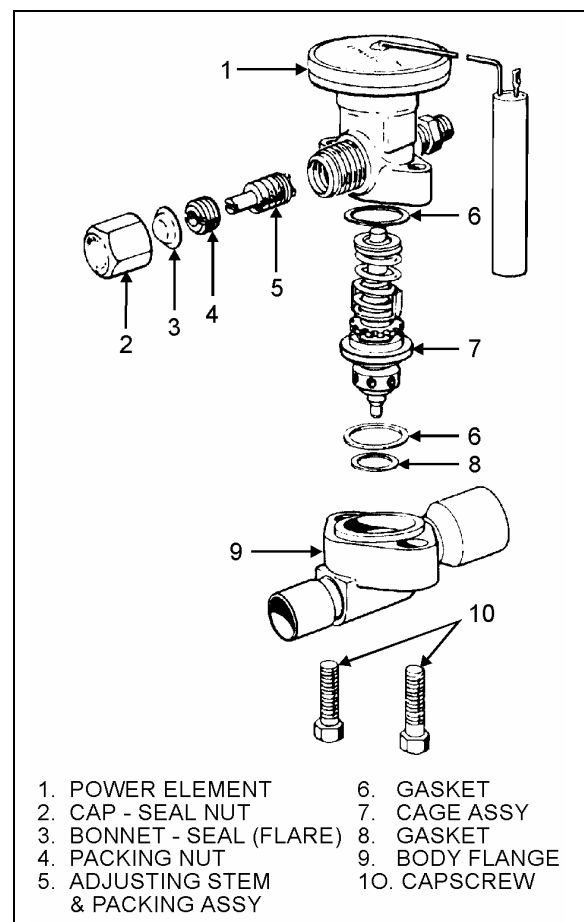


FIGURE 37: EXPANSION VALVE 22045

As the operating superheat is raised, the evaporator capacity decreases, since more of the evaporator surface is required to produce the superheat necessary to open the valve. It is obvious, then, that it is most important to adjust the operating superheat correctly and that a minimum change in superheat to move the valve pin to full open position, is of vital importance because it provides savings in both initial

evaporator cost of operation. Accurate and sensitive control of the refrigerant liquid flowing to the evaporator is necessary to provide maximum evaporator capacity under load conditions. The spring is adjusted to give 12 to 16° F (-11.1 to -8.8° C) of superheat at the evaporator outlet.

This ensures that the refrigerant leaving the evaporator is in a completely gaseous state when drawn into the suction side of the compressor. Liquid would damage the compressor valve, piston and heads if allowed to return in the suction line.

A vapor is said to be superheated when its temperature is higher than the saturation temperature corresponding to its pressure. The amount of the superheat is, of course, the temperature increase above the saturation temperature at the existing pressure.

As the refrigerant moves along in the evaporator, the liquid boils off into a vapor and the amount of liquid decreases until all the liquid has evaporated due to the absorption of a quantity of heat from the surrounding atmosphere equal to the latent heat of vaporization of the refrigerant. The gas continues along in the evaporator and remains at the same pressure. However, its temperature increases due to the continued absorption of heat from the surrounding atmosphere. The degree to which the gas refrigerant is superheated is related to the amount of refrigerant being fed to the evaporator and the load to which the evaporator is exposed.

Superheat Adjustment

The starting method of adjusting the superheat is to unscrew completely the main evaporator expansion valve adjusting screw, then screw in 13 turns clockwise for 134A (Fig. 38). Afterwards, the following procedure should be followed:

1. Operate coach for at least one-half hour at fast idle with temperature control set at 82°F (27,7°C), Then set temperature to minimum to keep the compressor on 6 cylinders.
2. Install pressure gauge at the evaporator suction header. You may install the pressure gauge at compressor suction, but then add 3 psi to reading.

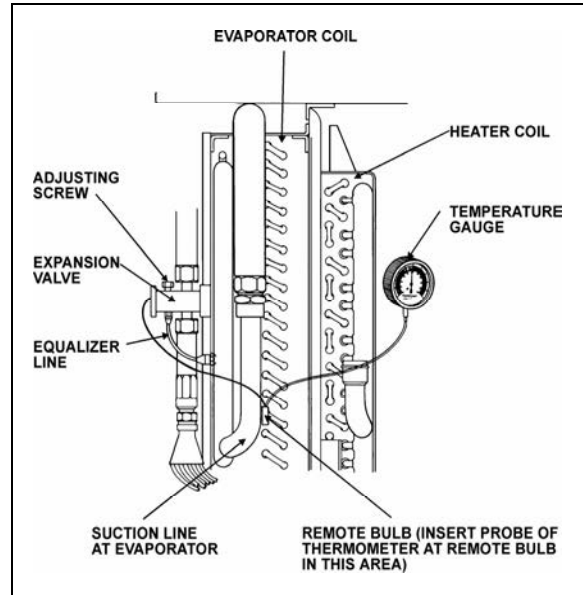


FIGURE 38: SUPERHEAT ADJUSTMENT INSTALLATION²²⁰⁴⁶

3. Install a remote reading thermometer to the evaporator outlet line near the existing remote bulb (Fig. 38).
4. Apply thermostatic tape around the bulb and evaporator outlet line to get a true reading of the line temperature.
5. Block condenser if necessary to keep pressure over 150 psi.

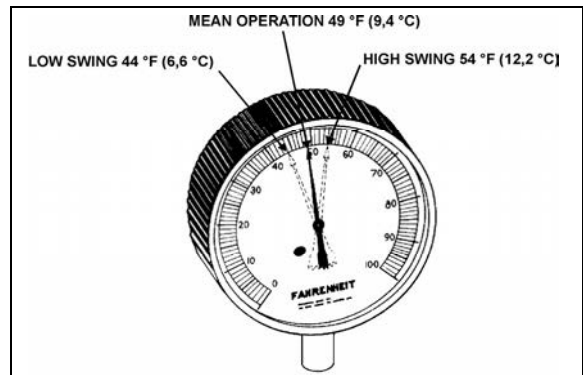


FIGURE 39: HIGH & LOW SWING TEMPERATURE AT REMOTE BULB²²⁰⁴⁷

6. Check approximately 5 readings of pressure at 2-minute intervals and convert to temperature using the temperatures & pressures table (page 38). Likewise check the temperature reading at the remote bulb at the same 2-minute intervals and record the low and high swing readings of the needle (refer to Fig. 39).

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Example of readings taken at fig. 39:

A/C pressure gauge converted to temperature at expansion valve fitting	Temperature on remote bulb	
40°F (4,4°C)	Low-swing 44°F (6,6°C)	High swing 54°F (12,2°C)
Formula for superheat 49°F-40°F=9°F (9,4°C-4,4°C = 5°C)	Average of low and high swing is 49°F (9,4°C)	

NOTE

The low swing of the superheat should be a minimum of 4°F (2,2°C) higher at the remote bulb and have an average of 8 to 12°F (4 to 6°C) higher range at the bulb than the fitting at the expansion valve.

NOTE

To reduce the superheat, flow of refrigerant is increased by turning adjusting screw of expansion valve lower evaporator temperature counterclockwise. To increase temperature or increase superheat, flow of refrigerant is reduced by turning adjustment screw of expansion valve clockwise.

- Regulate suction pressure to temperature reading according to temperature chart or to the R-134a temperature scale on the pressure gauge.

Example: Suction pressure 30 psi (207 kPa) converted to 32°F (0°C) on chart. If temperature reading is 40°F (4,4°C), subtract 32°F (0°C) and the result will be 8°F (4,4°C) of superheat.



CAUTION

Before proceeding to the expansion valve adjustment, check for restriction on suction side for plugged filter dryer and partially open valves. These conditions will give a high superheat.

Maintenance

- Pump down the system as previously indicated in this section.

- Disconnect the external equalizer line from the under side of the power head, and unclamp the remote control bulb from the evaporator coil outlet line.
- Remove the two cap screws holding the power assembly to the valve body flange. Lift off the power assembly and remove the cage assembly.
- When reassembling, replace with the new gaskets in proper location. Make sure the two lugs on the cage assembly fit into grooves provided in the power assembly. Do not force the valves together. The cage must fit properly before tightening the body flange. Tighten bolts evenly.
- Check for leaks.

Safety Instructions

- Make sure the valve is installed with the flow arrow on the valve body corresponding to the flow direction through the piping system.
- Before opening any system, make sure the pressure in the system is brought to and remains at the atmospheric pressure. Failure to comply may result in system damage and/or personal injury.

7.9 TORCH BRAZING

Use an electrode containing 35% silver.



CAUTION

When using heat near a valve, wrap with a water saturated rag to prevent overheating of vital parts.



DANGER

Before welding any part of refrigeration system, make sure the area is well ventilated.

7.10 TROUBLESHOOTING

7.10.1 Expansion Valve

PROBABLE CAUSE	PROBABLE REMEDY
LOW SUCTION PRESSURE-HIGH SUPERHEAT	
EXPANSION VALVE LIMITING FLOW:	
Gas in liquid line due to pressure drop in the line or insufficient refrigerant charge.	Locate cause of line flash and correct by use of any of the following methods. Add R-134a. Replace or clean filter dryer.
Inlet pressure too low from excessive low condensing temperature. Resulting pressure difference across valve too small.	Increase head pressure. Verify pressure switch for fan speed control.
Superheat adjustment too high.	Adjust superheat as outlined under "Superheat Adjustment".
Power assembly failure or partial loss of charge.	Replace power assembly or replace valve.
Air filter screen clogged.	Clean or replace air filter screen.
Plugged lines.	Clean, repair or replace lines.
LOW SUCTION PRESSURE-LOW SUPERHEAT	
Uneven or inadequate evaporator loading due to poor air distribution or liquid flow.	Balance evaporator load distribution by providing correct air or liquid distribution.
HIGH SUCTION PRESSURE-HIGH SUPERHEAT	
Compressor discharge valve leaking.	Replace or repair valve.
HIGH SUCTION PRESSURE-LOW SUPERHEAT (DEFECTIVE UNLOADER)	
Valve superheat setting too low.	Adjust superheat as outlined under "Superheat Adjustment".
Compressor discharge valves leaking.	Replace or repair discharge valve.
Incorrect superheat adjustment.	Superheat adjustment 12 to 16°F.
FLUCTUATING DISCHARGE PRESSURE	
Insufficient charge.	Add R-134a to system.

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PROBABLE CAUSE	PROBABLE REMEDY
HIGH DISCHARGE PRESSURE	
Air or non-condensable gases in condenser.	Purge and recharge system.
Overcharge or refrigerant.	Bleed to proper charge.
Condenser dirty.	Clean condenser.

7.10.2 A/C

TROUBLE	CAUSE
Low suction pressure and frosting at dryer outlet.	Clogged filter.
Low Oil Level.	Check for oil leaks and for leaking oil seal. Do not attempt to check oil level unless system has been stabilized at least 20 minutes. See oil level verification.
Excessively cold suction line.	Loss of contact between the expansion valve bulb and the suction line or sticking of the expansion valve. Check for foreign matter and clean, repair or replace the valve.
Excessively cold suction line and noisy compressor.	Check superheat adjustment. Check remote bulb contact. Check expansion valve for sticking.
Compressor squeaks or squeals when running.	Check oil level. Replace oil seal.
Noisy or knocking compressor.	Check for broken internal parts. Overhaul if required.
Compressor vibrates.	Check and tighten compressor mounting bolts and belt tension.
Low refrigerant level	Check for refrigerant leaks and add refrigerant if required.
Suction pressure rises faster than 5 pounds per minute after shutdown.	Check compressor valve for breakage or damage.
Insufficient cooling.	Check for refrigerant leaks. Check condition of air filter and motors.
Insufficient air flow.	Dirty or iced evaporator. Dirty air filter. Blowers inactive. Clogged ducts.
No flow of refrigerant through expansion valve.	Filter dryer is clogged. Remote bulb has lost charge or expansion valve is defective.
Expansion valve hisses. Bubbles in moisture and liquid indicator.	Gas in liquid line. Add refrigerant.
Loss of capacity	Clogged filter. Obstructed or defective expansion valve.
Superheat too high.	Reset superheat adjustment. Check for clogged external equalizer line, or filter dryer.
Reduced air flow: a. Dirty or clogged air filter; b. Evaporator motor inoperative; or c. Plugged return air ducts.	Dirty or iced evaporator coil. Clean air filter screen. Check return ducts for obstructions. Check blower motor.
Frequent starting and stopping on low pressure control switch.	Lack of refrigerant. Check for leaks. Recharge.

TROUBLE	CAUSE
Compressor intermittently starts and stops.	Intermittent contact in electrical control circuit. Compressor valves not in operating position.
Non-condensable in the refrigeration system.	<p>Leak on system, system in vacuum in low temp. Specific symptom, pressure in system will not correspond to ambient temperature on shutdown. Only non-condensable will cause this.</p> <p>(Example: Pressure of idle R-134a system in 80°F (26.6°C) room should be 86.4 psi (595.7 kPa). See temperature chart in this section.)</p> <p>An evaporator just does a proper cooling job without sufficient air. Shortage of air can be caused by the following:</p> <ul style="list-style-type: none"> * Dirty filters; or * Dirty coils.
<p>Testing condenser pressure.</p> <p><i>NOTE: R-134A pressure is function of the temperature variation.</i></p> <p>Example, for an exterior temperature of 100°F. Exterior temperature (100°F) + 30°F = 130°F. Refer to paragraph "10.11 Temperature & Pressure". Note the corresponding pressure for a temperature of 130°F, 199.8 psi. Read the condenser pressure, example 171.9 psi. 171.9 psi & 199.8 psi, the pressure in the condenser is inferior to the pressure corresponding to the exterior temperature, in this case the condenser pressure may be too low. Check for refrigerant leaks and add refrigerant if necessary. If the pressure corresponding to the condenser temperature is superior to the pressure corresponding to the exterior temperature, then the air cooled condenser pressure may be too high. Most frequent causes are:</p> <p>Reduced air quantity. This may be due to:</p> <ul style="list-style-type: none"> * Non-condensable in system; * Dirt on the coil; * Restricted air inlet or outlet; * Dirty fan blades; * Incorrect rotation of fan; * Fan speed too low; * Fan motor going out on overload; or * Prevailing winds. * Too much refrigerant in system. Remove refrigerant if necessary. 	

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7.11 TEMPERATURES & PRESSURES

VAPOR-PRESSURE			
TEMPERATURE		PRESSURE	
°F	°C	psi	kPa
-100	-73.3	27.8	191.7
-90	-67.8	26.9	185.5
-80	-62.2	25.6	176.5
-70	-56.7	23.8	164.1
-60	-51.1	21.5	148.2
-50	-45.6	18.5	127.6
-40	-40.0	14.7	101.4
-30	-34.4	9.8	67.6
-20	-29	3.8	26.2
-10	-23	1.8	12.4
0	-18	6.3	43.4
10	-12	11.6	80
20	-7	18.0	124.1
30	-1	25.6	176.5
40	4	34.5	237.9
50	10	44.9	309.6
60	16	56.9	392.3
70	21.1	70.7	487.5
80	27	86.4	595.7
90	32.2	104.2	718.5
100	38	124.3	857.0
110	43.3	146.8	1012.2
120	49	171.9	1185.3
130	54.4	199.8	1377.6
140	60	230.5	1589.3
150	65.6	264.4	1823.0
160	71	301.5	2078.8
170	76.7	342.0	2358.1
180	82.2	385.9	2660.8

VAPOR-PRESSURE			
TEMPERATURE		PRESSURE	
°F	°C	psi	kPa
190	87.8	433.6	2989.7
200	93.3	485.0	3344.1
210	98.9	540.3	3725.4

7.12 LEAK TESTING

Some methods such as nitrogen pressure, soap and electronic sniffer can be used for leak testing. However, the most common method used is a "Halide" torch consisting of an acetylene tank, a burner and a suction test hose. Proceed as follows:



DANGER

Do not inhale fumes from leak detector.

The flow of acetylene to the burner causes suction in the test line. Any gas refrigerant present will be drawn through the hose and into the burner where it decomposes into free acids.

These acids come in contact with the hot copper reaction plate in the burner, causing color reaction in the flame. A small concentration is indicated by a green tint and a large concentration by an intense blue. Do not confuse this change in color with the change caused by shutting off the air supply through the hose by holding the end too close to an object.

The procedure for testing is:

1. Adjust flame so that the top of the cone is approximately level or within one-half inch above the plate.
2. Probe end of suction test tube around all joints, valves, etc. When a leak has been found at a soldered joint, this section of the system must be pumped down. Do not solder as pressure will force hot solder out. If the system is empty, it is more economical to put in just enough R-134a to produce about 15 psi (103 kPa). The pressure can be raised to about 150 psi (1034 kPa) with dry nitrogen.

NOTE

This gas is put into the suction and discharge shutoff valves at the compressor. The receiver valves must be opened. If no leaks are found, dump this mixture, evacuate the system and fill with refrigerant.

8. AUXILIARY AIR CONDITIONING SYSTEM AND COMPONENTS

8.1 COMPRESSOR

Consult the SANDEN SD Compressor Service Manual included at the end of this section.



WARNING

Read the cautionary information in the SANDEN SD Compressor Service Manual included at the end of this section.

8.2 COMPRESSOR REMOVAL

8.2.1 When the compressor is operational

- * Perform the "OIL RETURN OPERATION" (Refer to paragraph 8.9).

8.2.2 When the compressor is inoperable

- * Perform the "Refrigerant Recovery" operation (Refer to paragraph 8.3.4).
- * Slacken bolts A (Refer to figure 40).
- * Remove bolts B & C (Refer to figure 40).
- * Remove the compressor.

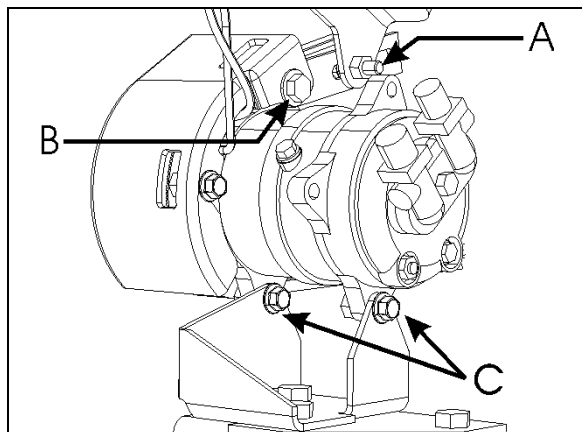


FIGURE 40: COMPRESSOR REMOVAL OR INSTALLATION 22349

8.2.3 Evacuating System Before Adding Refrigerant (Auxiliary System)

When a system has been opened for repairs, change the filter dryer and evacuate the system. X3 coaches equipped with an auxiliary system must use high-pressure service port located on the other side of check valve and low-pressure port located alongside rear truss (Fig. 16). It would be good practice to open solenoid valve.

1. Connect two hoses equipped with a micron gauge between the high-pressure service port, the low-pressure service port and the vacuum pump.
2. With the unit service valves open and the vacuum pump valves open, start the pump and draw the manifold and hoses into a very deep vacuum (700 microns).
3. Close manifold valve
4. Shut down the vacuum pump.
5. Check to insure that vacuum holds. (If the pressure continues to rise, it indicates a leak or moisture in the system).
6. Charge the system with the proper amount of refrigerant through the service port near the check valve using recommended charging procedures.
7. Remove the hoses.

8.3 OIL ADDITION

The chart below shows the approximate amount of oil to be added to the system when replacing a component.

Component replaced	Typical amount of oil
Evaporator	50 cm ³ (1.7 ozs)
Condenser	30 cm ³ (1.0 ozs)
Filter-Dryer	10 cm ³ (0.3 ozs)

The amount of oil recovered with the refrigerant recovery should be added at the same time.

8.4 COMPRESSOR OIL CONTAMINATION

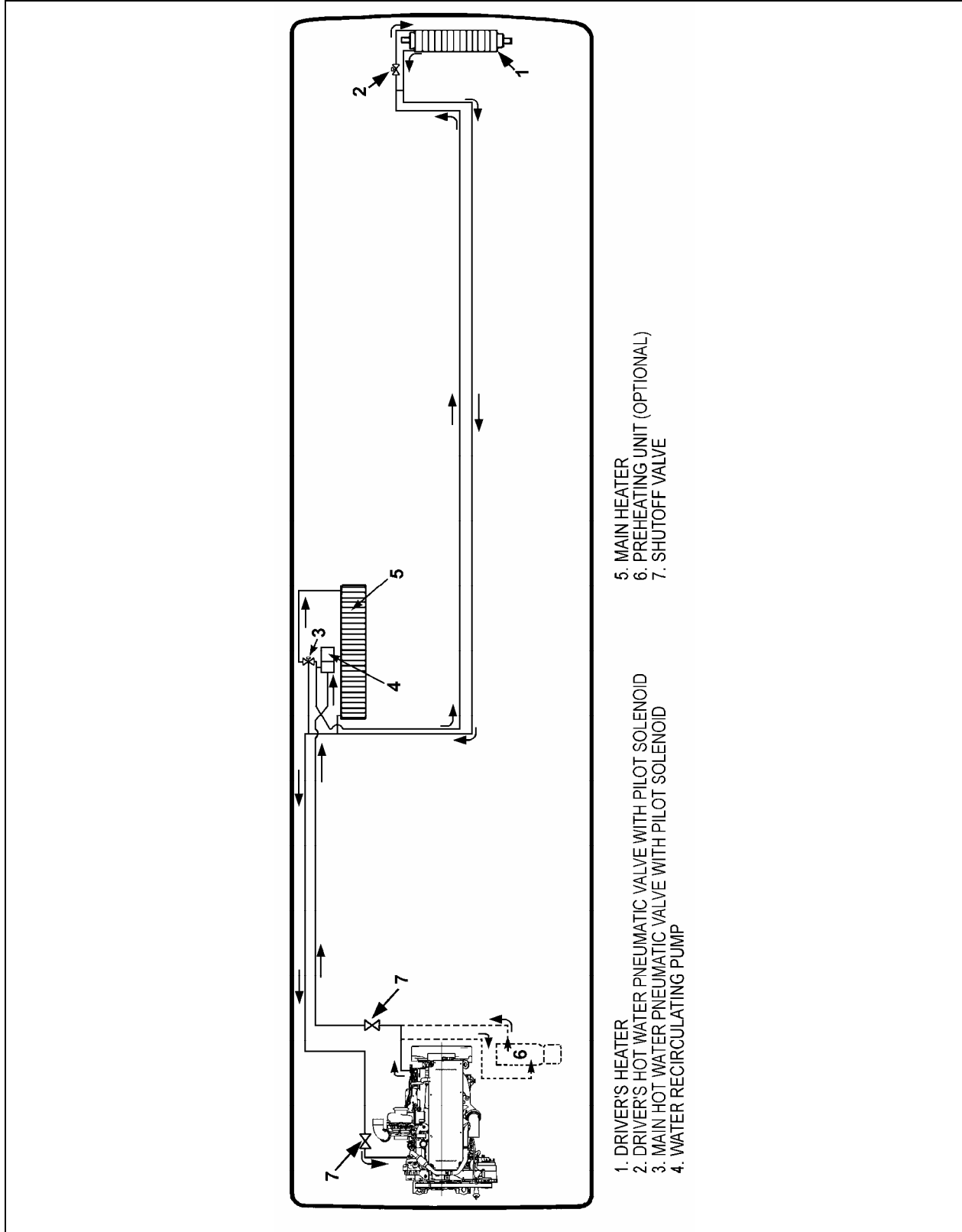
Unlike engine oil, no cleaning agent is added to the compressor oil. Even if the compressor is run for a long time, the oil never becomes turbid as long as there is nothing wrong with the compressor or its method of use. Inspect the extracted oil for any of the following conditions:

- * Dirt in the oil.
- * Change to a varnish color.
- * Presence of foreign substance, metal shavings, etc. in the oil. When the oil extracted from the compressor is as described above, replace the oil as follows:
 1. Clean the interior of the system with approved method.
 2. Replace the filter-dryer.
 3. Supply with new oil as specified in SANDEN SD Compressor Service Manual included at the end of this section.

8.5 OIL RETURN OPERATION

There is a close affinity between oil and refrigerant. During normal operation, part of the oil recirculates with the refrigerant in the system. Therefore, when checking the amount of oil in the system or replacing any system component, the compressor must be run in advance to ensure return. This procedure is as follows:

- * If the amount of refrigerant in the system has decreased, charge to the proper amount.
- * Start the engine and select fast idle.
- * Set the fan speed to full air/full A/C and let run for 20 minutes.



- 1. DRIVER'S HEATER
- 2. DRIVER'S HOT WATER PNEUMATIC VALVE WITH PILOT SOLENOID
- 3. MAIN HOT WATER PNEUMATIC VALVE WITH PILOT SOLENOID
- 4. WATER RECIRCULATING PUMP
- 5. MAIN HEATER
- 6. PREHEATING UNIT (OPTIONAL)
- 7. SHUTOFF VALVE

FIGURE 41: CENTRAL HEATING SYSTEM COMPONENTS

22325

Section 22: HEATING AND AIR CONDITIONING

9. HEATING SYSTEM

The schematic of figure 41 shows the central heating system with its components.

In addition to the normal heating provided by the engine, a preheating system (104,000 Btu/hr) (optional) may have been installed in the vehicle.

9.1 DRAINING HEATING SYSTEM

To drain the entire system, refer to Section 05, "Cooling". If only the driver's or main heater core must be drained, refer to the following instructions.

9.1.1 Draining Driver's Heater Core

1. Stop engine and allow engine coolant to cool.
2. Locate the normally open water pneumatic valve on the ceiling of the spare wheel compartment (Fig. 42), move the pilot-solenoid valve red tab to close the valve.



WARNING

Before proceeding with the following steps, check that coolant has cooled down.

3. Loosen hose clamp, install an appropriate container to recover coolant, and disconnect silicone hose from water solenoid valve.
4. From inside of vehicle, remove the two finishing panels in front of unit. Remove the three screws fixing the unit front panel. Open the manual vent located inside the HVAC unit, on the driver's side (Fig. 43) to ensure an efficient draining.

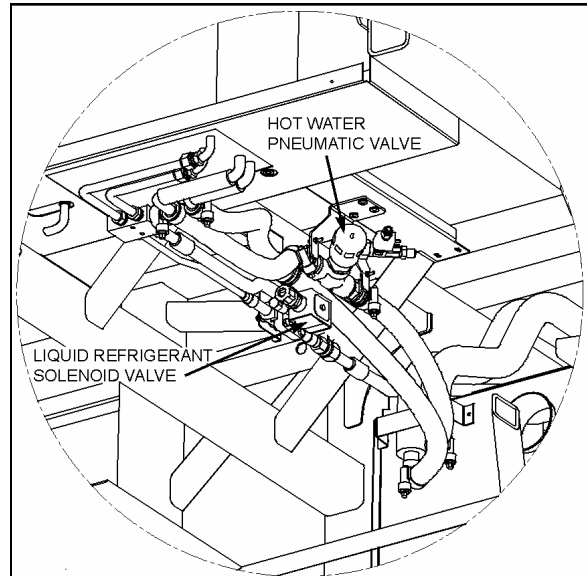


FIGURE 42: CEILING OF THE SPARE WHEEL COMPARTMENT

22324

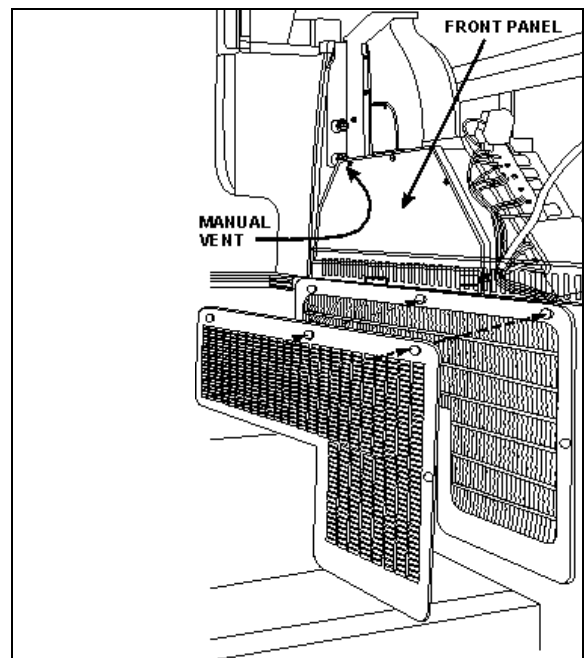


FIGURE 43: DRIVER'S HVAC UNIT

22328

9.1.2 Draining Main Heater Core

1. Stop engine and allow engine coolant to cool.
2. Close both heater line shutoff valves.

On X3 Coaches, the valves are located in engine compartment. One is on the L.H. side of compartment in front of the radiator and the other valve is located under the radiator fan gearbox (Fig. 44).

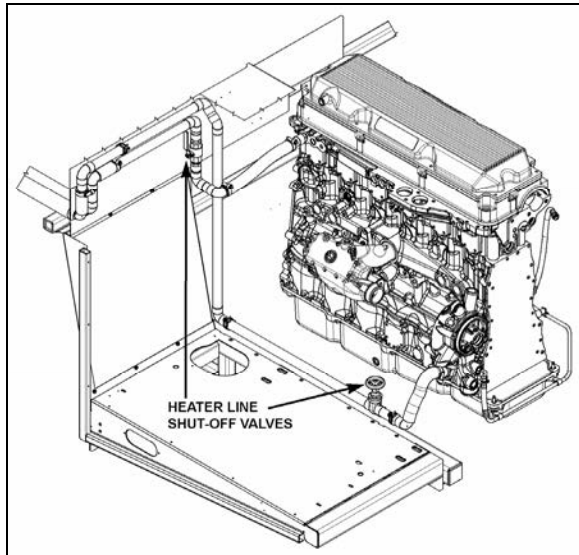


FIGURE 44: HEATER LINE SHUT-OFF VALVES 22326

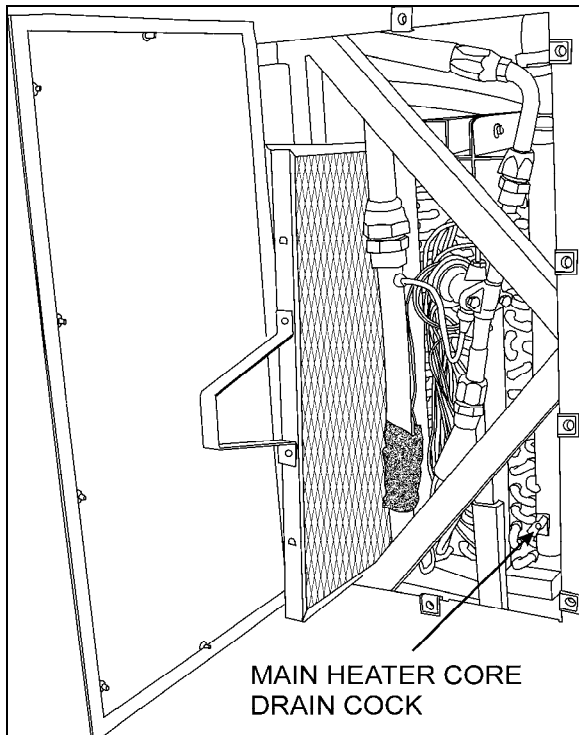


FIGURE 45: EVAPORATOR COMPARTMENT 22327

3. The main heater core drain cock is located in the evaporator compartment. To access the valve on X3 coaches, open baggage compartment door located in front of the evaporator compartment (L.H. side). Open access panel by turning the three screws of panel $\frac{1}{4}$ of a turn.



WARNING

Before proceeding with the following steps, check that coolant has cooled down.

4. Open drain cock in bottom of heater core, you can unfasten a hose connection on top of heater core (Fig.45) in order to allow air to enter while draining.

9.2 FILLING HEATING SYSTEM

1. Ensure that the drain hose is reconnected and the manual vent and drain cock are closed.
2. Open the surge tank filler cap and slowly fill the system to level of filler neck.
3. After initial filling, the water shut-off valves should be open and the water recirculating pump should be energized to assist in circulating coolant through the heating system. To perform this operation, start the engine, switch on the HVAC control unit, both driver and passenger sections, and set temperature to their maximum positions in order to request the heating mode in each of these sections.
4. When coolant level drops below the surge tank filler neck, slowly fill the system to level of filler neck.
5. Once the level has been stabilized, replace cap.

9.3 BLEEDING HEATING SYSTEM

Whenever the heating system has been drained and refilled, or the system has run low on coolant and coolant has been added, it is necessary to bleed air from heating system. Locate the manual vent illustrated in Figure 50, and open momentarily until no air escapes from the line.

9.4 SOLDERING

Before soldering any part of the system, make sure the area is well ventilated. Use (stay clean) flux sparingly and apply solder (95-5 round wire 1/8 inch [3,1 mm]). After completing repairs, test for leaks.

When using heat at or near a valve, wrap with a water saturated rag to prevent overheating of vital parts.

Section 22: HEATING AND AIR CONDITIONING

9.5 DRIVER'S HOT WATER PNEUMATIC VALVE ASSEMBLY

9.5.1 Description

The flow of hot water to the driver's heater core is controlled by a pneumatic NO water valve assembly. The valve, located at the ceiling of the spare wheel compartment, is designed so that the pilot solenoid valve, which is part of the assembly, opens and closes a port which directs air pressure to the actuator casing, thereby opening or closing the valve.

When the vehicle is operating with no current to the pilot solenoid valve, no air pressure is admitted to the actuator casing, the cylinder spring pushes up against the cylinder, thereby keeping the water valve open.

The driver's heater water valve requires a minimum amount of maintenance. The valve should be free of dirt sediment that might interfere with its operation. No other maintenance is needed unless a malfunction occurs.

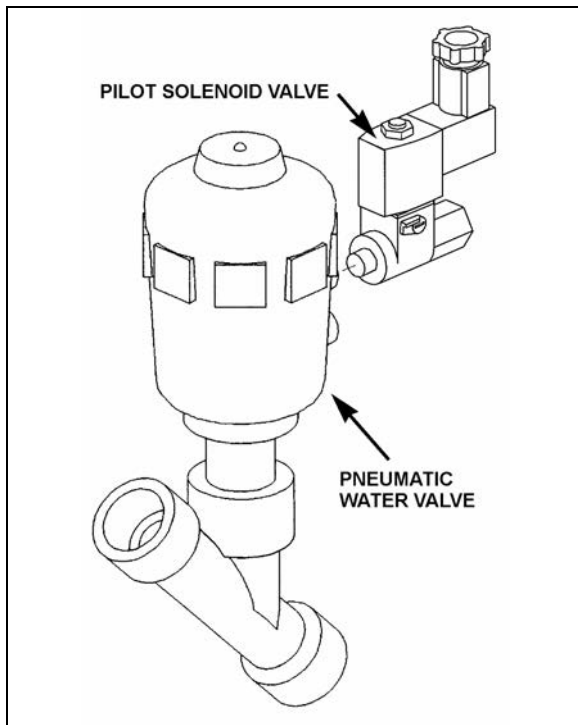


FIGURE 46: DRIVER'S HOT WATER PNEUMATIC VALVE ASSEMBLY 22240

9.5.2 Pneumatic Water Valve Disassembly

1. Shut off air supply pressure and electrical current to the pilot solenoid valve. Disconnect wires.

2. The water valve need not be removed from the line. Unscrew nipple, the actuator casing, tube, spindle and closure member can be removed (Fig. 47).
3. Remove the snap ring using a pair of pliers.
4. You can now access all seals for replacement

Pneumatic water valve replacement seal kits:

- * Water Side: 871311
- * Actuator Side: 871312

9.5.3 Pneumatic Water Valve Reassembly

1. Assemble the actuator casing, tube, nipple, spindle and closure member.
2. Tighten the nipple in place in the body cavity as per figure 54. Fasten pilot solenoid valve to the pneumatic water valve. Reconnect air supply pressure and electrical current to the pilot solenoid valve.
3. Check for proper operation.

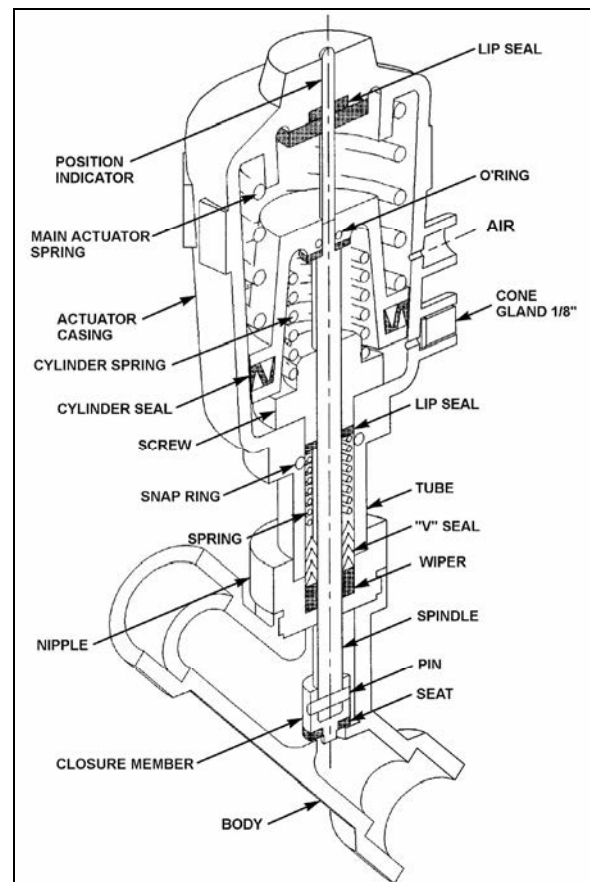


FIGURE 47: PNEUMATIC WATER VALVE 22241

9.5.4 Pilot Solenoid Valve

1. No maintenance is needed unless a malfunction occurs.
2. A pilot solenoid valve replacement seal kit is available: 871313.

9.5.5 Valve Troubleshooting

PROBLEM	PROCEDURE
Valve fails to close.	<ol style="list-style-type: none"> 1. Check electrical supply with a voltmeter. It should agree with nameplate rating. 2. Check pressure at pilot solenoid valve inlet. It must be at least equal to the minimum pressure stamped on the nameplate. It should not go below minimum while valve is operating.
	<ol style="list-style-type: none"> 1. Check that the closure member assembly, and that main actuator and cylinder springs are free to travel. 2. Check that there is no restriction to the air escaping from the actuator casing. 3. Make sure that pilot solenoid valve operates properly.

9.6 CENTRAL HOT WATER PNEUMATIC VALVE ASSEMBLY

9.6.1 Description

The flow of hot water to the vehicle's central heater core is controlled by a 3-way pneumatic water valve assembly. The valve, located in the evaporator compartment, is designed so that the pilot solenoid valve, which is part of the assembly, opens and closes a port which directs air pressure to the actuator casing, thereby allowing the hot water to enter the main heater core or bypassing it.

When the vehicle is operating with no current to the pilot solenoid valve, no air pressure is admitted to the actuator casing, the cylinder spring pushes up against the cylinder, thereby allowing the hot water to enter the main heater core.

The central heater water valve requires a minimum amount of maintenance. The valve should be free of dirt sediment that might interfere with its operation. No other maintenance is needed unless a malfunction occurs.

9.6.2 Pneumatic Water Valve Disassembly

1. Shut off air supply pressure and electrical current to the pilot solenoid valve. Disconnect wires.

2. The water valve need not be removed from the line. Unscrew nipple, the actuator casing, tube, spindle and closure member can be removed (Fig. 49).
3. Remove the snap ring using a pair of pliers.

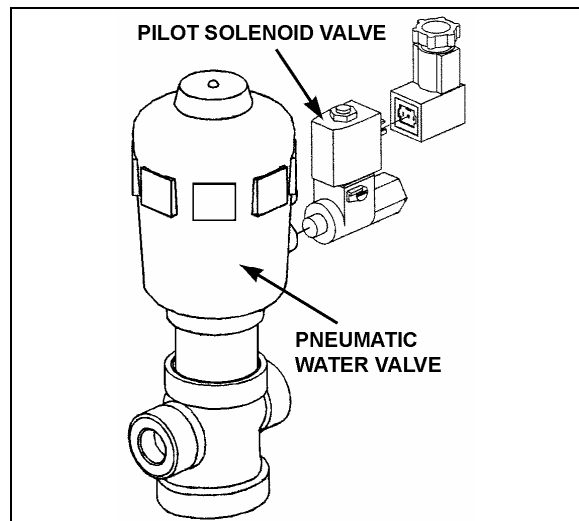


FIGURE 48: CENTRAL HOT WATER PNEUMATIC VALVE ASSEMBLY

22329

4. You can now access all seals for replacement

Pneumatic water valve replacement seal kits:

* Water Side: 871389

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* Actuator Side: 871388

9.6.3 Pneumatic Water Valve Reassembly

1. Assemble the actuator casing, tube, nipple, spindle and closure member.
2. Tighten the nipple in place in the body cavity as per figure 49. Fasten pilot solenoid valve to the pneumatic water valve. Reconnect air supply pressure and electrical current to the pilot solenoid valve.
3. Check for proper operation.

9.6.4 Pilot Solenoid Valve

1. No maintenance is needed unless a malfunction occurs.
2. A pilot solenoid valve replacement seal kit is available: 871390.

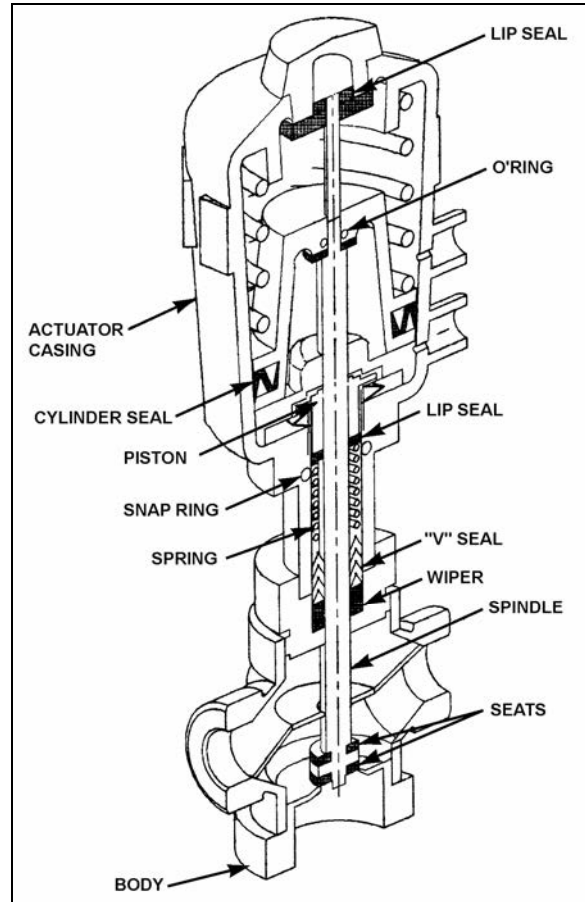


FIGURE 49: PNEUMATIC WATER VALVE

22330

9.6.5 Valve Troubleshooting

PROBLEM	PROCEDURE
Valve fails to close.	<ol style="list-style-type: none"> 1. Check electrical supply with a voltmeter. It should agree with nameplate rating. 2. Check pressure at pilot solenoid valve inlet. It must be at least equal to the minimum pressure stamped on the nameplate. It should not go below minimum while valve is operating.
Valve fails to open.	<ol style="list-style-type: none"> 1. Check that the closure member assembly, and that main actuator and cylinder springs are free to travel. 2. Check that there is no restriction to the air escaping from the actuator casing. 3. Make sure that pilot solenoid valve operates properly.

9.7 WATER RECIRCULATING PUMP

This vehicle is provided with a water recirculating pump which is located in the evaporator compartment (Fig. 50). The water recirculating pump consists of a centrifugal pump and an electric motor which are mounted in a compact assembly.

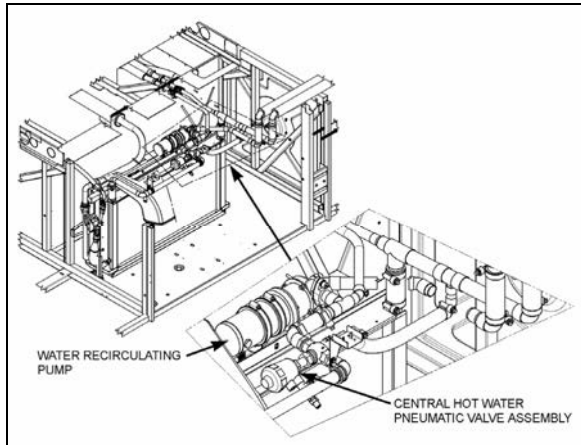



FIGURE 50: PUMP LOCATION (CENTRAL A/C) 22331

The (seal less) pump requires no periodic maintenance other than replacement of motor brushes. Replacement of motor brushes can be performed without removing the pump assembly. Inspection of the pump, to determine if the pump is working properly, should be made while the pump is in operation. If there is evidence that the pump is not operating as per specifications, the unit must be disassembled for corrective measures.

Disassembly of the pump will be necessary only in the case of a rotor failure or motor failure.

9.7.1 Removal

1. Stop engine and allow engine coolant time to cool.
2. Close shutoff valves. Refer to "05 COOLING" under heading "Draining Cooling System" for location of valves.
3. Disconnect the electrical wiring from the motor.

 <p>WARNING</p>
<p>Before proceeding with the following steps, check that coolant has cooled down.</p>

4. Disconnect water lines from pump at flange connections. Place a container to recover the residual coolant in the line.
5. Remove the two clamps holding the pump motor to its mounting bracket. Remove the pump with the motor as an assembly.

9.7.2 Disassembly

1. Separate the housing (1) from the adapter (7) by first removing the 4 capscrews. Remove housing carefully to prevent damaging the O-ring (2).
2. Remove rotor assembly (4), washers (3) and shaft (5) from the adapter.

Inspection

Components removed from the recirculating pump and motor assembly should be compared with new parts to determine the degree of wear.

9.7.3 Brushes

1. When removing brushes, note the position of the brush in the tube. Brush life is shortened if the brushes are not replaced properly.
2. Examine brushes for the following:

a. Wear

Replace the brushes if less than 25% of the usable brush is left (less than 0.300 inch [8 mm]).

b. Chipped edges

Chips can be caused by improper handling or installation. Badly chipped brushes should be replaced regardless of their length.

c. Annealed brush spring

This can be detected by noting the resiliency of the spring. Annealing is caused by failing to tighten the brush caps properly, thus not providing a good low resistance contact between the terminal and the brush tube. Replace brushes showing evidence of annealed springs.

d. Frayed or broken pigtail

An improperly installed brush may have the pigtail (shunt) pinched under the terminal or between the coils of the spring. If the pigtail is badly frayed or broken, replace the brush.

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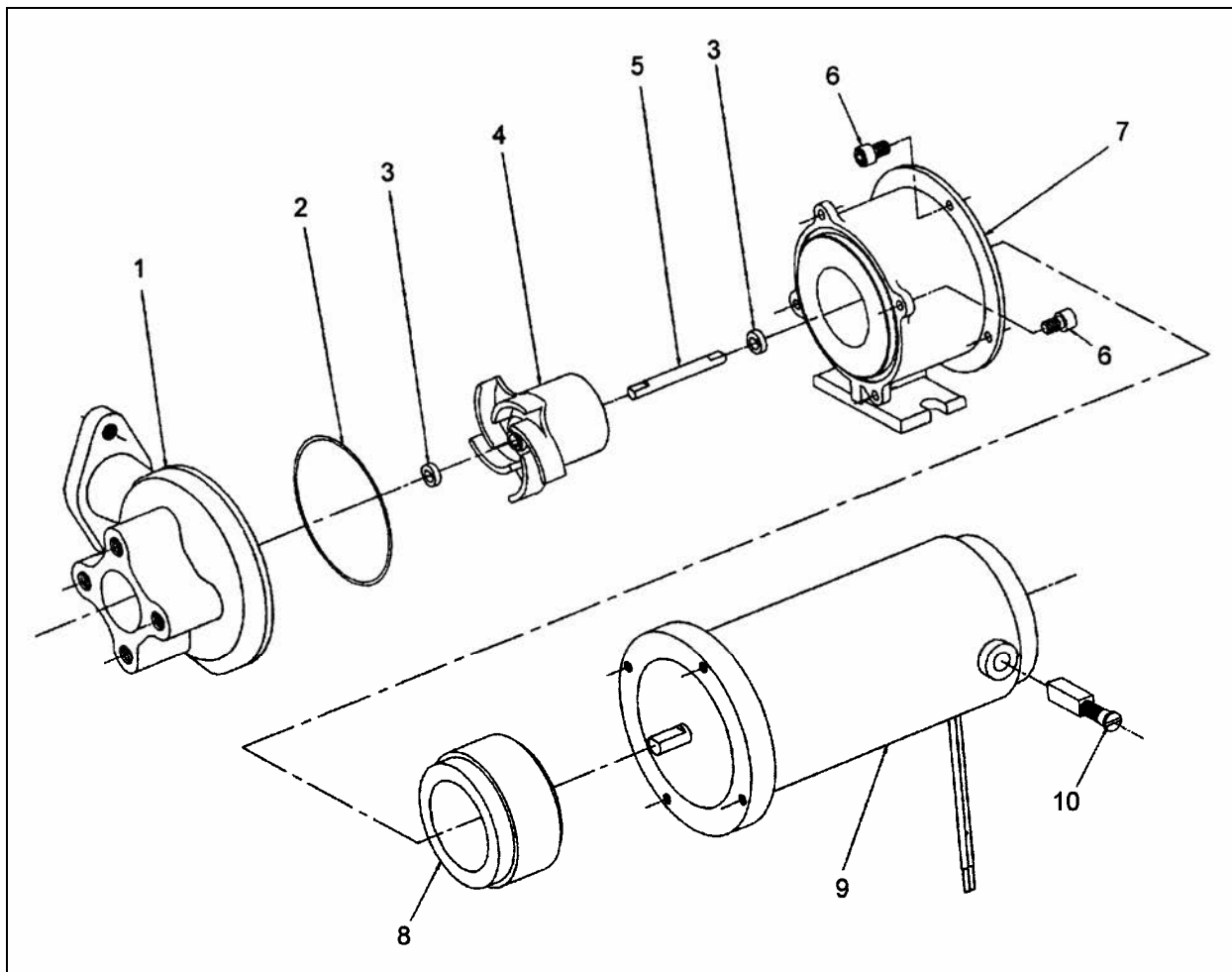


FIGURE 51: WATER RECIRCULATING PUMP (CENTRAL A/C)

22282

ITEM	DESCRIPTION	QTY.
1	Housing	1
2	O-Ring	1
3	Washer SS	2
4	Rotor Assembly	1
5	Shaft SS	1
6	Screw, Cap Hex Soc. Head 8-32 X 3/8	8
7	Adaptor	1
8	Drive Magnet	1
9	Motor Assembly 24V	1
10	Brush	2

3. Observe the following factors when replacing brushes:
 - a. The face of a new brush is carefully cut to cause proper seating during the "wear-in" period.
 - b. Improper installation can harm both the brush and the commutator.
 - c. Replacement brushes should be of the proper grade.
 - d. Brush performance will be affected if the spring and terminal are not properly placed in the brush tube. The spring should be free over its entire length and the terminal should make good contact with the metal brush tube insert.

9.7.4 Assembly

1. Install washer (3), shaft (5) and rotor assembly (4) into adapter (7).
2. Install O-ring (2) into housing (1) and assemble housing to the adapter.
3. Secure housing to adapter using 4 capscrews (6).

9.7.5 Installation

1. Apply gasket cement to the line flanges, put the two gaskets in place, and connect water lines to the pump at the flange connections. Position the pump and motor assembly on the mounting bracket. Position the mounting clamps over the motor and secure with mounting bolts.
2. Connect electrical wiring to the pump motor.
3. Open shutoff valve. Refer to "05 COOLING" under heading "Draining Cooling System" for location of valves.
4. Fill the cooling system as previously instructed in this section under "9.2 Filling Heating System", then bleed the system as previously instructed in this section under "9.3 Bleeding Heating System".

9.8 PREHEATING SYSTEM (OPTIONAL)

The preheater is located inside engine compartment and is accessible through engine compartment R.H. side door (refer to figure 52).

This Auxiliary Preheating System is used for preheating and retaining the heat of water-cooled engines. It can be used before starting the engine to ease its starting and to provide immediate inside heat upon operation of the heating system. It can also be used with engine running to maintain coolant heat and maintain the set temperature inside vehicle.

The heater operates independently from the vehicle engine. It is connected to the cooling and heating circuits, the fuel system and the electrical system of the vehicle.

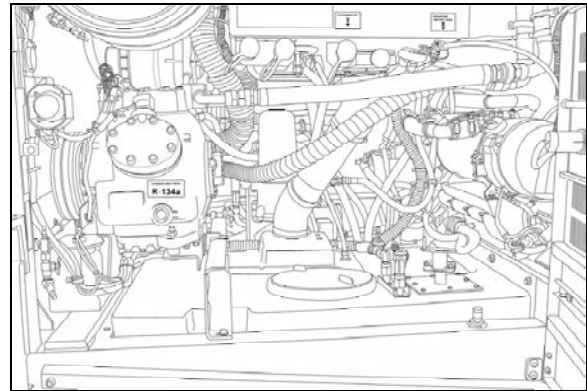


FIGURE 52: LOCATION OF PREHEATER

18607

The pilot lamp turns on when the heater is switched on. Combustion air flows in to flush out the combustion chamber and the water circulation pump is put into operation. The fuel metering pump conveys fuel in precise doses to the combustion chamber where fuel and combustion air form a combustible mixture which is ignited by the glow plug.

Once the flame sensor has signaled to the control unit that combustion has taken place correctly, the glow spark plug and ignition coil are switched off.

The hot combustion gases are diverted at the end of the flame pipe, then pass through the indirect heating surfaces of the heat exchanger and transmit their heat to the water passing through the heat exchanger.

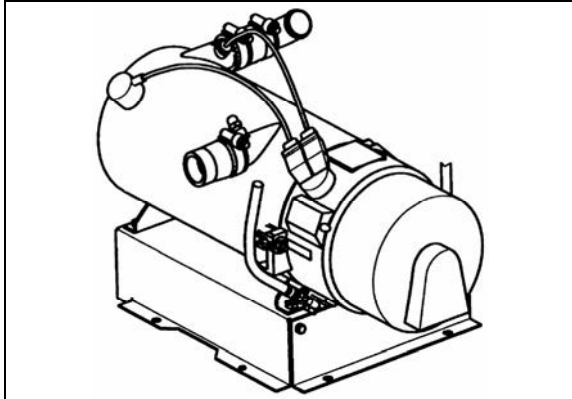


FIGURE 53: WEBASTO PREHEATER (104,000 BTU) 22224

The heat is thermostatically controlled and operates intermittently, i.e. the switched-on times of the burner vary depending on the heat requirement. The water temperature depends on the setting of the built-in water thermostat.

The water circulation pump remains in operation as long as the heater is operating, even in the regulation intervals and during the delayed cutout of the switched-off heater. The pump can also be operated independently from the heater by means of an appropriate circuit. The heater can be switched on at any time, even during the delayed cutout period. Ignition takes place once this delay time is over.

When the heater is switched off, the fuel supply is interrupted. The flame goes out, and at the same time a delayed cutout of some 2.5 minutes begins. The combustion air still flowing flushes the remaining combustion gases out of the chamber and cools off the hot parts on the exhaust side of the heat exchanger, while the water circulation pump, still running, transmits the heat present in the heat exchanger, thus preventing local overheats. Once the delayed cutout time is over, both the combustion air blower and the water circulation pump switch off automatically. A cutout will take place in case of any failure of the preheater.

9.8.1 Operation

Switch on the heater. The operation indicator lamp comes on and the heater motor and circulating pump begin to run. After about 10-25 seconds the solenoid valve opens and fuel is sprayed into the combustion chamber. At the same time, the electronic ignition unit produces high voltage (8000 V) and the mixture of fuel and air in the combustion chamber is ignited by the spark on the ignition electrodes. The flame is

indicated by the flame detector, then the electronic ignition unit stops producing high voltage and combustion continues by itself (spark on electrodes is required only to ignite the flame). At this moment, the heater is working and producing heat.

If the heater is switched off by the on/off switch, the solenoid valve interrupts fuel supply, combustion stops and indicator lamp turns off. Combustion air fan still blows air, cleaning the combustion chamber of any fumes and cooling down the combustion chamber. Coolant circulation pumps coolant, making a purge cycle for approximately 2-3 minutes, thus protecting the heater against overheating.

If the heater is not switched off by the on/off switch, the control thermostat will switch off the heater when coolant temperature reaches $165^{\circ} \pm 6^{\circ}\text{F}$ ($75^{\circ} \pm 3^{\circ}\text{C}$) and turns it on at $154^{\circ} \pm 9^{\circ}\text{F}$ ($68^{\circ} \pm 5^{\circ}\text{C}$). During this time, the heater (combustion) is off and the indication lamp and coolant pump are on. Combustion air fan blows air for 2-3 minutes and then turns off.

9.8.2 Preheating System Timer

The timer, located on L.H. lateral console is used to program the starting and stopping time of the preheating system. The system indicator light, located on the timer, illuminates when the system is functional.



CAUTION

The preheating system should not operate for more than one hour before starting engine as this could discharge batteries.



DANGER

Preheating system must not operate when vehicle is parked inside or during fuel fill stops.

NOTE

Preheating system uses the same fuel as the engine.

In case of failure:

1. Shut off and turn on again.
2. Check main circuit breaker and overheat fuse.

3. Have system repaired in a specialized shop.

9.8.3 Timer Operating Instructions (Webasto)

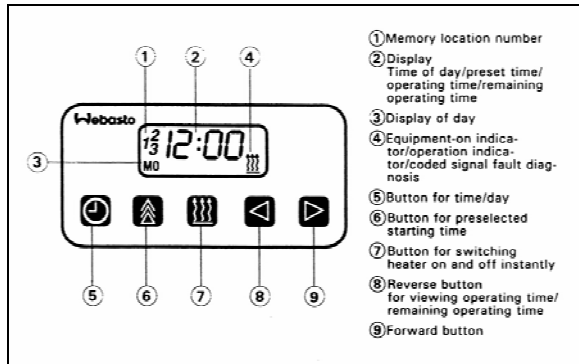


FIGURE 54: WEBASTO

22191

These instructions refer to the timer illustrated in figure 54. They are the same instructions provided in the Webasto instruction booklet, provided with your vehicle.

Remaining Operating Time

The remaining operating time refers to the period of time the heater still continues to remain in operation. It may be changed while the heater is in operation.

Setting the Digital Timer

After the power has been connected, all symbols on the digital display are flashing. The time of the day and the day of the week must be set.

All flashing symbols of the timer can be set by means of the Forward (9) or Reverse (8) buttons.

When buttons (8) and (9) are pressed for more than 2 seconds, the quick digit advance mode is activated.

Setting the Time and Day of the Week

1. Press button (5) for more than 2 seconds (time display flashes).
2. Press (8) or (9) button to set the time of day.
3. Wait 5 seconds. The time of day is stored (time of week flashes).
4. Press (8) or (9) button to set the correct day of week.
5. Wait 5 seconds. The day of week is stored.

Viewing the Time (Ignition ON)

Continuous display of current time and day of the week.

Viewing the Time (Ignition OFF)

Briefly press button (5) to display current time and day for 5 seconds.

SWITCHING HEATER ON (INSTANT HEATING)

With Ignition ON:

Press button (7). Heater is switched on (continuous operation) and continues to operate until button (7) is pressed again or ignition is switched off.

NOTE

If the ignition is switched off while heater is in operation, the remaining operating time of 5 minutes flashes on the display and the heater will continue to operate for this period of time.

With Ignition OFF:

Press button (7). Heater is switched on for preset operating time (the factory-set heater operating duration is 60 minutes)

SWITCHING HEATER OFF

Press button (7). The heater starts its after-run cycle and switches off thereafter.

Presetting Operating Duration

1. Press button (6). Memory location number flashes.

NOTE

By repeatedly pressing button (6), starting time 2 or 3 can be preset.

2. Press button (8) or (9) until correct startup time is set.
3. Wait 5 seconds. Preset starting time is stored and day of week flashes.
4. Press button (8) or (9) to select the correct startup day of week.
5. Wait 5 seconds. The startup day of week is stored.

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The number of memory location remains on the display. The timer is now in the programmed mode and will switch the heater in at the preset time.

NOTE

We recommend that memory locations 1 and 2 be used for presetting times within 24 hours of setting the timer. Memory location 3 can be used for a starting time within the next 7 days of setting the timer.

Recalling Preset Times

Press (6) repeatedly until the desired memory location number and preset time are displayed.

Canceling Preset Time

Press button (6) repeatedly until no more memory location number is visible on the display.

Setting Operating Time

1. With heater off, press button (8). Operating time flashes.
2. Press button (8) or (9) to set the operating time (between 1 and 120 minutes).

The heater remains in operation for the preset time (except for continuous operation).

Setting the Remaining Operating Time

1. With heater in operation, press button (8). Remaining operating time flashes.
2. Set remaining time with button (8) or (9).
3. Wait 5 seconds. Remaining operating time is stored.

Operational Failure Symptoms via Fault/Flash code

On heaters equipped with a fault diagnosis system using coded light signals, the equipment-on indicator/operation indicator flashes. Refer to the following table.

Failure Symptom	Probable Cause	Check and Correct
1X Flash (F 01) No combustion after completion of start up sequence.	- Fuel system - Combustion air - Electronic ignition	- Fuel level - Type of fuel being used - Fuel filter - Fuel line connections (air bubbles in fuel lines) - Fuel nozzle plugged - Air intake or exhaust, restricted or plugged - Incorrect electrode gap
2X Flashes (F 02) Flame out during burner operation no restart possible	- Fuel supply (shortage of fuel)	- Restriction in the fuel system - Fuel filter - Fuel line connections (air bubbles in fuel lines) - Type of fuel being used
3X Flashes (F 03) Low voltage for more than 20 seconds	- Electrical system	- Load test batteries - Corrosion at connections - Loose connections
4X Flashes (F 04) Flame detector recognizes false flame signal during pre-start or shut-down cycle	- Defective flame detector	- Replace flame detector
5X Flashes (F 05) Flame detector	- Wiring - Defective flame detector	- Damaged wiring, open or short circuit - Replace flame detector
6X Flashes (F 06) Temperature sensor	- Wiring - Defective temperature sensor	- Damaged wiring, open or short circuit - Replace temperature sensor
7X Flashes (F 07) Fuel solenoid valve	- Wiring - Defective solenoid valve	- Damaged or corroded wiring, open or short circuit - Replace solenoid valve
8X Flashes (F 08) Combustion air fan motor	- Wiring - Wrong RPM - Defective combustion air fan motor	- Damaged wiring, open or short circuit - Replace combustion air fan - Replace combustion air fan

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9X Flashes (F 09) Circulation pump motor	- Wiring - Defective circulation pump motor	- Damaged wiring, open or short circuit - Replace circulation pump motor
10X Flashes (F 10) Temperature limiter	- Overheat condition - Coolant flow - Wiring - Defective temperature limiter	- Reset temperature limiter - Coolant level or flow restriction - Air trapped in coolant circuit - Damaged or corroded wiring, open or short circuit - Replace temperature limiter
11X Flashes (F 11) Electronic ignition coil	- Wiring - Defective electronic ignition coil	- Damaged wiring, open or short circuit - Replace electronic ignition coil
12X Flashes (F 12) Heater lock out	- 3 repeated faults/flame-outs or 5 repeated start attempts	- Reinitialize control unit by switching heater on and disconnecting power.

9.8.4 Troubleshooting and Maintenance

Refer to the Webasto manual for more information.

NOTE

If there are no heater faults, the heater will go through a normal start cycle and regulate based on thermostat setting.

NOTE

Switch on the preheating system briefly about once a month, even during the warm season.



CAUTION

When welding on the vehicle, disconnect the preheater module connector in order to protect this system from voltage surges.



CAUTION

To avoid running down the batteries, do not turn on the preheating system for more than one hour before starting the engine.



DANGER

The preheating system uses the same fuel as the engine. Do not operate in a building or while refueling. Operate only in a well-ventilated area.

10. SPECIFICATIONS

Main evaporator motor

Make.....US MOTOR
TypeT-17
Voltage 27.5 V DC
Current draw 68 amps
Horsepower..... 2
Revolution 1st :1400 rpm, 2nd : 1880 rpm nominal
InsulationClass F
Motor Life20 000 hours
Brush life 10 000 hours
Motor Prevost number..... 563008
Brush Prevost number 562951

Condenser fan motors

Make..... EBMPAPST
TypeAXIAL BRUSHLESS
Voltage 24 V DC
Qty..... 4
Prevost number 563461

Evaporator air filter (Central system)

Make..... Permatron Corp.
Type Polypropylene
Prevost number 874272

Driver's unit evaporator motors

Make.....MCC
Voltage 24 V DC
Quantity 1
Prevost number 871135

Driver's unit evaporator air filters

Make.....MCC
TYPE Recirculating air 6-¼" x 28" Washable
Prevost number 871147

Make.....MCC
 TYPE Fresh air 3-5/8" X 5-1/4" Washable
 Prevost number 871144

Refrigerant

Type R-134a
 Quantity (standard) 24 lbs (10.89 Kg)
 Quantity (A/C Aux. system located in overhead compartments)4 lbs (1.8 Kg)

Compressor (Central system)

Make..... Carrier Transicold
 Capacity, option R-134a 41 CFM
 Capacity, option R-22..... 37 CFM
 Model, option R-134.....05G-134A
 Model, option R-22..... 05G-22
 No. of cylinders 6
 Bore..... 2" (50,8 mm)
 Operating speed.....400 to 2200 rpm (1750 rpm. Nominal)
 Minimum speed (for lubrication).....400 rpm
 Nominal horsepower 15
 Oil pressure at 1750 rpm 15 to 30 psi (103-207 kPa)
 Oil capacity..... 1.13 U.S. gal (4,3 liters)
 Weight 142 lbs (64,5 kg)
 Approved oils
 -Castrol..... SW 68 (POE)
 Prevost number, option R-134a 950314
 Prevost number, option R-22 950207

A/C Compressor (Auxiliary system)

Make..... Sanden
 Model..... SD7H
 Prevost number 950436
Approved oil Sanden SP-20 (PAG)
 Prevost number 950382

Compressor unloader valve

Make..... Carrier Transicold

Section 22: HEATING AND AIR CONDITIONING

Type Electric (AMC)
Voltage 24 V DC
Watts 15
Prevost number (without coil) 950095
Coil Prevost number..... 950096

Magnetic clutch

Make Carrier Transicold
Type Housing mounted 9" dia., 2-B grooves
Voltage 24 V DC
Coil resistance at 68 °F (20 °C)..... 5.15 – 5.69 ohms
Prevost number 950204

Compressor V belt (Carrier)

Make Dayco
Model BX100
Prevost number (with two BOSH Alternators) 506864

Condenser coil (Auxiliary system)

Make Valeo
Prevost number

Condenser coil (Central system)

Make Carrier Transicold
Aluminum
Prevost number 870654
Copper
Prevost number 870729

Evaporator coil (Central system)

Make Carrier Transicold
Prevost number 871070

Receiver tank (with sight glasses)

Make HENRY
Maximum pressure 450 psig
Prevost number 950261

Moisture indicator

Make..... Henry
Prevost number..... 950029

Driver's refrigerant liquid solenoid valve

Make..... Parker
Type Normally closed with manual bypass
Voltage 24 V DC
Amperage draw 0.67 amps
Watts 16
Prevost number (without coil) 95-0054
Coil Prevost number..... 950055
Repair kit Prevost number 950056

Hot water pneumatic valve (Central system)

Make..... Burkert
Type 3-WAY
Voltage 24 V DC
Prevost number 871381
Seal kit, Water Side..... 871389
Seal kit, Actuator Side..... 871388
Seal kit, Pilot Solenoid Valve 871390

Driver's hot water pneumatic valve

Make..... Burkert
Type Normally open
Voltage 24 V DC
Prevost number 871252
Seal kit, Water Side..... 871311
Seal kit, Actuator Side..... 871312
Seal kit, Pilot Solenoid Valve 871313

Water recirculating pump

Make..... M.P. pumps
Voltage 24 V DC
Prevost number 871342

Section 22: HEATING AND AIR CONDITIONING

Water filter (small A/C system)

Make.....BRAUKMANN
Prevost number..... 870807

Driver's expansion valve

Prevost number, option R-134a 950221
Prevost number, option R-22 950282

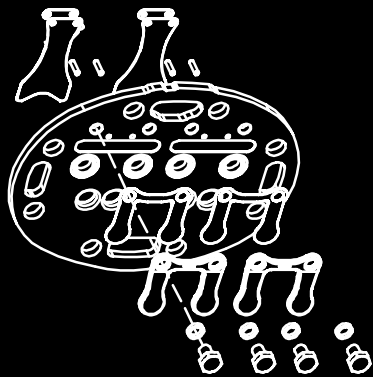
Expansion valve (Central system)

Make.....Alco
Model.....TCLE 5-1/2
Prevost number..... 950320

Preheating system

Make.....WEBASTO
Model..... THERMO 300
Capacity 104 000 Btu/h (30 kW)
Heating mediumCoolant
Rated voltage 24 V DC
Operating voltage..... 20-28 V DC
Electric power consumption (without coolant recirc. Pump) 110 watts
Fuel consumption..... 1,2 US gallons/hr (4,5 liters/hr)
Prevost number..... 871202

Carrier® Compressor



WORKSHOP MANUAL
for
**MODEL 05G TWIN PORT
COMPRESSOR**



TRANSICOLD

WORKSHOP MANUAL

MODEL 05G TWIN PORT

COMPRESSOR

SAFETY SUMMARY

GENERAL SAFETY NOTICES

The following general safety notices supplement the specific warnings and cautions appearing elsewhere in this manual. They are recommended precautions that must be understood and applied during maintenance of the equipment covered herein. The general safety notices are presented in the following three sections labeled: First Aid, Operating Precautions and Maintenance Precautions. A listing of the specific warnings and cautions appearing elsewhere in the manual follows the general safety notices.

FIRST AID

An injury, no matter how slight, should never go unattended. Always obtain first aid or medical attention immediately.

OPERATING PRECAUTIONS

Always wear safety glasses.

No work should be performed on the unit until all circuit breakers and start-stop switches are turned off, and power supply is disconnected.

Always work in pairs. Never work on the equipment alone.

MAINTENANCE PRECAUTIONS

Be sure power is turned off before working on motors, controllers, solenoid valves and electrical control switches. Tag circuit breaker and power supply to prevent accidental energizing of circuit.

Do not bypass any electrical safety devices, e.g. bridging an overload, or using any sort of jumper wires. Problems with the system should be diagnosed, and any necessary repairs performed, by qualified service personnel.

WARNING AND CAUTION STATEMENTS

To help identify the label hazards on the unit and explain the level of awareness each one carries, an explanation is given with the appropriate consequences:



DANGER - warns against an immediate hazard which **WILL** result in severe personal injury or death.



WARNING - warns against hazards or unsafe conditions which **COULD** result in severe personal injury or death.



CAUTION - warns against potential hazard or unsafe practice which could result in minor personal injury, or product or property damage.

NOTE

NOTE - gives helpful information that may help and avoid equipment and property damage.

SPECIFIC WARNING AND CAUTION STATEMENTS

The statements listed below are specifically applicable to this unit and appear elsewhere in this manual. These recommended precautions must be understood and applied during operation and maintenance of the equipment covered herein.



WARNING

Do not operate compressor unless suction and discharge service valves are open.



WARNING

Midseat service valves or by other means relieve pressure in replacement compressor before removing plugs.



WARNING

Do not unscrew capscrews all the way before breaking seal. Entrapped pressure could result in injury.



CAUTION

The high capacity oil pump must be set to rotate in the same direction as the crankshaft. (Refer to Section 3.5)



CAUTION

Ensure that thrust washer does not fall off dowel pins while installing oil pump.



CAUTION

Do not allow crankshaft to drop on connecting rods inside the crankcase when removing the crankshaft.



CAUTION

Do not allow crankshaft to drop on connecting rods inside the crankcase when installing the crankshaft.

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SECTION 1

DESCRIPTION

1.1 INTRODUCTION

This workshop manual covers the Carrier Transicold Model 05G Twin Port compressors. These compressors are designed for refrigeration (trailer) or air conditioning (bus & rail) applications. (See Figure 1-1) A detailed list of tools needed to service the 05G Twin Port compressor may be found in the Service Tool catalog 62-03213-. Replacement parts may be found in the Service Parts List for Model 05G Twin Port Compressor 62-11053-.

1.2 GENERAL DESCRIPTION

The 05G Twin Port compressors are of the open-drive reciprocating type. A crankshaft, connecting rods, pistons, and reed type valves accomplish vapor compression. Compressor wear is minimized by splash lubrication and by force feed lubrication. The oil pump is driven directly from the end of the compressor crankshaft. (See Figure 1-3)

The end of the crankshaft, which extends outside the crankcase, is adaptable to a variety of direct drive or belt-driven clutch mechanisms. A mechanical seal prevents refrigerant leakage where the rotating shaft passes through the crankcase. A shaft seal reservoir is provided to collect any oil seepage that might escape the seal.

The compressor is equipped with flanges for connecting suction and discharge service valves. Connections are also provided for pressure gauges and safety cutout switches. Sight glasses installed on both sides of the crankcase, provides a means for checking oil level in the compressor crankcase. A drain plug facilitates draining of oil from the crankcase and an oil fill plug enables addition of oil when necessary. A bottom plate provides access through the bottom of the crankcase for maintenance.



WARNING

Do not operate compressor unless suction and discharge service valves are open.

Capacity of the Model 05G Twin Port compressor is determined by piston displacement and clearance, suction and discharge valve size, compressor speed, suction and discharge pressure, type of refrigerant, and unloader valves.

1.3 COMPRESSOR REFERENCE DATA

Table 1-1. Compressor Reference Data

Model	05G-37CFM	05G-41CFM
Displacement	37CFM	41CFM
No. Cylinders	6	
Bore	50.8 mm (2.00 in)	
Stroke	49.2 mm (1.937 in)	54.36 mm (2.14 in)
Weight	62 kg (137 lbs)	
SPEED (RPM) FOR OIL PUMP		
Low Profile	500 to 2200	

NOTE

The oils below are suitable for use with evaporator temperatures above -40°F (-40°C).

Table 1-2. Oils

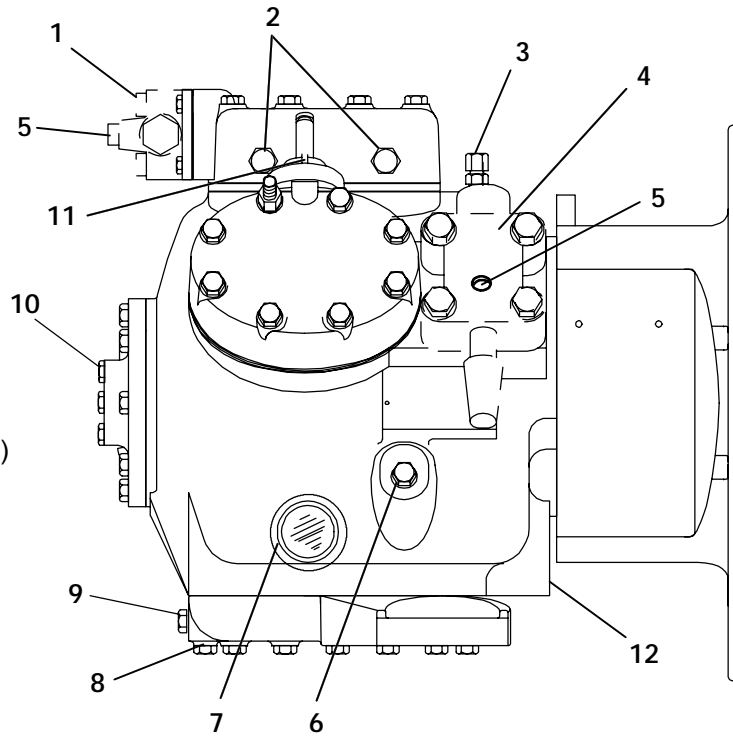
Approved Oil for REFRIGERATION USE (TRAILER)	
Refrigerant	Oil
R-12, R-22, R-500 or R-502	Alkyl Benzene (Synthetic) P/N 07-00274-00
R-404A	Polyolester (POE) P/N 07-00317-00PK6

Approved Oil for AIR CONDITIONING USE (BUS AND RAIL)	
Refrigerant	Oil
R-12, R-22, R-500 or R-502	Mineral (150 Viscosity) P/N 07-00275-00
R-12, R-22, R-502	Mineral (300 Viscosity) P/N 07-00377-00
R-22	Alkyl Benzene (Synthetic) P/N 07-00430-00
R-134a	Polyolester (POE) P/N 07-00317-00PK6

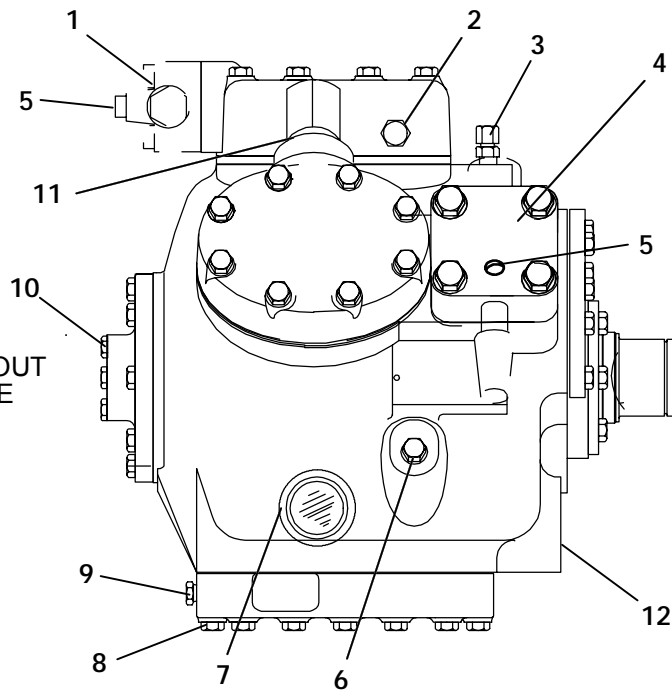
NOTE

Proper use and storage of Polyester (POE) type oil used with HFC refrigerants is critical. This type of oil is extremely hygroscopic, meaning that if allowed to become exposed to the atmosphere, it can collect moisture that leads to the formation of acids that will damage refrigeration components. Some refrigeration assemblies such as o-ring assemblies, compressor shaft seals and most solenoid valves require that refrigerant oil be applied to some of the parts during the assembly process. When this is needed, always use alkylated benzene oil CTD P/N 07-00274 (Zerol 150) even for R134a or R404A systems. All refrigerant oils must be stored in a sealed, airtight container.

COMPRESSOR WITH
MOUNTING FLANGE
(ULTRA TYPE SHOWN)



COMPRESSOR WITHOUT
MOUNTING FLANGE



- | | |
|-----------------------------|-------------------------------|
| 1. Discharge Service Valve | 7. Oil Level Sight Glass |
| 2. High Pressure Connection | 8. Bottom Plate |
| 3. Low Pressure Connection | 9. Oil Drain Plug |
| 4. Suction Service Valve | 10. Oil Pump (See Figure 1-3) |
| 5. Gauge Connection | 11. Unloader |
| 6. Oil Fill Plug | 12. Shaft Seal Reservoir |

Figure 1-1. Model 05G Compressor

1.4 DETAILED DESCRIPTION

1.4.1 Service Valves

The suction and discharge service valves used on the compressor are equipped with mating flanges for connection to flanges on the compressor. These valves are provided with a double seat and a gauge connection, which allows servicing of the compressor and refrigerant lines (See Figure 1-1).

Turning the valve stem counterclockwise (all the way out) will *backseat* the valve to open the suction or discharge line to the compressor and close off the gauge connection. In normal operation, the valve is backseated to allow full flow through the valve. The valve should always be backseated when connecting the service manifold gauge lines to the gauge ports.

Turning the valve stem clockwise (all the way forward) will *frontseat* the valve to close off the suction or discharge line to isolate the compressor and open the gauge connection.

To measure suction or discharge pressure, midseat the valve by opening the valve clockwise about 2 turns. With the valve stem midway between frontseated and backseated positions, the suction or discharge line is open to both the compressor and the gauge connection.

1.4.2 Suction And Discharge Valves

The compressor uses reed type suction and discharge valves made of highest quality steel for long life. The valves operate against hardened integral seats in the valve plate.

The downstroke of the piston admits refrigerant gas through the suction valve, and then compresses this gas on the upstroke, thereby raising its temperature and pressure. The compressed gas is prevented from re-entering the cylinder on its next downstroke by the compressor discharge valve. (See Figure 1-2)

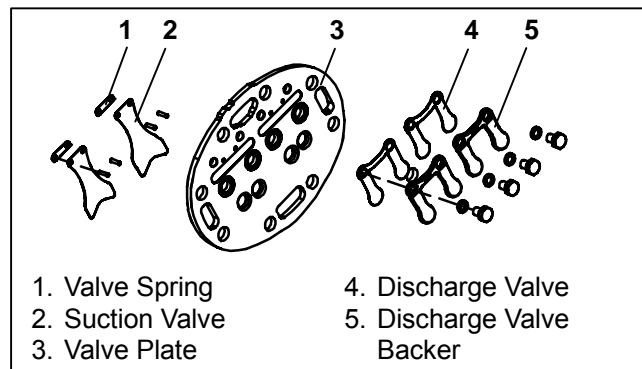


Figure 1-2. Suction & Discharge Valve

1.4.3 Lubrication System

Force-feed lubrication of the compressor is accomplished by an oil pump (See Figure 1-3) driven directly from the compressor crankshaft. Refrigeration oil is drawn from the compressor crankcase through the oil filter screen and pick up tube to the oil pump located in the bearing head assembly. The crankshaft is drilled to enable the pump to supply oil to the main bearings, connecting rod bearings, and the shaft seal.

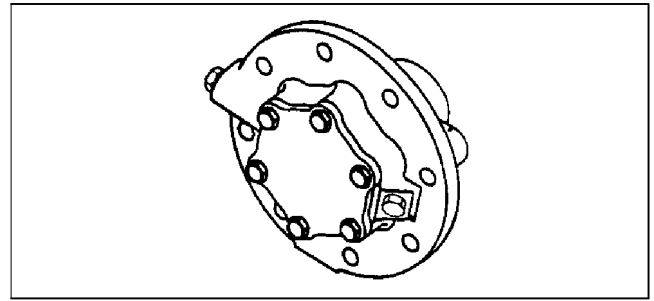


Figure 1-3. Oil Pump

The oil flows to the pump end main bearings, connecting rod bearings and seal end main bearings, where the oil path is divided into two directions. The largest quantity flows to the oil relief valve, which regulates oil pressure at 15 to 18 psi (1.02 to 1.22 bar) above suction pressure. When the oil pressure reaches 15 to 18 psi (1.02 to 1.22 bar) above suction pressure, the relief valve spring is moved forward allowing oil to return to the crankcase. The remaining oil flows through an orifice and into the shaft seal cavity to provide shaft seal lubrication and cooling. This oil is then returned to the crankcase through an overflow passage.

An additional oil pressure relief valve, built into the oil pump. It opens at speeds above 400 rpm to relieve a portion of the oil pressure to the crankcase in order to maintain oil pressure below an acceptable maximum. At low speeds, the valve is closed to ensure adequate oil pressure at 400 rpm. At speeds above 1900 rpm, the oil pressure will be 25 to 30 psi (1.70 to 2.04 bar) above suction pressure.

The crankcase pressure equalization system consists of two oil return check valves and a 1/8-inch pressure equalization port between the suction manifold and crankcase. Under normal conditions, check valves are open and allow for oil return to the crankcase. Under flooded start conditions, pressure rises in the crankcase and closes the check valves, preventing excess oil loss. The equalization port allows for release of excessive pressure, that has built up in the crankcase, to the suction manifold; this ensures that the oil loss is kept to a minimum.

1.4.4 Shaft Seal Reservoir

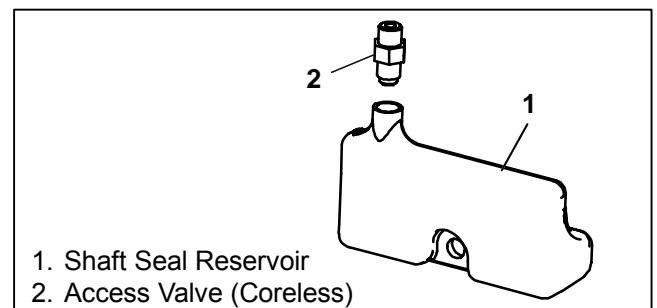


Figure 1-4. Shaft Seal Reservoir

The shaft seal oil reservoir has been fitted to the crankcase. The coreless access valve taps into the crankshaft seal cavity where any oil that escapes the crankshaft seal will form. The coreless access valve then drains that compressor oil that escapes the crankshaft seal into the shaft seal reservoir.

1.5 COMPRESSOR UNLOADERS

The compressor is equipped with unloaders for capacity control. This consists of a self-contained, cylinder head hot gas bypass arrangement. (See Figure 1-5)

The compressor unloader system can be controlled with either a pressure actuated valve or an electrically actuated (solenoid) valve.

1.5.1 Electric-Controlled Unloaders

The capacity controlled cylinder is easily identified by an electric solenoid which extends from the side of the cylinder head. When the solenoid energizes, the cylinder unloads allowing discharge gas to circulate as shown in Figure 1-6. The unloaded cylinder operates with little or no pressure differential, consuming very little power. A de-energized solenoid reloads the cylinder as shown in Figure 1-7.

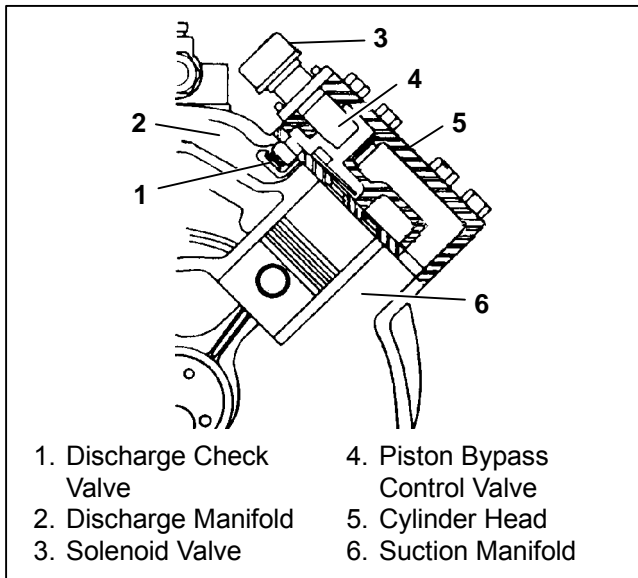


Figure 1-5. Compressor Unloader

a. Major Working Parts

1. Solenoid and valve system
2. Spring loaded piston type bypass control valve
3. Spring loaded discharge check valve

b. Unloaded Operation

Pressure from the discharge manifold (Figure 1-6, item 15) passes through the strainer (9) and bleed orifice (8) to the back of the piston bypass valve (7). Unless bled away, this pressure would tend to close the piston (6) against the piston spring (5) pressure.

With the solenoid valve (1) *energized* the solenoid valve stem (2) will *open* the gas bypass port (3).

Refrigerant pressure will be bled to the suction manifold (10) through the opened gas bypass port. A reduction in pressure on the piston bypass valve will take place because the rate of bleed through the gas bypass port is greater than the rate of bleed through the *bleed orifice* (8).

When the pressure behind the piston has been reduced sufficiently, the valve spring will force the piston bypass valve *back*, *opening* the gas bypass from the discharge manifold to the suction manifold.

Discharge pressure in the discharge manifold will close the discharge piston check valve assembly (14) isolating the compressor discharge manifold from the individual cylinder bank manifold.

The *unloaded* cylinder bank will continue to operate *fully unloaded* until the solenoid valve control device is *de-energized* and the gas bypass port is closed.

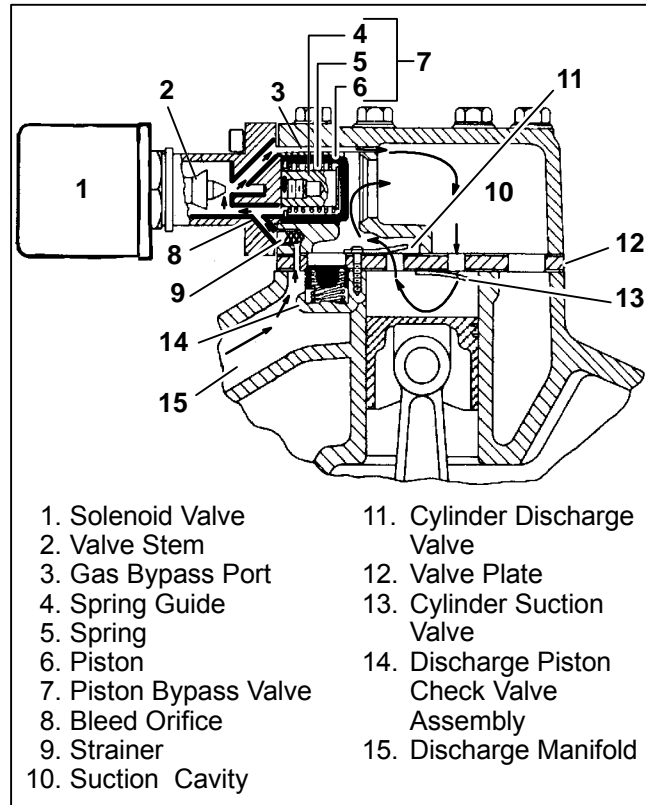


Figure 1-6. Electric-Operated Unloader- Unloaded Operation

c. Loaded Operation

Discharge pressure bleeds from the discharge manifold (Figure 1-7, item 15) through the strainer (9) and bleed orifice (8) to the solenoid valve stem (2) chamber and the back of the piston bypass valve (7).

With the solenoid valve (1) *de-energized* the solenoid valve stem (2) will *close* the gas bypass port (3).

Refrigerant pressure will overcome the bypass valve spring (5) tension and force the piston (6) *forward closing* the gas bypass from the discharge manifold to the suction manifold (10).

Cylinder discharge pressure will force open the discharge piston check valve assembly (14). Refrigerant gas will pass into the compressor discharge manifold.

The loaded cylinder bank will continue to operate fully loaded until the solenoid valve control device is energized and the gas bypass port is opened.

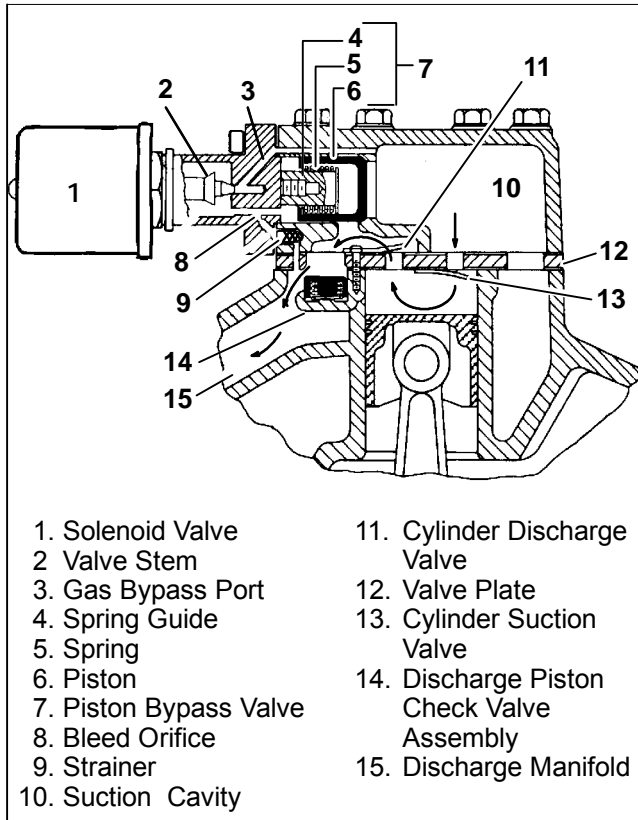


Figure 1-7. Electric-Operated Unloader - Loaded Operation

1.5.2 Pressure-Operated Unloaders

The pressure-operated unloaders are controlled by suction pressure and actuated by discharge pressure. The unloader valve controls two cylinders. On startup, controlled cylinders do not load up until differential between suction and discharge pressure is 10 psi (0.68 bar).

During *loaded operation*, (Figure 1-8) when suction pressure is above the valve control point, the poppet valve (4) will close. Discharge gas bleeds into the valve chamber; the pressure closes the piston bypass valve (5) and the cylinder bank loads up. Discharge gas pressure forces the discharge piston check valve (6) open, permitting gas to enter the discharge manifold.

During *unloaded operation*, (Figure 1-9) when suction pressure drops below the valve control point, the poppet valve (4) will open. Discharge gas bleeds from behind the bypass piston to the suction manifold. The bypass piston valve (5) opens, discharge gas is recirculated back to the suction manifold and the cylinder bank is unloaded. Reduction in discharge pressure causes the discharge piston check valve (6) to close, isolating the cylinder bank from the discharge manifold.

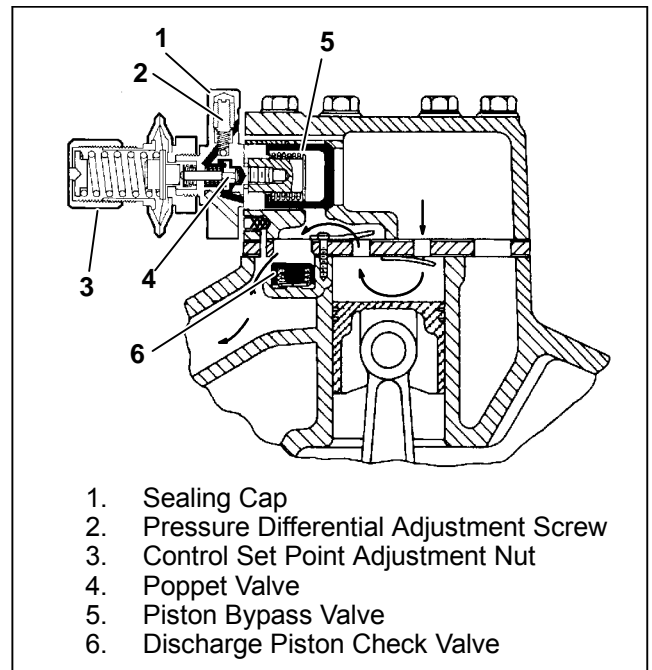


Figure 1-8. Pressure-Operated Unloader Loaded Operation

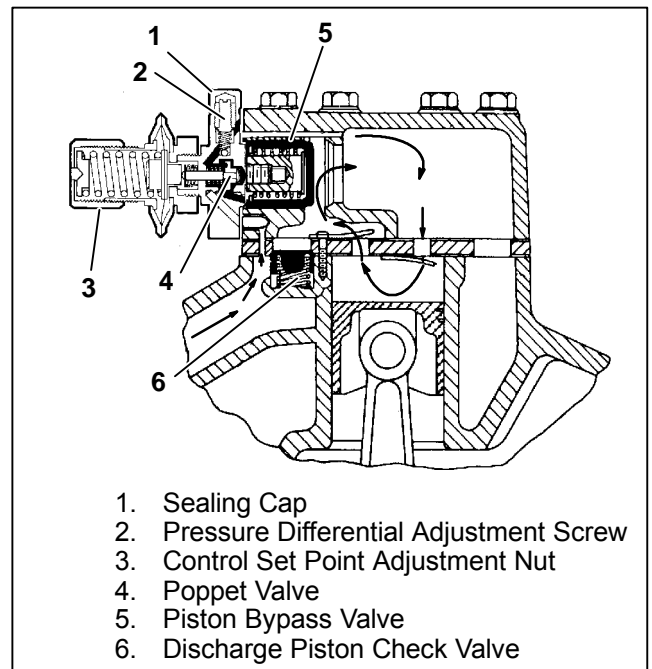


Figure 1-9. Pressure-Operated Unloader - Unloaded Operation

SECTION 2

COMPRESSOR REPLACEMENT

2.1 COMPRESSOR REMOVAL

Refer to the operation and service manual covering the equipment in which the compressor is installed for specific removal instructions. A general removal procedure is given below.

- If compressor is completely inoperative, frontseat the suction and discharge service valves to trap the refrigerant in the unit. If the compressor will operate, pump down the unit; then, frontseat the suction and discharge service valves.
- Ensure power source is removed from any controls installed on the compressor.
- Remove refrigerant from the compressor using a refrigerant recovery system.
- Disconnect refrigerant lines at service valve flange connections on the compressor; retain hardware.
- Remove any components necessary to gain access to the compressor or to enable removal.
- Disconnect the drive mechanism at the compressor.
- Remove mounting hardware and remove compressor from unit.
- If compressor is to be repaired, refer to section 3 for repair procedures. If a replacement compressor is to be installed, refer to section 2.2 for replacement procedures.

2.2 COMPRESSOR REPLACEMENT

Consult the unit service parts list for the correct replacement.

Service replacement compressors are furnished without suction and discharge service valves and unloader valves. The service valves are normally retained on the unit to isolate the refrigerant lines during compressor replacement. Blank-off pads are installed on the service replacement compressor valve flanges. These pads must be removed prior to installing the compressor. If the defective compressor is to be returned for overhaul or repair, install the pads on the compressor for sealing purposes during shipment.

Service replacement compressors are furnished with cylinder head bypass piston plugs installed on the unloader flanges in lieu of the unloader valves. The unloaders (if used) must be removed from the defective compressor and transferred to the replacement compressor prior to installation. Refer to section 2.2.1.

If the defective compressor is to be returned for overhaul or repair, install the plugs on the compressor for sealing purposes during shipment.

2.2.1 Installing Compressor Unloaders

- Remove the three socket head capscrews holding piston plug to cylinder head of the replacement compressor. See Figure 2-1.

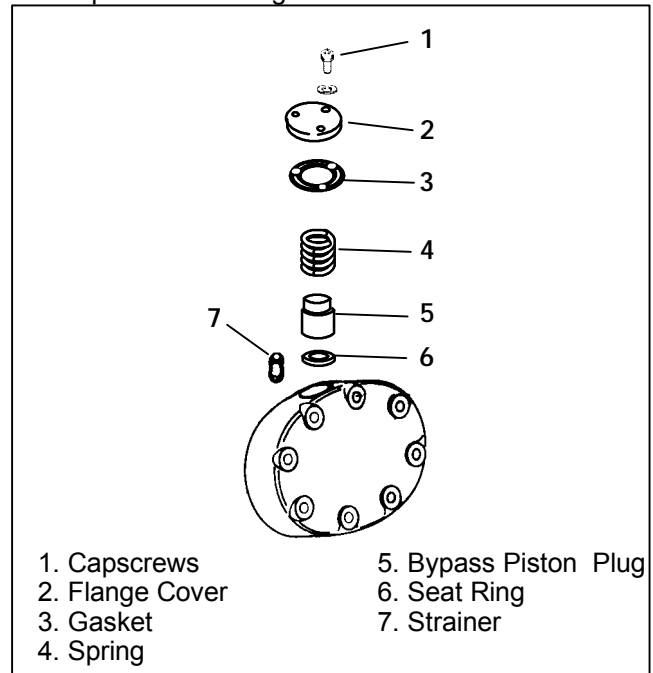


Figure 2-1. Removal of Piston Plug

- Remove flange cover, gasket, spring, bypass piston plug, and seat ring. A tapped hole is provided in piston plug for use with a jackscrew to enable removal of the plug. One of the socket head capscrews may be used as a jackscrew.
- Remove the three socket head capscrews holding unloader in the cylinder head of the defective compressor; remove the unloader and retain the capscrews.

NOTE

Capscrews removed from the bypass piston plug flange cover are not interchangeable with capacity control unloader valve capscrews. When installing the unloaders, be sure to use the unloader capscrews.

- Using a new gasket and unloader ring pliers (P/N 07-00223), install the unloaders in the cylinder heads of the replacement compressor. Refer to Table 3-1, for required torque values.
- If the defective compressor is to be returned for overhaul or repair, install the bypass piston plug, spring, seat ring and flange cover onto the cylinder heads.

2.2.2 INSTALLING COMPRESSOR



WARNING

Midseat service valves or by other means relieve pressure in replacement compressor before removing plugs.



CAUTION

The high capacity oil pump must be set to rotate in the same direction as the crankshaft. (Refer to Section 3.5)

- a. Install the compressor by reversing the procedure of section 2.1. Install new locknuts on compressor mounting bolts and new gaskets on suction and discharge service valves.
- b. Check oil level in sight glass (See Figure 2-2). If necessary, add or remove oil.
- c. Leak test, evacuate, and dehydrate the compressor.
- d. Fully backseat suction and discharge service valves.
- e. Run the compressor and check for leaks and noncondensibles in the refrigerant system.
- f. Check refrigerant level.

g. Recheck compressor oil level.

h. Check operation of compressor unloaders (if installed).

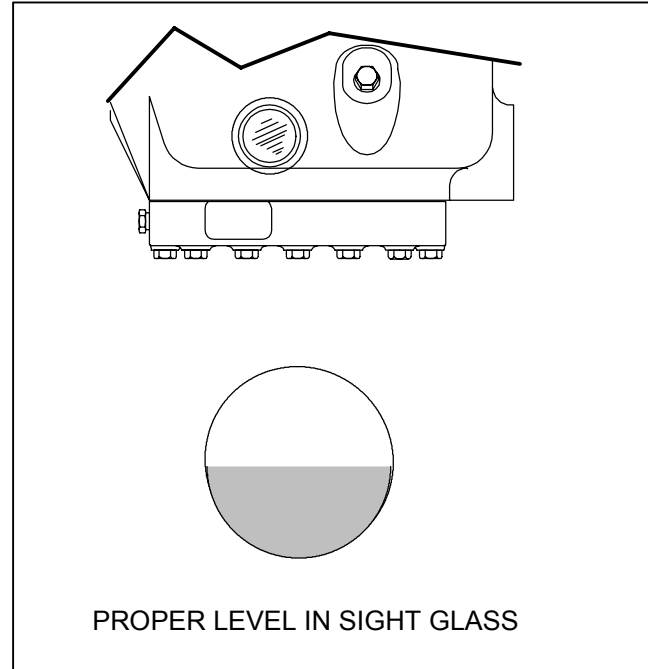


Figure 2-2. Oil Level in Sight Glass

SECTION 3

COMPRESSOR MAINTENANCE

3.1 SHAFT SEAL RESERVOIR

The shaft seal reservoir will accumulate up to 3.5 ounces of oil. It should be serviced (checked and drained) at least once a year. To service the reservoir:

- Remove the capscrew and washer that secures the reservoir to the crankcase.
- Remove the reservoir and properly dispense of the contents.

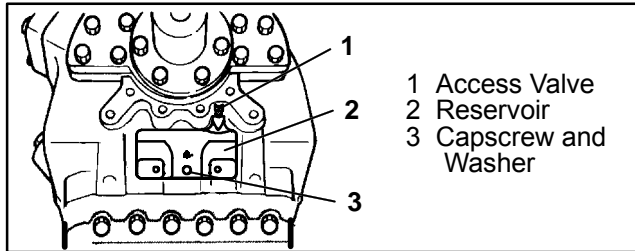


Figure 3-1. Shaft Seal Reservoir

NOTE

Do not return this oil to the compressor. This oil is contaminated. Dispose this oil in an environmentally correct manner.

- Return the reservoir to its mounting location insuring that the neck of the reservoir is seated over the access valve.
- Reinstall the capscrew and washer.

Refer to Table 3-1 for torque values for tightening the capscrew.

3.2 INTRODUCTION

Prior to disassembly of the compressor, oil must first be drained from the crankcase. Place the compressor in a position where it will be convenient to drain the oil. Remove the oil fill plug to vent the crankcase. Loosen the drain plug and allow the oil to drain out slowly.

If dismantled parts are to be left overnight or longer, dip them in clean compressor oil (to prevent rusting) and store in protected area.

Refer to Table 3-1 for torque values for tightening bolts.

3.3 INSPECTION AND PREPARATION FOR REASSEMBLY

- Clean all parts with an approved solvent. Use a stiff bristle brush to remove dirt from grooves and crevices.
- Inspect all parts for wear and overall condition. Replace any defective or excessively worn parts.

- Inspect suction and discharge valve seats (on valve plate).
- If unloaders are installed, inspect operation of unloader.
- After cleaning, ensure all moving parts are coated with compressor oil before reassembly.
- Use only new gaskets during reassembly. Ensure all gaskets (includes cylinder head, valve plate, and unloader or bypass plug gaskets) are installed dry.

3.4 CYLINDER HEAD AND VALVE PLATE

3.4.1 Disassembly



Do not unscrew capscrews all the way before breaking seal. Entrapped pressure could result in injury.

- Loosen cylinder head capscrews. If the head is stuck, tap it lightly with a wooden or lead mallet to free it. Be careful not to drop the head or damage the gasket sealing surface. Remove cylinder head capscrews and gasket. (See Figure 3-2)
- Remove the discharge valve capscrews, lock washers, stops, and valves.
- Free the valve plates from the cylinder deck by using the discharge valve capscrews, without washers, as jackscrews through the outermost tapped holes in the valve plate after the valve stops and valves have been removed. Remove the valve plate gasket.
- Discard valves and gaskets. Use only new valves and gaskets when assembling cylinder head and valve plate assemblies.

3.4.2 Reassembly

Install only new valves and gaskets, do not interchange valves.

- Install the discharge valves and discharge valve stops with capscrews and lock washers onto the valve plates. Torque the capscrews to a value shown in Table 3-1.
- Turn the valve plate over.
- Place suction valve on dowel pins.
- Install the suction valve spring on the dowel pins with the spring ends bearing away from the cylinder head. (See Figure 3-3)

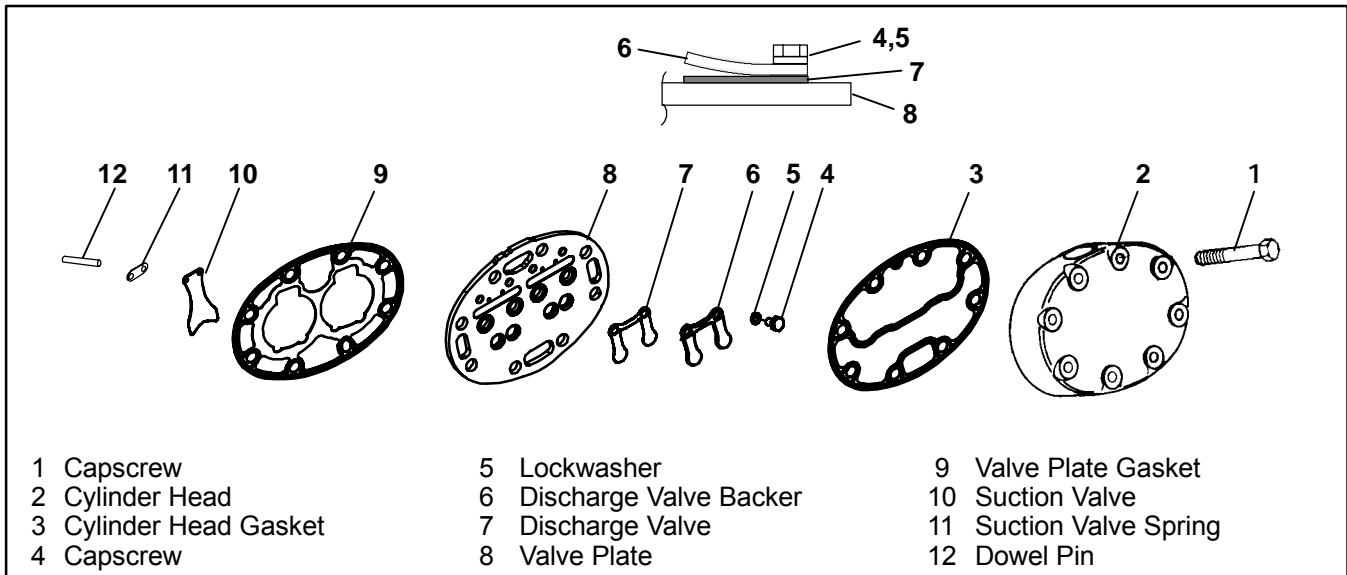


Figure 3-2. Cylinder Head & Valve Plate

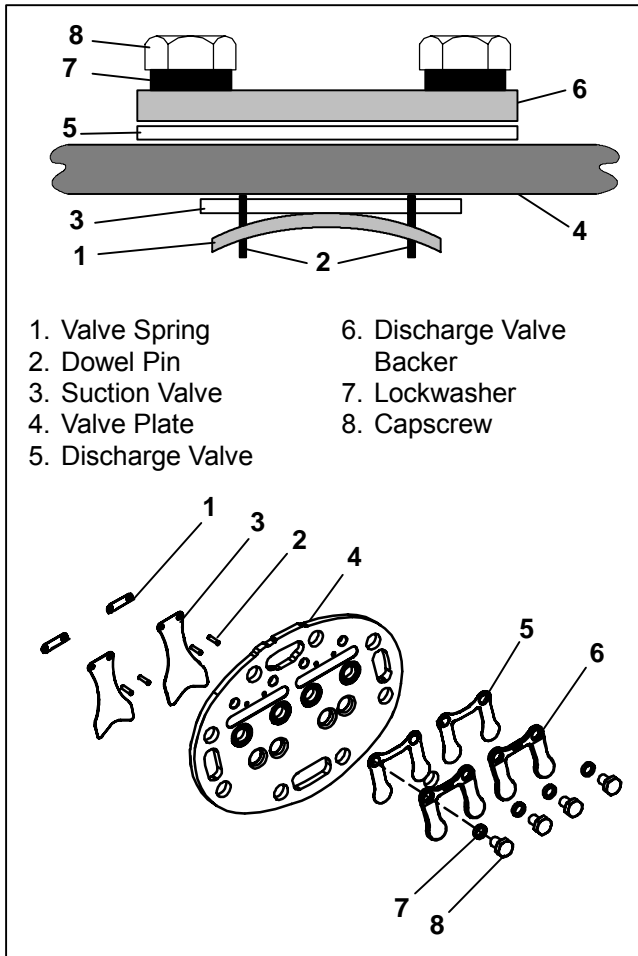


Figure 3-3. Installing Suction Valves

- e. Place the valve plate and new valve plate gasket on cylinder deck, ensuring that the valve plate is properly positioned on the four dowel pins.
- f. Using a small screwdriver, operate the suction valves to ensure that the valve tips are not being held by the valve plate gasket. (See Figure 3-4)
- g. Install cap screws, cylinder head and new cylinder head gasket with flat side to valve plate, ensuring that the gasket and cylinder head are properly positioned on the valve plate. Torque the cap screws, in a diagonal pattern, to a value shown in Table 3-1.

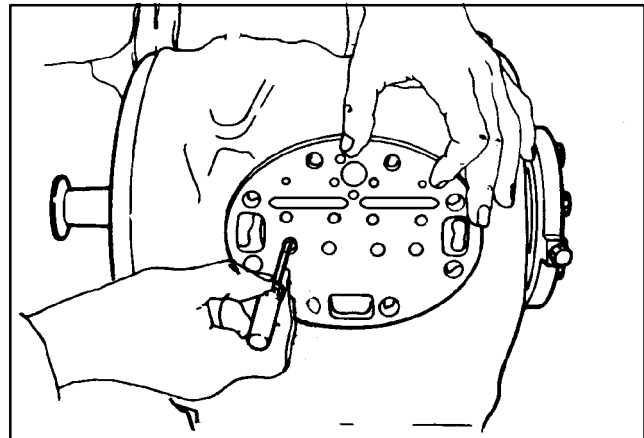


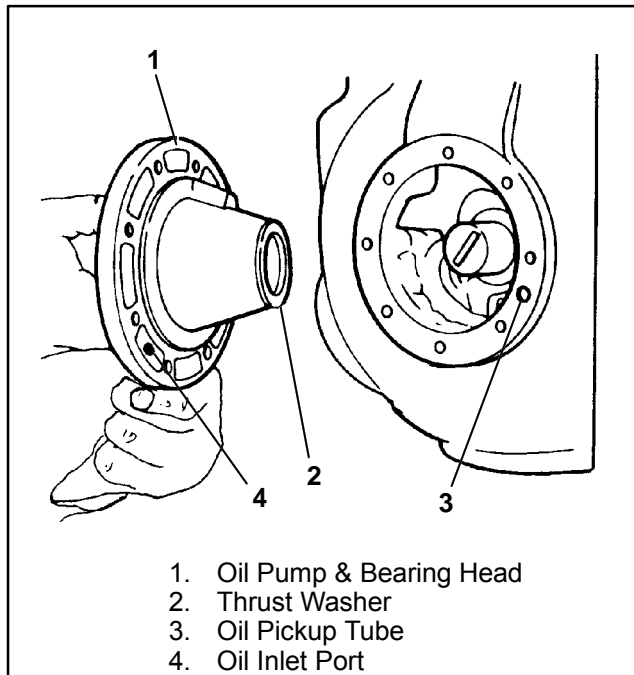
Figure 3-4. Checking Suction Valve

3.5 OIL PUMP AND BEARING HEAD

The oil pump is driven directly from the end of the compressor crankshaft.

3.5.1 Removal

Remove eight capscrews and remove the oil pump bearing head assembly, gasket and thrust washer. (See Figure 3-5.)

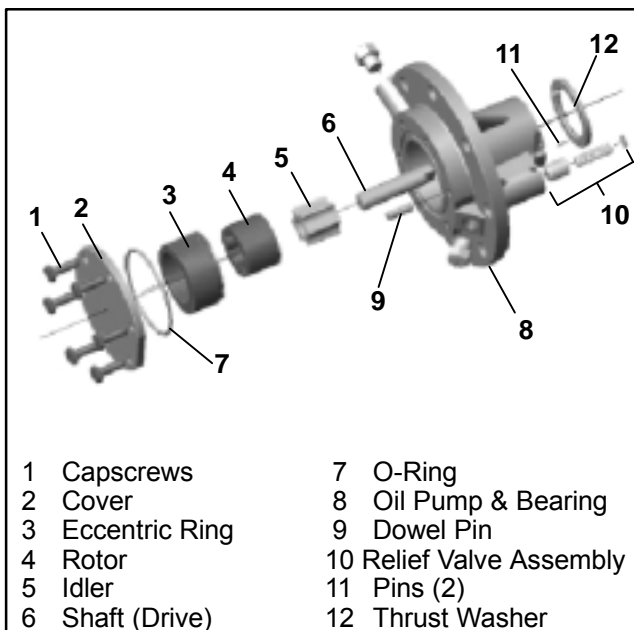


1. Oil Pump & Bearing Head
2. Thrust Washer
3. Oil Pickup Tube
4. Oil Inlet Port

Figure 3-5. Oil Pump and Bearing Head Assembly

3.5.2 Disassembly, & Inspection

If it is determined that the oil pump is not operating properly, the entire oil pump and bearing head assembly must be replaced. Replacement parts for the pump are not available except for the cover plate O-ring. However, in the event the pump requires inspection or cleaning, refer to Figure 3-6 for disassembly and reassembly. Clean all parts; coat all moving parts with compressor oil before proceeding with reassembly.



- | | |
|------------------|--------------------------|
| 1 Capscrews | 7 O-Ring |
| 2 Cover | 8 Oil Pump & Bearing |
| 3 Eccentric Ring | 9 Dowel Pin |
| 4 Rotor | 10 Relief Valve Assembly |
| 5 Idler | 11 Pins (2) |
| 6 Shaft (Drive) | 12 Thrust Washer |

Figure 3-6. Oil Pump

3.5.3 Reassembly

- a. Install the pump end thrust washer on the two dowel pins located on the bearing head. (See Figure 3-5.)



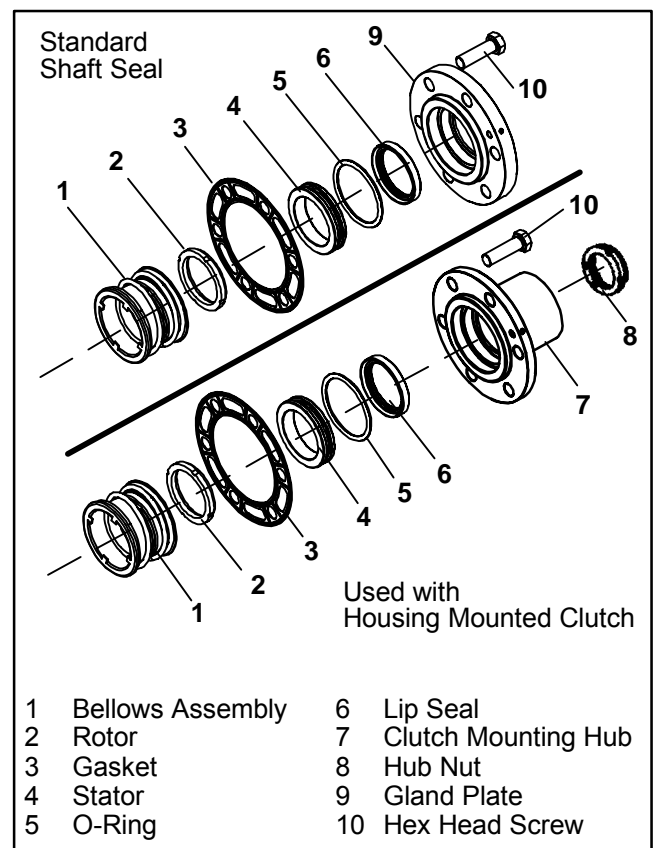
Ensure that thrust washer does not fall off dowel pins while installing oil pump.

- b. Install the bearing head assembly with a new gasket on the compressor crankshaft. Carefully push oil pump on by hand ensuring that the thrust washer remains on the dowel pins, the tang on the end of the drive engages the slot in the crankshaft, and the oil inlet port on the pump is aligned with the oil pickup tube in the crankcase. The oil pump should mount flush with the crankcase with the "TOP" stamp on the pump oriented straight up. (See Figure 3-12)
- c. Align the gasket and install the eight capscrews in the mounting flange. Refer to Table 3-1, for applicable torque values.

3.6 SHAFT SEAL

3.6.1 Disassembly

- a. Remove 6 capscrews, remove the shaft gland plate or clutch mounting hub. Remove rotor from top of bellows assembly. (See Figure 3-7)



- | | |
|--------------------|-----------------------|
| 1 Bellows Assembly | 6 Lip Seal |
| 2 Rotor | 7 Clutch Mounting Hub |
| 3 Gasket | 8 Hub Nut |
| 4 Stator | 9 Gland Plate |
| 5 O-Ring | 10 Hex Head Screw |

Figure 3-7. Shaft Seal

- b. Lubricate the end of the crankshaft with clean oil.
- c. Using two long screwdrivers, pry out the shaft seal but do not damage the gasket surface or the crankshaft. (See Figure 3-8)

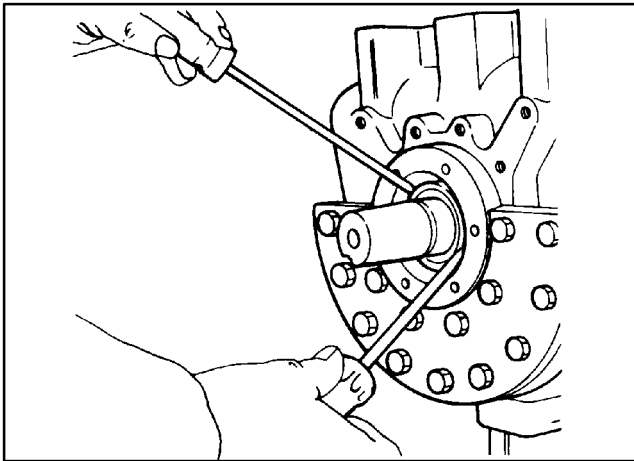


Figure 3-8. Shaft Seal Removal

3.6.2 Reassembly

NOTE

Install a new shaft seal assembly and cover gasket, with the shaft seal cover/clutch mounting hub. Never install a used seal assembly or gasket. A new rotor should never be installed with a used stator. When installing the seal assembly, use care not to damage the rotor or stator.

- a. Remove the **NEW** rotor from new seal assembly. Lubricate shaft and the neoprene seal bellows where it contacts the shaft with clean/fresh compressor oil. Slide the seal assembly onto shaft until the neoprene bellows starts to grip the shaft.
- b. Install the **OLD** rotor in the new seal seat. Install two capscrews in opposite sides of the old cover/mounting hub. Draw up capscrews evenly to properly position new seal assembly against the shoulder on the crankshaft. Remove the capscrews and old rotor and cover plate/mounting hub.
- c. Install the **NEW** rotor. Ensure that notches in rotor are aligned with two small knurls inside the seal seat. Install the new cover plate and gasket.
- d. Remove the old stator and O-ring from the shaft seal cover/clutch mounting hub.
- e. Inspect the lip seal that is still in the cover/clutch mounting hub. If it shows any signs of damage or wear remove it.
- f. Install the lip seal into the cover/clutch mounting hub. Insure that the back side of the lip seal seats on the shoulder machined in the cover/clutch mounting hub.
- g. Using clean refrigerant oil, lubricate the new O-ring and install it into the outside groove of the new stator being careful not to touch the sealing surfaces of the stator with your fingers.

NOTE

Do not touch the sealing surfaces with your fingers. If the sealing surfaces become contaminated, clean with isopropyl alcohol and a clean dry lint-free cloth.

- h. Install the stator into the cover/clutch mounting hub. Insure that the back side of the stator seats to the lip seal.

NOTE

The shaft seal cover or clutch mounting hub on this compressor must be oriented so that the oil communication hole in the cover/hub lines up correctly with the port in the crankcase. The cover/hub should mount flush with the crankcase with the "TOP" stamp on the pump oriented straight up.

- i. Assemble the seal cover/clutch mounting hub, the gasket and the six hex head screws on to the compressor, paying attention to the orientation of the cover/hub (see Figure 3-9).

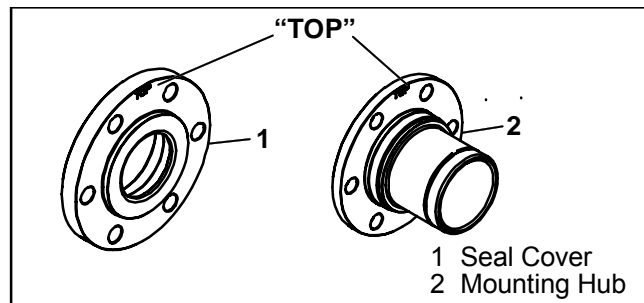


Figure 3-9. TOP Orientation

- j. Align the gasket and install the six capscrews in the mounting flange. Refer to Table 3-1, for applicable torque values.

3.7 COMPRESSOR RUNNING GEAR REMOVAL

In order to disassemble Piston, Rod and Rings, first the cylinder heads and valve plate assemblies, oil pump and bearing head assemblies and shaft seal must be removed. (Refer to sections 3.4, 3.5 and 3.6).

3.7.1 Bottom Plate, Strainer, and Connecting Rod Caps

- a. Turn the compressor over, bottom side up, and remove the bottom plate. (See Figure 3-10) Scrape off gasket.
- b. Remove the oil strainer.

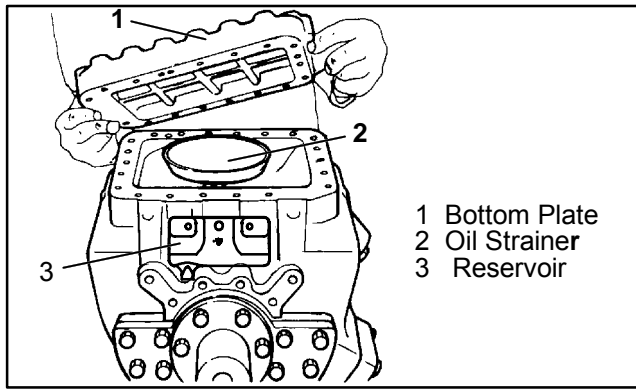


Figure 3-10. Bottom Plate Removal

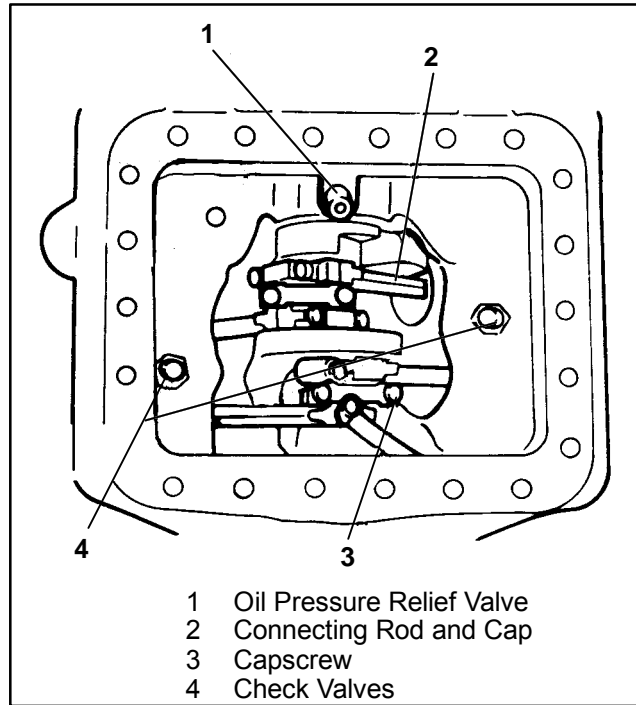


Figure 3-11. Bottom Plate and Oil Strainer Removed

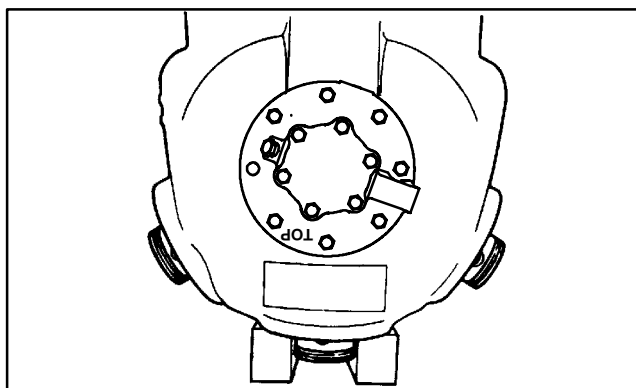


Figure 3-12. Piston Rings Removed

c. Match mark each connecting rod cap and connecting rod for correct reassembly. Remove the capscrews, flat washers and connecting rod caps. It is recommended that the capscrews and flat washers be discarded and new capscrews (special) and flat washers

be installed during compressor reassembly. (See Figure 3-11)

d. Push the piston rods down so that the piston rings extend below the cylinders. Remove and discard piston rings. Use only new rings when reassembling the compressor. (See Figure 3-12.)

3.7.2 Crankshaft and Seal End Thrust Washer



Do not allow crankshaft to drop on connecting rods inside the crankcase when removing the crankshaft.

- Push piston rod assemblies out of the way and remove crankshaft and seal end thrust washer.
- Remove and check operation of oil return check valves (See Figure 3-11). The check valves are free floating devices and can easily be checked visually.
- Remove and check oil pressure relief valve (See Figure 3-11). The oil pressure relief valve is a spring loaded device which can be checked by using a small piece of stiff wire to ensure that the spring can be depressed.
- Remove piston rod assemblies.

3.7.3 Pistons, Rods, and Rings

- Piston and pin, and connecting rod and rod cap are matched sets and must not be interchanged. That is, if either the piston or piston pin is to be replaced, you must replace both of them. Likewise, if a connecting rod or rod cap must be replaced, both must be replaced.
- Match mark and disassemble pistons, pins, connecting rods, and caps. (See Figure 3-13)

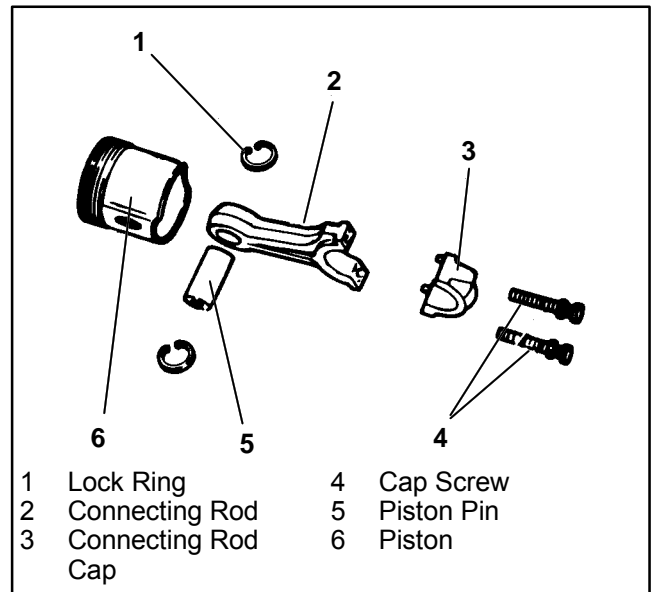


Figure 3-13. Connecting Rod, Piston, and Pin

c. Check wear dimensions of disassembled parts to determine if they are worn beyond limits given in Table 3-2.

- d. Measure side clearance between ring and ring groove in piston. Maximum dimensions are provided in Table 3-2.
- e. If parts are worn beyond limits, replace them in matched sets as specified above.
- f. Coat piston pins with compressor oil and reassemble pistons, pins, and connecting rods in matched sets.

NOTE

Pay particular attention to the orientation of the piston in relation to the connecting rod, and the cylinder they are intended for. See Figure 3-15 and .

3.7.4 Seal End Main Bearings

- a. Inspect seal end main bearings. Check wear dimensions to determine if they are worn beyond limits given in Table 3-2.
- b. If worn beyond limits remove seal end main bearings.

3.8 COMPRESSOR RUNNING GEAR REASSEMBLY

3.8.1 Seal End Main Bearings

- a. When installing new seal end main bearings the oil V grooves are oriented towards the top of the compressor with oil V grooves pointing to each other. When installed, there must be a 5/16 inch (7.93 mm) gap between the two bearings (See Figure 3-14).
- b. Line boring seal end main bearings.

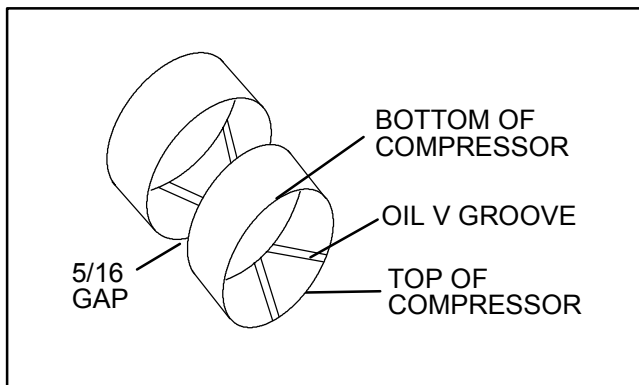


Figure 3-14. Seal End Main Bearings

3.8.2 Pistons, Rods, and Rings

Prior to installing new piston rings, it is necessary to break the hard glazed surface of the cylinder in order to reduce the wearing-in period of the new rings. Break the glaze by honing lightly in an up and down rotating motion. Clean thoroughly after breaking glaze.

Some 05G compressors for refrigeration use only may have contoured pistons (See Figure 3-15). When installing contoured pistons into compressor, check suction valve and contoured piston are in the same orientation.



Figure 3-15. Piston

- a. The gap between the ends of the piston rings can be checked with a feeler gauge by inserting the ring into the piston bore about one inch below the top of the bore. Align the ring in the bore by pushing it slightly with a piston. The maximum and minimum allowable ring gaps are shown in Table 3-2.

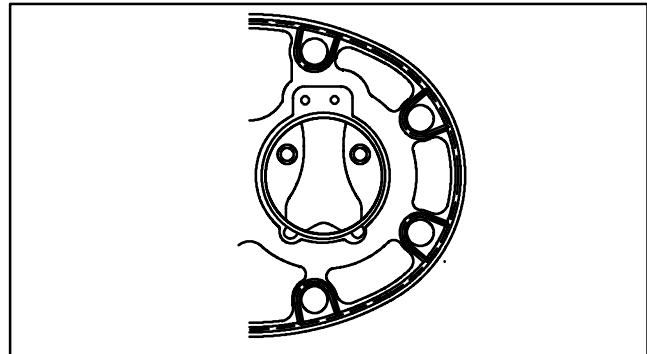


Figure 3-16. Correct Piston in Cylinder Orientation

- b. Install the piston and rod assemblies up through the bottom of the crankcase and into the cylinders. Allow pistons to extend beyond the top of the cylinder to enable installation of piston rings. Pistons must be installed so that the chamfer, on the connecting rod, faces toward the crankshaft journals. Center rods on each crankshaft throw may be installed in either direction. (See Figure 3-17)

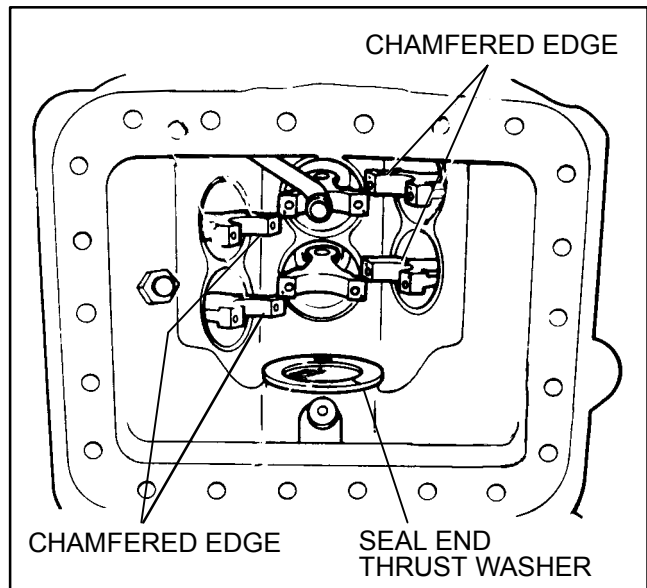


Figure 3-17. Installing Piston Rod Assemblies and Seal End Thrust Washer

c. The compressor will be fitted with double ring pistons.

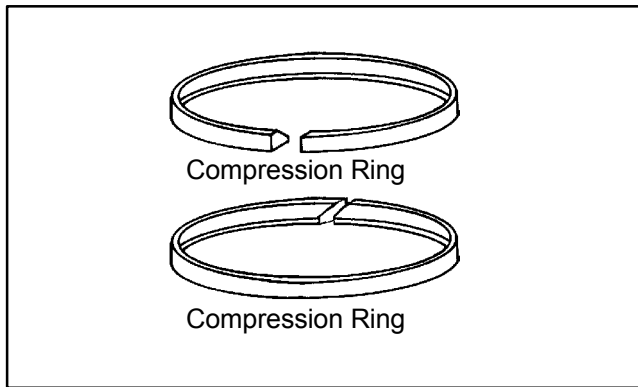


Figure 3-18. Piston Rings

d. The compression ring is chamfered on the inside circumference. This ring is installed with the chamfer towards the top. Stagger the ring end gaps so they are on opposite sides of the piston.

3.8.3 Crankshaft and Seal End Thrust Washer

- Two brass thrust washers are used. The pump end thrust washer is positioned on two dowel pins located on the bearing head and is installed with the oil pump and bearing head assembly. The seal end thrust washer is positioned just ahead of the seal end main bearing on one dowel pin installed in the crankcase. Both thrust washers should be inspected for wear and scoring before reassembly (Refer to Table 3-2).
- Install the seal end thrust washer on the dowel pin. (See Figure 3-17) Ensure piston rods are pushed out of the way and install the crankshaft.



CAUTION

Do not allow crankshaft to drop on connecting rods inside the crankcase when installing the crankshaft.

3.8.4 Bottom Plate, Strainer, and Connecting Rod Caps

- Do not tap piston with hammer if rings are caught at entrance to the cylinder. Using a ring compressor, squeeze rings sufficiently to allow piston to be pushed down into the cylinder. Ensure that ring ends are staggered so that the gaps are not aligned, and lightly tap piston down into the cylinder. (See Figure 3-19) The ring compressor can be easily fabricated from a piece of sheet metal.
- Install connecting rod caps on connecting rods using new capscrews (special) and flat washers. Reuse of the old capscrews is not recommended. Ensure that the caps are installed on the locating pins. Torque capscrews to torque value shown in Table 3-1. Ensure freedom of movement of crankshaft after capscrews are torqued on each rod cap.
- Check operation and reinstall check valves and relief valve. (See Figure 3-11). The check valves are free-floating devices and can easily be checked visually. The relief valve is a spring-loaded device which can

be checked by using a small piece of stiff wire to ensure that the spring mechanism can be depressed.

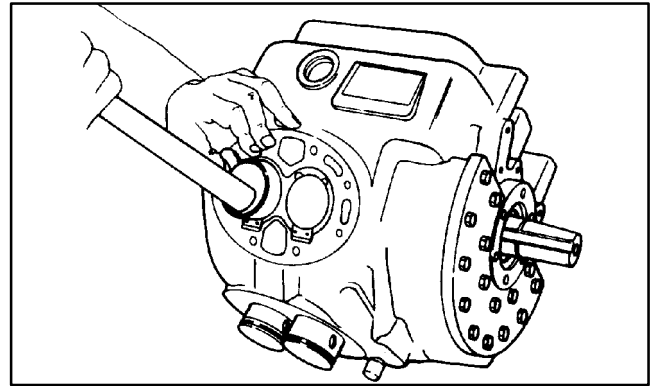


Figure 3-19. Installing Pistons

- Clean and reinstall the oil strainer.
- Using a new gasket, install the bottom cover plate. See figure 1-1 for relative location of compressor mounting flanges. Torque cover capscrews, in a diagonal pattern, to the torque value shown in Table 3-1.
- Reassemble the cylinder head, oil pump and shaft seal (Refer to sections 3.4, 3.5 and 3.6).

3.9 SUCTION STRAINER

NOTE

The suction strainer has been preformed to fit into the suction cavity.

Remove and clean the suction strainer. (See Figure 3-20) Check it for damage. If it is damaged, replace suction strainer. Install suction strainer and suction service valve using a new gasket.

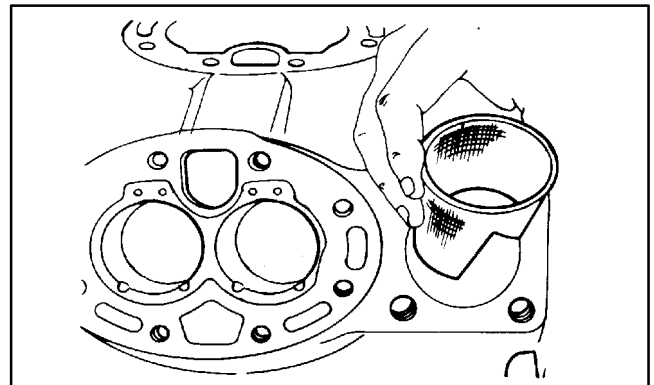


Figure 3-20. Installing Suction Strainer

3.10 ADDING OIL

Add the proper oil charge to the compressor through the oil fill plug. Refer to section 2.2.2 for the required oil charge. Refer to unit operation manual for other methods of adding oil to compressor.

3.11 INSTALLING COMPRESSOR

Refer to section 2.2.2 and the unit service manual to install the compressor.

Table 3-1. Torque Values

SIZE DIAMETER (INCHES)	THREADS PER INCH	TORQUE RANGE		USAGE
		FT-LB	MKG	
1/16	27 (pipe)	5.5 to 7	0.8 to 1.0	Crankshaft Center Web Plug
1/8	27 (pipe)	8 to 16	1.1 to 2.2	Oil Return Check Valve - Crankcase
7/16	20	8 to 14	1.1 to 1.9	Oil Fill/Drain Plug
1/4	20 (pipe)	20 to 25	2.8 to 3.5	Pipe Plug - Gauge Connection
1/4	20	8 to 12	1.1 to 1.7	Connecting Rod Capscrew
		10 to 13	1.4 to 1.8	Connecting Rod Counter Weight
1/4	28	5.5 to 7	0.8 to 1.0	Crankshaft Setscrew
		8 to 18	1.1 to 2.5	Unloader Valve
		12 to 16	1.7 to 2.2	Discharge Valve Backer
5/16	18	16 to 20	2.2 to 2.8	Cover - Oil Pump
		20 to 30	2.8 to 4.1	Discharge Service Valve
3/8	16	8 to 15	1.1 to 2.1	Oil Reservoir
		30 to 50	4.1 to 6.9	Bottom Plate - Crankcase
				End Flange - Crankcase
				Shaft Seal Cover
				Pump End Bearing Head
42 to 55	5.8 to 7.6	Cylinder Head		
1/2	13	55 to 80	7.6 to 11.1	Suction Service Valve
1-1/2	18 NEF	35 to 50	4.8 to 6.9	Oil Level Sight Glass

NEF - National Extra Fine

Table 3-2. Wear Limits

PART NAME	FACTORY MAXIMUM		FACTORY MINIMUM		MAXIMUM WEAR BEFORE REPAIR	
	INCHES	MM	INCHES	MM	INCHES	MM
SEAL END						
End Play (Seal Removed)	0.034	0.8636	.013	0.3302	-	-
Main Bearing Diameter	1.8760	47.6504	1.8754	47.6352	.002	0.051
Main Bearing Journal Diameter	1.8732	47.5793	1.8725	47.5615	.002	0.051
PUMP END						
Main Bearing Diameter	1.3761	34.9529	1.3754	34.9352	.002	0.051
Main Bearing Journal Diameter	1.3740	34.8996	1.3735	34.8869	.002	0.051
CONNECTING ROD						
Connecting Rod Diameter	1.3768	34.9707	1.3760	34.9504	.0020	0.051
Piston Pin Bearing	0.6883	17.4752	0.6878	17.4701	.001	0.0254
CRANKSHAFT						
Crankpin Diameter	1.3740	34.8996	1.3735	34.8869	.0025	0.0635
Throw - Height (37 CFM)	0.9698	24.6329	0.9678	24.5821	-	-
Throw - Height (41 CFM)	1.072	27.2288	1.070	27.1780	-	-
THRUST WASHER (Thickness)						
Pump End	0.145	3.6830	0.144	3.658	.0250	0.6350
Seal End	0.157	3.987	0.155	3.937	.0250	0.6350
CYLINDERS and PISTONS						
Bore	2.001	50.8254	2.000	50.800	.002	0.051
Piston (Diameter)	-	-	See Figure 3-21		.002	0.051
Piston Pin (Diameter)	0.6882	17.4803	0.6877	17.4676	.001	0.025
Piston Ring Gap	0.013	0.3302	0.005	0.127	.025	0.635
Piston Ring Side Clearance	0.002	0.051	0.001	0.0254	.002	0.051

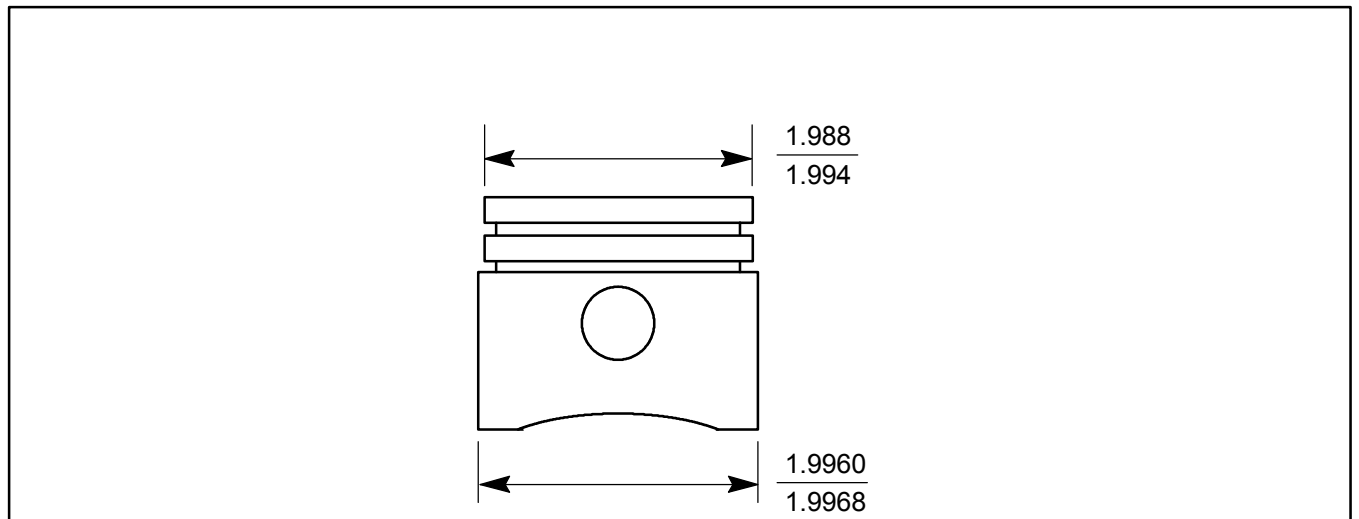


Figure 3-21. Piston Dimension (Wear Limits)

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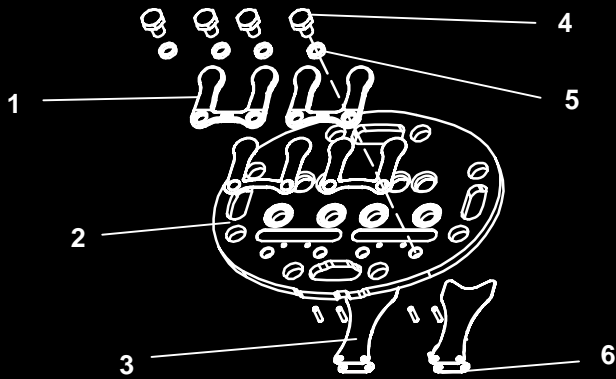
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Compressor



SERVICE PARTS LIST
for
**MODEL 05G TWIN PORT
COMPRESSOR**



TRANSICOLD

Service Parts List

Model 05G Twin Port Compressor

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INTRODUCTION

This parts list identifies service replacement parts for the 05G Twin Port Compressors listed in the Model Chart below. To find replacement parts, determine the major group in which the replacement parts are located (refer to the Table of Contents) and turn to the appropriate page for the illustrated parts breakdown of the replacement parts. A detailed list of the tools needed to service the 05G Twin Port Compressor may be found in the Service Tool List catalog 62-03213.

MODEL CHART

New Twin Port 05G Compressor Part Number	Carlyle/CSM Manufacturer's Number	Replaces This Part Number Of The Previous Design Three Port 05G Compressor	Compressor Configuration	Application
18-00091-103	6GDG009UA0313A	18-00059-126RM	Ultra Bottom Cover, 37 CFM , Contoured Pistons, Ultra Flange, 2 Electric Unloaders, No Oil	Trailer
18-00091-105	6GDJ009UA0313A	18-00059-72RM	Ultra Bottom Cover, 41 CFM , Contoured Pistons, Ultra Flange, 2 Electric Unloaders, No Oil	Trailer
18-00091-106	6GCG008WB03131	18-00059-130RM	Standard Bottom Cover, 37 CFM , Contoured Pistons, Star Flange, 1 Electric Unloader, No Oil	Truck (Supra 9XX)
18-00091-108	6GDG00DUA0313A	18-00059-128RM	Ultra Bottom Cover, 37 CFM , Contoured Pistons, Ultra Flange With Threaded Clutch Hub, 2 Electric Unloaders, No Oil	Trailer With Standby
18-00091-150	6GCF00ATA03031	18-00059-169	Standard Bottom Cover, 37 CFM , Flat Pistons, Half Moon Flange With Hub, 2 Electric Unloaders, No Oil	Bus (R-22 or R-134a)
18-00091-160	6GCH00ATA03431	17-44062-00	Standard Bottom Cover, 41 CFM , Flat Pistons, Half Moon Flange With Hub, 2 Electric Unloaders, 5.8 Pints POE Oil	Bus (R-134a)
18-00091-180	6GCF00A3A03031	18-00059-169	Standard Bottom Cover, 37 CFM , Flat Pistons, Half Moon Flange With Hub, 2 Pressure Unloaders, No Oil	Bus (R-22 or R-134a)

ORDERING INSTRUCTIONS

All orders and inquiries for parts must include: Unit Serial Number, Part Number, description of part as shown on list and quantity required. Address all correspondence for parts to the following address:

CARRIER TRANSICOLD DIVISION
 Replacement Components Group, TR-20
 P.O. Box 4805, Syracuse, NY 13221.
 or
 Fax to: (315) 432-3778

GENERAL NOTES

To find replacement parts consult table of contents, and turn to the appropriate page for the illustrated breakdown of replacement parts. The following letter designations are used to classify parts throughout this list.

A/R *As Required*

NSA *Non-Stock Assembly* - order components listed under the assembly.

NSS *Not Sold Separately* - order next higher assembly or kit.

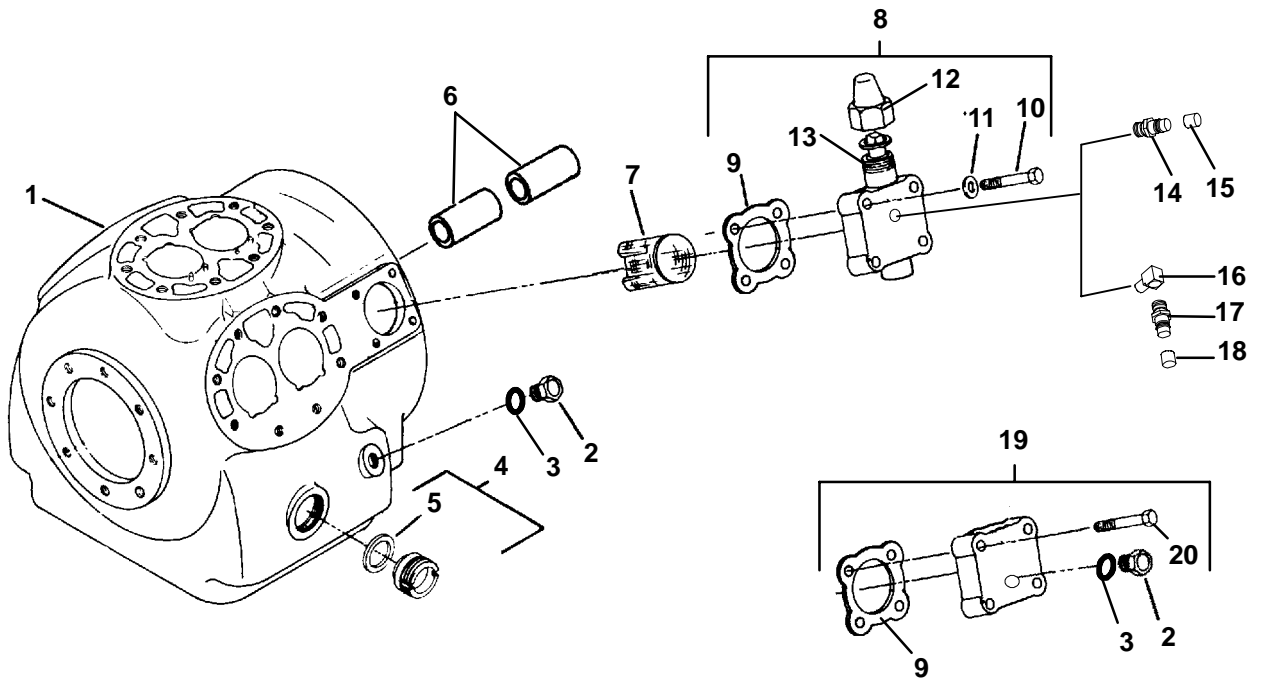
COMPRESSOR OIL CHART

Part Number	Oil Type	Viscosity	Refrigerants	Application	Packaging
07-00275-00	Mineral	150	R-12, R-22, R-500, R-502	Large Bus	1 Gallon x 6
07-00377-00	Mineral	300	R-12, R-22, R-500	Large Bus	1 Gallon x 6
07-00430-00	Alkyl Benzene (A/B)	68	R-22	Large Bus	1 Gallon x 6
07-00274-00	Alkyl Benzene (A/B)	150	R-12, R-22, R-500, R-502	Trailer	1 Gallon x 6
07-00317-00PK6	Polyolester (POE)	68	R-134a, R-404a	Truck, Trailer, and Large Bus	1 Gallon x 6

NOTE

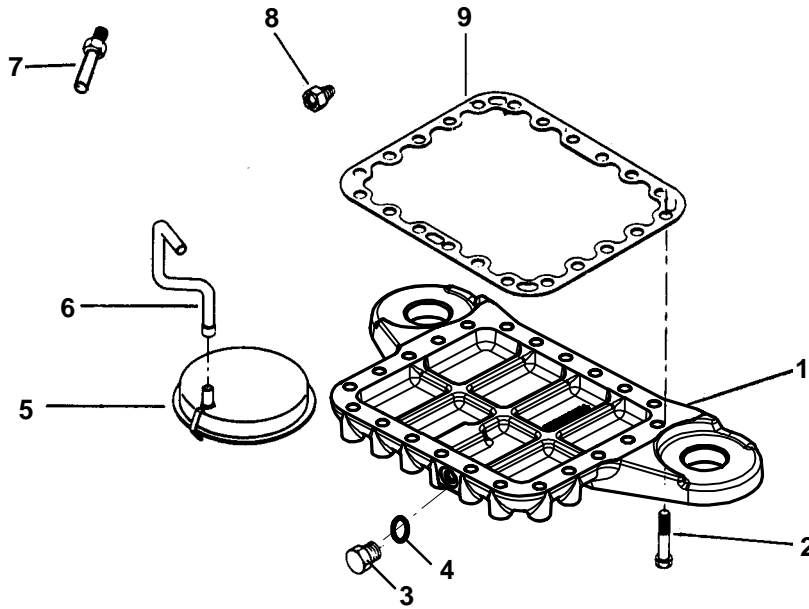
Refer to the unit operation and service manual for the correct procedure for checking compressor oil level.

1 CRANKCASE AND SUCTION SERVICE VALVE



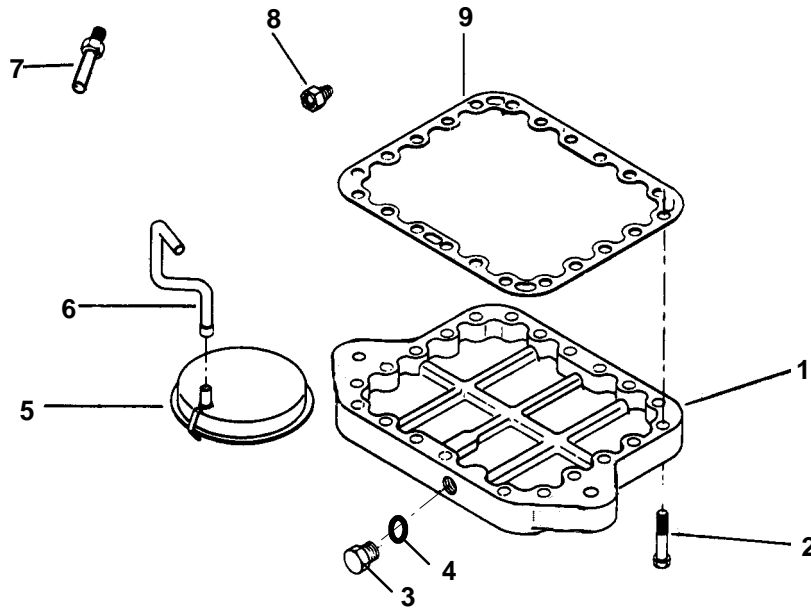
Item	Part Number	Description	Qty
1	NSA	Crankcase	1
2	17-44037-00	Plug, O-Ring, 7/16-20 - Includes:	1
3	42-00243-07	O-Ring	1
4	17-10218-00	Sight Glass, Oil Level - Includes:	2
5	17-10218-02	Gasket (Fiber)	1
	17-44021-00	Gasket (Metal)	
6	17-44015-00	Bearing, Main Seal End (Requires Line Boring)	2
7	17-44005-00	Strainer, Suction	1
8	17-31062-00	Valve, Service, 1-1/8 ODF (Bus/Supra 9xx) - Includes:	1
	17-40002-01	Valve, Service, 1-3/8 ODF (Truck/Trailer) - Includes:	
9	17-40005-05	Gasket, Service Valve (Fiber)	1
10	17-13020-00	Capscrew, 1/2-13 x 2-1/2 Inches Long - SAE Grade 8	4
11	17-40007-00	Gasket, Capscrew, 1/2 Inch	4
12	17-10812-00	Cap, Service Valve (Plastic)	1
	17-10806-10	Cap, Service Valve (Brass)	
9	17-44141-00	Gasket, 4 Bolt Service Valve (Metal)	1
13	17-13022-00	Packing, Service Valve Stem (package of 10)	1
14	06DA403-844	Valve, Access (1/4 Flare, Schrader) (for R-12, R-22, R-404A)	1
15	DD19CA061	Cap, 1/4 Flare, Schrader	1
16	40-00524-00	Elbow, 1/4 NPT x M13, Brass (for R-134a)	1
17	40-00520-00	Coupling, M13, R-134a, Brass - Includes:	1
18	40-00520-02	Cap, Service Port	1
19	17-13006-00	Kit, Valve Pad Blank Off, 4 Bolt Suction Service Valve - Includes:	1
2	17-44037-00	Plug, O-Ring, 7/16-20 - Includes:	1
3	42-00243-07	O-Ring	1
9	17-40005-05	Gasket, Service Valve (Fiber)	1
20	AABR293	Capscrew, 1/2-13 x 1-1/2 Inches Long	4

2 COMPRESSOR BASE GROUP - ULTRA STYLE



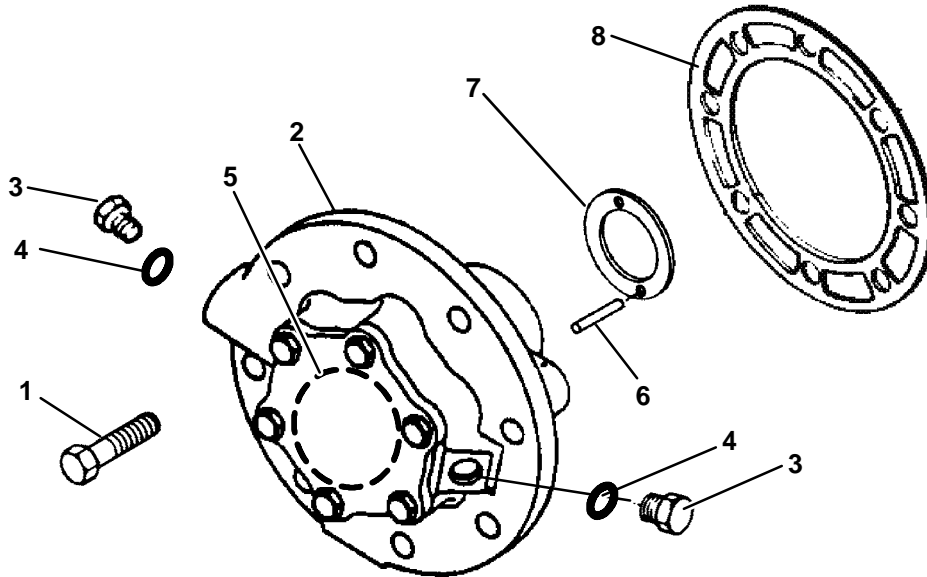
Item	Part Number	Description	Qty
1	17-44026-00	Plate, Bottom, Aluminum, (Ultra Style Compressors)	1
2	17-44117-00	Capscrew, Hex Head, 3/8-16 x 2-1/4 Inches Long - SAE Grade 8	22
3	17-44037-00	Plug, O-Ring, 7/16-20 - Includes:	1
4	42-00243-07	O-Ring	1
5	17-40020-00	Oil Filter Screen Assembly	1
6	17-40021-00	Tube, Oil Suction	1
7	17-44011-00	Oil Relief Valve	1
8	17-40042-00	Oil Return Check Valve Assembly	2
9	17-44129-00	Gasket, Bottom Plate (Metal)	1

3 COMPRESSOR BASE GROUP - STANDARD (NON-ULTRA) STYLE



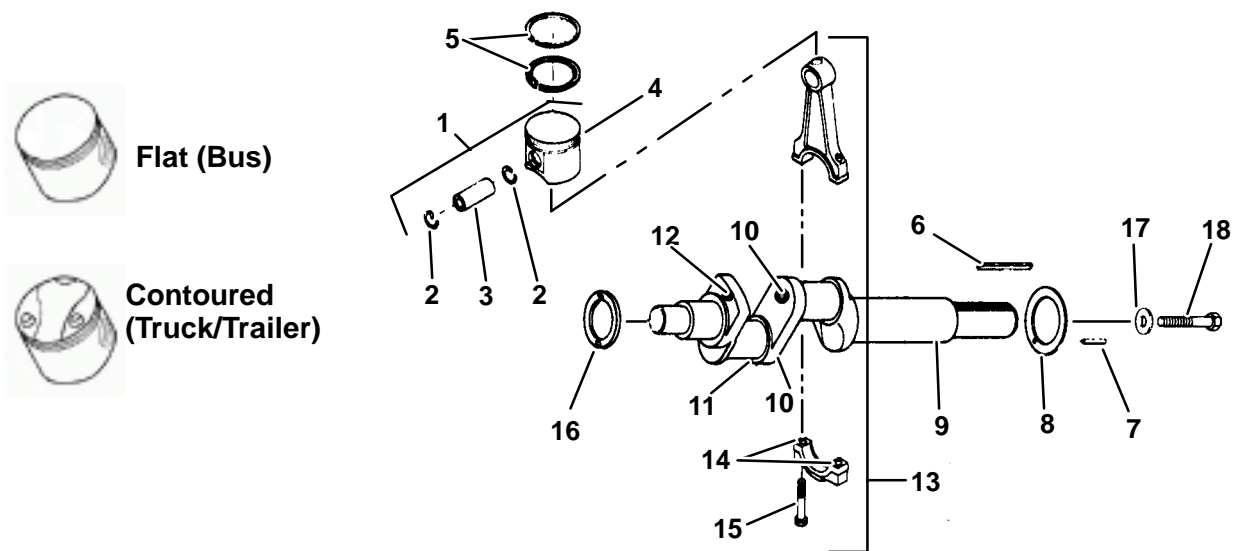
Item	Part Number	Description	Qty
1	17-44035-00	Plate, Bottom, Aluminum, (Non-Ultra Style Compressors)	1
2	17-44117-00	Capscrew, Hex Head, 3/8-16 x 2-1/4 Inches Long - SAE Grade 8	22
3	17-44037-00	Plug, O-Ring, 7/16-20 - Includes:	1
4	42-00243-07	O-Ring	1
5	17-40020-00	Oil Filter Screen Assembly	1
6	17-40021-00	Tube, Oil Suction	1
7	17-44011-00	Oil Relief Valve	1
8	17-40042-00	Oil Return Check Valve Assembly	2
9	17-44129-00	Gasket, Bottom Plate (Metal)	1

4 BEARING HEAD AND OIL PUMP



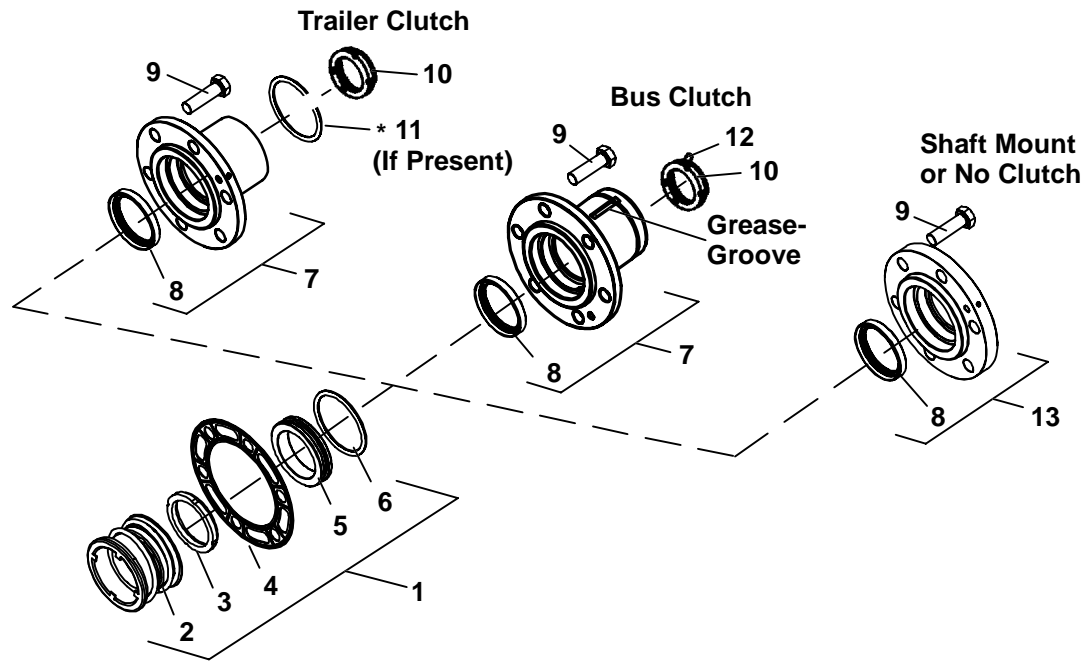
Item	Part Number	Description	Qty
1	17-10308-00	Capscrew, Hex Head, 3/8-16 x 1-1/4 Inches Long - SAE Grade 5	8
2	17-44137-00	Oil Pump and Bearing Head - Includes:	1
3	17-44037-00	Plug, O-Ring, 7/16-20 - Includes:	2
4	42-00243-07	O-Ring	2
5	17-44139-00	O-Ring, Pump Cover Plate	1
6	17-40204-00	Pin, Roll, 1/8 x 1/2 Inch	2
7	17-55009-01	Thrustwasher, Pump End	1
8	17-40078-05	Gasket, Bearing Head (Fiber)	1
	17-44022-00	Gasket, Bearing Head (Metal)	

5 CRANKSHAFT, ROD AND PISTON GROUP



Item	Part Number	Description	Qty
1	17-44045-01	Piston, 05G37 CFM, Flat , Standard - Includes:	6
	17-44045-03	Piston, 05G37 CFM, Flat , .020 Inch Oversize - Includes:	
	17-44121-01	Piston, 05G41 CFM, Flat , Standard - Includes:	
	17-44122-01	Piston, 05G41 CFM, Flat , .020 Inch Oversize - Includes:	
1	17-44070-00	Piston, 05G37 CFM, Contoured , Standard - Includes:	6
	17-44071-00	Piston, 05G37 CFM, Contoured , .020 Inch Oversize - Includes:	
	17-44072-00	Piston, 05G41 CFM, Contoured , Standard - Includes:	
	17-44073-00	Piston, 05G41 CFM, Contoured , .020 Inch Oversize - Includes:	
2	17-40053-00	Retainer, Piston Pin	2
3	NSS	Pin, Piston	1
4	NSS	Piston	1
5	17-40055-00	Ring, Compression (Standard)	12
	17-55025-00	Ring, Compression (.020 Inch Oversize)	12
6	17-40324-00	Key, Crankshaft, 1/4 x 1/4 x 1-1/2 Inches Long (For Shaft Mounted or No Clutch)	1
	68G2-9072	Key, Crankshaft (For Housing Mounted Clutch)	
7	17-44036-00	Pin, Spiral, 1/8 x 1/2 Inch Long	2
8	17-44008-00	Thrustwasher, Seal End	1
9	17-44074-00	Crankshaft Assembly, 05G37 CFM (05G Twin Port) - Includes:	1
	17-44075-00	Crankshaft Assembly, 05G41 CFM (05G Twin Port) - Includes:	
10	17-40317-00	Expansion Plug	2
11	AF55CQ164	Setscrew, 1/4-28 x 1/2 Inch Long	1
12	34-00300-07	Capscrew, Hex Head, 1/4-20 x 7/8 Inch Long - Grade 5	1
13	17-40056-02	Connecting Rod and Cap Assembly (Standard) - Includes:	6
	17-55023-00	Connecting Rod and Cap Assembly (.010 Inch Undersize) - Includes:	A/R
14	17-40057-00	Pin, Dowel	2
15	17-55008-00	Capscrew (Special)	2
16	17-55009-01	Thrustwasher, Pump End	1
17	34-00616-00	Washer, 13/32 ID x 1-1/2 OD x 3/16 Thick	1
18	34-00613-07	Capscrew, Hex Head, 3/8-24 UNF x 7/8 Inch Long - SAE Grade 8	1

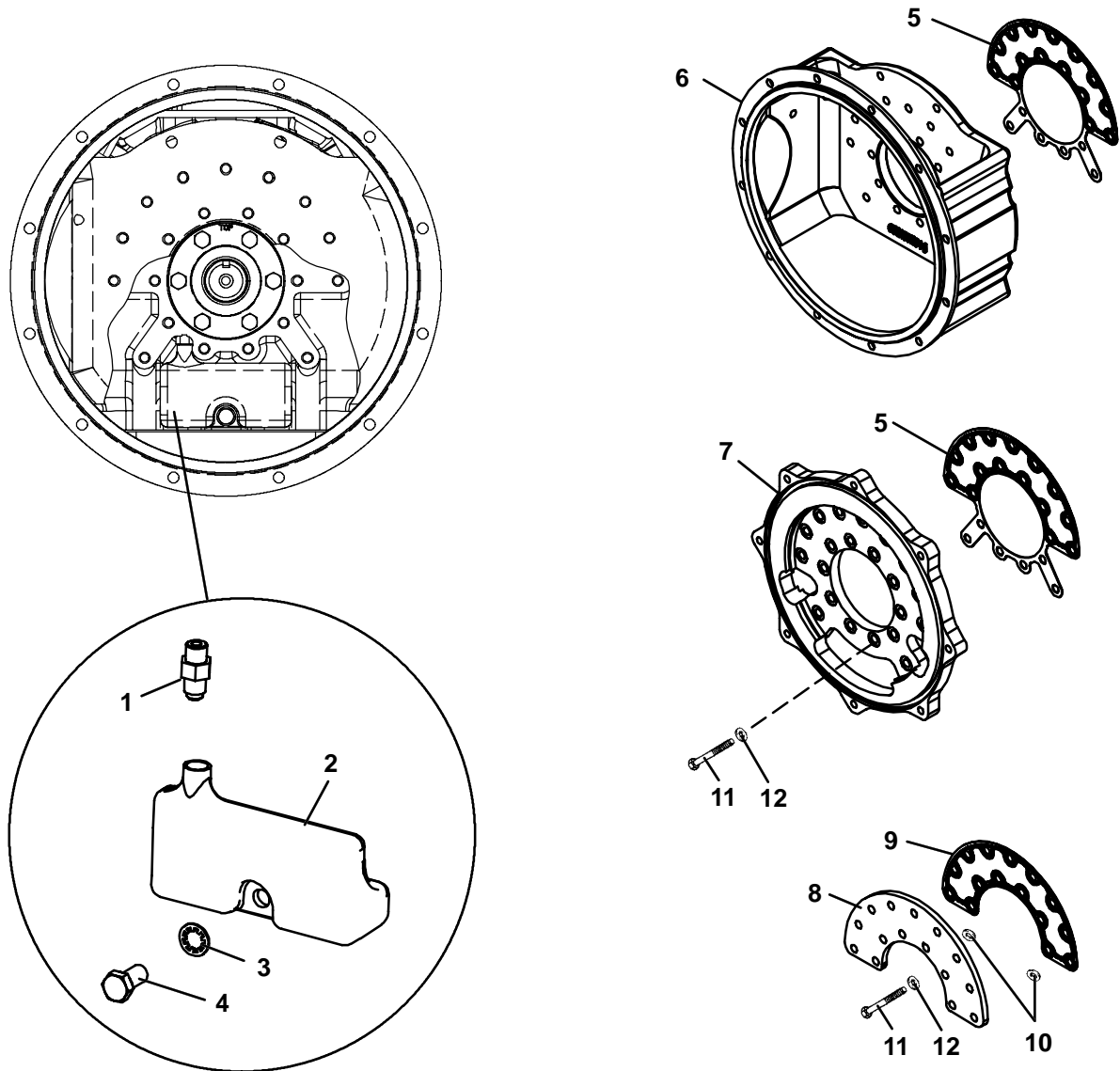
6 SHAFT END GROUP



*NOTE: Early production trailer compressors may have had the snap ring style clutch hub. Should the hub require replacement, it must be converted to the threaded clutch hub (Item 7).

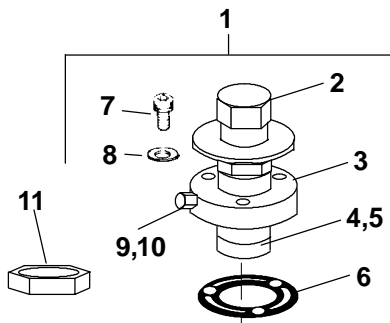
Item	Part Number	Description	Qty
1	17-44770-00	Seal Assembly (Shaft) - Includes:	1
2	NSS	Spring And Bellows Assembly, Shaft Seal	1
3	17-44768-00	Rotor, Seal	1
4	17-44004-06	Gasket, Seal Cover - (Metal)	1
5	NSS	Stator, Seal, (Wear Ring)	1
6	17-44773-00	O-Ring, Stator	1
7	17-44766-00	Hub Assembly, Housing Mounted Clutch, Threaded, No Groove - Trailer - Includes:	1
	17-44767-00	Hub Assembly, Housing Mounted Clutch, Threaded, W/Grease Groove - Bus - Includes:	
8	17-44765-00	Seal, Lip, Shaft Seal	1
4	17-44004-06	Gasket, Seal Cover - (Metal)	1
9	17-40308-00	Capscrew, 3/8-16 X 1-1/4 Inch Long Grade 5	6
10	34-01304-00	Nut, Hub, Without Grease Fitting Port (Trailer Only)	1
	34-06083-00	Nut, Hub, Without Grease Fitting Port - Bus	
	34-01161-00	Nut, Hub, With Grease Fitting Port - (Fitting Not Included) Bus	
11	50-00221-30	Ring, Snap (If Applicable)	1
12	40-01132-00	Fitting, Grease, 1/4-28 NPT- Bus	1
13	17-44772-00	Seal Cover Assembly, Shaft (Gland Plate) - Includes:	1
4	17-44004-06	Gasket, Seal Cover - (Metal)	1
8	17-44765-00	Seal, Lip, Shaft Seal	1

7 SHAFT SEAL RESERVOIR AND SHAFT END FLANGES

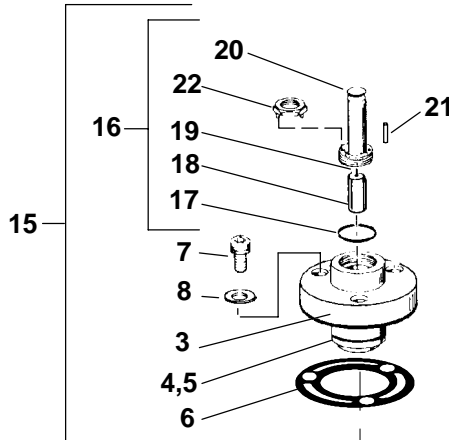


Item	Part Number	Description	Qty
1	05GA503-724	Access Valve, Coreless , 7/16-20, With O-Ring	1
2	17-44771-00	Reservoir, Shaft Seal	1
3	05GA503-734	Washer, Internal Tooth, 3/8 Inch, Plated	1
4	AA06GS228	Cap Screw, Hex Head, 3/8-16 X 0.75 Inch Long, Grade 8	1
5	17-44119-00	Gasket, End Flange, Ultra Style or Full Ring Flange (Used With Items 6 and 7)	1
6	17-44025-00	End Flange, Ultra Style (Trailer)	1
7	17-44002-00	End Flange, Full Ring (Star Flange)	1
8	17-44127-00	End Flange, Half Moon (Bus)	1
9	17-44118-00	Gasket, Half Moon End Flange (Used Only With Item 8)	1
10	17-44014-00	Gasket, Flange Spacer (Used Only With Items 8 and 9)	2
11	17-10308-00	Cap Screw, Hex Head, 3/8-16 X 1.25 Inch Long, Grade 5	A/R
12	17-40019-00	Gasket, Cap Screw	A/R

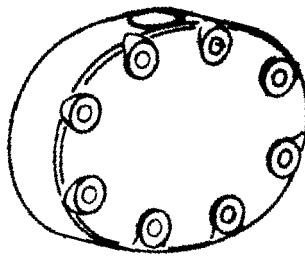
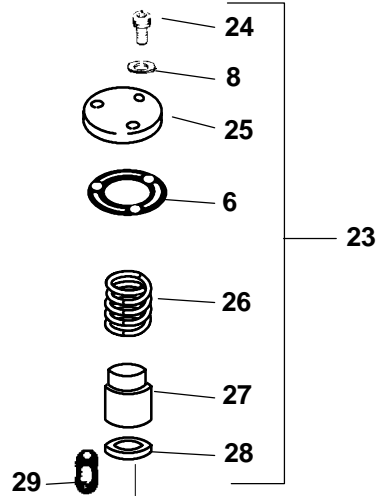
Pressure Valve



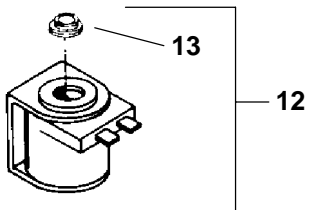
Electric Valve



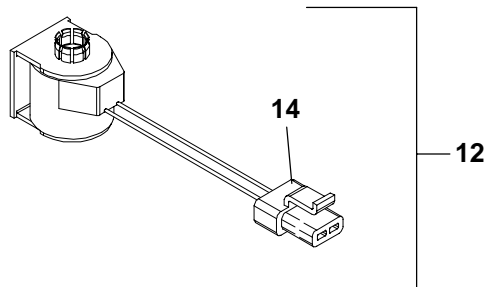
Valve Plug



COILS



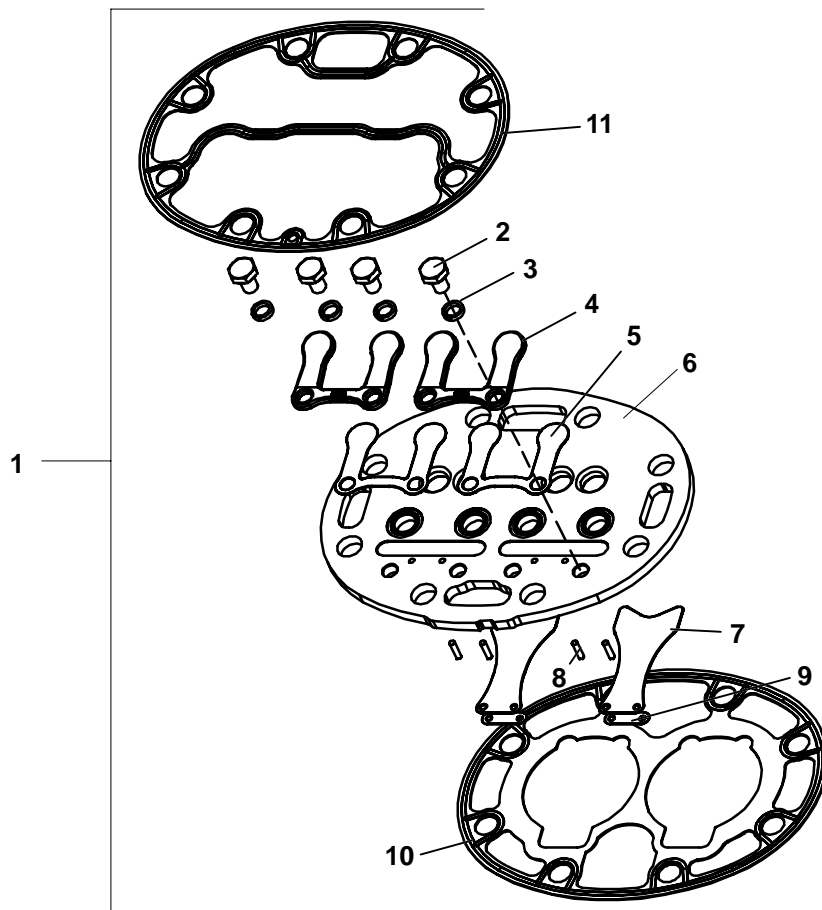
OR



8 UNLOADERS (Continued)

Item	Part Number	Description	Qty
1	17-55018-01	Valve Assembly (Pressure) - Includes:	A/R
2	NSS	Power Assembly, Unloader (Suction Pressure Activated)	1
3	NSS	Body Assembly, Valve	1
4	17-40409-00	Piston, Unloader - Includes:	1
5	17-55010-00	Ring, Piston	1
6	17-40104-07	Gasket, Unloader Valve	1
7	17-40111-00	Screw, Socket Head, 1/4-28 x 3/4 Inch Long	1
8	17-40104-20	Gasket, Socket Head Screw, 1/4 Inch	1
9	17-55028-00	Cap, Adjustment Screw	1
10	42-50019-00	O-Ring, Adjustment Screw Cap	1
11	34-01139-00	Nut, Unloader Adjuster Lock	1
12	22-02804-00	Coil, Valve, 12 VDC With Connector (Truck/Trailer) - Includes:	A/R
	22-02567-00	Coil, Valve, 12 VDC With Spade Terminal - Includes:	
	14-00143-07	Coil, Valve, 12 VDC With 6 inch wire leads - Includes:	
	22-50030-00	Coil, Valve, 24 VDC With 42 inch wire leads - Includes:	
	22-02567-01	Coil, Valve, 24 VAC With Spade Terminal - Includes:	
	16-00149-00	Coil, Valve, 115 VAC With 42 inch Wire Leads - Includes:	
	17-10829-00	Coil, Valve, 230 VAC With 42 inch Wire Leads - Includes:	
13	17-40408-02	Cap, Snap	1
14	22-50078-02SV	Connector, 2 Wire, 22-02804-00 Coil Only (Mates W/ 22-50078-01SV)	1
15	17-40417-00	Valve Assembly (Electric) - Includes:	A/R
3	NSS	Body Assembly, Valve	1
4	17-40409-00	Piston, Unloader - Includes:	1
5	17-55010-00	Ring, Piston	1
6	17-40104-07	Gasket, Unloader Valve	1
7	17-40111-00	Screw, Socket Head, 1/4-28 x 3/4 Inch Long	1
8	17-40104-20	Gasket, Socket Head Screw, 1/4 Inch	1
16	17-40418-00	Kit, Valve Stem Repair (For 17-40417-00) - Includes:	A/R
17	42-00243-03	Gasket, O-ring	1
18	NSS	Plunger Assembly	1
19	NSS	Spring, Plunger	1
20	NSS	Enclosing Tube	1
21	34-06026-00	Pin, Unloader Coil Retainer	1
22	NSS	Tool, Valve Stem Installation/Removal	1
23	17-55013-00	Kit, Plug, To Fully Load Cylinder Bank - Includes:	A/R
24	17-10721-00	Screw, Socket Head, 1/4-28 x 1.0 Inch Long	3
25	NSS	Plate Cover	1
26	NSS	Spring	1
27	NSS	Plug	1
28	17-55014-00	Ring, Seat	1
29	17-40108-00	Strainer	1
6	17-40104-07	Gasket, Unloader Valve	1
8	17-40104-20	Gasket, Socket Head Screw, 1/4 Inch	1

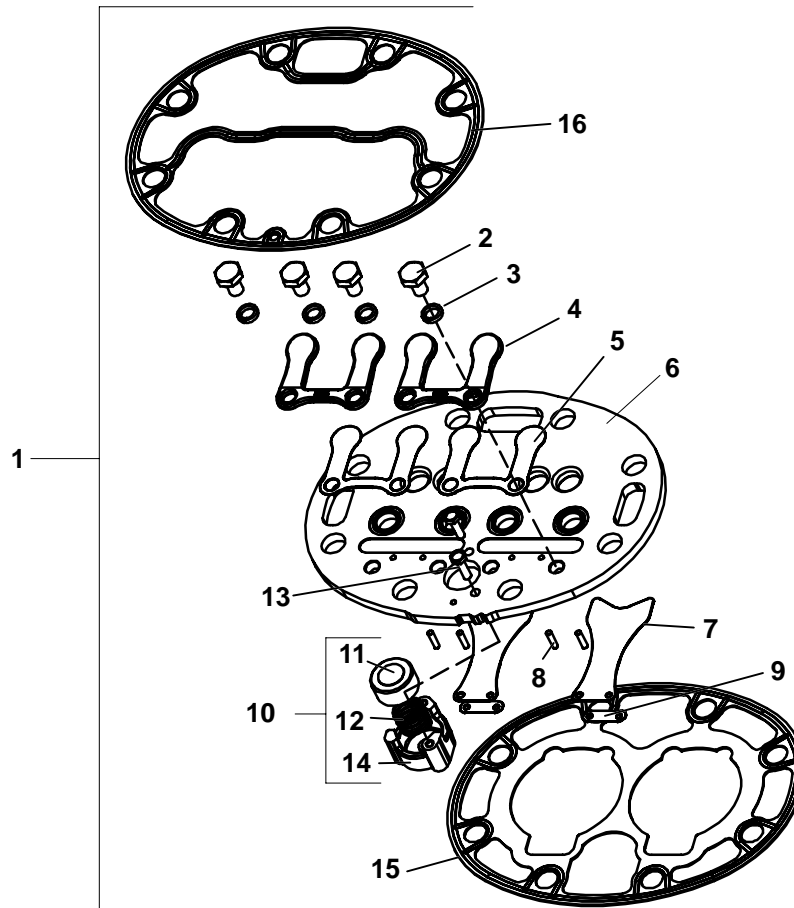
9 VALVE PLATE ASSEMBLY



CAUTION: The above valve plate can only be used on the Twin Port 05G compressor.
It will not function in the previous design (3 port) 05G compressor.

Item	Part Number	Description	Qty
1	17-44742-00	Valve Plate Assembly, Center or Side Bank With No Unloader - Includes:	1
2	17-44113-00	Capscrew, HexHead, 1/4-28 x 3/8 Inch Long	4
3	17-10715-00	Lockwasher, 1/4 Inch	4
4	17-44750-00	Backer, Discharge Valve	2
5	17-44749-00	Valve, Discharge	2
6	NSS	Valve Plate	1
7	17-44748-00	Valve, Suction	2
8	17-40057-00	Dowel, Pin Suction Valve	4
9	17-44751-00	Spring, Suction Valve	2
10	17-44746-00	Gasket, Valve Plate, Center or Side Banks	1
11	17-44747-00	Gasket, Cylinder Head, Center or Side Banks	1

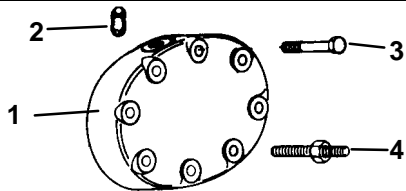
10 UNLOADER VALVE PLATE ASSEMBLY



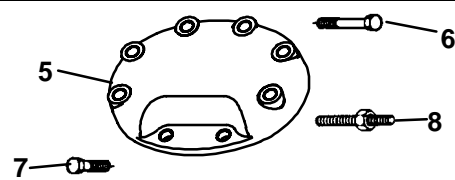
CAUTION: The above valve plate can only be used on the Twin Port 05G compressor.
It will not function in the previous design (3 port) 05G compressor.

Item	Part Number	Description	Qty
1	17-44744-00	Valve Plate Assembly, Side Bank With Unloader - Includes:	1
2	17-44113-00	Capscrew, HexHead, 1/4-28 x 3/8 Inch Long	4
3	17-10715-00	Lockwasher, 1/4 Inch	4
4	17-44750-00	Backer, Discharge Valve	2
5	17-44749-00	Valve, Discharge	2
6	NSS	Valve Plate	1
7	17-44748-00	Valve, Suction	2
8	17-40057-00	Dowel, Pin Suction Valve	4
9	17-44751-00	Spring, Suction Valve	2
10	17-55012-00	Check Valve, Unloader, - Includes:	1
11	17-40104-08	Piston, Check Valve	1
12	17-40104-09	Spring, Check Valve	1
13	NSS	Screw, Round Phillips Head, #6-32 x 1/2 Inch Long	2
14	NSS	Body Check Valve	1
15	17-44746-00	Gasket, Valve Plate, Center or Side Banks	1
16	17-44747-00	Gasket, Cylinder Head, Center or Side Banks	1

11 CYLINDER HEAD (SIDE)



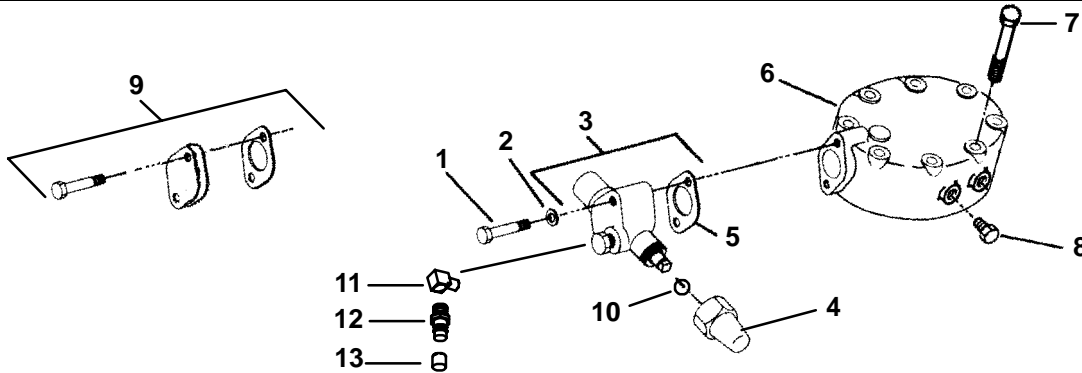
UNLOADER CYLINDER HEAD



STANDARD SHAVED CYLINDER HEAD

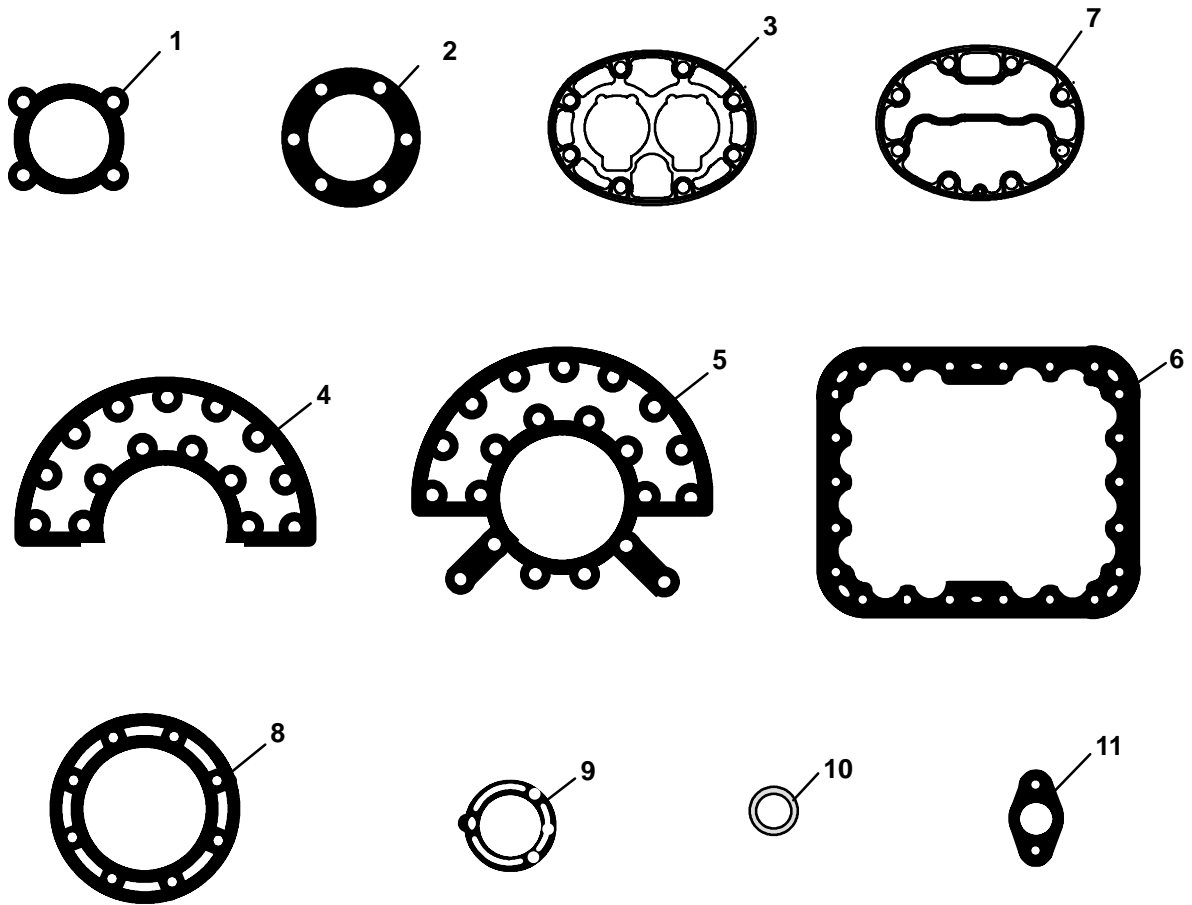
Item	Part Number	Description	Qty
1	17-44743-00	Cylinder Head, Unloader - Side Banks	2
2	17-40108-00	Strainer	1
3	17-10224-05	Capscrew, Hex Head, 3/8 -16 x 3-1/4 Inches Long - SAE Grade 8	8
4	17-44017-00	Stud, Cylinder Head (Unloader or Center), 3/8 -16 x 4-1/4 Inches Long	A/R
5	17-44753-00	Cylinder Head - Side Banks, Shaved (Standard, No Unloader)	2
6	17-44117-00	Capscrew, Hex Head , 3/8 -16 x 2-1/4 Inches Long - SAE Grade 8	6
7	AA06GR232	Capscrew, Hex Head, 3/8 -16 x 1-1/4 Inches Long - SAE Grade 8	2
8	17-44780-00	Stud, Cylinder Head (Shaved), 3/8 -16 x 3-1/4 Inches Long	A/R

12 CYLINDER HEAD (CENTER)



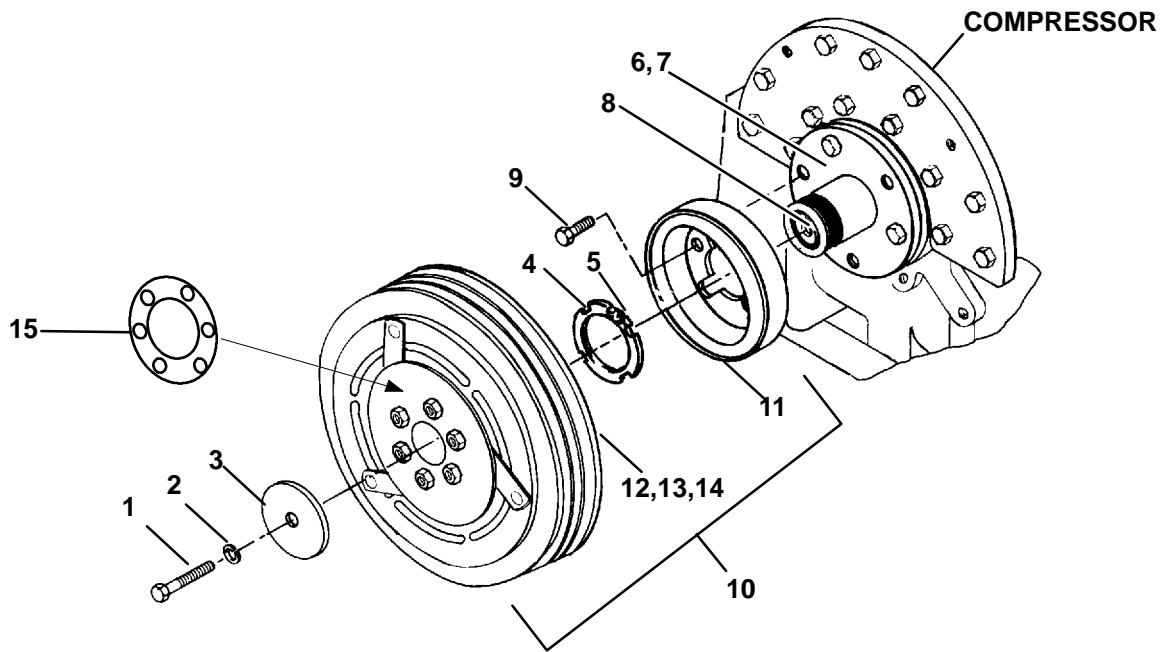
Item	Part Number	Description	Qty
1	17-40012-00	Capscrew, Hex Head, 5/16 -18 x 2 Inches Long - SAE Grade 8	2
2	17-40013-00	Gasket, Capscrew, 5/16 Inch	2
3	17-01042-04	Valve, Service 7/8 Inch ODF (1/8 Inch FPT Gauge Port)- Includes:	1
	14-00206-01	Valve, Service 7/8 Inch ODF (M15 Gauge Port For R-134a) - Includes:	1
4	17-10812-00	Cap, Service Valve (Plastic)	1
5	17-10811-05	Gasket, Service Valve (Fiber)	1
	17-44138-00	Gasket, Service Valve (Metal)	1
4	17-10806-10	Cap, Service Valve (Brass)	1
6	17-44752-00	Cylinder Head, Center Bank, One Pressure Port (Bus)	1
	17-44754-00	Cylinder Head, Center Bank, Two Pressure Ports (T/T)	1
7	17-10224-05	Capscrew, Hex Head, 3/8 -16 x 3 -1/4 Inches Long - SAE Grade 8	8
8	CA63AA051	Pipe Plug, 1/4 -18NPT (package of 20)	A/R
9	17-13004-00	Kit, Valve Pad Blank Off, 2 Bolt Suction Service Valve	1
10	17-13022-00	Packing, Service Valve Stem	1
11	40-00524-01	Elbow, 1/8 MPT x M15 - Brass (for R -134a)	1
12	40-00520-01	Coupling, M15, High Side - Brass - Includes:	1
13	40-00520-03	Cap, Service Port	1
11	40-00060-08	Elbow, 1/8 MPT x 1/4 FPT - Brass (for R -12, R -22)	1
12	06DA403-844	Valve, Access (1/4 Flare, Schrader)	1
13	DD19CA061	Cap, 1/4 Flare, Schrader	1

13 GASKET SET



Item	Part Number	Description	Qty
-	17-44775-00	Gasket Set, Metal - Includes:	1
1	17-44141-00	Gasket, Suction Service Valve - 4 Bolt	1
2	17-44004-06	Gasket, Shaft Seal	1
3	17-44746-00	Gasket, Valve Plate	3
4	17-44118-00	Gasket, End Flange	1
5	17-44119-00	Gasket, End Flange	1
6	17-44129-00	Gasket, Bottom Plate	1
7	17-44747-00	Gasket, Cylinder Head, Center or Side Banks	3
8	17-44022-00	Gasket, Pump End Bearing Head	1
9	17-40104-07	Gasket, Unloader Body	2
10	17-44021-00	Gasket, Sight Glass	2
11	17-44138-00	Gasket, Service Valve - 2 Bolt	2

14 CLUTCH ASSEMBLY - HOUSING MOUNTED (WARNER - GRAY IN COLOR)



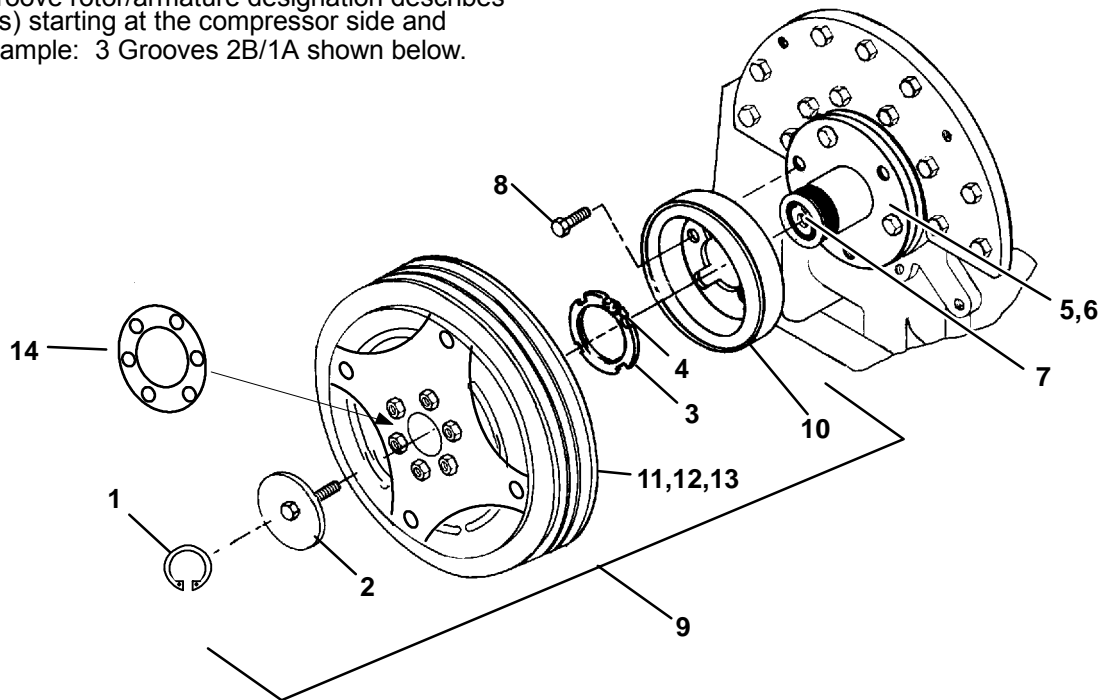
Item	Part Number	Description	Qty
NS	76-50013-00	Kit, Conversion Shaft to Housing Mounted Clutch	A/R
1	34-00613-07	Capscrew, Hex Head, 3/8-24 x 7/8 Inch Long - SAE Grade 8	1
2	--AU--11AR-241	Washer, Lock, Spring, 3/8 Inch	1
3	34-00616-00	Washer, 13/32 ID x 1-1/2 OD x 3/16 Inch Thick	1
4	34-01161-00	Nut, Hub, With Grease Fitting Port (Fitting Not Included)	1
	34-06083-00	Nut, Hub Without Grease Fitting Port	
5	40-01132-00	Fitting, Grease, 1/4-18	1
6	17-44041-01	Hub, Clutch Mounting - Includes:	1
7	17-44042-00	Ring, Felt and Retainer	1
8	68-G---2--9072	Key, Crankshaft, Special	1
9	17-10308-00	Capscrew, Hex Head, 3/8-16 x 1-1/4 Inches Long - SAE Grade 8	1
10	50-01122-01	Clutch, Assembly, 24 VDC, 2-C Grooves, 9 Inch Diameter - Includes:	1
11	50-01122-50	Coil, 24 VDC	1
12	50-01122-85	Rotor/Armature, 2-C Grooves, 9 Inch Diameter - Includes:	1
13	34-01186-00	Ring, Snap	1
14	04-00130-00	Bearing, Rotor	1
10	50-01122-04	Clutch, Assembly, 12 VDC, 2-C Grooves, 9 Inch Diameter - Includes:	1
11	50-01122-41	Coil, 12 VDC	1
12	50-01122-85	Rotor/Armature, 2-C Grooves, 9 Inch Diameter - Includes:	1
13	34-01186-00	Ring, Snap	1
14	04-00130-00	Bearing, Rotor	1
10	50-01122-02	Clutch, Assembly, 24 VDC, 3-3V Grooves, 8.48 Inch Diameter - Includes:	1
11	50-01122-50	Coil, 24 VDC	1
12	50-01122-86	Rotor/Armature, 3-3V Grooves, 8.48 Inch Diameter - Includes:	1
13	34-01186-00	Ring, Snap	1
14	04-00130-00	Bearing, Rotor	1

14 CLUTCH ASSEMBLY - HOUSING MOUNTED (WARNER - GRAY IN COLOR) - Continued

Item	Part Number	Description	Qty
10	50-01122-07	Clutch, Assembly, 24 VDC, 2-B Grooves, 9 Inch Diameter - Includes:	1
11	50-01122-50	Coil, 24 VDC	1
12	50-01122-90	Rotor/Armature, 2-B Grooves, 9 Inch Diameter - Includes:	1
13	34-01186-00	Ring, Snap	1
14	04-00130-00	Bearing, Rotor	1
10	50-01122-09	Clutch, Assembly, 24 VDC, 4 Grooves (2-A/2-B), 10.35 Inch Diameter - Includes:	1
11	50-01122-50	Coil, 24 VDC	1
12	50-01122-501	Rotor/Armature, 4 Grooves (2-A/2-B), 10.35 Inch Diameter - Includes:	1
13	34-01186-00	Ring, Snap	1
14	04-00130-00	Bearing, Rotor	1
10	50-01122-12	Clutch, Assembly, 24 VDC, 2-5V Grooves, 8.7 Inch Diameter - Includes:	1
11	50-01122-50	Coil, 24 VDC	1
12	50-01122-91	Rotor/Armature, 2-5V Grooves, 8.7 Inch Diameter - Includes:	1
13	34-01186-00	Ring, Snap	1
14	04-00130-00	Bearing, Rotor	1
10	50-01122-14	Clutch, Assembly, 24 VDC, 2-5V Grooves, 10.5 Inch Diameter - Includes:	1
11	50-01122-50	Coil, 24 VDC	1
12	50-01122-93	Rotor/Armature, 2-5V Grooves, 10.5 Inch Diameter - Includes:	1
13	34-01186-00	Ring, Snap	1
14	04-00130-00	Bearing, Rotor	1
15	50-01122-65	Shim, .010 Inch Thick	5
	50-01122-66	Shim, .020 Inch Thick	1

15 CLUTCH ASSEMBLY - HOUSING MOUNTED (LINNIG - GOLD IN COLOR)

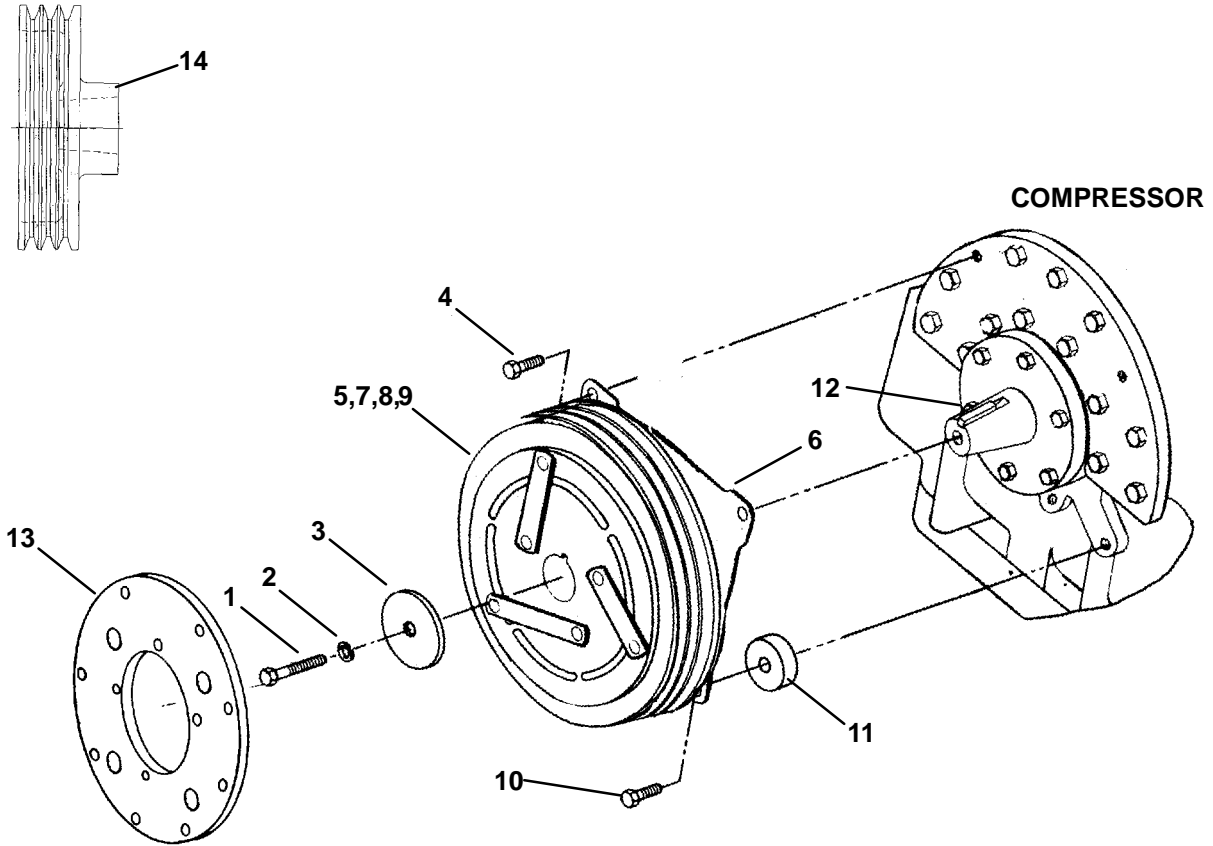
Note: Multiple groove rotor/armature designation describes groove location(s) starting at the compressor side and working out. Example: 3 Grooves 2B/1A shown below.



Item	Part Number	Description	Qty
NS	76-50013-00	Kit, Conversion Shaft to Housing Mounted Clutch	A/R
1	34-50035-00	Ring, Snap	1
2	34-50034-00	Bolt, Retaining, Special	1
3	34-01161-00	Nut, Hub, With Grease Fitting Port (Fitting Not Included)	1
	34-06083-00	Nut, Hub Without Grease Fitting Port	
4	40-01132-00	Fitting, Grease, 1/4-18	1
5	17-44041-01	Hub, Clutch Mounting - Includes:	1
6	17-44042-00	Ring, Felt and Retainer	1
7	68-G---2--9072	Key, Crankshaft, Special	1
8	17-10308-00	Capscrew, Hex Head, 3/8-16 x 1-1/4 Inches Long - SAE Grade 8	1
9	50-00226-09	Clutch Assembly, 24 VDC, 4 Grooves (2A/2B), 10.35 Inch Dia. - Includes:	1
10	50-00226-50	Coil, 24 VDC	1
11	50-00226-501	Rotor/Armature, 4 Grooves (2A/2B), 10.35 Inch Diameter - Includes:	1
12	50-50040-05	Ring, Snap	1
13	50-50040-04	Bearing	1
9	50-00226-09	Clutch Assembly, 24 VDC, 4 Grooves (A/B/2C), 10 Inch Dia. - Includes:	1
10	50-00226-50	Coil, 24 VDC	1
11	50-01130-13	Rotor/Armature, 4 Grooves (A/B/2C), 10 Inch Diameter - Includes:	1
12	50-50040-05	Ring, Snap	1
13	50-50040-04	Bearing	1
9	50-00226-18	Clutch Assembly, 12 VDC, 4 Grooves (2B/2A), 10.35 Inch Dia. - Includes:	1
10	50-00226-41	Coil, 12 VDC	1
11	50-50040-11	Rotor/Armature, 4 Grooves (2B/2A), 10.35 Inch Diameter - Includes:	1
12	50-50040-05	Ring, Snap	1
13	50-50040-04	Bearing	1

15 CLUTCH ASSEMBLY - HOUSING MOUNTED (LINNIG - GOLD IN COLOR) - continued			
Item	Part Number	Description	Qty
9	50-00226-19	Clutch Assembly, 24 VDC, 4 Grooves (2B/2A), 10.35 Inch Dia. - Includes:	1
10	50-00226-50	Coil, 24 VDC	1
11	50-50040-11	Rotor/Armature, 4 Grooves (2B/2A), 10.35 Inch Diameter - Includes:	1
12	50-50040-05	Ring, Snap	1
13	50-50040-04	Bearing	1
9	50-01130-03	Clutch Assembly, 24 VDC, 3-3V Grooves, 8.48 Inch Diameter - Includes:	1
10	50-00226-50	Coil, 24 VDC	1
11	50-50040-02	Rotor/Armature, 3-3V Grooves, 8.48 Inch Diameter - Includes:	1
12	50-50040-05	Ring, Snap	1
13	50-50040-04	Bearing	1
9	50-01130-20	Clutch Assembly, 12 VDC, 2-B Grooves, 10.35 Inch Diameter - Includes:	1
10	50-00226-41	Coil, 12 VDC	1
11	50-50040-03	Rotor/Armature, 2-B Grooves, 10.35 Inch Diameter - Includes:	1
12	50-50040-05	Ring, Snap	1
13	50-50040-04	Bearing	1
9	50-01130-21	Clutch Assembly, 24 VDC, 2-B Grooves, 10.35 Inch Diameter - Includes:	1
10	50-00226-50	Coil, 24 VDC	1
11	50-50040-03	Rotor/Armature, 2-B Grooves, 10.35 Inch Diameter - Includes:	1
12	50-50040-05	Ring, Snap	1
13	50-50040-04	Bearing	1
9	50-01130-22	Clutch Assembly, 12 VDC, 2-C Grooves, 10 Inch Diameter - Includes:	1
10	50-00226-41	Coil, 12 VDC	1
11	50-50040-12	Rotor/Armature, 2-C Grooves, 10 Inch Diameter - Includes:	1
12	50-50040-05	Ring, Snap	1
13	50-50040-04	Bearing	1
14	50-00226-65	Shim, .012 Inch Thick	5
	50-00226-66	Shim, .039 Inch Thick	1

16 CLUTCH ASSEMBLY - SHAFT MOUNTED

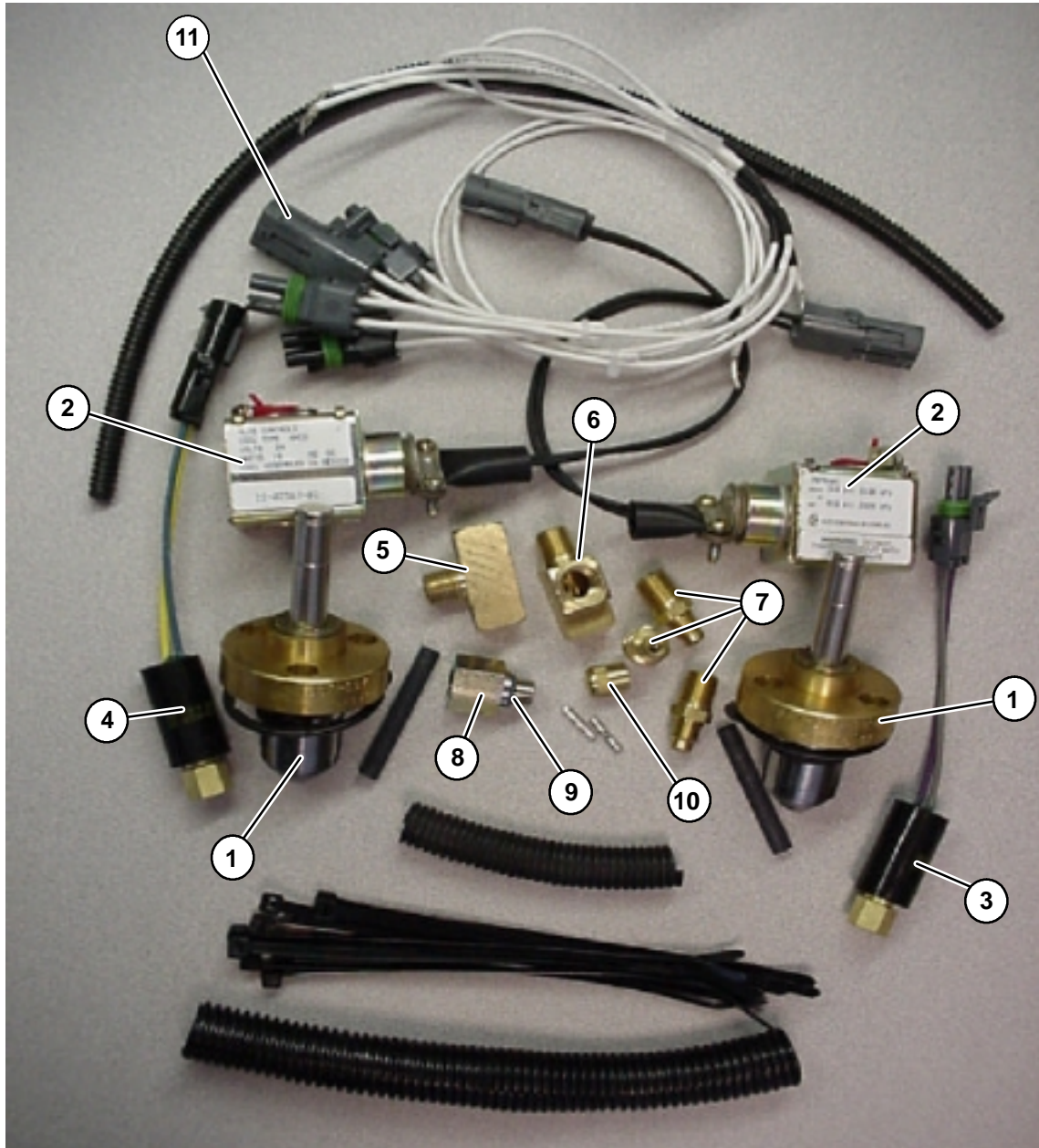


Item	Part Number	Description	Qty
1	34-00613-07	Capscrew, Hex Head, 3/8 UNF x 7/8 Inch Long - SAE Grade 8	1
2	--AU--11AR-241	Washer, Lock, Spring, 3/8 Inch	1
3	34-00616-00	Washer, 13/32 ID x 1-1/2 OD x 3/16 Inch Thick	1
4	17-40037-05	Capscrew, Hex Head, 3/8-16 x 1 Inch Long	2

16 CLUTCH ASSEMBLY - SHAFT MOUNTED

Item	Part Number	Description	Qty
5	50-01108-00	Clutch, 24 VDC, 2-C Grooves, 9 Inch Diameter	1
	50-01110-00	Clutch, 24 VDC, 3-3V Grooves, 8.48 Inch Diameter	
	50-01110-01	Clutch, 12 VDC, 3-3V Grooves, 8.48 Inch Diameter	
	50-01114-00	Clutch, 12 VDC, 2-B Grooves, 8.64 Inch Diameter	
6	50-50011-00	Coil, 24 VDC	1
	50-50014-00	Coil, 12 VDC	
7	50-50015-00	Ring, Retaining - External	1
8	50-50016-00	Ring, Retaining - Internal	1
9	50-50017-00	Bearing	1
10	17-10308-00	Capscrew, Hex Head, 3/8-16 x 1-1/4 Inches Long - SAE Grade 8	2
11	68-G---2--8522-1	Spacer, 1-3/8 OD x 1/2 Inch Thick - CRES	2
12	17-40324-00	Key, Crankshaft, 1/4 x 1/4 x 1-1/2 Inches Long	1
13	50-01115-00	Plate, Adapter (Used with 50-01114 Clutch)	1
14	68-G---2--1823	Sheave, Power Takeoff, 3-3V Grooves, 6 Inch Diameter, (On Allison Transmission)	1

17 UNLOADER KITS, BUS - PRESSURE TO ELECTRIC



17 UNLOADER KIT - PRESSURE TO ELECTRIC - R-134a ONLY - 24 VDC

Item	Part Number	Description	Qty
	74-50111-00	Kit, Convert Pressure Hot Gas Bypass to Electric Unloader (24 VDC), Includes:	2
1	17-40417-00	Unloader Valve	2
2	68PD-2-102-3	Solenoid Coil - 24 VDC	2
3	12-00334-02	Switch, Pressure (UPS2) - R-134a	1
4	12-00334-03	Switch, Pressure (UPS1) - R-134a	1
5	40-00249-01	Fitting, Tee, Male Branch, 1/4 FPT x 1/4 FPT x 1/4 MPT	1
6	40-00243-01	Fitting, Tee, Street, 1/4 MPT x 1/4 x 1/4 FPT	1
7	06DA403-844	Valve, Access (1/4 Flare, Schrader)	3
8	40-00528-02	Connector, 1/4 FPT x 7/16-20 Straight Thread With O-Ring - Includes:	1
9	42-00243-07	O-Ring	1
10	DD19CA061	Cap, 1/4 Flare, Schrader	1
11	22-50222-00	Wire Harness	1

17 UNLOADER KIT - PRESSURE TO ELECTRIC - R-22 ONLY - 24 VDC			
Item	Part Number	Description	Qty
	74-50111-01	Kit, Convert Pressure Hot Gas Bypass to Electric Unloader (24 VDC), Includes:	2
1	17-40417-00	Unloader Valve	2
2	68PD-2-102-3	Solenoid Coil - 24 VDC	2
3	12-00334-00	Switch, Pressure (UPS2) - R-22	1
4	12-00334-01	Switch, Pressure (UPS1) - R-22	1
5	40-00249-01	Fitting, Tee, Male Branch, 1/4 FPT x 1/4 FPT x 1/4 MPT	1
6	40-00243-01	Fitting, Tee, Street, 1/4 MPT x 1/4 x 1/4 FPT	1
7	06DA403-844	Valve, Access (1/4 Flare, Schrader)	3
8	40-00528-02	Connector, 1/4 FPT x 7/16-20 Straight Thread With O-Ring - Includes:	1
9	42-00243-07	O-Ring	1
10	DD19CA061	Cap, 1/4 Flare, Schrader	1
11	22-50222-00	Wire Harness	1
17 UNLOADER KIT - PRESSURE TO ELECTRIC - R-134a ONLY - 36 VDC			
	74-50111-02	Kit, Convert Pressure Hot Gas Bypass to Electric Unloader (36 VDC), Includes:	2
1	17-40417-00	Unloader Valve	2
2	14-50086-00	Solenoid Coil - 36 VDC	2
3	12-00334-02	Switch, Pressure (UPS2) - R-134a	1
4	12-00334-03	Switch, Pressure (UPS1) - R-134a	1
5	40-00249-01	Fitting, Tee, Male Branch, 1/4 FPT x 1/4 FPT x 1/4 MPT	1
6	40-00243-01	Fitting, Tee, Street, 1/4 MPT x 1/4 x 1/4 FPT	1
7	06DA403-844	Valve, Access (1/4 Flare, Schrader)	3
8	40-00528-02	Connector, 1/4 FPT x 7/16-20 Straight Thread With O-Ring - Includes:	1
9	42-00243-07	O-Ring	1
10	DD19CA061	Cap, 1/4 Flare, Schrader	1
11	22-50222-00	Wire Harness	1
17 UNLOADER KIT - PRESSURE TO ELECTRIC - R-22 ONLY - 36 VDC			
	74-50111-03	Kit, Convert Pressure Hot Gas Bypass to Electric Unloader (36 VDC), Includes:	2
1	17-40417-02	Unloader Valve	2
2	14-50086-00	Solenoid Coil - 36 VDC	2
3	12-00334-00	Switch, Pressure (UPS2) - R-22	1
4	12-00334-01	Switch, Pressure (UPS1) - R-22	1
5	40-00249-01	Fitting, Tee, Male Branch, 1/4 FPT x 1/4 FPT x 1/4 MPT	1
6	40-00243-01	Fitting, Tee, Street, 1/4 MPT x 1/4 x 1/4 FPT	1
7	06DA403-844	Valve, Access (1/4 Flare, Schrader)	3
8	40-00528-02	Connector, 1/4 FPT x 7/16-20 Straight Thread With O-Ring - Includes:	1
9	42-00243-07	O-Ring	1
10	DD19CA061	Cap, 1/4 Flare, Schrader	1
11	22-50222-00	Wire Harness	1

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34-06026-00	9	50-01122-09	15	AF55CQ164	5
34-06083-00	6	50-01122-12	15		
34-50034-00	16	50-01122-14	15	C	
34-50035-00	16	50-01122-41	14	CA63AA051	12
40-00060-08	12	50-01122-50	14, 15		
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40-00249-01	20, 21	50-01122-66	15	DD19CA061	1, 12, 20, 21
40-00520-00	1	50-01122-85	14		
40-00520-01	12	50-01122-86	14		
40-00520-02	1	50-01122-90	15		
40-00520-03	12	50-01122-91	15		
40-00524-00	1	50-01122-93	15		
		50-01122-501	15	Symbols	
				--AU--11AR-241	14, 18

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Housing-Mounted Clutch Installation

The procedure on the attached pages should be followed carefully when servicing the Carrier Transicold housing-mounted clutch.

The following tools are recommended when removing and replacing this clutch:

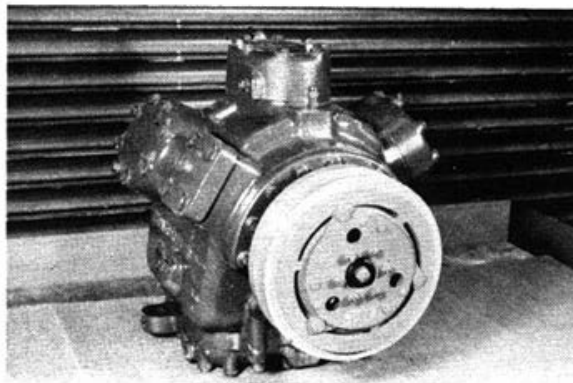
TOOL LIST

<u>DESCRIPTION</u>	<u>CTC PART NO.</u> <u>(WHERE APPLICABLE)</u>
Spanner Wrench	07-00240-01
Rotor Installation Tool	07-00241
Socket Bearing Retaining Nut-Large	07-00242-01
Socket Bearing Retaining Nut-Small	07-00242-02
3/8" Socket Set	
Torque Wrench	
3 Leg Puller w/ 3 1/4-20 UNC Cap Screws	
1 - Bolt 7/8-14 UNC x 2" Long	
Feeler Gauge .020 .030 .060	
Grease Gun, Manual, 0.1 Oz Per Stroke	
Depth Gauge 0-1/2"	
Ohmmeter	

05G COMPRESSOR HOUSING MOUNTED CLUTCH

The new housing-mounted electric clutch, HMC, eliminates drive belt loading on the 05G crankshaft, and applies this load directly to the crankcase of the compressor. The following procedure should be followed carefully whenever it becomes necessary to remove and replace the HMC.

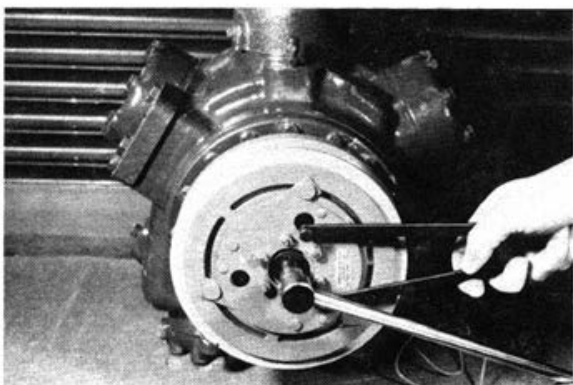
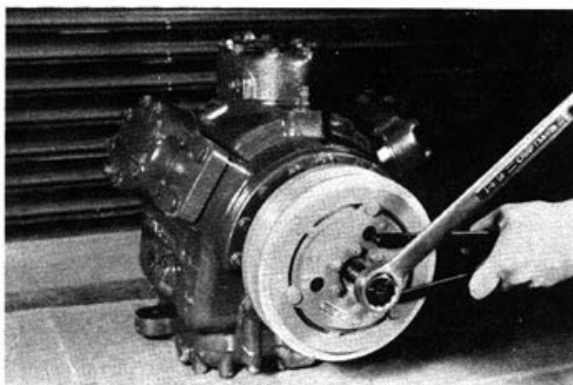
Housing-Mounted Clutch Removal



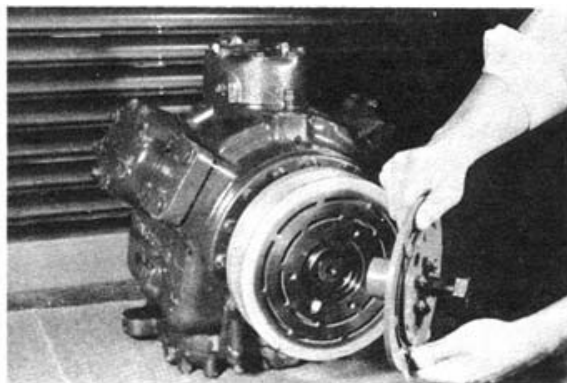
CAUTION: Remove drive belt before attempting to remove clutch.

1. Remove armature as a complete assembly by removing retaining capscrew (3/8-24 x 1-1/4" Lg.), lock washer, and special 3/8 washer from compressor crankshaft. Use special CTD tool P/N 07-00240-01 to prevent crankshaft rotation, as shown.
2. Install a 7/8-14 x 2" capscrew into the center hole of the armature assembly. Use this capscrew as a jacking bolt to remove the armature assembly. Use tool 07-00240-01 as in Step 1 to prevent crankshaft rotation.

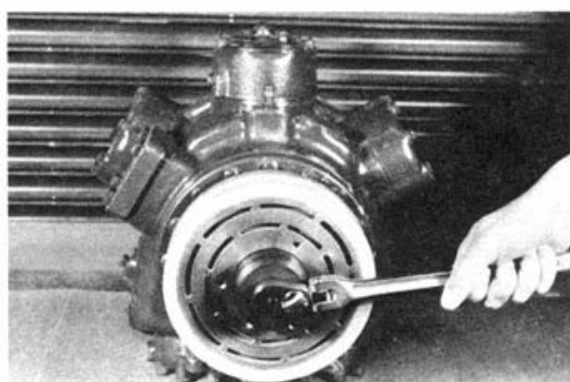
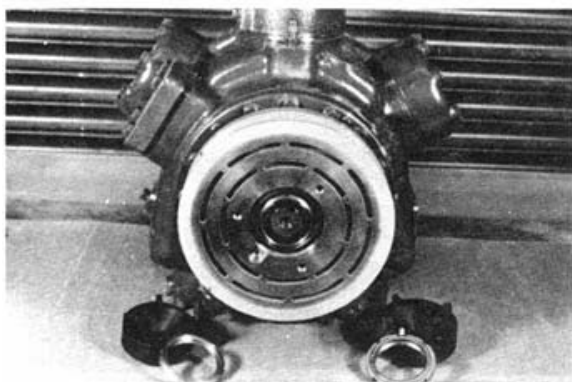
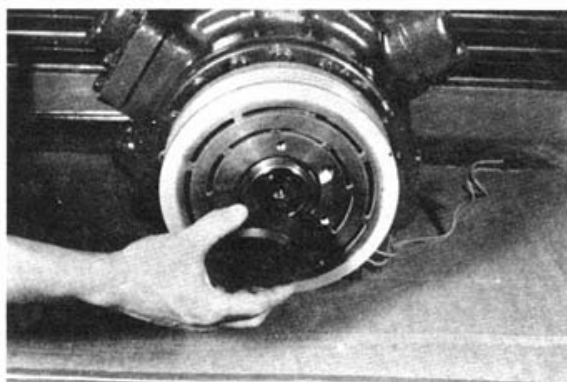
Note: Do not use a puller or pry against the armature hub or bumper plate, as this could cause damage to these parts.



3. Remove the clutch armature assembly from the compressor crankshaft as a complete assembly, as shown.

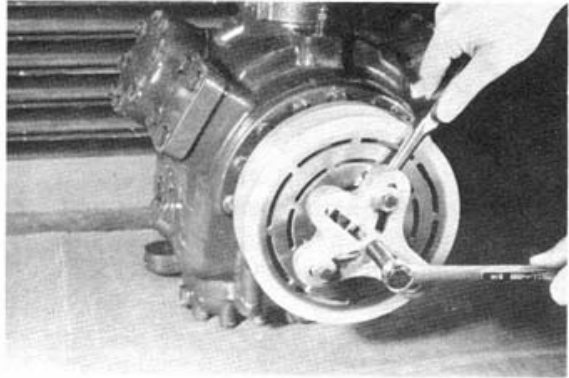


4. Remove the rotor retaining nut with special CTD tool P/N 07-00242-01.

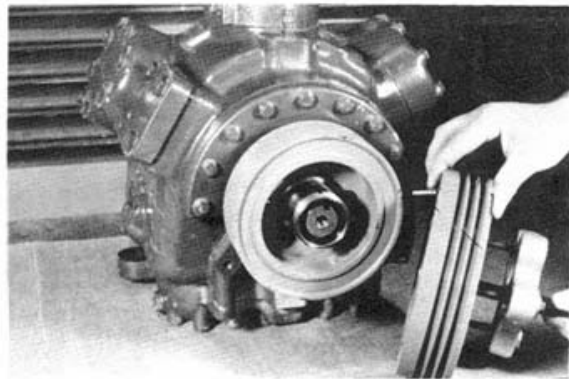


5. Install a flange-type gear puller into the three 5/16-18 tapped holes in the clutch rotor assembly, as shown.

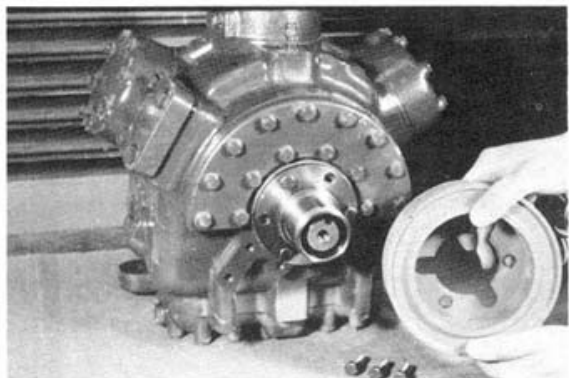
CAUTION: Use a washer or other protective device to prevent damage to crankshaft and threaded hole in the crankshaft by the puller. Never use a puller in the belt grooves, as damage to the rotor may result. Use a pry bar as shown to prevent rotation of the clutch rotor.



6. Once the rotor has been pulled from the clutch bearing mounting hub, carefully lift the rotor assembly away from the compressor, as shown.

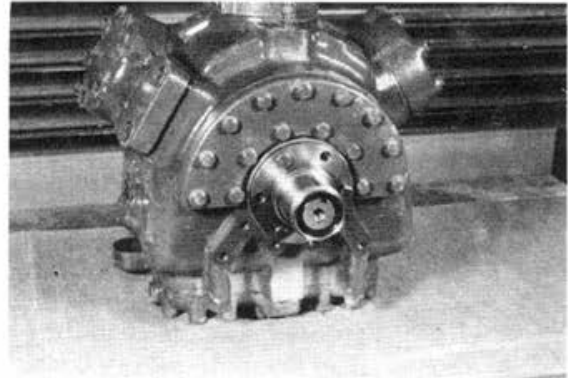


7. To remove the clutch coil, disconnect the coil's electrical cable from the wiring harness. Then remove only the three 3/8-16 capscrews holding the coil to the flange of the clutch bearing mounting hub, and carefully remove the coil, pulling straight out from the flange. Do not pry coil off, as it may bend the mounting plate.



Housing-Mounted Clutch Installation

1. Prior to installing the HMC, inspect for dents, nicks, or burrs on the clutch bearing mounting hub and clutch assembly. Correct if any are found, and clean clutch mounting hub and ID of clutch bearing with a chlorinated base or naphtha type solvent.



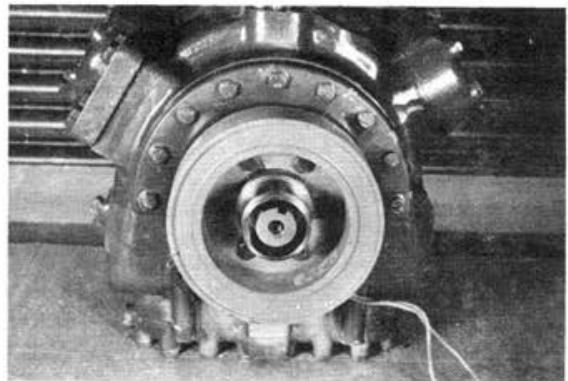
2. Inspect coil for damaged power leads, bent or cracked mounting plate, or burned or cracked potting material.

3. Check coil for electrical continuity, resistance, and shorts to ground.

Resistance at 68°F:	Lead to Lead	24 VDC coil	5.15-5.69 ohms
		12 VDC coil	1.92-2.12 ohms
	Lead to Ground	12/24 VDC coil	INF or open

Replace coil if above conditions are not met.

4. Slide the coil onto the clutch bearing mounting hub so that the lead wires exit between the 3 and 5 o'clock position, as shown.



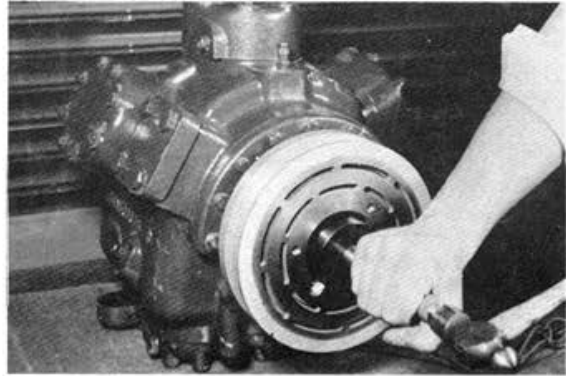
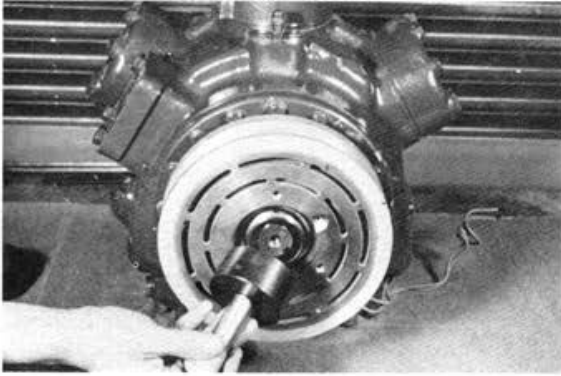
5. Secure the coil to the bearing mounting hub flange with the three 3/8-16 capscrews removed in Step 7 of Clutch Removal. Torque capscrews to 25-30 ft-lb (3.46-4.15 MKG).

CAUTION: Do not draw coil onto the clutch bearing mounting hub flange with the capscrews, as this may distort the coil.

6. To ease the installation of the rotor onto the clutch bearing mounting hub, preheat the inner race of the rotor bearing by placing an electric heater inside the bearing bore (a 75-100 watt outdoor post lamp style bulb applied for 15-30 minutes may be used).

CAUTION: Do not heat bearing with an open flame or heat bearing above 175°F.

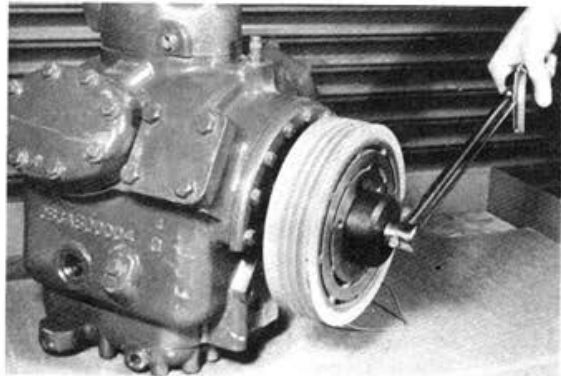
7. After preheating bearing, slide rotor assembly onto clutch bearing mounting hub. To facilitate seating of the bearing on the hub, place CTD tool P/N 07-00241 against the inner race of the bearing and tap gently with a hammer, as shown.



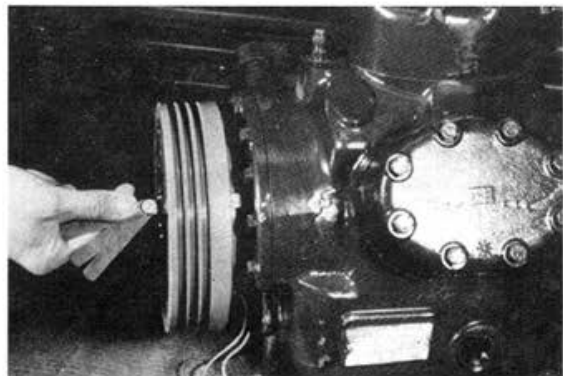
8. Install bearing retaining nut on clutch mounting hub and use torque wrench to tighten.

If the smaller nut without the grease fitting is used, torque nut to 50 ft-lb. with CTD tool P/N 07-00242-02. The taper on the nut faces the bearing.

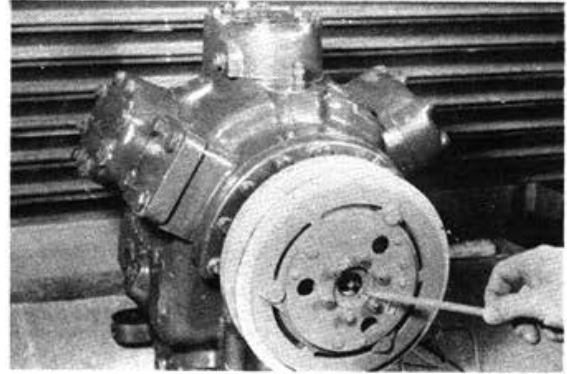
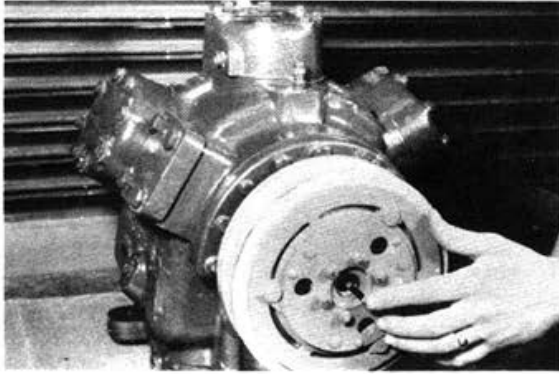
If the larger nut with the grease fitting is used, torque the nut with CTD tool P/N 07-00242-01. Due to the self-locking feature of the nut, the installation torque may vary. When installing the nut, observe the torque required to turn the nut onto the hub. After the nut seats the bearing against the hub, apply a torque 50 ft-lb. greater than the installation torque.



9. Check coil to rotor clearance by inserting .020 thick by .156 wide (max.) feeler gauge through an outer slot in rotor, as shown. Insert the feeler gauge so it extends beyond the rear face of the rotor and rotate the rotor one full turn. There should be no rubbing or binding.



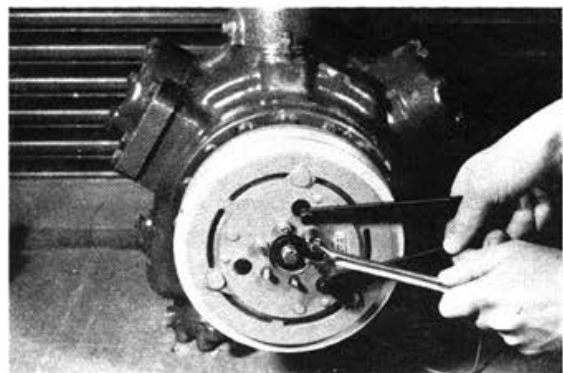
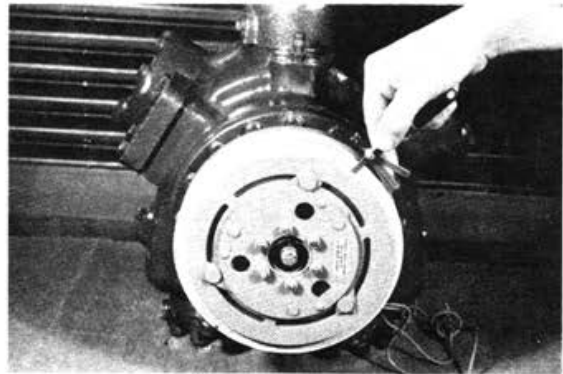
10. Place armature and hub assembly onto the compressor crankshaft and insure the hub seats on the crankshaft properly.
11. Insert the special key CTD P/N 68G2-9072 (1.75 x .250 x .199) in the keyway until outer end of key is flush with the hub's counter bore, as shown.



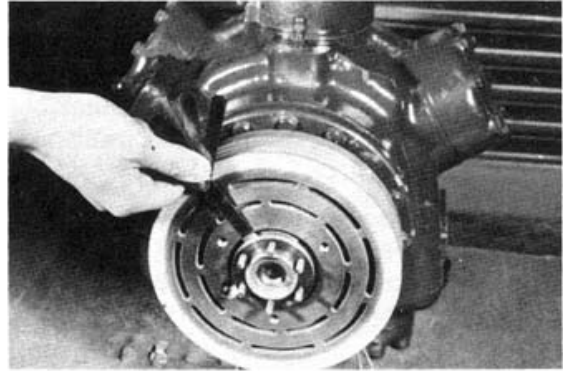
12. Secure armature assembly to crankshaft with the 3/8 special flat washer, lock washer, and 3/8-24 x 1-1/4" lg. capscrew removed in Step 1 of Clutch Removal. Torque capscrew to 16-20 ft-lb using CTD tool P/N 07-00240-01 to prevent crank shaft rotation.

Steps 13-19 are for new clutch installation only. After the initial adjustment, shim stack should not be changed.

13. Measure the air gap between the armature and rotor surfaces, as shown.
14. Record this measurement and determine the amount of shims that must be removed to obtain a .030/.060 air gap. The shims consist of (one) .010 and (six) .020 shims.
15. Remove the six armature plate to armature hub retaining nuts and washers. Use CTD tool P/N 07-00240-01 to prevent armature rotation, as shown.
16. Remove the required number of shims to obtain an air gap of .030/.060.



17. Insert a .020 feeler gauge between the outside edge of the clutch bearing mounting hub and the inside edge of the armature mounting hub, as shown. The clearance should be .020 or greater.



18. Reinstall armature plate, washers, and retaining nuts and torque to 7 ft-lb using CTD tool P/N 07-00240-01 to prevent crankshaft rotation.
19. Recheck air gap to confirm that you have obtained the .030/.060 clearance.

FIELD SERVICE PROCEDURES

1. Greasing of Clutch Bearing

The clutch bearings are pre-greased by the bearing manufacturer with the proper operating charge. Do not add grease to the bearing for at least 5000 hours of bus operation.

CAUTION: Over-greasing of the bearing will cause the bearing to operate at higher temperatures that may result in:

1. Blowing grease through the bearing seals onto the clutch friction faces, causing clutch slippage. A slipping clutch tends to run extremely hot, resulting in forcing more grease from the bearing, thereby increasing slippage and burning the magnetic coil.
2. Reduction in torque transmission capacity.

Recommended frequency for adding grease:

Up to 5000 hours bus operation	None
After initial 5000 hours	Add 0.1 oz SR1-2 grease during pre-season A/C system checkout (i.e., once per year during a Spring month)

Grease required must be "Chevron SR1-2" or CTD Engineering approved equal.

Procedure for Adding Grease to the Clutch Bearing

The grease fitting is located in the clutch bearing retaining nut. Access to the grease fitting is accomplished by removing the armature assembly as in Steps 1, 2, and 3 of HMC Removal.

NOTE: The removal of the armature in order to add grease to the bearing is deliberate to insure that all grease spillage can be cleaned from the clutch, reducing the potential for clutch slippage and the resulting loss of clutch torque transmission capacity.

Any unauthorized modification of the clutch armature to facilitate greasing of the bearing will void the clutch and compressor warranties.

It is recommended that a hand operated grease gun with approximately 0.1 oz delivery per stroke be used to add grease to the bearing. Grease gun must contain "Chevron SR1-2" grease.

Wipe the grease fitting clean of all dirt and foreign materials.

Attach grease gun to grease fitting. Insert 0.1 oz grease into bearing (1 to 2 strokes of the gun).

CAUTION: Do not give extra strokes "for good measure" as premature clutch performance degradation may result.

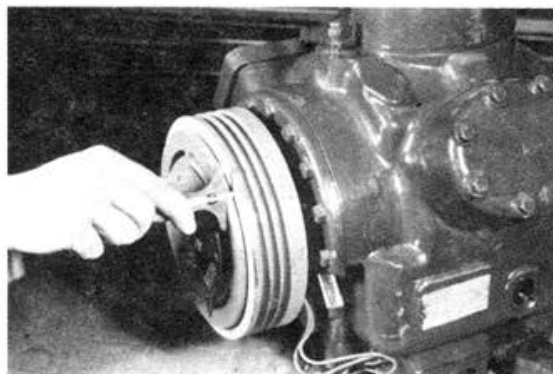
After adding grease to the bearing, wipe all grease spillage from clutch faces, retaining nut, and hubs. If you can see it, wipe it up.

Reinstall armature assembly and torque retaining nut to 16-20 ft-lb. torque, as in Steps 10, 11, and 12 of HMC Assembly.

2. Inspection for Wear

CAUTION: Insure bus or compressor drive engine is not operating. Take extra precautions to prevent inadvertent engine starting while clutch is being serviced.

- A) With clutch coil de-energized, measure distance from face of armature to face of rotor, as shown. Feeler gauges inserted between the rotor and armature friction faces is not recommended due to the uneven wear on friction surfaces.



Energize the clutch coil and repeat the measurement. If the difference between the first and second measurements exceeds .110 inches, the clutch rotor and armature are to be replaced.

NOTE: Do not attempt to readjust the armature travel by removing shims. A catastrophic clutch failure may result. After initial (new) air gap adjustment the shim stack should never be changed.

B) Never mix rotor and armature assemblies between used assemblies or new and used assemblies.

CAUTION: If either the armature or rotor assemblies are defective, both assemblies must be replaced.

C) If raised ribs on friction face are worn flat or nearly flat, replace armature and rotor assemblies.

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1. AUDIO AND VIDEO SYSTEM DESCRIPTION

The rack mounted components are gathered on the audio-video panel which is located in the first driver's side overhead compartment (Fig. 1). In addition to the power amplifier, options for AM/FM stereo radio and satellite radio, CD changer, karaoke, wireless microphone, DVD and videocassette player, scenic view and back-up camera system and GPS Navigation System module may be featured.

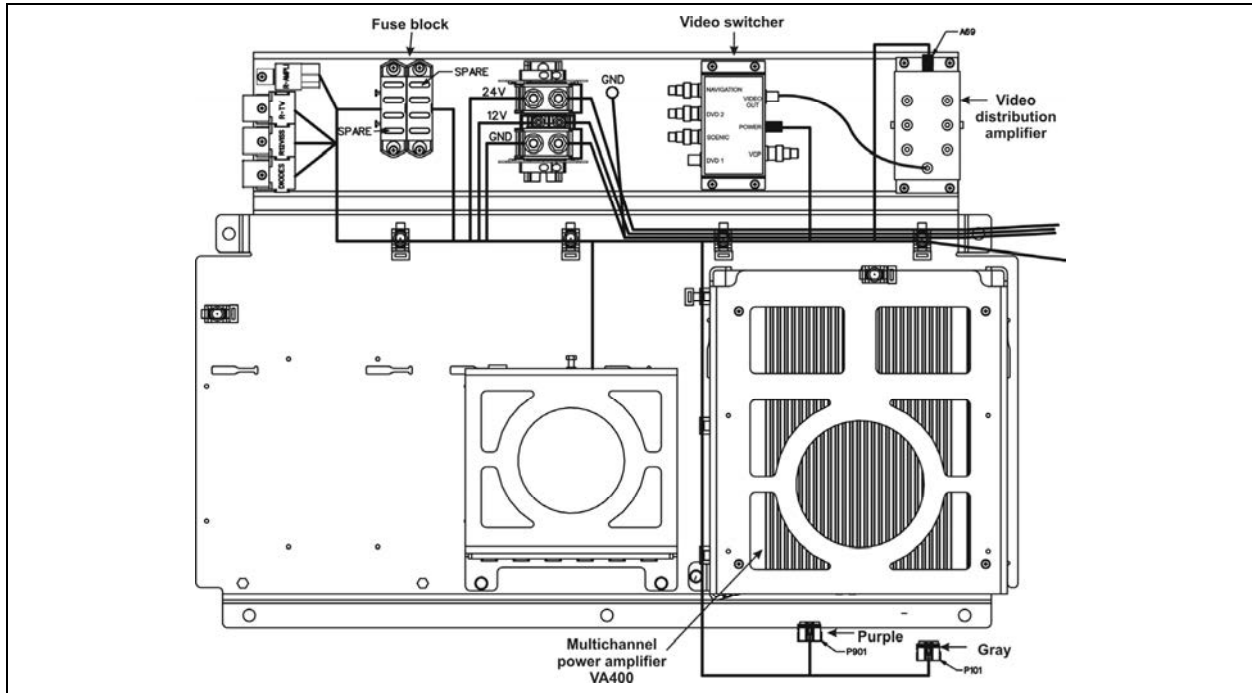


FIGURE 1 : AUDIO-VIDEO PANEL

Each service module mounted to the underside of the parcel racks contains a 40-watt speaker. The speakers in the passenger section are wired in stereo and are powered by the amplifier. A microphone outlet mounted in the driver's area is provided as standard equipment.

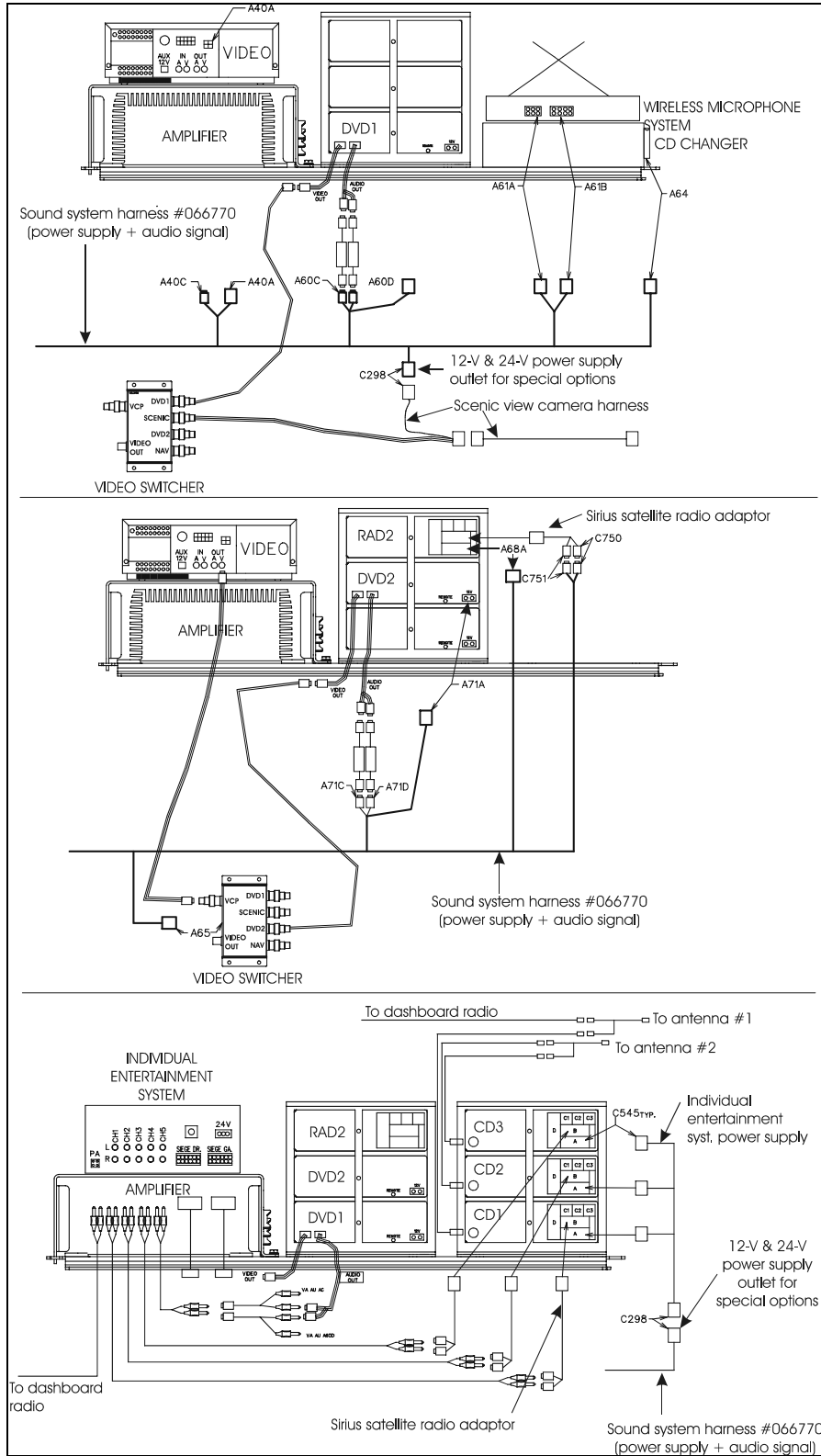


FIGURE 2: AUDIO & VIDEO CONNECTIONS

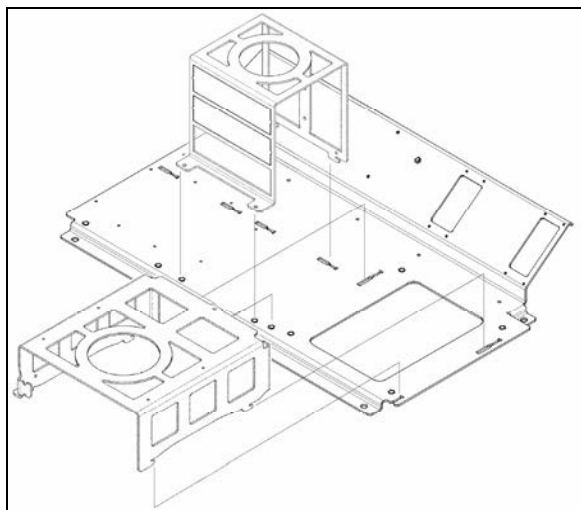


FIGURE 3: RACKS ON AUDIO-VIDEO PANEL 23059

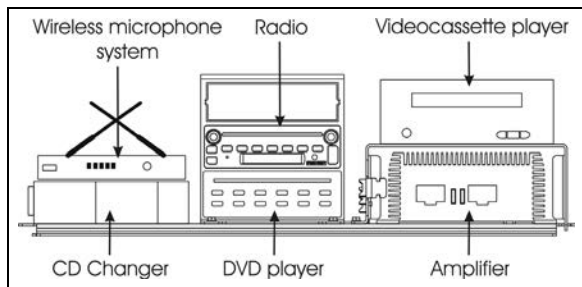


FIGURE 4: AUDIO-VIDEO PANEL

1.1 AM/FM RADIO

1.1.1 VR300 AM/FM Radio / CD Player

This AM/FM/WX (weather band) radio CD player model has external CD changer capability (Fig. 4).

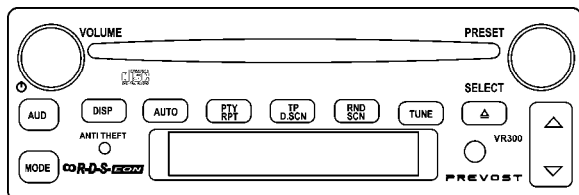


FIGURE 5: VR300 CD/AM/FM STEREO RECEIVER 23351

NOTE

Before attempting to solve an electrical problem on the sound system, refer to the wiring diagrams.

“VR300 Operating Instruction” manual is included at the end of this section. The radio is a serviceable component and should only be serviced by a qualified electronics technician.

Features:

- CD changer control
- Anti-theft
- Auto preset memory
- LED illumination
- Liquid crystal display
- Amber illumination
- Panel light dimming
- Quartz clock
- Mute function
- Search & repeat
- Track scan
- AUX input
- 4x20W power
- 4 low level outputs

1.1.2 Security Code

Your radio is protected by a security code. The security code can be found on a label delivered with the radio. The security code cannot be changed.

When the radio power is first turned on after power has been interrupted, “ID CHECK” and then “LOCK” is displayed for 3 seconds. Then “0000” is displayed.

To unlock the radio, enter the four-digit security code found on the removable label (refer to “VR300 Operating Instruction” manual).

If the code is entered correctly, the radio will switch to the last active mode (i.e. FM, CD, etc.) and is ready to use. If the code is entered incorrectly, you can try 2 more times. After 3 incorrect entries, the radio will display “LOCK.” You must turn the radio off, while leaving the ignition and battery on, for 1 continuous hour before attempting to unlock the radio again.

1.1.3 Removal

To remove the radio from its location, proceed as follows:

1. Place the ignition switch in the “OFF” position.
2. Remove the dashboard panel cover.
3. Disconnect the electrical cable connectors from radio and unfasten back plate securing nut.
4. To separate the radio from its support, insert the U shaped tool in the two pairs of holes found each side of the radio front panel.
5. Push the unit through the front dashboard panel.
6. Install a new unit by reversing the procedure.

NOTE

Remember that because power has been interrupted during removal, the radio must be unlocked by entering the four-digit security code after reinstallation.

1.1.4 DELPHI Premium Satellite Radio AM/FM/MP3 CD stereo (OPTIONAL)

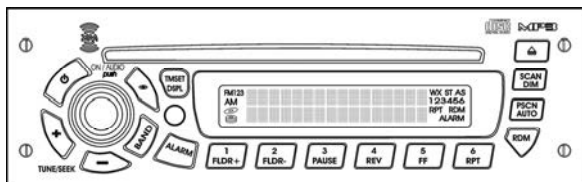


FIGURE 6: DELPHI PREMIUM SATELLITE RADIO 23355

This XM or SIRIUS satellite radio receiver can be located on the dashboard, replacing the standard radio or inside the first driver's side overhead compartment, where many radio can be installed.

Features:

- Satellite radio ready with weather band
- 7-channel weather band
- 18 FM & 6 AM presets
- Steering wheel control compatible
- Anti-theft
- Auto preset solutions
- MP3 playback capability
- LED illumination
- Liquid crystal display
- Quartz clock
- Single disc
- Random & repeat play modes
- SDARS receiver compatible
- AUX inputs
- 4x17W power

The complete operating instruction manual is included in your vehicle's *technical publications box*.

1.2 VSS-04 SOUND SELECTOR

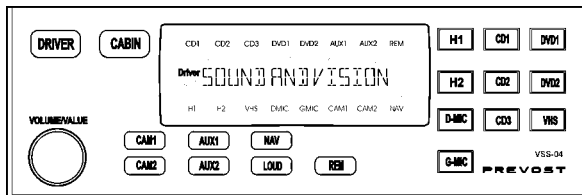


FIGURE 7: VSS-04 SOUND SELECTOR 23350

The VSS-04 Sound Selector enables the driver to select different audio or audio-video entertainment sources for the driver area and the passengers' area. The driver may be listening to the radio and watching the Navigation System route information on the monitor while the passengers may be watching a movie from the DVD player.

With this unit, you can adjust each audio source sound settings (e.g. volume, bass, treble, balance, fade).

Features:

7 audio sources

- Radios (2)
- Microphones (2)
- CD players (3)

5 audio-video sources

- DVD players (2)
- VCR (1)
- Auxiliary (2)

3 video sources

- cameras (2)
- GPS Navigation system (1)

1.2.1 Removal

To remove the Sound Selector from its location, proceed as follows:

1. Place the battery master switch in the "OFF" position.
2. Remove the dashboard panel cover.
3. Disconnect the electrical cable connectors from unit and unfasten back plate securing nut/screw.
4. To separate the Sound Selector from its support, insert a flat screwdriver each side of the unit front panel.
5. Push the unit through the front dashboard panel.
6. Install a new unit by reversing the procedure.

The operating instructions are included in your Operator's Manual.

Section 23: ACCESSORIES

1.3 VD-404 MOBILE DVD PLAYER



FIGURE 8: VD-404 MOBILE DVD PLAYER

The MOBILE DVD PLAYER is located in the first parcel compartment on the driver's side. Instructions for proper use of this unit are included at the end of this section.

Features:

- **POWER**
Operating voltage: 12-volt DC
- **COMPATIBILITY**
This DVD player can play the following disc formats:
DVD, CD, VCD, DVCD, MP3, CD-R, CD-RW
- **SYSTEM FUNCTIONS**
Video output system: system MULTI, NTSC or PAL switchable.
 - 1 L/R audio output
 - 1 L/R audio input
 - 1 AUX video output
 - 1 rear camera video input
 - 3 video outputs with one dedicated self switching rear view monitor
- **ADDITIONAL VIDEO FEATURES**
Multi-angle, multi-view, multi-audio function, multi-level forward and backward motion, play position memory, resume stop and repeat function.

1.4 MULTICHANNEL POWER AMPLIFIER VA400.8

This 400-watt, 6-channels brings an added dimension to your stereo equipment and increases the total output of the system.

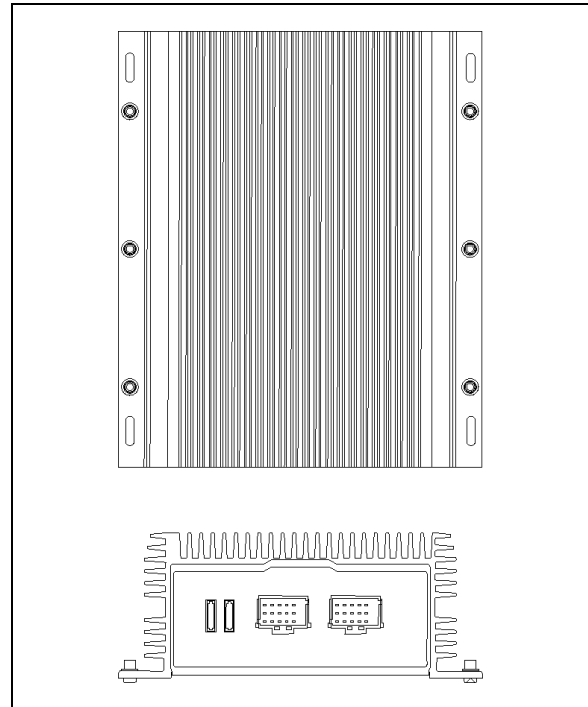


FIGURE 9: MULTICHANNEL POWER AMPLIFIER

For optimum sound quality, adjust the subwoofer crossover filter as shown on figure 10. This adjustment is necessary to balance the subwoofers volume in respect to the other speakers and also to cut high frequencies for a better sound quality.

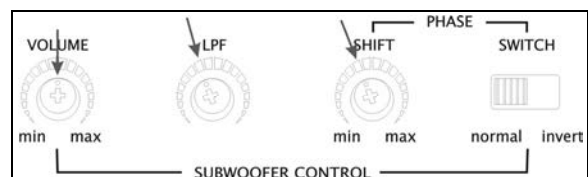


FIGURE 10: CROSSOVER ADJUSTMENT

1.5 SPEAKERS

Each passenger's overhead console mounted to the underside of the parcel racks contains a 20-watt Dual Cone 10cm speaker. The speakers in the passenger's section, wired in stereo and arranged in a delta configuration are powered by the amplifier.



FIGURE 11: 10cm DUAL CONE SPEAKER

The vehicle may be equipped with two additional Hi-Fi speakers in the driver's area, mounted one on each side. This arrangement provides the driver with clear stereo sound. Controls for the driver's audio allow selection between the radio and the auxiliary audio (independent of the passenger's speakers) or muting the speakers.

Two specially designed subwoofers may be fixed as an option under a passenger seat with anti-vibration supports.

1.6 VIDEO CASSETTE PLAYER (VCP)

The optional VCP is located on the audio-video panel in the first overhead compartment. Instructions for proper use of the VCP are provided in the technical publication box.



FIGURE 12: V3000 VIDEO CASSETTE PLAYER

1.6.1 Removal

1. Place the ignition switch in the "OFF" position.
2. Remove the VCP/VCR mounting locknuts from rubber mounts.
3. Disconnect wiring.
4. Remove VCP/VCR unit from parcel compartment.

1.6.2 Installation

1. Install VCP/VCR unit into parcel compartment aligning rubber mount studs with mounting holes. Insert mount studs through mounting holes.
2. Install locknuts on mount studs.
3. Reconnect wiring.
5. Place the battery master switch in the "ON" position.

1.7 BOOM-TYPE MICROPHONE

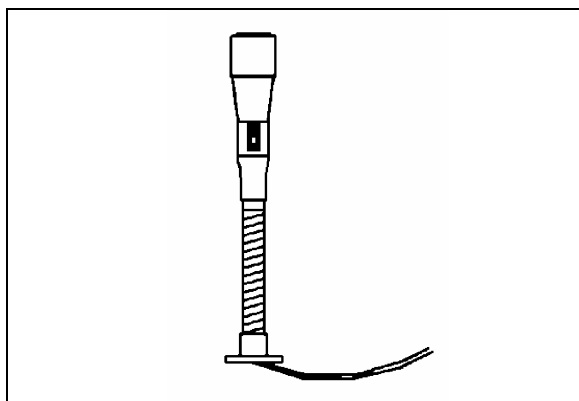


FIGURE 13: BOOM-TYPE MICROPHONE

23083

1.7.1 Removal

1. Place the ignition switch in the "OFF" position.
2. Remove the mounting screws at mounting flange.
3. Disconnect wiring.

1.7.2 Installation

1. Reconnect wiring.
2. Align mounting flange with holes and install screws.
3. Remove spacer block mounting screws.
4. Insert spacer block and install mounting screws.
5. Place the battery master switch in the "ON" position.

1.8 HANDHELD PRIORITY MICROPHONE

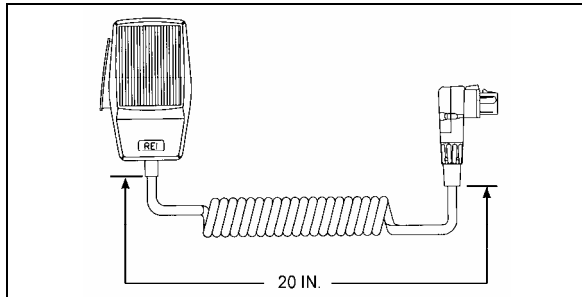


FIGURE 14: HANDHELD PRIORITY MICROPHONE 23216

1.9 WIRELESS MICROPHONE

The system 2000 16 channel wireless microphone, Receiver and Charging Cradle are custom designed units that allow for wireless PA communication from anywhere on the coach. The unit consists of a receiver mounted in the parcel area directly behind the driver, and a rechargeable hand-held microphone and charging unit. Instructions for proper use of the microphone are included in the "REI Operating Manual" which is provided in the technical publications box delivered with the vehicle.

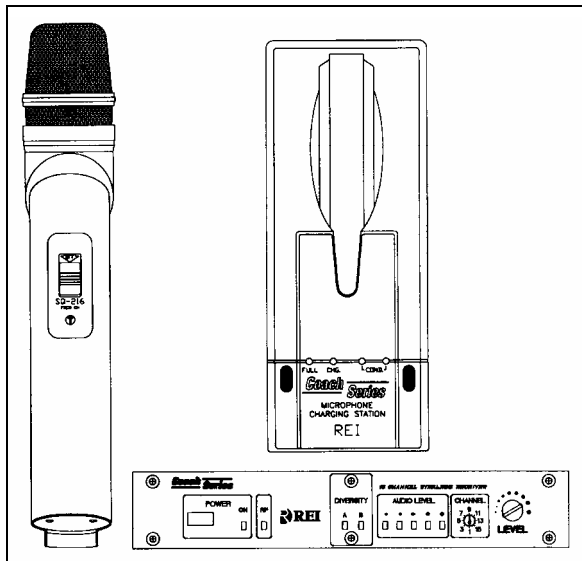


FIGURE 15: WIRELESS MICROPHONE

1.10 TV TUNER

For TV tuner control descriptions, refer to fig. 16.

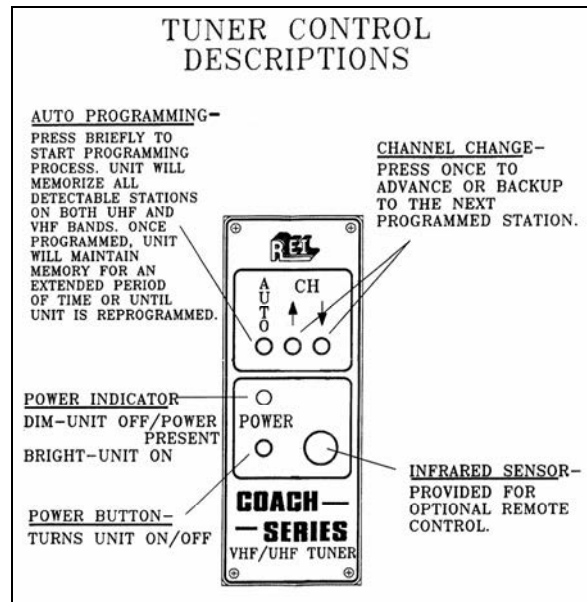


FIGURE 16: TUNER CONTROLS DESCRIPTION

1.11 KARAOKE

The modified Panasonic DVD Player powers up automatically when the video system is activated. The unit can be controlled with the plug-in remote control, or the control head, which has access to the PLAY and STOP commands.

If so equipped, instructions for proper use of the Karaoke system are included in the "Operating Manual" that is provided in the technical publications box delivered with the vehicle.

1.11.1 Karaoke Panasonic Sound System – MOBILE DVD PLAYER DV1500

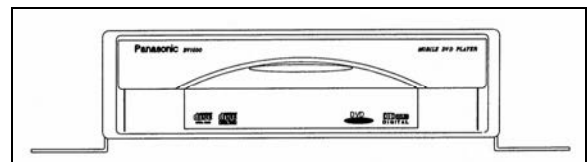


FIGURE 17: PANASONIC DV1500

1.12 DRIVER'S SPEAKERS

The driver's speakers are mounted one on each side. This arrangement provides the driver with clear stereo sound. Controls for the driver's audio allow selection between the radio and the auxiliary audio (independent of the passenger's speakers) or muting the speakers.

1.13 MONITOR

1. Place the ignition switch in the "OFF" position.
2. Unfasten the retaining screw located on the monitor R.H. side.
3. Slide the monitor to the right to release it from the mounting bracket.

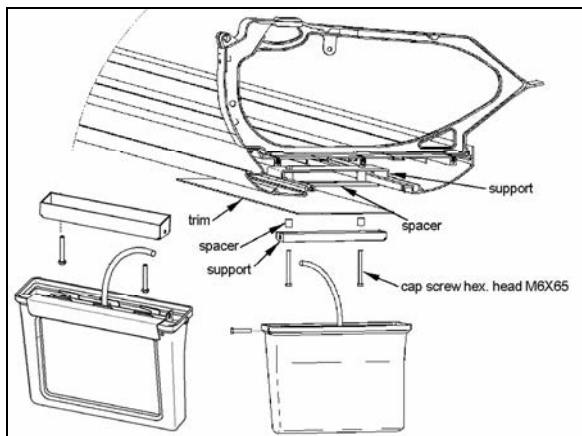


FIGURE 18: MONITOR MOUNTING 23221

1.14 SCENIC VIEWING SYSTEM

The scenic viewing system enables the passengers to view the road ahead of the vehicle. This system is composed of a camera, a dashboard mounted ON/OFF switch and the video switcher located on the audio-video panel (Figs. 1 & 19).



FIGURE 19: SCENIC VIEW CAMERA

1.15 ROOF ANTENNA INSTALLATION

1. Find the desire location and drill a hole according to specification.
2. To remove dirt and grease, wash hole edge with alcohol.

3. If so equipped, remove foam padding ring from antenna to free the metal surface (foam can produce air bulbs in new rubber seal).
4. With SIKA 205, wash the opening edge and the antenna base surface, wait at least two (2) minutes for chemical evaporation.
5. Apply new seal SIKA 221 on both, vehicle hole edge and antenna base.
6. Fix the antenna in place.
7. Remove excess seal and complete a finishing joint all around the antenna base.

2. HUBODOMETER

2.1 DESCRIPTION

An optional wheel hubodometer (Fig. 20) may have been installed on the R.H. side of the drive axle. It indicates the total distance in miles or kilometers covered by the coach since it has left the factory, including road testing.

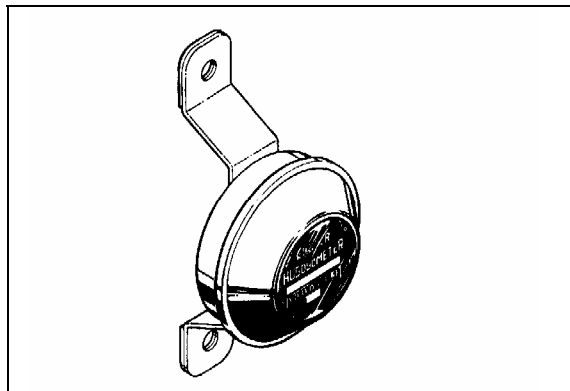


FIGURE 20: HUBODOMETER 23024

2.2 OPERATION

The hubodometer is calibrated for a specific wheel size (diameter). Wheel rotation causes a mechanism inside the hubodometer to record distance after a predetermined number of rotations. The unit should be serviced at a competent speedometer repair facility.

NOTE

Do not use paint, solvent or thinner on hubodometer face or on plastic hubcaps. Do not weld on hubodometer.

2.3 REMOVAL

To remove the unit, remove the two lock nuts and washers securing it to the wheel hub, and pull the unit off the studs.

2.4 INSTALLATION

Place the hubodometer unit over the wheel hub studs. Replace the lock washers and nuts. Torque stud nuts to 110-165 Lbf-ft.(150-225 Nm).

3. BACK-UP CAMERA AND MONITOR

An optional back-up camera is available which provides the driver with visual assistance when backing-up. The camera is automatically activated when the transmission is put in reverse gear and the ignition switch is "ON". The TV monitor is mounted on top of the dashboard. Refer to the Operator's Manual under "Controls & Instruments".

4. COLD STARTING AID (ETHER)

The vehicle can be equipped with an electrically-operated type ether cold starting aid designed to ease engine starting when temperature is low.

On vehicles equipped with cold starting aid, the system consists of the main following parts:

- Ether starting aid switch
- Ether cylinder
- Solenoid valve (24 V)
- Thermal cutout valve
- Atomizer

The control rocker switch is located on the dashboard. This switch is provided with a locking mechanism to avoid accidental use when engine is running. To activate the ether starting aid, proceed as follows:

1. Prior to cranking engine, press down rocker switch for three seconds to fill solenoid valve.
2. Release switch to discharge shot.
3. Allow three seconds for shot to discharge.
4. Start engine, use additional shots if necessary to keep engine running.



CAUTION

This practice should be performed only when absolutely necessary. Excessive use of fluid could result in serious engine damage.

The ether cylinder and solenoid valve assembly are mounted on the engine compartment wall and are accessible from the engine compartment R.H. side door.

The thermal cutout valve is mounted on the engine (radiator side). Its function is to prevent discharge of ether when engine is warm (over 90°F (32°C)). The atomizer is installed on top of the air intake duct (Fig. 21).

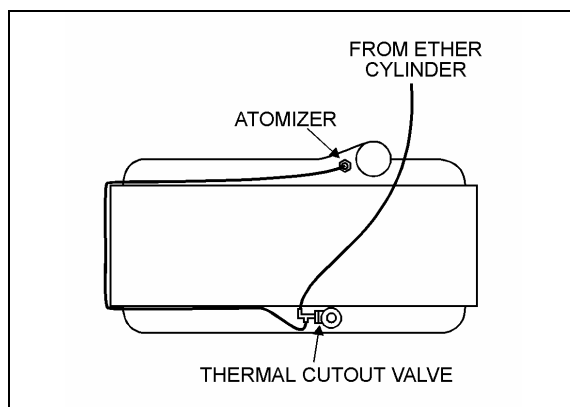


FIGURE 21: ENGINE

23032

4.1 PREVENTIVE MAINTENANCE

During the summer months, remove cylinder to avoid high temperature actuation of the cylinder safety relief device. Always screw valve cap into solenoid valve opening to prevent entrance of road dirt. When removing cylinder, be careful to prevent dirt from entering the valve.

4.2 TROUBLESHOOTING (IF SYSTEM IS NON-FUNCTIONING)



DANGER

During the following test, direct free end of tube away from personnel and all sources of ignition as this fuel is extremely flammable. Avoid breathing vapors and contacting fuel with skin. Never smoke during test.

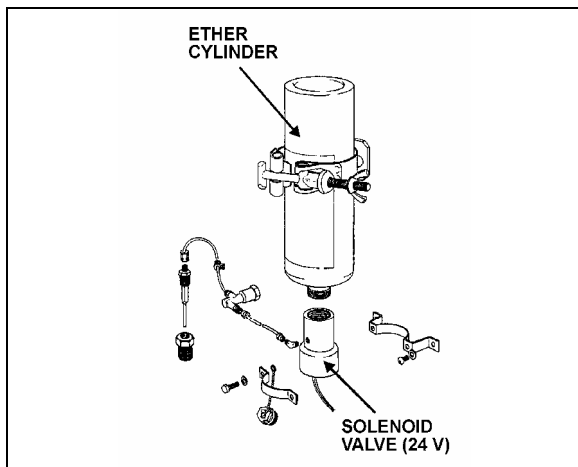


FIGURE 22: COLD STARTING AID

23048

1. Check cylinder for hand tightness and fuel supply (Fig. 22). Empty cylinder weight is approximately 17 oz (480 g); full cylinder weight is approximately 35 oz (990 g). If cylinder is empty, replace it. Before replacing cylinder, install new valve gasket in solenoid valve.
2. If still not functioning, disconnect tubing at solenoid valve fitting. Actuate solenoid valve. (Ask an assistant to actuate solenoid valve using the rocker switch on the dashboard).
 - If solenoid valve is non-functioning, check electric circuit, (refer to wiring diagrams). If sound, remove and replace the solenoid valve. If not, repair electric circuit.
 - If valve is functioning, reassemble valve fitting and connect tube. Disconnect tube at thermal cutout valve from port "Tube from valve".
3. Actuate the solenoid valve.
 - If fuel is not discharged from tube, remove tube and blow out or replace.
 - If fuel is discharged, connect tube to thermal cutout valve, and disconnect other tube.
4. Actuate the solenoid valve.
 - If fuel is not discharged, replace the cut-out valve.

NOTE

If engine coolant temperature is 90°F (32°C) or over, it is normal that fuel is not discharged as the valve is in closed position.

- If fuel is discharged, connect tube to thermal cutout valve, and disconnect tube from atomizer.

5. Actuate the solenoid valve.

- If fuel is not discharged from tube, fuel line is clogged. Remove tube and blow out or replace.
- If fuel is discharged, replace the atomizer.

4.3 THERMAL CUTOUT VALVE QUICK TEST

1. Engine coolant temperature must be below 90°F (32°C).
2. Temporarily disconnect tube at thermal cutout valve from port "Tube to atomizer".
3. Actuate solenoid valve (Ask an assistant to actuate solenoid valve by means of the rocker switch on the dashboard). Fuel should be discharged through the thermal cutout valve.

**DANGER**

Avoid breathing vapors and contacting fuel with skin. Never smoke during test.

4. Reconnect tube to thermal cutout valve.
5. Start engine, using cold starting aid if necessary. Stop engine when it reaches operating temperature.
6. Disconnect tube at thermal cutout valve as in step 2, and repeat step 3. No fuel should be discharged.

5. DESTINATION SIGN

5.1 ELECTRONIC DESTINATION SIGN (OPTIONAL)

The destination sign is located at upper front of the vehicle. To change the destination, depress the selecting switches until the desired destination appears in the LCD display.

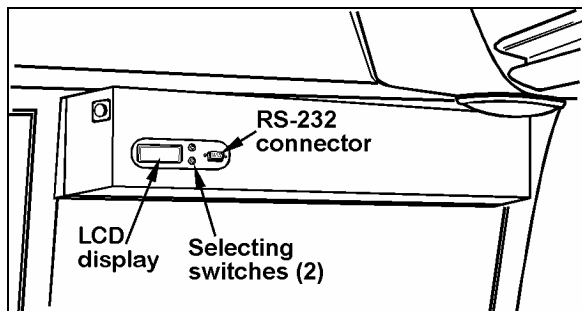


FIGURE 23; DESTINATION SIGN – ELECTRONIC 23123

NOTE

The destination sign must be programmed with a computer connected to the RS-232 connector prior to first use. Follow the instructions on the computer disk to install and run the software.

NOTE

The destination sign is equipped with lights (bulb light or fluorescent) which illuminates automatically when the headlight or fog light switch is activated.

6. LAVATORY

6.1 DESCRIPTION

The lavatory is located in the rear R.H. corner of the coach. It is equipped with a chemical flush toilet, bathroom tissue dispenser, washbasin, towel dispenser, waste container, mirror, ashtray, and a cleaning cabinet. A liquid soap dispenser and moist towel dispenser are optional.

Locking the lavatory door from the inside will illuminate a fluorescent light in the lavatory and two outside signs to indicate occupation. One sign is located on the outer wall of the lavatory and another sign is located over the windshield. An indicator light on the dashboard will illuminate to inform the driver when the lavatory is occupied. A night-light is permanently lit in the lavatory when the ignition switch is in the ON position.

If emergency assistance is required, the lavatory occupant can actuate a buzzer that will sound in driver's area. The buzzer's push-button (c/w instruction label) is located on the inner curbside wall of lavatory.

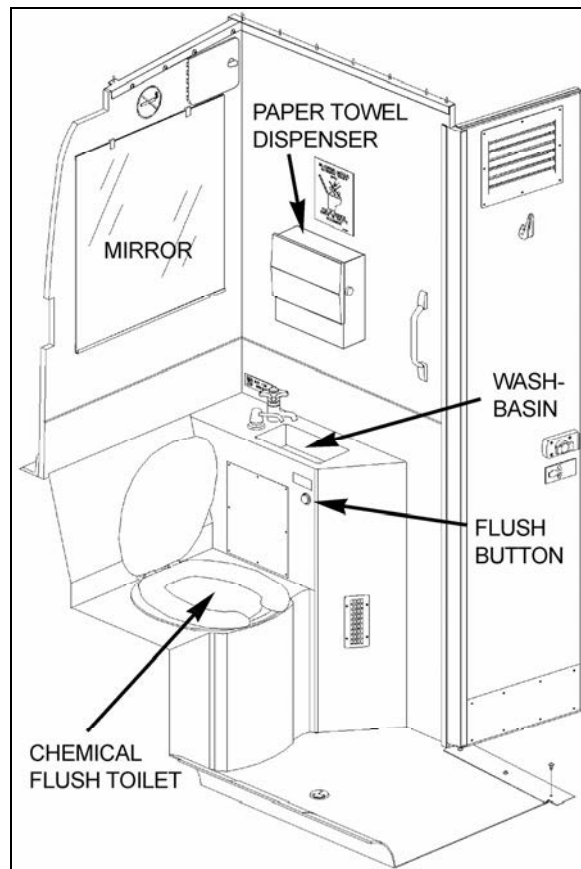


FIGURE 24: LAVATORY 23235

The lavatory has its own ventilation system that operates only when ignition switch is in the "ON" position. An auxiliary sump tank (Fig. 28) (optional) allows main tank to be drained by manually opening an interconnecting tank valve (5, Fig. 27). Lavatory can then be operated for longer periods until coach can be serviced at a facility equipped for disposal.

The fresh water tank, located behind compartment mirror (Fig. 28), is equipped with a thermal drain valve that will drain the tank when water temperature approaches the freezing point preventing damage to the tank (Fig. 28). The fresh water supplies water to the washbasin by gravity. Two tubes are connected on top of the tank. One serves as overflow as well as a vent tube and runs along the curbside wall to the engine compartment R.H. side (6, Fig. 27) while the other tube is connected to the fresh water fill connection which is also located in engine compartment R.H. side (1, Fig. 27). A third tube connected in the bottom of the fresh water tank allows fresh water to flow to the washbasin faucet. Water from washbasin drain tube flows to the main sump tank.

Also, a drain hole located on lavatory floor drain water splashed on the floor to the engine compartment R.H. side.

6.2 MAINTENANCE

The servicing procedure for the lavatory is described in the "Operator's Manual" included in the technical publications box delivered with the vehicle.

6.3 VENTILATION FAN

6.3.1 Description

The lavatory ventilation fan, mounted in engine compartment behind the oil reserve tank (Fig. 25), serves two purposes. It exhausts objectionable odors and provides a constant air circulation in the lavatory compartment by heating or cooling the lavatory with the vehicle ambient air. Air flows in the lavatory compartment through a vent grill located on the lavatory door and exhausts through a grill located next to the toilet.

NOTE

This fan runs constantly when the ignition switch located on the dashboard is in the "ON" position.

6.3.2 Maintenance

The frequency of preventive maintenance should be determined according to vehicle mileage and operating conditions. However, it is recommended to check this item every 50,000 miles (80 000 km) or once a year, whichever comes first.

Remove fan and motor assembly. Check for fan housing wheel and motor free operation. When defective motor occurs, new motor must be installed.

6.3.3 Removal and Installation

1. With the engine compartment rear doors opened, remove hose clamp securing duct to ventilation fan inlet, and disconnect duct.
2. Disconnect the ventilation motor wiring connector.
3. Remove the support bracket screw. Remove the three bolts fixing the ventilation fan housing support. Remove the ventilation fan assembly from its location.

4. The unit can now be disassembled and motor replaced.
5. Reverse previous steps to reinstall ventilation fan assembly on vehicle.

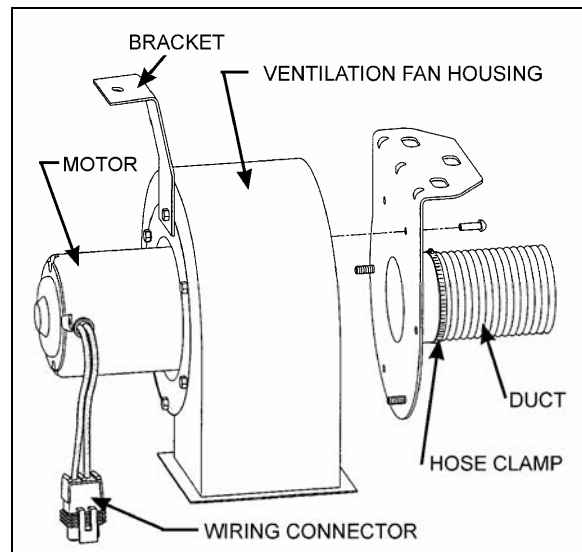


FIGURE 25: VENTILATION FAN INSTALLATION 23222

6.4 DOOR LOCK

Lavatory door lock has inside and outside handles, as well as an inside latch to lock door from inside the compartment. If the lock fails to release, the door can be opened from the outside using a special key which is supplied to the driver. Lock assembly can be removed from the door, then readily disassembled and parts replaced, if necessary (Fig. 26). A thin coat of lubricant on all moving parts will ensure trouble-free operation.

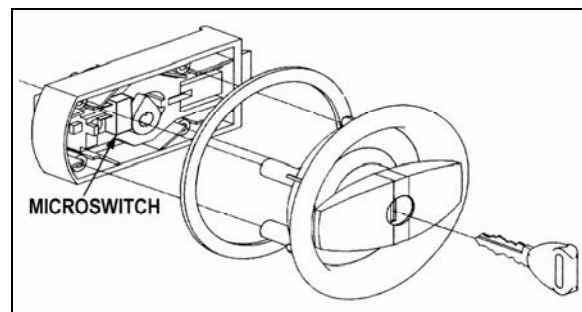


FIGURE 26: DOOR LOCK 23320

6.5 LAVATORY LIGHT

The lavatory light is installed on ceiling. A microswitch, which is mounted inside the latch housing, is activated by the door lock mechanism upon locking to energize the circuit. This switch is readily serviced by removing the

Section 23: ACCESSORIES

four Phillips-head screws securing the housing to the door interior frame.

Proceed as Section 06, Electrical System, *Dome, Rear Roof and Lavatory Lights* for lights replacement.

6.6 LAVATORY NIGHT-LIGHT

The lavatory night-light is illuminated as soon as the ignition switch is set to the "ON" position. See Section 06, Electrical System, *Parcel Rack / Lavatory Night Light - "Bulb Removal and Replacement"* for lights replacement.

6.7 EMERGENCY BUZZER

The lavatory emergency buzzer is mounted on the inner curb side wall of lavatory and sounds when the emergency call push-button switch in the lavatory compartment is activated. For specific wiring information, refer to wiring diagrams. To remove the emergency call push-button switch, proceed as follows:

1. Remove both Phillips-head screws retaining pushbutton switch plate to wall.
2. Remove steel plate located on L.H. side of pushbutton switch.
3. Remove switch through this opening, taking care to disconnect electric wires.

6.8 FRESH WATER TANK

One panel allows access to the fresh water tank. It is located behind the toilet mirror. Remove the tank as follows:

1. Remove the mirror.
2. Remove the fresh water tank tubing, bolts, and different connectors.
3. Remove the tank from the wall.
4. Reverse previous steps to reinstall fresh water tank assembly on vehicle.

6.8.1 Fresh Water Tank Draining

The fresh water tank can be drained by simply opening the fresh water drain cock (Fig. 27). Don't forget to close cock when draining is done.

NOTE

The fresh water reservoir is equipped with a thermal valve which is set to open at about 35°F, thereby automatically draining the reservoir in near-freezing temperatures.

Routine draining and filling of lavatory tanks should be performed by maintenance personnel only. If engine or heating failure occurs in extreme weather conditions, emergency draining of water tanks should be performed under the most suitable conditions and should at all times be supervised by driver.

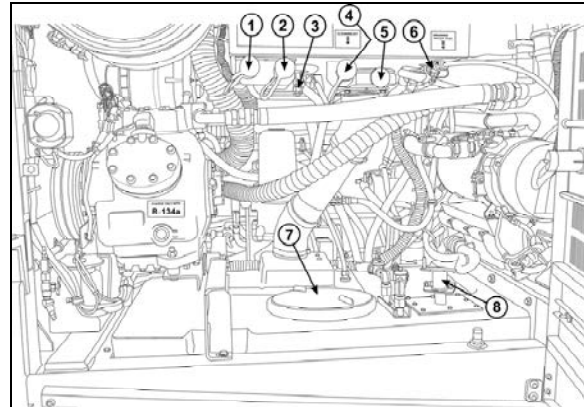


FIGURE 27: F/W TANK SERVICE VALVES

23378

- 1..... Fresh water tank fill connection
- 2..... Main sump tank fill connection
- 3..... Main sump tank overflow cock
- 4..... Cleaning kit hose connector
- 5..... Main sump tank drain valve
- 6..... Fresh water tank drain cock
- 7..... Auxiliary sump tank access cap
- 8..... Auxiliary sump tank drain valve

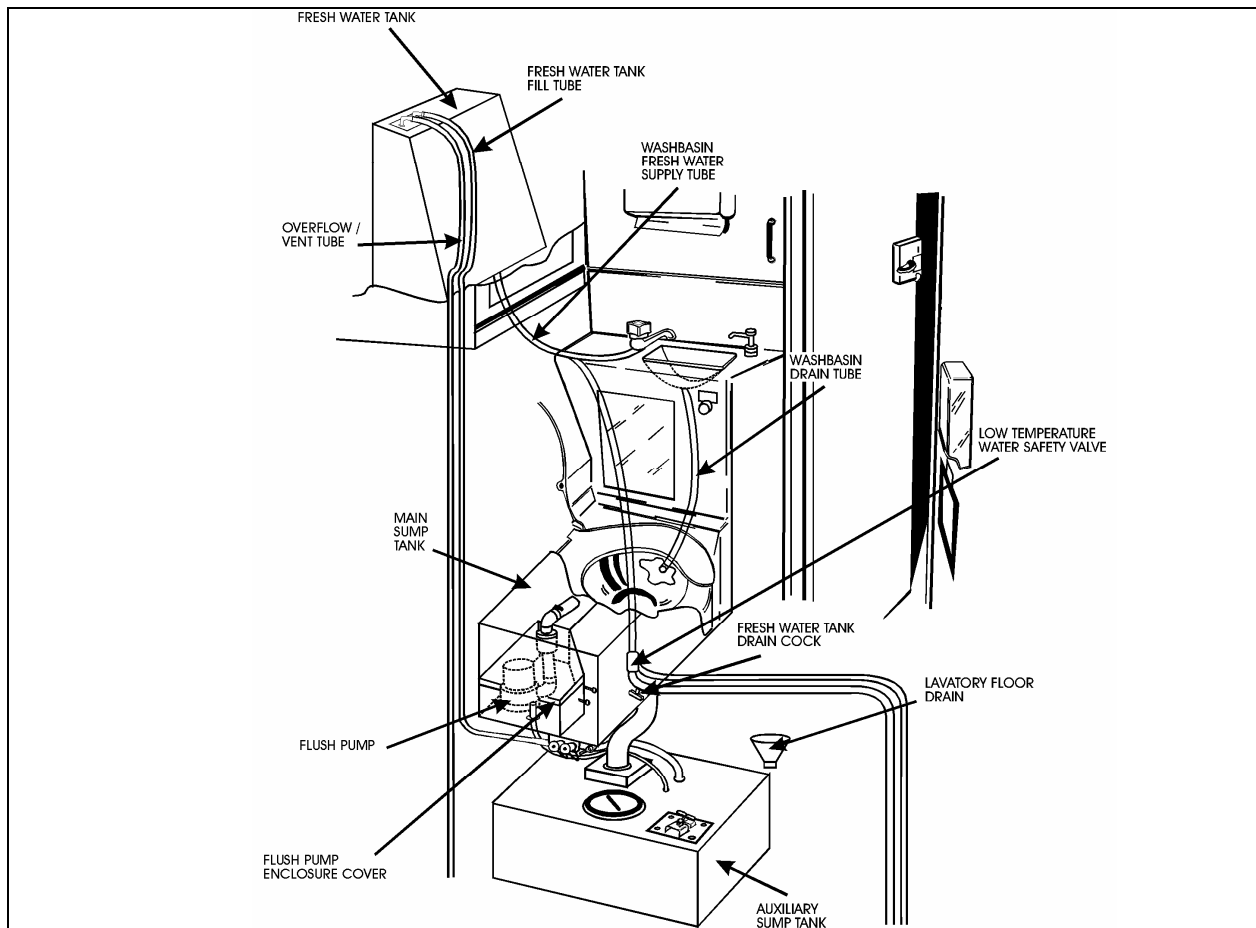


FIGURE 28: FUNCTIONING OF LAVATORY

23051

6.8.2 Fresh Water Tank Filling

Connect the fresh water supply hose to the fresh water reservoir fill connection (Fig. 27) located in the curb-side section of engine compartment. Fill the reservoir until the overflow tube leaks, signaling that the reservoir is full.

DANGER

Never put antifreeze in fresh water tank; antifreeze is toxic.

WARNING

If tank has not been drained for an extended period of time, draining and filling operations must be repeated three (3) times in order to clean tank and eliminate contaminated water.

6.9 LIQUID SOAP DISPENSER

A liquid soap dispenser may have been installed as optional equipment. To refill dispenser, proceed as follows:

1. Turn cover slightly clockwise until it stops.
2. Lift out piston and spout, cover and supply tube.

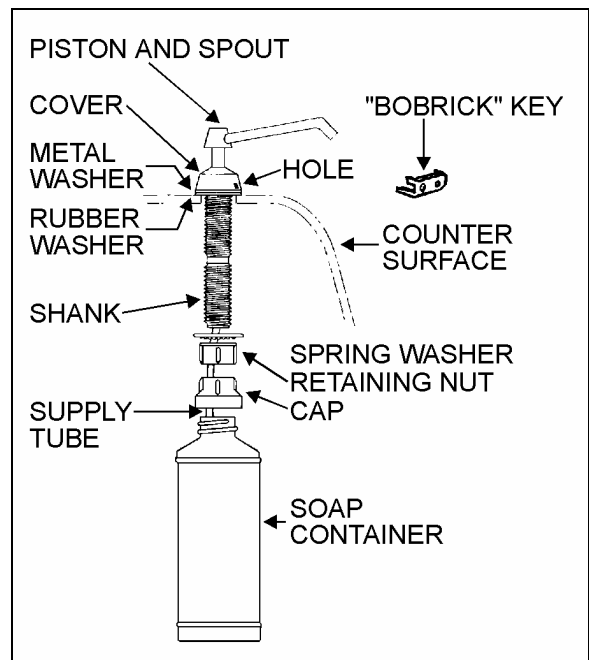


FIGURE 29: LIQUID SOAP DISPENSER 23039

3. Fill dispenser with soap. This model can dispense vegetable oil soaps, synthetic detergents, and lotion soaps.

CAUTION

Never use abrasive cleaners.

4. Replace supply tube, piston, and spout mechanism reversing the steps above.
5. Secure the cover by turning clockwise until lock snaps into position.

NOTE

The dispenser requires priming when extremely viscous lotion soaps are used. Remove piston and spout, cover and supply tube assembly. Pump water into assembly, then replace into dispenser.

6.10 FLUSH PUSH-BUTTON

The green flush push-button is located near the toilet. Press on push-button to actuate a pneumatic timer located on the other side of wall. This timer allows an electric current flow during a preset time to a pump into the sump tank.

6.10.1 Pneumatic Timer Removal and Installation

1. Unscrew and remove the flush push-button locking ring.
2. Remove steel plate located on L.H. side of pushbutton switch.
3. Remove pneumatic timer through this opening, taking care to disconnect electric wires.

NOTE

Care must be taken to avoid losing the spacers installed on the mounting sleeve.

4. Reverse the above procedure to reinstall timer. The recommended torque for the lock nut is 15 Lbf-ft. (21 Nm).


6.10.2 Timer Adjustment

Timer can be adjusted from 0.2 second to 3 minutes by turning the time adjustment screw clockwise to increase time, and counterclockwise to decrease time. To gain access to the time adjustment screw, repeat steps 1, 2 and 3 in the previous paragraph "6.10.1 Pneumatic Timer Removal and Installation".

6.11 FLUSH PUMP

The submersible-type flush pump is mounted inside an enclosure in the sump tank (Fig. 28). The enclosure is provided with a screened side which, serves as a strainer to prevent solid matters from entering the pump.

The pump requires no periodic maintenance other than cleaning of the strainer side using a water jet introduced through the circular cap opening, once the sump tank is completely drained. The pump can run dry periodically without damage. However, for maximum seal life, the run dry periods should be kept to a minimum.

 CAUTION
<p>If vehicle is stored for an extended period of time, make sure to clean the strainer as solid matter will tend to pack, and will necessitate replacement of strainer.</p>

6.11.1 Flush Pump Removal

1. Remove the toilet to gain access to the pump enclosure.
2. Remove the flush pump enclosure cover
3. Unsnap the flush pump.


6.12 SUMP TANKS

6.12.1 Main Sump Tank Draining

When recirculating water in the toilet is soiled, drain main sump tank. If equipped with the optional auxiliary sump tank, drain the main sump tank contents into the auxiliary tank and perform the filling procedure of the main tank.


6.12.2 Main Sump Tank Filling

Open the main sump tank overflow cock and connect a water supply hose to the toilet sump tank fill connection. The main tank is full when water starts flowing through the clear overflow tube. Close main sump tank overflow cock when the tank is full.

 CAUTION
<p>In cold weather, add 2 gallons (9 liters) of antifreeze (e.g.: ethylene glycol) in the toilet before filling main tank.</p>


6.12.3 Auxiliary sump Tank Draining


Remove drain cap located under auxiliary sump tank then turn the auxiliary sump tank drain valve lever counterclockwise eight or nine times. Remove the access cap and flush tank with clean water. To close, turn the valve lever several times clockwise until the rubber bladder seals the drain hole. Reinstall access and drain caps.


 CAUTION
<p>Lavatory tanks should be serviced only at suitably equipped stations.</p>

<i>NOTE</i>
<p><i>It is unlawful to dump sump tank contents in any location other than those designated as such.</i></p>

When a full draining is required, clean main tank by repeating the draining and filling operations while leaving the auxiliary sump tank drain cock opened. Close cocks and pour a pack of commercial toilet deodorant (Prévost part #900329) in toilet before adding the antifreeze and starting final filling of main tank.

 WARNING
<p>The toilet deodorant contains products that can be very irritating to skin. Use rubber gloves when handling and then clean toilet seat.</p>

 WARNING
<p>Antifreeze must comply with the effective environmental act.</p>

 CAUTION
<p>When cold weather is expected and there is no antifreeze in the tank, both sump tanks must be drained.</p>

<i>NOTE</i>
<p><i>If there is no antifreeze solution in the tank, there is less risk of freezing if engine is operating due to the heat it produces.</i></p>

<i>NOTE</i>
<p><i>New coaches are delivered with the sump and fresh water tanks empty. Fill with water before putting the coach in service.</i></p>

7. AIR HORN VALVE

The air horn valve is located in the front service compartment and the air horn valve button is on the steering wheel center.

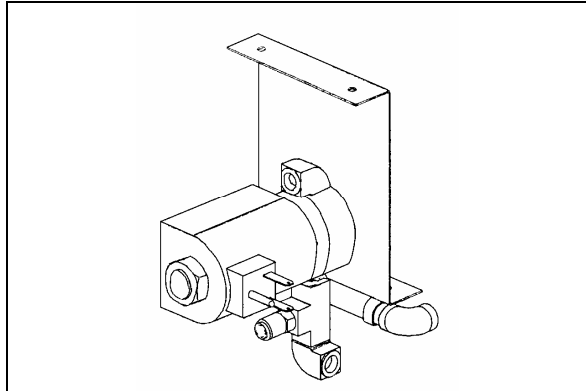


FIGURE 30: AIR HORN VALVE 23230

7.1 AIR HORN VALVE MAINTENANCE

When needed, the air horn valve can be serviced or replaced using the following procedure:

1. Unplug the cable connector;
2. Disconnect the air tubes;
3. Loosen the retaining bolts;
4. Service or replace the air horn valve;
5. Reinstall by reversing procedure.

8. HEADLIGHTS CLEANING SYSTEM

8.1 GENERAL DESCRIPTION

NOTE

When inspecting the headlights cleaning system, check the washer fluid hoses, fittings and connectors to be sure they are properly connected and seal with no restriction to the flow of washer fluid. Check that the washer nozzles are properly aimed.

The headlights cleaning system is independent from the windshield washer system and has its own washer fluid reservoir located in the front electrical and service compartment. However, this system shares the same telltale light than the windshield washer low level sensor (refer to Operator or Owner's manual for operation). Each pressing of this switch produces 2 successive 0.7 seconds jets.



CAUTION

Do not operate the headlights washer while the washer fluid reservoir is empty. This may damage the washer fluid pump.

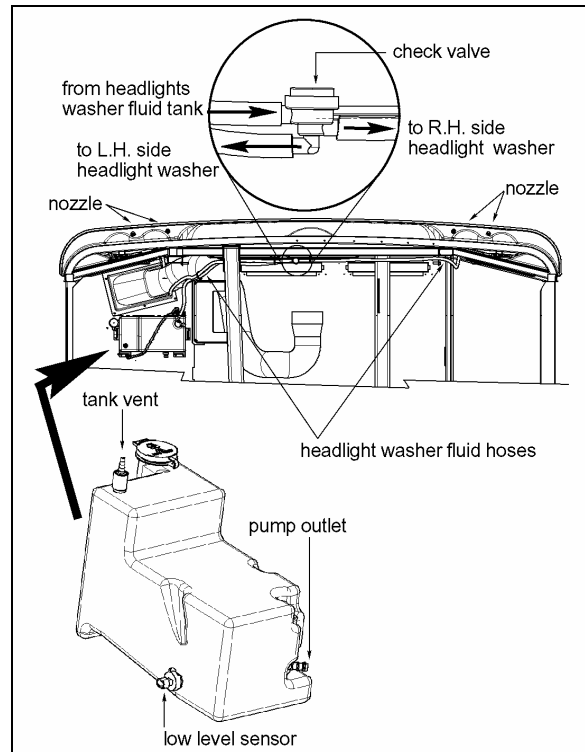


FIGURE 31: HEADLIGHTS CLEANING SYSTEM 23380

8.2 WASHER FLUID REFILLING

Open the filler neck cap and add regular windshield washer fluid as required. The tank has a capacity of 10 liters (2.6 US gallons). You may use water or windshield washer fluid as well but, during cold weather days, use windshield washer fluid suitable for freezing temperature only.

8.3 WASHER NOZZLES ADJUSTMENT

To avoid waste of washer fluid, assure the fluid jets are properly aimed. Adjust nozzles so they aim as described in figure 33. Align the jet adjustment tool #800377 with the reference line shown on the front view detail. As seen on the side view, position the end of the adjustment tool to a distance of ½" (high beam) and 1" (low beam) from the top of the headlight for proper aiming.



CAUTION

Because they are made of plastic, firmly tighten nozzle and bulkhead fittings by hand only.

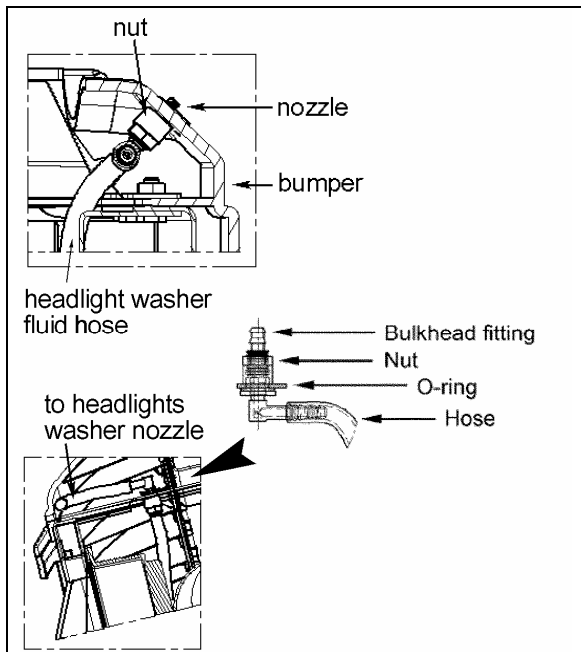


FIGURE 32: TUBING AND FITTINGS

23381

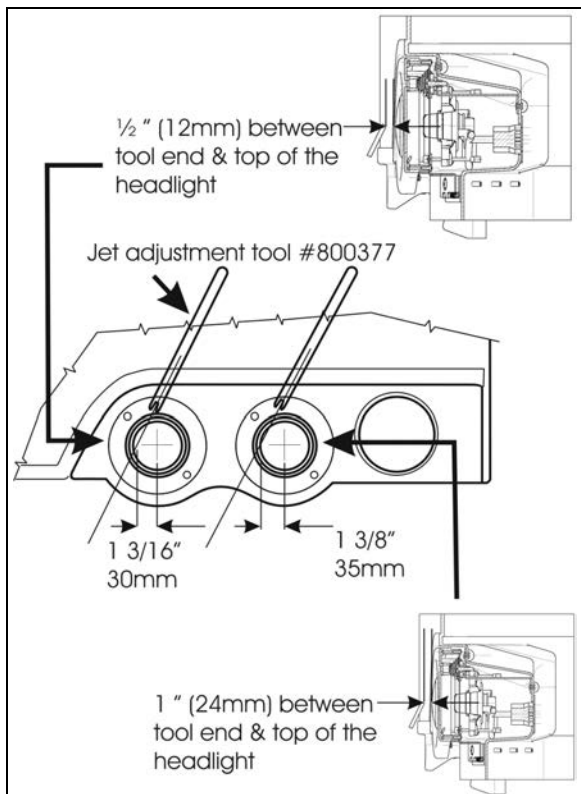


FIGURE 33: WASHER NOZZLES ADJUSTMENT

23382

9. WINDSHIELD WIPERS AND WASHERS

9.1 GENERAL DESCRIPTION

NOTE

When installing a wiper motor, arm or blade, follow recommended procedures to prevent misalignment, binding or malfunction. Check the windshield washer liquid hoses, fittings and connectors to be sure they are properly connected and seal with no restriction to the flow of washer liquid. Check that wiper arms have the proper sweep position and the washer nozzles are aimed so that spray is within the proper wiper pattern.

The windshield wipers are controlled by one electric wiper motor that is accessible for maintenance after removing the appropriate access panel beside the footwell (refer to figure 36). Turn the multifunction lever forward to activate windshield wipers (item 2, fig. 34). The first position operates the wipers at low speed and the second position operates the wipers at high speed. Turning the lever backwards will operate the wipers in the intermittent mode.

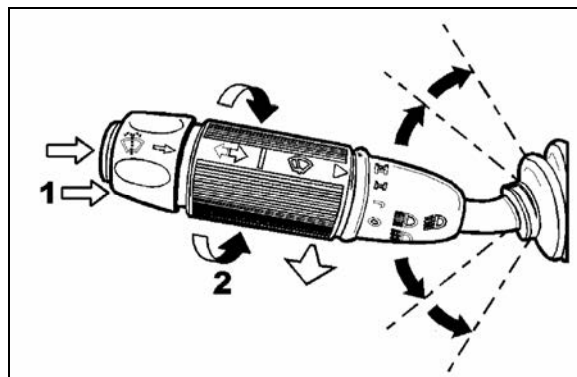


FIGURE 34: MULTIFUNCTION LEVER

23133

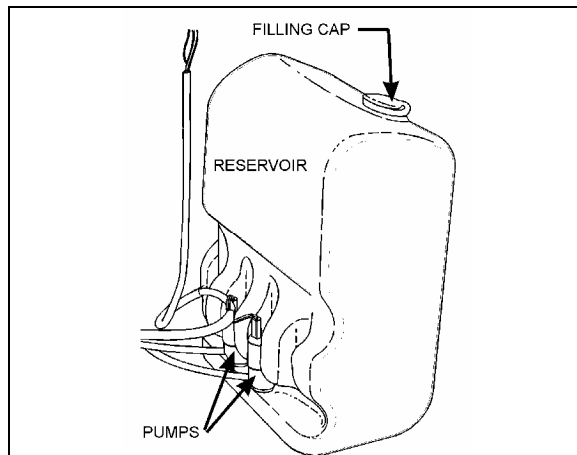


FIGURE 35: WINDSHIELD WASHER RESERVOIR

23220

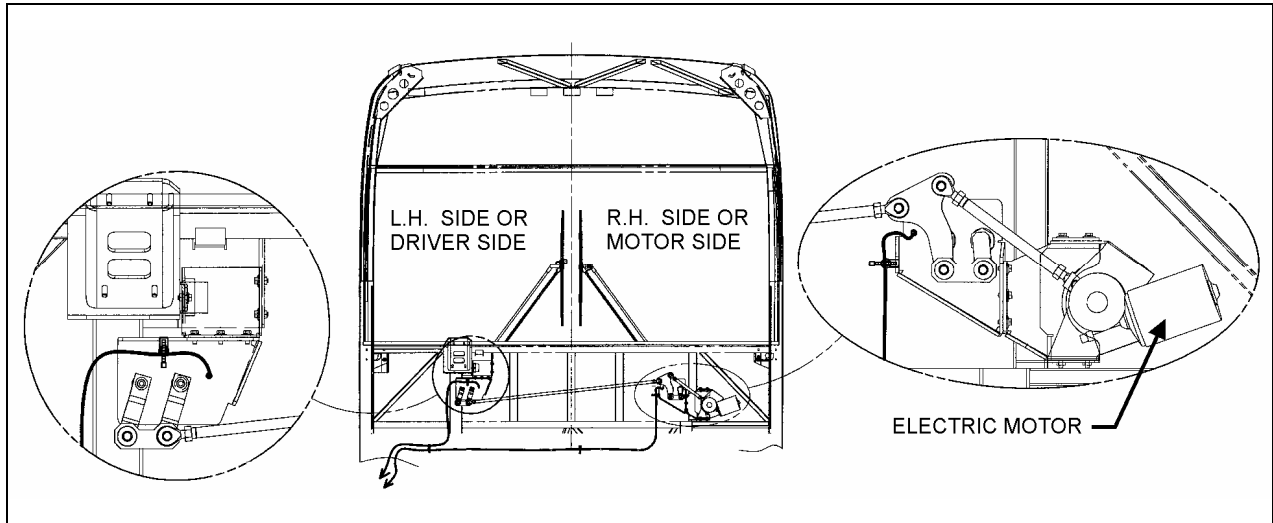


FIGURE 36: WINDSHIELD WIPER INSTALLATION

23287

The windshield washer pumps are electrically operated and are controlled by a washer control ring on the multifunction lever (item 1, fig. 34).

The windshield washer reservoir is located in the front service compartment (Fig. 35). This unit pumps the washer liquid to the spray nozzles where it is dispersed across the windshield.

9.2 WIPER ARM

Check operation of the wipers for proper blade sweep and angle.



CAUTION

Do not attempt to manually move the wiper arms to make wiper blade sweep adjustments as damage to the wiper linkage or motor may occur. If it is necessary to adjust the sweep of blades, remove the arms and make adjustment by positioning the arms using serration on the wiper arm pivot shafts.

9.2.1 Wiper Arms Positioning

1. Reinstall the wiper arms and position as shown in figure 41. Before positioning the wipers at their final position, tighten the nuts to 9 Ft-lbs (12 Nm) at first.
2. To find the final position of the wiper arms, lift then release the wiper arm so it falls back on the windshield

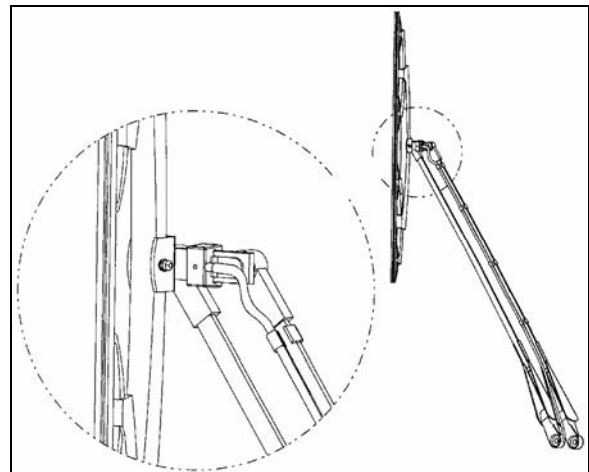


FIGURE 37: WINDSHIELD WIPER (MOTOR SIDE)

23329

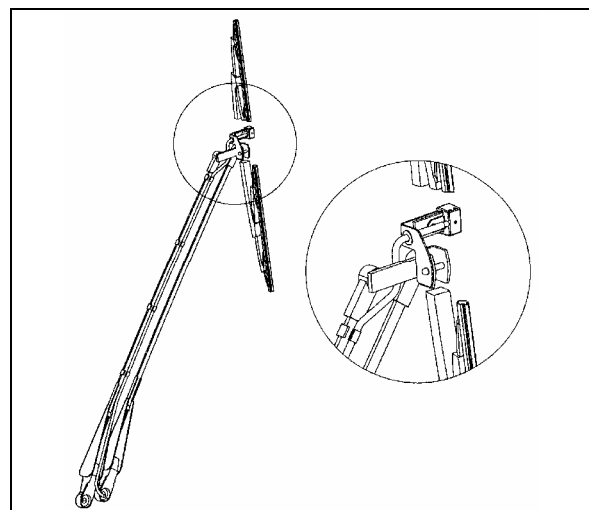


FIGURE 38: WINDSHIELD WIPER (DRIVER SIDE)

23328

- When the final position is found, tighten the wiper arm nuts to 22 Ft-lbs (30 Nm). Wait 30 minutes and tighten again to 22 Ft-lbs.

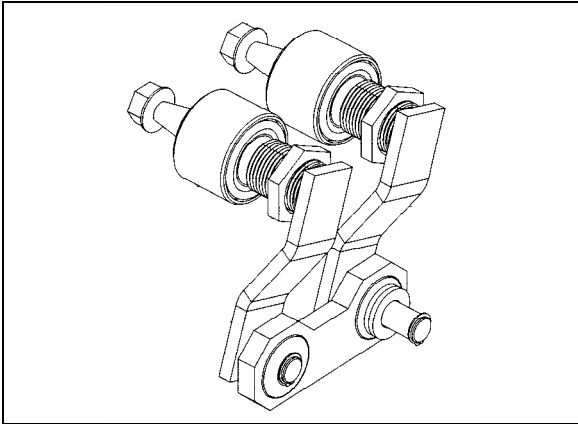


FIGURE 39: DRIVING MECHANISM (DRIVER SIDE) 23284

- Remove the Phillips-head screws retaining the defroster panels, and remove panels.
- Disconnect wiring connector from the windshield wiper motor.
- Loosen clamping screw retaining the lever at the end of the motor driving shaft.
- Remove the three bolts holding the motor to the steel plate.
- Remove the windshield wiper motor (Prévost #800328), reverse removal procedure to reinstall.

- Lower the protective cover.
- Connect the windshield washer tubing at the base of the wiper arm.
- Check the adjustment on a wet windshield.

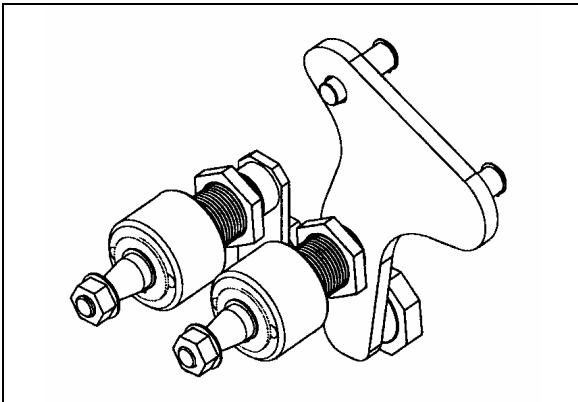


FIGURE 40: DRIVING MECHANISM (MOTOR SIDE) 23285

9.3 WINDSHIELD WIPER MOTOR

9.3.1 Windshield Wiper Motor Replacement

The windshield wiper motor is located at lower front of the vehicle, behind the defroster panel. Refer to figure 34 for motor location.



WARNING

Park vehicle safely, apply parking brake, stop engine and set battery master switch to the "OFF" position prior to working on the vehicle.

Section 23: ACCESSORIES

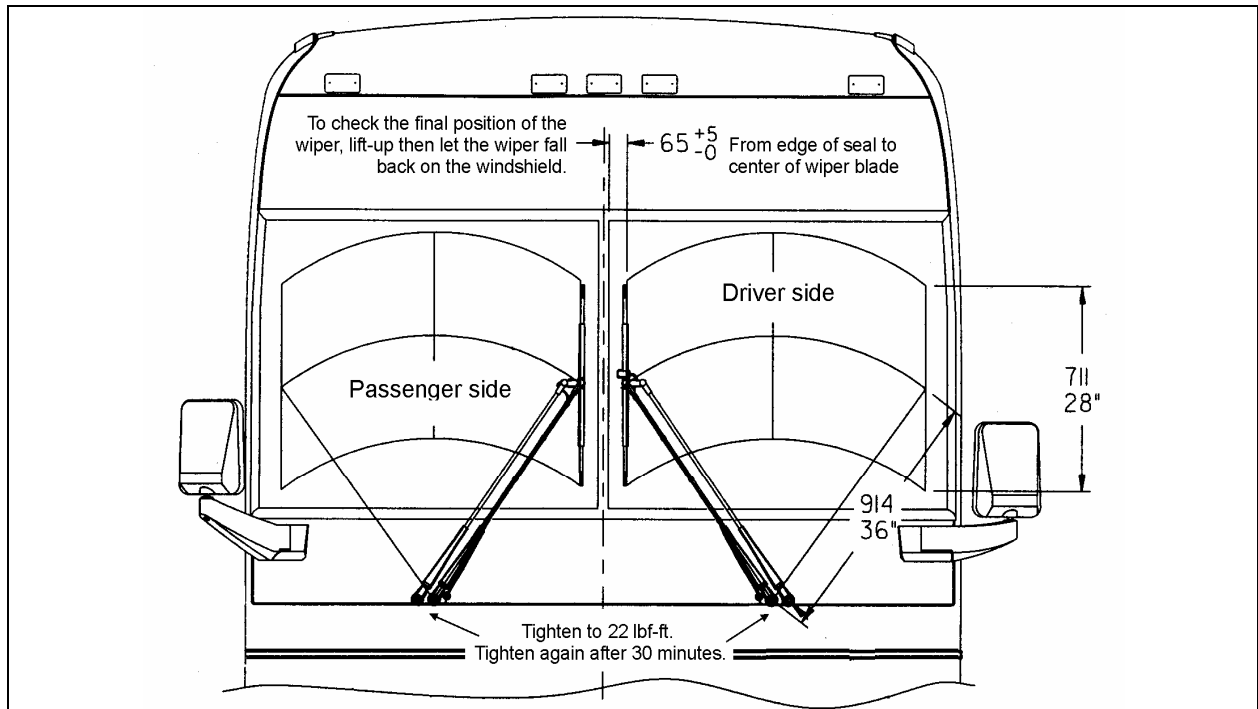


FIGURE 41: WIPER ARMS POSITIONING

23253

9.4 TROUBLESHOOTING




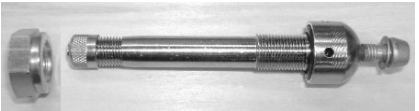

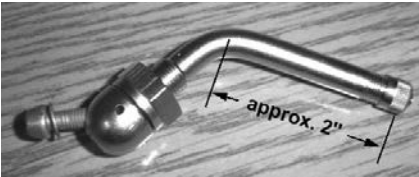

SYMPTOM	PROBABLE CAUSE	REMEDY
FAIL TO SPRAY WASHER FLUID	<p>A. Reservoir empty.</p> <p>B. If below 32°F (0°C), improper washer fluid frozen.</p> <p>C. Contamination in tubing or nozzles.</p> <p>D. Tubing damage.</p> <p>E. Tubing bent (kinked) or off one or more connections.</p>	<p>A. Add proper fluid.</p> <p>B. Store coach or parts in heated area, then purge system with low-temperature solution.</p> <p>C. Remove with compressed air, if severely clogged, replace items.</p> <p>D. Replace section.</p> <p>E. Realign tubing and/or refit. Trim end to ensure proper fit or replace.</p>
INADEQUATE SPRAYING	<p>A. Tubing failure.</p>	<p>A. Replace tubing.</p>
SLOW OPERATION	<p>A. Improper solution.</p> <p>B. Jet stream improperly directed.</p> <p>C. Check if valve is stuck in the open position.</p>	<p>A. Replace with proper type solution.</p> <p>B. Reposition nozzles.</p> <p>C. Remove, clean or replace.</p>

10. TIRE PRESSURE MONITORING SYSTEM (TPMS)







The optional active tire pressure and temperature monitoring system is a sensing device designed to identify and display tire operating data and activate an alert or warning when pressure or temperature irregularities are detected.

For more information on the operation and troubleshooting of the system, refer to the Operator’s Manual, chapters “Controls and Instruments”, “Safety Features and Equipment” and also “Appendix G”.

10.1 TIRE VALVE INSTALLATION



<p>Use as required a small rod to hold the valve in place when tightening.</p>			
<p>Steel Wheels</p>	<p><u>All wheels</u> a) Install Beru valve Torque valve to 44.5lb-in +/- 9.5 b) no extension piece</p>	 #Prevost 681083	
	<p><u>Front axle and tag axle wheels with 365 tires</u> a) Remove Alcoa valve b) Install Beru valve Torque valve to 102lb-in +/- 22 c) No extension piece</p>	 #Prevost 651080	
<p>Aluminum Wheels (new CPM wheels)</p>	<p><u>Front axle and tag axle wheels with 315 tires</u> a) Remove Alcoa valve b) Install Beru valve Torque valve to 102lb-po +/- 22 c) Small extension piece (approx 50mm)</p>	 #Prevost 651081	

Section 23: ACCESSORIES

Aluminum wheels (new CPM wheels)	<p><u>Drive axle inner and outer wheels with 315 tires—</u></p> <p>a) Remove Alco valve b) Install Beru valve Torque valve to 102lb-in +/- 22 c) no extension piece</p>	 <p>#Prevost 651081</p>	
	<p><u>“Super Single” Tires</u></p> <p>a) Remove Alcoa valve b) Install Beru valve Torque valve to 102lb-in +/- 22 c) no extension piece</p>	 <p>#Prevost 651079</p>	
Aluminum wheels (former CPG wheels)	<p><u>All wheels</u></p> <p>a) Remove Alcoa valve b) Install Beru valve Torque valve to 102lb-in +/- 22 c) no extension piece</p>	 <p>#Prevost 651082</p>	

10.2 BERU SENSORS INSTALLATION

<p><i>IMPORTANT NOTE</i></p> <p><i>Beru sensors have a limited lifespan (5 years on average)</i></p>

<p>Install sensor onto valve. Torx screw T-20. Torque to 35lb-in (4Nm) (supplier specification for the screw).</p> <p>Make sure sensor rests against rim flange.</p> <p>IMPORTANT</p> <p>Use the screw only once. This screw uses a thread lock. Replacement screw #651084.</p>	
<p>Note bar code and tie it up using wheel holes. Use supplied removable tie-rap.</p>	
<p>Decal</p> <p>Glue decal facing the valve.</p>	<p>#651091 ENGLISH #651090 BILINGUAL</p>

11. SPECIFICATIONS

AMPLIFIER

Model..... VA400-8
Output..... 400 watts, 6 channel RMS at 4 ohm @ 0.5 T.H.D.
Prevost number..... 901191

SOUND SELECTOR

Model..... VSS-04
Power source 12 volts
Prevost number..... 901192

AM/FM/CD PLAYER RADIO (standard)

Model..... VR300
Power source 12 volts
Prevost number..... 901190

AM/FM/CD SATELLITE RADIO (optional)

Model..... VR300
Power source 12 volts
Prevost number..... 901190

6 DISC CD CHANGER

Prevost number..... 901196

MOBILE DVD PLAYER

Power source 12 volts
Prevost number..... 901198

SPEAKER (standard)

Model..... Dual Cone
Impedance 4 ohms
Prevost number..... 901194

SPEAKER (optional)

Model..... Coaxial
Impedance 4 ohms
Prevost number..... 901195

SUBWOOFERS (optional)

Model..... J Drive VB170
Impedance 4 ohms
Prevost number..... 901193

VIDEO CASSETTE PLAYER (VCP)

Model..... V-3000
Prevost number..... 901030

VIDEO SWITCHER

Model..... V-3000
Prevost number..... 901030

BOOM-TYPE MICROPHONE

Prevost number..... 900763

HANDHELD PRIORITY MICROPHONE

Prevost number..... 900808

RUBBER COATED MICROPHONE

Prevost number 900745

16 CHANNEL WIRELESS MICROPHONE

Make..... R.E.I.

Prevost number 900954

16 CHANNEL WIRELESS MICROPHONE CHARGING STATION

Make..... R.E.I.

Prevost number 900953

16 CHANNEL WIRELESS MICROPHONE RECEIVER

Make..... R.E.I.

Prevost number 900952

KARAOKE

Make..... Panasonic

Model..... MOBILE DVD PLAYER DV1500

Prevost number 901033

TV RECEIVER

Power source 24V

Prevost number 901054

VIDEO DISTRIBUTION AMPLIFIER

Power source 24V

Prevost number 901117

TV MONITOR

Type 10.4" LCD

Power source 24V

Prevost number 901130

HUBODOMETER (US model: miles)

Make..... Stemco

Prevost number 650002

HUBODOMETER (Canada model: km)

Make..... Stemco

Prevost number 650117

ELECTRIC DESTINATION SIGN (FLUORESCENT TUBE)

Make..... General Electric

Length 30" (76 cm)

Outside diameter 1" (25 mm)

Wattage 20

Color..... Cool white

Quantity 1

Prevost number 830120

ELECTRONIC DESTINATION SIGN

Make..... Pocatec

Prevost number 940050

LAVATORY VENTILATION FAN MOTOR

Make..... Aurora
TypeRG500EF
Voltage 24 volts DC
Rotation R.H.
Prevost number 870844

LAVATORY FLUORESCENT TUBES

Make..... General Electric
Model.....F15T8CW
Length 18" (45 cm)
Wattage 15
Quantity 2
Prevost number 830102

EMERGENCY BUZZER SWITCH (PUSH BUTTON)

Make..... Cole Hersee Co.
Voltage 24 V
Prevost number 562117

FRESH WATER TANK

Make..... Prévost
Capacity 18 US gal (68 liters)
Prevost number 401591

FLUSH PUSH BUTTON PNEUMATIC TIMER

Make..... Furnas
Type Resettable
Time 0,2 to 180 seconds
Prévost number 900348

FLUSH PUMP

Make..... RULE 2000
Model number 12 - 24 V
Power source 24 volts DC
Capacity 1450 GPH
Prévost number 900960

AIR HORN

Make..... Allied Signal Inc.
Prévost number 640093

AIR HORN VALVE

Make..... Allied Signal Inc.
Prévost number 640128

WINDSHIELD WIPER MOTOR

Make..... BOSCH
Prévost number 800328

WIPER (BLADE)

Make..... BOSCH
Prévost number 800329

WIPER ARM

Make..... BOSCH
Prévost number 800331

SOUND SELECTOR

VSS-04

USER MANUAL

Please read this user manual before installation and operation.

Contents:

Preface

VSS-04 is a unit for multichannel sound selection and control. It can select multichannel sounds (e.g. CD, DVD, etc) and control outputs. It has two microphones inputs and can be controlled by computer and remote control. Meanwhile the other equipments in the bus can also be controlled through it.

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Features	4
Operation instruction	5
Operation with remote control	10
Maintain	13
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Specifications	15
Installation and service	15
In case of difficulty	16
Pins configuration	17
System connection	18

Precaution

- 1 The unit adapts to DC 12V and negative should be connected ground. Before installation, please make sure that the negative of the bus's system should be connected to ground
- 2 Please follow the operation instruction. If the connection is wrong, the unit maybe break down, or the electrical system may be damaged
- 3 Down-lead of speaker's line should be connected to the loudspeaker's port. Do avoid being connected to the bus or connected with other loudspeakers directly.
- 4 Make sure all the connections are correct, then turn on the unit
- 5 When change the burned-out fuse, please use fuse of same specification.
- 6 Do not plug up blowhole or radiator, or else the unit will heat and burn up
- 7 Do not rebuild the unit, or else may cause accidents.
- 8 Please do not scratch the display panel
- 9 If any operations, which will affect driving, please stop the bus first at a safe place, and then operate.
- 10 Do not operate the unit in very high temperature or very low temperature. Before turn on the power, make sure the operation temperature is 0 ~50
- 11 Do not open the unit, to avoid the unit being damaged.

Features

- At most 10 standard audio inputs are independently selectable and with independent settings of volume, bass, treble, etc. and sent to different back-ends. Driver and passenger systems are independent systems.
- Control inputs of driver and guide microphones and with setting of volume, bass, treble, etc. and sent to different back-ends.
- When there is vehicle phone present, the call can be sent out to the back-end, and meanwhile the radio will be mute.
- Control input of computer's signal and output to different back-ends.
- When press certain button, the relevant indicate lights will burn, and send out different gong sounds.
- With remote control to operate selection of audio sources, setting of vol, bas, tre, bal or fad, etc.
- Control of selected video equipments in bus.
- Control of loudness

Operation Instruction



• Basic instruction

Power Switch

There is no power button. When bus is connected to 12V, the unit will be auto turned on. The backlight lightens, and start image shows "SOUND AND VISION". When bus is power-off, the unit will auto turn off.

Loudness control

Press LOUD to turn on or off the loudness mode. When loudness mode is on, LCD panel will display LOUD.

Setting of VOL/BAS/TRE/BAL/FAD

1 Press VOLUME/VALUE knob time and again to select expected mode

Modes will be changed as following:



LCD panel will display relevant text: VOL BAS TRE BAL or FAD

Note: there is no FAD mode in driver system

2 Turn VOLUME/VALUE knob to adjust the loudness

3 When the mode of VOL BAS TRE BAL or FAD is active if there isn't any reaction, it will go back to the previous menu.

Selection for CAM1/CAM2

- 1 Press CAM1 or CAM2 CAM1 or CAM2 will be active and LCD panel will show texts of CAM1 or CAM2
- 2 Press CAM1 or CAM2 again CAM1 or CAM2 will be off and The texts of CAM1 or CAM2 will go out.

Selection for NAV

- 1 Press NAV to select NAV mode, and text of NAV will show on LCD panel.
- 2 Press NAV again to cancel the selection, and the text of "NAV" will be out.

• Operation for Driver System

- 1 At start image, press DRIVER, and LCD panel will display DRIVER and the setting of VOL/BAS/TRE/BAL/FAD in driver system.
- 2 Turn VOLUME/VALUE knob to adjust the volume of the last selected source (RAD1 as default)
- 3 Press VOLUME/VALUE knob to do the setting of VOL / BAS / TRE / BAL / FAD.
- 4 Press one of buttons for RAD1 RAD2 VHS CD1 CD2 CD3 DVD1 DVD2 AUX1 AUX2, the source will be selected, and relevant text will be shown on LCD panel.
- 5 If no button is pressed in 10 seconds, the previous selection and settings of VOL/BAS/TRE/BAL/FAD will be shown.

• Operation for Passenger System

- 1 At start image, press CABIN, and LCD panel will display CABIN and the setting of VOL/BAS/TRE/BAL/FAD in passenger system.

- 2 Turn VOLUME/VALUE knob to adjust the volume of the last selected source (RAD1 as default)
- 3 Press VOLUME / VALUE knob to do the setting of VOL / BAS / TRE / BAL / FAD.
- 4 Press one of buttons for RAD1 RAD2 VHS CD1 CD2 CD3 DVD1 DVD2 AUX1 AUX2, the source will be selected, and relevant text will be shown on LCD panel.
- 5 If no button is pressed in 10 seconds, the previous selection and settings of VOL/BAS/TRE/BAL/FAD will be shown.

• Operation for Driver Microphone

- 1 If there is a phone call present, the driver microphone will be auto opened, and the driver can talk to vehicle phone. When the signal of vehicle phone send out to driver hand-free speaker, the channel of RAD1 will be auto mute. After the phone call, RAD1 will be resumed
- 2 If the driver microphone should be used, just step on the foot switch. The button DMIC can also control the operation of the driver microphone. If at that time the driver is speaking in the vehicle phone, the phone will be shut off till release the foot switch.
- 3 When the driver microphone is active, turn VOLUME/VALUE knob to adjust the volume. Driver Speakers will be auto mute.
- 4 Release the foot switch or press DMIC again to turn off the driver microphone. Driver Speakers will be resumed
- 5 The driver microphone has priority on the guide microphone, i.e. when step on the foot switch, the driver microphone will be active, but if the driver microphone is connected to the vehicle phone, the guide microphone can be used.

6 Operation for guide operation

- 1 Turn on the guide microphone or press GMIC on the front panel to open the

- guide microphone.
- 2 When the guide microphone is active, turn VOLUME/VALUE knob to adjust the volume.
- 3 Turn off the guide microphone or press GMIC again to stop the operation of guide microphone.

• Operation for External Functions

The unit can be connected to Wheelchair Host Next stop”, or other external function buttons

When press one of the buttons. the relevant indicate light will be lighten, and GONG sound will be heard.

Note: When the door is open, the three buttons are of no effect.

• Operation for Computer Input

- 1 When E12 gets low level, audio input of computer can be input
- 2 The logic control signal of computer will input to the relevant ports. When input 001, the output of computer will to VA-400; when input 010, output to driver hand-free speaker; when input 100, output to VA-400 and driver loudspeaker; when input 011, output to mult central unit; when input 111, output to VA-400 and Mult central unit

Note: 1 for high level, 24V; 0 for low level, 0V.

- 3 When E12 gets high level, the input of computer will be shut off., and background music will come back to previous level.

• Volume Adjustment for background , gong sound and computer’s signal

- 1 Adjustment for background music

When the signals from microphone or computer send out to a relevant port, the former audio input will reduce to a certain low level, which has been set in the factory. If want to adjust it, do following steps:

Operation with Remote Control



- Press AUX1 and VOLUME/VALUE together
 - Turn VOLUME/VALUE knob to adjust the volume.
 - Press AUX1 and VOLUME/VALUE together to finish the setting.
- 2 Adjustment for GONG sound
- When press external buttons or the microphones are ready for use, the relevant GONG sounds will output, level of the GONG sounds have been set in the factory. If want to adjust, do following steps:
- Press AUX2 and VOLUME/VALUE together
 - Turn VOLUME/VALUE knob to adjust the volume.
 - Press AUX2 and VOLUME/VALUE together to finish the setting
- 3 Adjustment for computer's signal
- When the signals of computer input, they will be sent out to different ports according to orders. The volume are set in the factory. IF want to adjust it, do following steps:
- Press NAV and VOLUME/VALUE together
 - Turn VOLUME/VALUE knob to adjust the volume
 - Press NAV and VOLUME/VALUE together to finish the setting
- . **Operation for on-off door**
- When open the door, the RAD1 and driver loudspeaker will be mute; when close the door, the indicate light will be out and the output of driver loudspeaker will be resumed.
- . **Operation of remote control**
- 1 Press REM to start the operation of remote control
 - 2 Press REM again to finish the operation of remote control

1. **DRI**
Press DRI to enter driver system
 2. **CAB**
Press CAB to enter passenger system
 3. **RAD1/RAD2/VHS/CD1/CD2/CD3/DVD1/DVD2/AUX1/AUX2**
Press one of above buttons to select source.
 4. **DMIC**
Press DMIC to turn on driver microphone
Press again to close driver microphone.
 5. **GMIC**
Press GMIC to turn on guide microphone,
Press again to close guide microphone.
 6. **NAV**
Press NAV to start NAV device
Press again to close the device.
 7. **CAM1/CAM2**
Press CAM1/CAM2 to start CAM1/CAM2 devices
Press again to close the devices.
- 9 + / -
Press + / - to adjust VOL/BAS/TRE/BAL/FAD
 - 10 **LOUD**
Press LOUD to start mode of loudness
Press again to close the mode.
 - 11 **BAS/TRE/BAL/FAD**
Press the button to adjust VOL/BAS/TRE/BAL/FAD
 - 12 **AUX1+ +**
Press first + then press AUX1 to adjust the background music
 - 13 **AUX2+ +**
Press first + then press AUX2 to adjust GONG sound
 - 14 **NAV+ +**
Press first + then press NAV to adjust computer's signals

Maintain

- 1 Replace with a new fuse
When replace with a new fuse, do make sure to use the fuse of the specified capacity. If the fuse is blown, check first the power connection, and then replace the fuse. If the fuse is blown again after replacing, there may be interior problem. At this case please consult the dealers

Note: The fuse should be 15A

2 Replace lithium battery

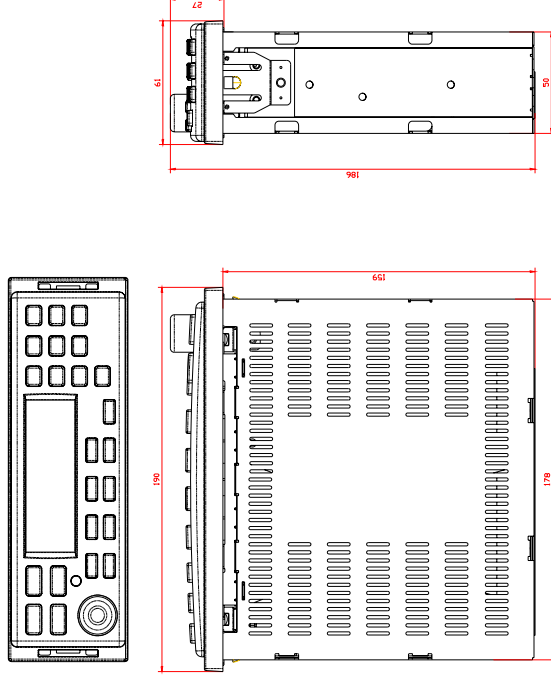
When the function distance of remote control is shorter or no function, do replace lithium battery (CR2025). DO make sure the polarity of battery before replacing:

- whiling pressing the plug, pull the battery base lightly;
- make the side marked + up insert the battery;
- insert the battery base into the remote control.

Caution when using lithium battery 6

- Put lithium battery to the place, where the child can not reach. If the child englutthe battery carelessly, go immediately to the doctor
- Use dry cloth to wipe the battery to ensure the good touch
- Do make sure / polarity is correct when loading the battery.
- Do not use metal forceps to rip battery, or else will cause short circuit.

Installation Drawing



Specifications

Power	12V DC	10-16V
Aver. power consumption:	1 5W	8
	2 20W	4
Max. output voltage:	1V/10K	
Distortion:	0.08%	
Signal-to-noise ratio:	100dB	
Frequency response:	20	20000HZ
BAS:	15dB	(30HZ)
TRE:	15dB	(10KHZ)
Weight:	ca.1.4KG	
Front measurement:	190	61 27mm w/h/d
Whole measurement:	178	50 159mm w/h/d

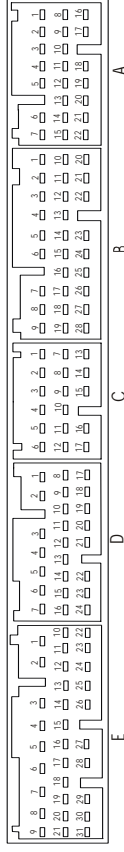
Installation & Service

1. Only professional or licensed persons can install the unit. To avoid damaging the bus, please consult the dealers before installing.
2. If need repair, please contact the dealers and the professional persons will repair the unit.

In case of difficulty

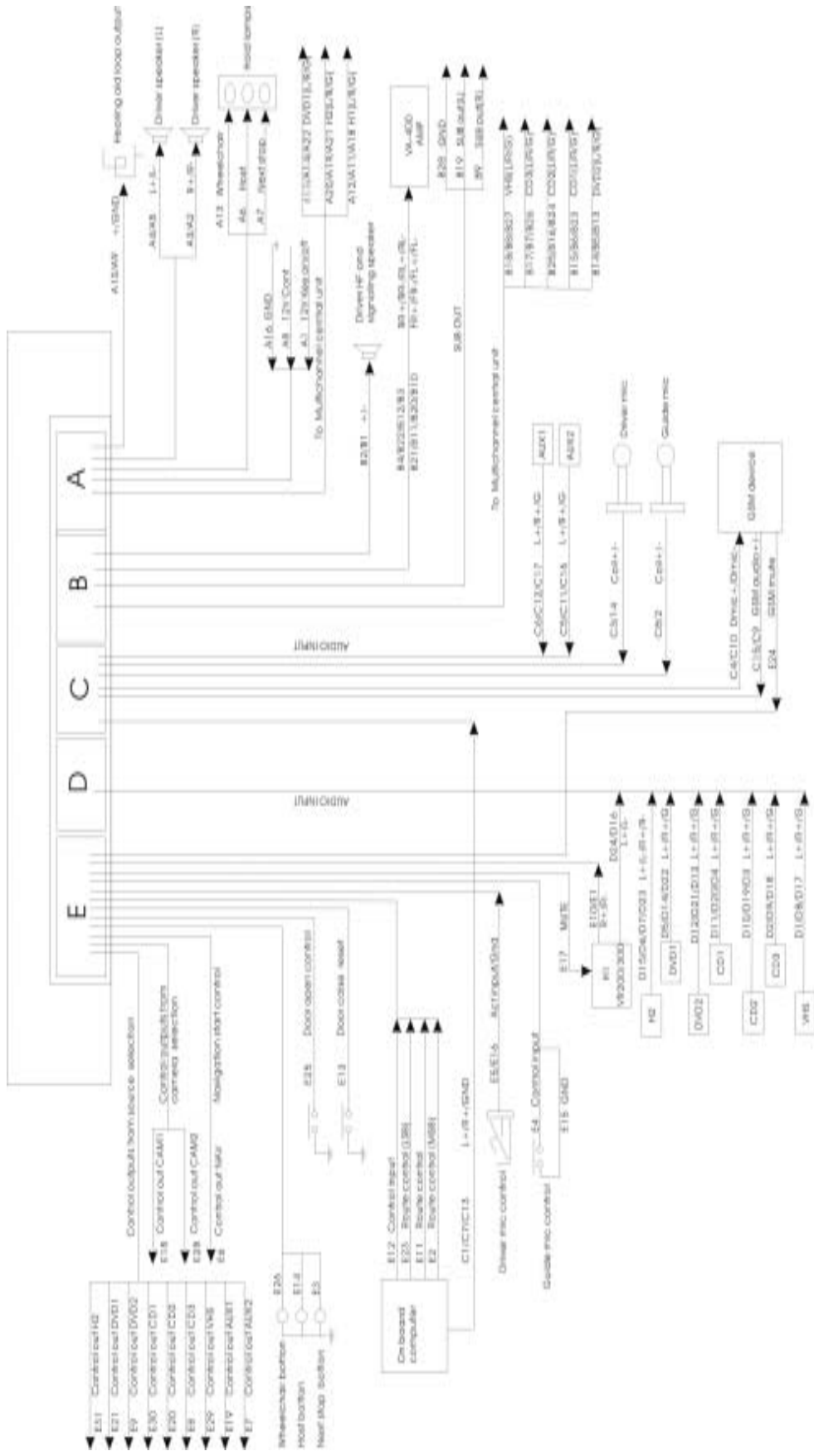
Symptom	Cause	Remedy
Unit does not operate	Fuse is blown	Replace with a fuse of specified capacity
	Unit's power is not on	Check if the connection is correct and ACC is on or not
Remote control does not function	Unit's function of remote control is not open	Press REM on the unit
	Remote control's battery is worn	Replace with a new battery
	Remote control's launcher and receiver are dirty	Clean the remote control's launcher and receiver
No sound	Wrong connection or select the wrong audio out	Correct the connection or switch to the correct mode.

Pins Configuration



Plug A		Plug B		Plug C		Plug D		Plug E	
NUM	SIGNAL	NUM	SIGNAL	NUM	SIGNAL	NUM	SIGNAL	NUM	SIGNAL
A22	Mult Output DVD1 GND	B28	SUB GND	C17	AUX1 Signal GND	D24	Line level input L+ from radio(HI)	E31	Control output H2
A15	Mult Output DVD1 L	B19	SUB OUT L+	C12	Line level input R+ from Aux1	D16	Line level input L- from radio(HI)	E21	Control output DVD1
A14	Mult Output DVD1 R	B9	SUB OUT R+	C6	Line level input L+ from Aux1	D7	Line level input R- from radio2	E9	Control output DVD2
A21	Mult Output H2 GND	B27	Mult Output VHS GND	C16	AUX2 Signal GND	D23	Line level input R- from radio2	E30	Control output CD1
A20	Mult Output H2 L	B18	Mult Output VHS L	C11	Line level input R+ from Aux2	D15	Line level input L+ from radio2	E20	Control output CD2
A19	Mult Output H2 R	B8	Mult Output VHS R	C5	Line level input L+ from Aux2	D6	Line level input L- from radio2	E8	Control output CD3
A18	Mult Output H1 GND	B26	Mult Output CD3 GND	C10	Dmic output(+) to HF device	D22	DVD1 signal GND	E29	Control output VHS
A12	Mult Output H1 L	B17	Mult Output CD3 L	C4	Dmic output(-) to HF device	D14	Line level input R+ from DVD1	E19	Control output AUX1
A11	Mult Output H1 R	B7	Mult Output CD3 R	C15	GSM audio + from HF device	D5	Line level input L+ from DVD1	E7	Control output AUX2
A10	Hearing aid loop out	B25	Mult Output CD2 L	C9	GSM audio -- from HF device	D13	DVD2 signal GND	E18	Control output CAM1
A9	Hearing aid loop out	B16	Mult Output CD2 R	C3	Dmic coil	D21	Line level input R- from DVD2	E28	Control output CAM2
A3	Driver speaker R	B24	Mult Output CD2 GND	C14	Dmic coil	D12	Line level input L+ from DVD2	E17	GSM mute output to radio
A2	Driver speaker R	B15	Mult Output CD1 L	C8	Dmic coil	D4	CD1 signal GND	E6	Control output Nav
A4	Driver speaker L	B6	Mult Output CD1 R	C2	Dmic coil	D20	Line level input R- from CD1	E16	DMIC Control GND
A5	Driver speaker L	B23	Mult Output CD1 GND	C13	On board comput Ann GND	D11	Line level input L+ from CD1	E5	Act input from Dmic
A13	Hold Lamps (Wheelchair) out	B14	Mult Output DVD2 L	C7	On board comput Ann R	D3	CD2 signal GND	E15	GMIC Control GND
A6	Hold Lamps (Host) out	B5	Mult Output DVD2 R	C1	On board comput Ann L	D19	Line level input R+ from CD2	E4	Control input Gmic
A7	Hold Lamps (Next stop) out	B13	Mult Output DVD2 GND			D10	Line level input L+ from CD2	E26	Wheelchair notification input control
A16	Power GND	B4	RR+ TO VA-400			D18	CD3 signal GND	E14	Host notification input control
A8	12 VDC continous	B22	RR- TO VA-400			D9	Line level input R+ from CD3	E3	Next stop notification input control
A1	12 VDC turn on	B12	RL+ TO VA-400			D2	Line level input L+ from CD3	E25	Door open control signal
		B3	RL- TO VA-400			D17	VHS signal GND	E13	Door close reset signal
		B21	FR+ TO VA-400			D8	Line level input R+ from VHS	E24	GSM mute input from HF device
		B11	FR- TO VA-400			D1	Line level input L+ from VHS	E12	Control input Announce
		B20	FL+ TO VA-400					E23	Routing control for ann message (LSB)
		B10	FL- TO VA-400					E11	Routing control for ann message
		B2	Driver HF Speaker+					E2	Routing control for ann message MSB
		B1	Driver HF Speaker-					E10	Line level input R+ from radio(HI)
								E1	Line level input R- from radio(HI)

System joint drawing



Operating Instructions

Radio

VR100, VR200, VR300, VR400

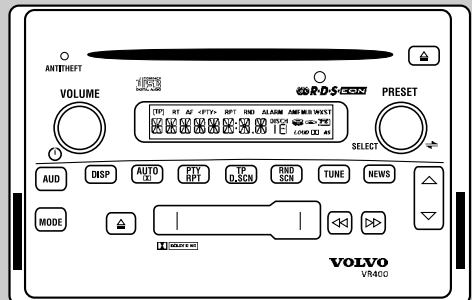
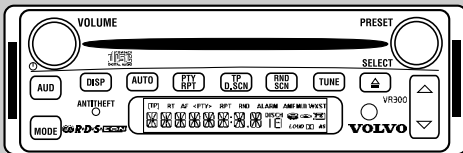
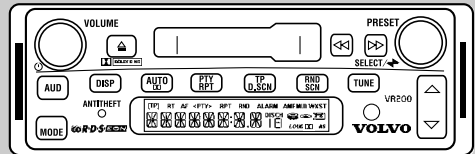
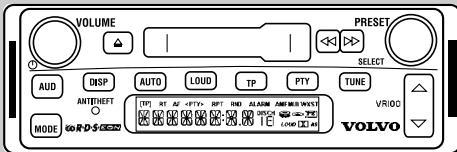


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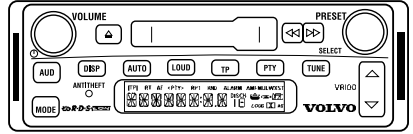
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System Overview

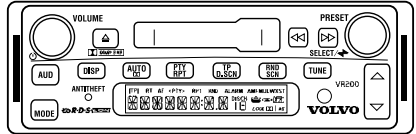
Four models of the radio are available:

- AM/FM/Mechanical Cassette – Model VR 100
- AM/FM/Logic cassette with external CD changer capability – Model VR 200
- 1-Din AM/FM/CD player with external CD changer capability – Model VR 300
- 2-Din AM/FM/Logic Cassette/CD player with external CD changer capability – Model VR 400

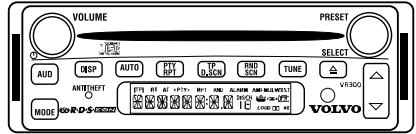
In addition to the front panel controls for these radios, most models can also be controlled using an optional remote wireless control or optional steering wheel-mounted controls.



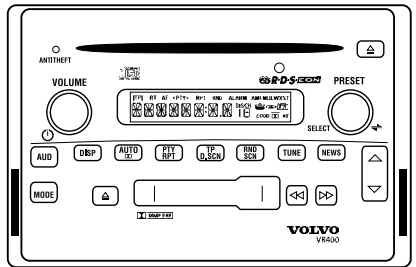
Model VR 100



Model VR 200



Model VR 300



Model VR 400

2 Using the Radio

Using the Radio

Notice: Before using the manual, check to see what radio model is in your vehicle. Some system features described may not apply to your radio.

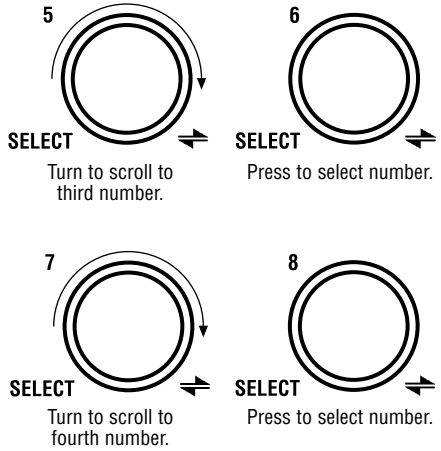
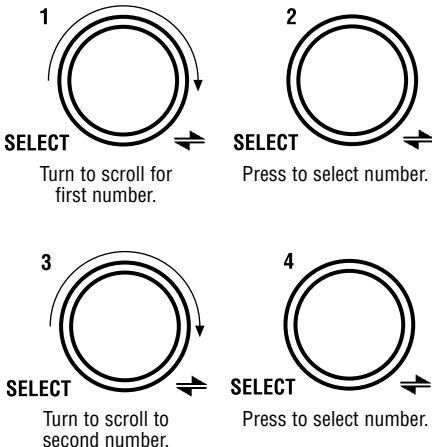
Security Code

Your radio is protected by a security code. The security code can be found on a label delivered with the radio. The security code cannot be changed.

Note: Certain vehicles have optional electronic devices that will automatically enter the security code if power is interrupted.

Note: Contact your local dealer regarding your security code if lost.

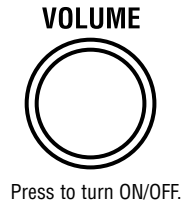
When the radio power is first turned on after power has been interrupted, “ID CHECK” and then “LOCK” is displayed for 3 seconds. Then “0000” is displayed. To unlock the radio, enter the four-digit security code found on the removable label by doing the following:



If the code is entered correctly, the radio will switch to the last active mode (i.e. FM, CD, etc.) and is ready to use.

If the code is entered incorrectly, you can try 2 more times. After 3 incorrect entries, the radio will display “LOCK.” You must turn the radio off, while leaving the ignition and battery on, for 1 continuous hour before attempting to unlock the radio again.

Power On/Off

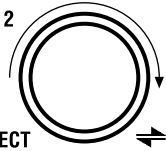


Language

To select the desired Radio Data System (RDS) Program Type Function (PTY) display language, turn the radio off,



1
Press and hold
for 2 seconds.



2
Turn to scroll
through available
languages.

(English, French, and Spanish in US-selected frequency bands, or English, French, German, Italian, and Spanish in European-selected frequency bands).

After the desired language is displayed for 5 seconds, the setting is saved and the display returns to the default.

Country Frequency Selection

Different countries broadcast on different sets of radio frequencies. You can select from several different country-specific radio frequency bands.

To select a country frequency band,



Press and hold
for 3 seconds.

until the current country frequency band is displayed.



Press to scroll
through available bands.

AMERICAS > EUROPE > AUSTRALI
> JAPAN > ARGENTIN > SAUDI

The selected band will be saved after 5 seconds.

Note: When a new country is selected, all preset stations from the previous country are erased.

Display Illumination

All of the radio controls are illuminated for nighttime viewing. Dimming the vehicle interior lights will also dim the radio controls.

4 Clock

Clock

Displaying the Time

When the ignition is on, the time of day is displayed, even when the radio is off. When the ignition is off, you can display the time for 5 seconds.



Press to display the time.

While the radio is on and in any mode, press and release the DISP button to change the display from the current display to the time of day.

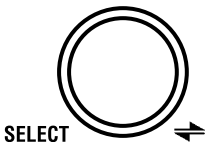
Note: If the radio is currently tuned to an RDS broadcast, it may require several presses to see the time of day.

Setting the clock

12- or 24-Hour Format

You can select either a 12-hour or 24-hour style time display.

To change the time format,



Press and hold for 3 seconds.

until "12/24" is displayed. The number shown after "12/24" indicates which format is selected (12-hour or 24-hour). To change this number, press the SELECT knob. After 5 seconds, the setting is saved and the display returns to default.

Note: When the European frequency is selected, 24-hour format is selected automatically; however, it can be changed by following the previous steps. Likewise, when Non-European frequency is selected, the 12-hour format is selected automatically, but can also be changed as described above.

Setting Time of Day

To change the time of day:

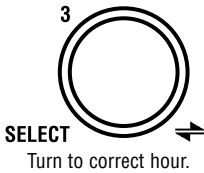
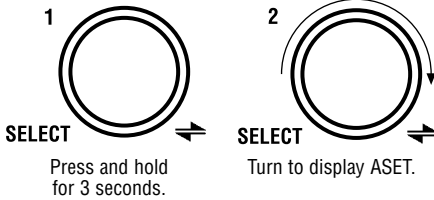
- 1 Press and hold for 3 seconds.
- 2 Turn to display TIMESSET, then press.
- 3 Turn to correct hour.
- 4 Press until minutes flash.
- 5 Turn to correct minutes.

After 5 seconds, the setting is saved and the display returns to the default.

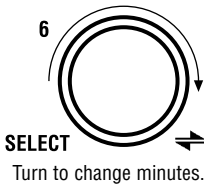
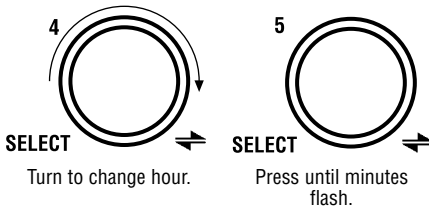
Alarm Clock and Timer (Except Model VR 100)

Setting the Alarm Clock

To set the alarm clock,



If the radio is set to the 12-hour format, “AM” or “PM” is also displayed.



After 5 seconds, the setting is saved and the display returns to the default.

Note: If the radio is in the 12-hour format, be sure the setting correctly shows AM or PM.

Alarm Clock On / Off / Snooze

To turn the alarm on or off, press and hold the SELECT knob for 3 seconds until “12/24” is displayed, then turn the SELECT knob until “ALARM” is displayed. Press the SELECT knob to choose between “Y” (On) or “N” (Off). After 5 seconds, the setting is saved and the display returns to the default. When the alarm is set, the alarm icon **ALARM** is displayed.

If the radio is on when the alarm time is reached, a beeping alarm sounds and the alarm time is shown. If the radio is off when the alarm time is reached, the last radio mode turns on.

In either case, if you press any of the radio buttons while the alarm is going off, the alarm “snoozes” for 9 minutes. After 9 minutes, the alarm turns on again and remains on until snooze is activated or the alarm is turned off, as described above.

Note: If the alarm is not turned off or the snooze mode is not activated, the alarm will stop after 18 minutes to avoid discharging the battery.

Alarm Volume

You can adjust the volume of the alarm by pressing and holding the SELECT knob for 3 seconds until “12/24” is displayed. Then turn the SELECT knob until “AL VOL” is displayed and turn the VOLUME knob to increase or decrease the volume of the alarm.

After 5 seconds, the setting is saved and the display returns to the default.

6 Clock

One-Hour Timer

You can set the radio to play for one hour and then automatically turn off.

To turn the radio on for another hour, with the ignition off, press the VOLUME knob. After 1 hour of play, the radio will turn off. To turn the radio on for another hour, press the VOLUME knob again.

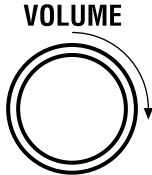
Audio Controls

The bass and treble audio settings apply to all radio modes (AM/FM, LW or WX, cassette and CD). A separate set of the following audio adjustments can be stored for each mode.

Note: LW (longwave) is available only on European models. WX (weather) is available only on U.S. models.

Volume Control

While listening in any mode,



Turn to adjust volume.

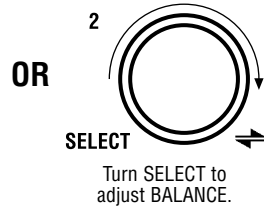
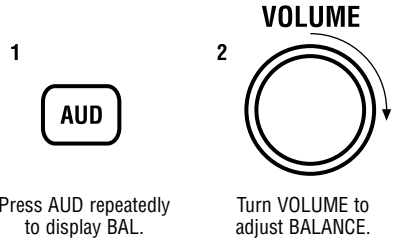
If you are currently adjusting the sound quality of the radio, (e.g., BASS, TREB, BAL, FADE), push the AUD button until “VOL” is displayed, then turn the VOLUME knob as described above.

Dynamic Distortion Limiting

Dynamic Distortion Limiting automatically limits the audio distortion level caused by playing the radio too loud. You do not need to set or adjust this feature.

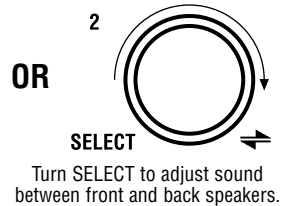
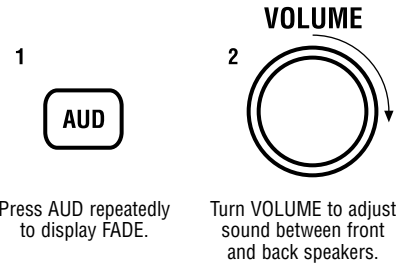
Balance Control

To adjust the left/right balance,



After 5 seconds, the display returns to the default.

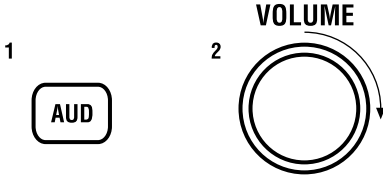
Fade Control



After 5 seconds, the display returns to default.

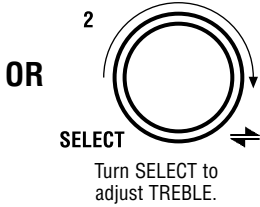
8 Audio Controls

Treble Control



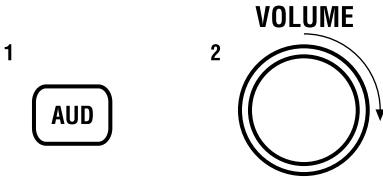
Press AUD repeatedly to display TREB.

Turn VOLUME to adjust TREBLE.



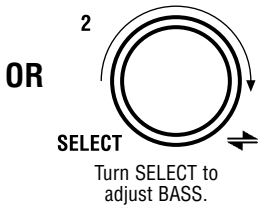
After 5 seconds, the display returns to the default.

Bass Control



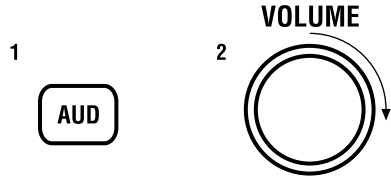
Press AUD repeatedly to display BASS.

Turn VOLUME to adjust BASS.



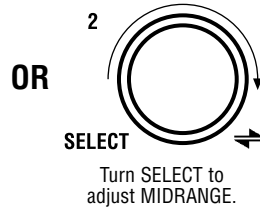
After 5 seconds, the display returns to the default.

Midrange Control (Model VR 400 only)



Press AUD repeatedly to display MID.

Turn VOLUME to adjust MIDRANGE.



After 5 seconds, the display returns to the default.

Loudness

The Loudness feature boosts the low (bass) frequency response at low volume levels, improving the sound quality. The amount of boost automatically decreases as volume is increased. On the Model VR 100,



Press to LOUDNESS on.
Press again to turn off.

The "LOUD" icon will be displayed.

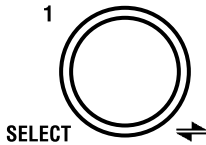


Press to turn off.

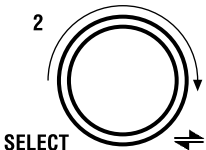
All other Models have an Auto-Loudness function. The feature cannot be turned on or off.

2- or 4-Speaker Select

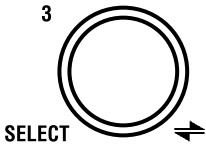
Depending on the radio speaker installation in your vehicle, 2- or 4-speaker output can be selected. To change this selection,



Press for 3 seconds to display 12/24.



Turn to display SPKR.



Press to choose 2 or 4.

When the 2-speaker option is chosen, the rear speakers are disabled and the fade adjust setting is not available.

After 5 seconds, the setting is saved and the display returns to the default.

Room Simulation (Model VR 400 Only)

You can select one of 5 acoustic settings, simulating different listening environments and providing a variety of sound qualities:

TALK: This mode limits the frequency response and delays audio from the rear speakers compared to the front speakers. This effect is very useful on AM talk radio because it filters much of the noise and moves the audio image forward.

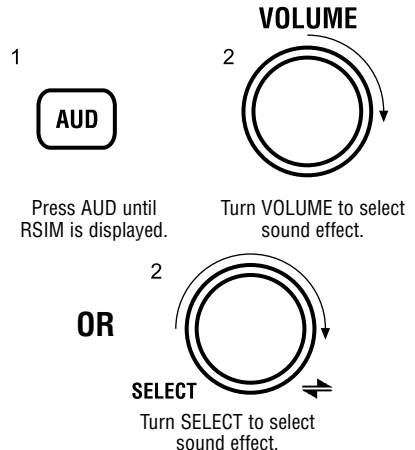
LIVE: Simulates the acoustics of live musical performance in a larger room.

AUDITORIUM: The same effect as LIVE, but more pronounced, giving the feeling of an even larger room.

ARENA: Creates the effect of being in a large arena.

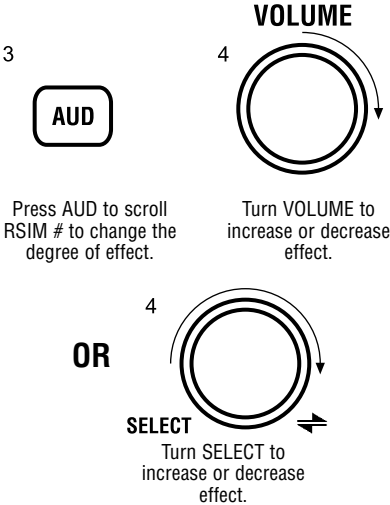
DRIVER L or DRIVER R: The sound from the driver side front speaker is delayed with respect to the passenger side front speaker, creating the effect of shifting or moving the audio image (for left hand and right hand drive vehicles).

To select a Room Simulation,



10 Audio Controls

To change the degree of effect for the selected simulation



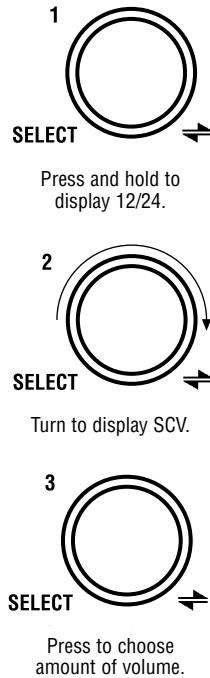
from 0 (minimum) to 15 (maximum).

After 5 seconds, the setting is saved and the display returns to default as indicated on the display.

Speed-Dependent Volume (Model VR 400 only)

The Model VR 400 can automatically adjust the volume based on your vehicle's speed, turning the volume up as you travel faster and down as you travel slower. This adjustment helps the radio to be heard over vehicle and road noise.

To turn on Speed-Dependent Volume,



change to "N" (off), "1" (low setting), "2" (medium setting) or "3" (high setting).

Note: The volume change is heard only while the vehicle is moving, but may not be noticeable due to the changes in road noise.

Tuning the Radio

Band Select

You can select from several bands of entertainment and information radio services:

U.S. models: AM, FM, WX

European models: FM, AM_MW,
AM_LW

To select a band, (AM, FM, WX):



Press MODE to display desired band.

To select AM_LW with the European model, first select AM_MW

EUROPEAN MODELS



First press and hold MODE for 3 seconds until beep to select AM_MW.



Press MODE to display AM_MW.

Weather Band

The National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce provides continuous broadcasts of taped weather messages. These messages are repeated every 4 to 6 minutes and routinely updated every 1 to 3 hours. Updates are more frequent during severe weather. Most NOAA weather stations broadcast 24 hours a day.

NOAA broadcasts on 7 channels. In some areas, more than one broadcast may be available. Select the broadcast location closest to your location for the best reception.

Note: The Weather Band option is only available when the country chosen is “Americas.” See the Country Frequency Selection section.

Note: Severe weather condition broadcasts are not automatically broadcasted by these radios. You must have the weather band selected to hear weather condition information.

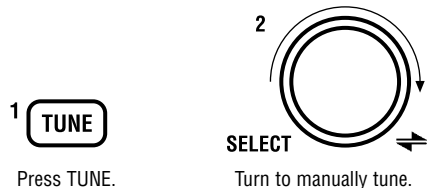
When the Weather band is selected, the radio will display “WX” and a channel number. The WX icon **WX** will also be illuminated.

Longwave Band

The longwave frequency band is a European AM broadcast in the frequency range of 153 to 279 kHz. It is only available when the European frequency band has been selected.

Tune

In any tuner mode (AM, FM, WX or LW)



Press TUNE.

Turn to manually tune.

If you reach the end of a frequency band, the radio will rollover or “wrap” to the opposite end of the band and continue through the band.

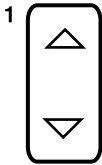
12 Tuning the Radio

If the select knob is not rotated within 5 seconds, the manual tune function is cancelled and the SELECT returns to its default function.

Seek

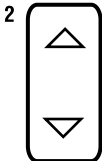
The radio can automatically seek stations, finding and stopping on the next station that exceeds the sensitivity level set.

To seek for a station in any tuner mode (AM, FM, WX, LW):



Briefly press up or down to SEEK.

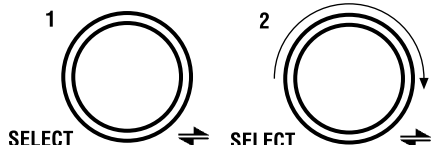
the next higher or lower station on the current band. The radio mutes as it searches for the next station with a strong signal. When it finds a station, the radio stops seeking and the audio returns to the original volume.



Press again for next station.

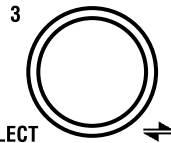
Seek Sensitivity - FM and AM (U.S. Frequency bands only)

In FM and AM tuner modes, the sensitivity of the Seek function can be adjusted to stop at stations with weaker or stronger signals. To adjust this sensitivity,



Press and hold to display 12/24.

Turn to display SEEK.



Press to scroll between -2 (min) and +2 (max).

After selecting SEEK, you can also rotate the VOLUME knob to scroll between the settings.

After 5 seconds, the setting is saved and the display returns to the default. The “-2” setting will stop only on very strong signals. The “+2” setting will stop on weaker signals.

Scan

You can also scan for stations. During a Scan, the radio searches for the next station, pauses on it for a few seconds, and then searches again for the next station.

To scan while in any tuner mode (AM, FM, WX or LW), press and hold the UP/DOWN rocker button to search for the next higher or lower station on the current band. The radio displays

“SCAN” and the audio mutes. The radio searches for and stops on the next station with a strong signal and the audio returns to the original volume. After 5 seconds, the audio mutes again and the radio continues the scan. To stop the scan, press the UP/DOWN rocker button.

If no station is found in 2 passes through the band, the scan will stop at the starting frequency.

RDS (Radio Data System) Features

RDS transmits additional information encoded on an FM station’s regular signal. The RDS feature works only with FM broadcast stations transmitting this encoded information. RDS broadcast is widely available in Europe, but less common in North America.

RDS features include:

- Alternate Frequency switching
- Traffic Program announcements
- Program Type selections
- Radio Text

Alternate Frequency Switching (AF)

With the AF feature, the radio automatically switches to another station or frequency, if available, that is broadcasting the identical program materials as the original station, when the original station begins to fade. With AF turned on, you can drive across a country or continent while listening to the same program, without retuning your radio.

To turn the AF feature on,

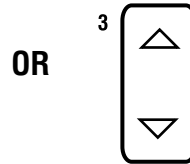


While in FM Mode, press and hold TUNE for 3 seconds to display AF-ON.

To turn AF off,



Press and hold TUNE for 3 seconds to display AF-OFF.



Press UP/DOWN rocker button.

Note: AF networks are common in Europe, but rare in the US.

Setting FM Memory (European programmed radio frequencies only)

You can help the radio make faster Seeks and AF switches to new frequencies by using the FM Memory function. This function searches for and stores the frequencies of local RDS and non-RDS FM stations in memory. The radio uses this information so it can more quickly find and switch to a stronger station when the currently tuned station begins to fade or a stronger signal becomes available.

Note: The stations stored using the FM Memory function are separate from stored FM Presets.

To manually activate the FM Memory function and store local radio frequency information, press and hold the AUTO

14 Tuning the Radio

button for 5 seconds while in FM mode. The radio also will automatically start an FM Memory search any time you Seek a TP station when AF is off, or Seek a TP station when the radio is not tuned to an RDS station.

Note: You can't start an FM Memory search while the radio is receiving a TP broadcast.

The radio displays "MEMORY" and the audio mutes as it seeks for and stores FM station information.

Note: If TP is turned on when you start the FM Memory function, the radio display will indicate "SEARCH" instead of "MEMORY".

The FM memory process typically takes less than 30 seconds, but can take up to several minutes, depending on the number and type of stations available. You can cancel the FM memory search by turning AF off or pressing and holding the AUTO button.

To keep the stored FM Memory information current, you should occasionally repeat the FM Memory search to update the information about local frequencies. FM Memory information remains stored until another FM Memory store function occurs.

Traffic Program (TP)

When the Traffic Program feature is turned on and a traffic announcement is received, the radio will automatically interrupt the current mode to broadcast traffic condition announcements that are provided by some stations or networks.



Press to turn on.
[TP] icon will display.



Press again to
turn off.

Note: TP cannot be turned on in AM, WX or LW mode.

If TP is turned on and the radio is not tuned to a station broadcasting traffic announcements, it will begin to SEEK a station that broadcasts announcements. The radio will display "SEARCH".

During a Traffic Announcement, the radio display shows "TRAFFIC".

There are 3 TP icons that may be displayed:

TP – Current station can broadcast traffic announcements, the function is not enabled.

[TP] Flashing – Current station can broadcast traffic announcements, the function is enabled.

[] – The function is enabled, but there are no stations/networks being received that broadcast traffic information. This can also occur if the TP function is enabled but the radio travels out of the broadcast area for the station/network that was broadcasting the traffic information.

Traffic Announcement Volume

You can adjust the volume of all Traffic Announcements by adjusting the volume while an announcement is being heard. When the next announcement is received, the volume will automatically increase to this volume. When the announcement is over, the radio will return to the previous volume setting of whatever radio mode was playing.

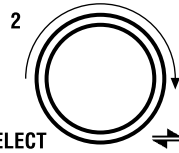
The Traffic Announcement volume setting will be saved for all future announcements until it is adjusted again.

Program Type Function (PTY)

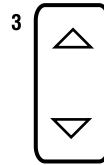
To select a particular type of music programming (Jazz, Sports, Country, etc.),



Press to display <PTY> icon.



Turn to scroll through available selections.



Press to SEEK or SCAN.

If a selection is not made within 10 seconds, no PTY will be saved and the radio will return to the default.

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European Program Type List

The PTY listing is shown below:

EUROPEAN PTY LISTING

CODE	TYPE	ENGLISH	FRENCH	GERMAN
* 0	NO TYPE	NO PTY	RIEN TPY	KEIN PTY
1	NEWS	NEWS	INFOS	NACHRICH
2	CURRENT AFFAIRS	AFFAIRS	MAGAZINE	AKTUELL
3	INFORMATION	INFO	SERVICES	INFO
4	SPORTS	SPORT	SPORT	SPORT
5	EDUCATION	EDUCATE	EDUCATIF	BILDUNG
6	DRAMA	DRAMA	FICTION	DRAMA
7	CULTURE	CULTURE	CULTURE	KULTUR
8	SCIENCE	SCIENCE	SCIENCES	WISSEN
9	VARIED	VARIED	DIVERS	VERSCHIE
10	POP MUSIC	POP M	M POP	POP
11	ROCK MUSIC	ROCK M	M ROCK	ROCK
12	EASY LISTENING MUSIC	EASY_M	CHANSONS	U-MUSIK
13	LIGHT CLASSICAL	LIGHT M	M CL LEG	LKLASSIK
14	SERIOUS CLASSICAL	CLASSICS	M CL SER	EKLASSIK
15	OTHER MUSIC	OTHER M	AUTRE M	ANDERE M
16	WEATHER	WEATHER	METEO	WETTER
17	FINANCE	FINANCE	FINANCE	FINANCE
18	CHILDREN'S PROGRAMS	CHILDREN	ENFANTS	KINDER
19	SOCIAL AFFAIRS	SOCIAL	SOCIETE	SOZIALES
20	RELIGION	RELIGION	RELIGION	RELIGION
21	PHONE-ON	PHONE IN	L OUVERT	ANRUFEN
22	TRAVEL	TRAVEL	VOYAGE	FREIZEIT

Tuning the Radio 17

EUROPEAN PTY LISTING (continued)

CODE	TYPE	ENGLISH	FRENCH	GERMAN
23	LEISURE	LEISURE	LOISIRS	REISEN
24	MUSIC	JAZZ	M JAZZ	JAZZ
25	MUSIC	COUNTRY	COUNTRY	COUNTRY
26	NATIONAL MUSIC	NATION M	M NATION	NATIONAL
27	OLDIES MUSIC	OLDIES	RETRO	OLDIES
28	FOLK MUSIC	FOLK_M	FOLKLORE	FOLKLORE
29	DOCUMENTARY	DOCUMENT	DOCUMENT	FEATURE
30	ALARM TEST	TEST	TEST	TEST
* 31	ALARM	ALARM!	ALERTE!	ALARM!
32		ANY	TOUS	ALLE
33		OFF	ARRET	AUS

ITALIAN & SPANISH PTY LISTINGS

CODE	TYPE	ITALIAN	SPANISH
0	NO TYPE	NO PTY	NO PTY
1	NEWS	NOTIZIE	NOTICIAS
2	CURRENT AFFAIRS	AFFARI	TOPICOS
3	INFORMATION	INFORM	INFORMAC
4	SPORTS	SPORT	DEPORTES
5	EDUCATION	EDUCAZ.	EDUC.
6	DRAMA	TEATRO	TEATRO
7	CULTURE	CULTURA	CULTURA
8	SCIENCE	SCIENZA	CIENCIAS
9	VARIED	VARIE	DIVERSOS
10	POP MUSIC	POP	M. POP
11	ROCK MUSIC	ROCK	M. ROCK
12	EASY LISTENING MUSIC	EASY_M	G-EXITOS
13	LIGHT CLASSICAL	CLASSICL	LIGERA.
14	SERIOUS CLASSICAL	CLASSIC2	CLASICA
15	OTHER MUSIC	ALTRA M.	OTRA M
16	WEATHER	TEMPO	TIEMPO
17	FINANCE	FINANZA	ECONOMIA
18	CHILDREN'S PROGRAM	BAMBINI	INFANCIA
19	SOCIAL AFFAIRS	SOCIALE	SOCIEDAD
20	RELIGION	RELIG.	RELIGION

18 Tuning the Radio

ITALIAN & SPANISH PTY LISTINGS (continued)

CODE	TYPE	ITALIAN	SPANISH
21	PHONE-ON	TELEF.	CONSULTA
22	TRAVEL	VIAGGI	VIAJES
23	LEISURE	HOBBY	OCIO
24	JAZZ	JAZZ	JAZZ
25	COUNTRY	COUNTRY	FOLKLORE
26	NATIONAL MUSIC	MUS.ITAL	M. NCNAL
27	OLDIES MUSIC	OLDIES	M_AYER
28	FOLK MUSIC	M_FOLK	M_FOLK
29	DOCUMENTARY	DOCUMENT	DOCUMENTAL
30	ALARM TEST	TEST	PRUEBA
31	ALARM	ALLARME	ALARMA!
32	ANY TYPE	TUTTI	ALGUNO
33	OFF	SPENTO	APAGADO

North American PTY Listing:

NORTH AMERICAN PTY LISTING

CODE	TYPE	ENGLISH	FRENCH	SPANISH
0	NO PROGRAM TYPE	NONE	AUCUN	NINGUNO
1	NEWS	NEWS	INFOS	NOTICIAS
2	INFORMATION	INFO	SERVICES	INFORMAC
3	SPORTS	SPORT	SPORT	DEPORTES
4	TALK	TALK	CAUSERIE	CHARLA
5	ROCK	ROCK_M	'M_ROCK	M._ROCK
6	CLASSIC ROCK	CLS_ROCK	ROCK_CLA	ROK_CLAS
7	ADULT HITS	ADLT_HIT	CONTEMP	HIT_ADTO
8	SOFT ROCK	SOFT_RCK	SOFT_RCK	ROK_BLDO
9	TOP 40	TOP_40	40_HIT_P	40_PRLES
10	COUNTRY MUSIC	COUNTRY	COUNTRY	COUNTRY
11	OLDIES MUSIC	OLDIES	OLDIES	OLDIES
12	SOFT	SOFT	SOFT	MUS_SUAV
13	NOSTALGIA	NOSTALGA	BIG_BAND	NOSTLGIA
14	JAZZ MUSIC	JAZZ	JAZZ	JAZZ
15	CLASSICAL	CLASSICL	CLASSIC	CLASICOS
16	R & B	R AND B	R AND B	CONTEMPOR
17	SOFT R&B	SOFT R B	SOFT R B	CONT_SUA

NORTH AMERICAN PTY LISTING (continued)

CODE	TYPE	ENGLISH	FRENCH	SPANISH
18	LANGUAGE	LANGUAGE	LANGUE	IDIOMAS
19	RELIGIOUS MUSIC	REL_MUSC	MUS_REL	MUS_REL
20	RELIGIOUS TALK	REL_TALK	CAU_REL	CHRL_REL
21	PERSONALITY	PERSNLTY	PERS	PRSONAJE
22	PUBLIC	PUBLIC	PUBLIC	PUBLICA
23	COLLEGE	COLLEGE	UNIV.	UNIVER
24-28	SPARE	BLANK		
29	WEATHER	WEATHER	METRO	TIEMPO
30	EMERGENCY TEST	TEST	TEST	PBA_EMRG
* 31	EMERGENCY ALERT	ALERT!	ALERTE	ALARMA!

* NOTE: PTYs marked with * cannot be used for a PTY SEEK, but can (only) be shown in the display.

Program Type Interrupt

Program Type Interrupt (PTY) will interrupt all other modes (cassette, CD, etc.) if a radio station begins to broadcast the chosen PTY program.

To designate an interrupt, follow the previous instructions to choose the desired program type, then press and hold the PTY button for 2 seconds while the desired PTY is selected, until “*” is displayed and the chosen PTY icon is enclosed in <brackets>.

To cancel the interrupt, press the PTY button and then rotate the SELECT knob to display the PTY designated by the “*”. Press and hold the PTY button for 2 seconds until “*” is no longer displayed.

Note: An RDS interrupt can't interrupt another RDS interrupt. The first interrupt received will be played and any others

received during the playback of the first interrupt will be ignored.

Program Type Seek

If PTY is not active, press the PTY button. Then press the UP/DOWN rocker button to Seek for the currently selected program type.

Program Type Scan

If PTY is not active, press the PTY button. Then press and hold the UP/DOWN rocker button until a beep is heard and the radio begins to scan for the currently selected program type.

Variants/Region Function

With this function turned on, the radio will seek or scan for AF network stations that have the same programming with only slight differences, like different commercials. With this function off, the radio will not switch to a network with similar programming.

20 Tuning the Radio

To turn this function on or off, press and hold the SELECT knob until “12/24” is displayed. Then turn the SELECT knob until “ACPT VAR” is displayed. You can choose from the following options:

- To look for identical and similar stations, choose “ACPT VAR” (in US) or “REG OFF” (in Europe).
- To look for only identical stations choose “RJCT VAR” (in US) or “REG ON” (in Europe).

Press the SELECT knob to choose the desired option.

After the desired choice is displayed for 5 seconds, the setting is saved and the display returns to the default.

Radio Text (RT) (Except Model VR 100)

The Radio Text function allows you to read any text messages transmitted by the currently tuned radio station on your radio display. These messages could include song title and artist, station slogans, contest information, etc.

Messages are available when the RT icon **RT** is displayed. To view the messages, press the DISP button until “TEXT” is displayed. After 3 seconds, the first line of the message is displayed.

After 2 seconds, the next line of the message is automatically shown. To scroll through the message at a faster pace, press the DISP button. Three seconds after the last line of text is displayed, or when the DISP button is pressed, the default display returns.

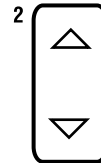
NEWS Program Button (Model VR 400 only)

When this feature is active, the radio will automatically interrupt the current programming to broadcast news programming.

To enable a news interrupt, while in FM mode,



Press to enable a news interrupt.



Press to SEEK news programming.

– OPTION –



Press again to turn off.

Presets

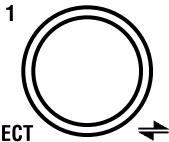
You can enter presets for your favorite radio stations on each of the radio's different bands.

Model VR 100 has 12 FM, 12 AM and 6 WX preset channels (U.S. models only) or 6 LW preset channels (European models only). All other models have 18 FM, 12 AM and 6 WX preset channels (U.S. models only) or 6 LW preset channels (European models only).

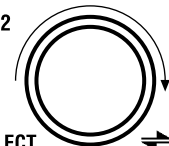
Storing Preset Stations

To store a station as a preset:

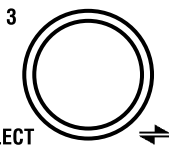
1. Tune to the desired station.



Push and release until STORE and a flashing preset number display.



Turn to change preset number.



Push to store station at that number.

“STORE” is cleared from the display and the preset number stops flashing.

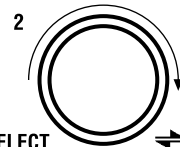
The audio returns to the original volume.

Note: If no preset is stored, the radio will return to the previous mode.

Accessing the Preset Stations



Press MODE until desired band is displayed (AM, FM, WX or LW).



Turn SELECT to choose preset station.

Note: If currently tuned to the desired band, you only need to turn the SELECT knob.

Preset Scan (Except Model VR 100)

You can Scan through each of the preset stations in each of the bands.

To Scan through your presets,



Press SCN to display PSCN and begin scanning presets.

22 Presets

While scanning, the radio pauses for approximately 5 seconds on each preset.

To stop the scan,



Press SCN again.

The scan continues until it is stopped.

Note: When scanning through presets, the radio will only stop on presets where the station strength is strong enough.

Auto-Store Presets

To automatically store the strongest 18 stations available (12 stations for Model VR 100) as presets, (AM, FM, WX or LW):



Press AUTO to scan for strongest signals and store as presets.

The radio displays **AS** and “AUTO” as the radio searches for and stores stations.

Auto-Store will stop after 18 stations (12 for Model VR 100) are found and stored. If there are not enough strong stations to fill the presets, the stations discovered will be duplicated until all memory locations are filled. If no stations are found, Auto-Store will automatically cancel.

Press the AUTO button at any time to cancel the Auto-Store function.

Note: When Auto-Store is turned off, the presets that were saved will be lost and the radio will return to the presets stored before Auto-Store was enabled.

Emergency Broadcast (Alert/Alarm)

The feature will interrupt the current mode and switch to an emergency radio broadcast. The radio will display “ALERT” (U.S. models) or “ALARM” (European models).



Select any MODE to cancel EMERGENCY BROADCAST ALERT/ALARM.

Emergency Broadcast Volume

You can adjust the volume of all Emergency Broadcasts while a broadcast is being heard. When the next Emergency Broadcast is received, the volume will automatically increase to this volume. When the broadcast is over, the radio will return to the previous volume setting of whatever radio mode was playing.

The Emergency Broadcast volume setting will be saved for all future announcements until it is adjusted again.

Note: You will not be able to adjust the volume lower than the minimum preset alert/alarm volume.

You can cancel an alert/alarm by selecting any mode (AM, FM, CASS, CD, etc.).

Using the Cassette Player

Cassette Select

Model VR 100

Insert a cassette into the radio and it will automatically begin to play. "TAPE_A" or "TAPE_B" is displayed, depending on which side of the tape is playing.

Model VR 200 and VR 400

With a cassette inserted, press the MODE button until "CASS" is displayed. "TAPE_A" or "TAPE_B" is displayed, depending on which side of the tape is playing. If no cassette is loaded when pressing the MODE button, the radio will display "NO TAPE" and return to FM mode.

Cassette Tightening and Error Detection (Except Model VR100)

Each time a cassette is inserted into the radio, the player automatically checks for a loosely wound tape and tightens it before playing. The player also detects tapes that are too tightly wound or broken. If a tightly wound or bad tape is detected, "BAD TAPE" is displayed and the tape is ejected.

The Cassette Tightening and Error Detection feature may prevent cleaning cassettes from working properly. To use cleaning cassettes, you can override the error detection.



If a cleaning tape is rejected, press and hold TUNE for 5 seconds (while the radio is OFF and the ignition is ON) until BAD TAPE and DETECT OFF display. Then insert cleaning tape.

After "BAD TAPE" and "DETECT OFF" are displayed, insert the cleaning tape.



To turn CASSETTE TIGHTENING and ERROR DETECTION back on, press and hold TUNE until BAD TAPE DETECTION is displayed.

Change Cassette Side

Model VR 100

To play the opposite side of a playing cassette, press the RW and FF buttons at the same time.

Model VR 200 and VR 400

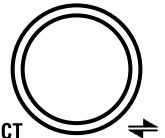
To play the opposite side of a playing cassette,

Model 100



Press and hold RW and FF buttons at the same time.

Models 200 & 400




Press SELECT.

Note: For all models, the cassette is automatically reversed when it reaches the end of a side.


24 Using the Cassette Player


Stop and Eject


Model VR 100

To eject the cassette, press the EJECT button . The tape is ejected and radio mode is activated. Tapes can be ejected even while the ignition is off.

Model VR 200 and VR 400

To stop play, press the EJECT button . The radio will return to the last selected mode.

Press the EJECT button  again to eject the cassette.



To eject the cassette when the radio is in another mode, press the EJECT button .



Pause (Model VR 100 only)

To pause a playing cassette, press the SELECT knob until "MUTE" is displayed. To begin playing the cassette again, press the SELECT knob again.


Fast Forward and Rewind


Model VR 100

To activate Fast Forward or Rewind, press the Fast Forward  or Rewind  button.

To cancel the Fast Forward or Rewind, press the opposite button,  or .

Model VR 200 and VR 400

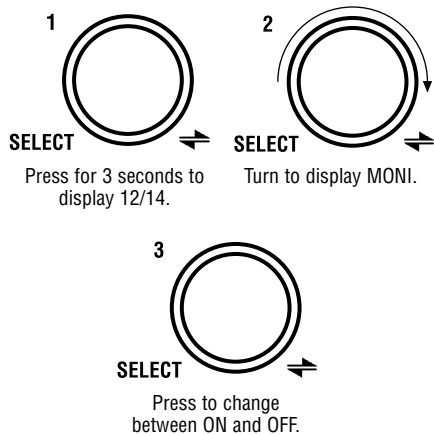
To activate Fast Forward, press the Fast Forward  button until "FWD >>" is displayed.

To activate Rewind, press the Rewind  button until "<< REV" is displayed. To cancel Fast Forward or Rewind, press the same button again.

Note: If Radio Monitor (following section) is on, you may seek a different station while the cassette is in Fast Forward or Rewind mode. While seeking, the display shows "FWD" or "REV" and the frequency number.

Radio Monitor Function

The Radio Monitor function allows the radio to be heard while fast forwarding or rewinding a cassette. To turn Radio Monitor on or off,

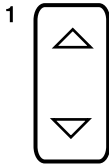


After 5 seconds the selection is saved and the display returns to the default.

Next Music Search (except Model VR 100)

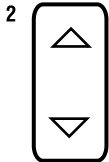
Most cassettes have blank space between each selection. You can use Next Music Search to find these pauses, allowing you to find the beginning of the next selection.

To fast forward to the next blank space on the cassette,



Press to display
NEXT>1.

To fast forward past several blank spaces,



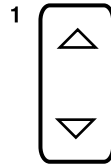
Press repeatedly to
pass several blank spots.

The number on the display shows how many blank spaces will be skipped.

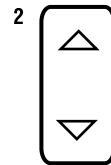
If the end of the side is reached during a Next Music Search, the cassette direction changes and begins to play the opposite side.

Previous Music Search (except Model VR 100)

To rewind to the previous blank space on the cassette,



Press to display
<PREV 1.



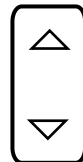
Press repeatedly to
pass several blank spots.

If the beginning of the side is reached during a Previous Music Search, the cassette begins to play at the beginning of the current side.

Note: If the current selection has been playing for less than 8 seconds, pressing the UP/DOWN rocker button will fast rewind to the blank space before the previous selection.

Canceling a Next/Previous Music Search

To cancel a music search,




Press until NEXT>1/<PREV 1
display is 0.

26 Using the Cassette Player

Dolby Noise Reduction (Models VR 200 and VR 400)

Enabling the Dolby B-type noise reduction function during cassette playback will reduce background noise on tapes that were recorded with this technology.

To turn on or turn off Dolby B-type noise reduction, press the button with the double-D logo . The double-D icon will display while the noise reduction is on.

Manufactured under a license from Dolby Laboratories. Dolby and the double-D symbol are trademarks of Dolby Laboratories.

Tape Player Care

The tape player must be cleaned after every 35 hours of use.

Caution: Not cleaning the tape player can cause reduced sound quality and may ruin your cassettes or damage the player.

Clean the player with a scrubbing-action, non-abrasive cleaning cassette. These cassettes have a bottle of cleaning liquid that is applied to cleaning pads and scrubs the tape heads. To properly clean your tape player, follow the instructions with the cleaning cassette. Cleaning cassettes should be replaced regularly.

Note: The cleaning cassette is not included with your radio and must be purchased separately.

Never touch the cassette head with magnetic or hard objects.

Do not lubricate the player mechanism.

Do not use cassettes that are longer than 90 minutes (C-90). Longer cassettes, like C-120, tend to have thinner tape that may stretch or break and may damage your player.

Cassette Tape Care

Do not use cassettes that are deformed, dirty or contaminated.

Cassette tapes that are not properly stored in their plastic cases away from contaminants, direct sunlight and extreme heat may not operate properly and may damage your tape player.

Cassette tapes are subject to wear and the sound quality may degrade over time. Always verify the cassette tape is in good condition before use.

Cassette Clean Indicator

The tape player will alert you that it should be cleaned by displaying the message "TP CLEAN". After the player is cleaned,



Press AUD for 5 seconds to clear display.
CLN RST will display for 3 seconds.

Then the display returns to the default.

Using the Cassette Player 27


Note: Do not release the AUD button before “CLN RST” is displayed to reset the clean condition.

If you experience poor sound quality from your cassette player, try playing a different cassette tape to see if the tape or tape player is at fault. If the second cassette tape also has poor sound quality, try cleaning the tape player, regardless of when the player was last cleaned.

28 Compact Disc (CD) Player

Compact Disc (CD) Player

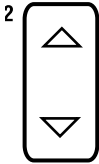
CD Select

Insert a CD in the radio's CD slot and it will automatically begin to play. The track number and the CD icon  are displayed.

If the radio is in another mode and a CD is already in the player,




Press MODE until CD is displayed.



Press UP/DOWN rocker button.

If you select the CD mode while no CD is loaded, the radio will display "NO CD" and return to FM mode.

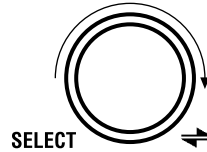
CD Eject

Press the EJECT button  to eject a CD from the player. CDs can be ejected even when the ignition is off.

If a CD is ejected but not removed within approximately 15 seconds, the CD automatically reloads but does not begin to play. The automatic reload feature helps protect the CD from possible damage.

Next Track

To skip forward to higher track numbers,

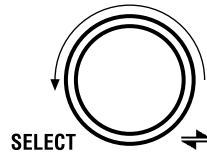


Turn clockwise to skip forward.

Continue to hold the knob and the player will continue to move forward through following tracks. The player will move through the tracks more quickly if the knob is turned further clockwise. Once the last track is reached, the player starts over at track 1 and continues to go up.

Previous Track

To skip backward to the beginning of the current track,



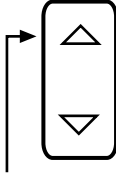
Turn counter clockwise to skip backward.

Continue to turn the knob and the player will continue to move backward through previous tracks. Once track 1 is reached, the player skips to the last (highest numbered) track and continues to go down.

Note: If the track has played for less than 8 seconds when the SELECT knob is turned, the player skips backward to the beginning of the previous track.

Fast Forward

To activate Fast Forward,



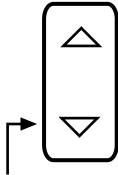
Press and hold to
FAST FORWARD.

After 3 seconds, the CD begins to fast forward until the rocker button is released. The elapsed time is displayed while the CD fast forwards.

Note: Because the audio disc is played at a faster rate when fast forwarding, you will be able to hear the audio but the quality will not be normal.

Fast Reverse

To activate Fast Reverse,



Press and hold to
FAST REVERSE.

After 3 seconds, the CD begins to fast reverse until the rocker button is released. The elapsed time is displayed while the CD reverses.

Note: Because the audio disc is played at a faster rate when fast reversing, you will be able to hear the audio but the quality will not be normal.

Repeat Play Function

To repeat the current track,



Press until RPT is displayed to REPEAT current track.



Press to cancel REPEAT.

Random Play Function

To play chosen tracks randomly,



Press RND to activate function.



Press RND again to cancel function.

30 Compact Disc (CD) Player

Scan Tracks Function (CD Player)

The Scan Tracks function plays the first 10 seconds of each track in order. To activate this function,



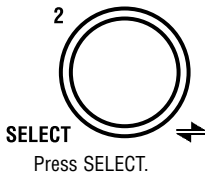
Press until SCN T# is displayed to scan tracks.

To cancel the scan,



Press and hold to cancel scan.

OR

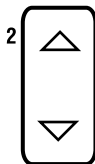


OR



Press MODE.

OR



Press and hold.


Using the CD Changer (CDX)

(CDX not compatible with Radio Model VR100)

CD Changer Select



Press MODE until CDX is displayed.

The last selected CD in the changer begins to play. The track number,  and CD number are displayed.

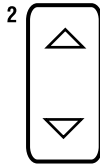
If there is no CD in the cartridge or a cartridge has not been inserted into the changer, the radio will display “NO CDX” and return to the previous mode.

CD Select

To select a CD in the changer



Press MODE until CD is displayed.



Press UP/DOWN rocker button.

The CD number on the display changes to match the number of the CD selected and the CD begins playing.

Repeat Track Function

To replay the current track,



Press RPT once to REPEAT current track.

The RPT icon  is displayed. To cancel the Repeat CD function,





Press RPT twice to cancel REPEAT.

Repeat CD Function

To replay the current CD,



Press RPT twice to repeat CD.

The RPT icon and the flashing CDX icon   are displayed.



Press RPT once to cancel REPEAT.

OR



Press D.SCN to cancel REPEAT.

OR



Press SCN to cancel REPEAT.

OR

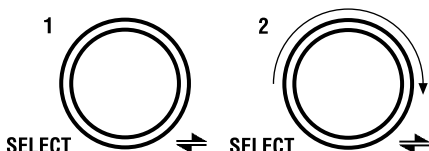


Press MODE to cancel REPEAT.

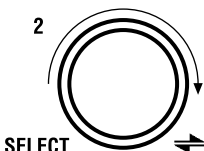
32 Using the CD Changer

Random Track Function

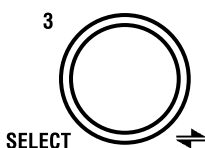
To play chosen tracks randomly on the current CD,



Press and hold SELECT until 12/24 displayed.



Turn to display RND.



Press to choose 1. After 5 seconds the selection is saved.



Press RND to activate function.

The RND icon  is displayed.

To cancel this function,



Press RND again to cancel function.

OR



Press D.SCN to cancel.



Press RPT to cancel.

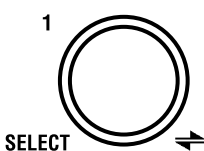
OR



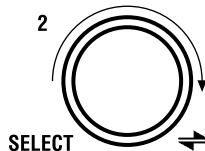
Press MODE to cancel.

Random CD/Track Function

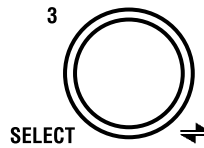
To play chosen tracks randomly from all CDs,



Press and hold SELECT until 12/24 displayed.



Turn to display RND.



Press to choose 6. After 5 seconds the selection is saved.



Press RND to activate function.

The RND icon  is displayed.



Press RND again to cancel function.

Scan Tracks Function

The Scan Tracks function plays the first 10 seconds of each track on the current CD. To activate this function,

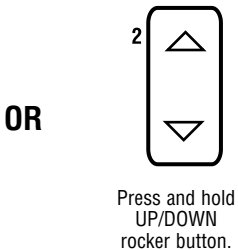
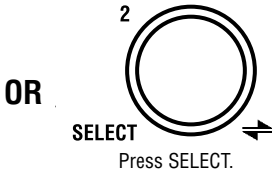


Press until SCN T# is displayed to scan tracks.

To cancel this function,



Press and hold.



Scan CDs Function

The Scan CDs function plays the first 10 seconds of the first track of each CD in the changer. To activate this function,



Press and hold until DISCSKAN.

To cancel this function,




Press and hold.

34 Infrared Remote

Infrared Remote (Accessory)

The infrared remote can be used to control all models except Model VR 100.


Power On/Off

Press the POWER button  to turn the receiver on or off. The vehicle must be turned on.

Volume

Press the “+” button to raise the volume or press the “-” button to lower the volume. “VOL” is displayed with the number that represents the volume level.

Mute

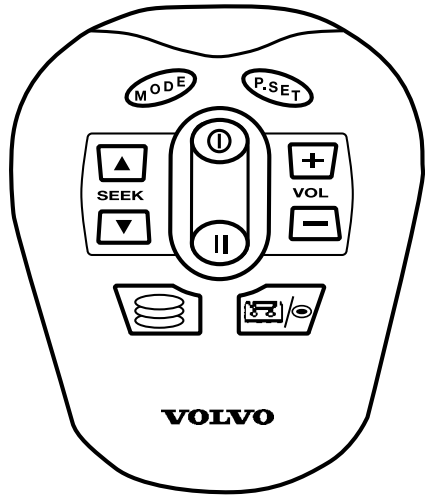
Press the MUTE button  to mute any mode. “MUTE” is displayed. To cancel the mute, press the MUTE button again. While muted, CDs and cassettes continue to advance.

Radio Select

Press the MODE button to change from a playback mode (cassette, CD, CD changer) to the radio mode. The radio plays the last selected band and station. To choose a different band, press the MODE button until the desired band is displayed.

Radio Tune

Press and hold the top or bottom of the SEEK button to slowly move through the frequencies on the current band. Continue to hold the SEEK button to activate a fast tune. Release the button to stop the tune.



Infrared Remote

Radio Seek


Press the top or bottom of the SEEK button to seek the next station. The audio mutes as the radio searches for and stops on the next station with a strong signal. After finding a station, the audio returns to the original volume.

Note: Seek will cancel if no signal is strong enough for the radio to recognize it.

Radio Presets

To listen to the preset stations, choose the desired band by pressing the MODE button. Then repeatedly press the P.SET button until the desired preset number is displayed.

Cassette Select

Press the cassette/CD button  until “CASS” is displayed. “TAPE_A” or “TAPE_B” is displayed, depending on which side of the tape is playing.



CD Select (Single, integrated CD)

Press the cassette/CD button until “CD” is displayed. The CD begins to play where it left off, and the track number and time elapsed are displayed.

Track Select

While in CD or CDX mode, rotate the SELECT knob to choose the desired track. The track number on the display increases or decreases depending on how many times the button is pressed.

CD Changer Select

Press the CD changer button  until the CD changer symbol and track number are displayed. The last selected CD and track begin to play and the track number, DISC icon,  and the CD number are displayed.

CD Select

To choose another CD, press the CD changer button until the desired CD number is displayed. You can also press and hold the CD changer button to quickly advance through the CDs in the changer. Release the button to stop on the currently displayed CD number.

36 Steering Wheel Controls

Steering Wheel Controls

The Steering Wheel Controls allow you to keep your hands on the wheel while controlling many radio functions. Steering Wheel Controls are not available with Model VR 100.

Volume

Press the “+” button to raise the volume or press the “-” button to lower the volume. “VOL” is displayed with the number that represents the volume level.

Radio Manual Tune

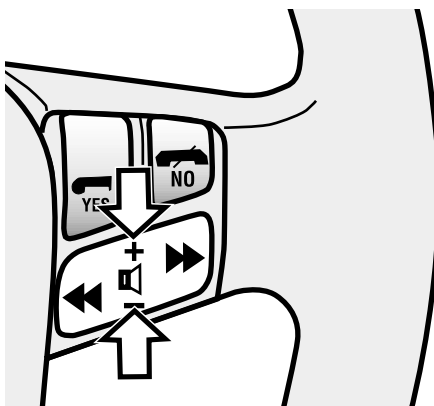
While in the radio mode, press the “▶▶” or “◀◀” button for 1 second to activate a slow tune. Press the “▶▶” or “◀◀” button for 3 seconds to activate a fast tune.

Radio Seek

Press the “▶▶” or “◀◀” button for less than 1 second to activate a Seek. The audio mutes. The radio searches and stops on the next station with a strong signal, and the audio returns to the original volume. The scan continues until a strong signal is found, but will cancel the Seek after passing through the band without finding a strong signal.

Cassette Fast Forward/Rewind

While in cassette mode, press the “▶▶” button to fast forward the cassette or press the “◀◀” button to fast rewind the cassette. To stop the fast forward or rewind, press the same button (“▶▶” or “◀◀”).



CD Track Select

While in CD mode, press the “▶▶” or “◀◀” button to choose the desired track. The track number on the display will increase or decrease depending on how many times the button is pressed.

CD Select

While in CDX changer mode, press and hold the “▶▶” and “◀◀” buttons at the same time until the desired CD number is displayed. The numbers will increase without stopping until the button is released.

Additional Inputs/Outputs

Note: The features below are applicable only with certain optional equipment. See an authorized Volvo dealer for details.

Switched Auxiliary Outputs

Switched Auxiliary Outputs (SAOs) are available to power or control external devices such as a power antenna, external amplifier or rear seat audio. Model VR 100 has a single SAO. All other Models have 3 SAOs.

Low-Level Audio Outputs

All radios except Model VR 100 have single-ended connections for low level audio outputs for the right front, left front, right rear and left rear audio signals. An optional amplifier is typically used with low-level outputs.

Auxiliary Audio Input

All radios except Model VR 100 have 2 monaural external audio inputs. Input #1 can be used for applications like navigation while input #2 is useful as a telephone input. The auxiliary audio source is automatically selected by the telephone or navigation unit when properly connected through the control lines.

When either external audio source is selected, the radio will display “EX AUDIO” along with any appropriate icons. The radio’s audio functions can be adjusted in the same way as they are in other modes.’

To override Auxiliary Audio mode,



Press and hold for at least 5 seconds.

The radio will return to the previous operating mode.

Selecting Speakers for Auxiliary Audio

Navigation audio can be directed to the left or right front speaker. To select the speaker for Navigation audio, press and hold the SELECT knob for more than 3 seconds. The display will show “12/24_XX.” Then rotate the SELECT knob through the various options until the display shows “Nav. X,” where X is either “L” for left or “R” for the right speaker. To change between the left and right speaker selection, press the SELECT knob.

Phone audio can be directed to either the front or all 4 speakers. To select the speakers for phone audio, press and hold the SELECT knob for more than 3 seconds. The display will show “12/24_XX.” Then rotate the SELECT knob through the various options until the display shows “PH_ X,” where X is either “FRONT” or “ALL.” To change between the front or all speaker selection, press the SELECT knob.

Cell Phone Mute

When equipped with the required optional equipment and properly connected, the radio will automatically mute audio and the display indicates “VOL 0” each time a call is made or received.

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VOLVO

Volvo Truck Corporation

Göteborg, Sweden

OPERATING INSTRUCTIONS

MOBILE DVD PLAYER



Please read this instruction before installation and operation.

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FEATURES

◆POWER

Operating voltage : 12V ^{+20%}_{-30%} DC
Low power consumption design.

◆COMPATIBILITY

This DVD player can play the following discs:
DVD, CD, VCD, DVCD, MP3, CD-R, CD-RW.

◆SYSTEM FUNCTIONS

◇VIDEO OUTPUT SYSTEM

System MULTI, NTSC or PAL switchable.

◇1 L/R Audio Output

1 L/R Audio Input

1 AUX Video Input

1 Rear Camera Video Input

3 Video Outputs with one dedicated self switching rear view monitor output

◆ADDITIONAL VIDEO FEATURES

Multi-angle, multi-view, multi-audio function

Multi-level forward and backward motion

Play position memory, Resume stop and repeat function

SAFETY PRECAUTIONS

This digital versatile disc (DVD) video player uses 12V $\pm 20\%$ DC. For future reference, record the model and serial number (located on the case of the DVD player) in the space provided.

CAUTION:

THIS DVD VIDEO PLAYER IS A CLASS I LASER PRODUCT. USE OF CONTROLS OR ADJUSTMENTS OR PERFORMANCE OF PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN MAY RESULT IN HAZARDOUS RADIATION EXPOSURE. AS THE LASER BEAM USED IN THIS DVD VIDEO PLAYER IS HARMFUL TO THE EYES, DO NOT ATTEMPT TO DISASSEMBLE THE CABINET. REFER SERVICING TO QUALIFIED PERSONNEL ONLY.

WARNING : class I laser product - Avoid Long Term viewing of Direct Laser Radiation.

WARNING OF DEW FORMATION

Dew may form on the pickup lens in the following conditions.

- Immediately after a heater has been turned on.
- In a steamy or very humid room.

When the unit is suddenly moved from a cold environment to a warm one.

If dew forms inside this unit, it may not operate properly.

In this case, turn on the power and wait about 2 or 3 hours for the dew to evaporate.

When the unit is used under low temperatures, the pick up lens might warm up very fast and dew will form.

In this case, turn on the power and wait a while for the dew to evaporate.

Precautions



Warning: *This symbol means important instructions.
Failure to heed them can result in serious injury or death.*

- 1、 Do not disassemble or alter this unit. Doing so may result in an accident, fire or electric shock.
- 2、 Keep small objects such as battery out of the reach of children. If swallowed, consult a physician immediately.
- 3、 Use the correct ampere rating when replacing fuses. Failure to do so may result in fire or electric shock.
- 4、 Use only in cars with a 12 VOLT negative ground. (Check with your dealer if you are not sure.) Failure to do so may result in fire, etc.
- 5、 Do not operate any function that takes your attention away from safely driving your vehicle. Any function that requires your prolonged attention should only be performed after coming to a complete stop.
Always stop the vehicle in a safe location before performing these function.
Failure to do so may result in an accident.
- 6、 Do not watch video while driving. Watching the video may distract the driver from looking ahead of the vehicle and cause an accident.
- 7、 Keep the volume at a level where you can still hear outside noise while driving. Failure to do so may result in an accident.
- 8、 Use this product for mobile 12V applications. Use for other than its designed application may result in fire, electric shock or other injury.
- 9、 Do not place hands, fingers or foreign objects in insertion slots or gaps. Doing so may result in personal injury or damage to the product.

Precautions

- 10、 Do not block vents or radiator panels. Doing so may cause heat to build up inside and may result in fire.



Caution: *This symbol means important instructions.*

Failure to heed them can result in injury or property damage.

- 1、 *Insert with the correct battery polarity.*

When inserting the battery, be sure to observe proper polarity (+ and -) as instructed. Rupture of the battery may cause fire or personal injury.

- 2、 Halt use immediately if a problem appears. Failure to do so may cause personal injury or damage to the product. Consult a professional mobile video installer.

- 3、 *Temperature.*

Be sure the temperature inside the vehicle is between $+55^{\circ}\text{C}$ ($+131^{\circ}\text{F}$) and -5°C ($+23^{\circ}\text{F}$) before turning your unit on.

- 4、 *Moisture condensation*

You may notice the CD playback sound wavering due to condensation. If this happens remove the disc from the player and wait an hour for the moisture to evaporate.

- 5、 *Damaged disc*

Do not attempt to play cracked, warped, or damaged discs. Playing a bad disc could severely damage the playback mechanism.

- 6、 *Maintenance*

If you have problems, do not attempt to repair the unit yourself. Consult a professional mobile video installer.

Precautions

7、 *Never attempt the following*

Do not grip or pull out the disc while it is being pulled back into the player by the automatic reloading mechanism.

Do not attempt to insert a disc into the unit when the unit power is off.

8、 *Inserting discs*

Your player accepts only one disc at a time for playback. Do not attempt to load more than one disc.

Make sure the label side is facing up when you insert the disc.

Playing a disc while driving on a very bumpy road may result in skips.

9、 *Irregular shaped discs*

Make sure the discs you use in this unit do not have any irregularities. The outer and inner edges should be round and smooth. Use of irregularly shaped discs may cause damage to the mechanism.

10、 *Installation location*

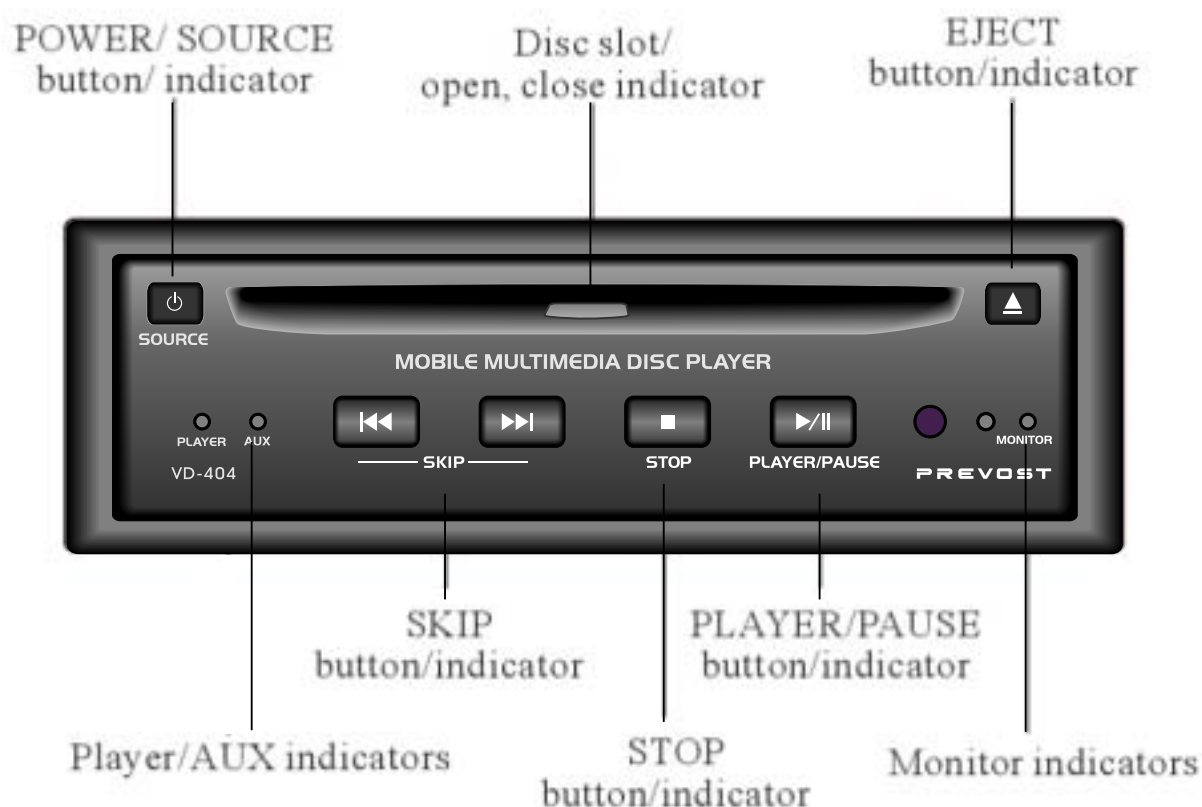
Make sure the unit will not be installed in a location subjected to:


- Direct sun and heat
- High humidity and water
- Excessive dust
- Excessive vibrations

Identification of controls

See the page in for the details.

Front panel



The button	
POWER	Power on/off by pressing this button 9
EJECT	To eject a disc 10
▶/||	Play/Pause 11
■	To stop playback 12
◀▶	To locate previous/next chapter or track 12

Identification of controls



Resetting the unit

Press the RESET button with a pointed object, such as a ballpoint pen, as shown.

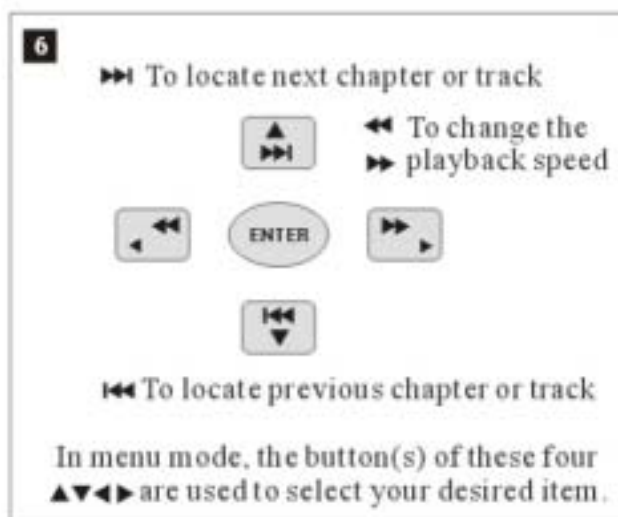
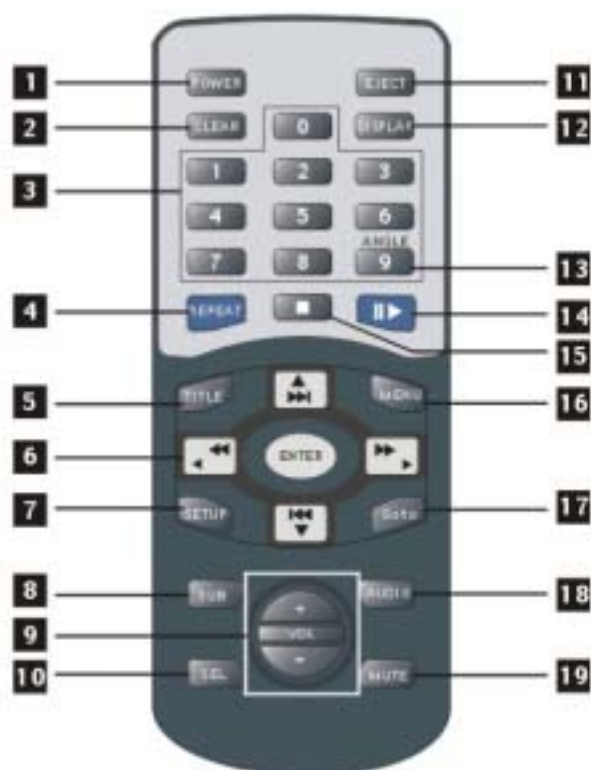
Unit will turn off momentarily after the RESET button is pressed.

Note: Pressing the RESET button will erase some stored contents.

SOURCE for AV SEL

Select DVD or AUX input by pressing and holding the SOURCE button for 6 seconds then release the SOURCE button.

Identification of controls



- | | |
|---|---|
| 1 POWER on/off button | 11 EJECT button to eject the disc |
| 2 CLEAR button to clear the wrong number you entered | 12 DISPLAY button to display the disc status |
| 3 Number button Used to input numbers | 13 ANGLE button to select the camera angle |
| 4 REPEAT button to play repeatedly | 14 ▶▶ Button Playing/Pausing |
| 5 TITLE button to locate a specific title chapter or track | 15 ■ Button to stop playback |
| 6 Joy stick | 16 MENU Button to locate a specific title chapter or track |
| 7 SETUP button to change the default settings | 17 Goto Button to Locate a location by entering its corresponding track number, chapter number or time |
| 8 VOL +/- button to control the volume | 18 AUDIO Button to switch the audio language |
| 9 SUB button to select subtitle | 19 MUTE Button playing with no sound |
| 10 SEL button to select the audio functions | |

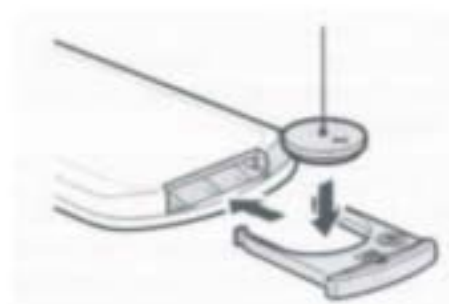
When using remote control

Preparing the remote control

Insert battery (3V, CR2025) into the remote control.
Make sure the + side of the battery faces up before closing the cover.



1) Open the cover,
pull the cover as illustrated



2) Insert cell (3V), Close the cover

Operating with the remote control

This section shows you how to use the remote control. Point the remote control at the remote sensor and press the buttons.

The remote range: about 4m from the front of the remote sensor.

(Is) off axis: more than 30L in each direction of the front of the remote sensor.

Do not expose the remote sensor of the DVD player and the remote control to a strong light source. such as direct sunlight or other illumination. If you do so, you may not be able to operate the DVD player via the remote control.

When using remote control



With about 4m



Notes on battery

To operate the remote control correctly, follow the instructions below.

Do not insert cell into the remote control in the wrong direction. Do not charge, heat, open, or short-circuit the cell. Do not throw cell into a fire.

If the remote control does not function correctly or if the operating range becomes reduced, replace the cell with new one.

Notes on the remote control

Direct the remote control at the remote sensor of the DVD player.

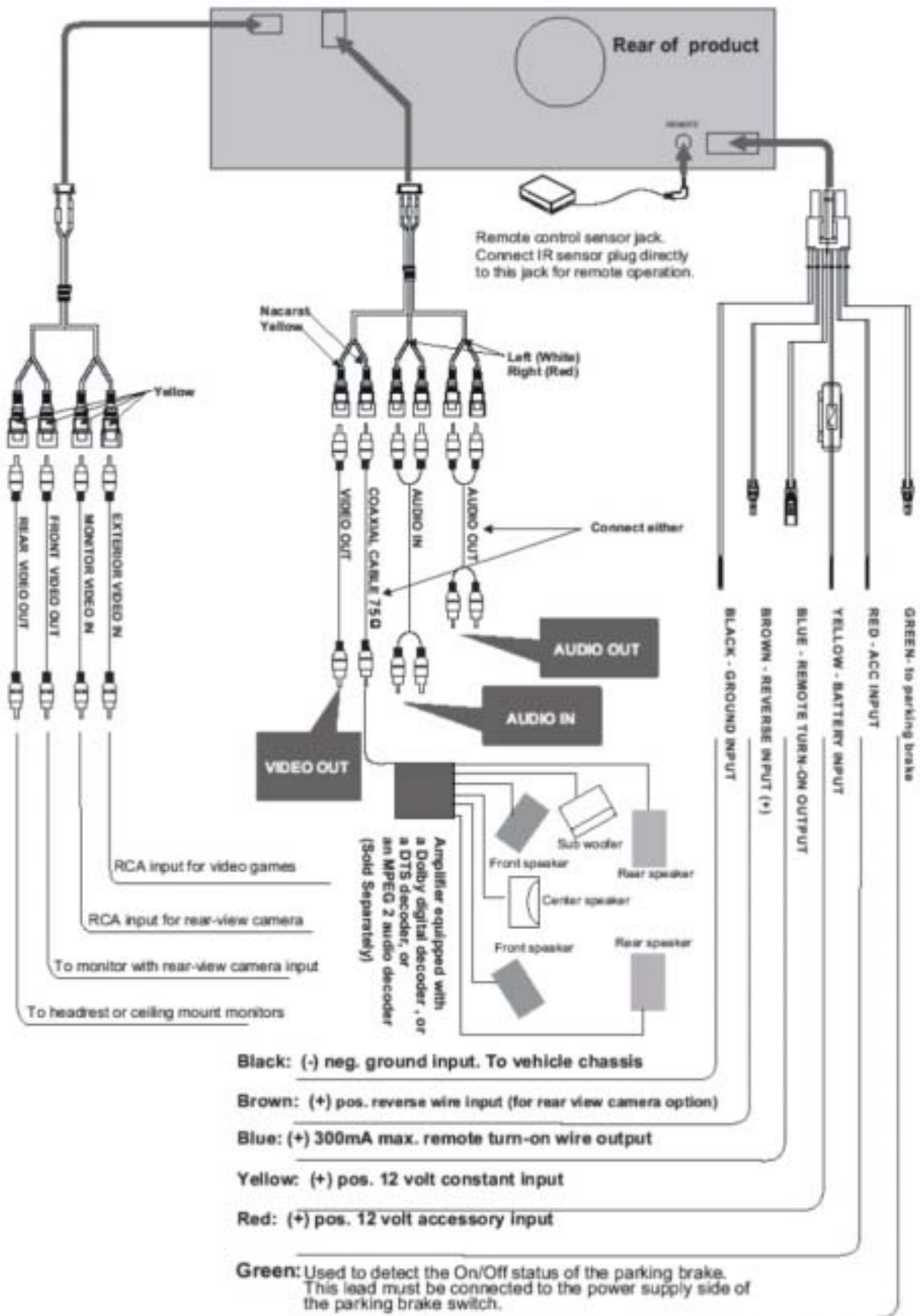
Do not drop or give the remote control a shock.

Do not leave the remote control near an extremely hot or humid place.

Do not spill water or put anything wet on the remote control.

Do not disassemble the remote control.

Connections



Connections

1 NOTE

Connect	Audio out(audio related, see page 19)
Coaxial cable	SPDIF/RAW RAW DATA VIA SPDIF
	SPDIF/PCM PCM DATA VIA SPDIF
Audio cable	ANALOG ANALOG OUTPUT

2 NOTE

- 1 Refer to the owner's manual "for the connected monitor " as well.
- 2 Refer to the owner's manual of the connected equipment for additional information.
- 3 When you connect the DVD player to other equipment, be sure to turn off the power .
- 4 If you place the DVD near a tuner or radio, the radio broadcast sound might be distorted.
In this case, place the DVD player away from any other tuner or radio.
- 5 The output sound of the DVD player has a wide dynamic range. Be sure to adjust the receiver's volume to a moderate listening level. Otherwise, the speakers may be damaged by a sudden high output.
- 6 Turn off the amplifier before you connect or disconnect the DVD player's power leads.
If you leave the amplifier power on, the speakers may be damaged.

3 NOTE

1. We advise to connect the EX-VIDEO-CON lead.
And so the front display only will be on while detecting the parking brake ON.
Or if the EX-MONITOR-CON and MONITOR VIDEO IN are used, the front display will be on while backing the car.
2. This product ' s REAR VIDEO OUT and VIDEO OUT are for connections of displays to enable passengers in the rear seats to watch the DVD or Video CD.



Warning: NEVER install the display in a location that enables the Driver to watch the DVD or Video CD while driving.

This product detects whether your car ' s parking brake is engaged or not, and prevents you from watching a DVD or Video CD on the display connected to Front Video Out while driving.

Example: When you attempt to watch a DVD, the screen is black. When you park your car in a safe place and apply the parking brake, the picture appears on the screen.

Loading and unloading a disc

Loading and unloading a disc

Turn on the power before loading and unloading discs.

1 Insert the disc with the side containing words diagrams facing upwards.

Once the disc is partially inserted, it is drawn in automatically. Playback starts.



2 Unloading disc

Press EJECT ▲ button, the disc is automatically ejected.









Notes:

If wrong disc, upside-down discs or dirty discs have been inserted, "NO DISC" is displayed.

Remove the disc.

Do not put any objects other than discs into the disc slot, doing so may cause the player to malfunction.

    These indicate the discs for which the function can be used.


 You can use this function with DVD discs.  You can use this function with MP3 discs


 You can use this function with VIDEO CDs.  You can use this function with CDs.

About this owner's manual

This owner's manual explains the basic instructions of this DVD player. Some DVD discs are produced in a manner that allows specific or limited operation during playback.

As such, the DVD player may not respond to all operating commands. This is not a defect in the DVD player. Refer to the instruction notes of discs.

"" may appear on the screen during operation.

A "" means that the operation is not permitted by the DVD player or the disc.

1 Turning the power on and off



Press POWER button

The power turns on.
 To turn the power off, Press POWER button again.

Play Position Memory Function

Even if you turn power off or switch the ignition Key to OFF during playback or change the video source, playback will continue from the point where playback stopped when the power is turned ON again.
 The play position memory is released if the disc is removed or the Reset switch is pressed.

2 Switching between DVD and AUX Video Input

To switch between DVD and AUX Video input, press and hold source button for 6 seconds then release button.



Connect		AV SEL
Using AUDIO and VIDEO OUT, connect the monitor or audio system		INTERNAL VIDEO
	Using AUDIO and VIDEO IN, connect the DVD video player to a VTR, TV/VTR combination or video selector	AUX Video Input

3 Adjusting the volume

Press the + button to increase the volume.
 Press the - button to decrease the volume.



*Playing a disc
Playing/pausing
Tuning the sound on and off*




1 *Playing a disc* DVD VCD CD MP3

Caution

With some DVDs, certain operations are disabled. Such operations are not possible on such DVDs. The DVD functions described in this manual are not supported by all instructions for details on the features supported.

Fingerprints on a disc may adversely affect playback. If a problem occurs, remove the disc and check for fingerprints on the playback side. Clean the disc if necessary.

When using the remote control, be careful to pressing multiple buttons at the same time may cause erroneous operation.

- ① **Press ► button.** 
Playback starts.

If a menu screen appears DVD VCD MP3

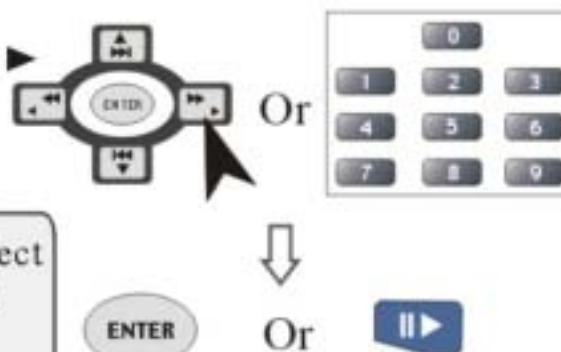
On DVDs and video CDs with playback control (PBC), menu screen may appear automatically.

If this happens, perform the operation described below to start

Note: For many discs, the menu screen can also be displayed by pressing MENU or TITLE.

DVD menu

Use the Joystick or the number keys(0~9) to select the desired item, then press ENTER or ►



Note: For some discs it is not possible to select items for the menu to menu screen using the number buttons (0~9).

Playing a disc
Playing/pausing
Tuning the sound on and off

VCD menu

Use the number keys(0~9) to select the desired item, then press ENTER or ►

Note: The menu screen does not appear when the PBC function is turned off. If this is the case press MENU to turn on the PBC function. In PBC off mode, you can use the number keys to input the desired track also.



Or



② *Playing/pausing*

During playback press ►► to pause playback.
Press ►► again to resume playback.



③ *Tuning the sound on and off*

During playback press MUTE, no sound is played. Press Mute to resume normal playback with sound.



Tips

Using the Number keys



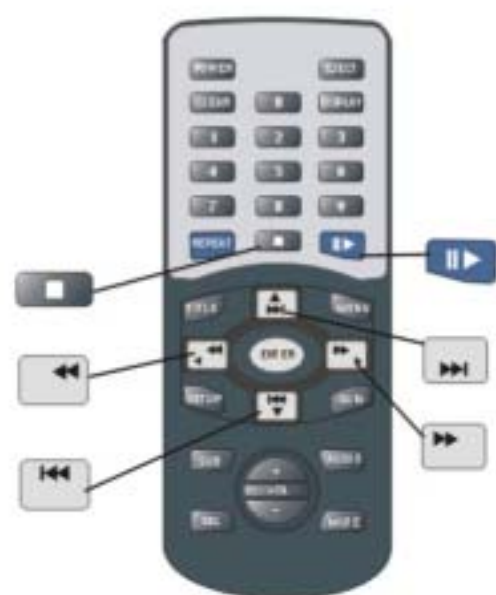
This describes use of the Number keys.

To input 16: Press the 1 button and then press the 6 key.

To input 28: Press the 2 key and then press the 8 key.

To input 108: Press the 1 key and then press the 0 and 8 button.

After the number input, press ENTER or PLAY button to start the playback.



Notes:

For some discs, the position at which playback was stopped may not be accurate.
For Video CD:
Press during playback,
1 in PBC off mode, playback stops.
Press PLAY, playback will start at the beginning of the disc.
2 in PBC on mode, playback stops and press PLAY then it will be Back to main page.

1 **Stopping playback**

DVD VCD CD MP3

Press the stop button during playback to stop playback.

Press ■ during playback.



Tips

Using the PRE-STOP function (DVD only.)

When the PRE-STOP function is used, the position at which playback is stopped is stored in the memory, and playback resumes from that position.

Press ■ once during playback.



PRESS PLAY TO CONTINUE is displayed.

Press ► in the PRE-STOP mode.



Playback starts from the position at which it was stopped.

To cancel the PRE-STOP function

Either press ■ again in the PRE-STOP mode, eject the disc or turn the power to clear the memory. Playback will start at the beginning of the disc.

2 **Fast-forwarding/fast-reversing**

DVD VCD CD MP3

① During playback press ◀◀ (fast-reverse) or ▶▶ (fast-forward)



Each time you press the ◀◀ or ▶▶ button, the playback speed changes to X1, X2, X3, X4 the normal speed or normal speed.



② Press ► to return to normal playback.



Notes:

No sound or subtitles are played during fast-forwarding/fast-reversing of DVDs or Video CDs.

However, sound is played during fastforwarding/fast-reversing of audio Cds.

3 *Finding the beginning of chapters or tracks* DVD VCD CD MP3

*During playback press **▶▶** or **◀◀**:*
The chapter/track switches each time the button is pressed, and playback of the selected chapter/track starts.



Or



▶▶ : Press this to start playback from the beginning of the next chapter or track.

◀◀ : Press this to start playback from the beginning of the previous chapter or track.

Note: Some DVDs do not have chapters.

Supplementary explanation

Chapters are divisions of movies or musical selections on DVDs.

Tracks are divisions of movies or musical selections on video and audio CDs.

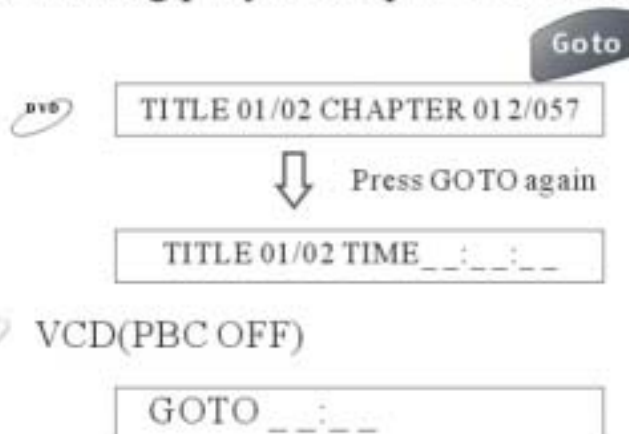
Playing from the desired location



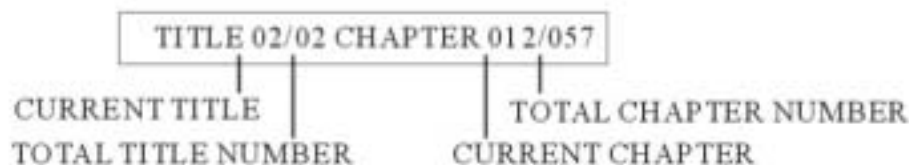
1 *Playing from the desired location*

Locating a specific location by entering the track number, the chapter number or the time.

① During playback, press GOTO.



② Input the chapter, the title or the time from which you want to start playback using the joystick and the numberkeys(0~9).



(When title 2 is input)

TITLE 02/02 CHAPTER 01 2/057

(When chapter 12 is input)

TITLE 01/02 TIME 01:30:00

(When 1 hour, 30 minutes is input as the elapsed time)

GOTO 30:00

(When 30 minutes is input as the elapsed time)

Notes:

- Input the hours first, followed by the minutes, then the seconds.
- Press CLEAR to delete all digits you input.
- Press GOTO to cancel the search mode and resume normal playback.
- Some discs may not respond to this process.
- Some scenes may not be located precisely as you specified.
- This method for accessing specific locations is available only within the current title of the DVD video disc or within the current track of the VIDEO CD/audio CD.

③ Press ENTER

Playback starts from the selected chapter, track or the time.

ENTER

Chapter/track/title repeat playback

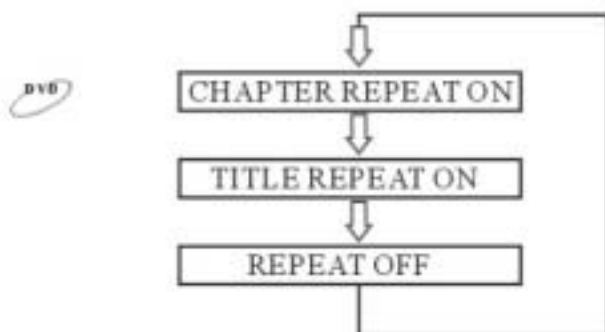
Switching the audio language



1 Chapter/track/title repeat playback

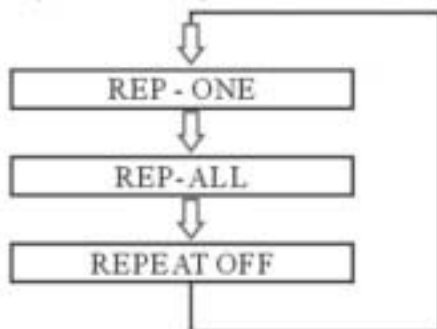
REPEAT

- ① During playback, Press REPEAT
The repeat mode switches each time the button is pressed.



VCD CD

VCD(PBC OFF)



2 Switching the audio language

DVD VCD

On DVDs including multiple audio modes or multiple audio languages, the audio language can be switched during playback.

- ① During playback, press AUDIO.

AUDIO

The sound switches between the different audio modes recorded on the disc each time the button is pressed.

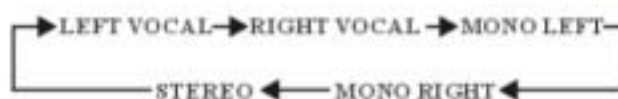
Notes:

- The language selected with the default setting is set when the power is turned on or the disc is replaced. If the disc does not include that language, the disc's default language is set.
- For some discs it is not possible to switch the audio language during playback.
- Some time may be required for the audio language to change.

Video CDs with multiplex audio

- ① During playback, press AUDIO.
The combination of the left and right channels changes each time the button is pressed.

AUDIO



Switching the angle Switching the subtitles



1 Switching the angle

With DVDs on which images photographed from multiple angles are recorded, the angle can be switched during playback.

① *During playback, press ANGLE.*

The angle switches between the angles recorded on the disc each time the button is pressed.



Note:

- Some time may be required for the angle to change.

2 Switching the subtitles

With DVDs on which multiple subtitle languages are recorded, the subtitle language can be switched during playback.

① *During playback, press SUB.*

A callout box containing the text 'SUB', with a line pointing to the 'SUB' button on the remote.

The subtitle language switches between the languages recorded and you also can select whether to display the subtitles on the disc each time the button is pressed.

Note:

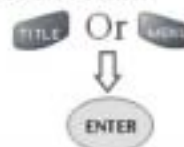
- Some time may be required for the subtitle to change.
- The language selected with the default setting is replaced. If the disc does not include that language, the disc's default language is set.
- For some discs, the subtitles will be displayed even when this is set to off.

Tips

Switching from the menu

For some discs, the audio language, angle and subtitle can be switched from the disc menu.

Press MENU or TITLE, select the item, then press ENTER.




Displaying the disc status

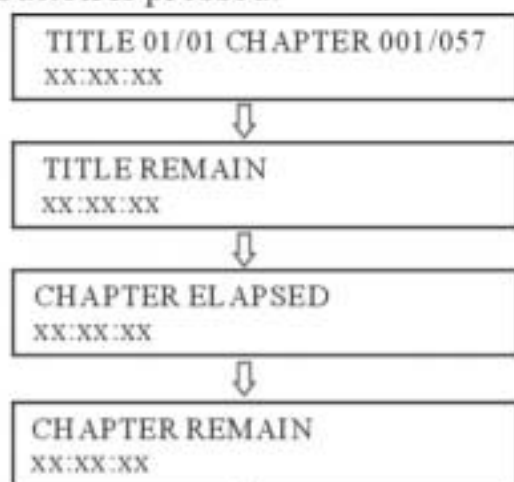


1 Displaying the disc status

Use the procedure described below to display the status (title number, chapter number, etc.) of the currently playing DVD on the screen.

- ① *During playback, press DISPLAY.* 

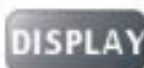
The playback status switches each time the button is pressed.



the display turns off.

2 Displaying the disc status

Use the procedure described below to display the status (track number, etc.) of the currently playing Video CD or Audio CD on the screen.

- ① *During playback, press DISPLAY.* 

The playback status switches each time the button is pressed.



Adjusting the sound setting



1 Adjusting the sound setting

DVD VCD CD MP3

The sound settings can be changed to suit your personal preferences and usage.

SEL

To select the audio functions as you like:

To	Press SEL button on the remote repeatedly until the item you want to adjust appears on the screen	Press the VOL +,- button adjust the setting as you like
Balance	BALANCE : L00	The level changes from L08~L00 and L00~R08
Bass	BASS : -00	The level changes from -07~+07
Treble	TREBLE : -00	The level changes from -07~+07
Loudness	LOUDNESS ON	ON or OFF
Volume	VOLUME 18	The level changes from 00~36

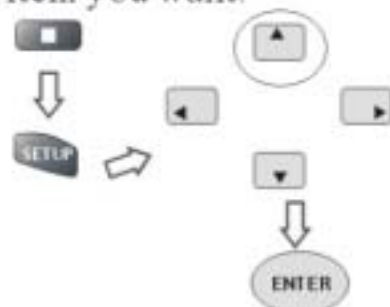
Changing the default settings(setup)



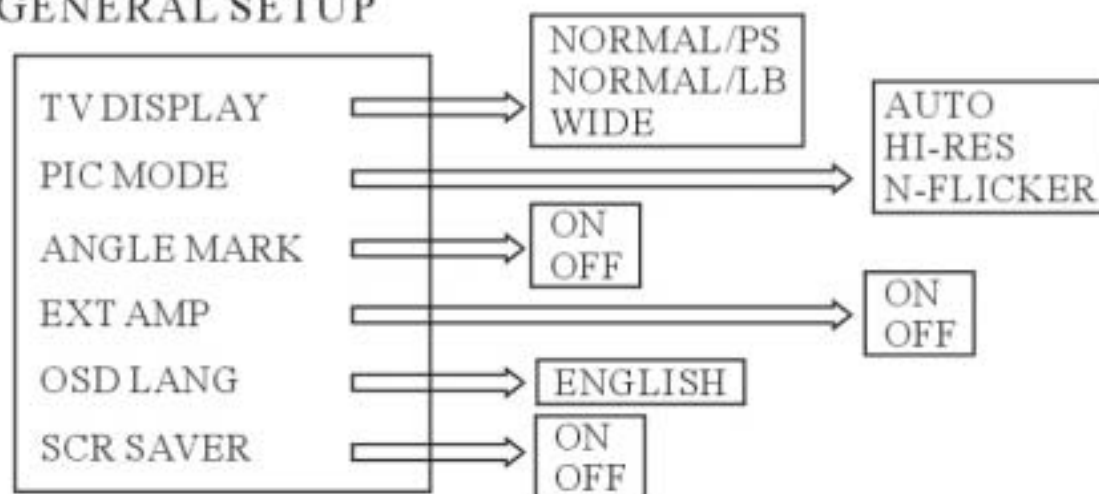
1 Changing ^{DVD VCD CD MP3} the default settings(setup)

Press SETUP during stop.
The setting menu appears.
Press joystick button to move the cursor to the item, then press ENTER to select the item you want.

SETUP MENU	MAIN PAGE
GENERAL	SETUP
SPEAKER	SETUP
AUDIO	SETUP
PREFERENCES	
EXIT	SETUP

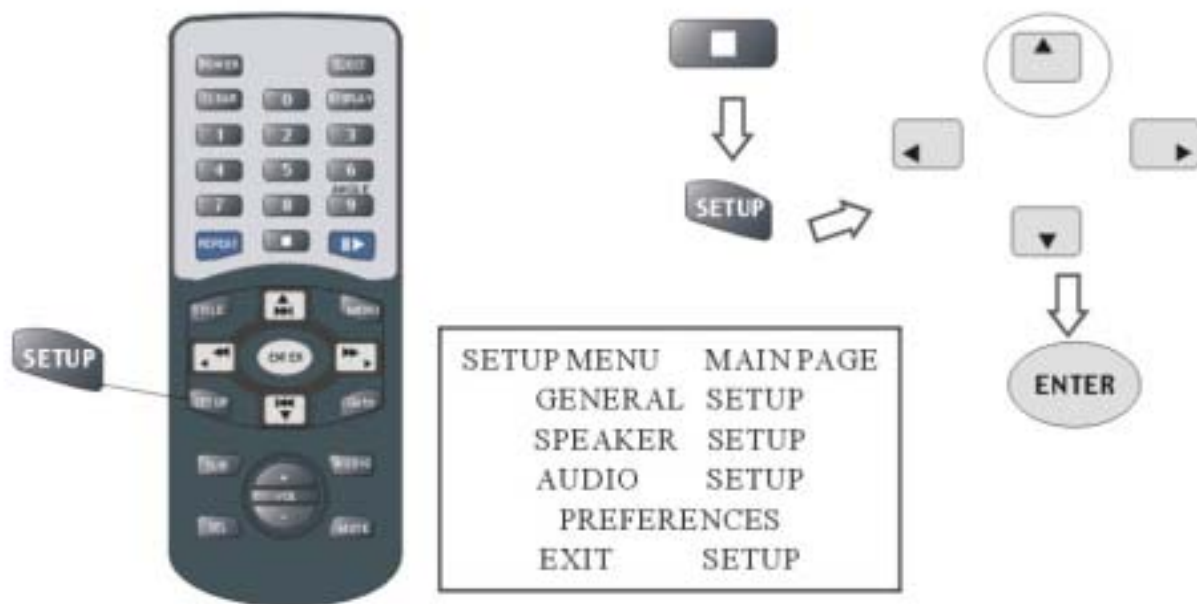


① GENERAL SETUP



TV DISPLAY	SET TV DISPLAY MODE	NORMAL/PS	NORMAL TV PAN SCAN
		NORMAL/LB	NORMAL TV LETTER BOX
		WIDE	WIDE SCREEN TV
PIC MODE	SET PICTURE MODE	AUTO	AUTO MODE
		HI-RES	HIGH-RESOLUTION MODE
		N-FLICKER	NONFLICKER MODE
ANGLE MARK	ANGLE ON/OFF		
EXT AMP	TURN EXT AMP ON/OFF		
OSD LANG	SET OSD LANGUAGE		
SCR SAVER	SCREEN SAVER		

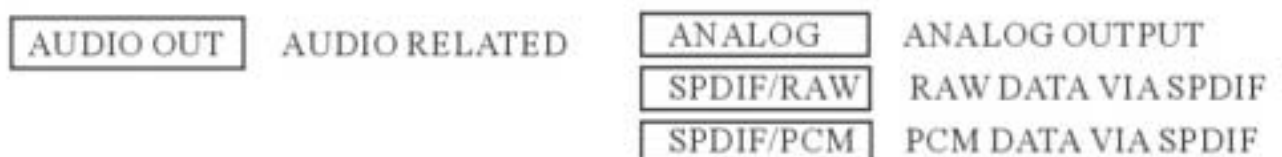
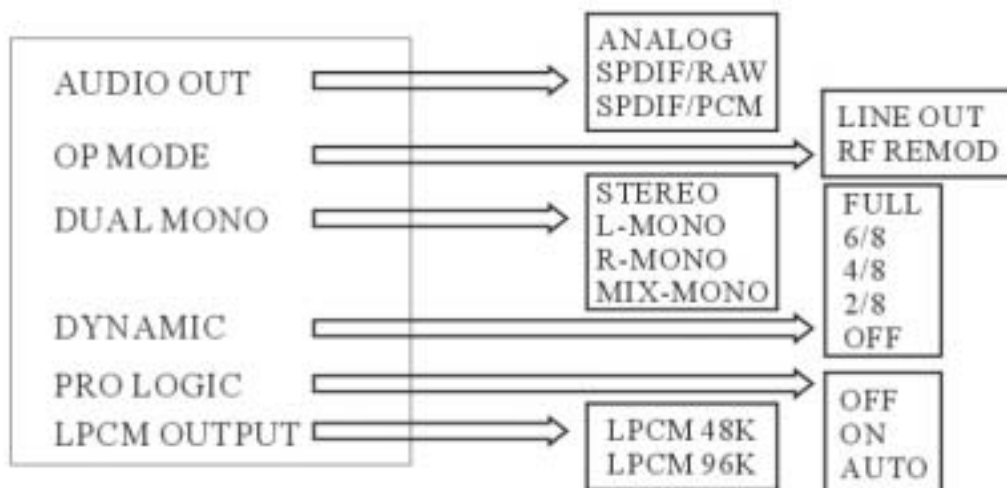
Changing the default settings(setup)



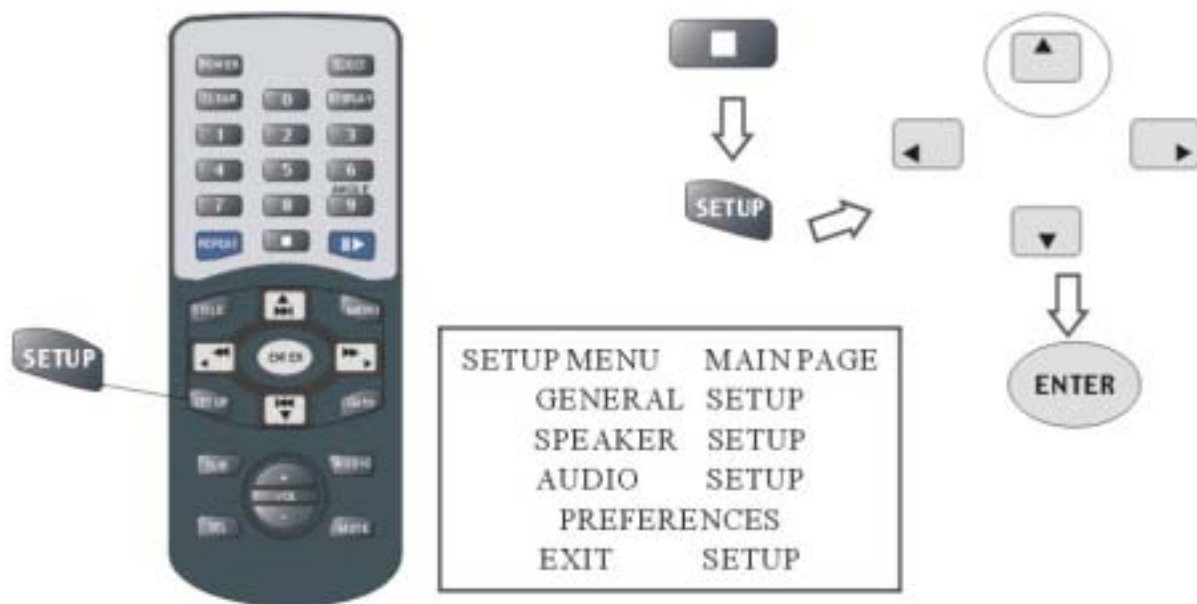
② SPEAKER SETUP



③ AUDIO SETUP

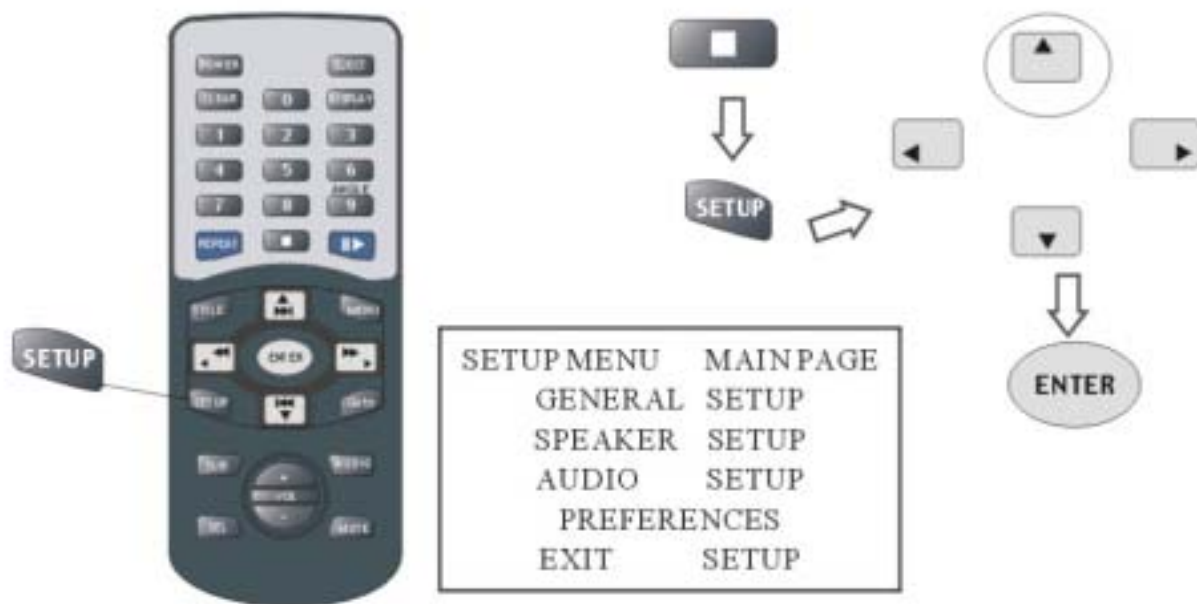


Changing the default settings(setup)

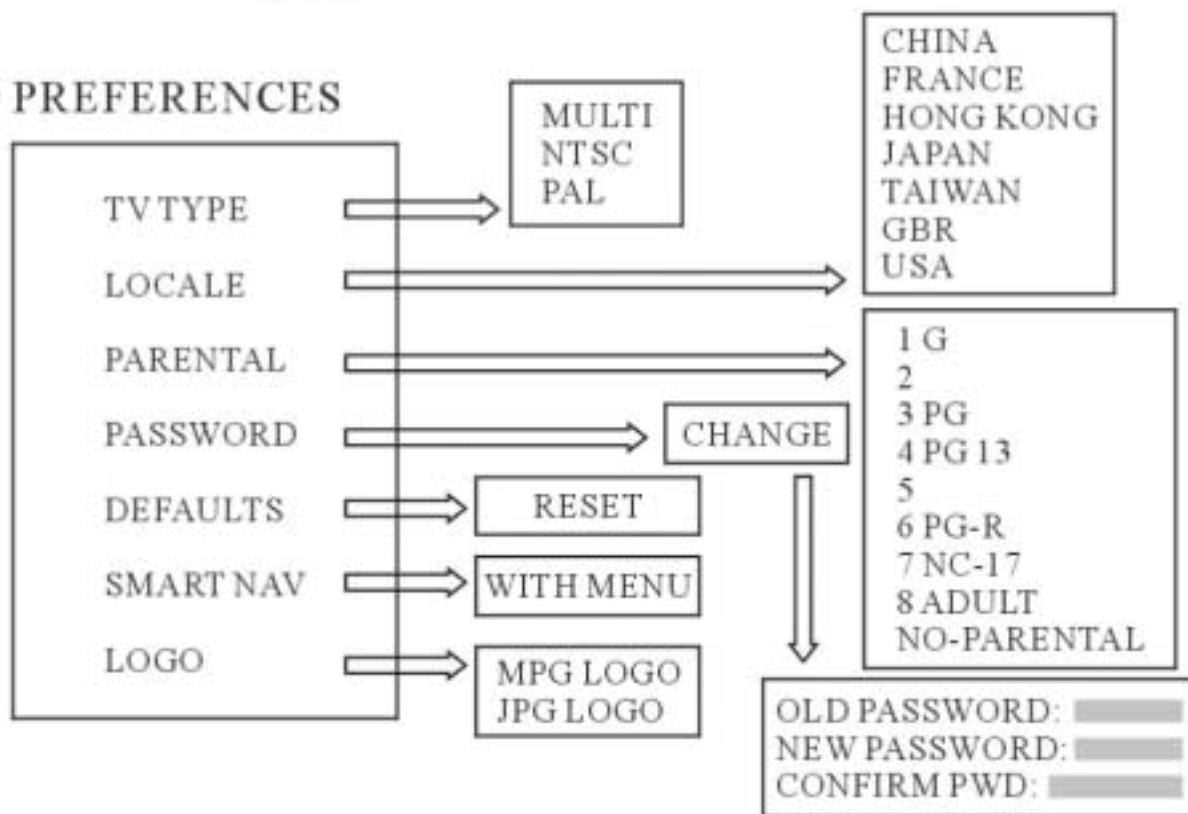


OP MODE	OPERATIONAL MODE SETUP	LINE OUT	LINE OUT MODE
		RF REMOD	TV WITH NO AV INPUT
DUAL MONO	DUAL MONO(1+1) SETUP	STEREO	SET STEREO MODE
		L-MONO	SET LEFT MONO MODE
		R-MONO	SET RIGHT MONO MODE
		MIX-MONO	SET MIXED MONO MODE
DYNAMIC	DYNAMIC RANGE COMPRESSION	FULL	FULL DYNAMIC RNG COMPRESSION
		--	DYNAMIC RNG COMPRESSION 7/8
		6/8	DYNAMIC RNG COMPRESSION 3/4
		--	DYNAMIC RNG COMPRESSION 5/8
		4/8	DYNAMIC RNG COMPRESSION 1/2
		--	DYNAMIC RNG COMPRESSION 3/8
		2/8	DYNAMIC RNG COMPRESSION 1/4
		--	DYNAMIC RNG COMPRESSION 1/8
		OFF	DYNAMIC RNG COMPRESSION OFF
PRO LOGIC	SET PRO LOGIC ON/OFF	OFF	PRO LOGIC OFF
		PRO	LOGIC ON ON
		AUTO	PRO LOGIC AUTO
LPCM OUTPUT	SET LPCM TO 48K OR 96K	LPCM 48K	LPCM OUTPUT 48K
		LPCM 96K	LPCM OUTPUT 96K

Changing the default settings(setup)



④ PREFERENCES



TV TYPE SET TV STANDARD

MULTI MULTISYNC TV

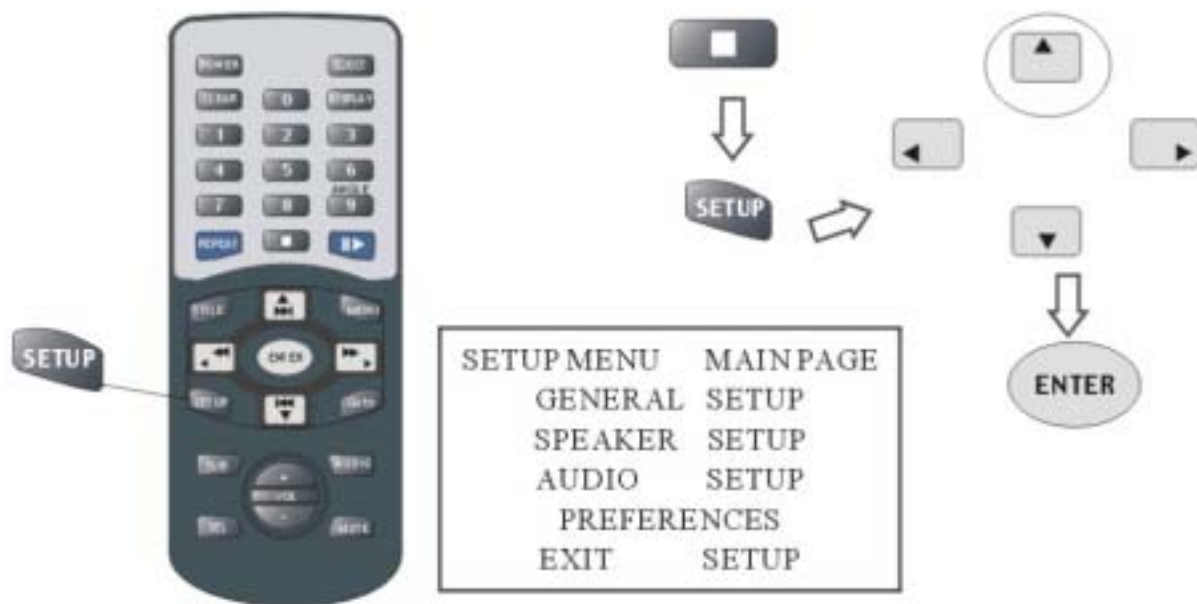
NTSC NTSC TV

PAL PAL TV

LOCALE PREFERRED LOCALITY CODE

GRB UNITED KINGDOM

Changing the default settings(setup)



SETUP MENU	MAIN PAGE
GENERAL	SETUP
SPEAKER	SETUP
AUDIO	SETUP
PREFERENCES	
EXIT	SETUP

PARENTAL

SET PARENTAL CONTROL

1 G
2
3 PG
4 PG 13
5
6 PG-R
7 NC-17
8 ADULT
NO-PARENTAL

SET TO G, LEVEL 2, PG, PG13, LEVEL 5, PG-R, NC-17, ADULT, OR NO-PARENTAL

PASSWORD

CHANGE

OLD PASSWORD:	_____
NEW PASSWORD:	_____
CONFIRM PWD:	_____

DEFAULTS

RESET

LOAD FACTORY SETTINGS

SMART NAV

SMART NAV TYPE

WITH MENU

PLAYING MP3 WITH MENU

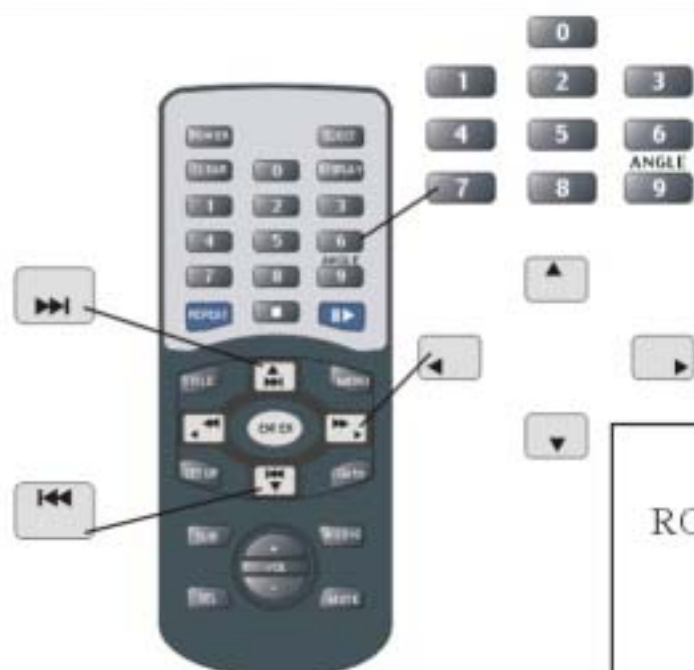
LOGO

OPEN SCREEN LOGO

MPG LOGO

JPG LOGO

MP3 instruction



↑ Mp3 instruction

Insert the MP3 disc then playback starts, the MENU of elapsed track appears.

	SMART	NAV 1	
ROOT	MP3	J&Z	1
	Mp3	xxx	2
	MP3	xxx	3
	Mp3	xxx	4
	Mp3	xxx	5
PLAY MODE	REP-ONE		

PRESS	
⏮ ⏭	To play the preceding or the next track
◀ ▶	In play mode, it starts to fast-forward or fast-revers
Number button	To select the track with the number button Note: For some discs it is not possible to select items for the menu to menu screen using the number buttons (0~9).
PLAY MODE	In stop mode, move cursor to PLAY MODE with joy stick ◀ ▶, pressing joy stick ▼ ▲ to change PLAY MODE: SINGLE, REP-ONE, FOLDER, FOLDER REP, DISC SCAN, DISC, DISC REP, RANDOM, SHUFFLE ON, PROGRAM P0. Select the play mode, then move the cursor back to the track menu and you desired track with ◀ ▶ ▼ ▲, finally press PLAY to start playback again. Desired
DISPLAY	STATUS DISPLAYED: CHAPTER ELAPSED XX:XX:XX CHAPTER REMAIN XX:XX:XX
Playing MP3 disc, the play position memory is not available.	

Others

In case of difficulty

If operation freezes, the screen goes black or the unit should otherwise not function properly, try turning the power off then back on. Alternatively, try the following methods in the order listed until the unit returns to normal playback mode.

1) Turn the car's ignition OFF and back ON again.

2) Press the RESET button on the face of the unit

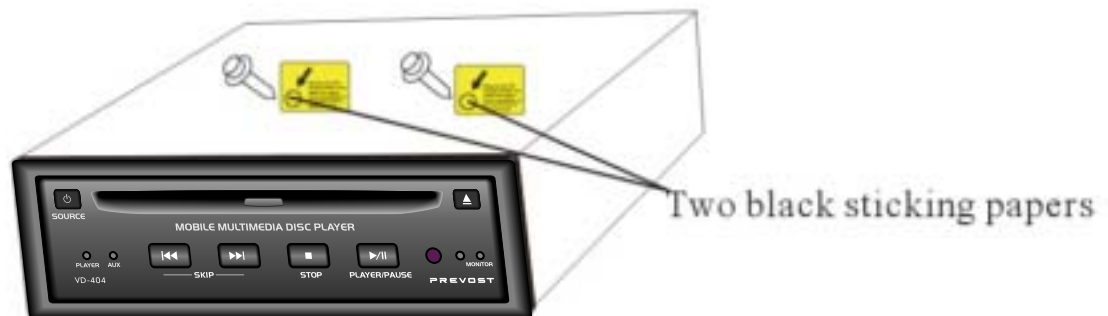
This guide will help you isolate the problem if the unit is at fault. Otherwise, make sure the rest of your system is properly connected or consult a professional mobile video installer.

<i>Symptom</i>	<i>Cause</i>	<i>Remedy</i>
Unit does not operate.	Fuse is blown.	Replace with a fuse of the specified capacity.
	Monitor's power is not turn on.	Turn on the monitor's power
	Condensation	Wait a while(about 1 hour) for the condensation to dry.
Operation is unstable.	Remote control unit's battery is worn.	Replace the remote control unit's battery with new one.
	Remote control sensor or transmitter is dirty.	Clean the sensor or transmitter.
No picture is produced.	Monitor's mode is not switched to the mode you want to see.	Switch to the mode you want to see.
Playback does not start.	Disc is loaded upside-down.	Check the disc and load it with the labeled side facing upward.
	Disc is dirty.	Clean the disc.
	A disc not able to playback with this unit is loaded.	Check if the disc is able to be played back.
	Parental lock is set.	Cancel the parental lock or change the rating level.
Picture is unclear or noisy	Disc is being fast-forwarded or fast-reversed.	The picture may be slightly disturbed, but this is normal.
	Vehicle's battery power is weak.	Check the battery power and wiring. The unit may malfunction if the battery power is under 10.8 volts with a load applied.
	Monitor's fluorescent tube is worn.	Replace the monitor's fluorescent tube.
Image stops sometimes.	Disc is scratched.	Replaced with a non-scratched disc.
No disc	No disc is loaded.	Load a disc.
	Disc is dirty.	Clean the disc.
Not valid	Remote control operation is not possible.	For some discs or playing modes, certain operations are not possible. This not a malfunction.
VIDEO SIGNAL SYSTEM IS NOT CORRECT	PAL(or NTSC) disc is loaded.	Change the TV TYPE of the unit(see SETUP).
No sound	Select the wrong Audio Out	According to the connection, set ANALOG for using audio cable, set SPDIF/RAM/PCM for using coaxial cable. See page 7,8 and 19.

Specifications

Note

Note



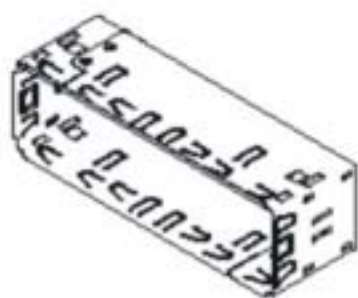
There are 2 mounting screws on the case of the DVD player(as above figure shows) to protect the unit during shipping.

You need to remove the sticking papers and screws after unpacking this product. Apply the black sticking papers(supplied)on the screw holes to keep out dust.

Specifications

<i>Audio</i>	Audio output(analog) : Audio output(coaxial): Signal-to-noise ratio: Dynamic range: Distortion:	$2 \pm 0.2V$ 100k Ω 0.5V 75 Ω more than 90dB more than 85dB less than 0.08%
<i>Video</i>	Video output: Resolution:	$1 \pm 0.2V$ more than 500 line
<i>Power</i>	Power requirement: Power consumption:	$12^{+20\%}_{-10\%}$ VDC , 1.5A less than 20W
<i>General</i>	Dimensions(approx.): Weight: Normal operating temperature range:	178x50x183mm (w/h/d)incl. Projecting parts 1.4Kg 23 $^{\circ}$ F to 131 $^{\circ}$ F
<ul style="list-style-type: none">• Design and specifications are subject to change without notice.• The illustrations in this manual may appear different from the actual product due to printing conditions.		

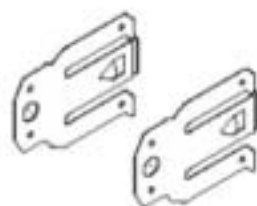
Accessories and Hardware



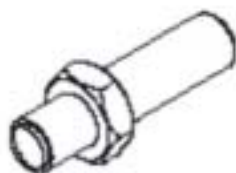
Mounting Bracket
(Half Sleeve) × 1



Rear Strap
(Brace) × 1



Side bracket × 2



Mounting Screw M5
× 1



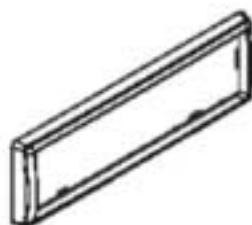
Hex bolt M5 x 14
× 2



Flat head screw M5 × 4
× 2



Mounting Grommet
× 1



Removable Trim Ring
equipped on the unit
× 1



Remote control × 1



Lithium Button Cell (3V) × 1



IR sensor × 1

SECTION 24: LUBRICATION

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Section 24: LUBRICATION

1. LUBRICATION

The efficiency and life expectancy of mechanical equipment is largely dependent on proper lubrication and servicing. All mechanical components rely on a lubricating film between moving parts to reduce friction, prevent wear and oxidation. Proper lubrication also helps cool the parts and keep dirt particles away from mating surfaces. Efficient lubrication depends upon using the right type of lubricant, at specified intervals and by filling to correct capacities. Past experience shows that many service problems can be traced to an improper lubricant or to incorrect lubrication procedures.

A comprehensive maintenance and lubrication program is important to ensure the long service life this vehicle was designed for and to avoid costly repairs and associated downtime caused by premature part failure.

A lubrication schedule is included in this section to give the location of key service points on the vehicle as well as the lubricant specifications for each component to be serviced. Specific instructions on how to check and service different components are covered in their respective sections in this maintenance manual.

The recommended lubrication intervals are based on normal operating conditions and mileage accumulation.

Shorten the intervals if your vehicle operates in more severe conditions. Severe conditions include heavy towing, high vehicle weight or operation in mountainous areas. Some parts and equipment referred to in this section may not be installed on your vehicle. Check your vehicle's "Coach Final Record" for equipment list.

Dispose of used lubricants and filters in an environmentally safe manner, according to federal and/or local recommendations.

2. LUBRICATION AND SERVICE SCHEDULE

Following this service schedule is the most economical and easiest way to ensure your vehicle performs at its best, safest and longest. Also, unscheduled maintenance will be minimized since inspection should expose potential problems before they become major ones.

2.1 FLEXIBLE HOSE MAINTENANCE


The performance of engine and equipment are greatly related to the ability of flexible hoses to supply lubricating oil, air, coolant, and fuel oil. Maintenance of hoses is an important step to ensure efficient, economical, and safe operation of the engine and related equipment.

2.1.1 Hose Inspection

Check hoses daily as part of the pre-starting inspection. Examine hose for leaks, and check all fittings, clamps, and ties carefully. Ensure that hoses are not resting on or touching shafts, couplings, heated surfaces including exhaust manifolds, any sharp edges, or other obviously damaging areas. Since all machinery vibrates and moves to a certain extent, clamps and ties can fatigue with time. To ensure proper support, inspect fasteners frequently and tighten or replace them as necessary.

2.1.2 Leaks

Investigate leaks immediately to determine if fittings have loosened or cracked, and also if hoses have ruptured or worn through. Take corrective action immediately. Leaks are not only potentially detrimental to machine operation, but can also result in added expenses caused by the need to replace lost fluids.

 WARNING
Personal injury and/or property damage may result from fire due to the leakage of flammable fluids, such as fuel or lube oil.

2.1.3 Service life

The limited service life of a hose is determined by the temperature and pressure of the gas or fluid within it, the time in service, its installation, the ambient temperatures, amount of flexing, and the vibration it is subjected to. With this in mind, it is recommended that all hoses be thoroughly inspected at least every 500 operating hours or after 15,000 miles (24 000 km). Look for surface damage or indications of damaged, twisted, worn, crimped, brittle, cracked, or leaking lines. Hoses having a worn outer surface or hoses with a damaged metal reinforcement should be considered unfit for further service.

It is also recommended that all hoses in this vehicle be replaced during major overhaul and/or after a maximum of five service years. Quality of replacement hose assemblies should always be equal to or superior to those supplied by the Original Equipment Manufacturer.

Section 24: LUBRICATION

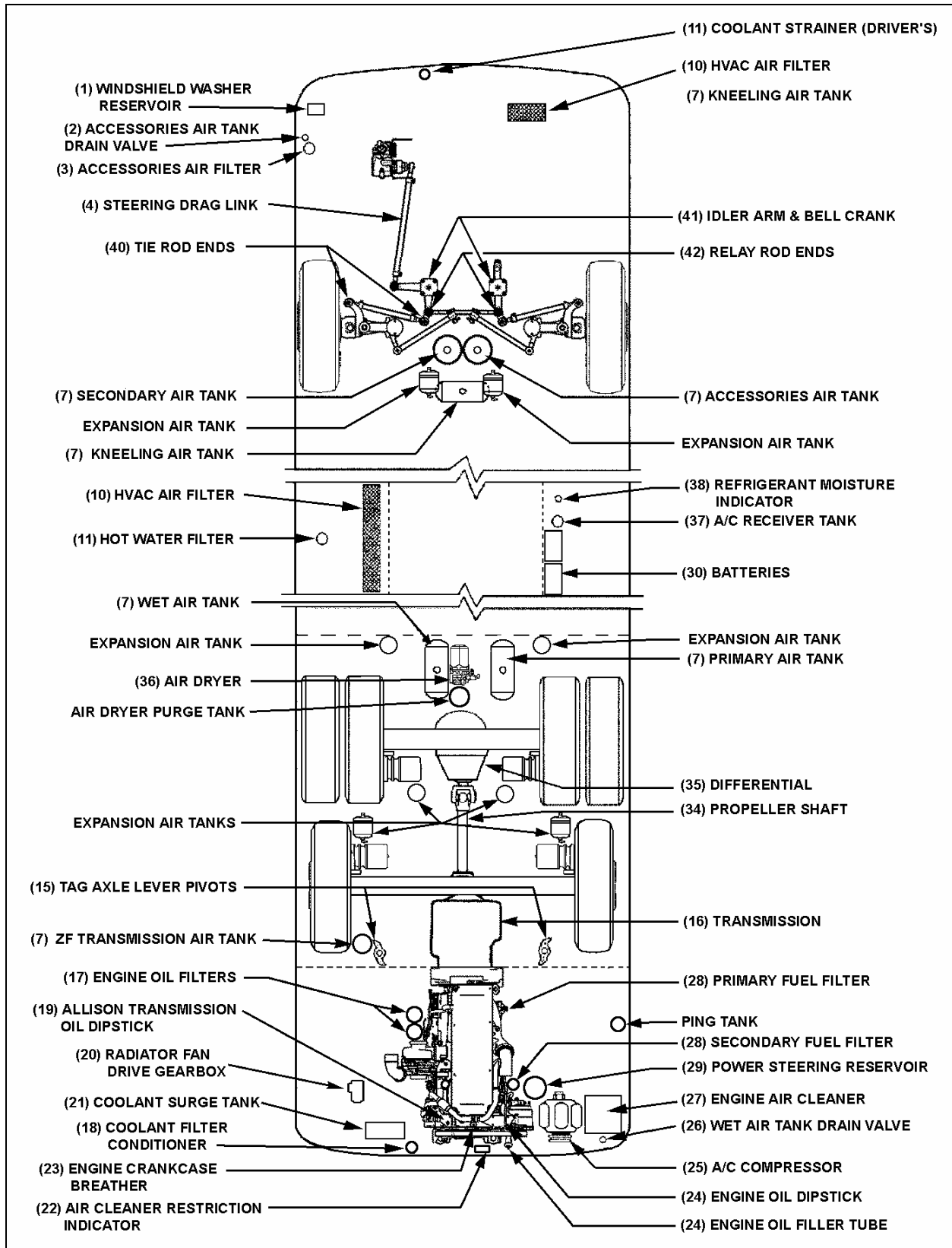


FIGURE 1: LUBRICATION AND SERVICING POINTS ON INDEPENDENT FRONT SUSPENSION VEHICLES

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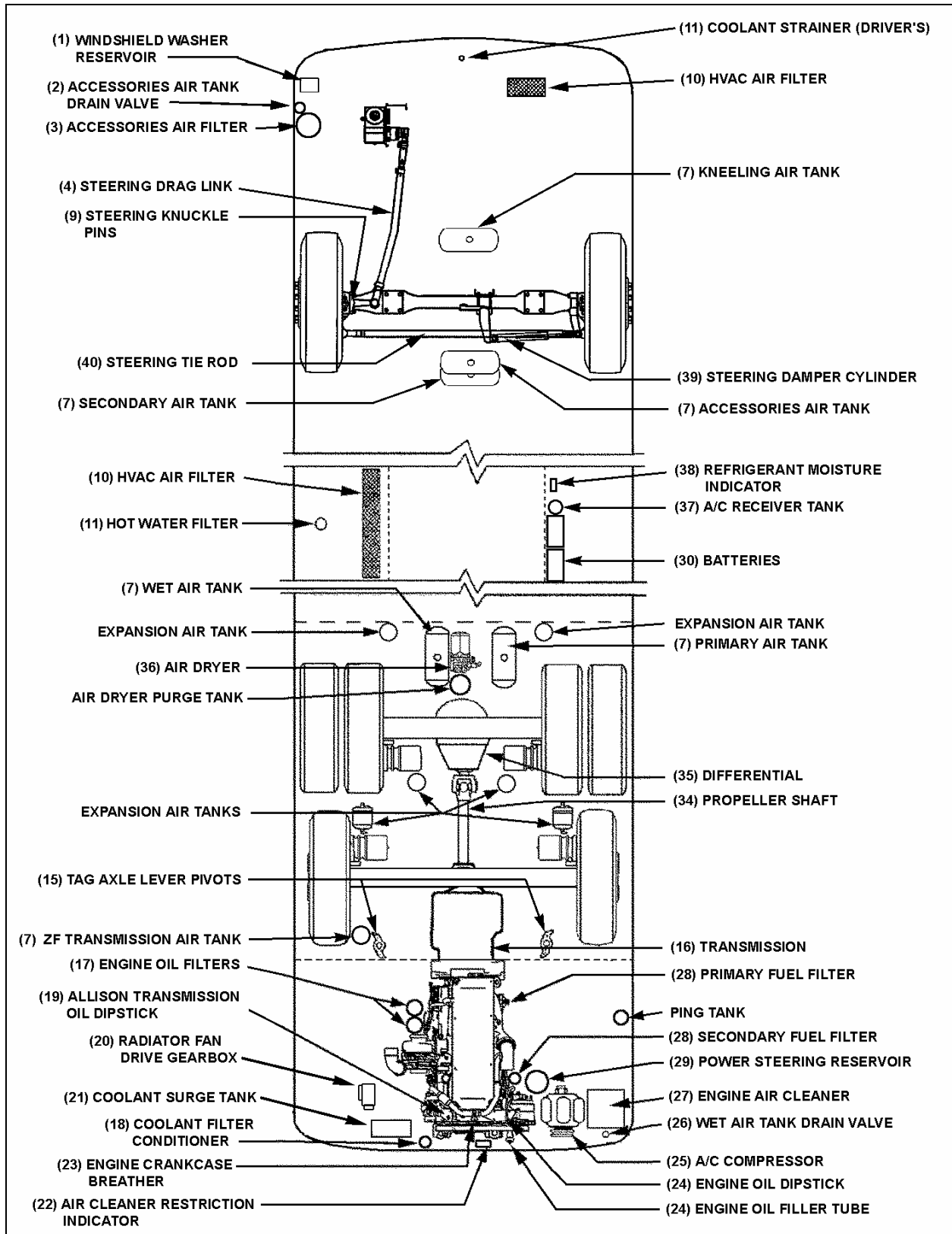


FIGURE 2: LUBRICATION AND SERVICING POINTS ON I-BEAM AXLE FRONT SUSPENSION VEHICLES

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Section 24: LUBRICATION

2.2 LUBRICANT AND COOLANT SPECIFICATIONS

REF	DESCRIPTION	SPECIFICATIONS
A	Engine Oil	DETROIT DIESEL SERIES 60 SAE Viscosity Grade: 15W-40 API Classification: CJ-4
		VOLVO D13 SAE Viscosity Grade: 15W-40 API Classification: CJ-4 meeting Volvo specification VDS-4
B	Power Steering Oil	Automatic Transmission Oil, Dexron-III
C	Engine Coolant	DETROIT DIESEL SERIES 60 Low silicate, ethylene glycol coolant 50% antifreeze/water solution is normally used Antifreeze concentration should be between 30% and 67%
		VOLVO D13 Texaco or Chevron Extended Life Coolant (ELC) 50% antifreeze/water solution is normally used
D	A/C Compressor Oil	Central HVAC system: Polyolester oil, HFC 134a compatible; Castrol SW-68 (POE) or equivalent
		Small HVAC system: PAG oil
E	Differential Oil	Multigrade gear oil meeting MIL-L-2105-D: 85W140. If temperature drops below 10°F (-12°C), 80W90 should be used. Below -15°F (-26°C), 75W90 should be used. (In extreme conditions or for better performance, full synthetic gear oil can be used.)
F	Differential Oil (Full Synthetic)	Multigrade gear oil meeting MIL-L-2105-D: 85W140. If temperature drops below 10°F (-12°C), 80W90 should be used. Below -15°F (-26°C), 75W90 should be used.
G	Cooling Fan Gearbox Oil	Synthetic gear lubricant 75W-90
H	Allison Automatic Transmission Oil	Castrol TranSynd™ Synthetic Transmission Fluid for Allison or TES 295 approved equivalent
I	Allison Automatic Transmission Oil	Dexron-VI® or approved equivalent 1 Schedule 1 TES-389 fluids;
J	ZF-ASTronic Transmission Oil	Castrol Syntrans Grade SAE 75W-85 (Synthetic)
K	Multi Purpose Grease	Good quality lithium-base grease: NLGI No.2 Grade is suitable for most temperatures NLGI No.1 Grade is suitable for extremely low temperatures
L	Multi Purpose Grease	Molykote longterm 2/78 grease

2.3 PART NUMBER SPECIFICATIONS

REF	DESCRIPTION	PREVOST NO
P1	Engine oil filters	#510458
P2	Engine oil filters – Volvo D13	#510938 (one by-pass) (Volvo #477556) #478736 (two full-flow)
P3	Power steering oil reservoir filter element	#660987
P4	Engine air filter	#530197
P5	Refrigerant filter dryer unit	#950332 Central A/C syst. #950370 Small A/C syst.
P6	Primary fuel filter/water separator – DDC Series 60	#032700 #541407
P7	Racor primary fuel filter and water separator (optional) – DDC Series 60	#531390
P8	Secondary fuel filter – DDC Series 60	#510794
P9	Primary fuel filter cartridge (used with water separation bowl) - Volvo D13	#20879806
P10	Secondary fuel filter - Volvo D13	#20405160
P11	Engine coolant precharge element filter – DDC Series 60	#550629
P12	Engine coolant maintenance element filter – DDC Series 60	#550630
P13	Engine coolant filter cartridge - Volvo D13	#20458771
P14	HVAC driver's air filter	#871147-871144
P15	HVAC cabin air filter	#874272
P16	Allison transmission High Capacity fluid filter kit	#571709
P17	Accessories air filter element	#641340
P18	Air dryer cartridge	#3097369
P19	Fuel Pro 382 filter element	#510795
P20	Overhead compartment fan air filters	#871159
P21	Engine coolant	#685125
P22	Bosch T1 alternators, voltage regulator	#562981
P23	Bosch T1 alternators, brush set	#562983
P24	Bosch T1 alternators, ball bearing	#562972
P25	Bosch T1 alternators, roller bearing	#562976

2.4 LUBRICATION AND SERVICING SCHEDULE

For lubrication and servicing schedule, refer to table A.

IMPORTANT NOTE

Refer to the manufacturers documentation included in this maintenance manual for specific manufacturer's maintenance requirements.

