PREVOST

COACH MANUFACTURER

MAINTENANCE MANUAL

LE MIRAGE XLII

BUS SHELLS & COACHES

PA1218

(3rd edition)

SECTION 00: GENERAL INFORMATION

CONTENTS

ILLUSTRATIONS

1. FOREWORD

This manual includes procedures for diagnosis, service, maintenance and repair for components of the XL2 series coach or bus shell model 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.

Prévost Car 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 ⚠
Cut off battery power in main power compartment using battery safety switch.

1. Disconnect *"Ground"* cables from battery terminals.

NOTE
Disconnect "Ground" cables only.

2. If welding must be done near the dashboard i.e. steering column, you must disconnect all electronic control modules (radio & control head, HVAC, TTLT cluster Volvo). You must also disconnect alternator module located in front service compartment.
3. Disconnect three wiring harness connectors from ECM (Electronic Control Module). The ECM is mounted on the starter side of the engine.
4. For vehicles equipped with an Allison automatic transmission, disconnect three wiring harness connectors from ECU (Electronic Control Unit). The ECU is located in front service compartment.
5. For vehicles equipped with WCL system, disconnect electronic controller connector.
6. For vehicles equipped with ABS (Anti-Lock Brake System), disconnect wiring harness connectors from ABS Electronic Control Unit. The ABS Electronic Control Unit is located in front service compartment.
7. Cover electronic control components and wiring to protect from hot sparks, etc.
8. Do not connect welding cables to electronic control components.
9. Do the appropriate welding on vehicle.

⚠ CAUTION ⚠
Position welding machine ground clamp as close as possible to the work.

10. When welding is complete, reconnect ECM, ECU, ABS electronic control units, etc.
11. Terminate by reconnecting *"Ground"* cables to battery terminals.

STEEL – STEEL WELDING

⚠ CAUTION ⚠
Before welding, disconnect electronic modules and battery terminals.

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

⚠ WARNING ⚠
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 ½”	26 ± 2 volts	260 Amps	450 ipm. approx.	75% argon – 25% CO_2 or 100% 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 (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, disconnect electronic modules and battery terminals.

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

⚠ WARNING ⚠
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% CO_2
1/8” and more	Any type	22±1.5 volts	160±15 Amps	330 ipm approx.	90% He, 7.5% Ar, 2.5% CO_2

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:

⚠ WARNING ⚠
Identifies an instruction which, if not followed, could cause personal injuries.

⚠ CAUTION ⚠
Outlined an instruction which, if not followed, could severely damage vehicle components.

NOTE
Indicates supplementary information needed to fully complete an instruction. 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

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 is written on the option plate. Refer to this information when ordering replacement parts (Fig. 1).

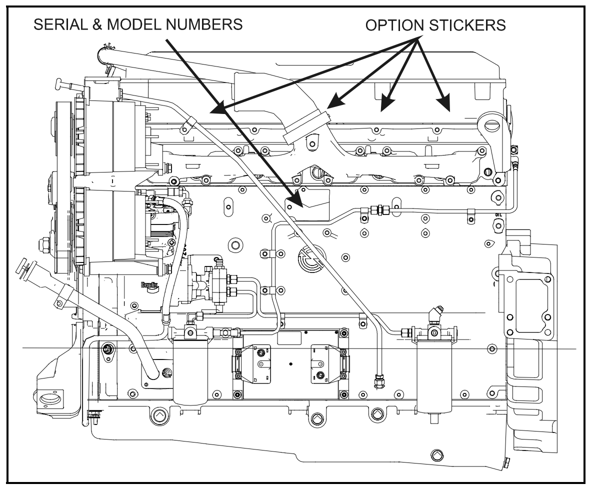


FIGURE 1 : DETROIT DIESEL SERIES 60 00043

4.1.2 Transmission

The transmission identification plate is located on the fluid level dipstick side of the transmission (WT) or on transmission, on the vehicle R.H. side (ZF) (Fig. 2 & 3). The identification plate shows the transmission serial number, part number (assembly number), and model number. Use all three numbers when ordering parts.

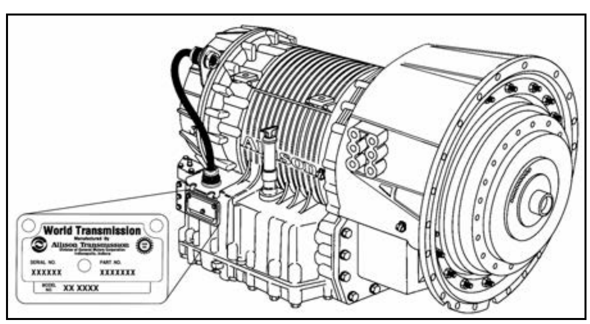


FIGURE 2: WORLD TRANSMISSION 07076

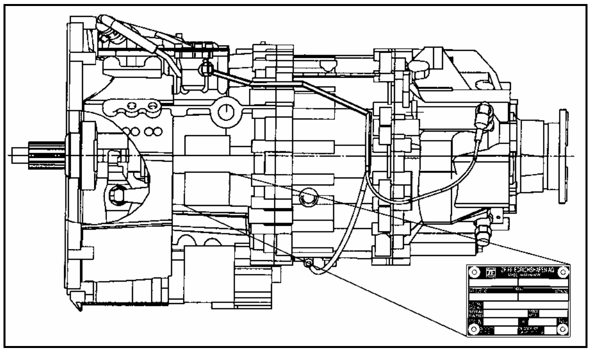


FIGURE 3: ZF-ASTRONIC TRANSMISSION 00040

4.1.3 Drive Axle

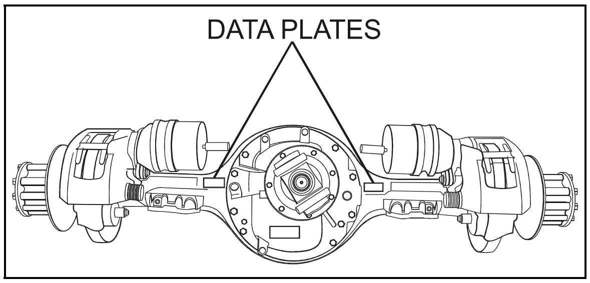


FIGURE 4: TYPICAL SERIAL & MODEL NUMBERS 11019

4.1.4 Front Axle

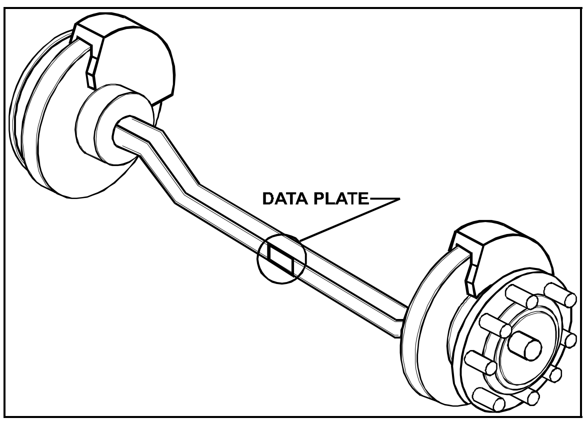


FIGURE 5: TYPICAL SERIAL & MODEL NUMBERS 10024

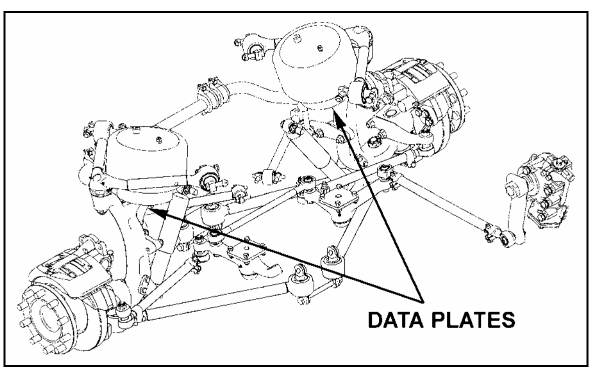


FIGURE 6: ISS TYPICAL SERIAL & MODEL NUMBERS

4.1.5 Power Steering Pump

Power steering pump serial number is located on a tag on the pump (Fig. 7). The pump is mounted on the engine beside the crankshaft pulley.

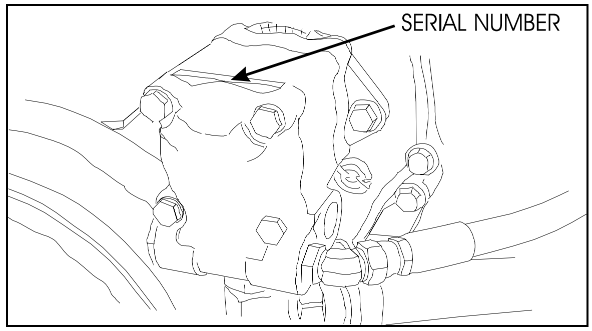


FIGURE 7 : POWER STEERING PUMP NAMEPLATE 00035

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 L.H. control panel.

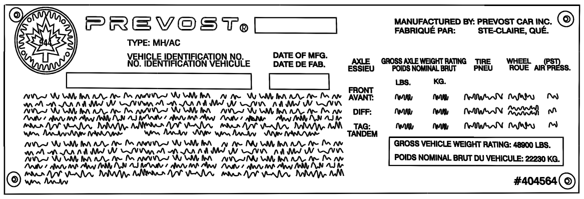


FIGURE 8: DOT CERTIFICATION PLATE 00016

4.1.9 EPA Engine Label

The exhaust emission certification label affixed to the rear junction box certifies that the engine conforms to federal and any state exhaust emission regulations (Fig. 9). It gives the operating conditions under which certification was made.

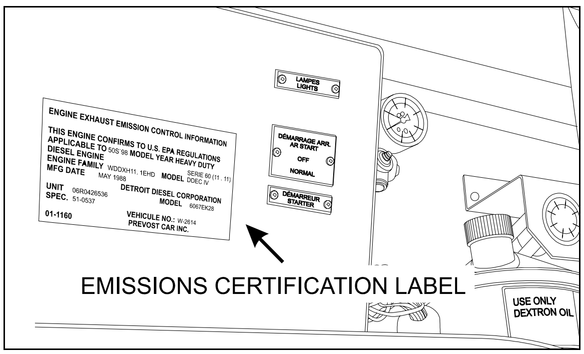


FIGURE 9 : ENGINE COMPARTMENT 00019

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. 10 & 11) 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.

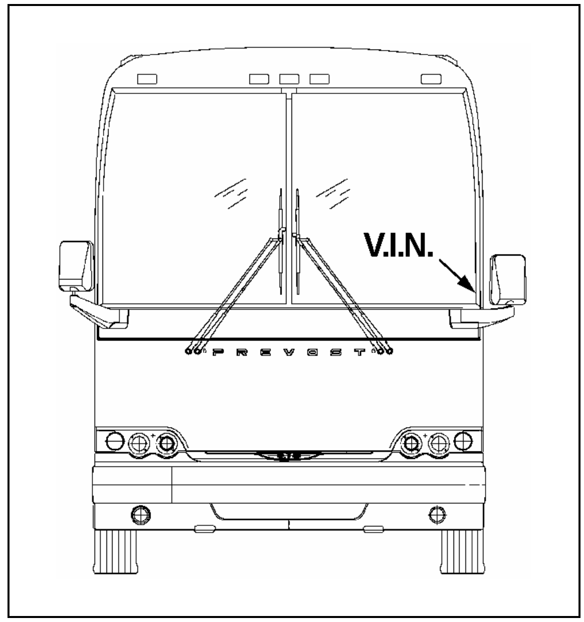
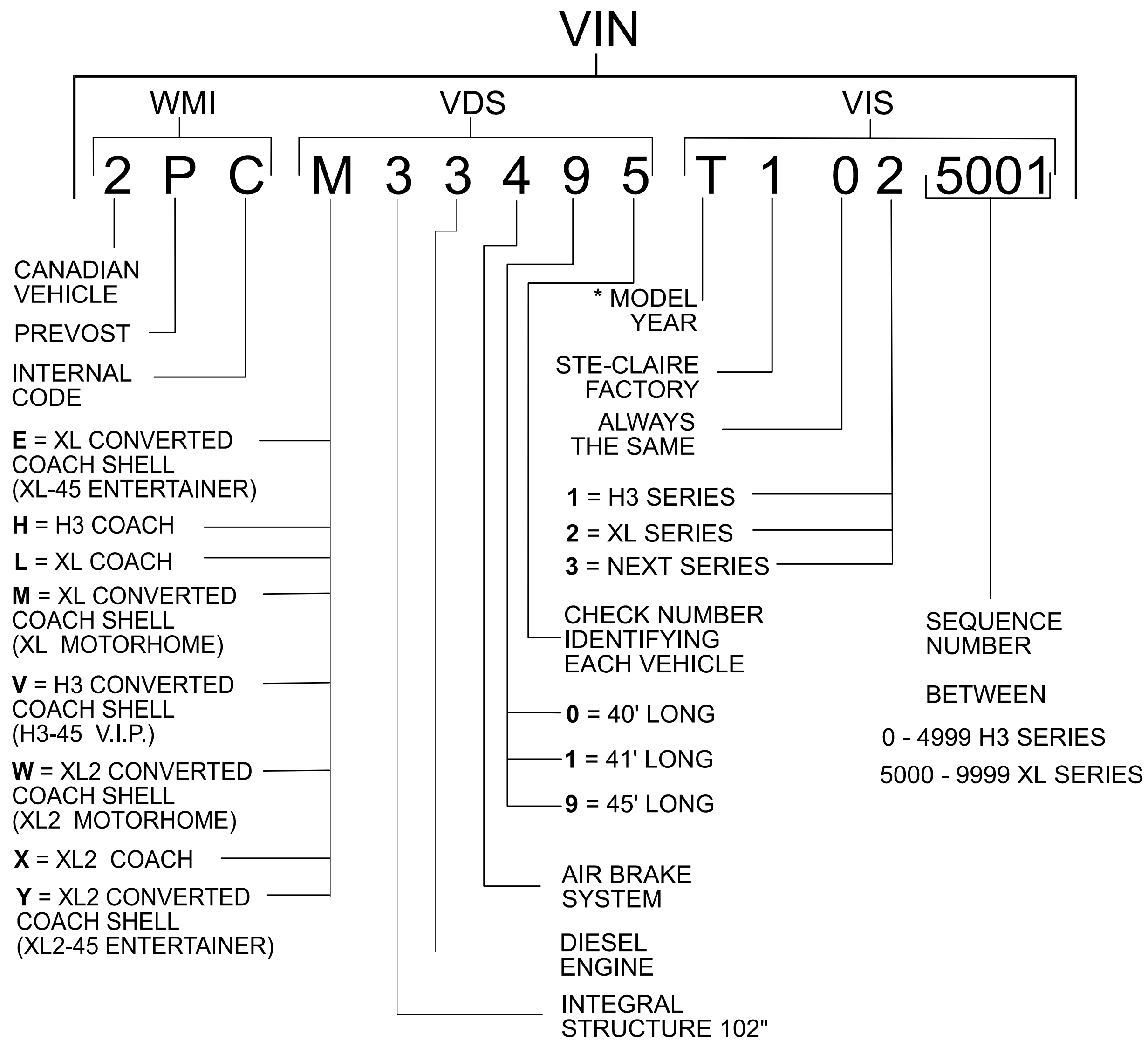


FIGURE 10 : VEHICLE I.D. 00020

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.



VIN Vehicle Identification Number: a structured combination of characters assigned to a vehicle by the manufacturer for identification purposes.

WMI World Manufacturer Identifier: Designating the manufacturer of the vehicle.

VDS Vehicle Descriptor Section: Provides information describing the general attributes of the vehicle.

VIS Vehicle Indicator Section: Combination of characters assigned by the manufacturer to distinguish one vehicle from another.

FIGURE 11 : VEHICLE IDENTIFICATION NUMBER VIN1

YEAR	CODE	YEAR	CODE
1995	S	2001	1
1996	T	2002	2
1997	V	2003	3
1998	W	2004	4
1999	X	2005	5
2000	Y	2006	6

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. 13 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 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.

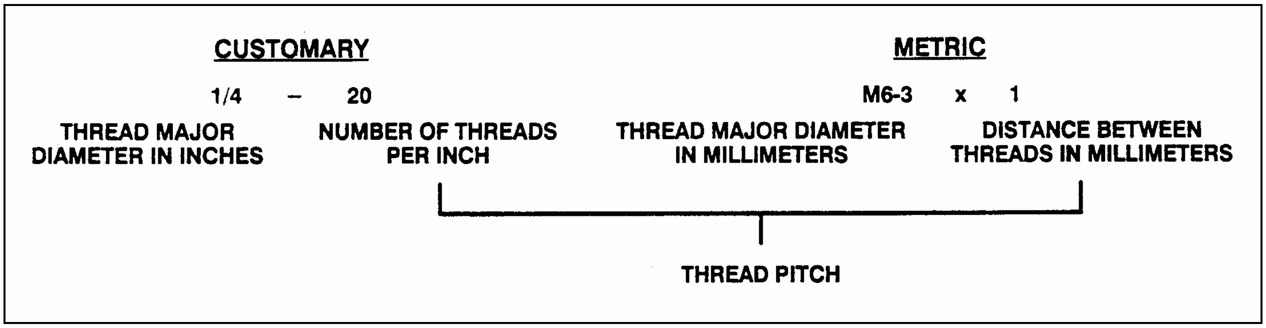


FIGURE 12 : THREAD NOTATION 00002

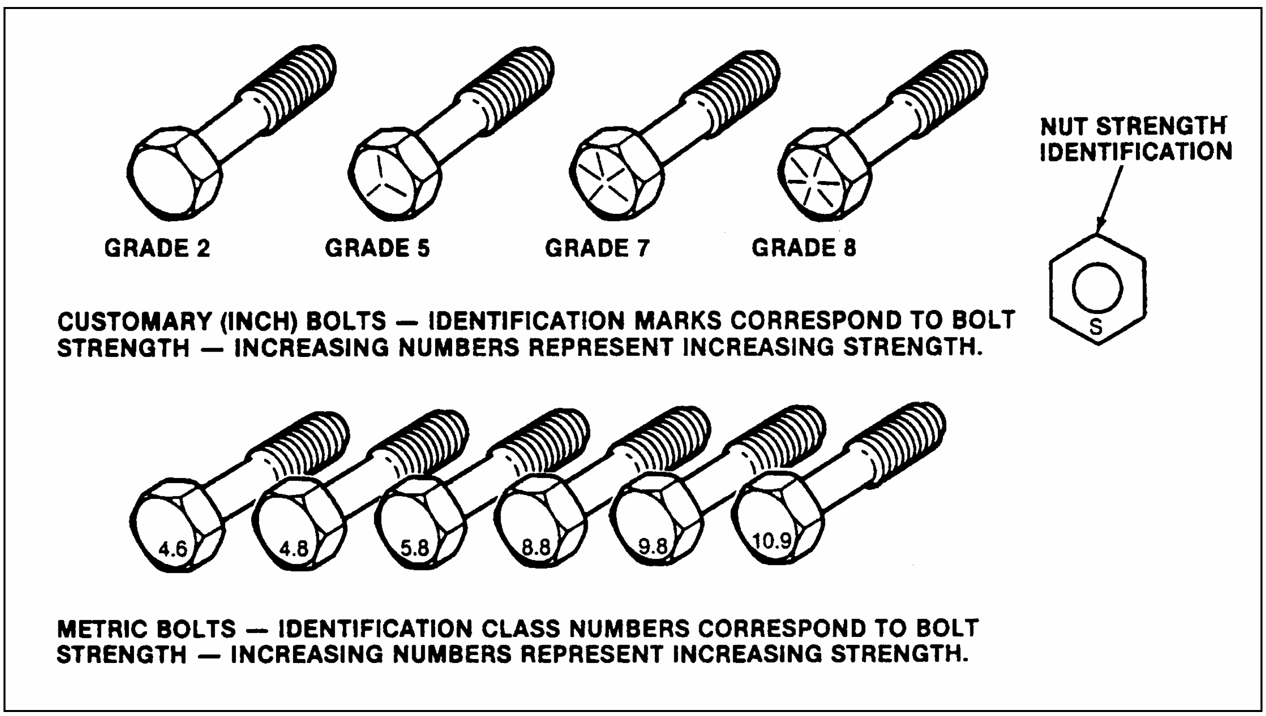


FIGURE 13: BOLT STRENGTH MARKINGS 00003

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;

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. 14).

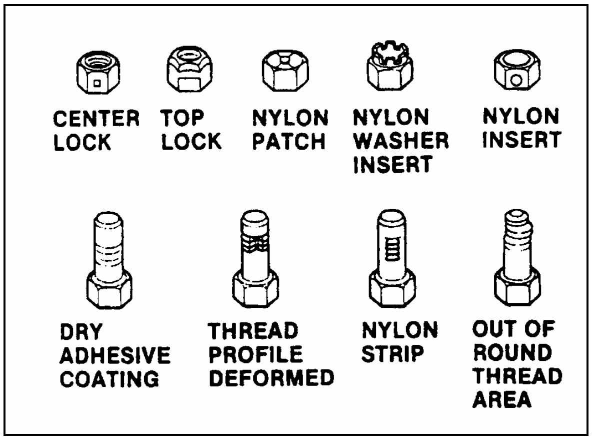


FIGURE 14 : SELF-LOCKING FASTENERS 00004

5.2 RECOMMENDATIONS FOR REUSE

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

a) Clean dirt and other foreign matter from the fastener;

b) 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;

c) Assemble parts and hand start fastener;

d) 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;

e) 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

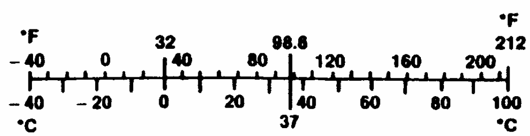
METRIC		6 & 6.3	8	10	12	14	16	20
NUTS AND ALL-METAL BOLTS	Nm	0.4	0.8	1.4	2.2	3.0	4.2	7.0
	Lbf-in	4.0	7.0	12	18	25	35	57
ADHESIVE OR NYLON COATED BOLTS	Nm	0.4	0.6	1.2	1.6	2.4	3.4	5.6
	Lbf-in	4.0	5.0	10	14	20	28	46

US STANDARD		.250	.312	.375	.437	.500	.562	.625	.750
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:
	LENGTH	
Inch	25.4	millimeters (mm)
Foot	0.305	meters (m)
Yard	0.914	meters
Mile	1.609	kilometers (km)
	AREA	
Inch^2	645.2	millimeters^2 (mm^2)
	6.45	centimeters^2 (cm^2)
Foot^2	0.093	meters^2 (m^2)
Yard^2	0.836	meters^2
	VOLUME	
Inch^3	16 387.0	mm^3
	16.387	cm^3
	0.016	liters (l)
Quart	0.946	liters
Gallon	3.785	liters
Yard^3	0.765	meters^3 (m^3)
	MASS	
Pound	0.453	kilograms (kg)
Ton	907.18	kilograms (kg)
Ton	0.907	ton (t)
	FORCE	
Kilogram	9.807	newtons (N)
Ounce	0.278	newtons
Pound	4.448	newtons
	TEMPERATURE	
Degree Fahrenheit	(† 0F − 32) ÷ 1.8	Degree Celsius (C)



Multiply	by	to get equivalent number of:
	ACCELERATION	
Foot/sec^2	0.305	meter/sec^2 (m/s^2)
Inch/sec^2	0.026	meter/sec^2
	TORQUE	
Pound-inch	0.113	newton-meters (N·m)
Pound-foot	1.35	newton-meters
	POWER	
Horsepower	0.746	kilowatts (kW)
	PRESSURE OR STRESS	
Inches of water	0.249	kilopascals (kPa)
Pounds/sq. in.	6.895	kilopascals
	ENERGY OR WORK	
BTU	1 055.0	joules (J)
Foot-pound	1.356	joules
kilowatt-hour	3 600 000.0 or 3.6 x 10^6	joules (J = one W's)
	LIGHT	
Foot candle	1.076	lumens/meter^2 (lm/m^2)
	VELOCITY	
Miles/hour	1.609	kilometers/hr (km/h)

FIGURE 15: 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 16: CONVERSION CHART 00006

CONTENTS

ILLUSTRATIONS

1. ENGINE

This vehicle is powered by a 6-cylinder, four-cycle, Detroit Diesel series 60 engine equipped with an electronic control system (DDEC V).

Two engine displacements are used in the Series 60 engines: 12.7 and 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 DDEC V Service Manual. This maintenance manual covers engine accessories, controls and related components.

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 a diagnostic code.

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

DDEC V (**D**etroit **D**iesel **E**lectronic **C**ontrol) controls the timing and quantity 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 Electronic Control Module (ECM). The ECM computes the electrical signals and determines the correct fuel output and timing for optimum power, fuel economy and emissions. The ECM also has the ability to display warnings or shut down the engine completely (depending on option selection) in the event of damaging engine conditions, such as low oil pressure, low coolant level, or high oil temperature.

Two categories divide system components: engine-mounted components and engine-related components.

2. ENGINE-MOUNTED COMPONENTS

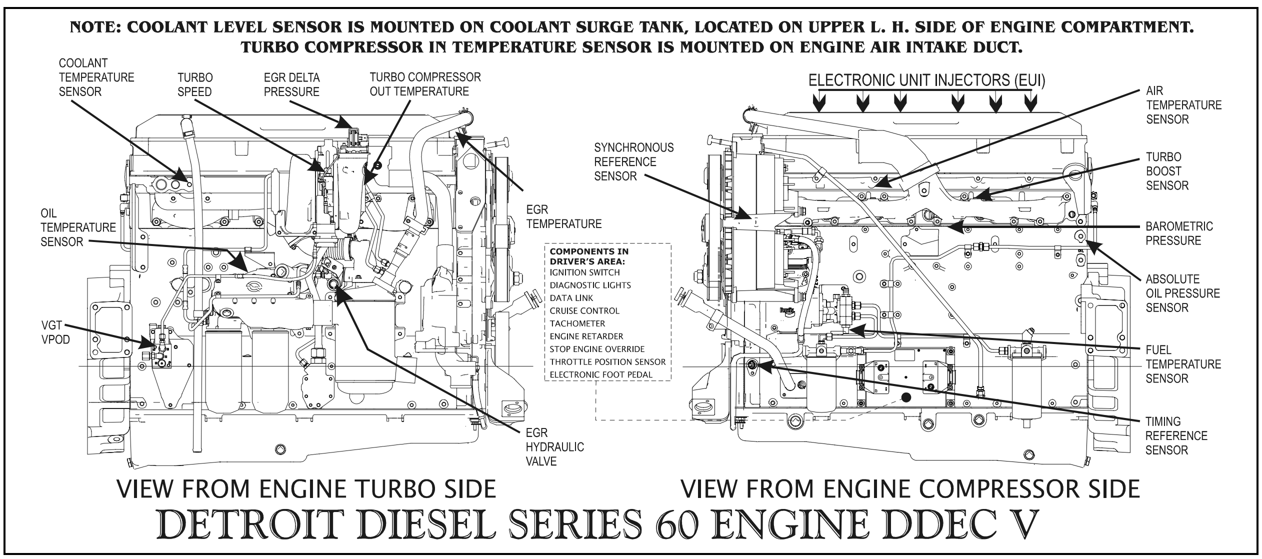


FIGURE 1: DETROIT DIESEL SERIES 60 ENGINE (TYPICAL) 01113

Engine-mounted components are as follows:

- Electronic Control Module
- Electronic Unit Injector
- Synchronous Reference Sensor
- Timing Reference Sensor
- Turbo Boost Pressure Sensor
- Coolant Temperature Sensor
- Fuel Temperature Sensor
- Air Temperature Sensor
- Absolute Oil Pressure Sensor
- Oil Temperature Sensor
- Barometric Pressure
- EGR Delta Pressure
- EGR Temperature
- Turbo Speed
- Turbo Compressor Out Temperature
- Turbo Compressor In Temperature

2.1 ELECTRONIC CONTROL MODULE

The Electronic Control Module is mounted, on the starter side of the engine (Fig. 2). Considered the *"Brain"* of the DDEC V 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 (**E**lectrically **E**rasable, **P**rogrammable, **R**ead-**O**nly **M**emory) within the Electronic Control Module. After comparing the input data with the calibration data, the ECM sends high-current command pulses to the Electronic Unit Injectors (EUI) to initiate fuel injection. The ECM also receives feedback regarding the start and end of injection for a given cylinder. The EEPROM within the Electronic 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 V Diagnostic Codes" in this section).

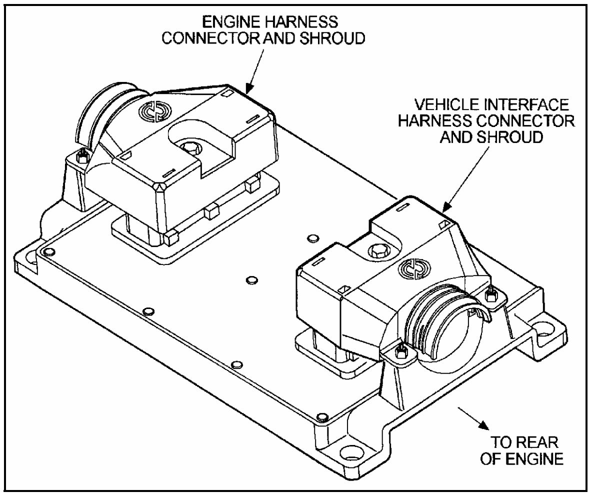


FIGURE 2: ELECTRONIC CONTROL MODULE (ECM) 01145

2.2 N3 ELECTRONIC UNIT INJECTOR

The N3 Electronic Unit Injector (EUI) is a compact device that injects diesel fuel directly into the combustion chamber (Fig. 3). The amount of fuel injected and injection timing is determined by the Electronic Control Module (ECM). The ECM sends a command pulse, which activates the injector solenoid. The EUI performs four functions:

- Creates the high-fuel pressure required for efficient injection;
- Meters and injects the exact amount of fuel required to handle the load;
- Atomizes the fuel for mixing with the air in the combustion chamber;
- Permits continuous fuel flow for component cooling**.**

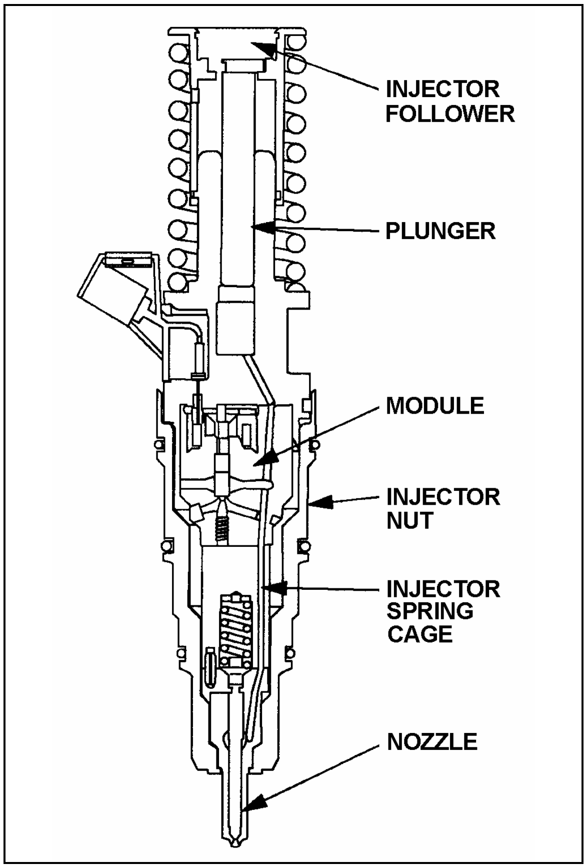


FIGURE 3: UNIT INJECTOR CROSS SECTION 01146

2.3 VPOD

There is one air-operated Variable Pressure Output Device (VPOD) that controls the Variable Geometry Turbo (VGT). The location of the VPOD is to the left of the engine oil filters (Fig. 4). Pneumatic system supplies air pressure.

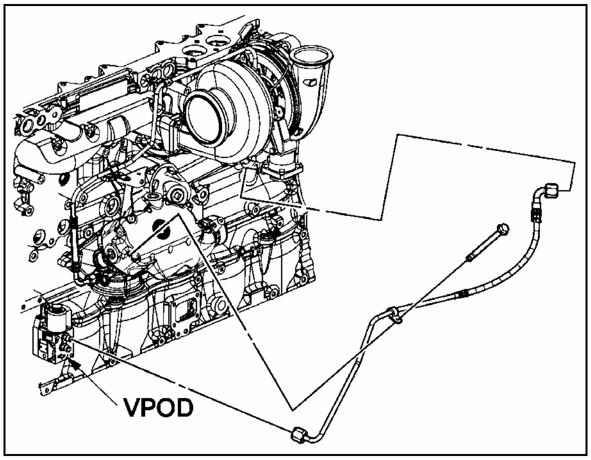


FIGURE 4: VPOD LOCATION 01149

2.3.1 VPOD Removal

1. Remove airline from VPOD.
2. Unplug harness connection.
3. Remove two bolts and one stud holding VPOD assembly and bracket to engine block.

2.3.2 VPOD Installation

1. Align VPOD assembly and bracket to threaded holes in engine block; install two bolts and one stud. Torque the M10 bolts and M10 stud to 43-54 Lbf-ft (58-73 Nm). Torque the M8 bolt to 22-28 Lbf-ft (30-38 Nm).
2. Connect airline to VPOD and tighten.
3. Plug harness connection into VPOD assembly.

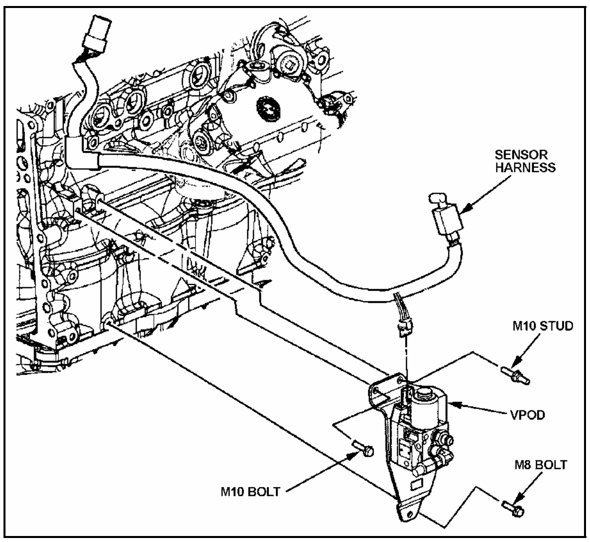


FIGURE 5: VPOD INSTALLATION 01147

NOTE
VPOD assembly is not serviceable, remove and replace only.

2.4 EGR HYDRAULIC VALVE

The hydraulic valve that controls the Exhaust Gas Recirculation (EGR) system is located on the same side as the VPOD but near the EGR cooler (Fig. 1 & 6).

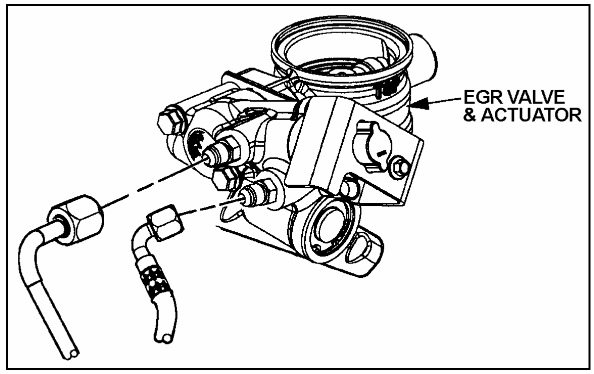


FIGURE 6: EGR VALVE & ACTUATOR ASSEMBLY 01148

2.5 SYNCHRONOUS REFERENCE SENSOR

The Synchronous Reference Sensor (SRS) is an electronic component, mounted to the rear of the gear case (Fig. 1). The SRS senses a raised metal pin on the rear of the camshaft idler gear and sends a signal to the ECM via a black connector wire. The SRS sensor extends through a hole in the gear case. It is positioned near the rear of the idler gear. A bolt, inserted through a hole in the SRS bracket, secures the SRS assembly to the gear case.

The idler gear pin passes by the SRS as piston number one crank pin reaches 45° before Top-Dead-Center. The ECM uses this information to determine engine speed.

The SRS is non-serviceable and must be replaced as a unit. No adjustment is required.

2.6 TIMING REFERENCE SENSOR

The Timing Reference Sensor (TRS) is an electronic component mounted on the left side of the gear case (right side of coach), near the crankshaft centerline. The TRS is positioned near the timing wheel gear teeth and extends through an opening in the gear case. A bolt, inserted through a hole in the TRS bracket, secures the TRS assembly to the gear case. The TRS connector is gray. The TRS sends a signal to the ECM, this signal is generated by a series of evenly spaced special teeth on the timing wheel. A tooth passes by the TRS as each cylinder crank pin reaches 10° before Top-Dead-Center.

The ECM uses these signals to determine injector solenoid operation time. The TRS is non-serviceable and must be replaced as a unit. No adjustment is required.

2.7 TURBO BOOST PRESSURE SENSOR

The Turbo Boost Pressure Sensor is located on the intake manifold. This device is a pressure sensor that sends an electrical signal to the ECM. The ECM uses this information to compute the volume of air entering the engine. Turbo boost sensor information regulates fuel supply to control engine exhaust.

The turbo boost pressure sensor is non-serviceable and must be replaced as an assembly. No adjustment is required.

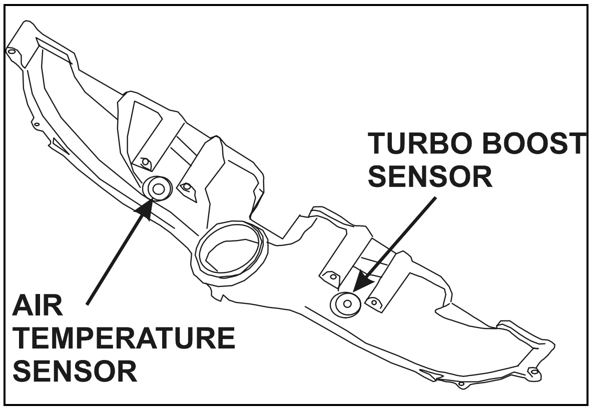


FIGURE 7: TURBO BOOST PRESSURE SENSOR 01023

2.8 COOLANT TEMPERATURE SENSOR

The coolant temperature sensor (Fig. 1) is mounted on the engine's radiator side (turbo side). The sensor helps protect the engine against overheating by sensing coolant temperature.

2.9 FUEL TEMPERATURE SENSOR

The Fuel Temperature Sensor (FTS) is installed underneath the fuel pump (Fig. 8).

The FTS sends an electrical signal to the ECM indicating fuel inlet temperature. The ECM uses this information to calculate fuel consumption.

The FTS is non-serviceable and must be replaced as a unit. No adjustment is required.

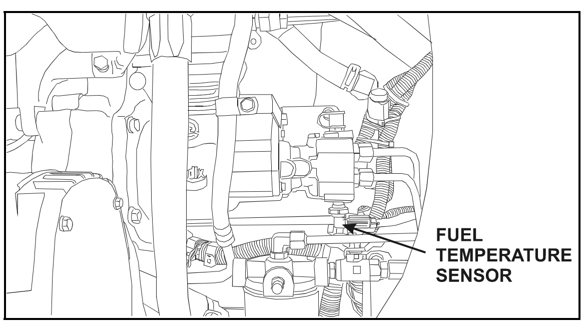


FIGURE 8: FUEL TEMPERATURE SENSOR 01024

2.10 AIR TEMPERATURE SENSOR

The Air Temperature Sensor (Fig. 1 & 7) located on the intake manifold provides input data to vary hot idle speed and injection timing. This helps to improve cold starts and reduces white exhaust smoke.

2.11 TURBO COMPRESSOR IN TEMPERATURE SENSOR

The Turbo Compressor In Temperature Sensor is located on the engine air intake pipe (Fig. 9).

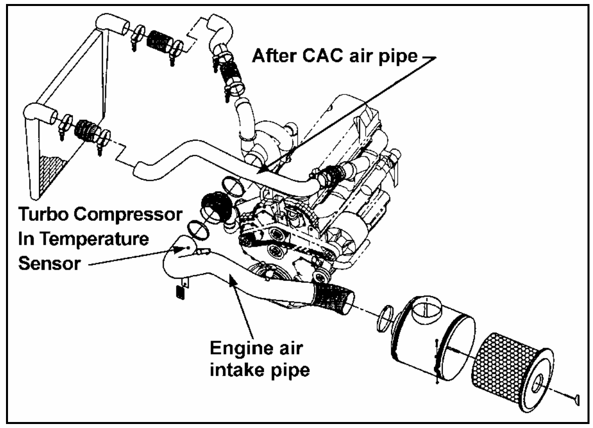


FIGURE 9: TURBO COMPRESSOR IN TEMPERATURE SENSOR LOCATION

2.12 ABSOLUTE OIL PRESSURE SENSOR

The Absolute Oil Pressure Sensor (OPS) is installed in the main engine-oil gallery. A typical location is the left rear corner of the cylinder block (Fig. 10). The OPS sends an electrical signal to the ECM indicating the engine oil pressure at any given speed. A low oil pressure signal exceeding seven seconds is used by the ECM to begin the stop engine or warning function. The OPS is non-serviceable and must be replaced as a unit. No adjustment is required.

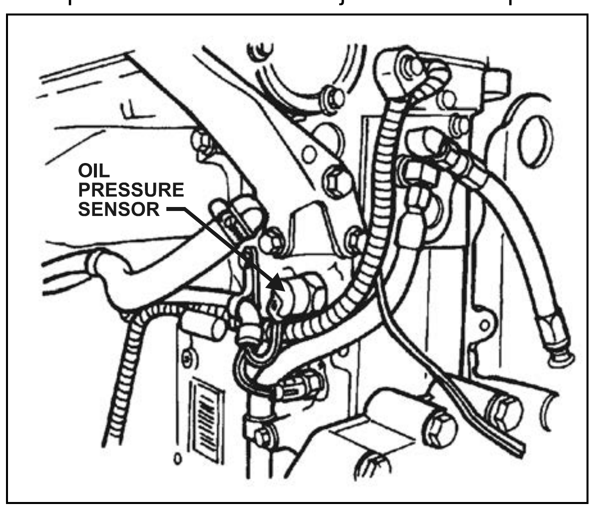


FIGURE 10: ENGINE OPS 01025B

2.13 OIL TEMPERATURE SENSOR

The Oil Temperature Sensor (OTS) is installed behind the engine oil filters manifold (Fig. 1). The

OTS sends an electrical signal to the ECM indicating engine oil temperature. The ECM uses this information to modify engine speed for better cold weather starts and faster warm-ups. Oil temperatures exceeding engine specifications for two seconds or more will illuminate the Check Engine Light.

The OTS is non-serviceable and must be replaced as a unit. No adjustment is required.

3. ENGINE-RELATED COMPONENTS

Engine-related components include:

- Coolant Level System (CLS)
- Electronic Foot Pedal Assembly (EFPA) and Throttle Position Sensor
- Cruise Control Switch (CCS)
- Diagnostic System Accessories (DSA)

3.1 COOLANT LEVEL SYSTEM (CLS)

The coolant level system consists of a conductivity probe mounted in the surge tank and an electronic interface module located inside the rear junction box. Coolant level is determined by the change in impedance of the probe and its brass mount when immersed in coolant. The electronic device in the module conditions the signal to levels compatible with DDEC. A low coolant level will trigger the engine warning functions.

The probe and electronic interface module are non-serviceable items and should be replaced as units, if found defective. No adjustment is required.

3.2 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 Electronic Control Module (ECM). The TPS signal 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. 11). The (TPS) converts the operator's foot pedal input into a signal for the ECM. The (EFPA) is shown in Figure 11.

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.

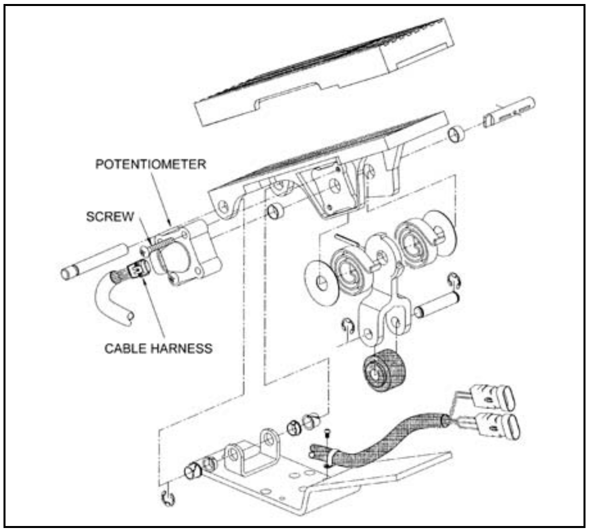


FIGURE 11: ELECTRONIC FOOT PEDAL ASSEMBLY 03035

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 ECU will signal diagnostic codes of 21-12 for idle error and 21-23 for wide-open throttle error.

3.3 CRUISE CONTROL SWITCHES (CCS)

The four cruise control switches are located in the driver's area on the L.H. side control panel.

1. **Cruise:** This is the main switch that actuates the ECM memory in order to use the speed-regulating mode.
2. **Set:** This switch is used to set the cruise control speed or to decrease the set speed by 2 MPH at each application.

NOTE
Cruise control system will not accept speed settings, nor will the "Resume" switch operate below 20 mph (32 km/h) and the engine speed must be above 1100 RPM.

3. **Resume:** Each time this switch is actuated, the speed will be increased by 2 mph (3,5 km/h). This switch allows the driver return to the last regulated speed following a brake or *"DECEL"* switch application.

NOTE
On-off switch must be in the "ON" position in order to return to the last regulated speed.

4. **Decel:** Will cancel the cruise temporarily and let the vehicle coast. Set speed is still in memory for resume.

For additional information, see the "Operator's Manual" or the "Owner's Manual".

3.4 DIAGNOSTIC SYSTEM ACCESSORIES (DSA)

The DDEC V engine Diagnostic System Accessories includes the following:

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

3.4.1 Check Engine Telltale Light

The Check Engine telltale, mounted on the telltale light panel indicates that a problem has been detected and that a code has been stored in the ECM memory. This light also has a 5-second bulb check when the ignition is first turned on. The Check Engine telltale illuminates when the temperature at coolant sensors exceeds 217°F (103°C) and the temperature at oil sensors exceeds 260°F (127°C). When sensors reach those temperatures, DDEC starts to decrease engine power linearly.

3.4.2 Stop Engine Telltale Light

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). The Stop Engine Light illuminates when the temperature at coolant sensors exceeds 222°F (106°C) and the temperature at oil sensors exceeds 239°F (115°C). When sensors detect such temperatures, DDEC shuts the engine down after a 30 seconds grace period. This 30-second delay may be extended another 30 seconds (if absolutely necessary) by using the STOP ENGINE OVERRIDE switch.

NOTE
Once engine is stopped, it can not be restarted until the malfunction is corrected.

3.4.3 Stop Engine Override Switch

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. Refer to “DDEC V DIAGNOSTIC CODES” in this section for more information.

3.4.4 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.

4. DDEC V DIAGNOSTIC CODES

4.1 READING DIAGNOSTIC CODES - FLASHING LIGHT METHOD:

DDEC V 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 ECM (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 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.

A code "43" consists of four flashes, followed by a short pause, then three flashes in quick succession.

Refer to DDEC Troubleshooting Manual 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 ECM to provide for engine operation if a sensor failure is present.

DDEC V Code	PID	SID	FMI	DESCRIPTION
11	187	--	4	Variable Speed Governor Sensor Voltage Low
11	187	--	7	Variable Speed Governor Switch System Not Responding
12	187	--	3	Variable Speed Governor Sensor Voltage High
13	111	--	4	Coolant Level Sensor Input Voltage Low
13	111	--	6	Add Coolant Level Sensor Input Voltage Low
13		146	6	EGR Valve Current too High
14	52	--	3	Intercooler Coolant Temperature Sensor Input Voltage High
14	110	--	3	Coolant Temperature Sensor Input Voltage High
14	175	--	3	Oil Temperature Sensor Input Voltage High
15	52	--	4	Intercooler Coolant Temperature Sensor Input Voltage Low
15	110	--	4	Coolant Temperature Sensor Input Voltage Low
15	175	--	4	Oil Temperature Sensor Input Voltage Low
16	111	--	3	Coolant Level Sensor Input Voltage High
16	111	--	5	Add Coolant Level Sensor Input Voltage High
16		146	5	EGR Valve Current too Low
17	51	--	3	Throttle Plate Position Sensor Input Voltage High
17	72	--	3	Blower Bypass Position Input Voltage High
17	354	--	3	Relative Humidity Sensor Circuit Failed High

DDEC V Code	PID	SID	FMI	DESCRIPTION
18	51	--	4	Throttle Plate Position Sensor Input Voltage Low
18	72	--	4	Blower Bypass Position Input Voltage Low
18	354	--	4	Relative Humidity Sensor Circuit Failed Low
21	91	--	3	Throttle Position Sensor Input Voltage High
22	91	--	4	Throttle Position Sensor Input Voltage Low
23	174	--	3	Fuel Temperature Sensor Input Voltage High
23	--	65	3	Oxygen Content Circuit Input Voltage High
24	174	--	4	Fuel Temperature Sensor Input Voltage Low
24	--	65	4	Oxygen Content Circuit Input Voltage Low
25	--	--	--	Reserved for ‘‘No Codes"
26	--	25	11	Aux. Shutdown #1 Active
26	--	61	11	Aux. Shutdown #2 Active
27	105	--	3	Intake Manifold Temperature Sensor Input Voltage High
27	171	--	3	Ambient Air Temperature Sensor Input Voltage High
27	172	--	3	Air Temperature Sensor Input Voltage High
28	105	--	4	Intake Manifold Temperature Sensor Input Voltage Low
28	171	--	4	Ambient Air Temperature Sensor Input Voltage Low
28	172	--	4	Air Temperature Sensor Input Voltage Low
29	351	—	4	TCI Temperature Circuit Failed Low
29	404	—	4	Turbo Compressor Temperature Out Sensor Input Voltage Low
31	--	51	3	Aux. Output #3 Open Circuit (High Side) – Pin E-49
31	--	51	4	Aux. Output #3 Short To Ground (High Side) – Pin E-49
31	--	51	7	Aux. Output #3 Mechanical System Fail - Pin E-49
31	--	52	3	Aux. Output #4 Open Circuit (High Side) - Pin E-48
31	--	52	4	Aux. Output #4 Short to Ground (High Side) - Pin E-48
31	--	52	7	Aux. Output #4 Mechanical System Failure - Pin E-48
31	--	260	3	Aux. Output #12 Open Circuit (High Side) - Pin E-46
31	--	260	4	Aux. Output #12 Short to Ground (High Side) - Pin E-46
31	--	260	7	Aux. Output #12 Mechanical System Failure - Pin E-46
31	--	261	3	Aux. Output #13 Open Circuit (High Side) - Pin E-47
31	--	261	4	Aux. Output #13 Short to Ground (High Side) - Pin E-47
31	--	261	7	Aux. Output #13 Mechanical System Failure - Pin E-47
31	--	262	3	Aux. Output #14 Open Circuit (High Side) - Pin E-50
31	--	262	4	Aux. Output #14 Short to Ground (High Side) - Pin E-50
31	--	262	7	Aux. Output #14 Mechanical System Failure - Pin E-50
31	--	263	3	Aux. Output #15 Open Circuit (High Side) - Pin E-51

DDEC V Code	PID	SID	FMI	DESCRIPTION
31	--	263	4	Aux. Output #15 Short to Ground (High Side) - Pin E-51
31	--	263	7	Aux. Output #15 Mechanical System Failure - Pin E-51
31	--	264	3	Aux. Output #16 Open Circuit (High Side) - Pin E-52
31	--	264	4	Aux. Output #16 Short to Ground (High Side) - Pin E-52
31	--	264	7	Aux. Output #16 Mechanical System Failure - Pin E-52
31	--	265	3	Aux. Output #17 Open Circuit (High Side) - Pin E-53
31	--	265	4	Aux. Output #17 Short to Ground (High Side) - Pin E-53
31	--	265	7	Aux. Output #17 Mechanical System Failure - Pin E-53
32	--	238	3	RSL Short to Battery (+)
32	--	238	4	RSL Open Circuit
32	--	239	3	AWL Short to Battery (+)
32	--	239	4	AWL Open Circuit
33	102	--	3	Turbo Boost Pressure Sensor Input Voltage High
34	102	--	4	Turbo Boost Pressure Sensor Input Voltage Low
35	19	--	3	High Range Oil Pressure Sensor Input Voltage High
35	100	--	3	Oil Pressure Sensor Input Voltage High
36	19	--	4	High Range Oil Pressure Sensor Input Voltage Low
36	100	--	4	Oil Pressure Sensor Input Voltage Low
37	18	--	3	High Range Fuel Pressure Sensor Input Voltage High
37	94	--	3	Fuel Pressure Sensor Input Voltage High
37	95	--	3	Fuel Restriction Sensor Input Voltage High
38	18	--	4	High Range Fuel Pressure Sensor Input Voltage Low
38	94	--	4	Fuel Pressure Sensor Input Voltage Low
38	95		4	Fuel Restriction Sensor Input Voltage Low
39	—	146	2	EGR Leak- Boost Power
39	—	146	12	EGR Leak- Boost Jake
39	—	146	7	EGR Valve Not Responding
39	—	147	2	VNT Vanes Not Responding – Boost Power
39	—	147	11	VNT Vanes at Max – Jake
39	—	147	12	VNT Vanes Not Responding – Boost Jake
39	—	147	14	EGR Flow too low
39	—	147	7	VNT Vanes Not Responding – EGR
41	--	21	0	Too Many CKP Sensor (missing CMP Sensor)
42	--	21	1	Too few CKP Sensor (missing CKP Sensor)
43	111	--	1	Coolant Level Low
44	52	--	0	Intercooler Coolant Temperature High
44	105	--	0	Intake Manifold Temperature High

DDEC V Code	PID	SID	FMI	DESCRIPTION
44	105	--	14	Engine Power Derate Due to Intake Manifold Temperature
44	110	--	0	Coolant Temperature High
44	110	--	14	Engine Power Derate Due to Coolant Temperature
44	172	--	0	Air Inlet Temperature High
44	175	--	0	Oil Temperature High
45	19	--	1	High Range Oil Pressure Low
45	100	--	1	Oil Pressure Low
46	168	--	1	ECM Battery Voltage Low
46	--	155		Injector V (reg) Voltage Failed Low
46	--	211	1	Sensor Supply Pins V-11/V-12 Low
46	--	212	4	Injector V (slope) Voltage Failed Low
46	--	214	1	RTC Backup Battery Voltage Low, Pin E-59
46	--	221	4	Injector I (pull-in) Voltage Failed Low
46	--	232	1	Sensor Supply Voltage Low, Pin E-12/E-26
47	18	--	0	High Range Fuel Pressure High
47	94	--	0	Fuel Pressure High
47	102	--	0	Turbo Boost Pressure High
47	102	--	14	Engine Power Derate Due to Turbo Boost Pressure
47	106	--	0	Air Inlet Pressure High
47	164	--	0	Injection Control Pressure High
48	18	--	1	High Range Fuel Pressure Low
48	94	--	1	Fuel Pressure Low
48	106	--	1	Air Inlet Pressure Low
48	164	--	1	Injection Control Pressure Low
48	351	--	1	TCI Temperature Low
48	404	—	1	Turbo Compressor Temperature Out Low
48	404	--	14	Engine Power Derate Due to Turbo Compressor Out Temperature
48	411	--	1	EGR Differential Pressure Low
48	412	--	1	EGR Temperature Low
49	351	--	0	TCI Temperature High
49	404	--	0	Turbo Compressor Out Temperature High
51	351	--	3	TCI Temperature Circuit Failed High
51	404	--	3	Turbo Compressor Out Temperature Sensor Input Voltage High
52	--	254	12	A/D Conversion Fail
53	--	253	2	Nonvolatile Checksum Incorrect
53	--	253	12	EEPROM Write Error

DDEC V Code	PID	SID	FMI	DESCRIPTION
53	--	253	13	Out of Calibration
54	84	--	12	Vehicle Speed Sensor Fault
55	--	216	14	Other ECU Fault (This fault is logged in conjunction with another fault to indicate missing information from another ECU.)
55	--	231	12	J1939 Data Link Fault
55	--	248	8	Proprietary Data Link Fault (Master)
55	--	248	9	Proprietary Data Link Fault (Receiver)
56	--	250	12	J1587 Data Link Fault
57	--	249	12	J1922 Data Link Fault
58	92	--	0	Torque Overload
61	--	xxx	0	Injector xxx Response Time Long
62	--	26	3	Aux. Output #1 Short to Battery (+) – Pin V-4
62	--	26	4	Aux. Output #1 Open Circuit - Pin V-4
62	—	26	7	Aux. Output #1 Mechanical System Not Responding Properly - Pin V-4
62	--	40	3	Aux. Output #2 Short to Battery (+) - Pin V-5
62	--	40	4	Aux. Output #2 Open Circuit - Pin V-5
62	—	40	7	Aux. Output #2 Mechanical System Not Responding Properly – Pin V-5
62	--	53	3	Aux. Output #5 Short to Battery (+) - Pin V-6
62	--	53	4	Aux. Output #5 Open Circuit - Pin V-6
62	—	53	7	Aux. Output #5 Mechanical System Not Responding Properly - Pin V-6
62	--	54	3	Aux. Output #6 Short to Battery (+) - Pin V-7
62	--	54	4	Aux. Output #6 Open Circuit - Pin V-7
62	--	54	7	Aux. Output #6 Mechanical System Not Responding Properly - Pin V-7
62	--	55	3	Aux. Output #7 Short to Battery (+) - Pin V-40
62	--	55	4	Aux. Output #7 Open Circuit - Pin V-40
62	—	55	7	Aux. Output #7 Mechanical System Not Responding Properly - Pin V-40
62	--	56	3	Aux. Output #8 Short to Battery (+) – Pin V-53
62	--	56	4	Aux. Output #8 Open Circuit - Pin V-53
62	--	56	7	Aux. Output #8 Mechanical System Not Responding Properly - Pin V-53
62	--	257	3	Aux. Output #9 Open Circuit – Pin V-54
62	--	257	4	Aux. Output #9 Short to Gnd – Pin V-54
62	--	257	7	Aux. Output #9 Mechanical System Failure – Pin V-54
62	--	258	3	Aux. Output #10 Open Circuit – Pin V-55
62	--	258	4	Aux. Output #10 Short to Gnd – Pin V-55

DDEC V Code	PID	SID	FMI	DESCRIPTION
62	--	258	7	Aux. Output #10 Mechanical System Failure – Pin V-55
62	--	259	3	Aux. Output #11 Open Circuit – Pin E-13
62	--	259	4	Aux. Output #11 Short to Gnd – Pin E-13
62	--	259	7	Aux. Output #11 Mechanical System Failure – Pin E-13
63	--	57	0	PWM #1 Above Normal Range, Pin V-53
63	--	57	1	PWM #1 Below Normal Range, Pin V-53
63	--	57	3	PWM #1 Short to Battery (+), Pin V-53
63	--	57	4	PWM #1 Open Circuit, Pin V-53
63	--	58	0	PWM #2 Above Normal Range, Pin V-46
63	--	58	1	PWM #2 Below Normal Range, Pin V-46
63	--	58	3	PWM #2 Short to Battery (+), Pin V-46
63	--	58	4	PWM #2 Open Circuit, Pin V-46
63	--	59	0	PWM #3 Above Normal Range, Pin E-3
63	--	59	1	PWM #3 Below Normal Range, Pin E-3
63	--	59	3	PWM #3 Short to Battery (+), Pin E-3
63	--	59	4	PWM #3 Open Circuit, Pin E-3
63	--	60	0	PWM #4 Above Normal Range, Pin E-4
63	--	60	1	PWM #4 Below Normal Range, Pin E-4
63	--	60	3	PWM #4 Short to Battery (+), Pin E-4
63	--	60	4	PWM #4 Open Circuit, Pin E-4
63	--	267	0	PWM #5 Above Normal Range - Pin E-8
63	--	267	1	PWM #5 Below Normal Range - Pin E-8
63	--	267	3	PWM #5 Short to Battery (+) - Pin E-8
63	--	267	4	PWM #5 Open Circuit - Pin E-8
63	--	267	7	PWM #5 Mechanical System Failed - Pin E-8
63	--	268	0	PWM #6 Above Normal Range - Pin E-11
63	--	268	1	PWM #6 Below Normal Range - Pin E-11
63	--	268	3	PWM #6 Short to Battery (+) - Pin E-11
63	--	268	4	PWM #6 Open Circuit - Pin E-11
63	--	268	7	PWM #6 Mechanical System Failed - Pin E-11
64	103	--	0	Turbo Overspeed
64	103	--	8	Turbo Speed Sensor Input Failure – Abnormal Period
65	51	--	0	Throttle Plate Position Above Normal Range
65	51	--	1	Throttle Plate Position Below Normal Range
65	51	--	2	Throttle Plate Position Erratic
65	51	--	7	Throttle Plate Not Responding
65	107	--	3	Air Filter Restriction Sensor Voltage High

DDEC V Code	PID	SID	FMI	DESCRIPTION
65	107	--	4	Air Filter Restriction Sensor Voltage Low
66	99	--	3	Oil Filter Restriction Sensor Voltage High
66	99	--	4	Oil Filter Restriction Sensor Voltage Low
66	--	76	0	Engine Knock Level Above Normal Range
66	--	76	3	Engine Knock Level Sensor Input Voltage High
66	--	76	4	Engine Knock Level Sensor Input Voltage Low
66	--	76	7	Engine Knock Level Sensor Not Responding
67	20	--	3	High Range Coolant Pressure Sensor Input Voltage High
67	20	--	4	High Range Coolant Pressure Sensor Input Voltage Low
67	106	--	3	Air Inlet Pressure Sensor Input Voltage High
67	106	--	4	Air Inlet Pressure Sensor Input Voltage Low
67	109	--	3	Coolant Pressure Sensor Input Voltage High
67	109	--	4	Coolant Pressure Sensor Input Voltage Low
68	--	230	5	TPS Idle Validation Circuit Fault (open circuit)
68	--	230	6	TPS Idle Validation Circuit Fault (short to ground)
71	--	xxx	1	Injector xxx Response Time Short
72	84	--	0	Vehicle Overspeed
72	84	--	11	Vehicle Overspeed (Absolute)
72	--	65	0	Oxygen Content Too High
72	--	65	1	Oxygen Content Too Low
73	107	--	0	Air Filter Restriction High
73	--	77	0	Gas Valve Position Above Normal Range
73	--	77	1	Gas Valve Position Below Normal Range
73	--	77	3	Gas Valve Position Input Voltage High
73	--	77	4	Gas Valve Position Input Voltage Low
73	--	77	7	Gas Metering Valve Not Responding
74	70	--	4	Optimized Idle Safety Loop Short to Ground
74	99	--	0	Oil Filter Restriction High
75	168	--	0	ECM Battery Voltage High
75	--	155	3	Injector V (reg) Voltage Failed High
75	--	211	0	Sensor Supply Pins V-11/V-12 Voltage High
75	--	212	3	Injector V (slope) Voltage Failed High
75	--	221	3	Injector V (pull-in) Voltage Failed High
75	--	214	0	RTC Backup Battery Voltage High
75	--	232	0	Sensor Supply Voltage High, Pin E-26
76	121	--	0	Engine Overspeed With Engine Brake
77	19	—	0	High Range Oil Pressure High

DDEC V Code	PID	SID	FMI	DESCRIPTION
77	20	—	0	High Range Coolant Pressure High
77	21	—	0	ECU Temperature Above Range
77	21	—	1	ECU Temperature Below Range
77	21	—	3	ECU Temperature Above Failed High
77	21	—	4	ECU Temperature Above Failed Low
77	72	—	0	Blower Bypass Door Position High
77	72	—	1	Blower Bypass Door Position Low
77	73	—	1	Fire Pump Pressure Low
77	81	—	0	Exhaust Back Pressure High
77	81	—	1	Exhaust Back Pressure Low
77	81	—	3	Exhaust Back Pressure Sensor Voltage High
77	81	—	4	Exhaust Back Pressure Sensor Voltage Low
77	81	—	12	Exhaust Back Pressure at Rampdown Threshold
77	95	—	1	Fuel Filter Differential Pressure Low
77	99	—	1	Oil Filter Differential Pressure Low
77	100	—	0	Engine Oil Pressure High
77	102	—	1	Turbo Boost Pressure Low
77	105	—	1	Inlet Manifold Temperature Low
77	107	—	1	Air filter Restriction Pressure Low
77	108	—	0	Barometric Pressure High
77	108	—	1	Barometric Pressure Low
77	109	—	0	Coolant Pressure High
77	110	—	1	Coolant Temperature Low
77	111	—	0	Coolant Level High
77	171	—	0	Ambient Air Temperature High
77	171	—	1	Ambient Air Temperature Low
77	172	—	1	Air Inlet Temperature Low
77	174	—	0	Fuel Temperature High
77	174	—	1	Fuel Temperature Low
77	175	—	1	Engine Oil Temperature Low
77	222	—	14	Anti-Theft Fault Present
77	251	—	10	Clock Module Abnormal Rate of Change
77	251	—	13	Clock Module Failure
77	252	—	10	Clock Module Abnormal Rate of Change
77	252	—	13	Clock Module Failure
77	354	—	0	Relative Humidity Above Range
77	354	—	1	Relative Humidity Below Range

DDEC V Code	PID	SID	FMI	DESCRIPTION
77	446	—	0	Cylinder Head Temperature Above Range
77	—	151	11	Service Now Lamp Fault Expiration
78	86	--	14	Cruise Control/Adaptive Cruise Control Fault
81	98	--	3	Oil Level Sensor Input Voltage High
81	101	--	3	Crankcase Pressure Sensor Input Voltage High
81	153	--	3	Extended Crankcase Pressure Input Voltage High
81	164	--	3	Injection Control Pressure Sensor Input Voltage High
81	173	--	3	Exhaust Temperature Sensor Input Voltage High
81	411	—	3	EGR Delta Pressure Sensor Circuit Failed High
81	412	—	3	EGR Temperature Circuit Failed High
81	412	—	9	EGR Temperature Network Sensor Not Responding
81		20	3	Timing Actuator Failed High
81		20	4	Timing Actuator Failed Low
81	--	129	3	Exhaust Port Temperature #1 Sensor Voltage High
81	--	130	3	Exhaust Port Temperature #2 Sensor Voltage High
81	--	131	3	Exhaust Port Temperature #3 Sensor Voltage High
81	--	132	3	Exhaust Port Temperature #4 Sensor Voltage High
81	--	133	3	Exhaust Port Temperature #5 Sensor Voltage High
81	--	134	3	Exhaust Port Temperature #6 Sensor Voltage High
81	--	135	3	Exhaust Port Temperature #7 Sensor Voltage High
81	--	136	3	Exhaust Port Temperature #8 Sensor Voltage High
81	--	137	3	Exhaust Port Temperature #9 Sensor Voltage High
81	--	138	3	Exhaust Port Temperature #10 Sensor Voltage High
81	--	139	3	Exhaust Port Temperature #11 Sensor Voltage High
81	--	140	3	Exhaust Port Temperature #12 Sensor Voltage High
81	--	141	3	Exhaust Port Temperature #13 Sensor Voltage High
81	--	142	3	Exhaust Port Temperature #14 Sensor Voltage High
81	--	143	3	Exhaust Port Temperature #15 Sensor Voltage High
81	--	144	3	Exhaust Port Temperature #16 Sensor Voltage High
81	—	277	9	EGR Rate Sensor not Responding
81	—	277	12	EGR Rate Sensor Failed
82	98	--	4	Oil Level Sensor Input Voltage Low
82	101	--	4	Crankcase Pressure Sensor Input Voltage Low
82	153	--	4	Extended Crankcase Pressure Input Voltage Low
82	164	--	4	Injection Control Pressure Sensor Input Voltage Low
82	173	--	4	Exhaust Temperature Sensor Input Voltage Low
82	411	—	4	EGR Delta Pressure Sensor Circuit Failed Low

DDEC V Code	PID	SID	FMI	DESCRIPTION
82	412	—	4	EGR Temperature Circuit Failed Low
82	412	—	12	EGR Temperature Network Sensor Failed
82	--	129	4	Exhaust Port Temperature #1 Sensor Voltage Low
82	--	130	4	Exhaust Port Temperature #2 Sensor Voltage Low
82	--	131	4	Exhaust Port Temperature #3 Sensor Voltage Low
82	--	132	4	Exhaust Port Temperature #4 Sensor Voltage Low
82	--	133	4	Exhaust Port Temperature #5 Sensor Voltage Low
82	--	134	4	Exhaust Port Temperature #6 Sensor Voltage Low
82	--	135	4	Exhaust Port Temperature #7 Sensor Voltage Low
82	--	136	4	Exhaust Port Temperature #8 Sensor Voltage Low
82	--	137	4	Exhaust Port Temperature #9 Sensor Voltage Low
82	--	138	4	Exhaust Port Temperature #10 Sensor Voltage Low
82	--	139	4	Exhaust Port Temperature #11 Sensor Voltage Low
82	--	140	4	Exhaust Port Temperature #12 Sensor Voltage Low
82	--	141	4	Exhaust Port Temperature #13 Sensor Voltage Low
82	--	142	4	Exhaust Port Temperature #14 Sensor Voltage Low
82	--	143	4	Exhaust Port Temperature #15 Sensor Voltage Low
82	--	144	4	Exhaust Port Temperature #16 Sensor Voltage Low
82	—	277	12	EGR Rate Sensor Failed
82	412	—	9	EGR Temperature Smart Sensor not Responding
82	412	—	12	EGR Temperature Smart Sensor failed
83	73	—	0	Pump Pressure High
83	98	--	0	Oil Level High
83	101	--	0	Crankcase Pressure High
83	153	--	0	Extended Crankcase Pressure High
83	173	--	0	Exhaust Temperature High
83	411	—	0	EGR Delta Pressure High
83	412	—	0	EGR Temperature High
83	--	129	0	Exhaust Port Temperature #1 High
83	--	130	0	Exhaust Port Temperature #2 High
83	--	131	0	Exhaust Port Temperature #3 High
83	--	132	0	Exhaust Port Temperature #4 High
83	--	133	0	Exhaust Port Temperature #5 High
83	--	134	0	Exhaust Port Temperature #6 High
83	--	135	0	Exhaust Port Temperature #7 High
83	--	136	0	Exhaust Port Temperature #8 High
83	--	137	0	Exhaust Port Temperature #9 High

DDEC V Code	PID	SID	FMI	DESCRIPTION
83	--	138	0	Exhaust Port Temperature #10 High
83	--	139	0	Exhaust Port Temperature #11 High
83	--	140	0	Exhaust Port Temperature #12 High
83	--	141	0	Exhaust Port Temperature #13 High
83	--	142	0	Exhaust Port Temperature #14 High
83	--	143	0	Exhaust Port Temperature #15 High
83	--	144	0	Exhaust Port Temperature #16 High
84	98	--	1	Oil Level Low
84	101	--	1	Crankcase Pressure Low
84	153	--	1	Extended Crankcase Pressure Low
85	190	--	0	Engine Overspeed
85	190	--	14	Engine Overspeed Signal
86	73	--	3	Pump Pressure Sensor Input Voltage High
86	108	--	3	Barometric Pressure Sensor Input Voltage High
87	73	--	4	Pump Pressure Sensor Input Voltage Low
87	108	--	4	Barometric Pressure Sensor Input Voltage Low
88	20	--	1	High Range Coolant Pressure Low
88	109	--	1	Coolant Pressure Low
89	95	--	0	Fuel Restriction High
89	111	--	12	Maintenance Alert Coolant Level Fault

5. ENGINE OIL LEVEL

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. 12). 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.

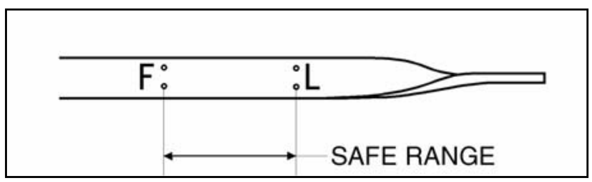


FIGURE 12: ENGINE OIL LEVEL DIPSTICK 01027

⚠ 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. 13).

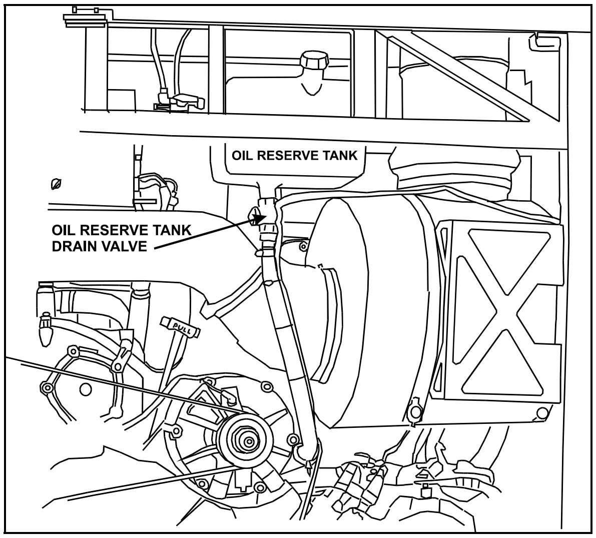


FIGURE 13: OIL RESERVE TANK 01063

6. ENGINE OIL AND FILTER CHANGE

Both the oil and filter should be changed every 12,500 miles (20,000 km) or once a year, whichever comes first. 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. 14).

⚠ 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.

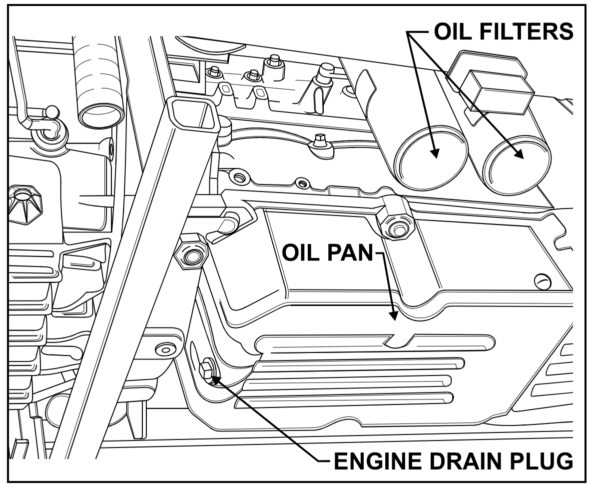


FIGURE 14: ENGINE DRAIN PLUG AND OIL FILTERS 01029

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. 12).
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. 12).

7. RECOMMENDED ENGINE OIL TYPE

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

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.

Lubricant Selection World Wide: Oils meeting API CD or CC specifications may be used if they also meet military specification MIL-L-2104 D or E. Oils which meet European CCMC D4 specifications may also be used.

Modification of drain interval may be necessary, depending on fuel quality. Contact Detroit Diesel Corporation for further guidance.

8. 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 ECM are serviceable. If found defective, replace the complete ECM 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".

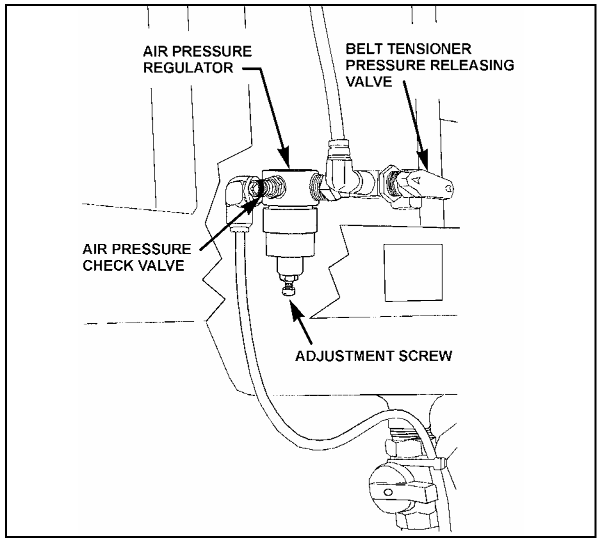


FIGURE 15: BELT TENSIONER VALVE 12200

4. Locate the belt tensioner pressure releasing valve (Fig. 15). 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 (1, Fig.17, 18).

⚠ 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 (2, Fig.17, 18).
8. Disconnect and remove section of coolant pipe assembly mounted between the radiator outlet and the water pump inlet (3, Fig.17, 18).
9. Disconnect the coolant delivery hose located close to the water pump.
10. Disconnect the electric fan-clutch connector, close to the water pump (Fig. 17, 18).

11. Dismantle the air bellows from the upper bracket of the fan-drive assembly tensioner. Remove the upper bracket (4, Fig.17, 18).

12. If necessary, remove the fan drive from the engine compartment by removing the four retaining bolts, washers and nuts securing the fan drive to the floor.

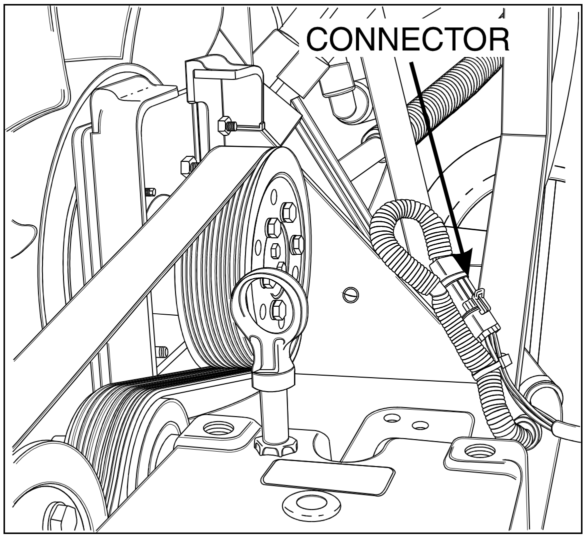


FIGURE 16: ELECTRIC FAN-CLUTCH CONNECTOR 010XX

13. Disconnect and remove the air intake duct mounted between the turbocharger outlet and the air cooler inlet (5, Fig. 17, 18).

14. Disconnect two vent hoses from the thermostat housing and from the coolant pipe assembly.

15. Disconnect and remove a section of coolant pipe assembly mounted between the thermostat housings and the radiator inlet.

16. Disconnect and remove the small hose connected to the heater line valve and to the water pump.

17. Disconnect the small heater hose located on the cylinder head at the back of the engine.

18. Disconnect and remove the exhaust pipe mounted between the turbocharger outlet and the exhaust bellows. If necessary, refer to Section EXHAUST SYSTEM under MUFFLER REMOVAL AND INSTALLATION".

⚠ CAUTION ⚠

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

19. Disconnect the steel-braided airline from the A/C compressor air bellows.

20. Disconnect the power steering pump supply and discharge hoses. Cap hose openings immediately to limit fluid loss. Remove retaining clips from cradle (6, Fig. 17, 18).

21. Disconnect the oil delivery hose from the valve located at the reserve tank drain (7, Fig. 17, 18).

22. Disconnect the block heater connector from the power steering pump if applicable.

23. 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.

24. Disconnect the air compressor discharge, governor steel-braided airlines and manual filling airlines from compressor. Remove retaining clips.

25. Disconnect the hose connecting the compressor head to the sump tank.

26. Disconnect ground cables from rear subframe ground-stud located close to the starter motor.

27. Disconnect positive cable (red terminal) from starting motor solenoid.

28. Disconnect the power plant wiring-harness main connectors from ECM and remove retaining clips from engine compartment backwall.

29. 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.

30. Disconnect fuel return line from bulkhead fixed on engine cylinder head end.

31. 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.

32. Disconnect turbo boost pressure gauge airline from engine air intake.

33. Only if the vehicle is equipped with a retarder, remove the transmission rubber-damper assembly above transmission by removing: nut, bushing, rubber damper, rubber damper guide, bolt and washer. Remove the rubber damper bracket from transmission.

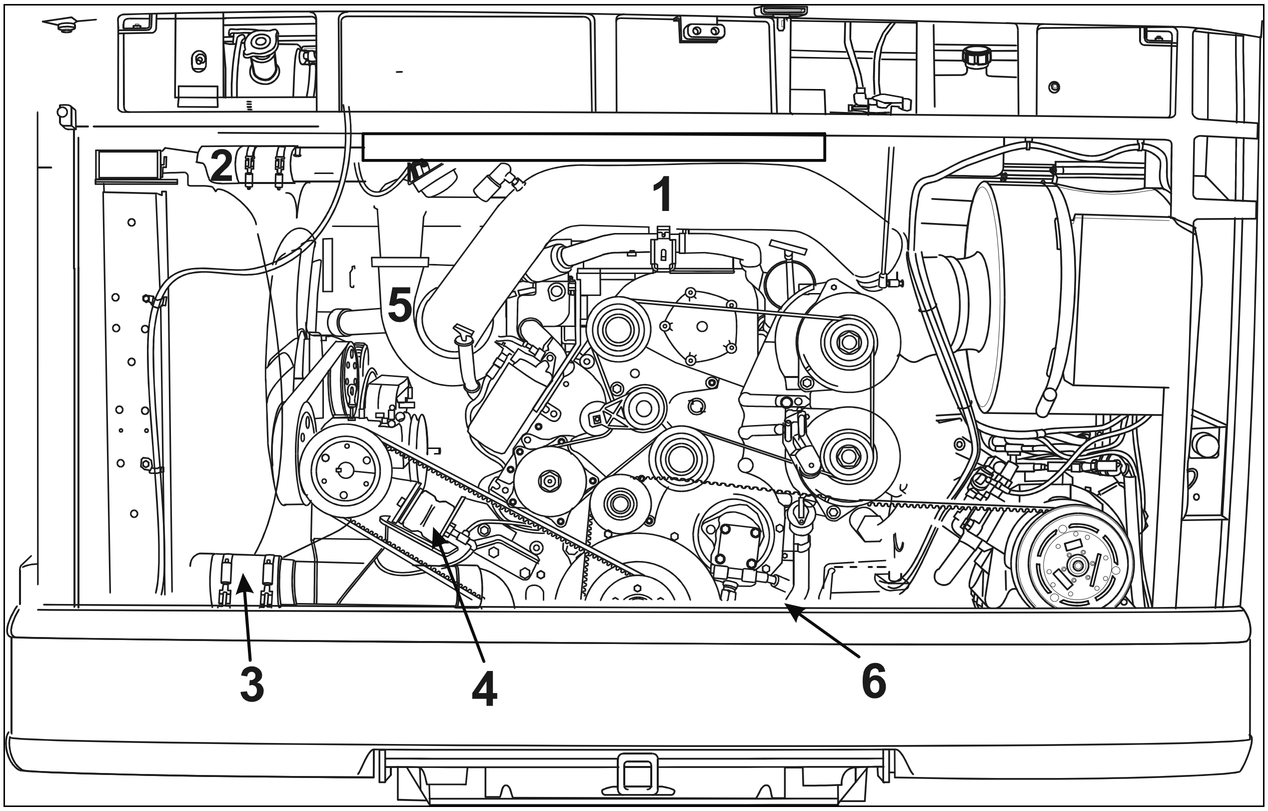


FIGURE 17: ENGINE COMPARTMENT XL2 COACHES (TYPICAL)

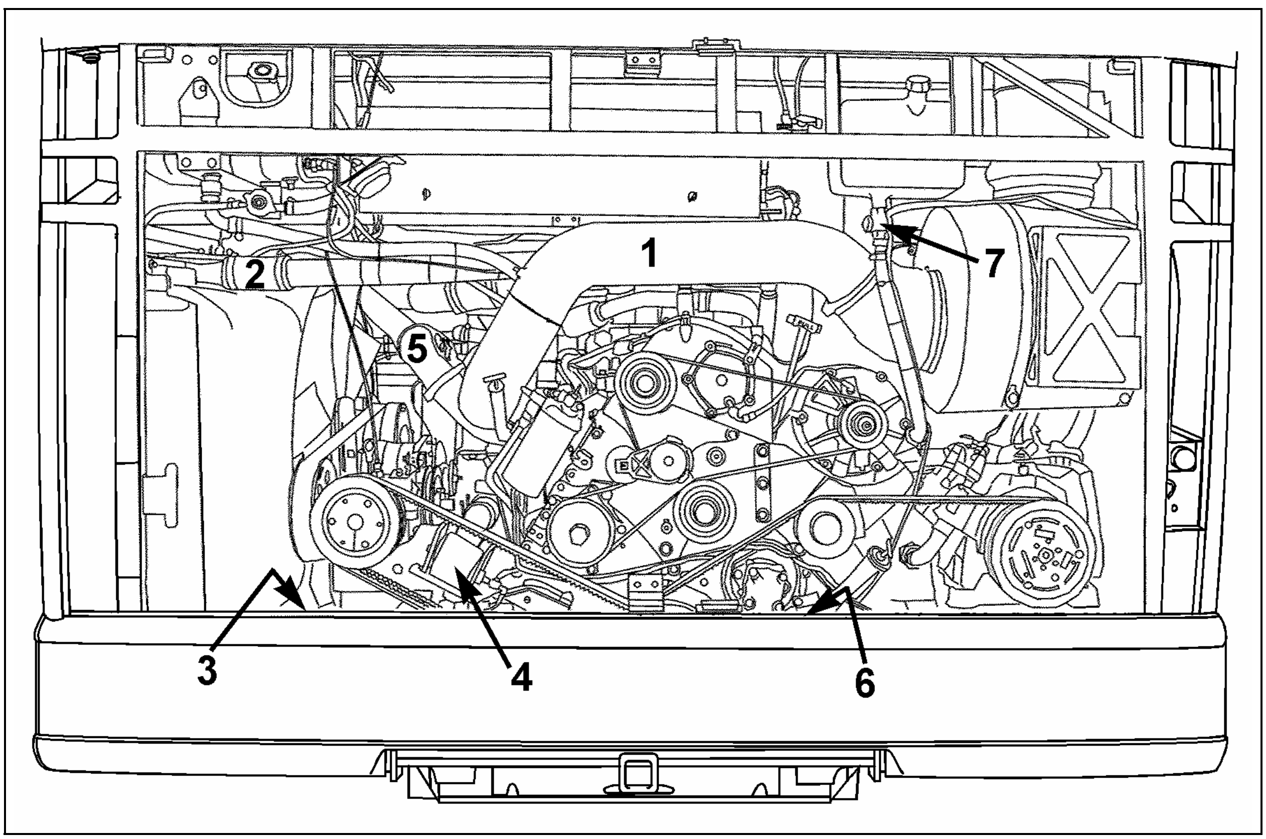


FIGURE 18: ENGINE COMPARTMENT XL2 MTH (TYPICAL)

01112

34. Disconnect connectors from transmission. On the left side: four on rear side with one close to yoke. On right side: close to the solenoid valve of the output retarder.
35. From under the vehicle, disconnect the propeller shaft as detailed in Section 09, under heading "Propeller Shaft Removal".
36. 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.
37. Remove the six retaining bolts, washers and nuts securing the power plant cradle to the vehicle rear subframe (Fig. 20).

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.

38. Using a forklift, with a minimum capacity of 4,000 lbs (1 800 kg), slightly raise the power plant cradle.
39. 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).

9. 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).

* For vehicles equipped with an Allison automatic transmission and a retarder:

a) Install transmission bracket (Fig. 19), tighten to 71-81 lbf-ft (96-110 Nm).

b) Install the transmission's rubber damper assembly above transmission by assembling: bolt, washer, rubber damper guide, rubber damper, bushing nut.

c) Respect damper tolerance of 58 mm (Fig. 19)

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).

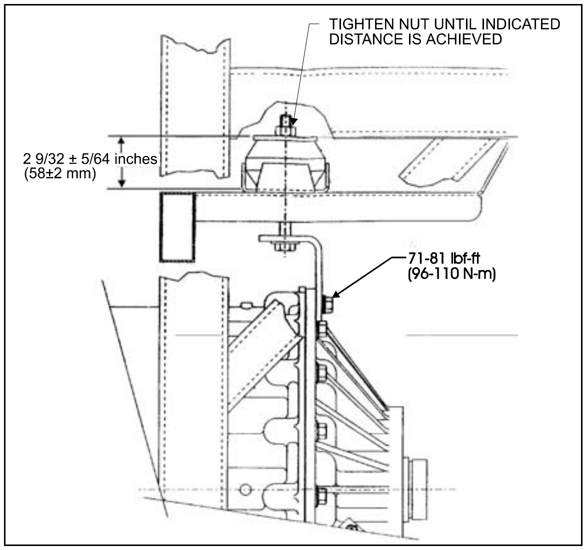


FIGURE 19: RUBBER DAMPER TOLERANCE 07014

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.

10. VALVE COVER REMOVAL

Refer to the series 60 Detroit diesel service manual for injectors and valves adjustment. Access to engine cover differs depending on vehicle model.

Wait until engine is cold prior to working on vehicle.

10.1 XL2-45 COACHES AND MOTORHOMES

1. Remove air intake pipe.
2. Remove the after CAC (Charger-Air-Cooler) air pipe.
3. Disconnect ventilation pipe from valve cover.

4. Remove trap door located in the middle rear end of vehicle.

NOTE
On coaches, last seat has to be removed to access trap door. On motorhomes, it will depend on interior design

5. Remove engine cover.
6. Adjust Jake brakes (if applicable), injectors and valves using Detroit Diesel service manual for series 60 engines.
7. Verify engine cover gasket and replace if necessary.

NOTE
New gasket must be ordered directly from Detroit Diesel.

8. Reinstal engine cover with a tightening torque of 18-22 Lbf-ft (25-30 Nm).
9. Connect ventilation pipe to engine cover.
10. Reinstall air intake and after CAC air pipes.
11. Reinstall trap door, seats or interior finish for motorhomes.

11. 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.

12. 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. 20).

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

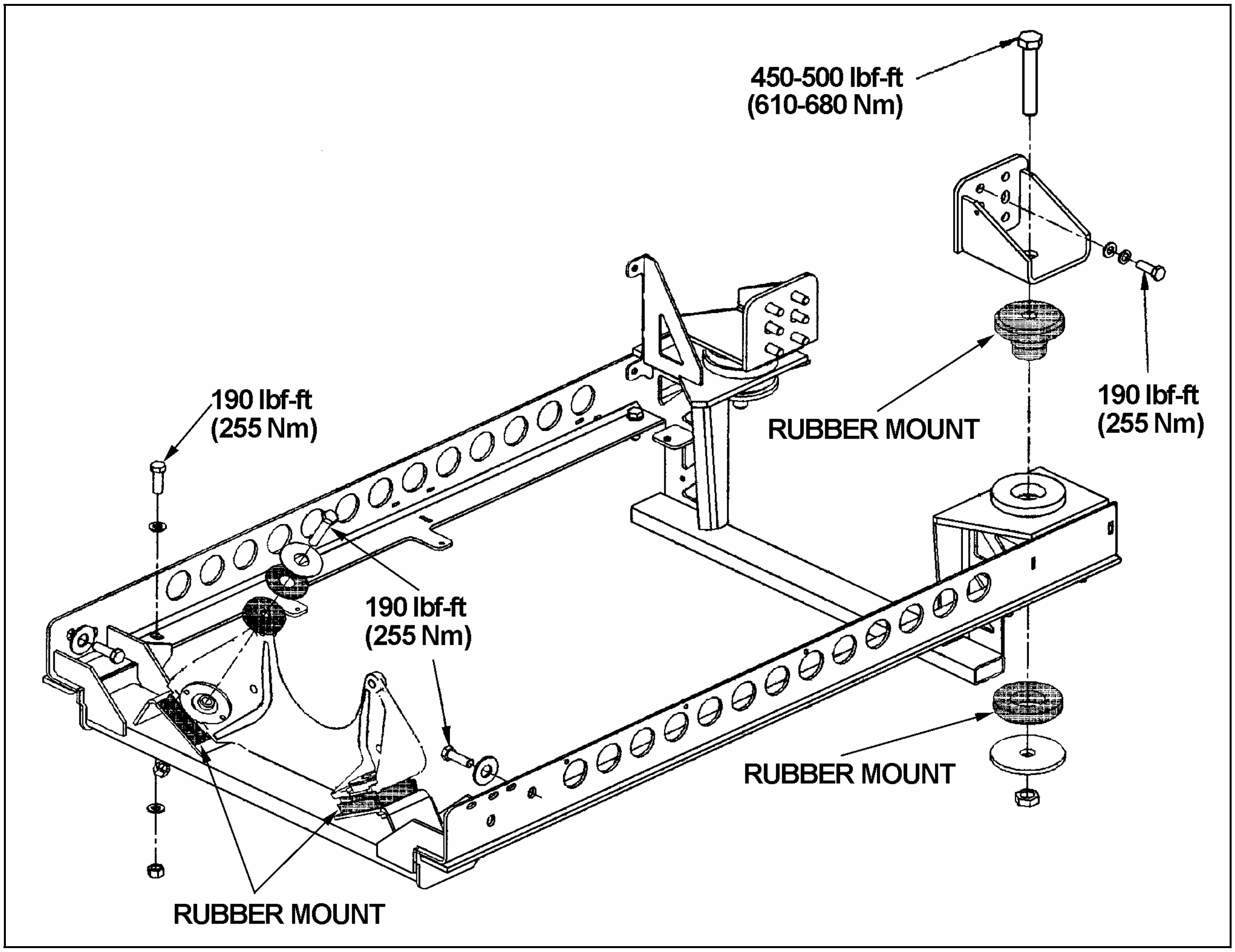
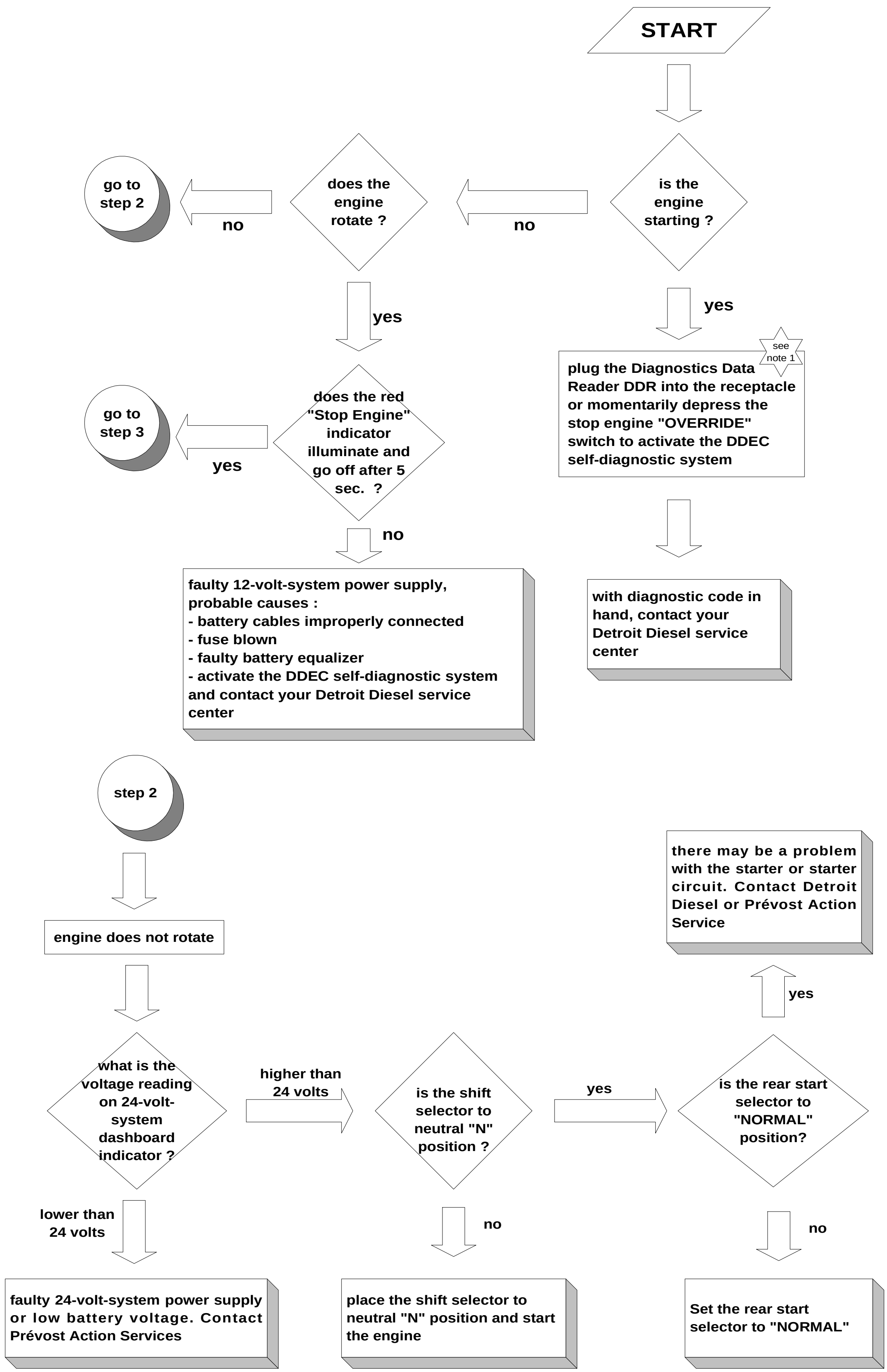
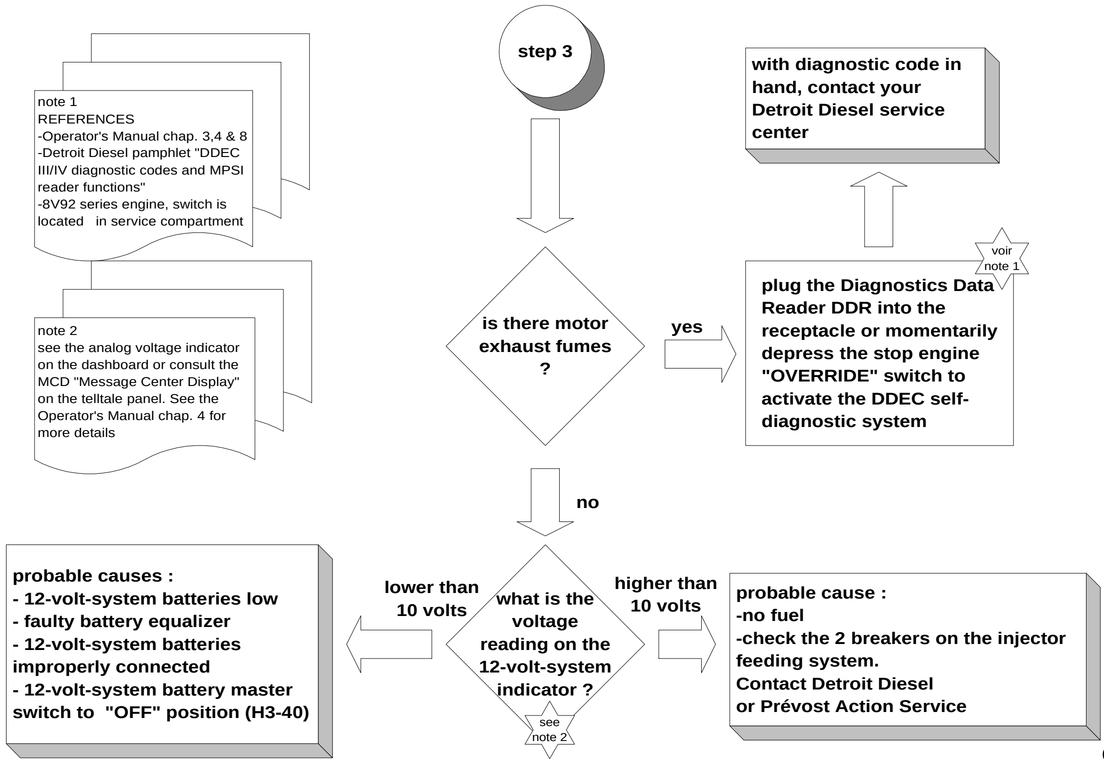


FIGURE 20: POWER PLANT CRADLE INSTALLATION 01140

13. ENGINE TROUBLESHOOTING GUIDE





01089

14. SPECIFICATIONS

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

Lubricant

Heavy-duty engine oil SAE Viscosity Grade 15W-40, API Classification CI-4. Synthetic oil may be used if it meets the performance and chemical requirements of non-synthetic oils outlined previously. Some engine operating conditions may require exceptions to this recommendation.

⚠ **CAUTION** ⚠

To avoid possible engine damage, do not use single grade (Monograde) lubricants in Detroit Diesel four-cycle Series 60 engines, regardless of API classification.

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 Base Engine (12.7L)	
380 HP	**@1800 rpm; 1350 lb-ft @1200 rpm**

Coach Standard Engine (12.7L)	
425 HP	@1800 rpm; 1450 lb-ft @1200 rpm
435 HP	**@1800 rpm; 1450 lb-ft @1200 rpm**
445 HP	@1800 rpm; 1450 lb-ft @1200 rpm
425/445 HP	@1800 rpm; 1450 lb-ft @1200 rpm

XL2 Entertainer & 40' MTH Engine (12.7L)	
445 HP	@1800 rpm; 1550 lb-ft @1200 rpm
450 HP	@1800 rpm; 1550 lb-ft @1200 rpm
455 HP	**@1800 rpm; 1550 lb-ft @1200 rpm**
445/455 HP	@1800 rpm; 1550 lb-ft @1200 rpm

XL2 45' MTH Engine (14.0L)	
470 HP	@1800 rpm; 1650 lb-ft @1200 rpm
490 HP	@1800 rpm; 1650 lb-ft @1200 rpm
515 HP	**@1800 rpm; 1650 lb-ft @1200 rpm**
470/515 HP	@1800 rpm; 1650 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

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

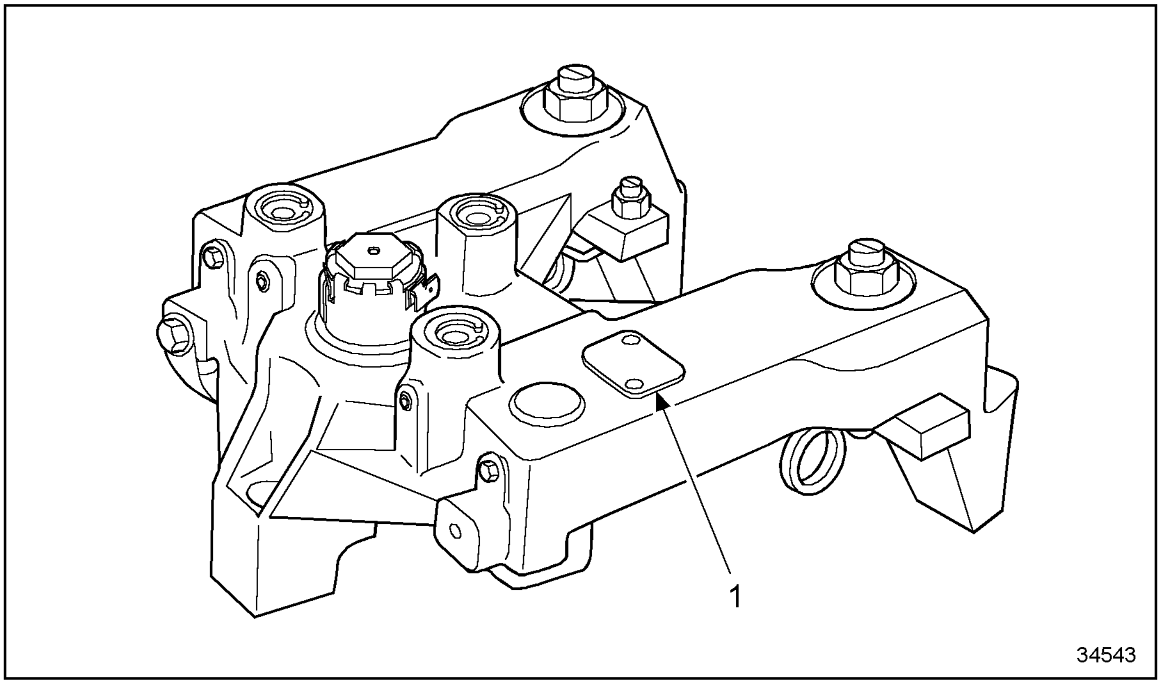
Prévost number 550630

NOTE
For primary and secondary fuel filters, refer to Specifications in section 03

1.29 JAKE BRAKE

The engine brake has been designed to fit on the Series 60 engine with no additional valve cover spacers. There are three styles of valve covers for the Series 60 engine. On engines equipped with a two-piece aluminum valve cover, it is NOT necessary to remove the lower valve cover to install the engine brake. However, one style of upper valve cover may require modification at the breather housing location (inside) for engine brake clearance.

The model, part number and serial number are located on the nameplates at the top of each housing. See Figure 1-414.



1. Identification Plate

Figure 1-414 Nameplate Location on Housing

NOTICE:
Only the specific brake model can be used with the engine model it was designed for. Also, the correct slave piston adjustment specification must be used. Failure to follow these instructions may result in serious engine or engine brake damage.

Listed in Table 1-9 are the different Jake Brake models used and the slave piston adjustment specification.

Model Number	Model Year	Engine Displacement	Engine Brake	Slave Piston Adjustment
6067WU40	Pre-1991	11.1L	760/760A	0.660 mm (0.026 in.)
6067GU40	Pre-1991	12.7L	760/760A	0.508 mm (0.020 in.)
6067WU60	1991	11.1L	760/760A	0.660 mm (0.026 in.)
6067GU40	1991	12.7L	765	0.660 mm (0.026 in.)
6067GU28	1991	12.7L	765	0.660 mm (0.026 in.)
6067GU91	1991	12.7L	765	0.660 mm (0.026 in.)
6067WK60	1994	11.1L	760A	0.660 mm (0.026 in.)
6067GK60	1994	12.7L	765	0.660 mm (0.026 in.)
6067GK28	1994	12.7L	765	0.660 mm (0.026 in.)
6067EK60	1998	11.1L	760B	0.584 mm (0.023 in.)
6067PK60	1998	12.7L	765A	0.584 mm (0.023 in.)
6067TK60	1998	12.7L	765A	0.584 mm (0.023 in.)
6067TK45	1998	12.7L	765A	0.584 mm (0.023 in.)
6067MK60	1998	12.7L	770	0.660 mm (0.023 in.)
6067BK60	1998	12.7L	770	0.660 mm (0.023 in.)
6067HKXX	1998 (Non-Line Haul)	14L	770	0.660 mm (0.023 in.)
6067MK28, 6067MK45, 6067MK57, 6067MK60	2000	12.7L Standard	790	0.660 mm (0.026 in.)
6067BK28, 6067BK45, 6067BK57, 6067BK60	2000	12.7L Premium	790	0.660 mm (0.026 in.)
6067HK45, 6067HK60	2000	14L U.S.	790A	0.660 mm (0.026 in.)
6067WK28, 6067WK60	2000	11.1L	790B	0.660 mm (0.026 in.)
6067LK28, 6067LK45, 6067LK60	2000	11.1L	790B	0.660 mm (0.026 in.)
6063GK60, 6067GK28, 6067GK45, 6067GK91, 6067PK62, 6067TK28, 6067TK60, 6067TK62	2000	12.7L	790B	0.660 mm (0.026 in.)
6067HK62	2000	14L Australian	790C	0.660 mm (0.026 in.)

All slave piston adjustments shown here are current as of the date of this manual and supersede all previous adjustments.

XXXX = Model numbers to be determined.

Table 1-9 Jake Brake Model Information

NOTE:
All engines built after serial number 06R0004455 have the correct engine parts for engine brake installation. The model numbers have changed because of design changes in the engine brakes.

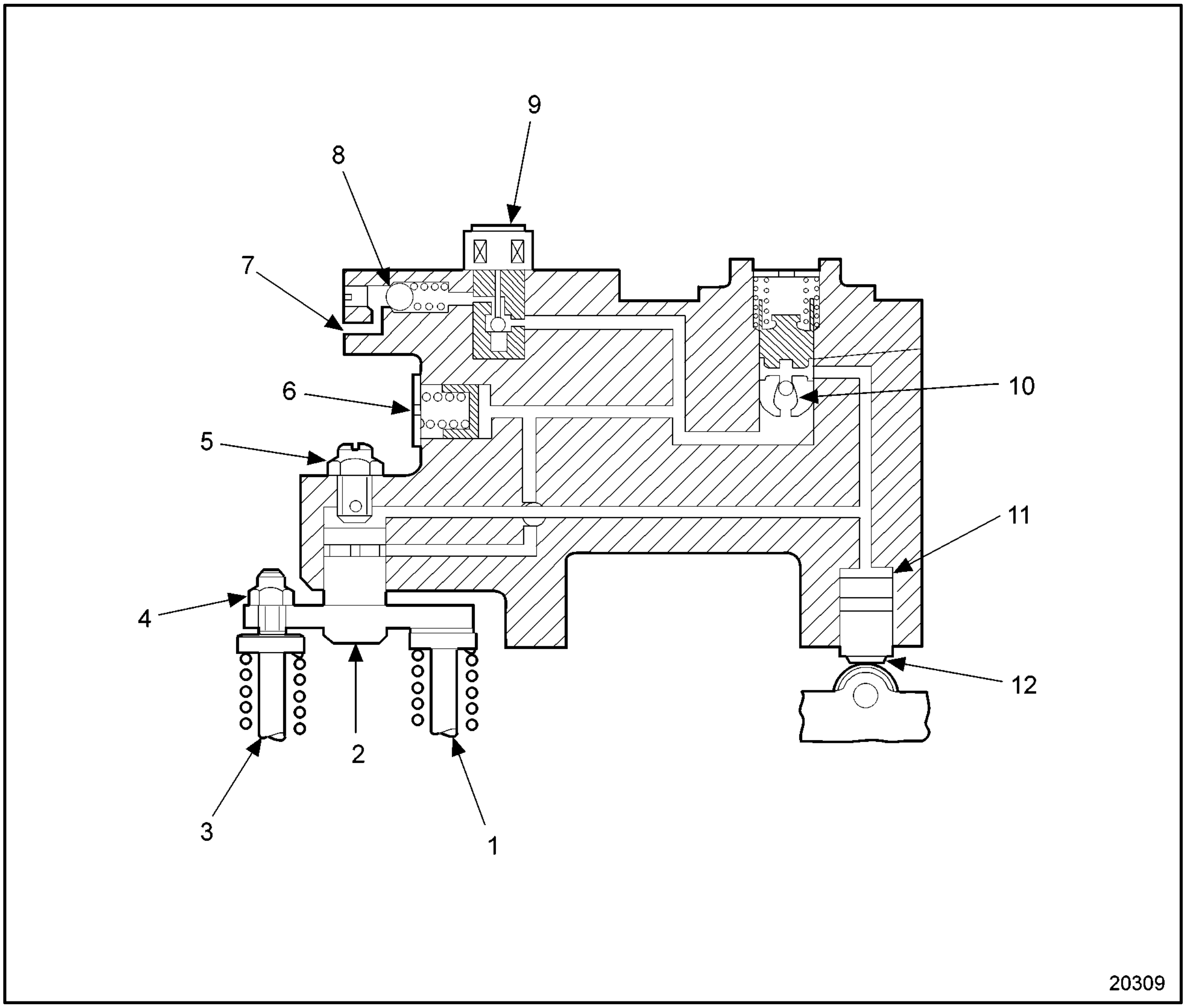
NOTE:
All Series 60 engines with serial numbers 06R0004455 or higher are Jake Brake ready. Do not install a Jake Brake on engines with lower serial numbers.

Effective December 16,1999, Model 790 Jake Brakes are used on all Series 60 engines requiring an engine brake.

Former Jake Brake production models for the Series 60 engine were the 760A (which replaced model 760), 760B, 765, 765A, and 770.

Detroit Diesel engine model Nos. 6067GU28 and 6067GK28 are for bus/coach applications. Due to interference fits on some coach chassis, a two-housing Jake Brake kit may be required. Contact your Detroit Diesel Distributor for information on these kits.

Energizing the engine brake effectively converts a power-producing diesel engine into a power-absorbing air compressor. This is accomplished through motion transfer using a master-slave piston arrangement which opens cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust. See Figure 1-415.



1. Exhaust Valve
2. Slave Piston Assembly
3. Exhaust Valve
4. Leveling Screw
5. Slave Piston Adjusting Screw
6. Accumulator
7. Oil In
8. Check Valve (Model 760)
9. Solenoid Valve
10. Control Valve
11. Master Piston
12. Injector Pin and Roller

Figure 1-415 Jake Brake Schematic

The blowdown of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the expansion stroke, the effect being a net energy loss, since the work done in compressing the cylinder charge is not returned during the expansion process.

Exhaust blowdown occurs as the energized solenoid valve permits engine lube oil to flow under pressure through the control valve to both the master piston and the slave piston. See Figure 1-415.

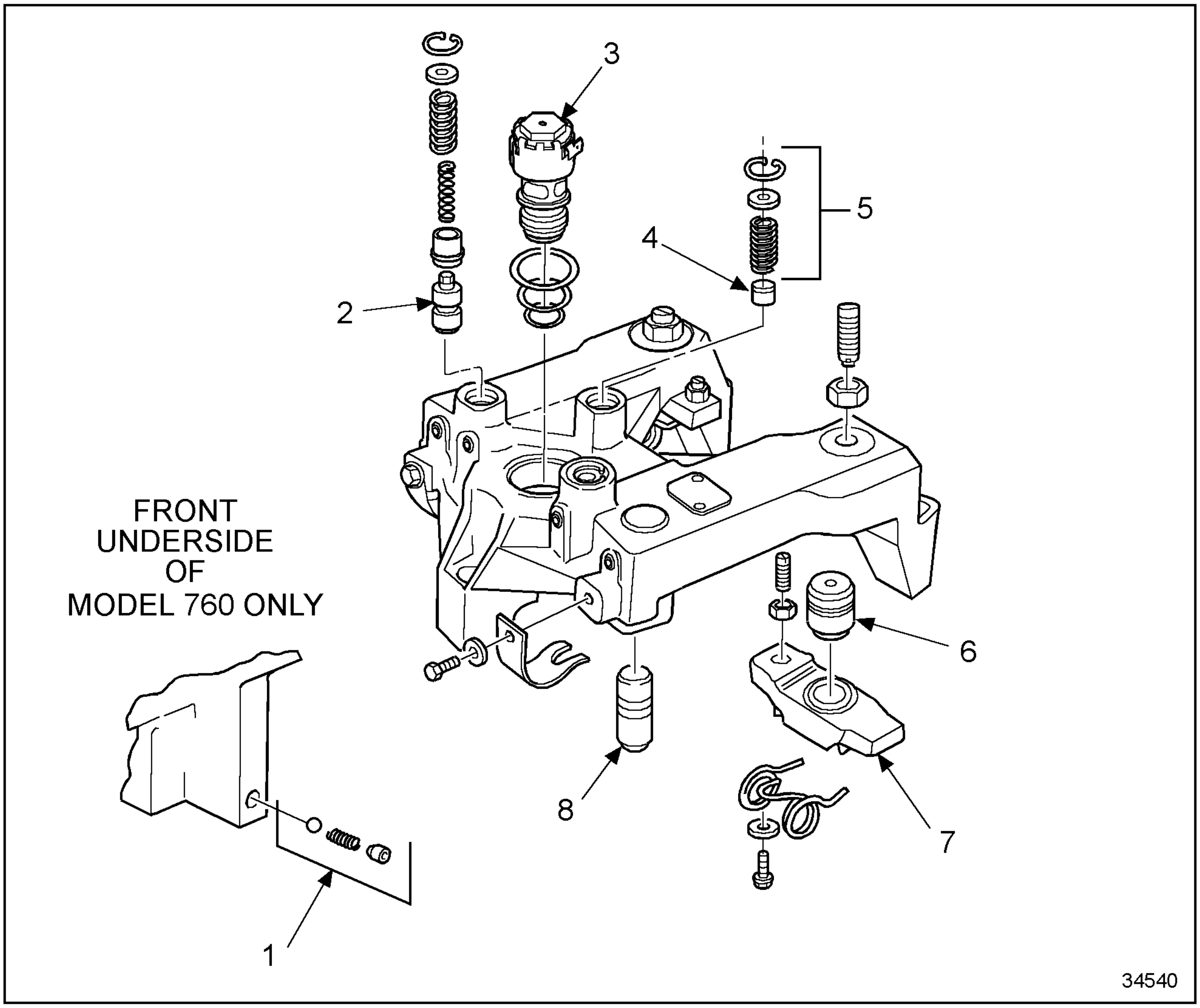
Oil pressure causes the master piston to move down, coming to rest on the injector rocker arm roller.

The injector rocker arm begins its travel as in the normal injection cycle, moving the master piston upward and directing high-pressure oil to the slave piston. The ball check valve in the control valve traps high-pressure oil in the master-slave piston system.

High pressure oil causes the slave piston to move down, momentarily opening the exhaust valves, while the engine piston is near its top-dead-center position, releasing compressed cylinder air to the exhaust manifold.

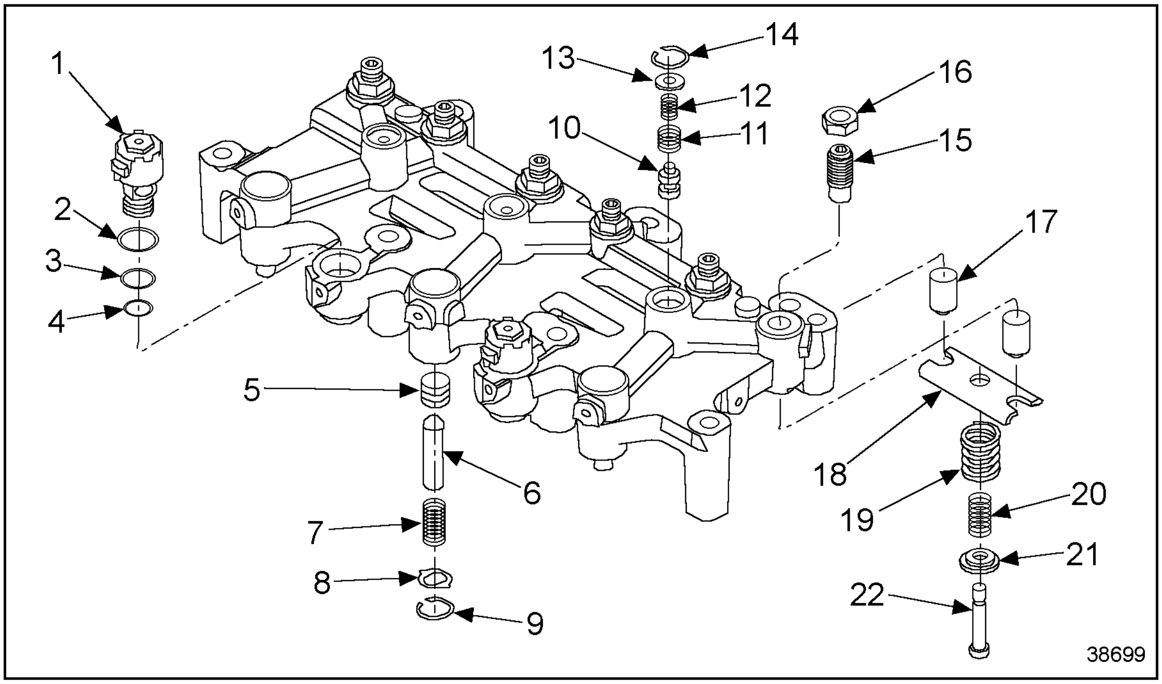
At the bottom of its stroke, the slave piston separates from the valve in the slave piston adjusting screw, allowing high pressure oil to flow into the accumulator. This reduces the pressure in the high pressure circuit, permitting the slave piston to retract and the exhaust valves to close in preparation for the normal exhaust valve cycle. The oil pressure reserved in the accumulator ensures that the hydraulic circuit is fully charged for the next cycle. Compressed air escapes to the atmosphere, completing a compression braking cycle.

The Jake Brake is electronically controlled. Jake Brake control system wiring will vary depending on the vehicle manufacturer. For a general overview of the Jake Brake, see Figure 1-416 and see Figure 1-416a.



1. Ball Check Valve (Model 760 Only)
2. Control Valve
3. Solenoid Valve
4. Accumulator Piston
5. Power Lash Assembly
6. Slave Piston
7. Bridge
8. Master Piston

Figure 1-416 Typical Model 760, 765, or 770 Jake Brake Assembly



1. Solenoid Valve
2. Upper Seal
3. Center Seal
4. Lower Seal
5. Master Piston
6. Master Piston Pushrod
7. Master Piston Spring
8. Washer
9. Retaining Ring
10. Control Valve
11. Outer Control Valve Spring
12. Inner Control Valve Spring
13. Washer
14. Retaining Ring
15. J-Lash® Screw
16. Locknut
17. Slave Piston
18. Slave Piston Bridge
19. Outer Slave Piston Spring
20. Inner Slave Piston Spring
21. Slave Piston Spring Seat
22. Shoulder Bolt

Figure 1-416a Typical Model 790 Jake Brake Assembly

NOTICE:
This application and adjustment information must be strictly followed. Failure to follow these instructions may result in serious engine or engine brake damage.

1.29.1 Repair or Replacement of Jake Brake

To determine if repair is possible or replacement is necessary, perform the following procedure. See Figure 1-417.

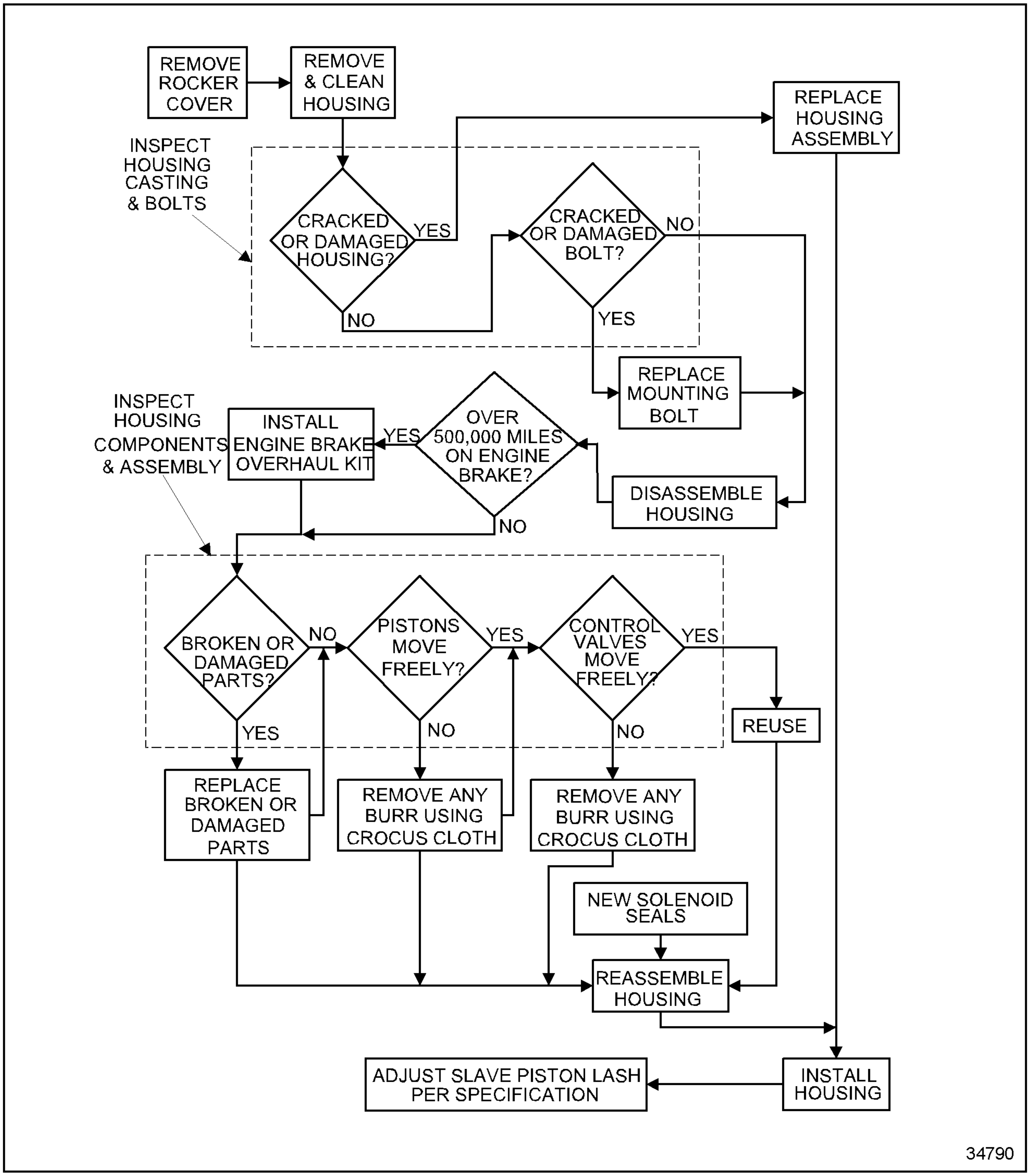


Figure 1-417 Jake Brake Repair or Replacement Flowchart

1.29.2 Removal of Model 760, 765, or 770 Jake Brake

Remove the model 760, 765, or 770 Jake Brake as follows:

NOTE:
The following procedures apply to Model 760, 765, and 777 Jake Brakes. For Model 790 Jake Brake removal procedures, refer to section 1.29.6.

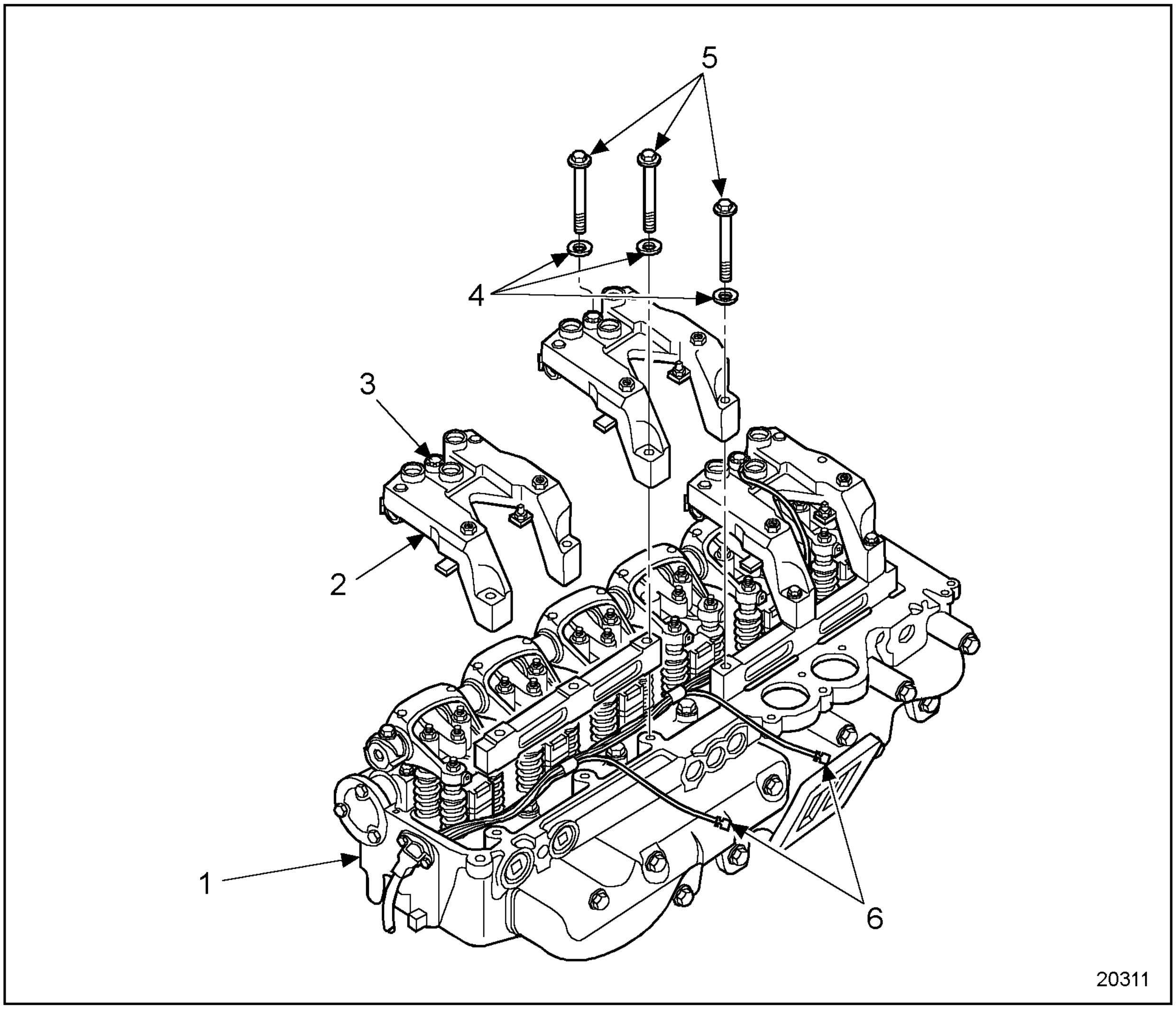
CAUTION:

To avoid possible personal injury, never remove any engine brake component with engine running.

1. Disconnect starting power for engine. Refer to OEM guidelines.
2. Remove the engine rocker cover. Refer to section 1.6.2 for one-piece, refer to section 1.6.3 for two-piece and refer to section 1.6.5 for three-piece.

NOTE:
If the engine is equipped with an aluminum two-piece valve cover, remove only the upper valve cover when installing the engine brake.

3. Note the location of the rocker arm shaft, the exhaust valve rocker arm, the fuel injector rocker arm, and the intake valve rocker arm.
4. Disconnect the solenoid wiring harness connectors from the engine brake solenoids. See Figure 1-418.



1. Cylinder Head
2. Jake Brake Assembly
3. Solenoid
4. Washers (3 each)
5. Mounting Bolts (3 each)
6. Engine Brake Harness

Figure 1-418 Jake Brake Assembly

5. Remove the nine mounting bolts and washers that secure the engine brake assemblies to the cylinder head. See Figure 1-418.

NOTE:
Only the Model 760 Jake Brake uses two different length mounting bolts. Six bolts, 120 mm (4.72 in.) long, are used on the exhaust side of the engine. Three bolts, 110 mm (4.33 in.) long, are used on the intake side of the engine. These bolts must be reinstalled in their correct positions.

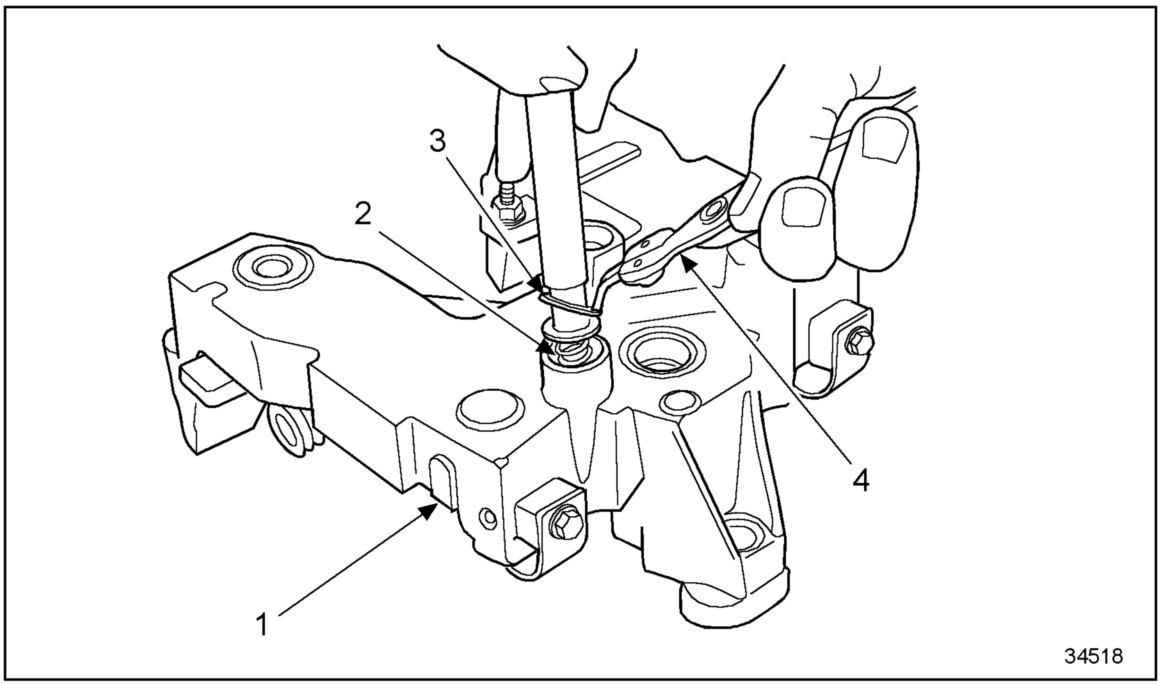
6. Remove the engine brake assemblies and the spacer bar.

1.29.3 Disassembly of Model 760, 765, or 770 Jake Brake

Remove the control valve as follows:

CAUTION:
To avoid personal injury, remove control valve covers carefully. Control valve covers are under load from the control valve springs.

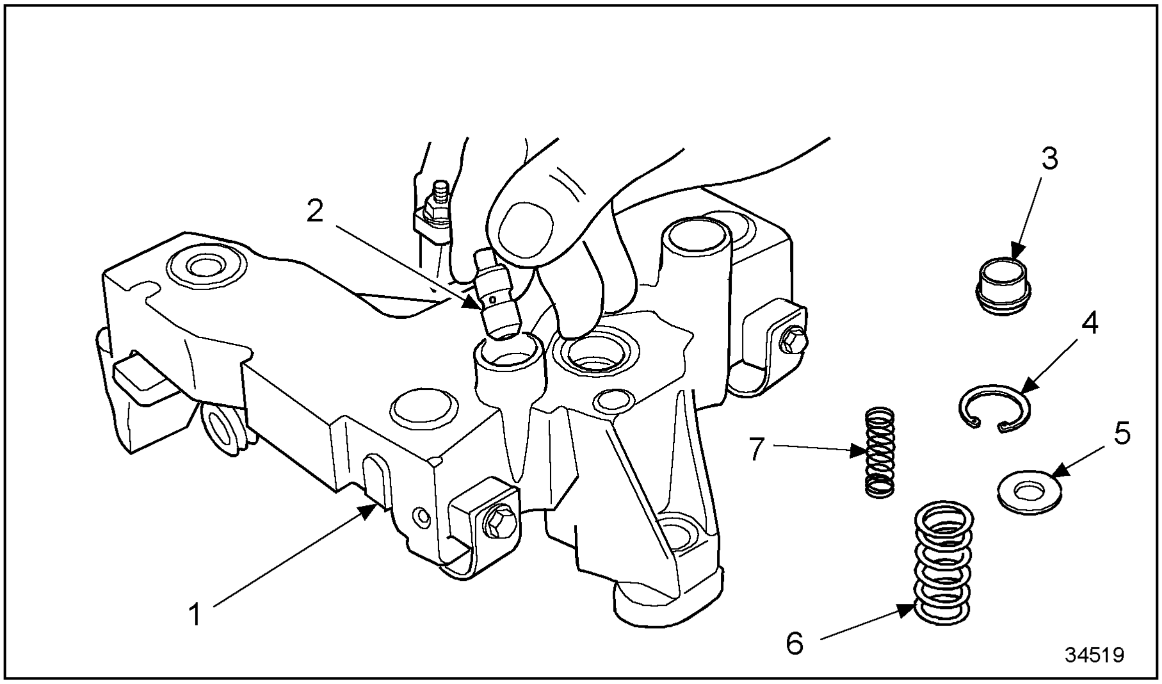
1. Press down on control valve washer using an appropriate diameter rod to relieve spring pressure. See Figure 1-419.



1. Jake Brake Assembly
2. Spring
3. Snap Ring Retainer
4. Snap Ring Pliers

Figure 1-419 Relieving Spring Pressure

2. Using retaining ring pliers, remove retaining ring.
3. Slowly remove cover until spring pressure ceases, then remove the two control valve springs and collar. See Figure 1-420.



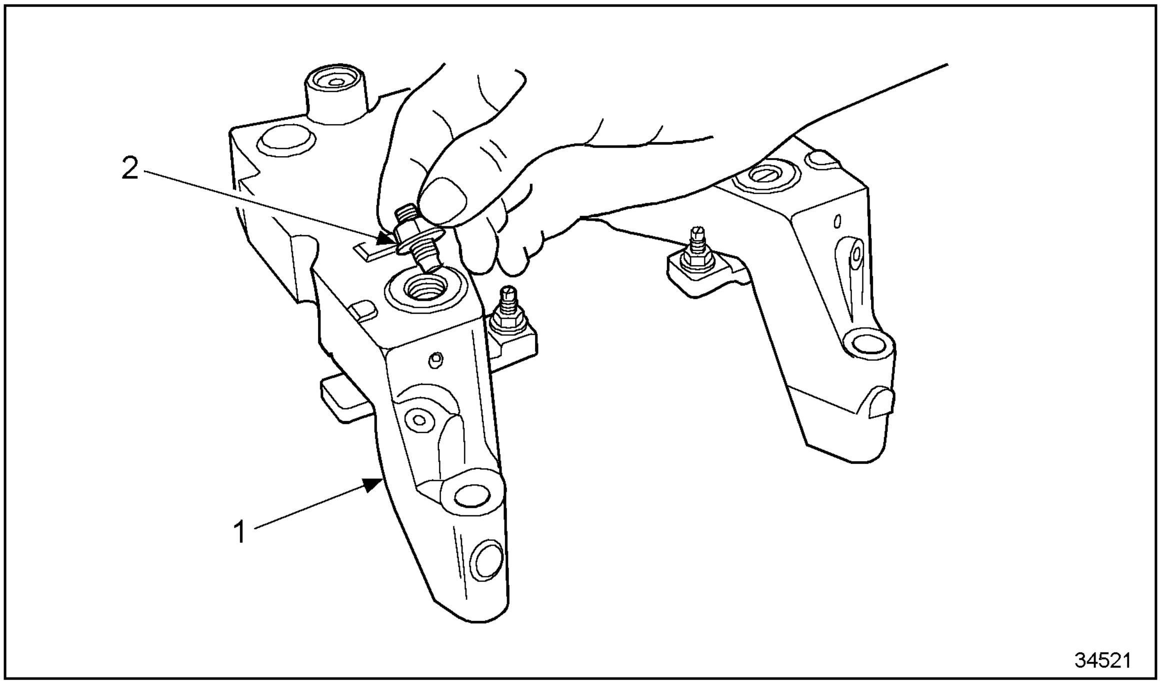
1. Jake Brake Assembly
2. Control Valve
3. Collar
4. Snap Ring Retainer
5. Washer
6. Collar Spring
7. Control Valve Spring

Figure 1-420 Removing Control Valve Springs and Collar

4. Using needle-nose pliers, reach into the bore and grasp the stem of the control valve. Remove control valve.

Remove the slave piston adjusting screw as follows:

1. Loosen slave piston adjusting screw locknut.
2. Remove adjusting screw from housing. See Figure 1-421.



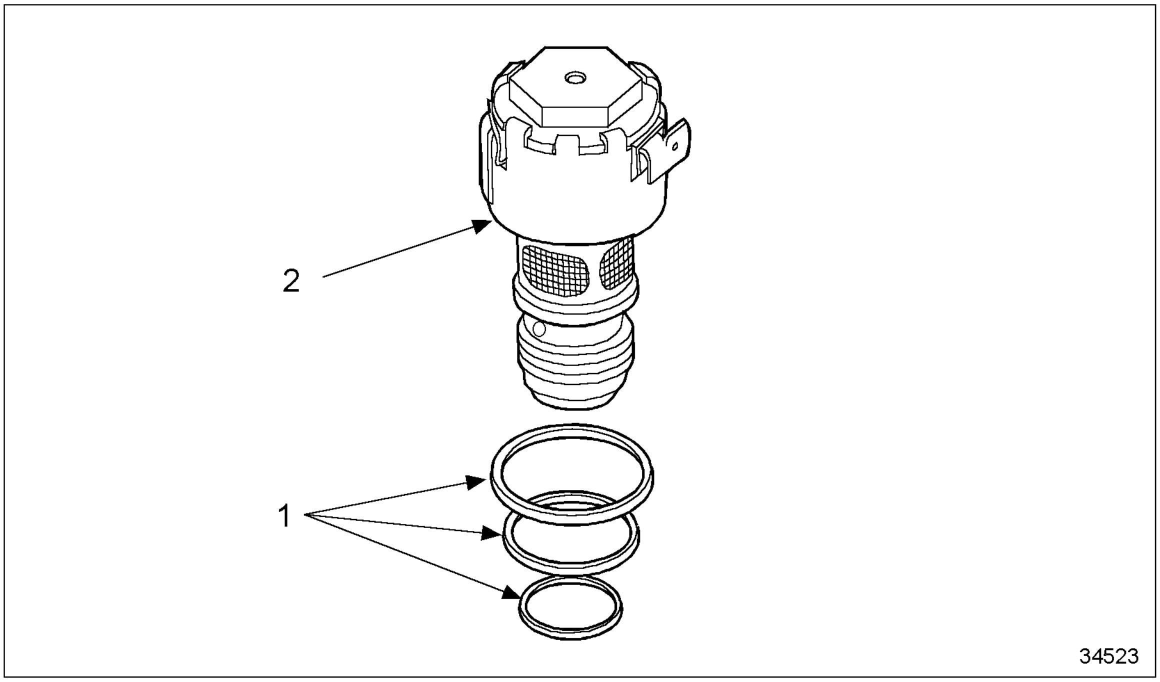
1. Jake Brake Assembly
2. Slave Piston Adjusting Screw

Figure 1-421 Removing Slave Piston Adjusting Screw

Remove the solenoid valve as follows:

NOTICE:
To avoid possible engine damage, do not disassemble or tamper with the solenoid valve.

1. Disconnect solenoid valve harness.
2. Using a 7/8 in. socket and extension for former solenoids or a 3/4 in., 6 point socket and extension for current solenoids, unscrew solenoid valve.
3. Remove and discard the three rubber seal rings. See Figure 1-422.



1. Seal Rings (3)
2. Solenoid

Figure 1-422 Removing Rubber Seal Rings

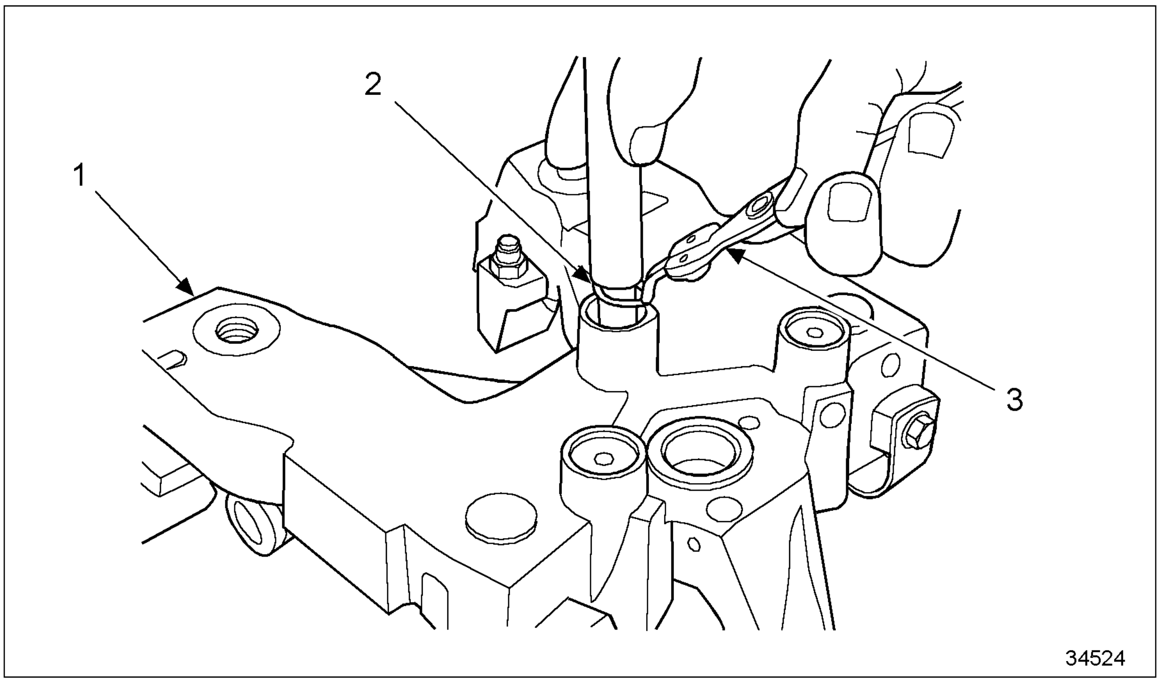
4. If the lower ring stays in the bottom of the housing bore, remove with a piece of wire.

Remove the accumulator as follows:

CAUTION:

The accumulator spring is under strong compression. To avoid possible personal injury if the accumulator spring is discharged, wear safety glasses and use caution when removing the retaining ring and cover.

1. Push down on the accumulator cover using the appropriate diameter rod, and remove the retaining ring. See Figure 1-423.

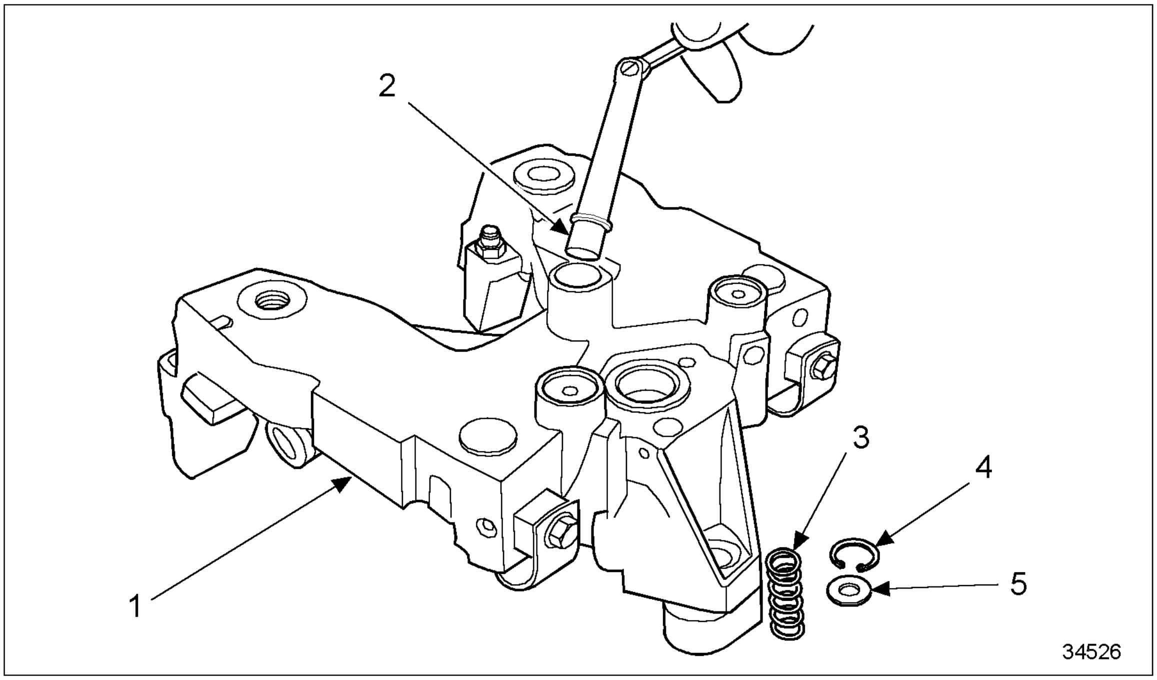


1. Jake Brake Assembly
2. Retaining Ring
3. Retaining Ring Pliers

Figure 1-423 Removing Retaining Ring

2. Relieve pressure on the accumulator cover.
3. Remove the cover and spring.

4. Use a magnet to remove the piston from the accumulator bore. See Figure 1-424.



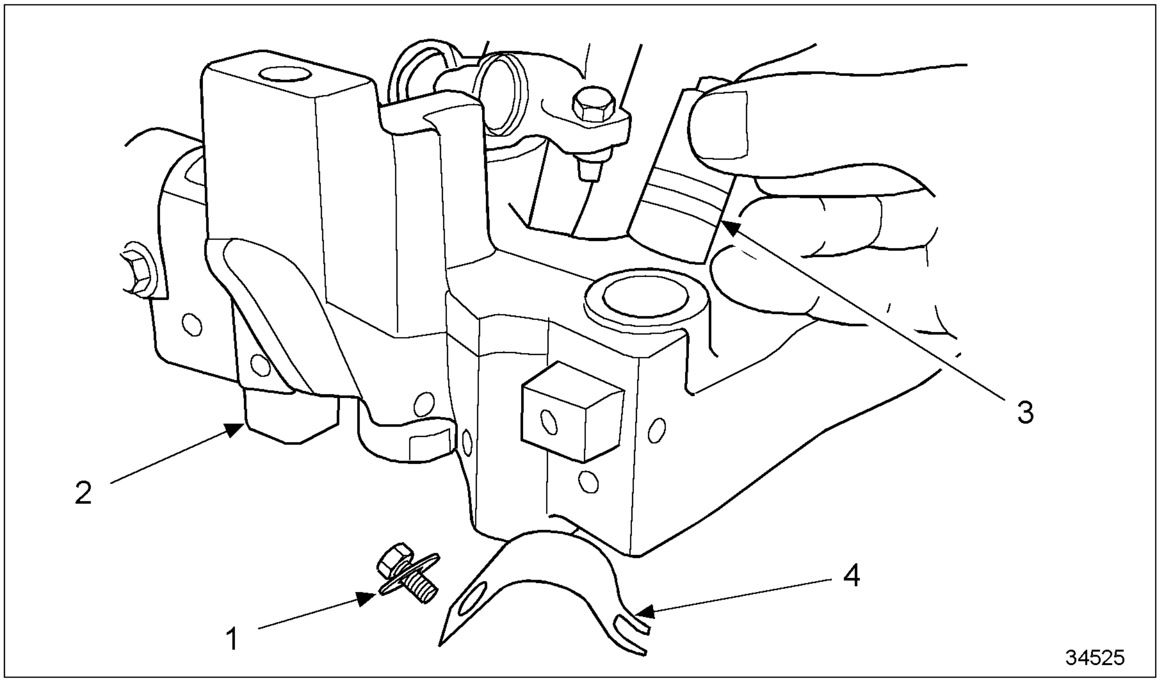
1. Jake Brake Assembly
2. Piston
3. Spring
4. Retaining Ring
5. Washer

Figure 1-424 Removing Piston from Accumulator Bore with Magnet

Remove the master piston as follows:

1. Remove the screw, washer, and master piston spring from the housing.
2. Remove the master piston. See Figure 1-425.

NOTE:
Use needle-nose pliers, if necessary.



1. Washer and Screw Assembly
2. Jake Brake Assembly
3. Master Piston
4. Master Piston Spring

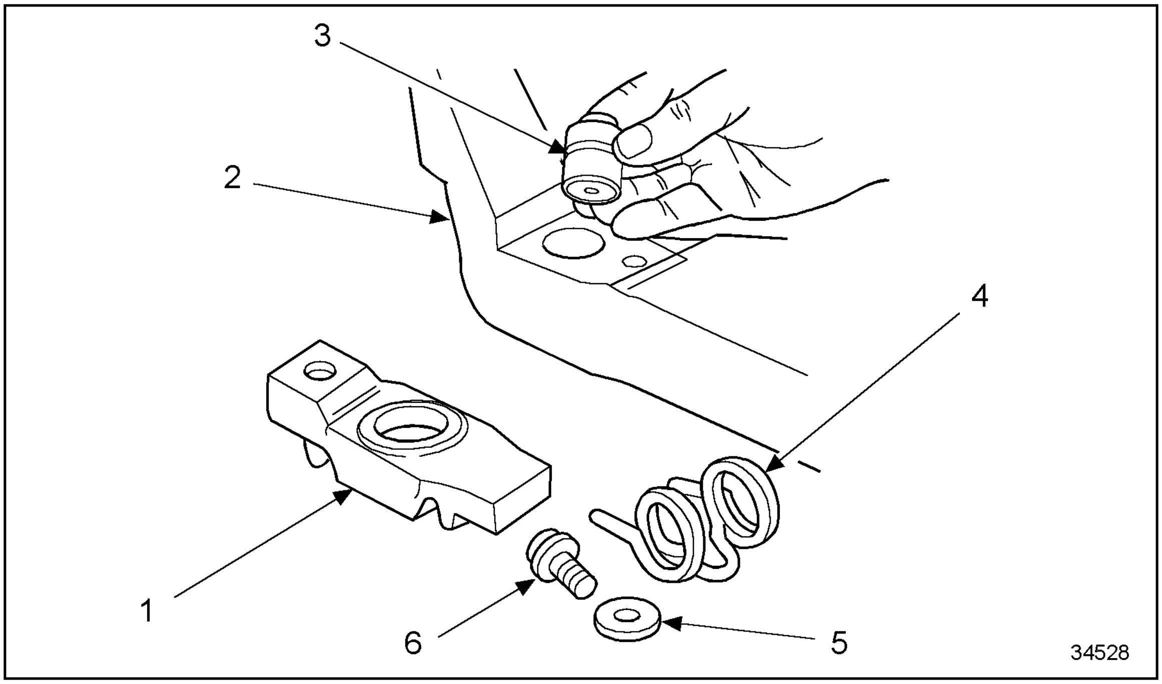
Figure 1-425 Removing The Master Piston

On Model 760 only, remove the ball check valve as follows:

1. Remove the plug.
2. Remove the ball check valve and spring.

Remove the slave piston as follows:

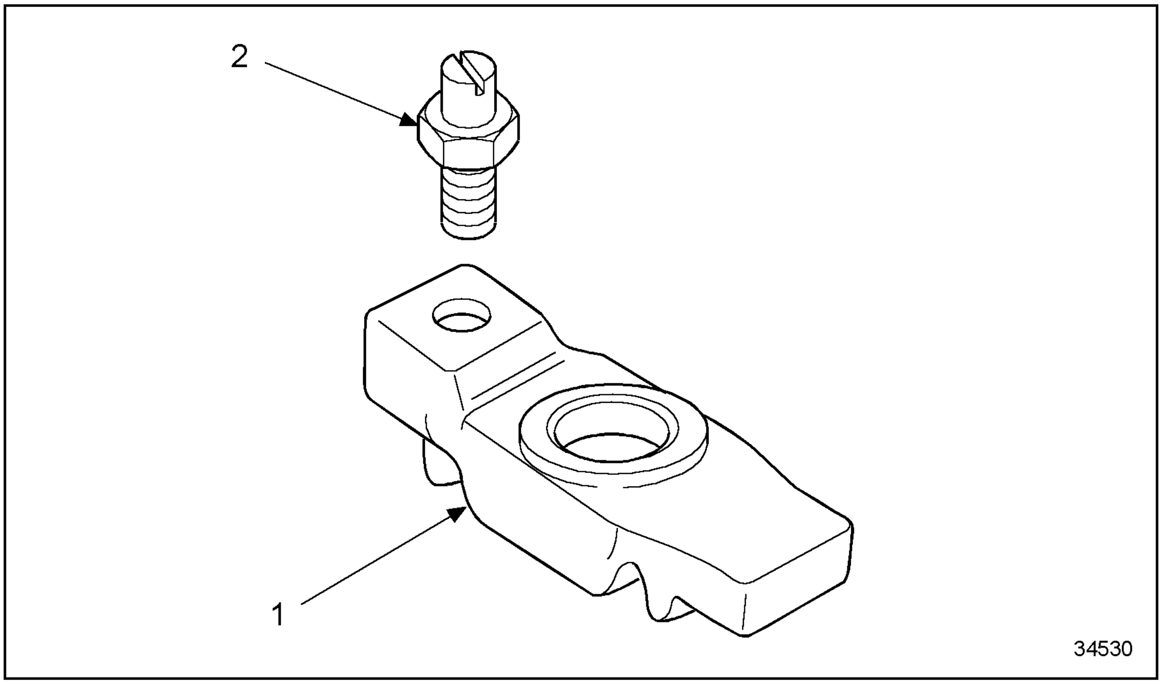
1. Remove the screw and spring that retains the slave piston return spring.
2. Remove the bridge and the slave piston. See Figure 1-426.



1. Slave Piston Bridge
2. Jake Brake Housing
3. Slave Piston
4. Return Spring
5. Washer
6. Screw

Figure 1-426 Removing Bridge and Slave Piston

3. Loosen the leveling screw locknut and remove the leveling screw from the bridge. See Figure 1-427.



1. Slave Piston Bridge
2. Slave Piston Leveling Screw

Figure 1-427 Removing the Leveling Screw from the Bridge

The injector rocker arm contains a pin and roller for actuating the engine brake master piston. If excessive wear or damage to the roller is present, replace the rocker arm assembly. Refer to Section 1.6.2.

1.29.3.1 Cleaning of Model 760, 765, or 770 Jake Brake

Clean the Jake Brake as follows:

NOTE:
Use an OSHA-approved cleaning solvent when washing parts. Be sure to coat parts with clean engine oil when reinstalling them.

1. Wash the control valves with approved cleaning solvent.
2. Push a wire through the hole in the base of the valve to the distance required to ensure that the ball check is free.

NOTE:
The ball should lift with light pressure on the wire.

CAUTION:

To prevent possible personal injury when using compressed air, wear adequate eye protection (face plate or safety glasses) and do not exceed 40 psi (276 kPa) air pressure.

3. Dry the valve with compressed air, and wipe clean with a paper towel.
4. Thoroughly clean the control valve bore in the housing using clean paper towels.
5. Clean slave piston adjusting screw in an approved cleaning solvent.
6. Clean out the solenoid valve bore in the housing.

NOTICE:

Use clean paper towels to clean the solenoid valve bore. Never use rags, as they may leave lint and residue which can plug the oil passageways, causing Jake Brake malfunction.

7. Clean the master piston in approved cleaning solvent.

1.29.3.2 Inspection of Model 760, 765, or 770 Jake Brake

The Jacobs engine brake is typically a trouble-free device. However, inspections are necessary and some maintenance is required. Use the following procedures to keep the engine brake in top condition.

Inspect the Jake Brake as follows:

1. Inspect slave piston adjusting screw for protrusion, spring pressure and freedom of movement.

NOTE:
The plunger should protrude from the bottom of the screw, have light spring pressure apparent when depressed, and move freely. Be sure the retaining ring is fully engaged in its groove (groove is located on the bottom of the reset screw and top of the POWER-LASH assembly).

   [a] If the plunger does not protrude, the spring does not have light pressure or does not move freely, replace the entire screw assembly. Refer to Section 1.29.4

   [b] If the slave piston adjusting screw meets specifications, continue with inspection.

2. Inspect the accumulator for wear or damage.

   [a] If worn or damaged, replace the accumulator. Refer to Section 1.29.4.

   [b] If accumulator is not worn or damaged, continue with inspection.

3. Inspect the master piston bore for wear or damage.

NOTE:
Some wear marks are permissible.

   [a] If worn or damaged, replace the master piston. Refer to Section 1.29.4.

   [b] If not worn or damaged, continue with inspection.

4. Apply clean lube oil to the piston, and insert into bore.

NOTE:
Master piston should move in and out freely with no binding.

   [a] If binding occurs, replace master piston and/or housing. Refer to Section 1.29.4.

   [b] If no binding occurs, continue with inspection.

5. Inspect master piston spring for relaxation.

NOTE:
The spring should hold the master piston completely in the housing.

   [a] If relaxed, replace the spring. Refer to Section 1.29.4.

   [b] If spring holds tightly, continue with inspection.

6. Inspect the ball check valve (Model 760 only) for wear or damage.
   [a] If worn or damaged, replace ball check valve. Refer to Section 1.29.4.
   [b] If not worn or damaged, proceed with inspection.
7. Inspect slave piston components for excessive wear or damage.
   [a] If worn or damaged, replace slave piston component.
   [b] If not worn or damaged, proceed with inspection.

1.29.3.3 Inspection of Control Valve

Inspect the control valve as follows:

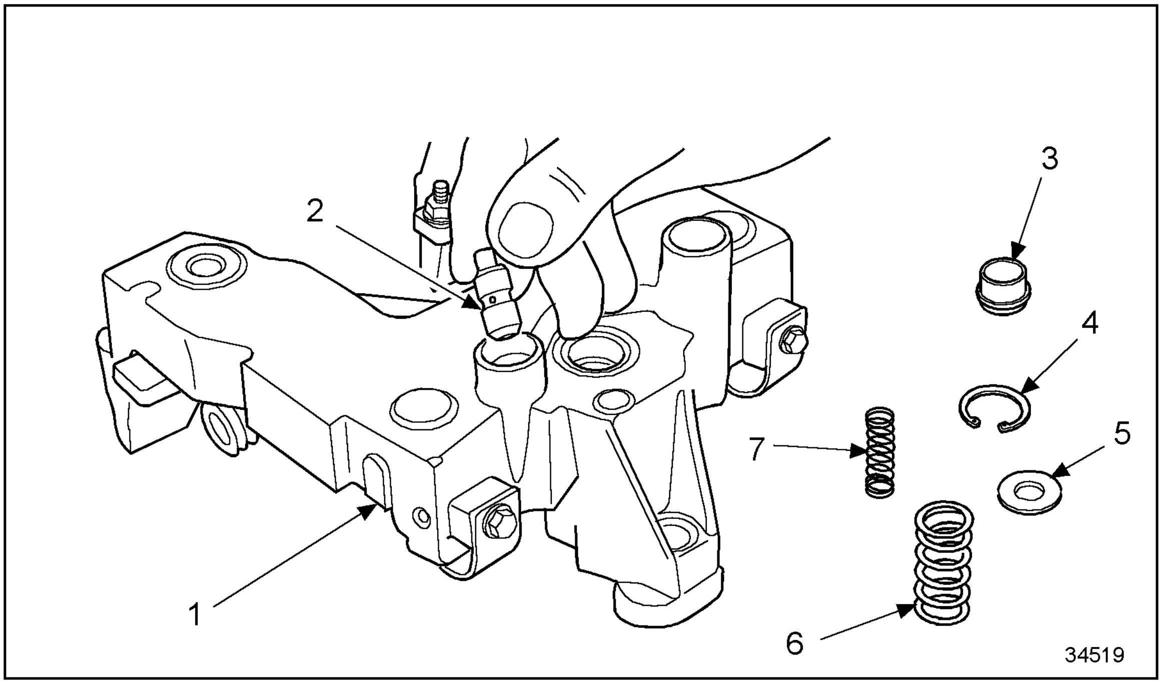
1. Dip the control valves in clean lube oil.
2. Holding the control valve by the stem, let it drop into the bore.
   [a] If binding occurs or if the ball sticks in the valve, replace the control valve. Refer to Section 1.29.4.
   [b] If no binding occurs and the ball does not stick in the control valve, assemble the Jake Brake. Refer to Section 1.29.4.

1.29.4 Assembly of Model 760, 765, or 770 Jake Brake

Install the control valve as follows:

1. Slip the control valve into the bore. See Figure 1-428.

NOTE:
Make sure the control valve collar is installed with the longer sleeve area facing up. If the collar is installed upside down, the engine brake cylinder will not operate.



1. Jake Brake Assembly
2. Control Valve
3. Collar
4. Snap Ring Retainer
5. Washer
6. Collar Spring
7. Control Valve Spring

Figure 1-428 Installing the Control Valve

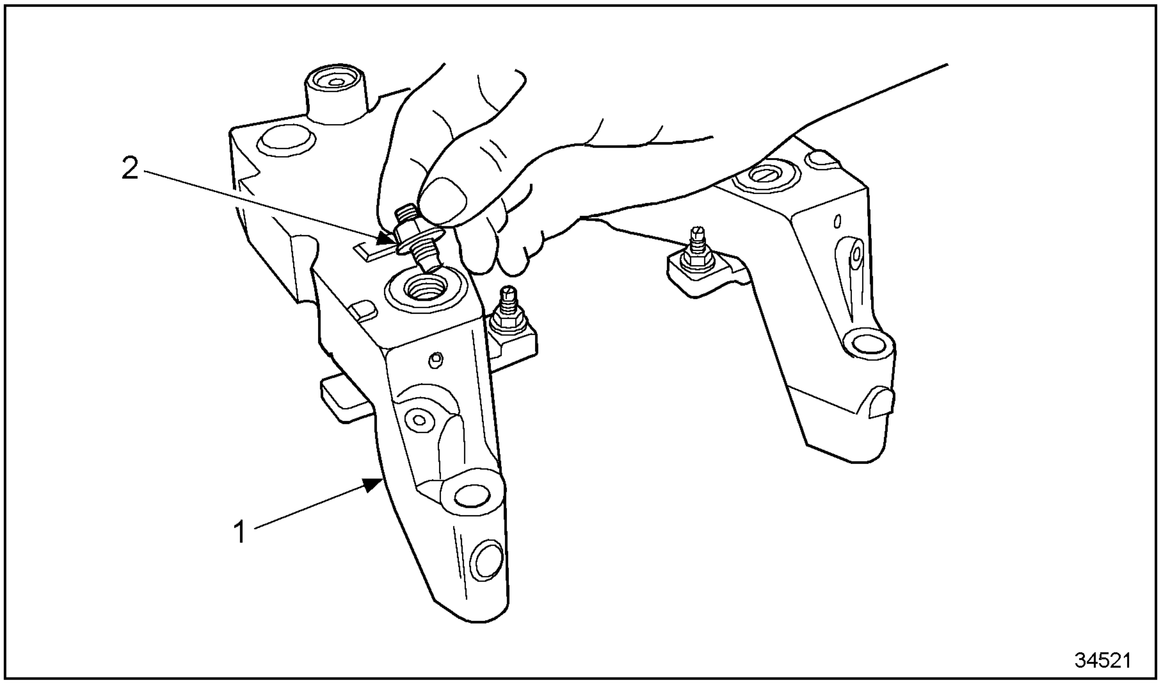
2. Install the control valve collar and two springs.

NOTE:
Ensure the collar is installed with the longer sleeve area facing up. If the collar is installed upside down, the engine brake cylinder will not operate.

3. Press the cover (washer) into place.
4. While holding the cover tightly in place, install the retaining ring.
5. Rotate retaining ring ears 90 degrees to assure ring is seated in groove.

Install the slave piston adjusting screw as follows:

1. Place the screw in the housing. See Figure 1-429.



1. Jake Brake Assembly
2. Slave Piston Adjusting Screw

Figure 1-429 Installing the Slave Piston Adjusting Screw

2. Torque the slave piston adjusting screw locknut to 35 N·m (25 lb·ft).

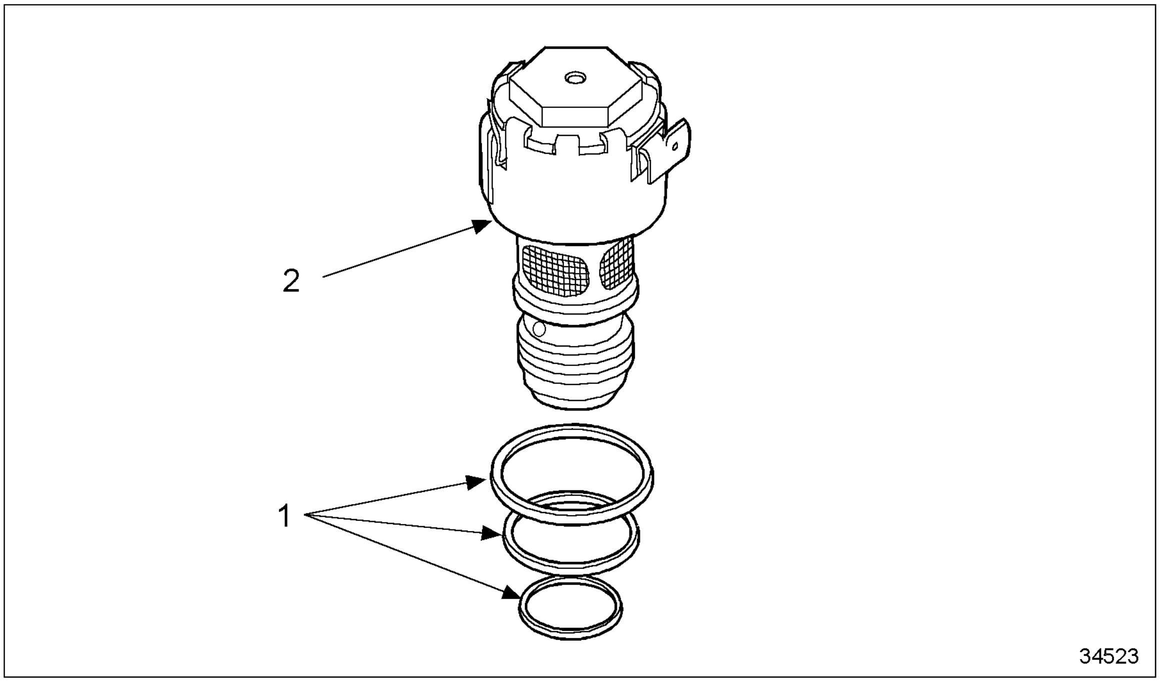
Install the solenoid valve as follows:

NOTE:
As of October 19, 1997, former solenoids have been replaced with the current improved solenoids. The current solenoids have an increased installation torque and improved durability. The current solenoid is interchangeable with the former.

1. Coat new solenoid valve seal rings with clean lube oil.

NOTE:
Use current upper seals when installing current solenoids. New seals are identified with yellow stripes.

2. Install the upper and center seal rings on the solenoid valve body and the lower seal ring into the bottom of the bore in the housing. See Figure 1-430.



1. Seal Rings (3)
2. Solenoid

Figure 1-430 Installation of Solenoid Valve Seal Rings

3. Make sure the seals are seated properly.
4. Using a 7/8 in. socket and extension for former solenoids or a 3/4 in., 6 point socket and extension for current solenoids, carefully screw the solenoid valve into the housing without unseating the seals.
5. Torque the former solenoid to 12.4 N·m (9 lb·ft). Torque the current solenoid to 20 N·m (15 lb·ft.)

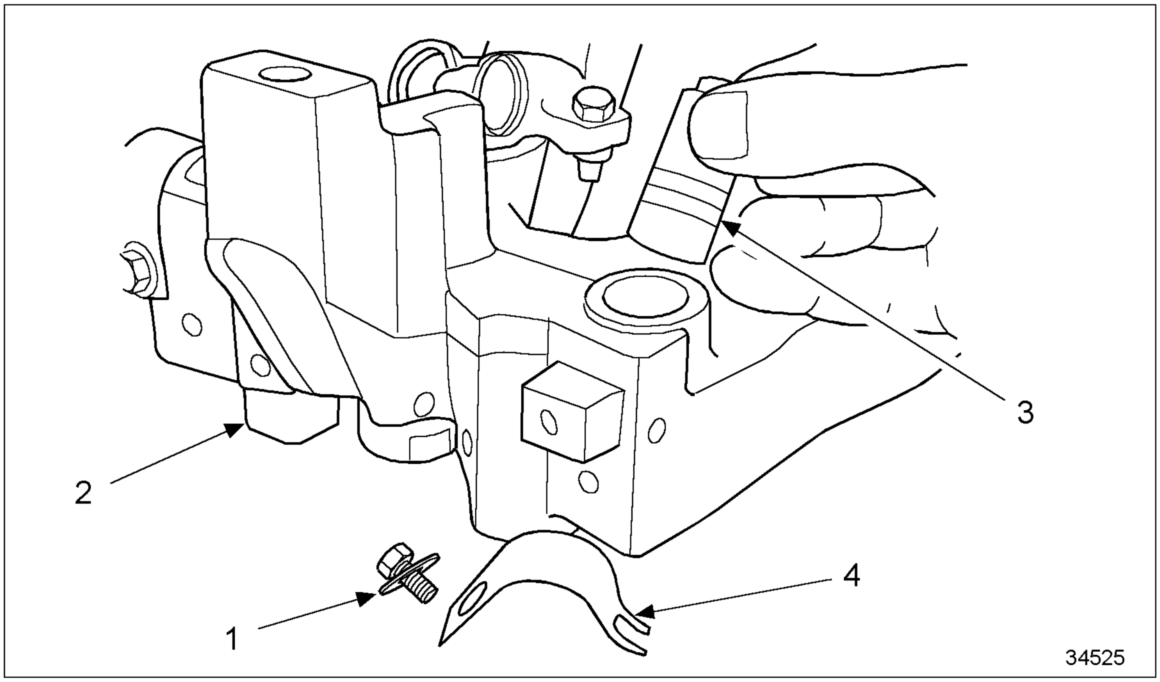
NOTE:
Be careful not to twist the seals while installing.

Install the accumulator as follows:

1. Place the piston into the accumulator bore.
2. Insert the spring, and install the cover.
3. Push down the accumulator cover, and insert retaining ring.

Install the master piston as follows:

1. Apply clean lube oil to the piston.
2. Insert master piston into bore. See Figure 1-431.



1. Washer and Screw Assembly
2. Jake Brake Assembly
3. Master Piston
4. Master Piston Spring

Figure 1-431 Inserting Master Piston into Bore

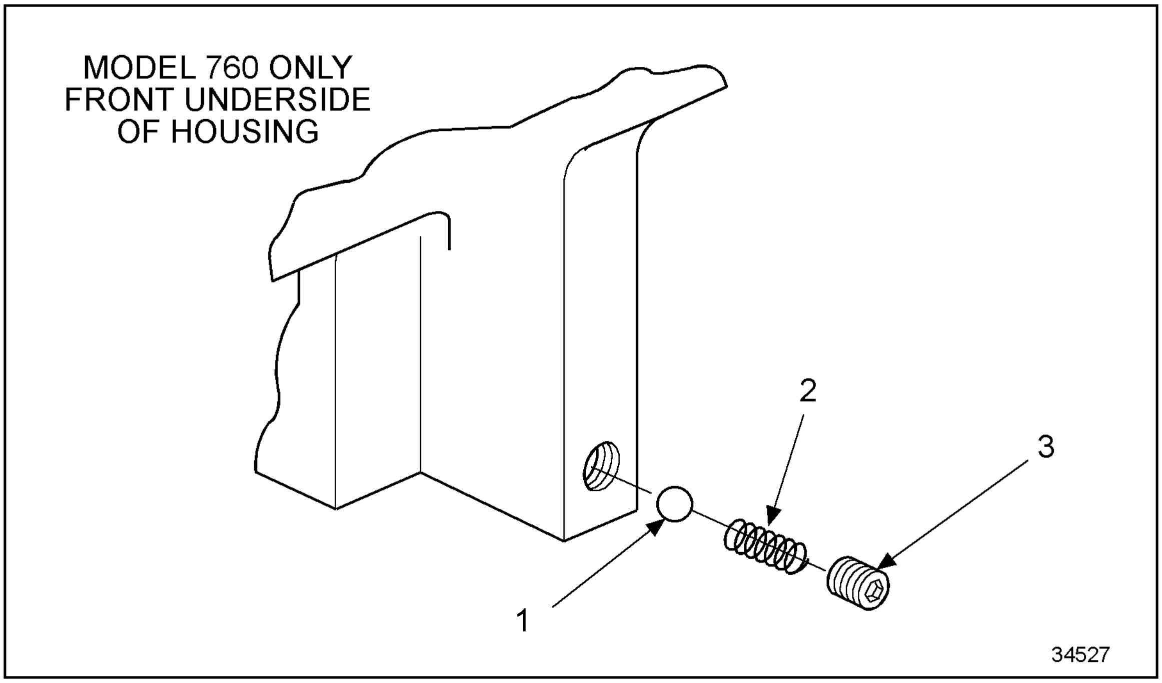
3. Install spring, washer, and screw.

NOTE:
Make sure spring legs are centered around master piston boss.

4. Torque screw to 10 N·m (7.4 lb·ft).

On model 760 only, install the ball check valve as follows:

1. Install the ball check valve and spring. See Figure 1-432.



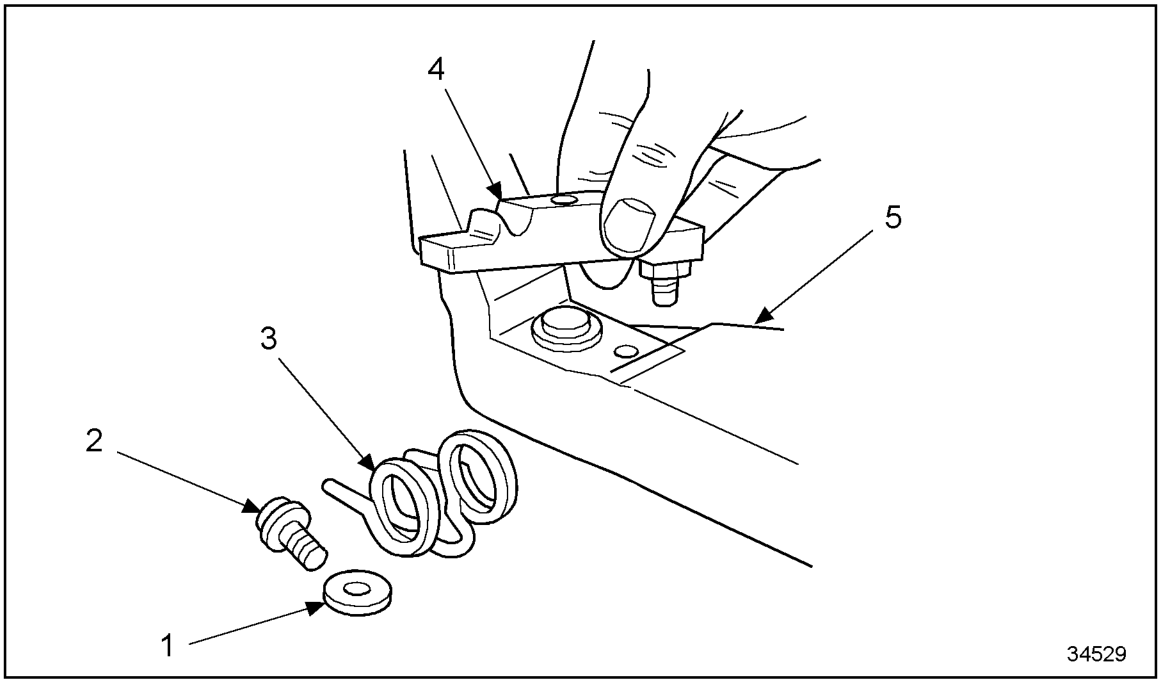
1. Ball Check Valve
2. Spring
3. Pipe Plug

Figure 1-432 Installation of Ball Check Valve

2. Insert the plug. Torque pipe plug to 11.2 N·m (8.3 lb·ft).

Install the slave piston as follows:

1. Install the screw from the slave piston side of the bridge.
2. Install the leveling screw locknut.
3. Install the bridge with the leveling screw toward the center of the housing. See Figure 1-433.



1. Washer
2. Screw
3. Torsion Spring
4. Bridge Assembly
5. Jake Brake Housing

Figure 1-433 Installing Bridge with Leveling Screw Toward Center of Housing

4. Install the slave piston assembly torsion spring with the ends over the bridge. See Figure 1-434.

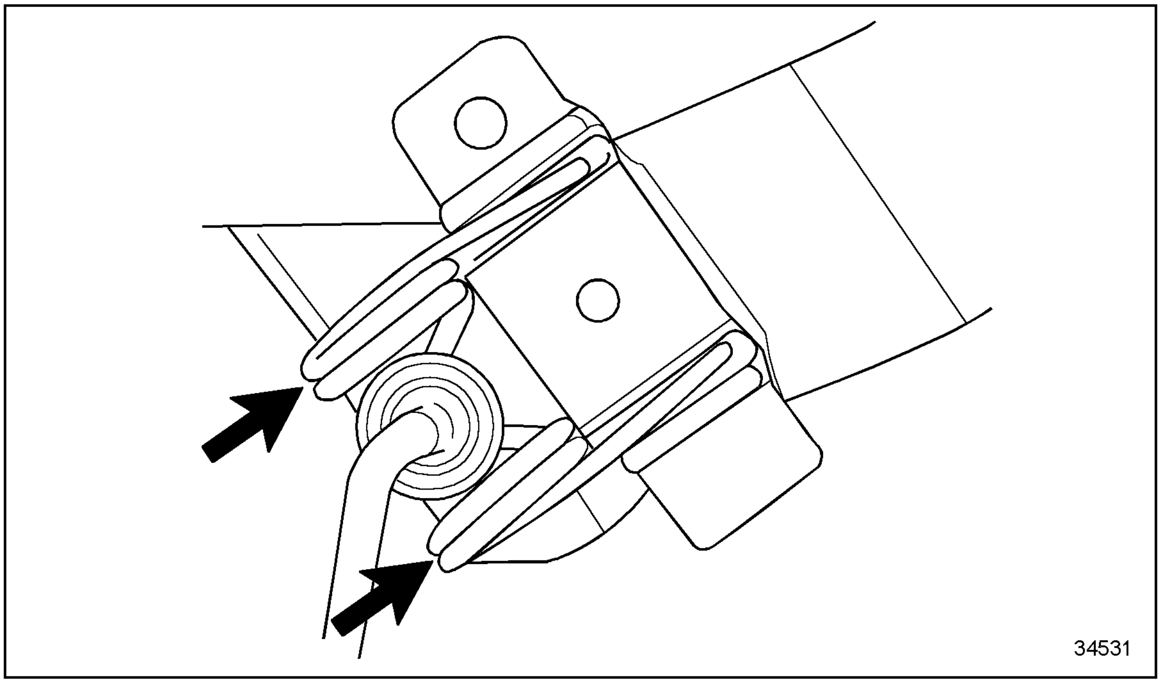


Figure 1-434 Installing the Slave Piston Assembly Torsion Spring

5. Install the screw over the center part of the spring.

NOTICE:
While tightening the screw on the torsion spring, push the spring toward the slave piston assembly. Failure to do so may result in contact between the intake valve adjusting screw and torsion spring. Serious engine damage may result.

6. Torque the screw to 20 N·m (15 lb·ft.).
7. Torque the slave piston leveling screw locknut to 47 N·m (35 lb·ft.).

1.29.5 Installation of Model 760, 765, or 770 Jake Brake

Install the model 760, 765, or 770 Jake Brake as follows:

NOTE:
The following procedures apply to Model 760, 765, and 770 Jake Brakes. For Model 790 Jake Brake installation procedures, refer to section 1.29.10.

1. Adjust the intake and exhaust valve clearances and set the injector heights. Refer to section .

CAUTION:

To prevent possible personal injury when using compressed air, wear adequate eye protection (face plate or safety glasses) and do not exceed 40 psi (276 kPa) air pressure.

2. Attach the length of tubing to a blow gun nozzle, and blow out the oil from the bolt holes.
3. Cover the holes with hand towels to minimize oil spray.

NOTE:
Removing the oil from the bolt holes prevents the cylinder head from cracking when tightening the bolts.

4. Place the spacer bar on the exhaust manifold side of the cylinder head with the "OUT" markings adjoining each other and facing the exhaust manifold. See Figure 1-435, and see Figure 1-436.

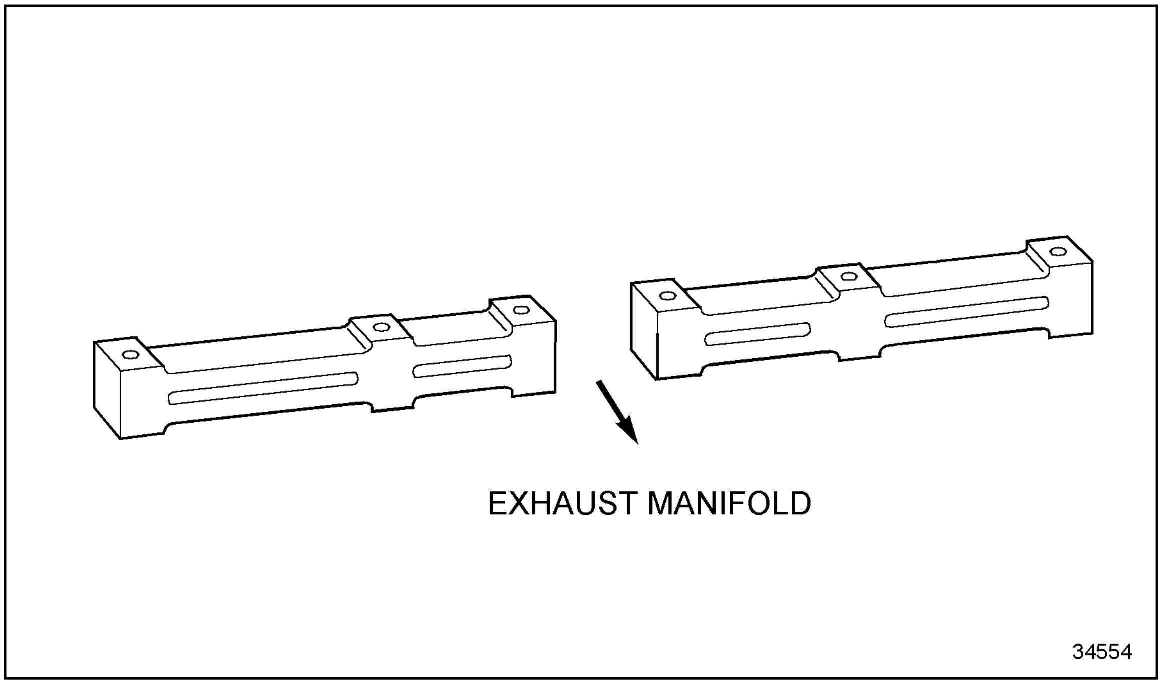


Figure 1-435 Spacer Bars with "Out" Marks Adjoined

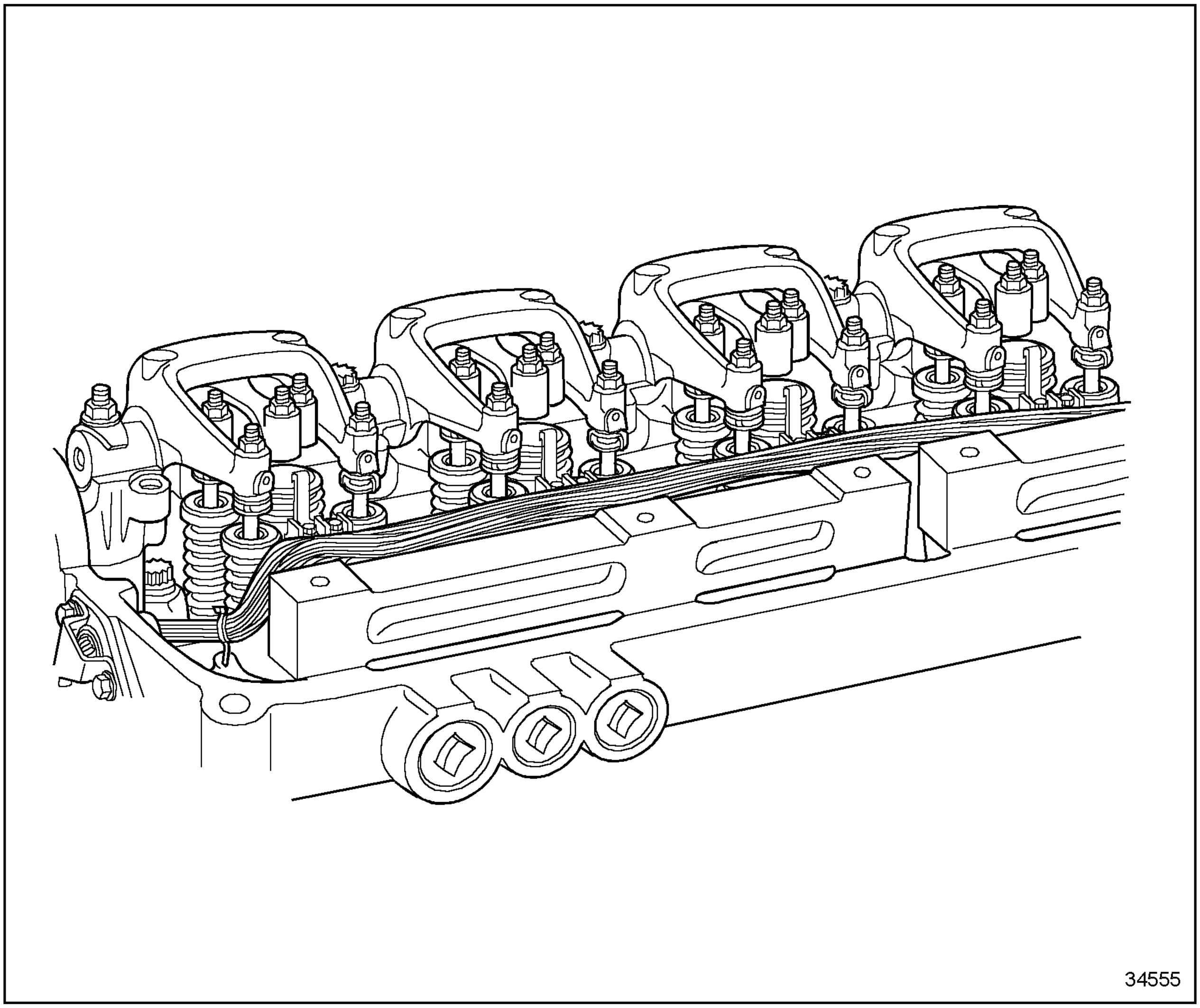


Figure 1-436 Location of Spacer Bars

5. Place the three engine brake housings over the rocker shafts with the solenoid valves toward the camshaft side of the engine.

NOTE:
Be sure housings do not interfere with wiring harness.

NOTICE:
Do not mix the rocker arm shaft bolts and the Jake Brake mounting bolts. If the rocker arm shaft bolt is mistakenly used to mount the Jake Brake housing, the longer shoulder on the bolt will block the oil supply to the Jake Brake on the camshaft side of the housing. The brake will not retard the engine as designed. This condition could cause loss of vehicle braking control on downgrades, which may create a risk of personal injury to the vehicle operator or other persons and damage to the vehicle or property of others.

NOTE:
The rocker arm shaft mounting bolt and Jake Brake mounting bolt, part of the Jake Brake assembly, are similar in appearance. Both are M12 x 110 mm (4.33 in.) long and have 12–point heads.

NOTE:
In the event of a housing hold down bolt failure on a Jacobs engine brake housing, replace all bolts on that particular housing.

NOTICE:
Use bolts that have the Jacobs logo, circled "J". Installation of bolts that do not have the circled "J" may result in damage to the engine, engine brake or both.

[a] The Jake Brake bolt has the Jacobs logo (circled "J") and the letters "EF" marked on the head. The bolt length is no longer marked atop the bolt head.

[b] The DDC rocker arm shaft bolt has the DDC logo (spinning arrows) and the vendor I.D. (F-C) on its head.

[c] Jake Brake model 760 requires two bolts along with one bolt and new washers.

NOTE:
Be sure that only Jake Brake bolts, see Figure 1-437, are installed in the Jake Brake housing.

[d] The DDC bolt shoulder is much longer, 17.0 mm (0.669 in.) versus 4 mm (0.157 in.) than the Jake Brake bolt. See Figure 1-437.

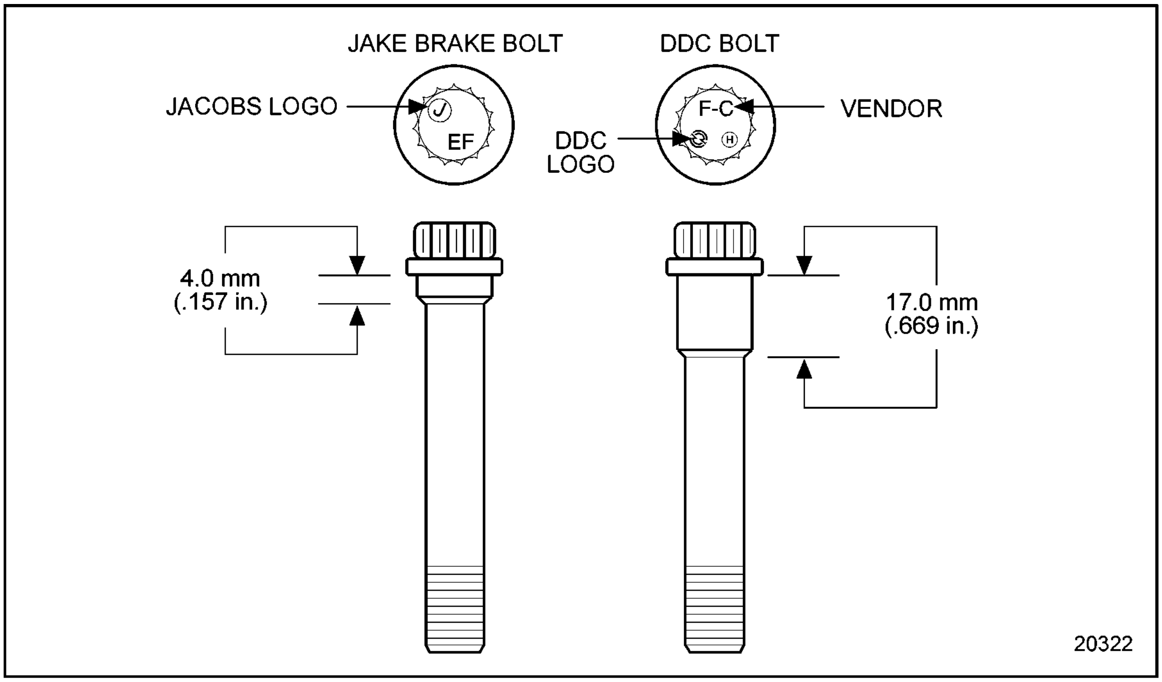
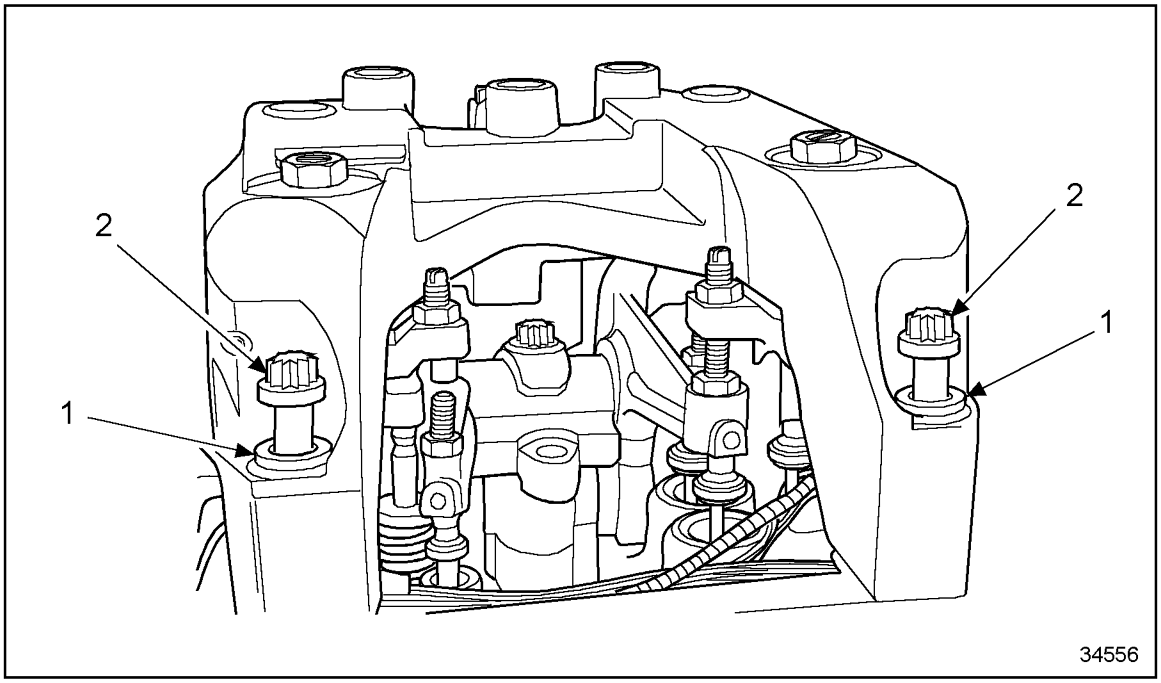


Figure 1-437 Jake Brake and DDC Bolt Identification

NOTICE:
The model 760 uses two lengths of mounting bolts. Six 120 mm bolts should be installed on the exhaust side of the engine. Three 110 mm bolts should be installed on the camshaft side of the engine. Failure to do so will result in engine damage.

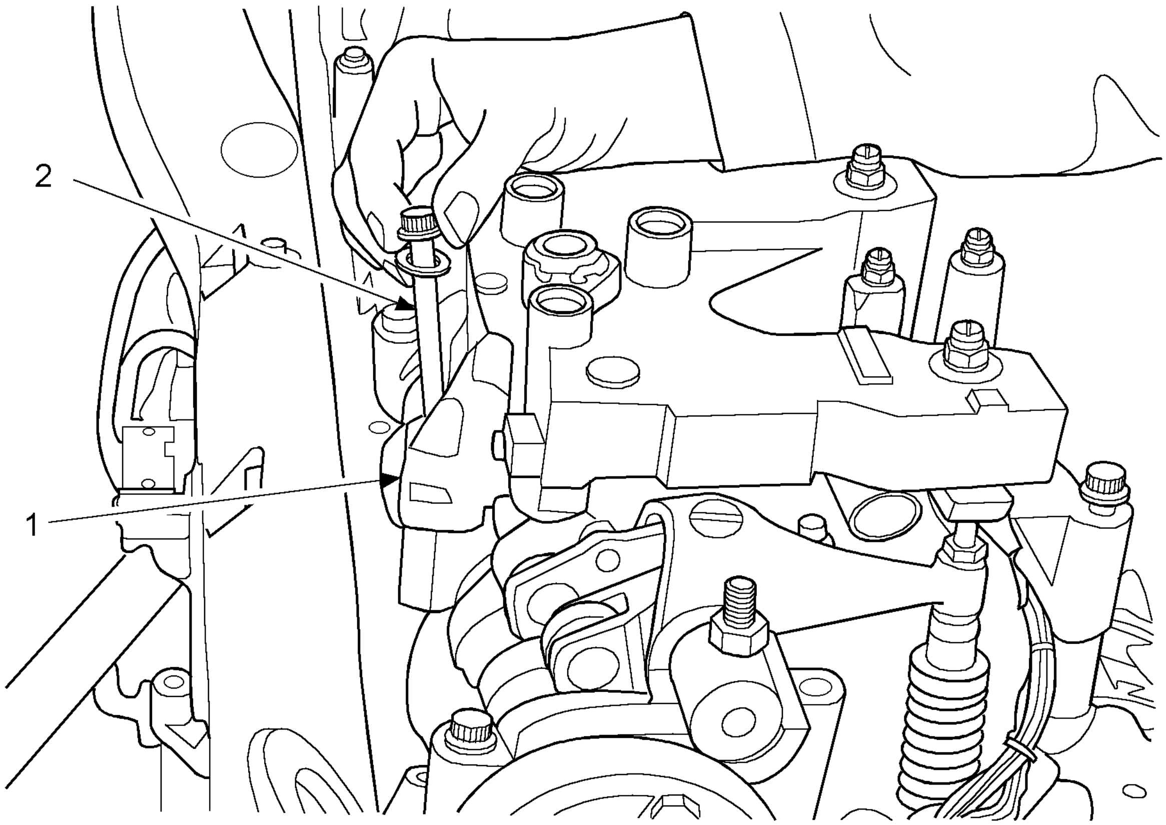
6. On model 760, install one washer onto each 120 mm (4.75 in.) bolt, and insert into brake housing on the exhaust manifold side (two per housing). See Figure 1-438.



1. Washer
2. Long Bolt

Figure 1-438 Installation of Brake Housing Bolts on Exhaust Manifold Side

7. On model 760, install one washer on the 110 mm (4.375 in.) bolt, and insert into brake housing at the camshaft side (one per housing). See Figure 1-439.



1. Jake Brake Housing Assembly
2. Mounting Bolt

Figure 1-439 Installation of Brake Housing Bolts on Camshaft Side

8. On models 760A, 760B, 765, and 765A, lubricate each hold down bolt with clean engine oil.

NOTE:
All the housing mounting bolts for these models are the same length of 110 mm (4.375 in.).

9. On models 760A, 760B, 765, and 765A, install a washer on each bolt, and install into housings (three bolts per housing).

10. On models 760A and 765, move the housing from side to side, and locate the housing in the center position of the movement. See Figure 1-440.

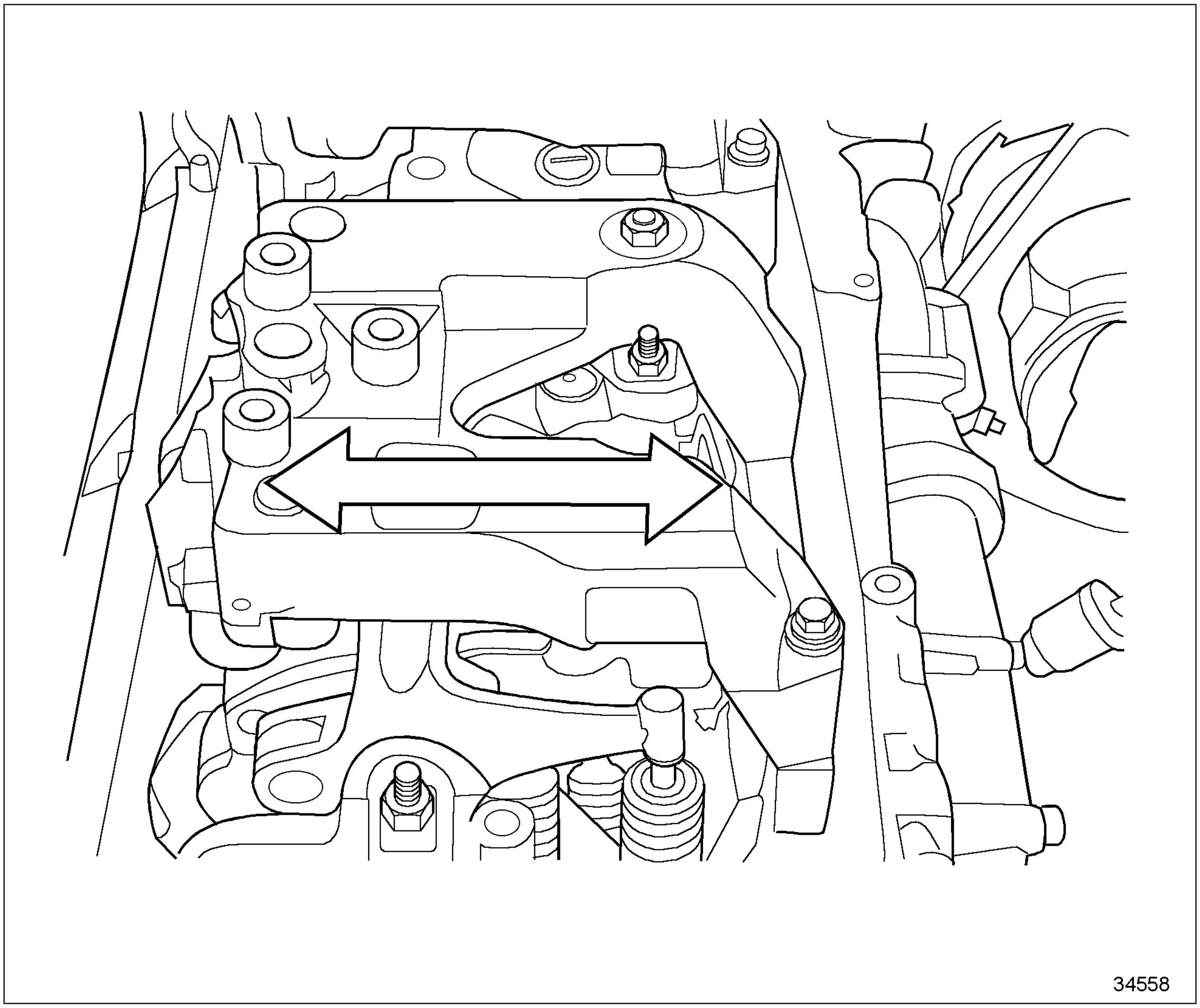


Figure 1-440 Locating Center Position of Housing

11. On models 760B and 765A, move the housing from side to side, and locate as far toward the camshaft side of the engine as possible.
12. On all models, torque the engine brake mounting bolts using the following sequence:
    [a] Torque the three bolts on the camshaft side of the engine to 55 N·m (40 lb·ft).
    [b] Torque the six bolts on the exhaust manifold side of the engine to 55 N·m (40 lb·ft).
    [c] Repeat the tightening sequence and re-torque all bolts to 136 N·m (100 lb·ft).
    [d] Check the torque to 136 N·m (100 lb·ft).
13. Secure wire harness to spacer bars with plastic ties.
14. Connect wiring harness solenoid connectors to solenoids.

1.29.5.1 Adjustment of Slave Piston on Model 760, 765, or 770 Jake Brake

Make the following adjustment with the engine stopped and cold, and the oil temperature at 60°C (140°F) or below. The exhaust valves on the cylinder *must* be in the closed position (rocker arm roller on the base circle of the camshaft). When setting the engine brake lash, the exhaust valves must be in the closed position. Adjust the slave piston on all models as follows:

NOTE:
The following procdures apply to Model 760, 765, and 770 Jake Brakes. For Model 790 Jake Brake slave piston lash setting procedures, refer to section 1.29.10.1.

NOTE:
Model 770 Jacobs engine brake requires a special procedure for adjusting the slave piston. The procedure is clearly indicated in the following adjustment steps.

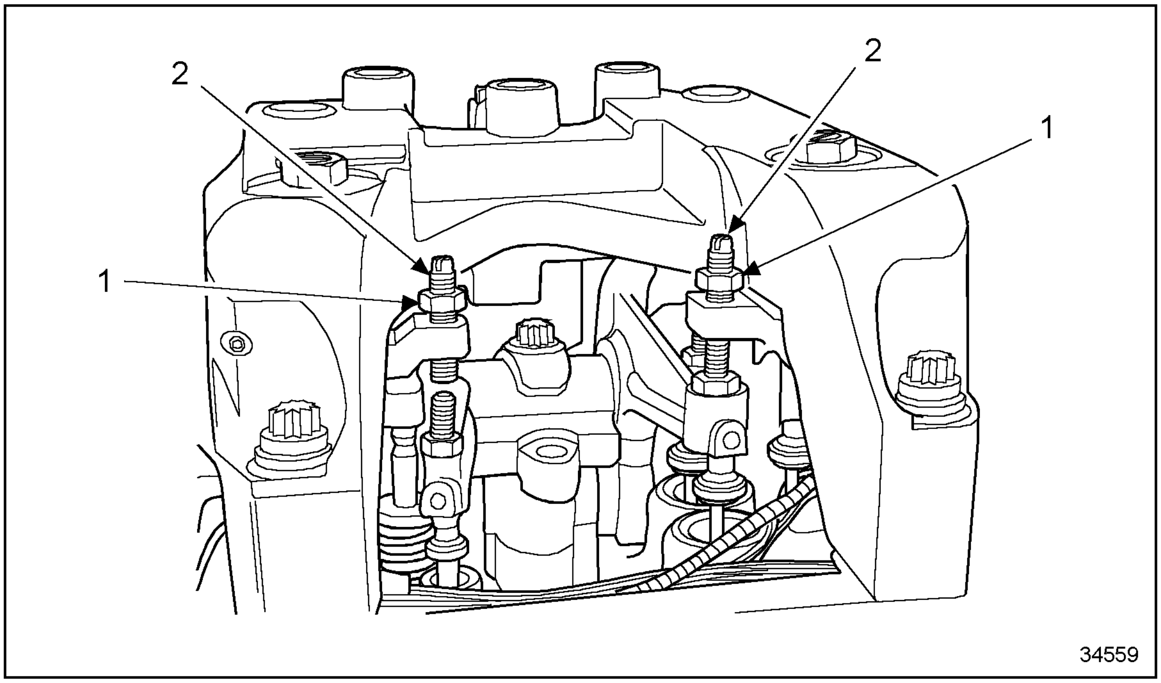
NOTICE:
Improper slave piston adjustment can result in engine or brake housing damage.

NOTICE:
Strictly follow the slave piston adjustment procedure. Failure to use the proper adjustment procedure will result in poor engine brake performance and/or serious engine damage.

1. Refer to section 1.29 for proper slave piston clearance setting.

2. Back out the leveling screw in the slave piston assembly until the end of the screw is beneath the surface of the bridge in the slave piston assembly. See Figure 1-441.

NOTE:
The leveling screw is located in the bridge member of the slave piston assembly.

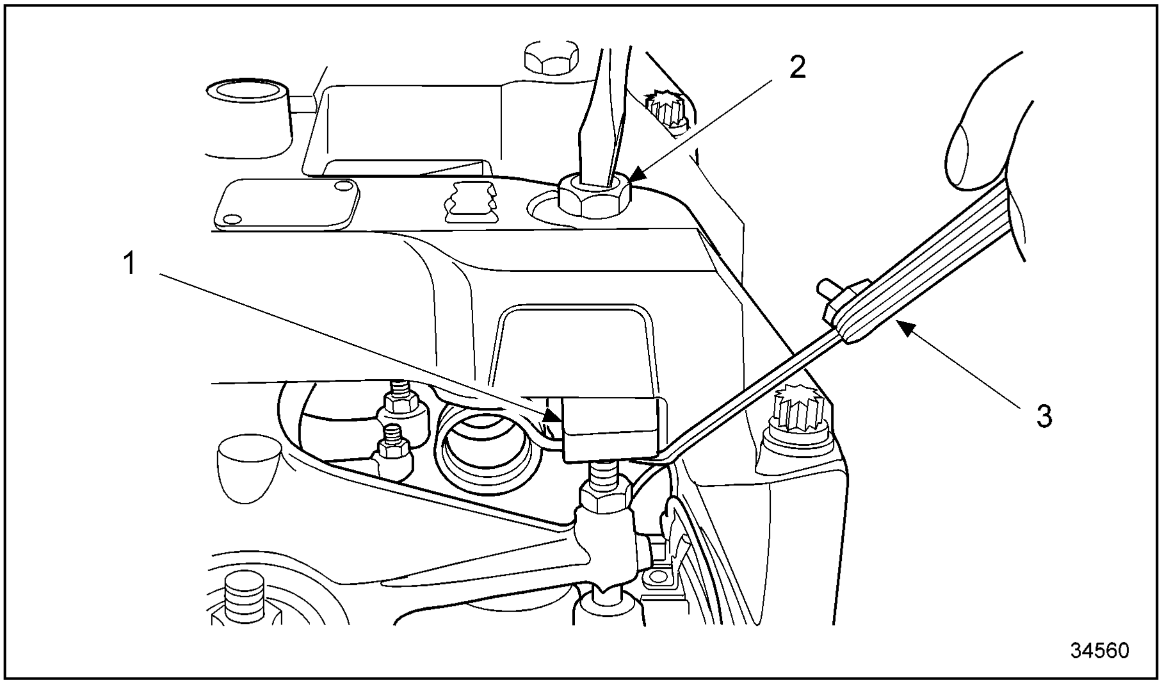


1. Leveling Screw
2. Locknut

Figure 1-441 Location of Leveling Screw

3. On models 760, 760A, 760B, 765, and 765A, place the correct size feeler gage between the solid side of the slave piston (the side without the leveling screw) and the exhaust rocker arm adjusting screw. Feeler gage sizes are listed in Table 1-9.

4. On models 760, 760A, 760B, 765, and 765A, turn the slave piston adjusting screw clockwise until a slight drag is felt on the feeler gage. See Figure 1-442.



1. Slave Piston Bridge
2. Slave Piston Adjusting Screw
3. Feeler Gage

Figure 1-442 Turn Slave Piston Adjusting Screw Clockwise

5. Perform the following additional steps on model 770:

   [a] Turn in the J-Lash® adjusting screw until the solid side of the slave piston bridge assembly contacts the exhaust valve and the valve springs begin to compress. Turn in one additional turn.

NOTICE:
All oil must be purged from the J-Lash adjusting screw. Oil remaining in the J-Lash screw will cause inaccurate clearance adjustment, resulting in possible engine or engine brake damage. If oil is below room temperature (below 60°F), wait at least two minutes for oil to be purged from the J-Lash adjusting screw.

NOTE:
Wait at least 30 seconds for oil to be purged from the J-Lash adjusting screw.

   [b] Back out the adjusting screw **only** until the correct size feeler gage can be inserted between the solid side of the slave piston bridge assembly and the exhaust valve.

   [c] Adjust the J-Lash so that a light drag is felt on the feeler gage.

NOTE:
Do not back out the J-Lash more than required to obtain a light drag on the feeler gage.

   [d] Use a screwdriver to hold the J-Lash in place, and torque the lock nut to 34 N·m (25 lb·ft).

NOTE:
If the J-Lash screw is backed out until it no longer compresses the slave piston spring, oil will enter the screw and the adjustment will be incorrect. If this occurs, repeat the J-Lash adjustment procedure.

   [e] Recheck the lash settings. If clearance setting is incorrect, repeat the J-Lash adjustment procedure.

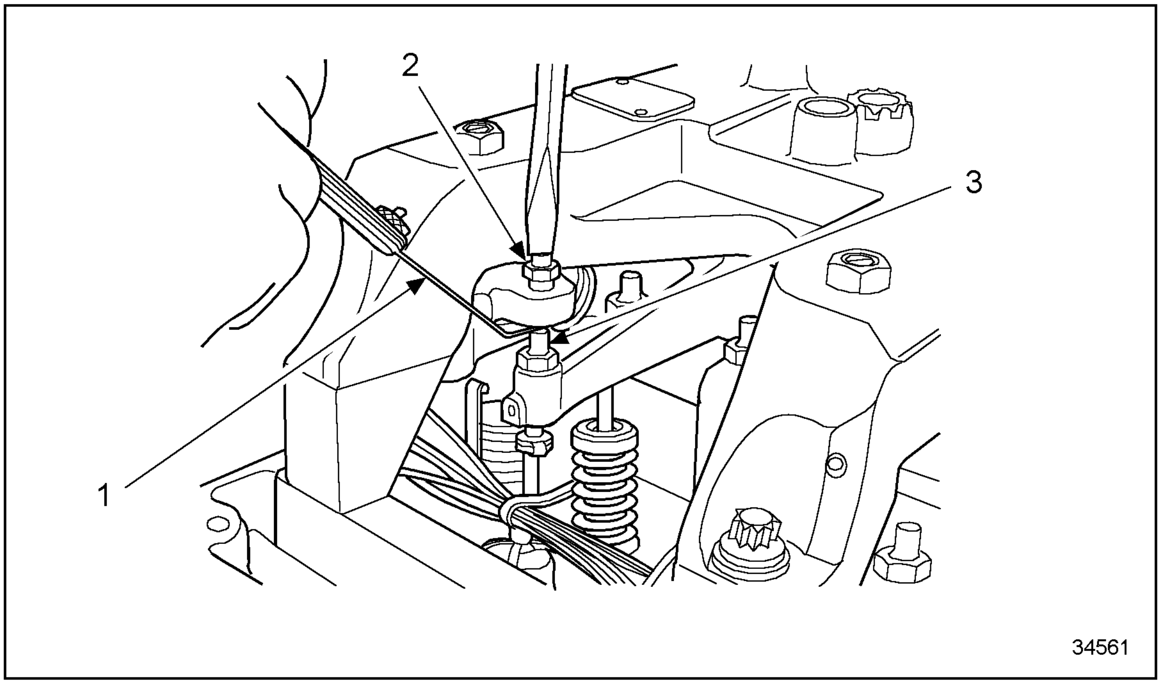
NOTE:
Once the engine brake has been run, oil enters the J-Lash screw making the engine brake adjustment unreadable. If unsure of the adjustment, repeat the J-Lash adjustment procedure.

6. On all models, hold the screw in position, and torque the locknut to 35 N·m (26 lb·ft).
7. Check the adjustment, and repeat if necessary.

NOTE:
Do not disassemble the slave piston adjusting screws.

8. Place the correct feeler gage between the leveling screw and the rocker arm adjusting screw.

9. Turn the leveling screw clockwise until a slight drag is felt on the feeler gage. See Figure 1-443.



1. Feeler Gage
2. Slave Piston Leveling Screw
3. Rocker Arm Adjusting Screw

Figure 1-443 Setting Clearance on Leveling Screw and Rocker Arm Adjusting Screw

10. Hold the leveling screw in position, and torque the locknut to 47 N·m (35 lb·ft).
11. Check adjustment, and repeat if necessary.
12. Repeat the adjustment procedures for the remaining cylinders. Refer to step 2 through step 11.

NOTE:
Bar over the engine when necessary to place the exhaust valves in the closed position for slave piston adjustment.

13. Install the engine rocker cover. Refer to section 1.6.2 for one-piece, refer to section 1.6.3 for two-piece, and refer to section 1.6.5 for three-piece.
14. Install all remaining components that were removed for this procedure.
15. Connect starting power for the engine.
16. Verify proper Jake Brake installation by driving the vehicle, then checking engine brake performance.

1.29.6 Removal of Model 790 Jake Brake Assembly

Remove the Model 790 Jake Brake as follows:

CAUTION:

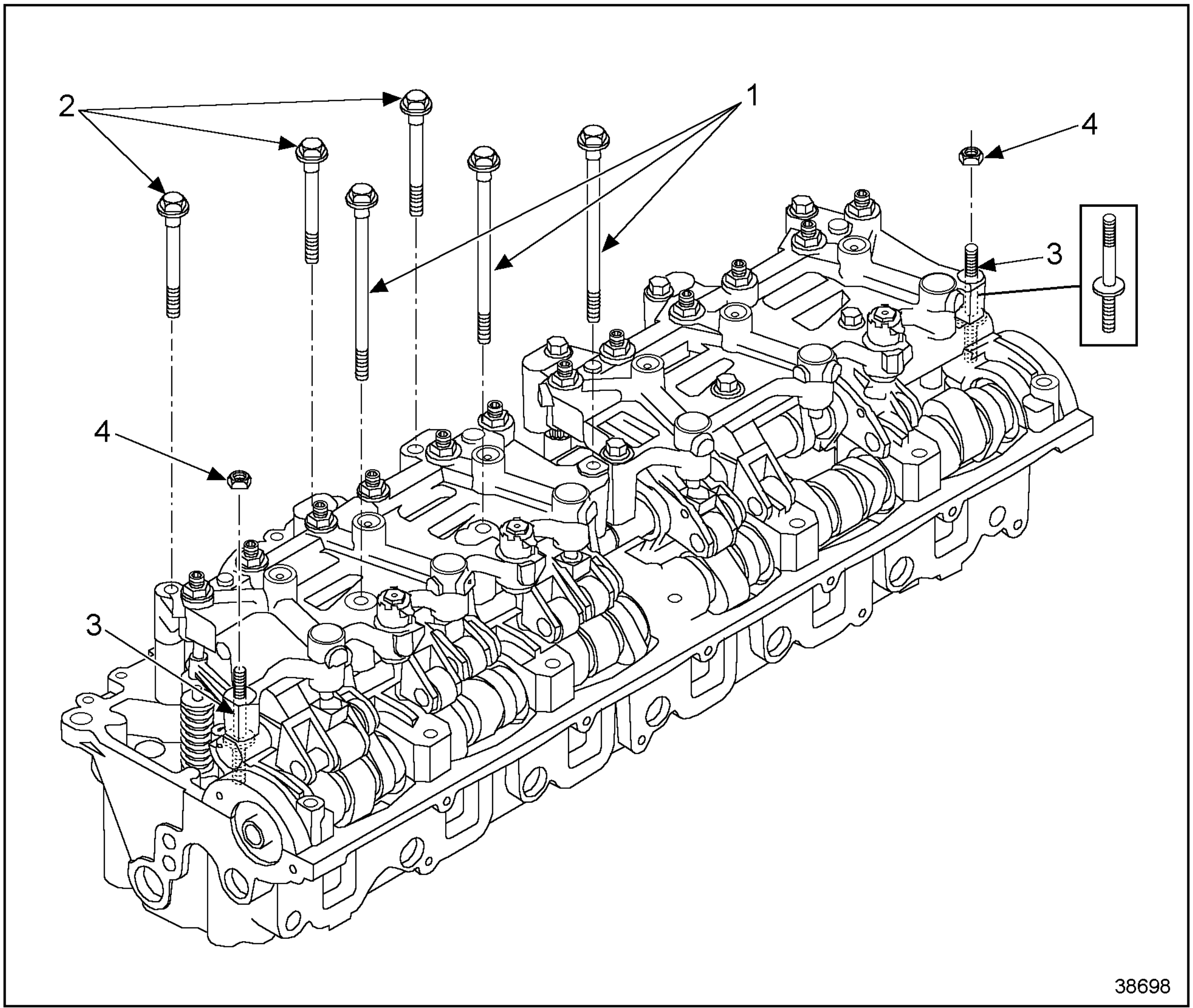
To avoid injury from hot engine surfaces, stop the engine and allow it to cool ambient temperature before working on it.

CAUTION:

To avoid injury from accidental engine start-up, disable/disconnect power to the engine starting system.

1. With the engine at ambient temperature and power to the starting system disconnected, Refer to section of the *Series 60 Service Manual,* 6SE483 and remove the engine rocker cover.
2. Note the location of the rocker arm shaft, the exhaust valve rocker arm, the fuel injector rocker arm, and the intake valve rocker arm.
3. Disconnect the solenoid wiring harness connectors from the Jake Brake solenoids.

4. Remove the three (3) 140 mm long mounting bolts that secure the engine brake to the cylinder head. See Figure 1-443a.



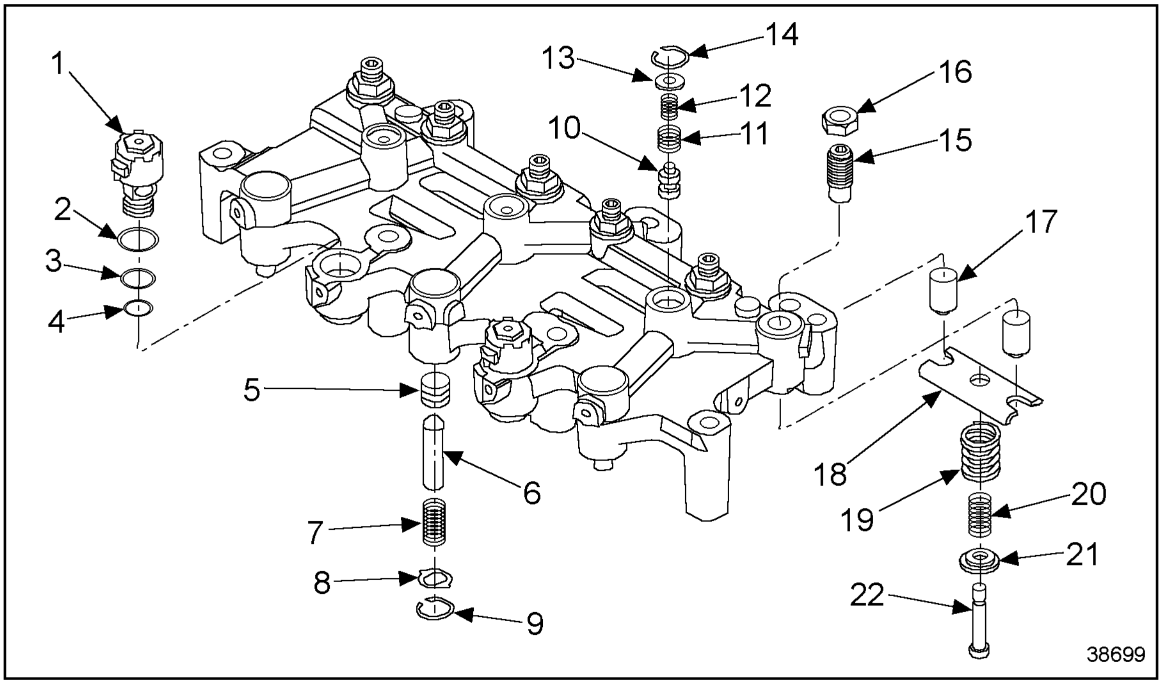
1. Mounting Bolt — 170 mm Long
2. Mounting Bolt — 140 MM Long
3. Stud Bolt
4. Nut

Figure 1-443a Model 790 Jake Brake Fasteners

5. Remove the three (3) 170 mm long mounting bolts and the two (2) nuts that secure the engine brake to the cylinder head.
6. Remove the engine brake assembly.
7. Repeat steps 1 through step 5 and remove the second Jake Brake assembly from the engine.

1.29.6.1 Disassembly of Model 790 Jake Brake

Instructions for disassembly of Model 790 Jake Brakes are incomplete at time of publication, but will be provided at a future date. For components of Model 790 Jake Brakes, see Figure 1-443b.



1. Solenoid Valve

3.Center Seal

4. Lower Seal

5. Master Piston

6. Master Piston Pushrod

7. Master Piston Spring

8. Retaining Ring

9.Control Valve

10. Outer Control Valve Spring

11. Inner Control Valve Spring

12. Washer

13. Retaining Ring

14.J-Lash® Screw

15. Locknut

16. Slave Piston

17. Slave Piston Bridge

18. Outer Slave Piston Spring

19. Inner Slave Piston Spring

20. Slave Piston Spring Seat

21. Shoulder Bolt

22. Shoulder Bolt

Figure 1-443b Typical Model 790 Jake Brake Assembly

1.29.7 Cleaning of Model 790 Jake Brake

Instructions for cleaning of Model 790 Jake Brake are incomplete at the time of publication, but will be provided at a future date.

1.29.8 Inspection of Model 790 Jake Brake

Instructions for inspection of Model 790 Jake Brake are incomplete at the time of publication, but will be provided at a future date.

1.29.9 Assembly of Model 790 Jake Brake

Instructions for assembly of Model 790 Jake Brake are incomplete at the time of publication, but will be provided at a future date.

1.29.10 Installation of Model 790 Jake Brake Assembly

The installation procedures for the model 790 Jake Brake assemblies differ slightly from the former engine brakes. Two brake housings are used, instead of three, and spacer bars are not required. Install the model 790 Jake Brake assemblies as follows:

1. With the engine at ambient temperature, install front Jake Brake housing (with two solenoids) over the front three cylinders. Position with solenoids on camshaft side of engine.
2. Install the rear housing (with one solenoid) over the rear three cylinders. Position with solenoid on camshaft side of engine.

NOTE:
There is one extra mounting hole drilled on the slave piston side of each housing. These holes are for manufacturing purposes only and are not used for installation.

3. Install six (6) 170 mm bolts through the housings into the rocker shafts in locations 1 through 6, and install two (2) nuts in locations 7 and 8. See Figure 1-443c.

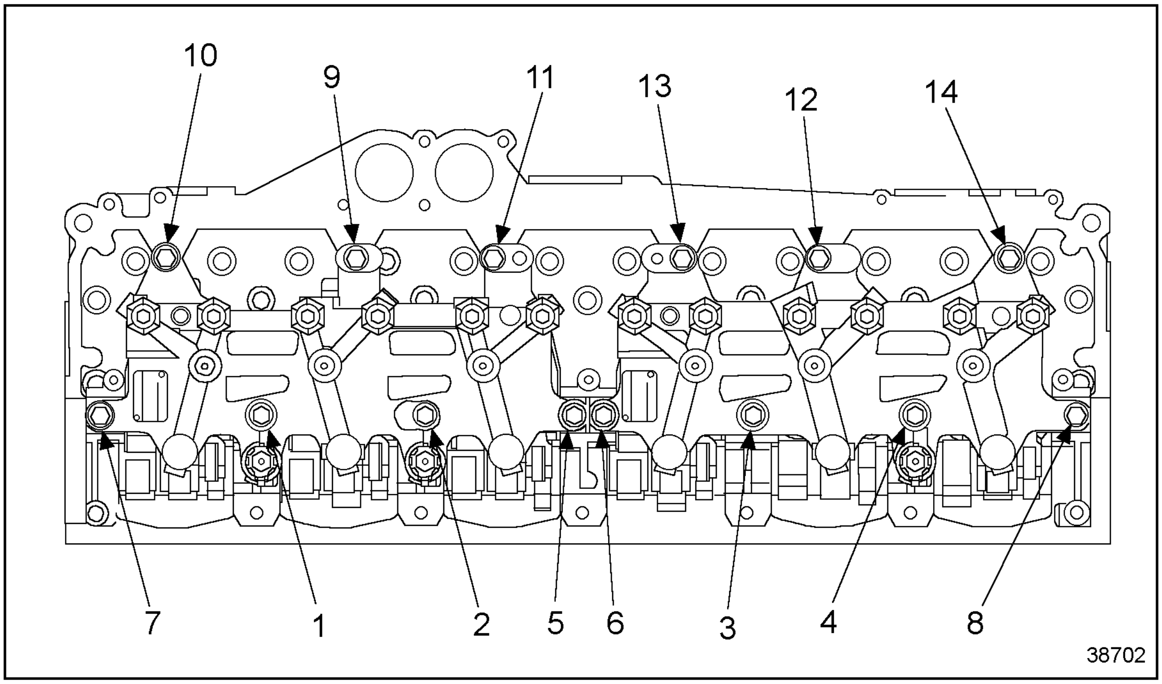


Figure 1-443c Housing Hold-Down Bolt Locations

NOTICE:
To ensure proper engine brake housing installation, Jake Brake mounting bolts (identified by a circle "J" on the heads) and required one-piece spacers *must* be used when mounting the brake assemblies.

4. Install six (6) 140 mm bolts into each housing and through the spacers in locations 9 through 14.
5. Torque all mounting bolts to 136 N·m (100 lb-ft) in bolt location number sequence shown. See Figure 1-443c.
6. Route the wire to the solenoid for cylinder 1 through the front retaining clip on the front housing and connect to the solenoid. Torque screw to 1.13 N·m (10 lb·in.).
7. Route wire to the solenoid for cylinders 3 and 4 through the rear retaining clip on the front housing and connect to the solenoid. Torque screw to 1.13 N·m (10 lb·in.).
8. Route wire to the solenoid for cylinders 4, 5 and 6 through the single retaining clip on the rear housing and secure to the terminal screw on the solenoid. Torque screw to 1.13 N·m (10 lb·in.).
9. Secure any excess wire to the injector harness with wire ties.

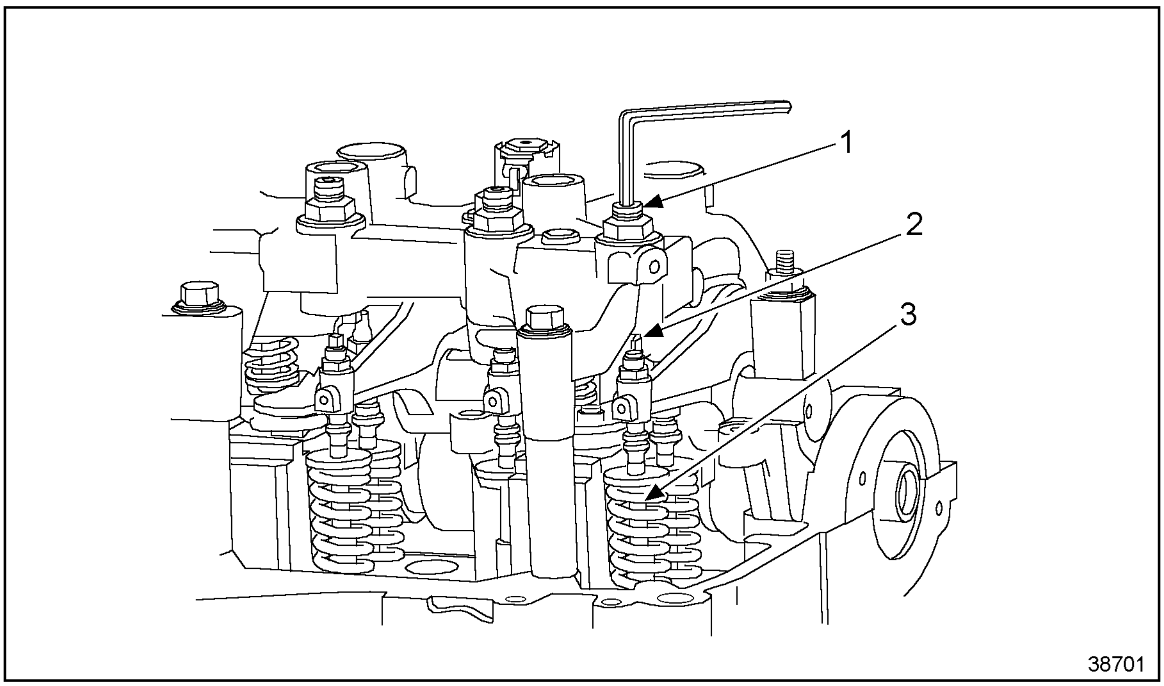
1.29.10.1 Set Slave Piston Lash

The slave piston lash must be set after Jake Brake housings are installed. Adjustments must be made with the engine stopped and cold and the oil temperature at 60°C (140°F) or below. Exhaust valves on the cylinder must be in the closed position (rocker arm roller should be on the base circle of the camshaft).

NOTICE:
The slave piston adjustment procedure *must* be followed exactly. Failure to properly adjust Jake Brakes will result in inefficient engine brake performance and may lead to severe engine or Jake Brake damage.

Adjust Jake Brake Model 790 slave piston lash as follows:

1. Loosen the locknut. Then, using a 5/16 in. Allen wrench, turn the J-Lash adjusting screw counter-clockwise until a 0.660 mm (0.026 in.) feeler gauge can be inserted between the slave piston and the exhaust rocker adjusting screw. Insert the feeler gauge.
2. Using the 5/16 in. Allen wrench, turn the J-Lash adjusting screw in (clockwise) until the slave piston contacts the feeler gauge and the exhaust rocker adjusting screw. When the valve spring begins to compress, turn the screw clockwise *one* additional turn. *Wait at least 30 seconds for oil to be purged from the J-Lash adjusting screw.* See Figure 1-443d.

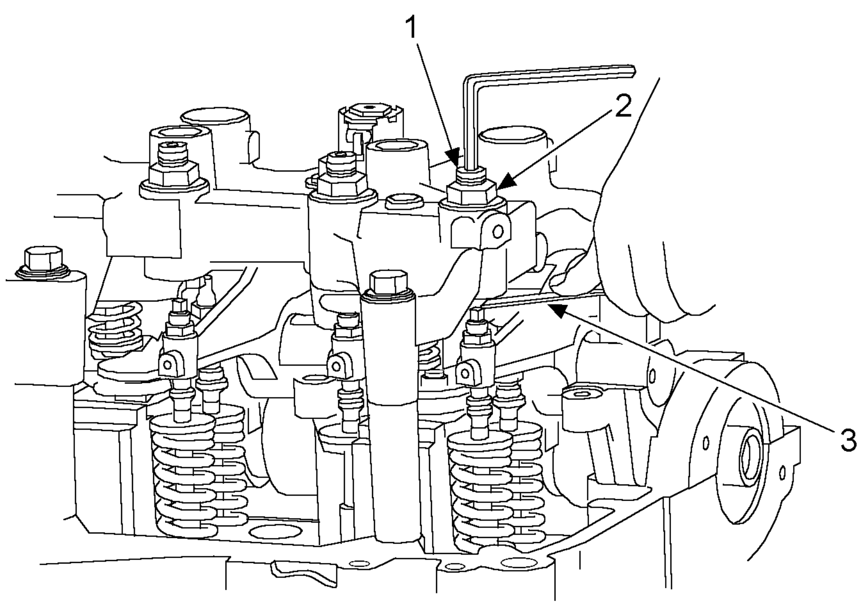


1. J-Lash Adjusting Screw
2. Slave Piston
3. Exhaust Valve Spring

Figure 1-443d Turn the Adjusting Screw Until the Valve Spring Compresses

NOTICE:
Oil *must* be purged from the J-Lash adjusting screw. Oil remaining in the J-Lash screw will cause inaccurate clearance adjustment, which could result in damage to the engine or Jake Brake. ***If oil is below room temperature (below 16° C or 60° F), wait at least two minutes for oil to be purged from the J-Lash adjusting screw.***

3. After waiting the required interval to purge oil from the J-Lash adjusting screw, back out the adjusting screw (turn counter-clockwise) ***only*** until a 0.660 mm (0.026 in.) feeler gage can be moved with a slight resistance. See Figure 1-443e. *Do not back out the J-Lash adjusting screw more than required to obtain a light drag on the feeler gage.* Using the Allen wrench to hold the J-Lash adjusting screw in place, torque the lock nut to 35 N·m (25 lb-ft).



1. J-Lash Adjusting Screw
2. Locknut
3. Feeler Gage

Figure 1-443e Adjusting Slave Piston Lash

NOTE:

If the J-Lash adjusting screw is backed out until it no longer compresses the slave piston spring, oil will enter the screw and the adjustment will be incorrect. If this occurs, repeat step 1 and step 2.

4. After torquing the adjusting screw lock nut, recheck lash setting. If lash is incorrect, repeat step 1 and step 2.

NOTE:
Once the engine brake has been run, you will not be able to check Jake Brake adjustment. This is because of oil retained in the J-Lash adjusting screw. If unsure of the adjustment, you must repeat step 1 through step 3.

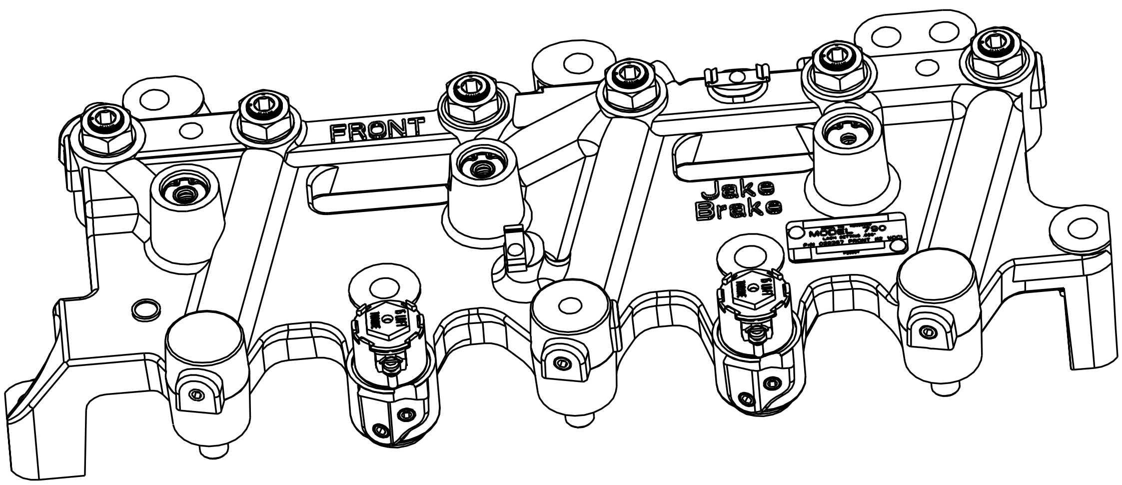
5. Repeat step 1 through step 3 for the remaining slave piston on the same cylinder.
6. Repeat step 1 through step 4 for the remaining cylinders.
7. Complete the installation by installing the rocker cover. Refer to section 1.6 of the service manual.
8. Install all remaining components that were removed for this procedure.
9. Connect starting power for the engine.
10. Start and drive the vehicle to verify proper Jake Brake performance.

Jacobs Vehicle Systems™

TUNE-UP KIT INSTRUCTIONS

Jacobs Engine Brake™

Tune-Up Kit
790/795 Series
P/N 29013

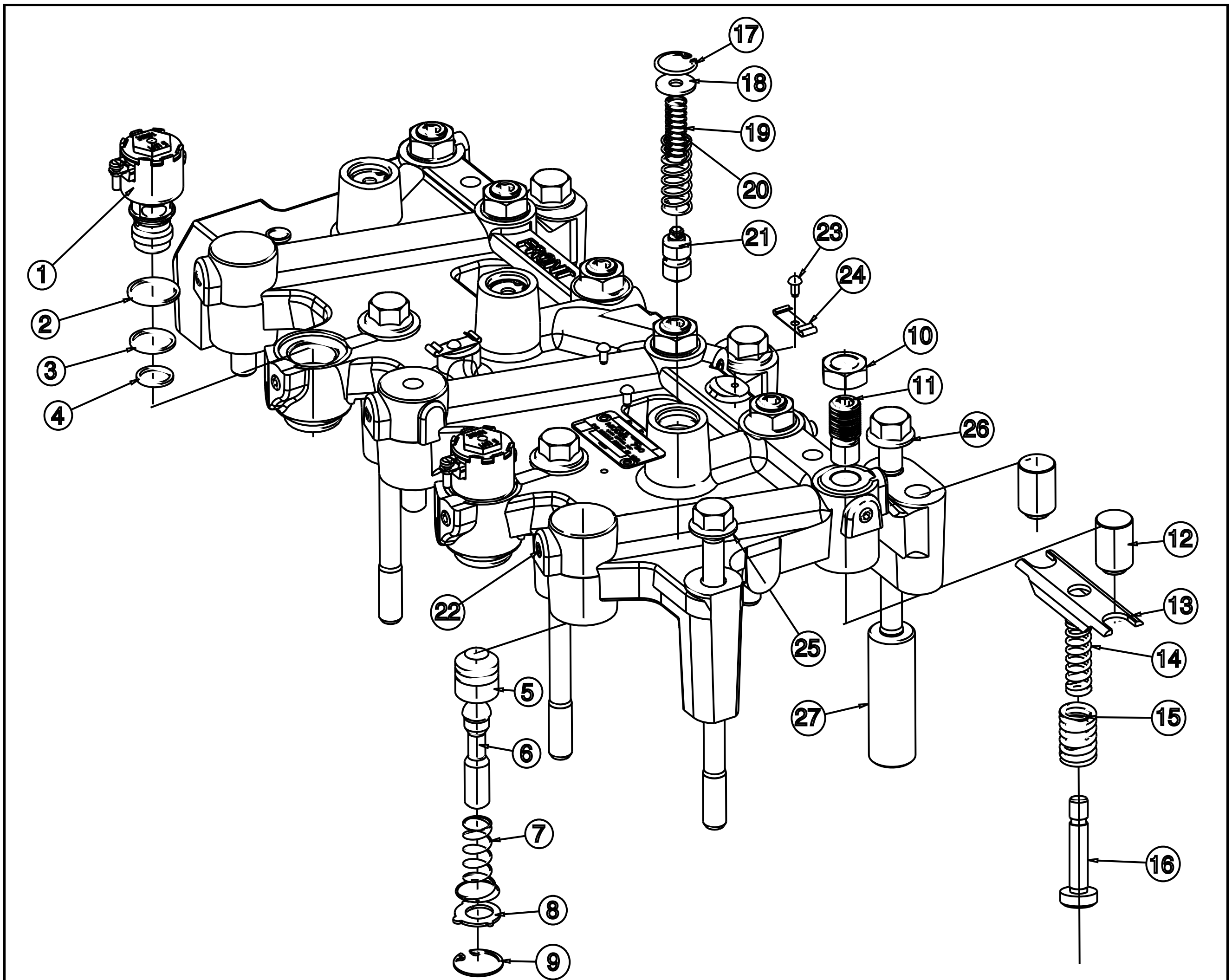


Information in this manual was current at time of printing and is subject to change without notice or liability.

Refer to the Application guide, P/N 24770 for specific application information. Also refer to the Install Manual, P/N 29901 and the engine manual for specific installation instructions.

Tune-up Kit Contents Model 790/795

Illus. No.	P/N	Part Name	Quantity per kit
1	1024612	Solenoid, 12VDC S/L	0
1	1024619	Solenoid, 24VDC S/L	0
2	20229	Seal, Solenoid Upper	3
3	1082	Seal, Solenoid Center	3
4	1083	Seal, Solenoid lower	3
5	26932	Master Piston	0
6	28791	Push Rod, Master Piston	0
7	28768	Spring, Master Piston	6
8	29944	Retainer, Master Piston	6
9	26555	Ring, Retainer	6
10	19987	Nut, Hex (790 series)	0
10	29908	Nut, Hex (795)	0
11	28341	J-lash™ assembly (790)	0
11	29300	J-lash™ assembly (790A)	0
11	29317	J-lash™ assembly (790B)	0
11	29310	J-lash™ assembly (790C)	0
11	29908	Solid Screw 3/8-24 (795)	0
12	26142	Slave Piston	0
13	28379	Bridge, Slave Piston	0
14	28372	Spring, Inner Slave Piston	6
15	28373	Spring, Outer Slave Piston	6
16	29295	Bolt, Shoulder-Slave Piston	6
17	12991	Ring, Retainer	6
18	16505	Washer	6
19	18179	Spring, Inner Control Valve	6
20	10843	Spring, Outer Control Valve	6
21	11930	Control Valve	6
22	18485	Pipe Plug	0
23	17303	Drive Screw	0
24	29127	Clip, Wire Harness	0
25	28346	CapScrew, M12X1.75X170	0
26	29132	CapScrew, M12X1.75X140	0
27	29118	Spacer Tube	0
NI	29015	Instructions	0



General Information

These instructions describe how to properly remove, clean and reinstall Jacobs Engine Brake™ components. For additional information on the 790/795 Series engine brakes, refer to the Series 60 Engine Service Manual, P/N 6SE483.

For slave piston clearance refer to the Jacobs Application Guide for Detroit Diesel Engines, P/N 24770.

Use OSHA-approved cleaning solvent for cleaning parts. Original parts to be reused should be inspected for wear and replaced as required. Be sure to coat parts with clean engine oil when reinstalling them.

The standard Jacobs Vehicle Systems Service Parts Warranty applies to the components of this Tune-up Kit. The warranty is administered by Detroit Diesel Corporation.

Safety Precautions

The following symbols in this manual signal conditions potentially dangerous to the mechanic or equipment. Read this manual carefully. Know when these conditions can exist. Then take necessary steps to protect personnel as well as equipment.

⚠ WARNING — THIS SYMBOL WARNS OF POSSIBLE PERSONAL INJURY.

⚠ CAUTION — THIS SYMBOL REFERS TO POSSIBLE EQUIPMENT DAMAGE.

NOTE: INDICATES AN OPERATION, PROCEDURE OR INSTRUCTION THAT IS IMPORTANT FOR CORRECT SERVICE.

Fuels, electrical equipment, exhaust gases and moving engine parts present potential hazards that could result in personal injury. Take care when installing equipment or parts. Always wear safety glasses. Always use correct tools and follow proper procedures as outlined in this manual.

Instructions

⚠ WARNING — NEVER REMOVE OR ADJUST ANY ENGINE BRAKE OR COMPONENT WITH THE ENGINE RUNNING.

Access Engine Brake

1. Thoroughly clean engine.
2. Remove valve rocker cover and gasket.

NOTE: IF THE ENGINE HAS A TWO-PIECE COVER, THE LOWER VALVE COVER BASE DOES NOT HAVE TO BE REMOVED TO GAIN ACCESS TO THE ENGINE BRAKE HOUSINGS.

3. Disconnect the lead wires from each of the solenoid valves (1) and detach them from the wire clips (24).
4. Remove the six capscrews (25&26) and nut securing each engine brake housing. Remove the housings.
5. Retain six spacer tubes (27).

Disassemble Housings

1. Remove the solenoid valve (1) and discard the three seal rings (2,3,4).

⚠ WARNING — WEAR SAFETY GLASSES. REMOVE CONTROL VALVE COVERS CAREFULLY TO AVOID PERSONAL INJURY. COVERS ARE UNDER LOAD FROM CONTROL VALVE SPRINGS (19,20).

2. Hold down the control valve cover while removing the retaining ring (17). Remove and discard all parts.
3. Loosen the locknut (10) and remove the adjusting screws (11) and locknuts. Retain the adjusting screws and locknuts.
4. Remove the retaining rings (9), retainers (8) and springs (7) that retains the master pistons; discard the springs, retainers and retaining rings. Remove and save the master pistons (5) and the push rods (6).
5. Remove the shoulder bolt (16) and springs (14,15) that retain the slave piston; discard springs only. Remove and save the bridge (13) and slave piston (12).

Assemble Housings

1. Clean all parts in an approved cleaning solvent. Dry with compressed air.

2. Coat all parts to be installed into housings with clean lube oil.

3. Reinstall the original slave piston (12) and bridge (13), reversing the removal procedure.

4. Install the new shoulder bolts (16) and springs (14,15). Tighten the bolt to 23 N•m (200 lb-in).

5. Reinstall the master pistons (5) and push rods (6). Install the new springs (7), retainers (8) and retaining rings (9). Rotate the retaining rings 90° to ensure that the ring is seated in the groove.

6. Install the adjusting screw (11) and locknut (10). Do not tighten the locknut at this time.

7. Install the new control valves (21), springs (19,20), washers (18) and retaining rings (17). Rotate the retaining ring 90° to ensure that the ring is seated in the groove.

8. Install the lower (smallest) solenoid seal ring (4) into the bottom of the solenoid valve bore. Install the upper (2) and center (3) seal rings on the solenoid valve. Coat the seals with engine oil prior to assembly.

   NOTE: NEW UPPER SEAL RINGS CAN BE IDENTIFIED BY A YELLOW STRIPE.

9. Insert the solenoid valve and torque to 20 N•m (15 lb-ft).

   NOTE: INSTALL THE SOLENOID CAREFULLY TO AVOID CUTTING OR TWISTING THE SEAL RINGS. IMPROPER INSTALLATION COULD RESULT IN POOR ENGINE BRAKE PERFORMANCE.

Install Engine Brake Housings

⚠ CAUTION REMOVING THE OIL FROM THE BOLT HOLES PREVENTS THE CYLINDER HEAD FROM CRACKING WHEN BOLTS ARE TIGHTENED. ATTACH A LENGTH OF TUBING TO AN AIR GUN NOZZLE AND BLOW OUT THE OIL FROM THE HOUSING HOLD-DOWN BOLT HOLES. COVER THE HOLES WITH HAND TOWELS TO MINIMIZE OIL SPRAY.

⚠ WARNING WEAR SAFETY GLASSES WHILE BLOWING THE OIL FROM THE BOLT HOLES.

1. Place the engine brake housings on the rocker shafts and spacer tubes with the solenoids on the camshaft side of the engine and the slave pistons over the exhaust valves.

2. Lubricate each hold-down capscrew with clean engine oil prior to installation.

3. Install three M12x170 capscrews (25) on solenoid side of brake. Install three M12x140 capscrews (26) on the exhaust side of the engine.

⚠ CAUTION INSTALLING 170 MM CAPSCREWS (25) ON THE EXHAUST SIDE OF THE ENGINE CAN RESULT IN SERIOUS ENGINE DAMAGE.

4. Before tightening the capscrews, move the housing from side to side. Position housing in the center of the range of motion.

5. Tighten the capscrews in the following sequence:

   a. Starting with the middle capscrew, tighten the three capscrews on the camshaft side of the engine to 55 N•m (40 lb-ft).

   b. Starting with the middle bolt, tighten the three bolts on the exhaust manifold side of the engine to 55 N•m (40 lb-ft).

   c. Tighten the nut at the end of the rocker shaft to 55 N•m (40 lb-ft)

   d. Repeat the tightening sequence and torque all capscrews to 136 N•m (100 lb-ft).

   e. Follow the same sequence for the other brake.

6. Connect the lead wires to the solenoid valves passing the wires through the wire clips. Torque solenoid screw to 1 N•m (9 lb-ft) and pull the lead wires away from the housing.

Adjust Slave Piston Clearance

⚠ CAUTION FAILURE TO FOLLOW ADJUSTMENT PROCEDURES CAN RESULT IN ENGINE OR ENGINE BRAKE DAMAGE.

NOTE: MAKE SLAVE PISTON ADJUSTMENT WITH THE ENGINE STOPPED AND COLD. ADJUST EACH CYLINDER WITH THE EXHAUST VALVES IN THE CLOSED POSITION.

1. Back out the adjusting screws on the slave pistons until the slave piston does not touch the rocker arm.

2. Insert the proper feeler gage between the slave piston and the exhaust rocker adjusting screw. Using a 3/16 inch hex wrench turn in the adjusting screw until the slave piston contacts the exhaust rocker adjusting screw through the feeler gage. For Model 795 applications, skip to step 4, For J-Lash installation only, continue turning in the adjusting screw until the valve springs begin to compress, then turn in one (1) additional turn. Wait at least 30 seconds for oil to be purged from the J-Lash adjusting screw.

NOTE: ALL OIL MUST BE PURGED FROM THE J-LASH ADJUSTING SCREW. IF OIL IS BELOW 60 °F, 16 °C, WAIT AT LEAST TWO MINUTES FOR OIL TO BE PURGED FROM THE J-LASH ADJUSTING SCREW.

⚠ CAUTION SERIOUS ENGINE DAMAGE MAY OCCUR FROM IMPROPER LASH SETTING.

3. After the time interval specified in step (2), back out the adjusting screw ONLY until a light drag is felt on the feeler gage. Do not retract more than required to obtain a light drag on the feeler gage.

NOTE: IF THE J-LASH ADJUSTING SCREW IS BACKED OUT UNTIL IT NO LONGER COMPRESSES THE SLAVE PISTON SPRING, OIL WILL ENTER THE SCREW AND THE ADJUSTMENT WILL BE INCORRECT. IF THIS OCCURS, REPEAT STEPS (1) AND (2).

4. Hold the J-Lash adjusting screw in place and torque the lock nut to 38 N•m (336 lb-in). Recheck lash settings. If lash setting is incorrect, repeat steps (1) through (3) above.

NOTE: ONCE THE ENGINE BRAKE HAS BEEN RUN YOU WILL NOT BE ABLE TO CHECK THE ENGINE BRAKE ADJUSTMENT FOR ENGINES USING J-LASH ADJUSTING SCREWS. THIS IS BECAUSE OF OIL RETAINED IN THE J-LASH ADJUSTING SCREW. IF UNSURE OF THE ADJUSTMENT, YOU MUST REPEAT STEPS (1) THROUGH (4) ABOVE.

Engine Brake Operational Check

⚠ WARNING WEAR EYE PROTECTION AND DO NOT EXPOSE YOUR FACE OVER THE ENGINE AREA. TAKE PRECAUTIONS TO PREVENT OIL LEAKAGE ONTO THE ENGINE. COVER CONTROL VALVE AREAS SUFFICIENTLY TO PREVENT OIL SPLASH.

Bleed the engine brake housings.

1. Be sure wires are away from moving parts.

2. Start the engine and allow to run for a few minutes.

3. Manually activate the solenoid valve several times to allow the housing to be filled with oil.

NOTE: THE SOLENOID VALVE IS MANUALLY ACTIVATED BY DEPRESSING THE ARMATURE. THE ARMATURE IS LOCATED IN THE CENTER OF THE TOP OF THE SOLENOID.

Check for proper operation.

1. Manually activate the solenoid valve and watch the master piston to be sure it is moving down onto the roller in the injector rocker arm.

2. Watch the slave piston assembly. It should move down to contact the exhaust valve rocker arm adjusting screws.

3. Check each housing to be sure it is functioning.

4. Shut down engine.

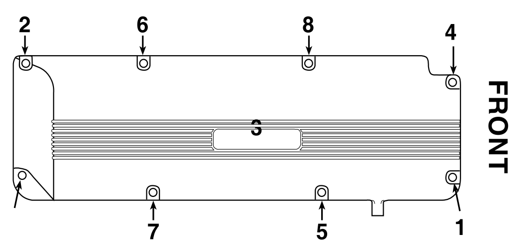
Rocker Cover Installation

1. Make sure the seal is in place in the rocker cover base and set the cover in place on the cover base.

2. Install the bolt with a flat washer, isolator and limiting sleeve into the cover holes.

3. Tighten the bolts to 14 N•m (10 lb-ft) in the sequence shown in Fig. 1.

4. Torque the bolts to 27 N•m (20 lb-ft).



SERIES 60 ROCKER COVER

FIG. 1

Jacobs Vehicle Systems
22 East Dudley Town Road
Bloomfield, CT 06002

Jacobs Vehicle Systems™

Visit us on the Internet:
www.jakebrake.com

P/N 29015 Rev. A

Printed in U.S.A.

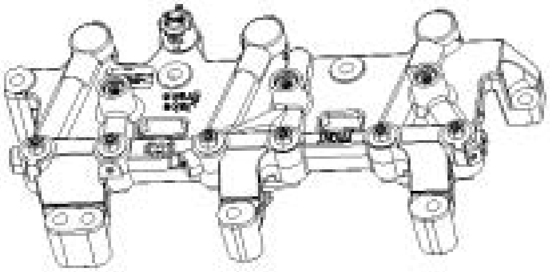
Rev. 10/00

SPECIFICATIONS - 790/795/797

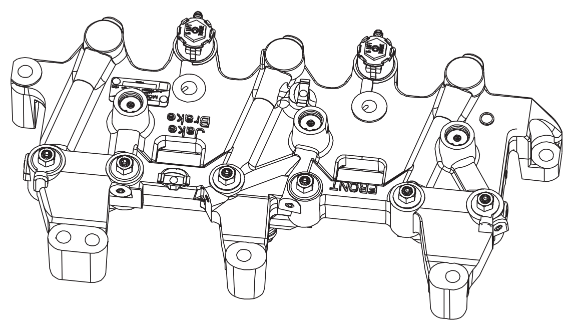
Jake Brake® Models 790, 795 & 797

for Detroit Diesel Series 60® Engines

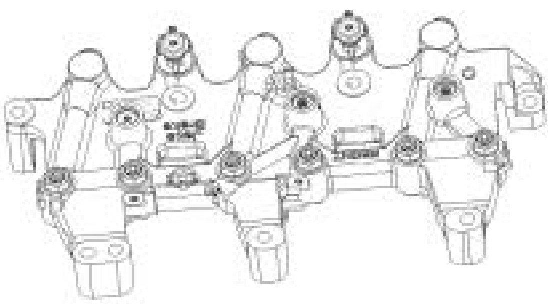
Year 2000 Production Engines and Beyond



797 Series
For engines manufactured 10/01/02-



Model 795
For engines manufactured 8/10/00-9/30/02



790 Series
For engines manufactured 12/15/99-8/10/00

Features & Benefits

Designed in partnership with Detroit Diesel to yield a more simplified design, reducing weight while increasing performance & reliability:

- *Significant low & mid-range RPM performance improvements*
- *Respected Jake Brake® reliability & durability*

Jake Brake is the only engine brake brand installed at Detroit Diesel

Backed by Detroit Diesel's worldwide distributor & dealer network

2-year/unlimited mileage standard warranty

OVER 40 YEARS OF LEADERSHIP Since 1961

Engineered for the Road Ahead™

Jake Brake® Models 790, 795 & 797

for Detroit Diesel Series 60® Engines

Technical Specifications

Height	4.2"	107 mm
Length	19.6"	498 mm
Width	4"	102 mm
Kit Added Weight	75 lbs.	34 kg.
Housings Per Engine	2	

Application Information

For the most accurate application information, refer to the Detroit Diesel Application Guide (Jacobs P/N 24770), available from your Detroit Diesel Distributor or online at www.jakebrake.com.

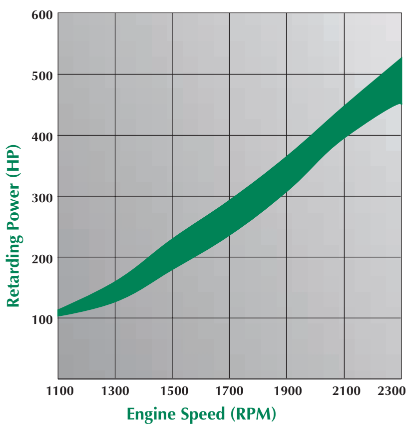
How The Jake Brake® Works:

Energizing the engine brake effectively converts a power-producing diesel engine into a power-absorbing air compressor. This is accomplished through motion transfer using a master/slave piston arrangement which opens cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust.

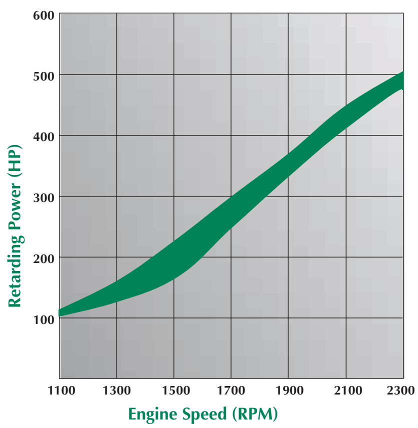
The blowdown of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the expansion stroke, the effect being a net energy loss since the work done in compressing the cylinder charge is not returned during the expansion process.

Retarding Performance

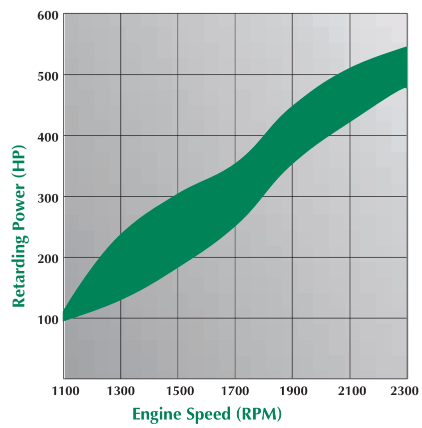
790



795



797



RPM	790				
	12.7L 330-350	12.7L Std	12.7L Prem	14L US Hwy	14L Australia
1100	101	101	105	105	110
1300	138	136	142	143	163
1500	193	194	190	185	235
1700	267	273	251	241	294
1900	342	351	323	308	368
2100	406	413	397	401	455
2300	465	470	480	483	525

RPM	795			
	12.7L 330-350	12.7L Std	12.7L Prem	14L US Hwy
1100	110	108	102	109
1300	157	150	135	140
1500	220	215	165	193
1700	299	280	250	253
1900	359	363	340	333
2100	419	445	420	412

RPM	797					
	12.7L 426	12.7L 433	12.7L Australia	14L 430	14L 489	14L 500
1100	111	104	99	116	113	109
1300	156	150	135	233	238	151
1500	226	229	191	285	302	221
1700	307	320	262	324	348	305
1900	366	382	359	404	448	404
2100	426	433	439	443	510	489
2300	475	479	496	492	564	552

Important Note: The performance data shown above is measured in accordance with SAE J1621 power measurement standard, up to engine manufacturer's rated engine speed of 2100 RPM.

Others may claim higher retarding performance. Only the Jacobs Engine Brake® is designed and tested in cooperation with Detroit Diesel to provide the highest performance available while maintaining or improving engine brake system reliability and durability.

Jacobs Vehicle Systems™

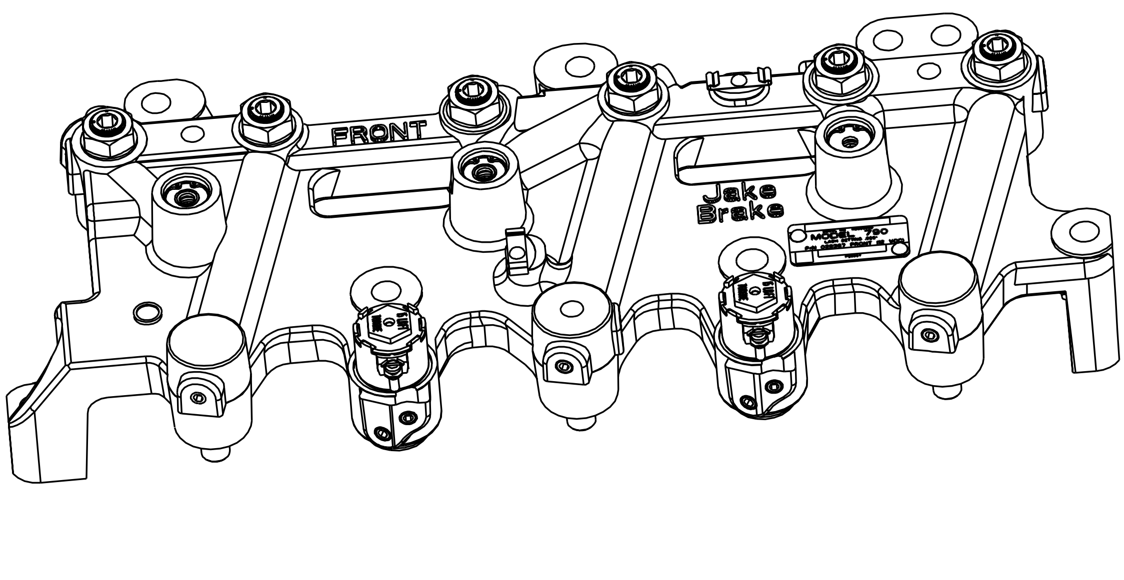
P/N 030562 Rev. B 3/03

Jacobs Vehicle Systems™

PARTS MANUAL

Jacobs Engine Brake®

Models 790/795/797



Information in this manual was current at time of printing and is subject to change without notice or liability.

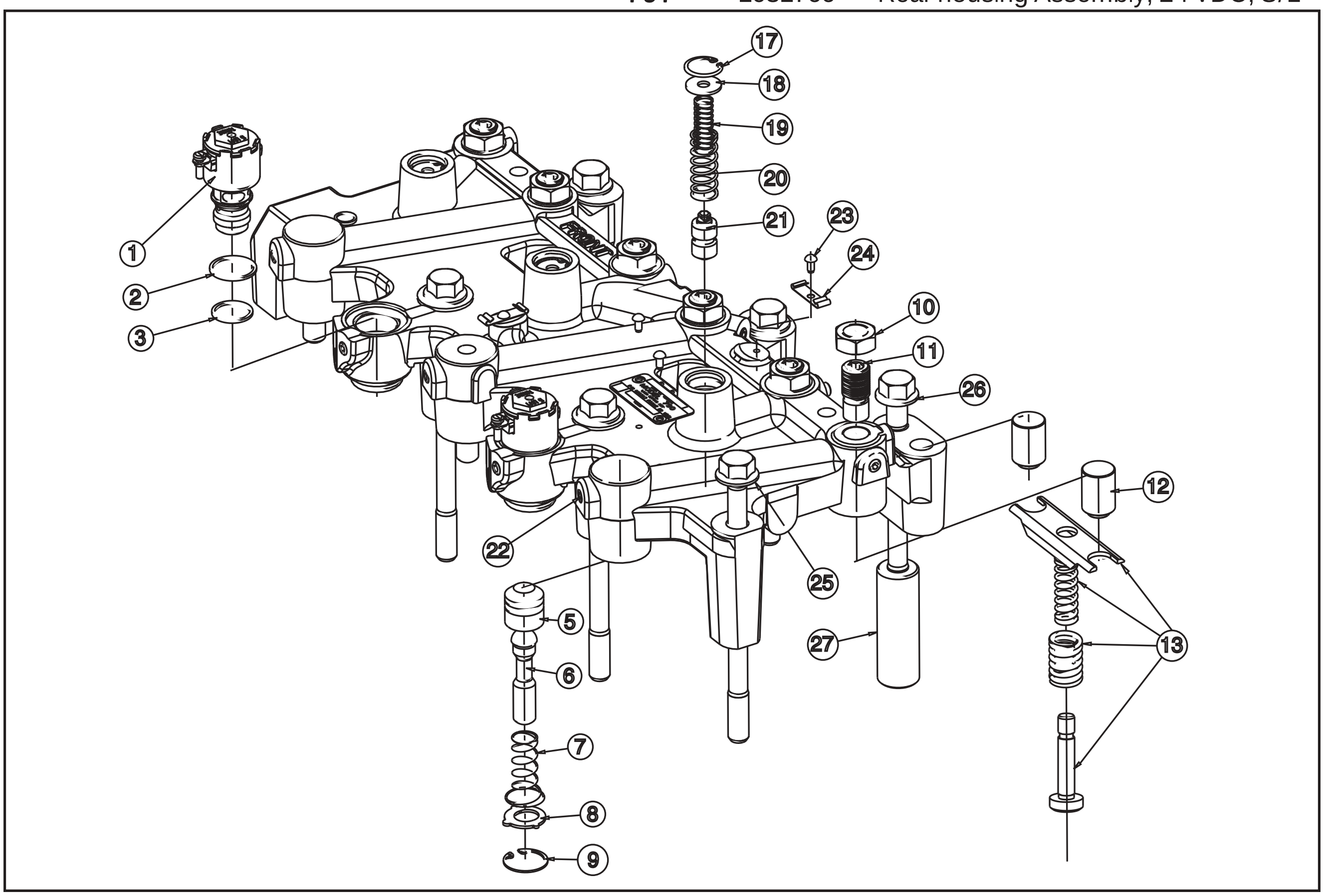
Refer to the Application guide, P/N 24770 for specific application information. Also refer to the Installation Manual, P/N 29901 and the Engine Manual for specific installation instructions.

790/795/797 KITS

Model No.	P/N	Description
790	29240	Engine Brake Kit, 12 VDC
790	29020	Engine Brake Kit, 24 VDC
790A	29123	Engine Brake Kit, 12 VDC
790A	29232	Engine Brake Kit, 24 VDC
790B	29302	Engine Brake Kit, 12 VDC
790B	29304	Engine Brake Kit, 24 VDC
790C	29321	Engine Brake Kit, 12 VDC
790C	29323	Engine Brake Kit, 24 VDC
795	30505	Engine Brake Kit, 12 VDC
795	30506	Engine Brake Kit, 24 VDC
797	31361	Engine Brake Kit, 12 VDC
797	31860	Engine Brake Kit, 24 VDC

790/795/797 HOUSING ASSEMBLIES

Model No.	P/N	Description
790	28367	Front housing Assembly, 12 VDC, S/L
790	28368	Rear housing Assembly, 12 VDC, S/L
790	29017	Front housing Assembly, 24 VDC, S/L
790	29018	Rear housing Assembly, 24 VDC, S/L
790A	29029	Front housing Assembly, 12 VDC, S/L
790A	29030	Rear housing Assembly, 12 VDC, S/L
790A	29124	Front housing Assembly, 24 VDC, S/L
790A	29125	Rear housing Assembly, 24 VDC, S/L
790B	29128	Front housing Assembly, 12 VDC, S/L
790B	29129	Rear housing Assembly, 12 VDC, S/L
790B	29130	Front housing Assembly, 24 VDC, S/L
790B	29131	Rear housing Assembly, 24 VDC, S/L
790C	29148	Front housing Assembly, 12 VDC, S/L
790C	29149	Rear housing Assembly, 12 VDC, S/L
790C	29150	Front housing Assembly, 24 VDC, S/L
790C	29151	Rear housing Assembly, 24 VDC, S/L
790D	1031226	Front housing Assembly, 12 VDC, S/L
790D	1031227	Rear housing Assembly, 12 VDC, S/L
790D	1031228	Front housing Assembly, 24 VDC, S/L
790D	1031229	Rear housing Assembly, 24 VDC, S/L
795	29902	Front housing Assembly, 12 VDC, S/L
795	29903	Rear housing Assembly, 12 VDC, S/L
795	29904	Front housing Assembly, 24 VDC, S/L
795	29905	Rear housing Assembly, 24 VDC, S/L
797	1031322	Front housing Assembly, 12 VDC, S/L
797	1031323	Rear housing Assembly, 12 VDC, S/L
797	1031765	Front housing Assembly, 24 VDC, S/L
797	1031766	Rear housing Assembly, 24 VDC, S/L



HOUSING ASSEMBLY 790/795/797

Illus. No.	Part Name	790	795	797	Qty per housing
1	**Solenoid**		1024612(12VDC) -or- 1024619(24VDC)		2*
2	**Seal, Solenoid Upper**		20229		2*
3	**Seal, Solenoid Middle**		1082		2*
4	Seal, Solenoid Lower	not required		not required	2*/***
5	Master Piston	26932		31282	3
6	**Pushrod - Master Piston**		28791		3
7	**Spring, Master Piston**		28768		3
8	Washer- MP Retainer	29944		31854	3
9	Ring, Retainer	26555		31331**	3
10	Nut, Hex	19987	29908		6
11	Adjusting Screw	(See 790 J-Lashes)	29864	31270	6
12	Slave Piston	26142		31324	6
13	Slave Piston Spring Group	32160		32127	3
	Bridge, Slave Piston	n/a		n/a	-
	Spring, Inner Slave Piston	n/a		n/a	-
	Spring, Outer Slave Piston	n/a		n/a	-
	Shoulder Bolt, Slave Piston	n/a		n/a	-
17	**Ring, Retainer**		12991		3
18	**Washer**		16505		3
19	**Spring, Inner Control Valve**		18179		3
20	**Spring, Outer Control Valve**		10843		3
21	**Control Valve Assembly**		11930		3
22	**Pipe Plug**		18485		-
23	**Drive Screw**		17303		-
24	**Clip, Wire Harness**		29127		-

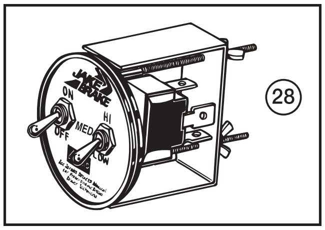
Notes: **Bold** text deplicts parts that are common to all brake models listed.
*For 790/795, front housing has two solenoid and the rear housing has one;
For 797, both front and rear housings have only one solenoid.
**Requires assembly tool part #J-45976
***Reference Technical Service Letter 02TS-17

790 J-lash™ Assemblies & Groups

Illus. No.	Part Name	790	790A	790B&D	790C	Qty per housing
11	J-lash™ Assembly	28341	29300	29317	29310	6
	J-lash™ Assy Group (12 pack)	29019	29414	29415	29416	-

ATTACHING PARTS

Illus. No.	P/N	Part Name	Quantity per kit
NI	**29133**	**Attaching Parts Group**	1
25	28346	CapScrew, M12X1.75X170	6
26	29132	CapScrew, M12X1.75X140	6
27	29118	Spacer Tube	6



CAB CONTROL GROUP

Illus. No.	P/N	Part Name	Quantity per kit
NI	**20220**	**Cab Control Group**	
NI	20244	Harness, 6ft	1
28	20035	Switch	1

SERVICE PARTS 790/795/797

P/N	Part Name
17671	Feeler gauge 0.026 IN. (0.660 mm)
16590	Screw, Rocker Adjusting
29013	Tune up kit - 790/795 Series
29589	Wire Clip Kit - Model 790
30503	Solid Screw Group (12 pack), 795
32128	Solid Screw Group (12 pack), 797
32146	Tune up kit - 797 Series
J-45976	Master Piston Assembly Tool, 797
29901	Installation Manual

2.15 ELECTRONIC ENGINE CONTROL

The Detroit Diesel Electronic Control System (DDEC) controls fuel injection timing and output by the electronic unit injectors (EUI) on the Series 60 Diesel engine. DDEC controls throttle, gas valve and the ignition system on the Series 60G engine. The system also monitors several engine functions using electrical sensors which send electrical signals to the Electronic Control Module (ECM). The ECM then computes the incoming data and determines the correct fuel output and timing for optimum power, fuel economy and emissions. The ECM also has the ability to display warnings or shut down the engine completely (depending on option selection) in the case of damaging engine conditions, such as low oil pressure, low coolant, or high oil temperature.

Early Series 60 engines have the DDEC system called DDEC I. Later Series 60 engines have the 2nd generation DDEC system called DDEC II. See Figure 2-78. The current engines have the third generation DDEC system, DDEC III/IV.

Series 60 2004 Exhaust Gas Recirculation (EGR) engines will use the fifth generation of the DDEC system, DDEC V® Electronic Control Unit. See Figure 2-78a.

The replacement of DDEC components is based on indicated diagnostic codes leading to faulty components. Check the *Detroit Diesel Single ECM Troubleshooting Manual* (6SE497) for more complete information on diagnosis of components and system problems.

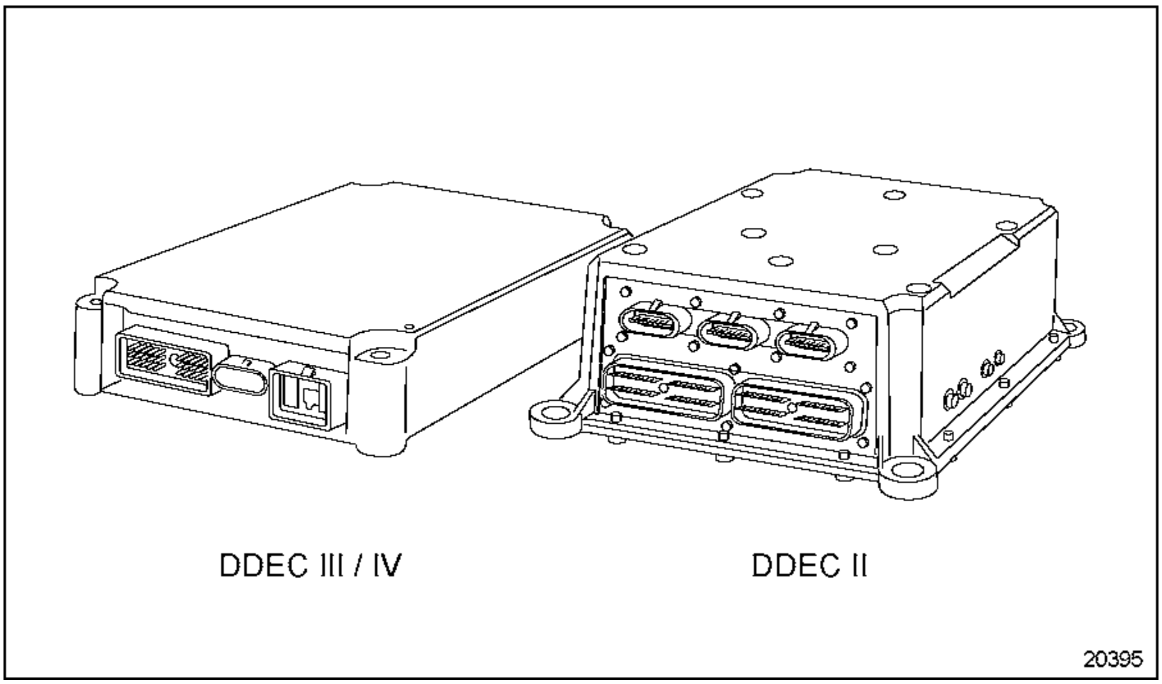


Figure 2-78 DDEC III/IV and DDEC II Electronic Control Module (ECM)

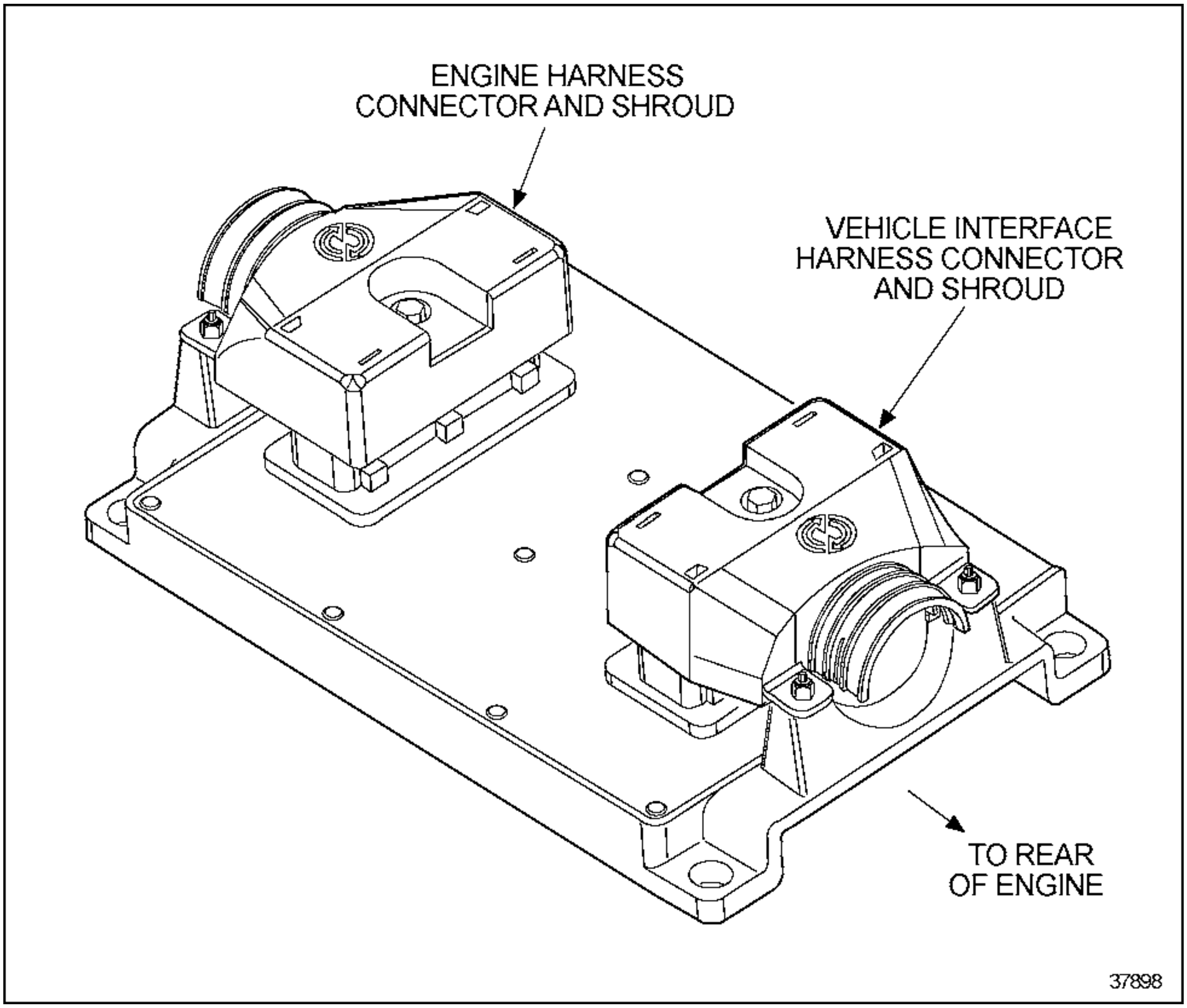


Figure 2-78a DDEC V Electronic Control Unit

2.16A DDEC V ELECTRONIC CONTROL UNIT

DDEC V provides an indication of engine and vehicle malfunctions. The ECU continually monitors the DDEC V system. See Figure 2-79a.

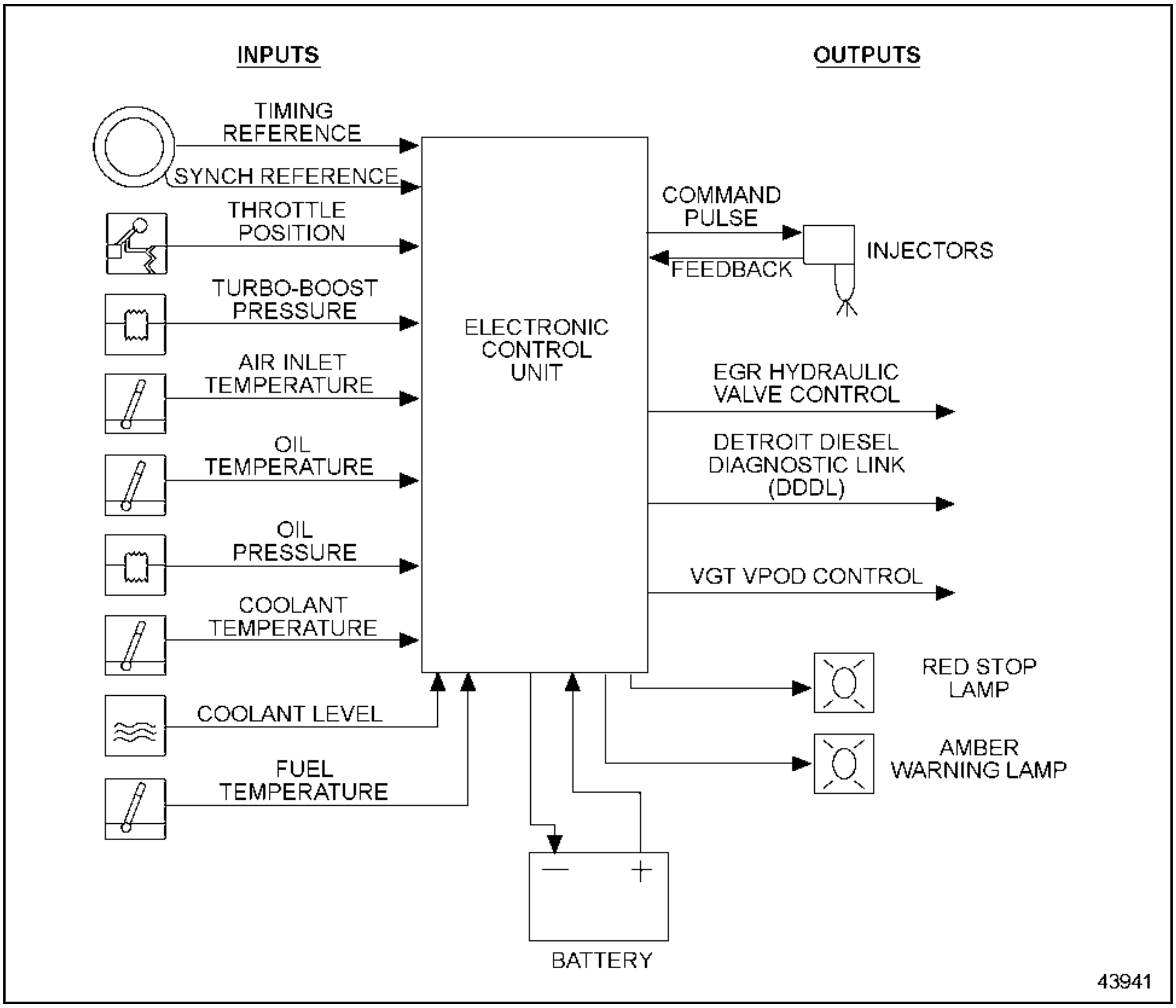


Figure 2-79a DDEC V System Series 60 Diesel Engine

Any faults that occur are stored as codes in the ECU's memory. These codes can be accessed in any of three ways:

1. A DDDL® can be used to read the codes.
2. A personal computer (PC) connected to the ECM through a translator device which converts J1708 to RS232 protocol can be used.
3. The Amber Warning Lamp (AWL) or the Red Stop Lamp (RSL) is illuminated.
    - The AWL (panel mounted yellow indicator light) illuminated diagnose condition as soon as convenient.
    - The RSL (panel mounted red indicator light) and AWL illuminated, a major fault occurred and immediate attention required to avoid engine damage.
    - Automatic engine shutdown or rampdown is available as an option. A shutdown override switch is required to allow the vehicle to be moved to a safe location during automatic shutdown or rampdown.

The Detroit Diesel Diagnostic Link® (DDDL) is a sophisticated PC software package that requests and receives engine data and diagnostic codes. The Detroit Diesel Diagnostic Link® DDDL supports DDEC V and the Series 60 2004 engine. See Figure 2-79b.

The DDDL functions are:

- Read and display current calibration for an ECU.
- Create a calibration for the ECU on an individual engine.
- Save a single calibration with an ECU password, this same password can be used for fleet of vehicles with the same password or technican who does not have access to the password.
- Change the engine rating of a vehicle.
- Set the injector calibration when you replace the injectors.
- View an audit trail of ECU and injector calibration changes.

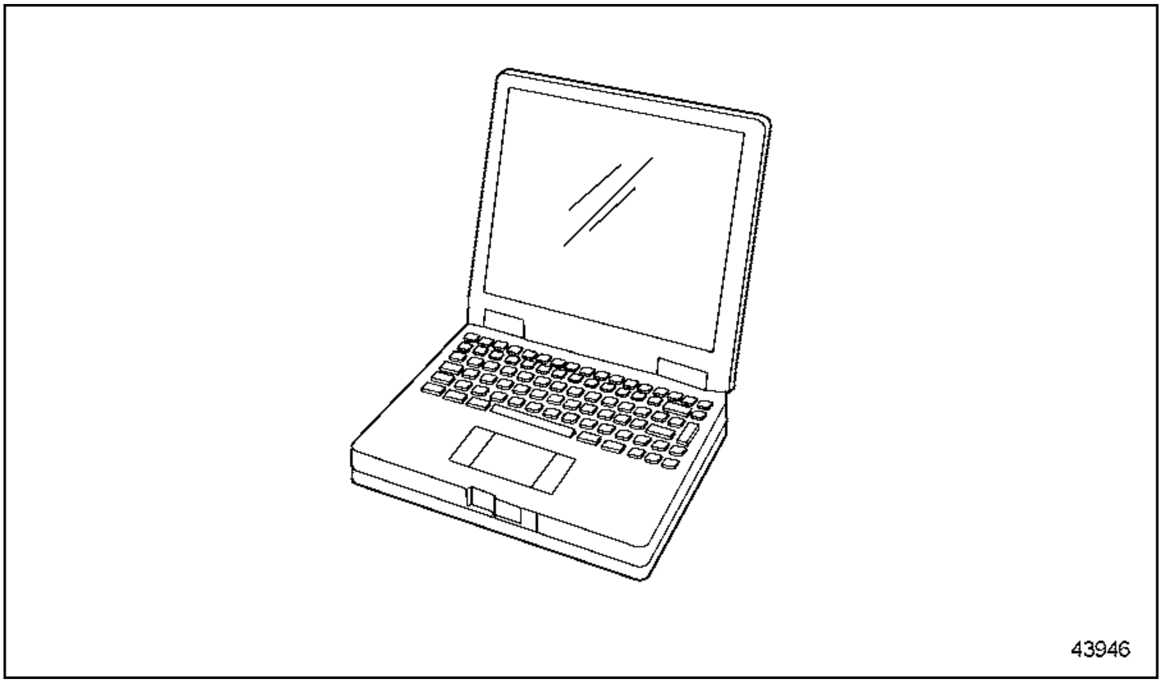


Figure 2-79b Detroit Diesel Diagnostic Link® (DDDL)

The SAE Standard Communications of the DDEC V system are listed in Table 2-6a. The fan control inputs and outputs for DDEC V are listed in Table 2-6b. The engine brake control features of DDEC V are listed in Table 2-6c. DDEC V can identify faulty components and other engine-related problems by providing the technician with a diagnostic code. Standard sensors are listed in Table 2-6d. OEM installed sensors are listed in Table 2-6e.

SAE Standard Communication
SAE J1587 protocol on J1708 hardware
Diagnostics
Electronic dashes
Data Hub
SAE J1922 protocol on J1708 hardware
Traction control systems
Transmission controls
SAE J1939 high speed data link
Vehicle controls

Table 2-6a SAE Standard Communications for DDEC V

Inputs	Outputs
Coolant temperature	Single on/off fan clutch
Oil temperature	Dual on/off fan clutch
Air temperatures	Two-speed single fan
Air conditioning	Modulated fan clutch

Table 2-6b Fan Controls for DDEC V

Engine Brake Control
Cruise Control with Engine Brake
Engine Brake Disable
Engine Brake Active
Engine Fan Braking
Clutch Release Input
Service Brake Control of Engine Brakes
Min. MPH for Engine Brakes

Table 2-6c Engine Brake Controls with DDEC V

DDEC V
Barometric Pressure Sensor (Baro Sensor)
Camshaft Position Sensor (CPM Sensor)
Crankshaft Position Sensor (CKP Sensor)
EGR Delta Pressure Sensor (EGR Delta Pressure)
EGR Temperature Sensor
Engine Coolant Temperature Sensor (ECT Sensor)
Engine Oil Level (EOL Sensor)
Engine Oil Pressure Sensor (EOP)
Engine Oil Temperature Sensor (EOT)
Fuel Restriction Sensor
Intake Air Temperature Sensor (IAT)
Intake Manifold Pressure Sensor (IMP)
Mass Air Flow Sensor
Supply Fuel Temperature Sensor (SFT Sensor)
Turbo Compressor Temperature Out Sensor
Turbo Speed Sensor (TSS)

Table 2-6d Standard Sensors for DDEC V

DDEC V
Accelerator Pedal Sensor (AP Sensor)
Add Engine Coolant Level Sensor (AECL Sensor)
Air Filter Restriction Sensor (AFR Sensor)
Engine Coolant Level Sensor (ECL)
Fire Truck Pump Pressure Sensor *
Turbo Compressor In Temperature Sensor
Vehicle Speed Sensor (VSS)

Table 2-6e OEM Installed Sensors

* Available in some applications

2.16a.1 Repair or Replacement of the DDEC V Electronic Control Unit

The DDEC V ECU is a sealed, nonserviceable unit. Tag defective ECU for recore.

2.16a.2 Removal of the DDEC V Electronic Control Unit

Perform the following steps for ECU removal:

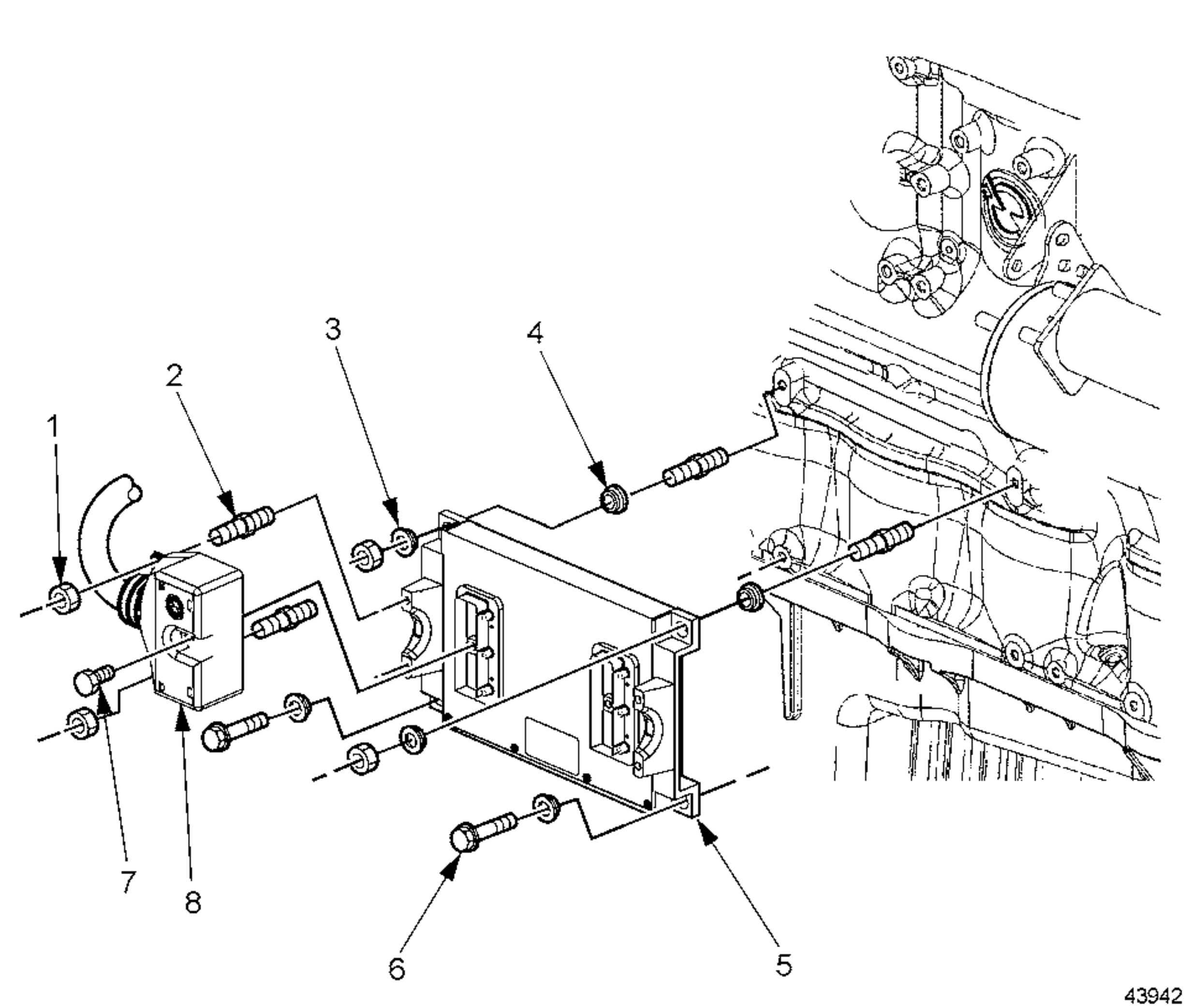
1. Remove screw from center of shroud and connector. Remove two nuts from threaded studs at the base of the shroud and ECU see Figure 2-79c.
2. Remove shroud and connector from ECU.
3. Remove the two through-bolts, two nuts and two studs holding the ECU to the engine, remove the ECU from engine. See Figure 2-79c.

2.16a.3 Installation of the DDEC V Electronic Control Unit

Perform the following steps for ECU installation:

1. Inspect the ECU isolators for damage and replace if required.
2. Mount the ECU to the engine.
3. Secure the ECU to the engine with two through-bolts, two studs and nuts. Torque the ECU-to-engine bolts to 23-27 N·m (17-20 lb·ft).
4. Install the engine harness connector and shroud to the ECU. Torque center screw and two nuts to 5.6 N·m (50 in.· lb).

5. Turn the ignition to the "ON" position. Observe the DDDL for any diagnostic code(s). If any code(s) other than code 25 is logged, refer to the *Detroit Diesel DDEC V Single ECM Troubleshooting Manual* (6SE565).



1. Nut	5. Electronic Control Unit
2. Stud	6. Bolt
3. Isolater	7. Bolt
4. Isolater	8. Shroud

Figure 2-79c DDEC V Electronic Control Unit and Related Parts

CAUTION:

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

- **Always start and operate an engine in a well ventilated area.**
- **If operating an engine in an enclosed area, vent the exhaust to the outside.**
- **Do not modify or tamper with the exhaust system or emission control system.**

6. Start the engine, and check for leaks.

tyco / Electronics

AMP

68–Position Heavy Duty Hybrid Connector

Application Specification
114–13053
14 MAR 02 Rev O

NOTE *All numerical values are in metric units [with U.S. customary units in brackets]. Dimensions are in millimeters. Unless otherwise specified, dimensions have a tolerance of ±0.13 and angles have a tolerance of ±2°. Figures and illustrations are for identification only and are not drawn to scale.*

1. INTRODUCTION

This specification covers the requirement for application of the 68–Position Heavy Duty Hybrid Connector. This connector is used on engine control modules and consist of sixty 1 mm contacts and eight 1.6 mm contacts. It is a vertical–mount wire–to–board connector system which mounts to the exterior of modules.

NOTE *Refer to Application Specifications 114–6071 and 114–13045 for all termination and application information for the contacts which are used in the 68–Position Heavy Duty Hybrid Connector.*

When corresponding with Tyco Electronics personnel, use the terminology provided in this specification to facilitate your inquiry for information. Basic terms and features of components are provided in Figure 1.

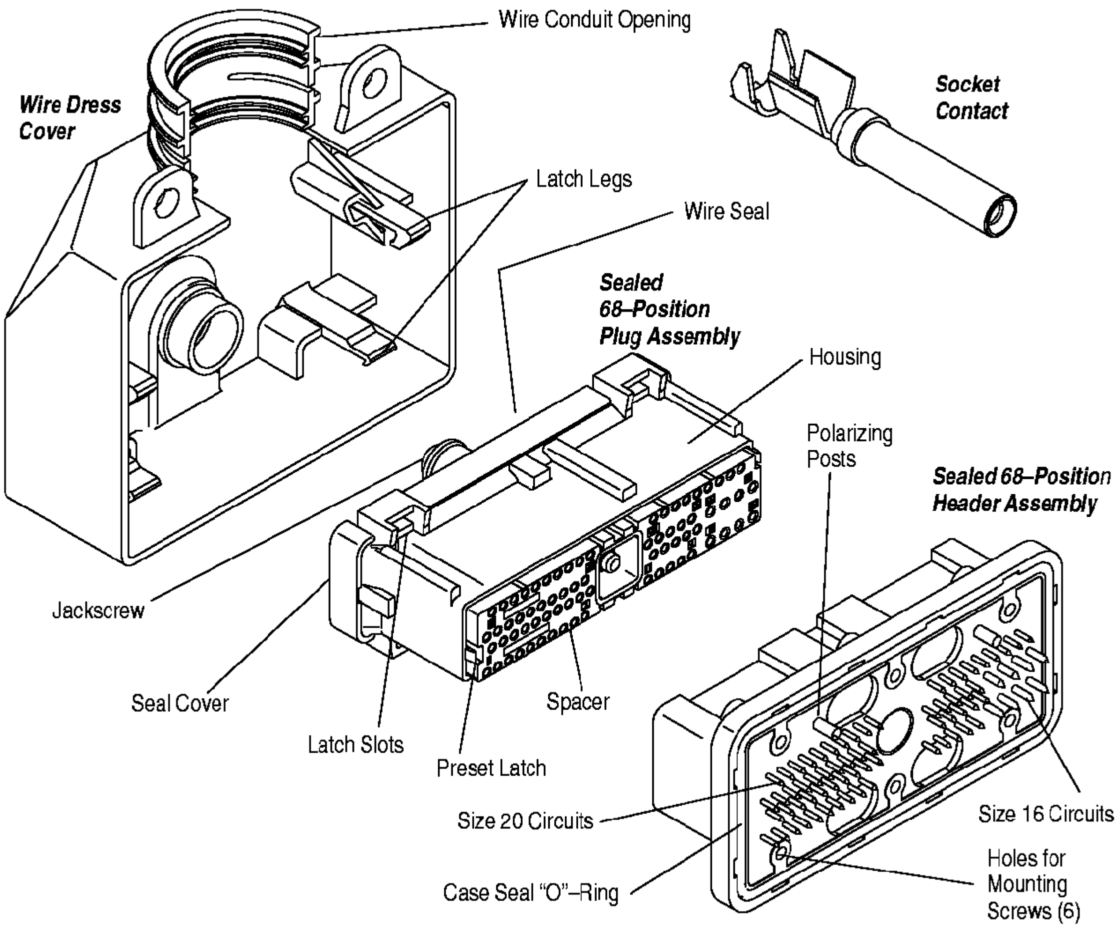


Figure 1

2. REFERENCE MATERIALS

2.1. Revision Summary

Per EC 0990–1179–01

- Initial release of application specification

2.2. Customer Assistance

Reference Base Part Number 776315 and Product Code A243 are representative numbers that identify the 68–Position Heavy Duty Hybrid Connector product line. These numbers are used in the customer service network to access tooling and product application information. This service is provided by your local Tyco Electronics Representative (Field Sales Engineer, Field Application Engineer, etc.) or, after purchase, by calling the Tooling Assistance Center number at the bottom of page 1.

2.3. Drawings

Customer Drawings for each product part number are available from the service network. The information contained in the Customer Drawings takes priority if there is a conflict with this specification or with any other technical documentation supplied by Tyco Electronics.

2.4. Specifications

Product Specification 108–1945 provides product performance requirements and test information. Application Specifications 114–6071 and 114–13045 provide information for termination and requirements of the contacts used in this connector assembly.

2.5. Manuals

Manual 402–40 is available upon request and can be used as a guide in soldering. This manual provides information on various flux types and characteristics along with the commercial designation and flux removal procedures. A checklist is included in the manual as a guide for information on soldering problems.

2.6. Instructional Material

The following list includes available instruction sheets (408–series) that provide information for the handling of this product line.

Document Number	Document Title
408–3295	Preparing Reel of Contacts for Application Tooling
408–6927	Design Recommendations for Printed Circuit (PC) Board Support Fixture
408–7424	Checking Terminal Crimp Height Gaging Die Closure
408–9816	Handling Of Reeled Products

3. REQUIREMENTS

3.1. Storage

A. Ultraviolet Light

Prolonged exposure to ultraviolet light may deteriorate the chemical composition used in the connectors.

B. Reel Storage

When using reeled contacts, store coil wound reels horizontally and traverse wound reels vertically.

C. Shelf Life

The contacts and connectors should remain in the shipping containers until ready for use to prevent deformation to the product. The contacts and connectors should be used on a first in, first out basis to avoid storage contamination that could adversely affect signal transmissions.

D. Storage Temperature

Maximum storage temperature should not exceed 150° C [302° F].

E. Chemical Exposure

Do not store contacts near any chemicals listed below, as stress corrosion cracking in the contacts may occur.

Alkalies	Ammonia	Citrates	Phosphates Citrates	Sulfur Compounds
Amines	Carbonates	Nitrites	Sulfur Nitrites	Tartrates

NOTE *Where the above environmental conditions exist, phosphor–bronze contacts are recommended if available.*

3.2. Exposure Limitations

The operating temperature range of this connector assembly is –40° to 125° C [–40° to 257° F].

3.3. Special Considerations

Size 16 circuits (8 larger circuits) will seal properly with 14 AWG GXL, 16 AWG GXL, and 14 AWG Teflon•wire, with wire insulation (OD) between 2.5 and 3.18 mm. Size 20 circuits (60 smaller circuits) will seal properly with 18 AWG GXL and 16 AWG Teflon wire, with wire insulation (OD) between 2 and 2.5 mm.

3.4. Strain Relief Arrangement

CAUTION *Care should be taken when attaching the wire dress cover as not to bend or crush any wires. make sure that the wires are not bent or angled coming through the wire seal. Doing so may cause the wires to open the wire seal holes too much and form leak paths. The wires should be bent after exiting the wire cover, in order to fit all the wires comfortably underneath the wire dress cover.*

3.5. Contact Termination

Terminate the contacts in according to the specific tooling instructional material and crimp requirements provided in Application Specifications 114–6071 and 114–13045.

3.6. Plug Assembly Procedures

CAUTION *Seal cover and wire seal must not be removed or altered in any way.*

CAUTION *The back of the connector must be completely sealed. Those cavities that are not used must have individual seal plugs. Use seal plug 776363–1 for size 16 holes, and seal plug 776364–1 for size 20 holes. See Figure 2.*

NOTE *Contact retention fingers will not engage if contact assemblies are inserted into plug housing cavity while the plug spacer (TPA) is in the closed position.*

Check to be sure the plug spacer is in the *open*, or as–shipped position. See Figure 2. Proceed as follows:

1. To insert a terminated contact, push it straight into the appropriate circuit cavity as far as it will go. See Figure 2.

2. Pull back on the contact wire with a force or 8.9 to 13.3 N [2 to 3 lbs] to be sure the retention finger is holding the contact.

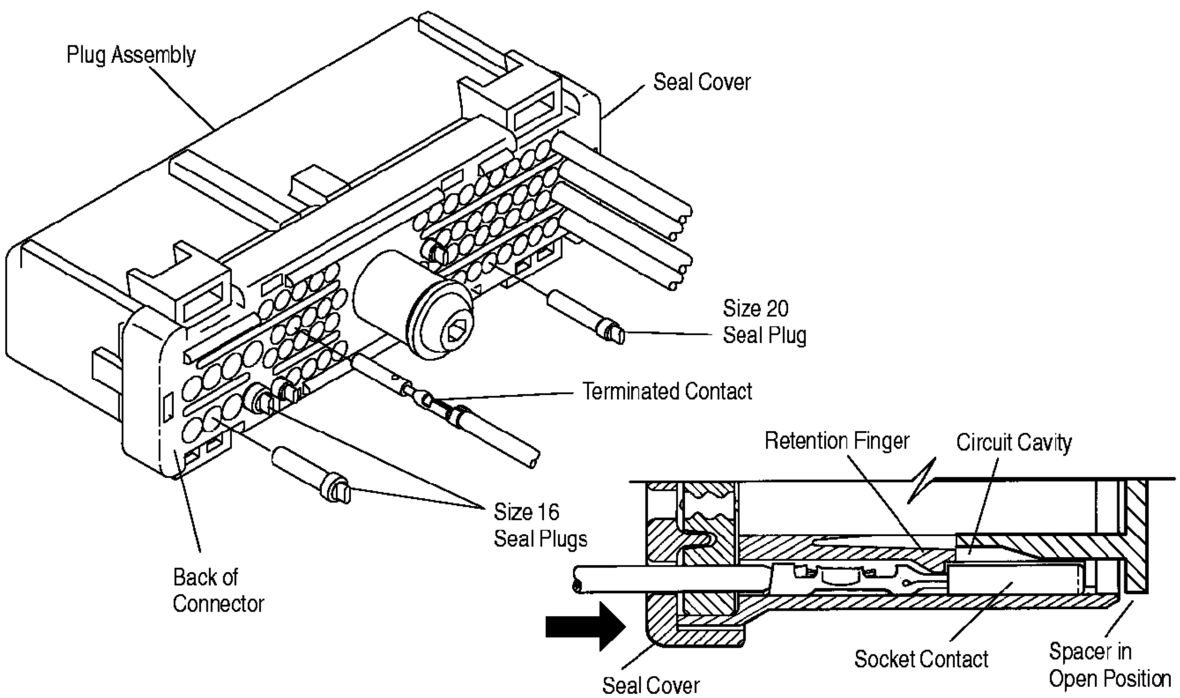


Figure 2

• Trademark of E. I. DuPont de Nemours and Company Corporation

3. After all required contacts have been inserted, the spacer must be closed to its *locked* position. Release the locking latches by squeezing them inward and slide the spacer forward until it is flush with the housing plug assembly. See Figure 3.

NOTE *The spacer should seat with a force of 56 N [12.5 lbs]. If the spacer does not seat, verify that all contacts are fully inserted.*

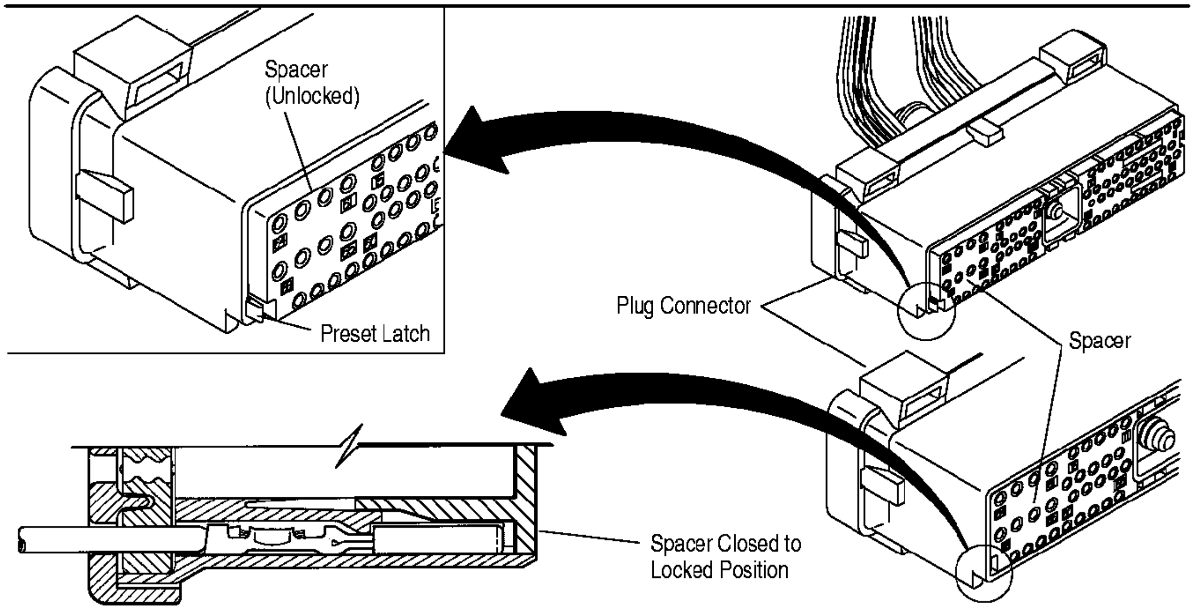


Figure 3

4. Assemble the wire dress cover and dress wires as shown in Figure 4.

5. Bolt the wire dress cover to the electronics module using customer supplied hardware. See Paragraph 3.15.

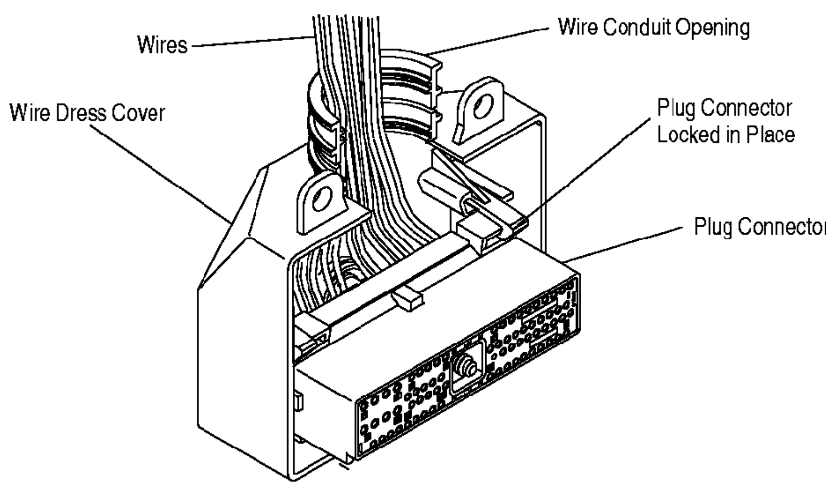


Figure 4

3.7. Plug Disassembly Procedures

Refer to Figure 5 and proceed as follows:

1. To remove the wire dress cover, loosen the two bolts holding the wire dress cover to the electronics module.

2. Cut the wire tie around the conduit, and release the four latch legs going into the plug assembly. See Figure 5.

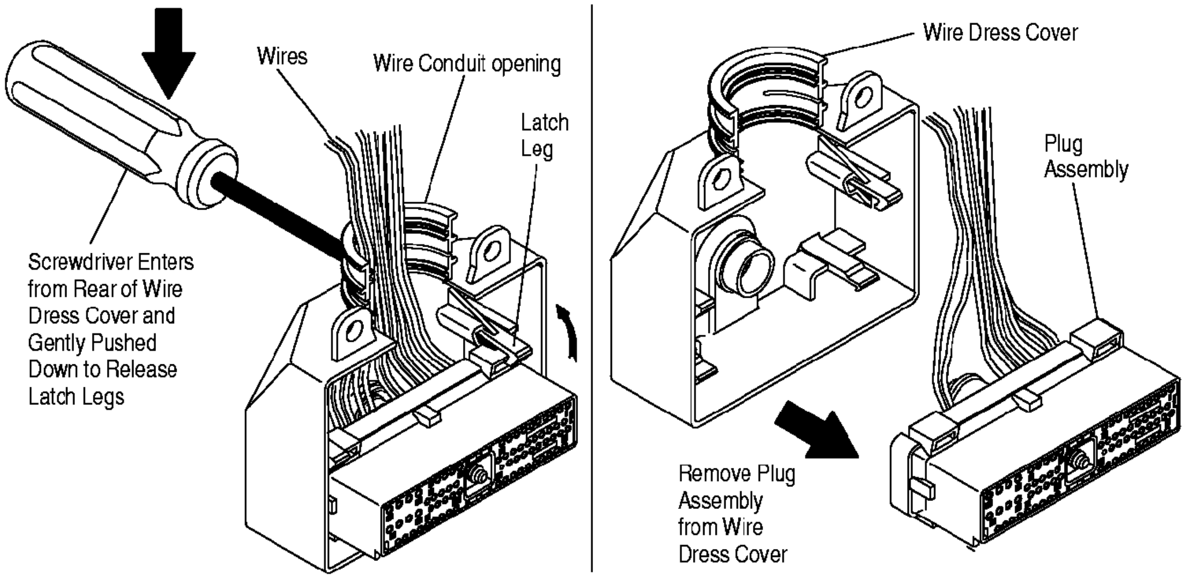


Figure 5

3. To remove the plug spacer, insert any hooked tool into the opening around the jackscrew. Rotate the tool to catch the underneath the spacer. Pull spacer straight out from the plug housing. See Figure 6.

CAUTION *Do not pry against the wall of the plug housing, as damage to the connector sealing system could occur.*

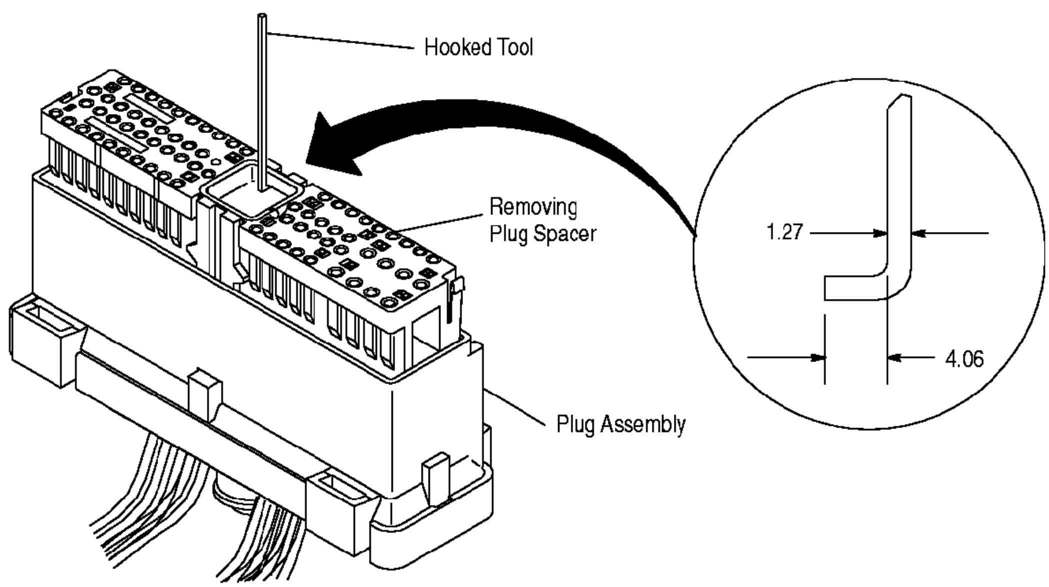


Figure 6

4. Insert a 1.4 mm screwdriver into the contact cavity and deflect the retention finger holding the contact. Gently pull the wire until the contact is free from the housing. Repeat this procedure for the remaining number of contacts to be removed as shown in Figure 7.

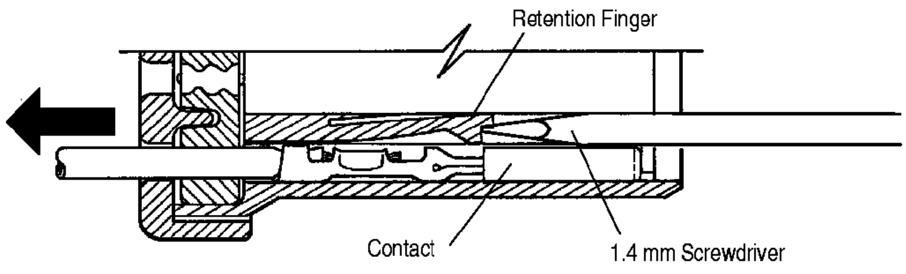


Figure 7

3.8. Printed Circuit Boards

A. Thickness

The header assembly has been designed to accommodate a pc board thickness of 2 mm thick. Contact the Product Information Center or the Tooling Assistance Center at the number listed at the bottom of page 1 for suitability of other board thicknesses.

B. Tolerance

The maximum bow of the pc board shall be 0.03 over the length of the header assembly.

C. Layout

The mounting and contact holes in the pc board must be precisely located to ensure proper placement and optimum performance of the header assembly. The "X" and "Y" symbols on the pc board layout represent customer established datums. They are the origin for the basic dimension (XXX and YYY datum), the point from which ALL hole positions must be located. Design the pc board using the dimensions provided in Figure 8.

NOTE: PC board layout is for reference only.

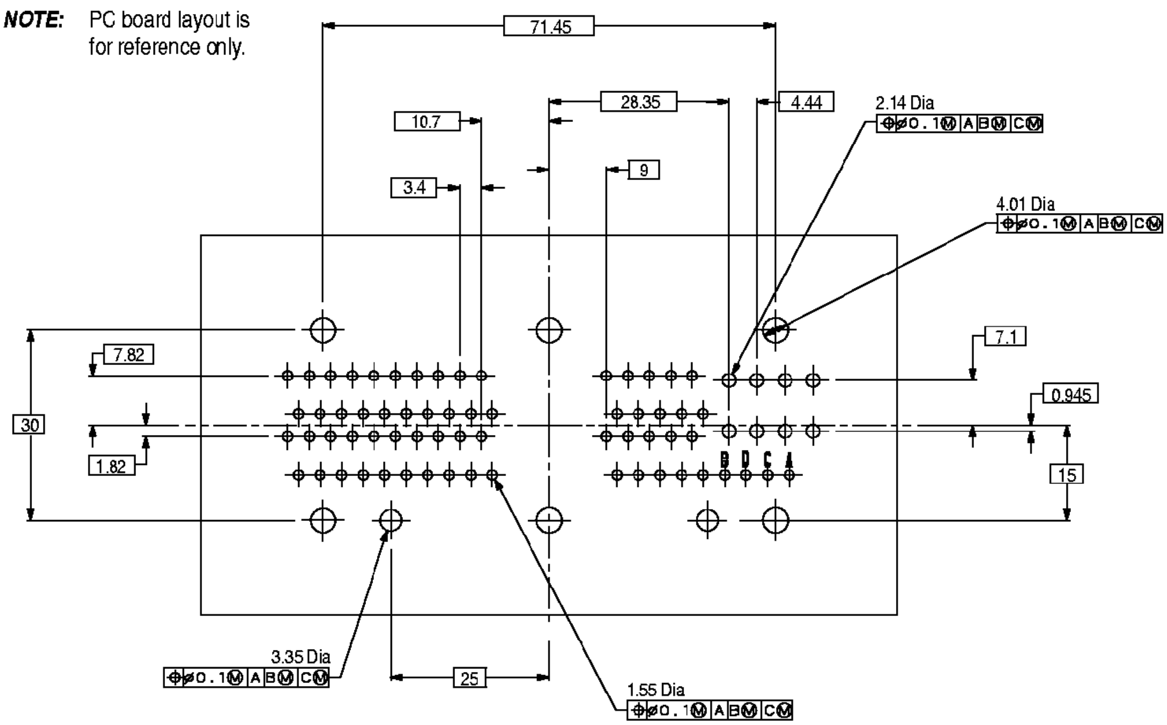


Figure 8

3.9. Contact Holes

The holes in the pc board for all contacts must be prepared as specified in Figure 9.

NOTE: The drilled hole diameter must be sized so that the diameter of the finished hole after plating meets the dimensions as shown.

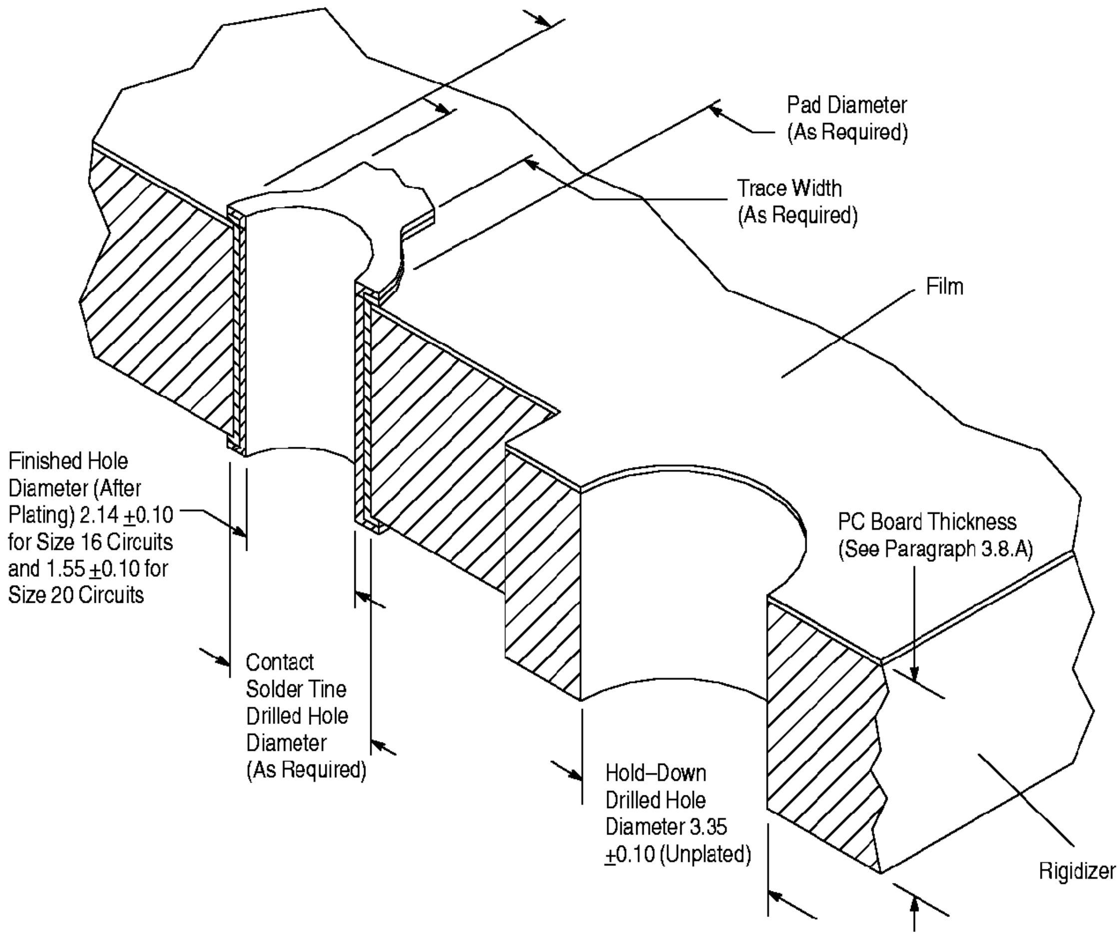


Figure 9

3.10. Header Assembly Application

This connector is for a vertical, surface mount application with pc boards. The header housing has a case seal for sealing against electronic module housings.

3.11. Header Assembly Placement

NOTE *Make sure that the case seal o–ring is properly placed inside the groove on the bottom side of the header assembly before mating to the rigidizer. The seal should not be bunched up or popping out of its retention features.*

1. The header assembly contains two plastic posts on the underside which are meant to polarize the header through the rigidizer and pc board.

2. All six mounting screws must be torqued through the rigidizer plate into the header assembly. The torque shall be 2.25 ±.22 N•m [20 ±2 in–lbs].

3. Check for proper placement of the header interface seal, which sits inside the header pocket. This seal should be flush against the bottom of the pocket. See Figure 10.

CAUTION *The interface seal and case seal must be in place to use the connector. Removing either seal will result in module failures.*

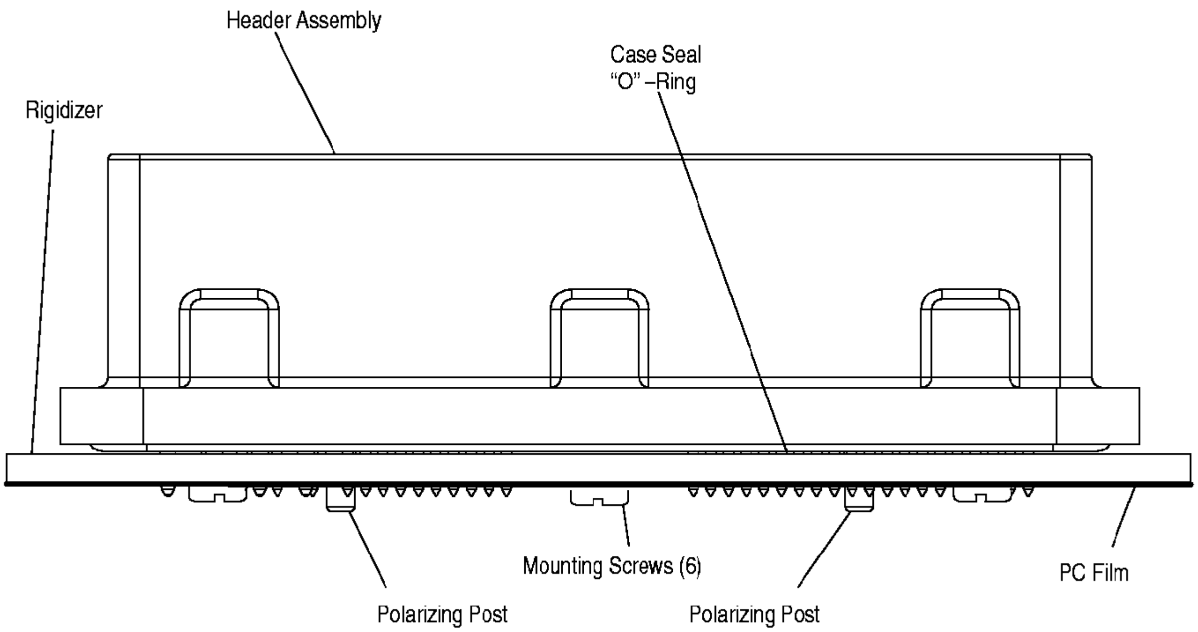


Figure 10

3.12. Soldering Header Assembly

The 68–Position Heavy Duty Hybrid Connector Header Assembly may be soldered to the pc board with an infrared reflow process, provided the temperature and exposure time is within the ranges specified in Figure 11. Tyco Electronics recommends the use of SN60 or SN62 solder for the connectors. Refer to Paragraph 2.5 for documentation material that is available for establishing soldering guidelines.

SOLDERING PROCESS	TEMPERATURE		TIME (At Max Temperature)
	CELSIUS	FAHRENHEIT	
Infrared Reflow Soldering	225	437	30 Seconds

Figure 11

A. Flux Selection

The connector solder tines must be fluxed prior to soldering with a mildly activated rosin base flux. Selection of the proper flux will depend on the type of pc board and other components mounted to the board.

B. Reflow Parameters

Due to the many variables involved with the reflow process (e.g., component density, orientation, etc.), Tyco Electronics recommends that the user conduct trial runs under actual manufacturing conditions to ensure product and process compatibility.

C. Cleaning

After soldering, removal of fluxes, residues, and activators is necessary. Consult with the supplier of the solder and flux for recommended cleaning solvents. For a list of common cleaning solvents that will not affect the connectors or assemblies for the times and temperatures provided without any adverse effects on the connector assembly, refer to Figure 12.

DANGER *Consideration must be given to toxicity and other safety requirements recommended by the solvent manufacturer. Trichloroethylene and Methylene Chloride can be used with no harmful affect to the connectors; however Tyco Electronics does not recommend them because of the harmful occupational and environmental effects. Both are carcinogenic (cancer–causing) and Trichloroethylene is harmful to earth ozone layer.*

NOTE *If you have a particular solvent that is not listed, contact the Tooling Assistance Center or Product Information number at the bottom of page 1.*

CLEANER		TIME (Minutes)	TEMPERATURES (Maximum)	
NAME	TYPE		CELSIUS	FAHRENHEIT
Alpha 2110■	Aqueous	1	132	270
Bioact EC–7◆	Solvent	5	100	212
Butyl Carbitol●	Solvent	1	Room Ambience	
Isopropyl Alcohol	Solvent	5	100	212
Kester 5778⌘	Aqueous	5	100	212
Kester 5779⌘	Aqueous	5	100	212
Loncoterge 520●	Aqueous	5	100	212
Loncoterge 530●	Aqueous	5	100	212
Terpene Solvent	Solvent	5	100	212

■ Product of Fry's Metals, Inc. ◆ Product of Petroferm, Inc. ● Product of Union Carbide Corp. ⌘ Product of Litton Systems, Inc.

Figure 12

D. Drying

CAUTION *Excessive temperatures may cause housing degradation. Do NOT solder the header assembly with the plug connector or wire dress cover attached to it.*

The header assembly can withstand a temperature of –40 to 225°C [–40 to 437°F]. Values may vary with different automatic cleaning equipment (see equipment manufacturer's recommendations).

E. Checking Installed Connector

All solder joints should conform to those specified in Workmanship Specification 101–21. The mounting screws must be torqued to 2.25 ±0.22 N•m [20 ± 2 in–lbs]. The housing wall should be almost flush against the rigidizer. See Figure 13.

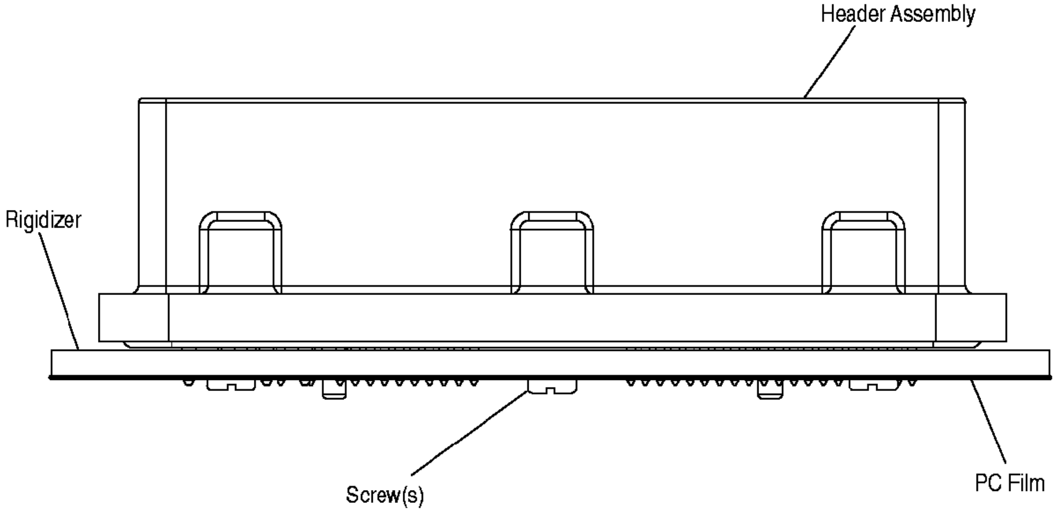


Figure 13

3.13. Polarization and Keying Features

The header assembly has key slots on the sides of the pocket which will accept corresponding keying protrusions from the plug assembly. There are four different possible keying arrangements. See Figure 14.

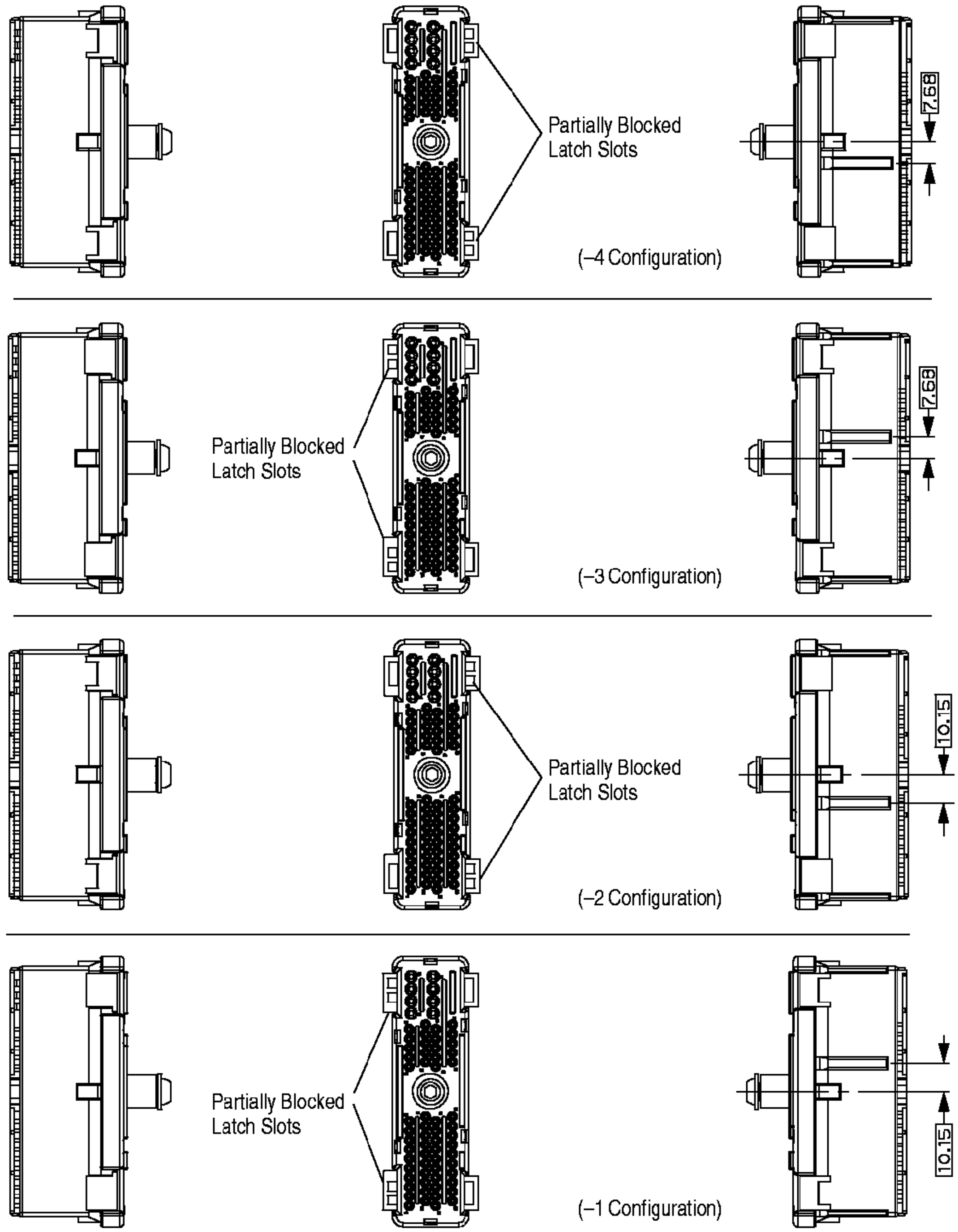


Figure 14

The plug assembly has polarized latch holes for mating with the wire dress cover. Two of the latch slots will be partially blocked, allowing the wire dress cover to only be mated in one direction. See Figure 15.

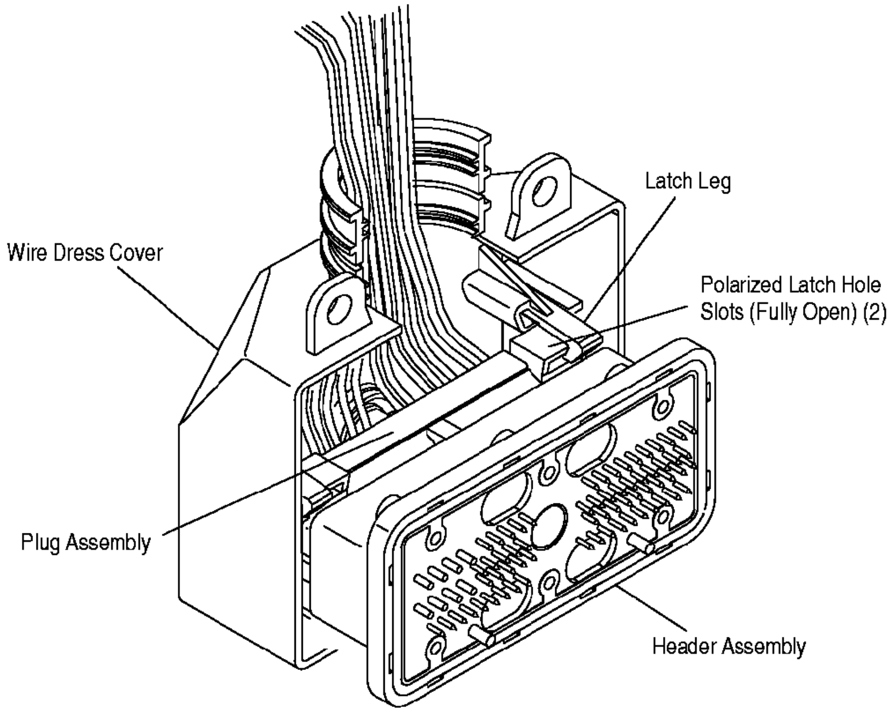


Figure 15

3.14. Mounting Hardware

Six customer supplied No. 6–19 screws are required to mount the header assembly to the rigidizer. Also, to mount the wire dress cover to the electronic module, two customer supplied screws are required. These screws must have a shaft of <7.0 mm diameter, and a head flange diameter > 9.0 mm.

3.15. Reading Voltage During Service

CAUTION *Do NOT pierce wire insulation to take voltage readings.*

It has been common practice in electrical troubleshooting to probe wires by piercing the insulation with a sharp point. This practice must be strongly discouraged when dealing with the 68–Position Heavy Duty Hybrid Connector System, or any other sealed connector system. The resulting pinholes in the insulation will allow moisture to invade the system by traveling along the wire strands. This nullifies the effectiveness of the connector seals and may result in system failure.

3.16. Repair/Replacement

Damaged crimped contacts or housings must be removed, discarded, and replaced with new components. Damaged pc board connectors must be removed from the pc board by standard desoldering methods and replaced.

CAUTION *If a damaged contact is apparent before the the contacts are inserted into the housing, cut the wire in back of the contact and reterminate the wire end. If contacts or housing are damaged after insertion, the wire must be cut directly in back of the housing and reterminated with new contacts and housing.*

4. QUALIFICATIONS

The 68–Position Heavy Duty Hybrid Connector is not required to be Listed or Recognized by Underwriters Laboratories Inc. (UL), or Certified by the Canadian Standards Association (CSA).

5. TOOLING

No specific application tooling is required for the application of the 68–Position Heavy Duty Hybrid Connector. Information for crimp termination tooling for the contacts is available in Application Specifications 114–6071 and 114–13045.

6. VISUAL AID

Figure 16 shows a typical application of 68–Position Heavy Duty Hybrid Connector. This illustration should be used by production personnel to ensure a correctly applied product. Applications which DO NOT appear correct should be inspected using the information in the preceding pages of this specification and in the instructional material shipped with the product or tooling.

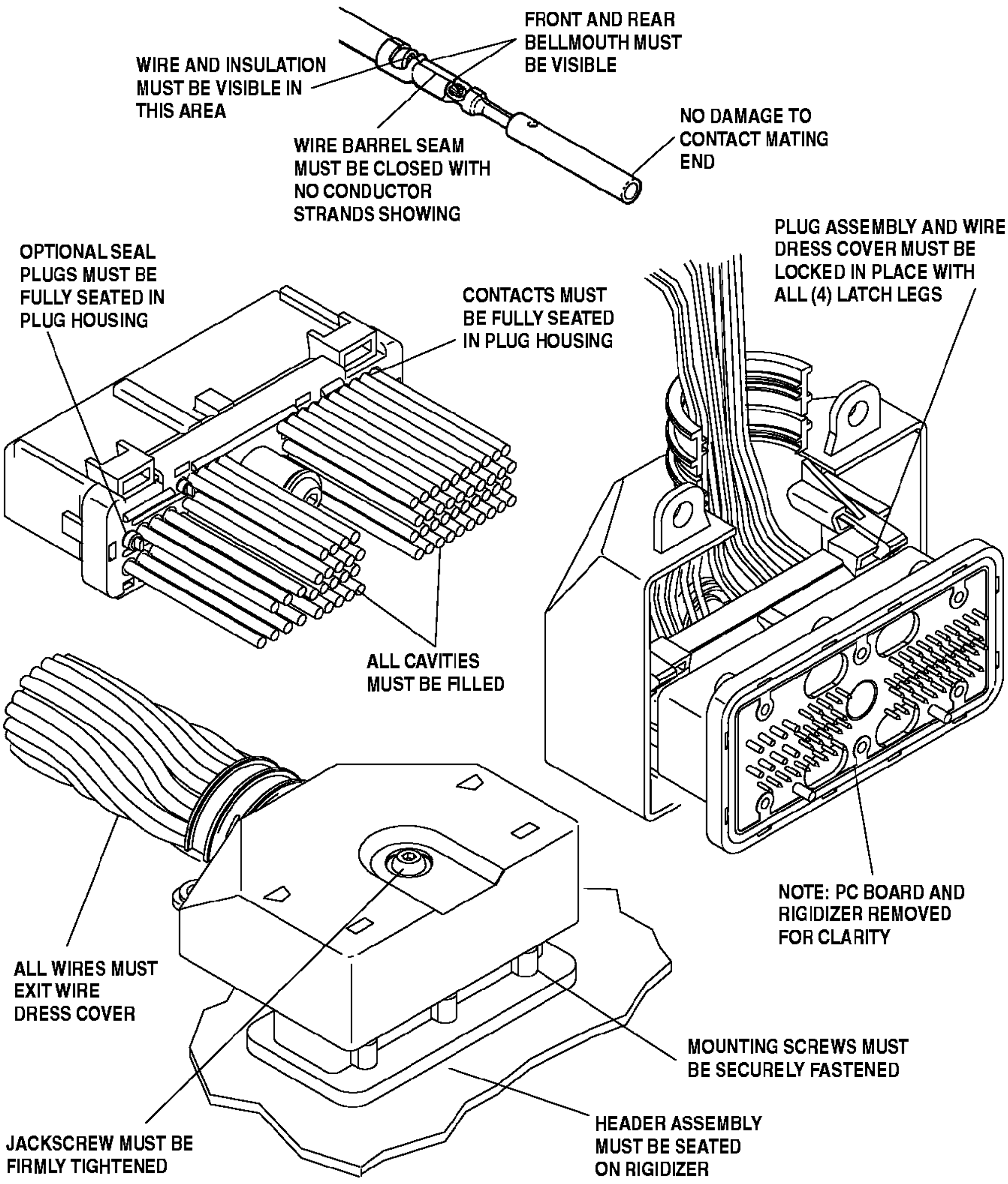
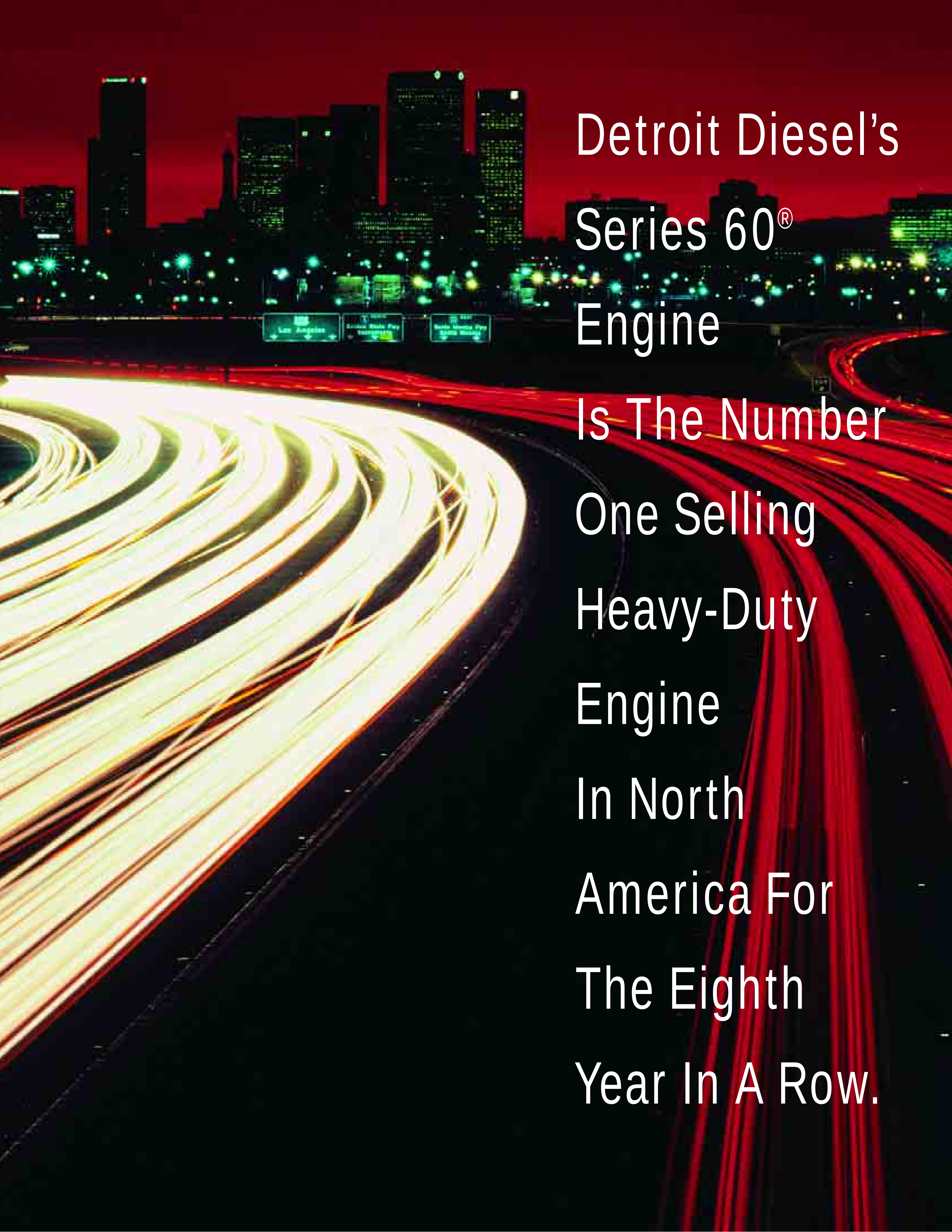


FIGURE 16. VISUAL AID

DETROIT DIESEL

SERIES 60

The Most Popular Heavy-Duty Motor Coach Engine In North America


Detroit Diesel's
Series 60®
Engine
Is The Number
One Selling
Heavy-Duty
Engine
In North
America For
The Eighth
Year In A Row.

Why?

Fleets Want An Engine That:

- Doesn't use a lot of fuel
- Is reliable
- Doesn't cost a lot to maintain
- Lives a long time
- Makes money
- Keeps drivers happy

The Most Complete Power Range In A Single Engine Package From 330 To 500 HP

2000 On-Highway Coach Ratings

Series 60 DDEC® IV

330 HP @ 2100 RPM . . . . . . 1250 FT-LB @ 1200 RPM
350 HP @ 2100 RPM . . . . . . 1250 FT-LB @ 1200 RPM
330/350 HP @ 2100 RPM . . 1250 FT-LB @ 1200 RPM
330 HP @ 2100 RPM . . . . . . 1350 FT-LB @ 1200 RPM
350 HP @ 2100 RPM . . . . . . 1350 FT-LB @ 1200 RPM
330/350 HP @ 2100 RPM . . 1350 FT-LB @ 1200 RPM

370 HP @ 2100 RPM . . . . . . 1450 FT-LB @ 1200 RPM
370 HP @ 2100 RPM . . . . . . 1550 FT-LB @ 1200 RPM
400 HP @ 2100 RPM . . . . . . 1450 FT-LB @ 1200 RPM
400 HP @ 2100 RPM . . . . . . 1550 FT-LB @ 1200 RPM
430 HP @ 2100 RPM . . . . . . 1450 FT-LB @ 1200 RPM
430 HP @ 2100 RPM . . . . . . 1550 FT-LB @ 1200 RPM
370/430 HP @ 2100 RPM . . 1450 FT-LB @ 1200 RPM
370/430 HP @ 2100 RPM . . 1550 FT-LB @ 1200 RPM
430/470 HP @ 2100 RPM . . 1550 FT-LB @ 1200 RPM

430 HP @ 2100 RPM . . . . . . 1650 FT-LB @ 1200 RPM
470 HP @ 2100 RPM . . . . . . 1550 FT-LB @ 1200 RPM
470 HP @ 2100 RPM . . . . . . 1650 FT-LB @ 1200 RPM
500 HP @ 2100 RPM . . . . . . 1550 FT-LB @ 1200 RPM
500 HP @ 2100 RPM . . . . . . 1650 FT-LB @ 1200 RPM
470/500 HP @ 2100 RPM . . 1550 FT-LB @ 1200 RPM
430/500 HP @ 2100 RPM . . 1540 FT-LB @ 1200 RPM

Big Power With All The Other Benefits Of A Series 60 Engine

With more than 20 different power ratings to choose from, it's easy to match a Series 60 engine to your exact needs. But sometimes needs change. That's not a problem with the Series 60 engine! The power chart on the left shows the groups of engine ratings for the bus and coach market. The ratings are grouped into rating families.

The families contained in each of the color sections have identical hardware. The groups displayed in each family show the preprogrammed horsepower range in a single engine. A simple electronic tool is all that is required to change power within a group. Power changes from one group to another within the same family simply require reprogramming of the engine's electric control module.

It is also possible to change power from one group to another, (just make sure the bus cooling, air intake and exhaust systems and the driveline can handle the change). Upping the horsepower to the maximum limit at time of trade-in is an easy way to increase both the resale value and desirability of any coach.

What Makes The Series 60 Engine So Popular?

It Provides The Best Combination Of:

- Performance
- Economy
- Driver Satisfaction
- Reliability
- Durability
- Total Cost of Operation
- Residual Value.

One Of The Most Important Aspects Of The Series 60 Engine Is Its Great Residual Value. As The Chart Below Indicates, The Residual Value Of The Series 60 Is Substantially Better Than The Competition.

Series 60 Residual Value

Mileage	Series 60	Competition	Series 60 Advantage
21-50K	9,213.38	7,491.80	1,721.58
51-75K	8,189.69	5,240.08	2,949.61
76-100K	7,165.97	3,669.45	3,496.52
101-150K	6,142.27	2,557.50	3,584.77
151-200K	5,118.55	0.00	5,118.55
201-250K	4,092.61	-899.06	4,991.67
251-300K	3,072.22	-1,875.32	4,947.54
301-350K	2,046.31	-2,768.86	4,815.17
315K+	0.00	-3,530.02	3,530.02

Source - The Official Bus Book Market Report. "Blue Book" (January, 2000 Edition) Bus Book Publishing

What Else Makes The Series 60 Engine So Popular?

Fuel Economy

The Series 60 engine is the acknowledged industry fuel economy leader. Fuel economy is one of the main reasons operators specify Series 60 engines. Fleets track fuel economy down to the third decimal. They know what works and what does not. And they buy more Series 60 engines than any other engine.

Cost Per Mile

Cost per mile is based on more than fuel economy. It includes oil usage and oil changes, routine maintenance and on some competitive engines, required replacement of pumps, turbos or bearings according to a set schedule.

There is no requirement to routinely replace pumps, turbos or bearings on the Series 60 engine. The Series 60 engine doesn't require special lube oils or expensive filters.

The Fleets With The Lowest Cost Per Mile... Buy Series 60 Engines.

Reliability

In today's troublesome world, people look for something that they can rely on. Detroit Diesel created the Series 60 for just that purpose. Charter and Line Haul markets demand reliability, perhaps that's why the Series 60 has been chosen by today's top motor coach fleets.

Durability

The Series 60 engine just celebrated its twelfth birthday; nearly 90,000 Series 60 engines have gone over the million-mile mark!

Series 60 Total Production Engine Mileage

June 30, 1999
Total Engines In Service

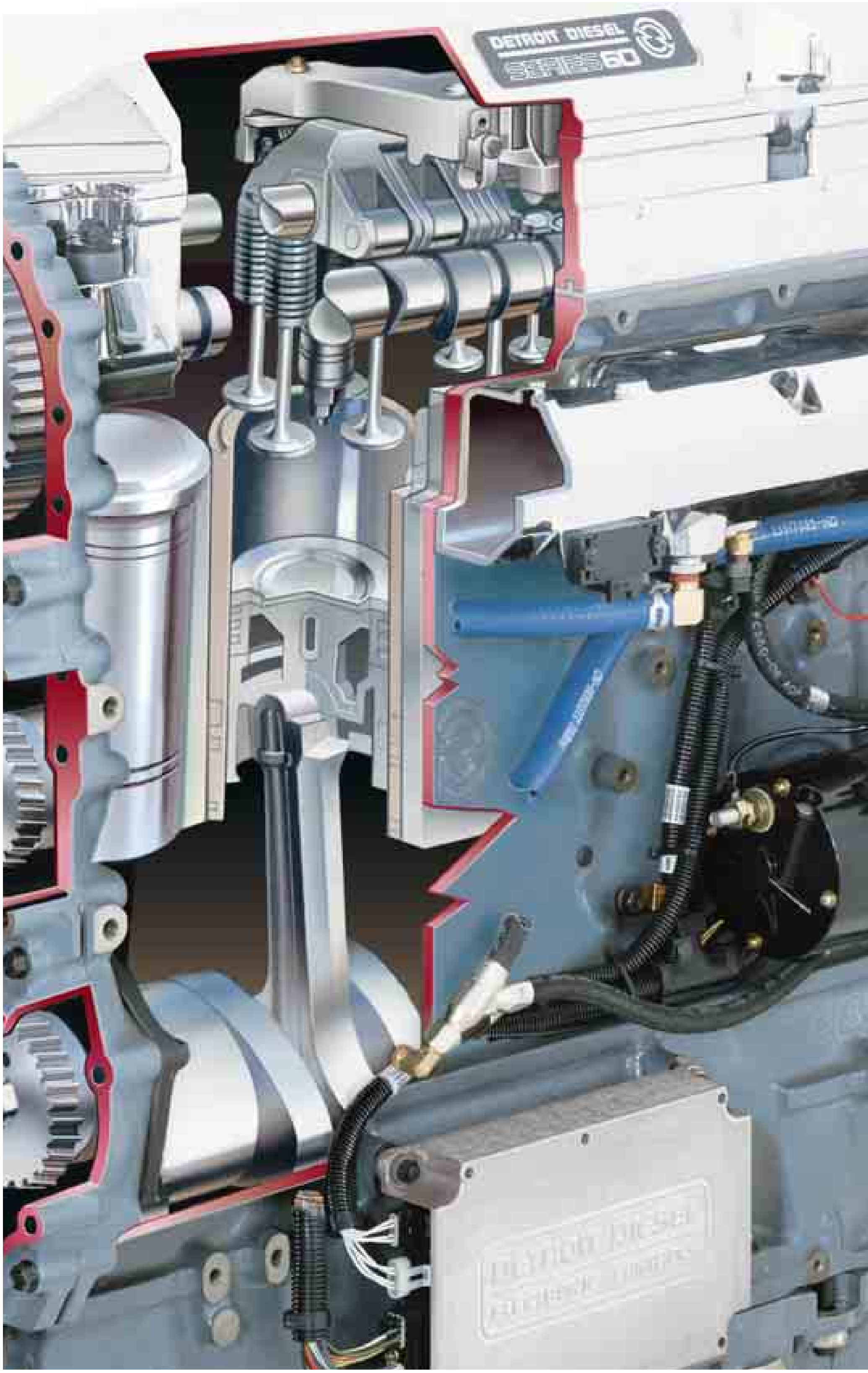
Mileage Interval	Number of Engines	Mileage Interval	Number of Engines
0-100,000	69,334	800,000- 900,000	24,563
100,000-200,000	54,071	900,000-1,000,000	21,039
200,000-300,000	47,064	1,000,000-1,100,000	18,015
300,000-400,000	42,287	1,100,000-1,200,000	11,213
400,000-500,000	40,149	1,200,000-1,300,000	7,991
500,000-600,000	37,867	1,300,000-1,400,000	5,769
600,000-700,000	32,899	1,400,000-1,500,000	3,921
700,000-800,000	28,067	1,500,000-	7,308
		TOTAL	**451,557**

Want To Know More?

Take A Look At The Simple Design Of The Engine. The One-Piece Cylinder Head Contains The Overhead Camshaft. This Camshaft Arrangement Provides A Variety Of Benefits:

- Intake and exhaust passages are straight for easy entry and exit of air from the cylinder. The engine doesn't waste fuel "pumping" air in and out.
- Intake and exhaust passages are also short. Intake air is not overly heated as it passes through the head. The resulting cooler air in the cylinder improves economy. And the hot exhaust gases don't transfer too much heat into the head as they exit, preserving more energy to operate the turbo.
- The overhead cam allows for direct actuation of the fuel injectors without push rods or push tubes. The result is high fuel injection pressure and better fuel economy.
- The overhead cam also allows for the use of 38 head bolts, providing over 1,000,000 pounds of clamp load on the head gasket.

These Features Combine To Produce The Economy, Durability And Performance The Series 60 Engine Is Known For.



More Reasons The Series 60 Engine Is Number One.

Inside each cylinder liner is the DDC™ Iron Cross Head Piston.

This iron piston provides a hard surface for the rings to seal against, unlike aluminum, which requires a special cast insert.

The engines in the 500 hp family (shown in the red box on the previous page) all use the new two piece steel piston, another Series 60 engine durability enhancement.

Outside, the cylinder liner is cooled all the way to the top, using a patented DDC feature called top lining cooling. This reduces ring temperatures by 100 degrees F. Another reason Series 60 engines live so long.

Main and rod bearings are big. That's why the Series 60 engine has no requirement to roll out bearings - it's just not necessary.

The Series 60 engine block, with no camshaft, is a simple, trouble-free design.

The Series 60 has a smaller turbocharger for improved low speed performance and economy. At higher speeds, a wastegate bypasses unneeded turbo boost to keep cylinder pressures down and extend engine life further.

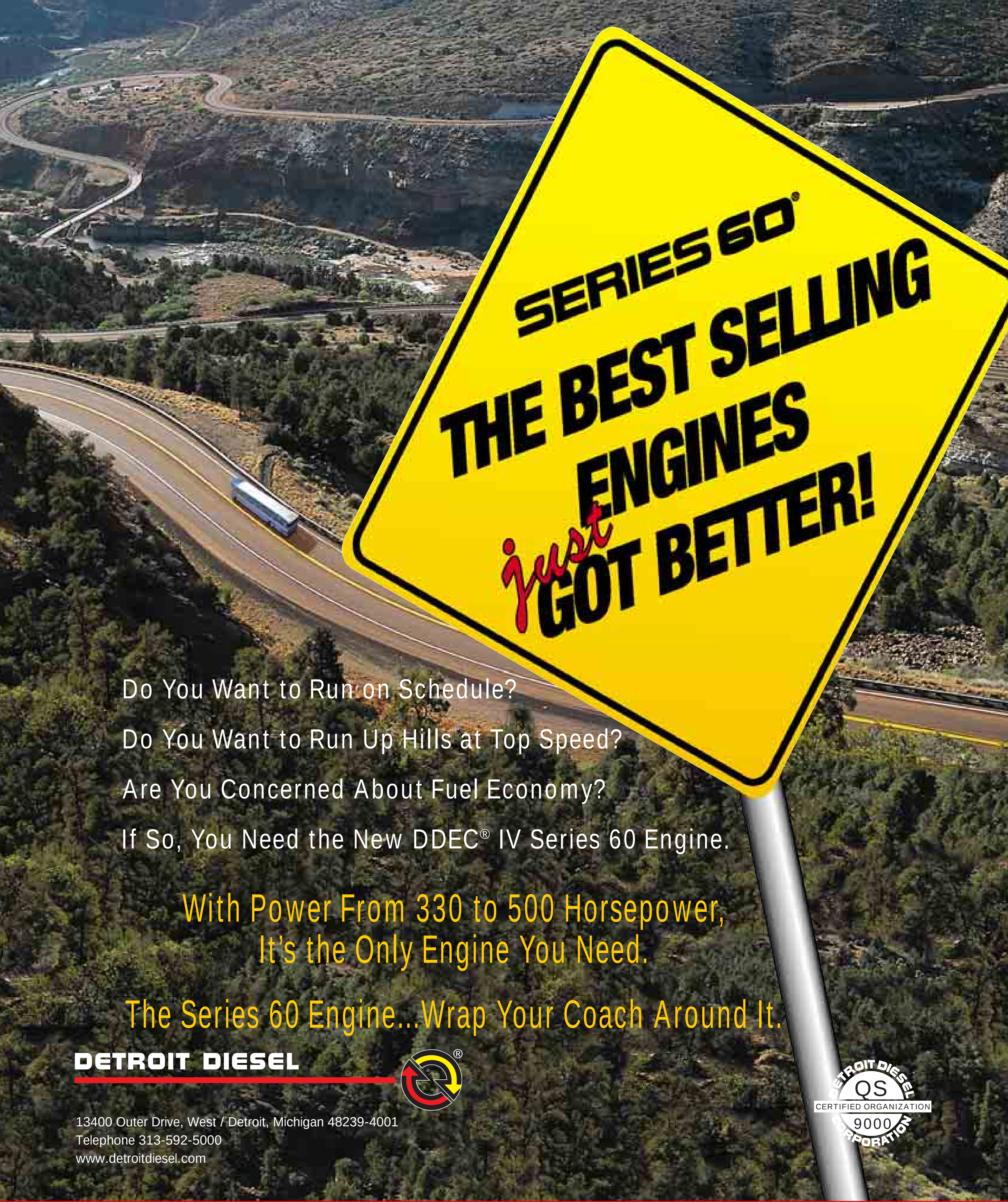
Add the gear train to drive the accessories and the camshaft, and you have a complete Series 60 engine.

- Simple
- Rugged
- Easy to work on
- Key components are right under the rocket cover
- Fewer parts

And More...

Every Series 60 engine is equipped with Detroit Diesel Electronic Controls (DDEC). DDEC is the most popular electronic control system available. DDEC IV, the fourth generation of DDEC, is now standard equipment on all Series 60 engines. In addition to precisely controlling fuel injection, DDEC offers all of the following:

- Three levels of engine protection
  - – Warning only
  - – Power ramp down
  - – Automatic shut down
- Cruise control
- Auto resume cruise control
- Multiple hp ratings
- Three levels of engine braking
- Engine fan braking
- Vehicle speed limiting
- Starter lock out
- Remote PTO control
- Communication capability with electronically controlled transmissions
- Idle speed adjustment
- Droop adjustment
- Idle timer shutdown
- Air temperature shutdown
  - – High or low
- Warnings for:
  - – Low voltage
  - – Low coolant
  - – High oil temperature
  - – Low oil pressure
- Self diagnosis
- Four levels of security
- Is the addition of more memory
- Built-in clock and calendar
- Built-in battery back-up.



Do You Want to Run on Schedule?

Do You Want to Run Up Hills at Top Speed?

Are You Concerned About Fuel Economy?

If So, You Need the New DDEC® IV Series 60 Engine.

With Power From 330 to 500 Horsepower, It's the Only Engine You Need.

The Series 60 Engine...Wrap Your Coach Around It.

DETROIT DIESEL®

13400 Outer Drive, West / Detroit, Michigan 48239-4001
Telephone 313-592-5000
www.detroitdiesel.com

DETROIT DIESEL CORPORATION
QS
CERTIFIED ORGANIZATION
9000

6SA512 0008 As technical advancements continue, specifications will change.

DETROIT DIESEL

SERIES 60®

The ONLY Motor Coach Choice

Since 1992, More Have Selected The SERIES 60® Than Any Other Heavy-D

Why Is The Series 60 So Popular?

Because It Offers Motor Coach Operators The Best Combination Of:

- Performance
- Fuel Economy
- Low Cost Of Operation
- Reliability
- Long Life To Overhaul
- Driver Satisfaction
- Ease of Service
- Warranty Satisfaction
- Ratings Flexibility
- Electronic Controls
- Lightweight
- Residual Value

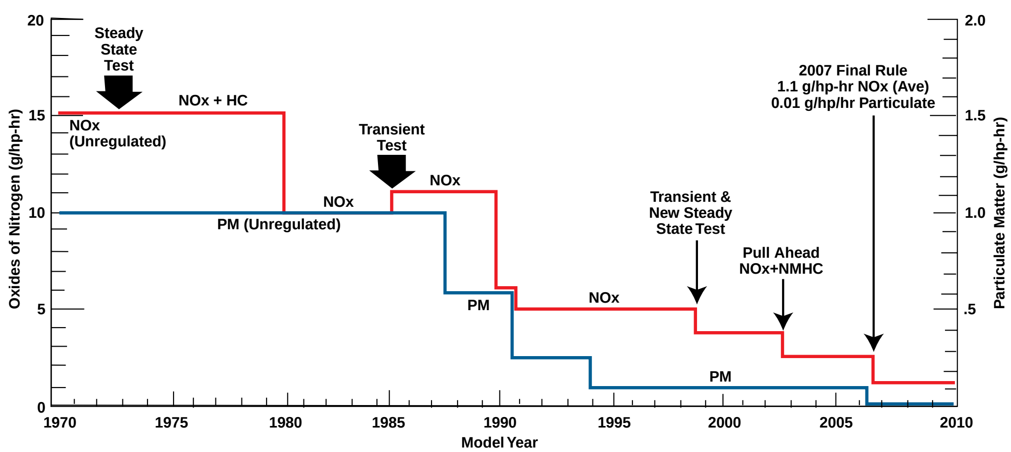
Coach Operators

uty Engine

And The Tradition Carries On Into 2003

Effective October 1, 2002, all heavy-duty on-highway diesel engines built in North America must meet new emission standards. The following chart shows the history of emission reductions in heavy-duty diesels since 1970, the new standards effective October 1, and the next emission reductions set for 2004. It's worth noting that the emissions levels of modern heavy-duty diesel engines are approaching zero.

EPA Heavy-Duty Engine Emission Standards



Exhaust Gas Recirculation (EGR)

What is EGR?

Exhaust gas recirculation (EGR) is the technology chosen by all but one major engine maker in North America.

EGR has been in use on automobile engines worldwide since the mid-1970's, and on Detroit Diesel engines since 2000. Between 2000 and 2002, Detroit Diesel placed over 3000 EGR engines into service and they accumulate over 30,000,000 miles of service each year.

EGR is a simple concept. The October 2002 regulations require a reduction of oxides of nitrogen (NOx) to 2.5 g/hp-hr. NOx is a by-product of high temperatures in the combustion chamber. The higher the temperature, the higher the production of NOx.

The challenge faced by Detroit Diesel and the other engine makers is how to reduce NOx without affecting fuel economy, performance, durability and other factors of engine operation.

EGR has proven to be the best way to reduce NOx while maintaining excellent driveability, fuel economy and engine life.

How Does EGR Work?

During certain conditions of engine operation, the EGR valve is opened and measured amounts of exhaust gas are routed to the intake manifold. The exhaust gas mixes with the incoming fresh air and displaces some of the oxygen. Since there is now slightly less oxygen in the air, the peak temperatures created in the cylinder during combustion are reduced, and the levels of NOx are also reduced.

A major advantage of EGR is that engine timing can be optimized, which further enhances performance and fuel economy.

Non-EGR engines have to rely on retarded timing, which has a negative effect on fuel economy, performance, and acceleration, and leads to the production of more soot in the engine oil.

Series 60
Program Goals

- **Comply with the Emission Standards**
- **Demonstrate Equal or Better Reliability and Durability**
- **Maintain Fuel Economy**
- **Leadership**
- **Minimize Vehicle Impact**

Series 60 EGR Reliability Growth
Total Plan = 8 Million Miles

Supplier Testing	330,000 Miles
Durability Testing	2,700,000 Miles
Probe Testing	300,000 Miles
Vehicle Durability Testing	500,000 Miles
Total Miles to Date	3,830,000 Miles
Fleet Evaluation Testing	2,500,000 Miles
Durability & Vehicle Testing	1,770,000 Miles

"We have utilized Cummins, Detroit Diesel and Caterpillar diesel engines over the past 13 years and have found the Detroit Diesel to be the most trouble free and efficient."

Series 50 Experience...
What Did We Learn?

EGR technology is not new to Detroit Diesel. In 2000, we applied this same technology to our Series 50 engines to meet the emission regulations in the Bus and Coach industry.

Today, we have more than 3000 buses running with EGR. We have been able to gain the experience of operating these engines in demanding stop-and-go operations, and have also been able to develop a highly qualified supplier base.

We found there are two ways to meet tougher emission standards. One way is to retard engine timing which reduces fuel economy, hurts performance and places excess soot in the lube oil.

A much better way is to use proven EGR technology. Our experience with EGR on Series 50 is: low soot in the oil, low oil consumption, lower cylinder temperatures for longer component life, excellent acceleration and improved fuel economy compared to engines with retarded timing.

DDEC Electronic

Ordinary Diesel Engines Have Electronic Controls

DDEC takes electronic engine management to a whole new level with a sophisticated control system that provides the ability to customize the engine to your application for peak efficiency.

DDEC electronic control optimizes fuel injection in real time to maximize fuel economy, performance and emissions. It diagnoses your Series 60 on the fly, using onboard diagnostics. It even protects the engine from damage by directing system shutdowns to prevent catastrophic failures.

- Sensors signal operations outside of preset engine parameters
- Auto shutdown will prevent engine damage
- Data can be downloaded to fleet managers
- Multiple performance and fuel economy reports are available
- Built-in electronic redundancies for superior reliability

Fully electronic, fully automatic and fully reliable, with fewer moving parts than less sophisticated engine management systems

- **Self-diagnosing and self-protecting** to eliminate guesswork and accidental damage
- **Modular components** can be replaced easily and inexpensively
- **Data collection/sharing enabled** for fleet management
- **Supported by Detroit Diesel Distributors, the world's most experienced engine electronics service network**

ProDriver® DC

ProDriver DC is a dashboard-mounted display with data card extraction capabilities. It provides real time and summary information on vehicle and engine operation, as well as graphic displays of driver performance relative to fleet goals. ProDriver DC is a second generation display product. It delivers all the functionality provided by the original ProDriver display, along with many new features and capabilities.

Effective coach management starts with quick performance data retrieval. The key benefit of ProDriver DC is instant feedback on fuel economy so that the operator can adjust driving habits to maximize mpg and thereby reduce costs.

ProDriver DC works to:

- Increase fuel economy
- Improve driver performance
- Increase driver satisfaction
- Lower operating costs
- Improve safety records
- Reduce maintenance expenses

Diagnostic Link™ Software

Detroit Diesel Diagnostic Link is a PC Windows® based software engine troubleshooting tool that includes a built-in service manual and can aid in extracting data, analyzing and managing information from ECMs.

This tool can view or change:

- Engine Configurations
- Fault Codes
- Vehicle Speed Settings
- Total Engine and Trip Data
- Engine Protection Options
- Information From DDEC Data
- Idle Shutdown
- Cruise Control

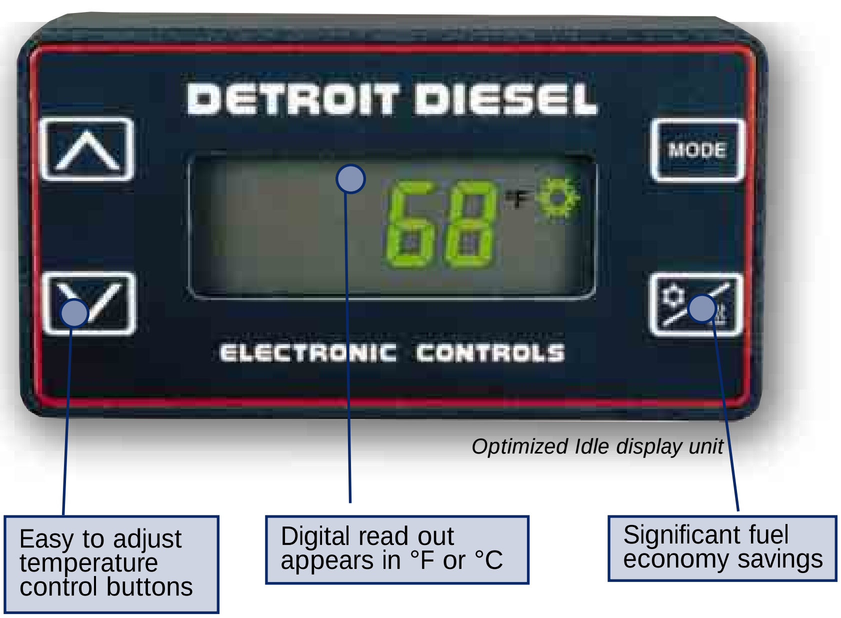
Diagnostic Link™

The immediate feedback from ProDriver® DC allows the driver to take a more active role in meeting coach goals.

ProDriver® DC

Technology

IRIS - Infrared Information System



Optimized Idle display unit

IRIS – Infrared Information System

The IRIS system consists of simple infrared transmitters and receivers (transceivers). One transceiver is mounted on the vehicle. Another transceiver is mounted at the location (or locations) where the vehicle owner wants to extract information, such as the entrance to the shop or the fuel island. IRIS provides a wireless connection between vehicle systems and off-board PC software applications.

Optimized Idle®

Optimized Idle is an engine controlled management tool that automatically starts and stops the engine based on:

- Battery Voltage
- Engine Temperature
- Cab/Sleeper Temperature

When these variables fall below predetermined values, DDEC will start the engine and allow it to idle until the parameters are brought to in-range values. Optimized Idle provides benefits of:

- Less Fuel Used
- Extended Battery Life
- Reduced Idle Time
- Safety

"We had to switch to the Series 60 because the residual value is higher."

By Using EGR, The Series 60 Will Be The Only Heavy-Duty Coach Engine After October 2002 That Is Fully Certified To The New Standards, Is Based On The Most Proven Design, And Has The Highest Level Of Acceptance In The Industry.

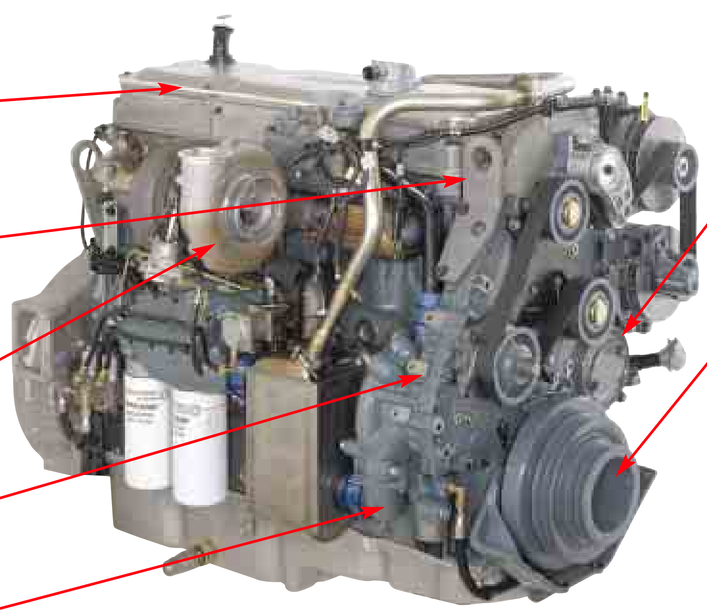
SERIES 60

PROVEN - POPULAR - CERTIFIED

The ONLY Choice for Motor Coaches

In Addition To EGR, Additional Refinements Have Been Made To The Series 60's Proven Design.

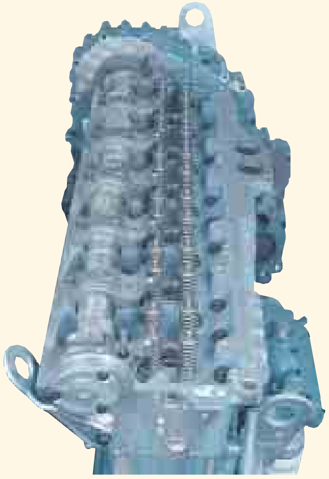
Technology Leadership



Base Engine Improvements

Power Assembly

- **Piston**
  - — Enhance Combustion Piston Bowl
- **Fire Ring**
  - — Increase Thickness from 2.5 mm to 3.0 mm
  - — Base Material and Face Coating Material Enhancements
- **Connecting Rod**
  - — 12.7L Common Rod with 14L
  - — 12% More Rod Bearing Area
- **Crankshaft**
  - — 12.7L "Big Pin" 95 mm Rod Journals
- **Higher Output Water Pump**
  - — Improved Cooling



Cylinder Head Assembly

- **Cylinder Head Modifications**
  For Long Life and Fuel Efficiency
  - — Head Bolt Bosses
  - — Top Deck Thickness
  - — Intake Manifold Bolt Pattern
  - — Intake Port Machining
  - — Recessed Exhaust Valves
- **Valves, Guides & Seals**
  For Long Life
  - — Nickel Chrome Intake Valves
  - — Pyromet Exhaust Valves
  - — Nickel Based Valve Seat Material
  - — Powdered Metal Valve Guides

Next Generation Gear Train

- **Less Vibration and Noise**
- **Decreased Frontal Area for Improved Under Hood Air Flow**
- **Improvements in Component Bracketry**
- **Higher Water Pump Flow**
- **Less Weight (53 lbs)**

Single Cylinder Air Compressor

- **Bendix Model DF-359**
- **Same Output as TF-750 (16CFM)**
- **Naturally Aspirated**
- **Less Friction**
- **Reduced Oil Consumption (up to 60% less)**
- **Less Weight (20 lbs)**

"We ran Series 60 for years and then other guys made us a deal we couldn't refuse. We're trading them in and going back to the Series 60."

Engine Weight

2002 Series 60 Weight

- Highest Big Bore Engine

Next Generation Gear Train

- Less Weight (53 lbs)

Single Cylinder Air Compressor

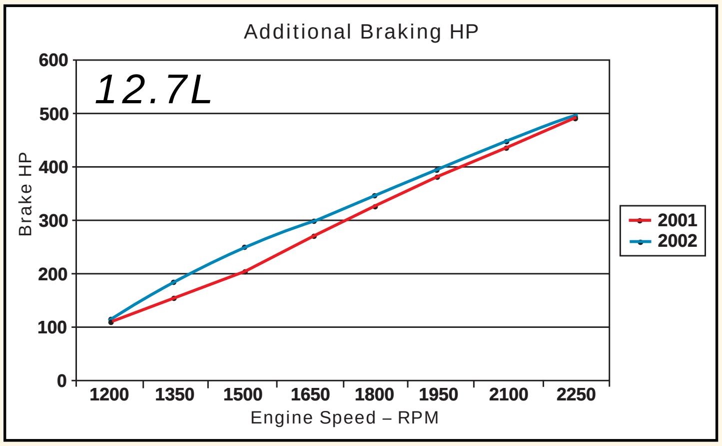
- Less Weight (20 lbs)

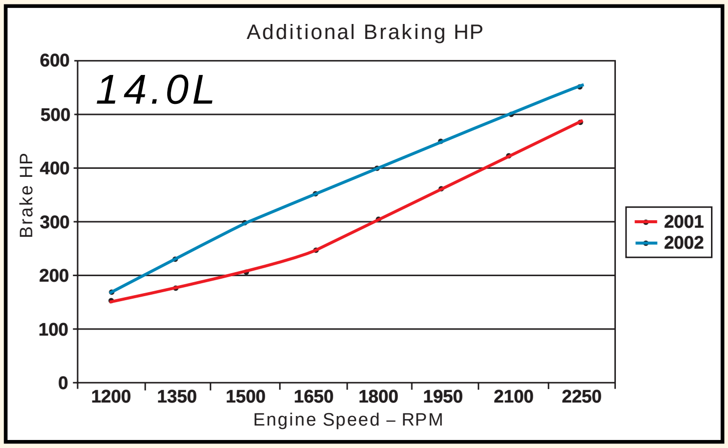
Vehicle Driveability

The Series 60 Is Known For Excellent Performance & Driveability …
The 2002 With The High Performance Turbo is Even Better!

- Excellent Clutch Engagement Torque
- Improved Acceleration
- Improved Torque Response
- More Engine Braking

Series 60 2002 Engine Braking





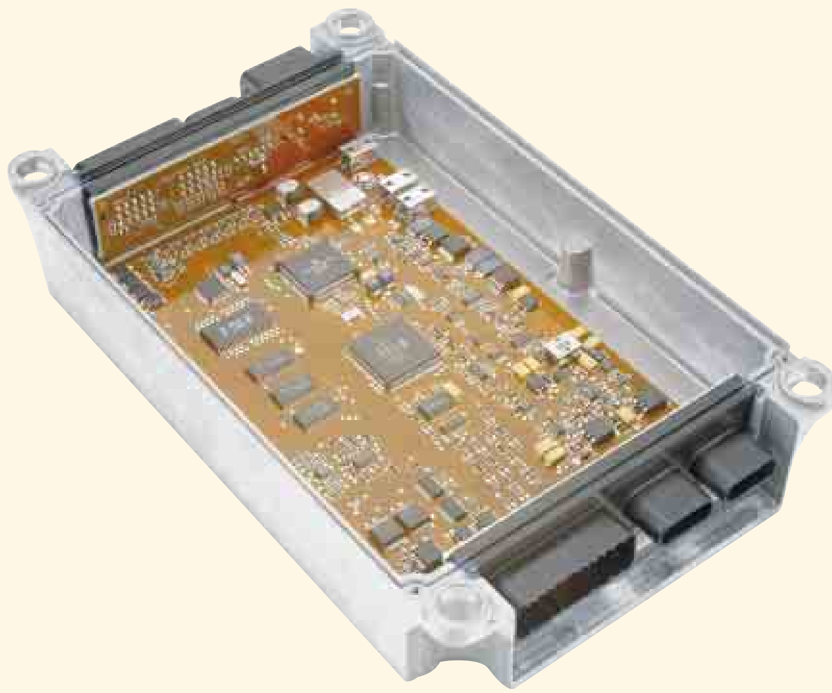
Fuel Injection System

Electronic Unit Injector

- **Higher Injection Pressure For Lower Emissions And Better Fuel Economy**
- **Oxidize Particulates Late In The Combustion Event For Reduced Emissions And Better Fuel Economy**
- **NAFTA-Wide Parts Availability And Service Support**

"To be Number 1 takes a great engine...To be Number 1 eleven years in a row takes a Series 60

The Fourth Generation Detroit Diesel Electronic Control System (DDEC IV) Is The Most Powerful And Proven System Available



Oil Drain Intervals

Maintain Current Oil Drain Intervals with CI-4 Oils

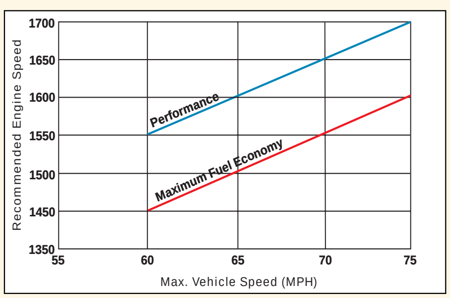
- **Compared to CH-4 Oil, CI-4 Oils will have:**
  - — Greater Acid Neutralization Capability (Higher TBN)
  - — Increased Soot Dispersancy
  - — Increased Anti-wear Properties (Additional Shear Capability)
- **Most Oil Companies Have Already Introduced CI-4 Oils**

330-550 HP

The Most Complete Power Range In A Single Engine Package

12.7L	
Maximum HP @ RPM	Peak Torque @ RPM
330 HP @ 2100 RPM	1350 LB-FT @ 1200 RPM
350 HP @ 2100 RPM	1350 LB-FT @ 1200 RPM
330/350 HP @ 2100 RPM	1350 LB-FT @ 1200 RPM
375 HP @ 2100 RPM	1450 LB-FT @ 1200 RPM
400 HP @ 2100 RPM	1450 LB-FT @ 1200 RPM
430 HP @ 2100 RPM	1450 LB-FT @ 1200 RPM
375/430 HP @ 2100 RPM	1450 LB-FT @ 1200 RPM
14.0L	
Maximum HP @ RPM	Peak Torque @ RPM
435 HP @ 2100 RPM	1550 LB-FT @ 1200 RPM
475 HP @ 2100 RPM	1550 LB-FT @ 1200 RPM
500 HP @ 2100 RPM	1550 LB-FT @ 1200 RPM
435/500 HP @ 2100 RPM	1550 LB-FT @ 1200 RPM
435 HP @ 2100 RPM	1650 LB-FT @ 1200 RPM
475 HP @ 2100 RPM	1650 LB-FT @ 1200 RPM
500 HP @ 2100 RPM	1650 LB-FT @ 1200 RPM
435/500 HP @ 2100 RPM	1650 LB-FT @ 1200 RPM
550 HP @ 2100 RPM	1650 LB-FT @ 1200 RPM

Gearing Recommendations Remain the Same



"Another engine maker was going to give me a fuel economy guarantee, but they backed off when they discovered how well the Series 60 was doing."

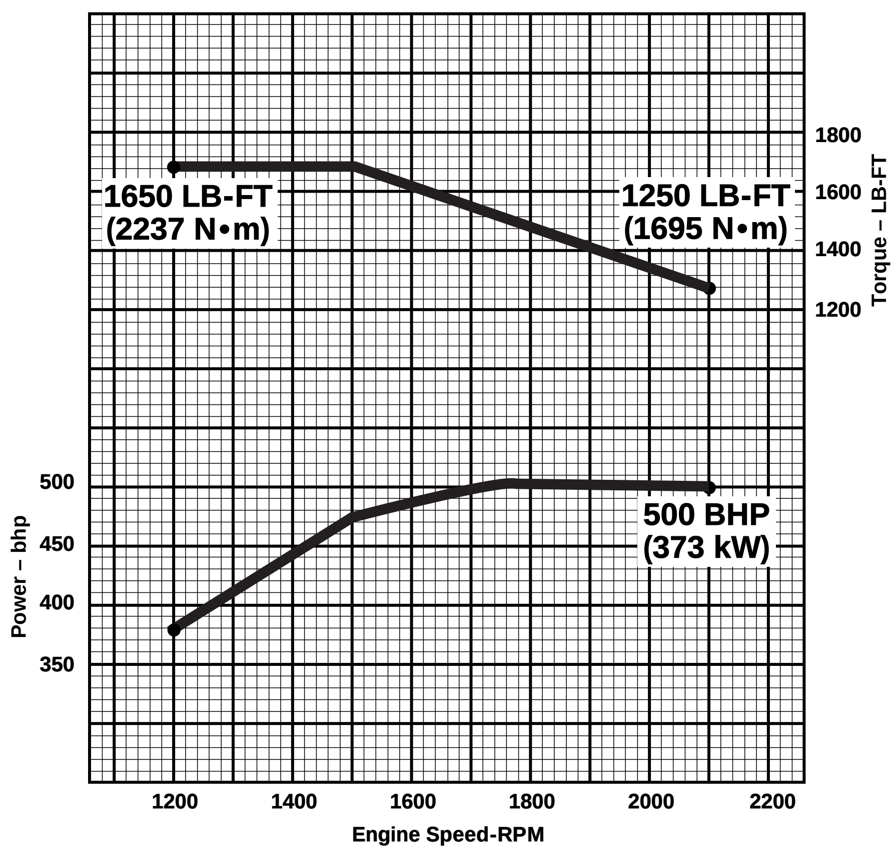
Big Power With All The Other Benefits Of A Series 60 Engine

With more than 15 different power ratings to choose from, it's easy to match a Series 60 engine to the exact needs of any coach operator. But sometimes their needs change. That's not a problem with the Series 60 engine! The power chart on the left shows the groups of engine ratings within each family.

The families contained in each of the shaded sections have identical hardware. The groups displayed in each family show the preprogrammed horsepower range in a single engine. A simple electronic tool is all that is required to change power within a group. Power changes from one group to another within the same family simply require reprogramming of the engine's electronic control module.

It is possible to change power from one group to another (just make sure the coach cooling, air intake and exhaust systems and the driveline can handle the change). Upping the horsepower to the maximum limit at time of trade-in is an easy way to increase both the resale value and desirability of any coach.

500 BHP



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- Intake and exhaust passages are also short. Intake air is not overly heated as it passes through the head. The resulting cooler air in the cylinder improves economy. And the hot exhaust gases don't transfer too much heat into the head as they exit, saving more energy to operate the turbo and increase fuel economy.
- The overhead cam allows for direct actuation of the fuel injectors without push rods or push tubes. The result is high fuel injection pressure and better fuel economy.
- The overhead cam also allows for the use of 38 head bolts, providing over 1,000,000 pounds of clamp load on the head gasket.

These Features Combine To Produce The Economy, Durability And Performance The Series 60 Engine Is Known For

Inside each cylinder liner is the DDC™ Steel Two-Piece Piston. Unlike aluminum, which requires a special cast insert, this steel piston provides a hard surface for the rings to seal against…another Series 60 engine durability enhancement.

Outside, the cylinder liner is cooled all the way to the top, using a patented DDC feature called top liner cooling. This reduces ring temperatures by 100ºF, another reason Series 60 engines live so long.

Main and rod bearings are big. That's why the Series 60 engine has no requirement to roll out bearings—it's just not necessary.

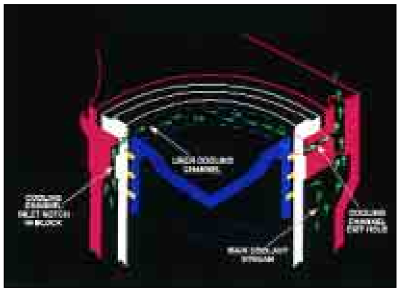
The Series 60 engine block, with no camshaft, is a simple, trouble-free design.

The Series 60 engine features a high performance variable output turbocharger for improved low speed performance, economy and excellent driveability.

Another benefit is the Pad Mounted Alternator System with a Poly V belt and self tensioner. It's strong, rugged and simple.

Add the gear train to drive the accessories and the camshaft, and you have a complete Series 60 engine.

- Simple
- Rugged
- Easy to work on
- Key components are right under the rocker cover
- Fewer parts



DDEC Engine Management Technology

More Reasons The Series 60 Engine Is Number One

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  — Automatic shutdown
- Cruise control
- Auto resume cruise control
- Multiple hp ratings
- Three levels of engine braking
- Engine fan braking
- Progressive shifting
- Vehicle speed limiting
- Vehicle overspeed diagnostics
- Low gear torque limiting
- Starter lockout
- Remote PTO control
- Communication capability with electronically controlled transmissions
- Idle speed adjustment
- Droop adjustment
- Idle timer shutdown
- Air temperature shutdown
  — High or low
- Warnings for:
  — Low voltage
  — Low coolant
  — High oil temperature
  — Low oil pressure
- Self diagnosis
- Four levels of security

New for DDEC IV is the addition of more memory, a built-in clock and calendar and built-in battery backup.

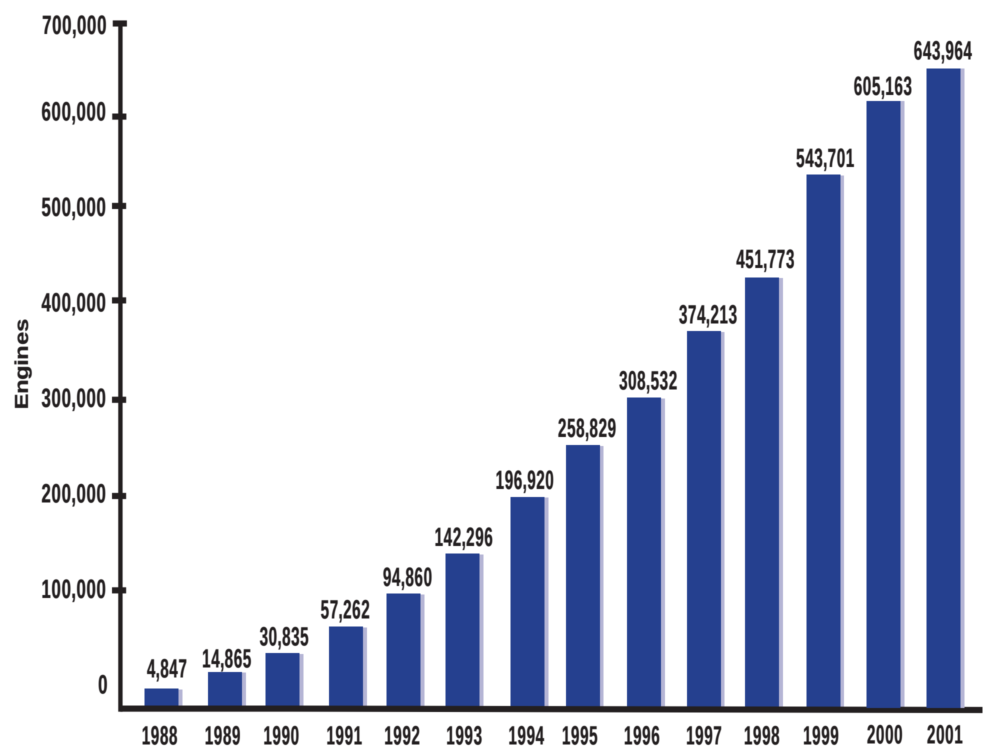
“Our Driver Acceptance Is At The Highest Level I Can Remember.”

Coach Fleets Want To Attract And Keep Good Drivers.

Good Drivers Take An Interest In Their Coach Power Because Its Performance Affects Their Performance.

Together They Have Made The Series 60 Engine Their Top Choice.

Series 60 Engine Population



In Addition To Everything Else, The Series 60 Engine Is The Lightest Of The Current Big Block Engines

Weighing 30 pounds less than its predecessor, the next generation Jacobs Engine Brake™ is now available on Series 60 engines. We achieved the 30-pound weight reduction through a simplified design and the use of higher strength, lighter weight components. The new brake provides improved braking performance and is easier to assemble, ensuring higher quality. This weight reduction solidifies the Series 60 engine as the lightest of the full-size heavy-duty engines available for the North American on-highway market.

And There Is More … Fuel Economy

The Series 60 engine is the acknowledged fuel economy leader. Fuel economy is one of the main reasons coach operators buy Series 60 engines. Coach operators track the fuel economy down to the third decimal, and know what works and what doesn't. And they buy more Series 60 engines than any other engine.

Series 60 Production Engine Mileage

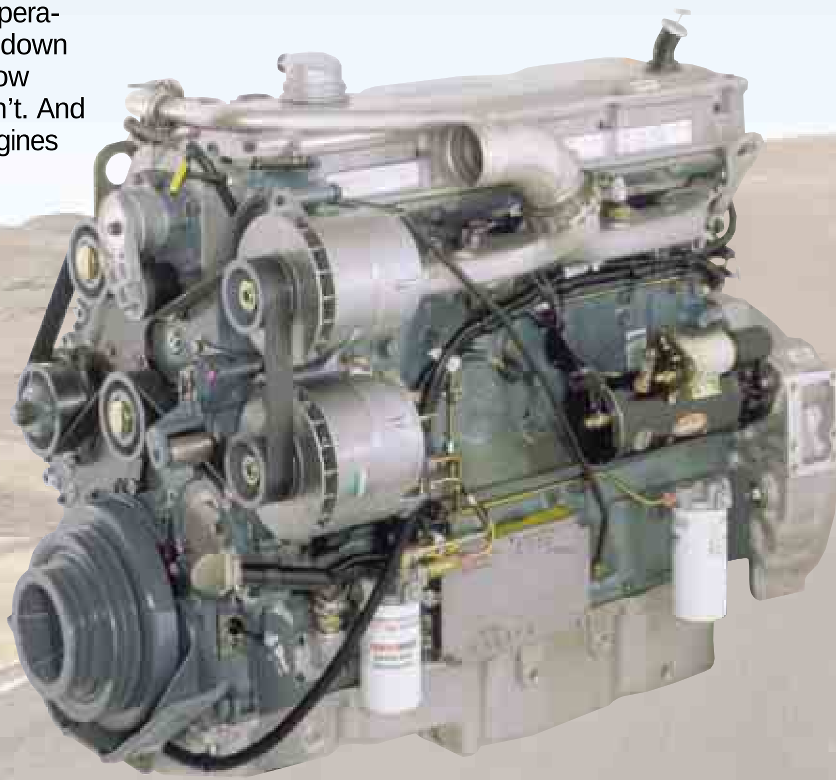
December, 2001 – Engines in Service

Mileage Interval	Number of Engines	Mileage Interval	Number of Engines
0-100,000	38,214	800,000- 900,000	36,204
100,000-200,000	48,059	900,000-1,000,000	33,121
200,000-300,000	58,220	1,000,000-1,100,000	28,421
300,000-400,000	57,267	1,100,000-1,200,000	25,300
400,000-500,000	52,723	1,200,000-1,300,000	21,711
500,000-600,000	46,210	1,300,000-1,400,000	18,881
600,000-700,000	41,543	1,400,000-1,500,000	12,043
700,000-800,000	38,657	1,500,000-1,600,000	35,516
		TOTAL	592,090

Durability

A million miles is a long way. The top coach operators with the longest hauls choose Series 60 engines. That's why, even though the Series 60 engine will celebrate its 15th birthday this year, over 141,872 Series 60 engines have gone over the million mark!

"Great acceleration throughout a full day of stop and go driving."



What About Warranty?

The Series 60 engine is covered by a standard warranty of two years, unlimited miles with 100% parts and labor coverage, and 5 years or 500,000- mile..

Want more coverage? Custom-tailor a support package to fit your needs. Extended service coverage is available from 3 years or 300,000 miles or as much as 5 years or 500,000 miles.

And Everything Is Backed Up With A Parts And Service Organization Of Over 1300 Outlets In North America.

What Can You Expect From The 2002 Series 60?

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6SA0581 **0209** As technical advancements continue, specifications may change. Printed in U.S.A.

SECTION 03: FUEL SYSTEM

CONTENTS

ILLUTRATIONS

1. FUEL SYSTEM 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 or a fuel filter/water separator (optional) before it enters the fuel pump. If the vehicle is equipped with the optional “Davco Fuel Pro 382”, it is designed to be the only fuel filter in the system, no secondary fuel filter is necessary. 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.

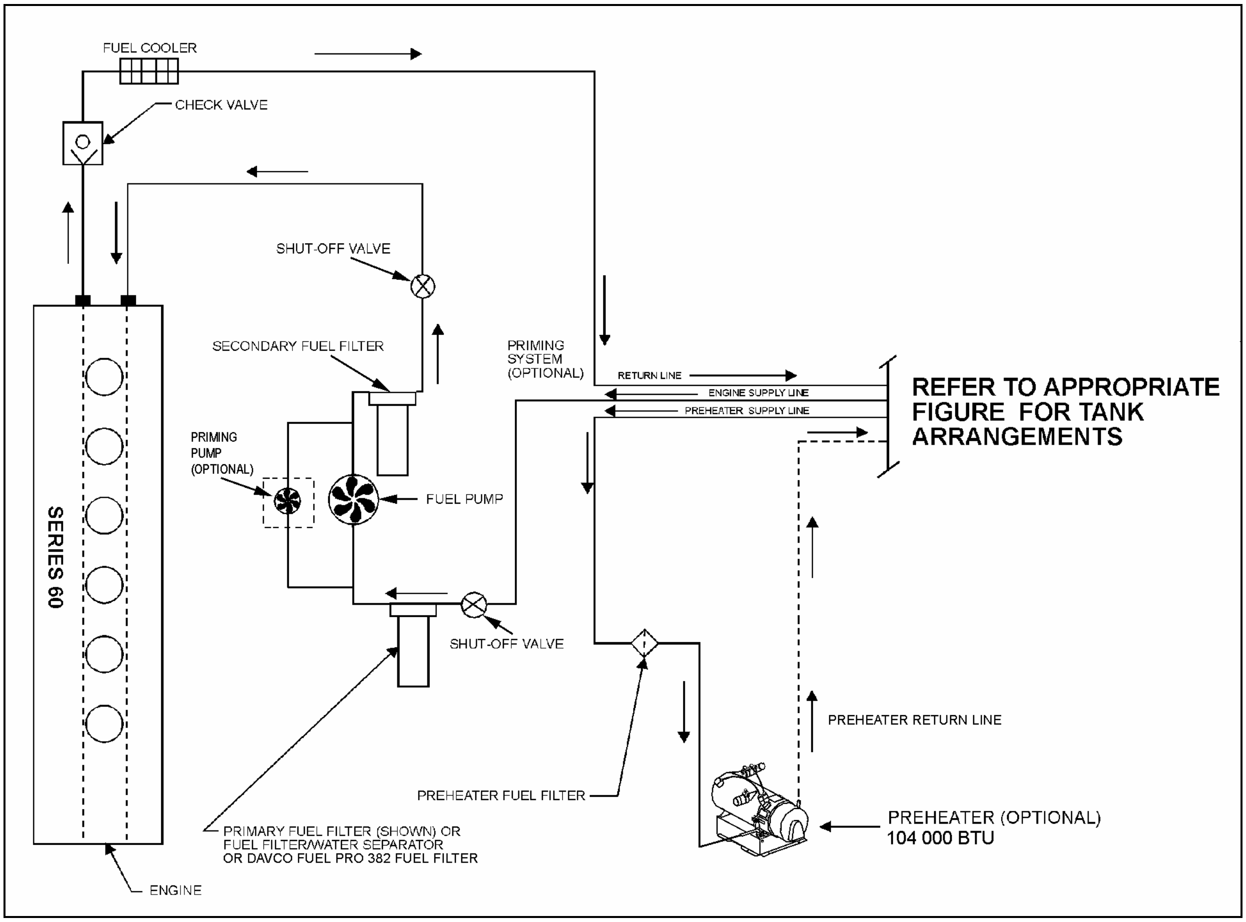


FIGURE 1: FUEL SYSTEM SCHEMATIC 03055

2. 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.

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. 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).

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

3. FUEL VALVES

Manual shut-off valves on engine fuel-supply line are located on the R.H. side of engine compartment (Fig. 2). A manual shut-off valve is located at the inlet side of the primary fuel filter (fuel filter/water separator, if vehicle is so equipped) under the starter. Another manual shut-off valve is located at the outlet side of the secondary fuel filter, under the air compressor. 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.

4. FILTERS AND WATER SEPARATOR

The fuel system is equipped with primary and secondary fuel filters for additional protection of the injectors. A fuel-filter/water-separator may be installed in primary fuel-filter location, to prevent water infiltration in engine fuel system (Fig. 2). It should be drained periodically, or when the water separator telltale light on the dashboard illuminates. To drain, loosen positive seal drain valve below separator, and tighten after water has been flushed out.

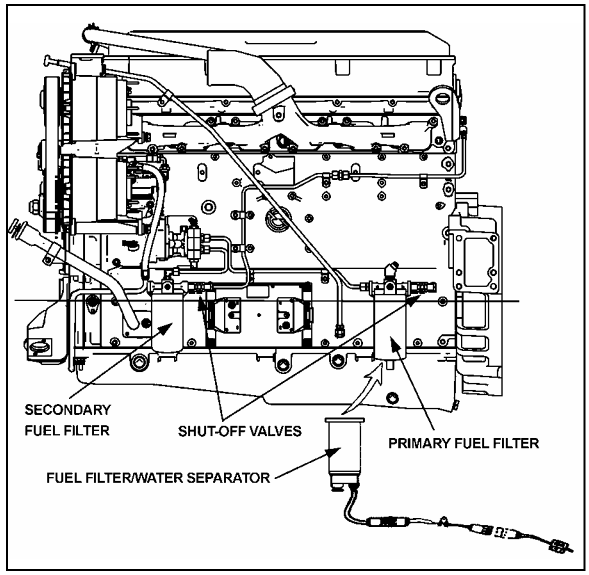


FIGURE 2: MANUAL SHUT-OFF VALVES 03060

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.

4.1 FUEL FILTER/WATER SEPARATOR SERVICING

The fuel filter/water separator is located on the starter side of the engine, below the starter. The water separator must be drained periodically or when the telltale light on the dashboard illuminates.

Replace the water separator element as follows:

1. Drain the fuel filter/water separator as stated previously.
2. With engine "OFF" and engine fuel supply line valves closed; remove the filter element/bowl assembly from cover (for valve location, see *"3. FUEL VALVES"* in this section).

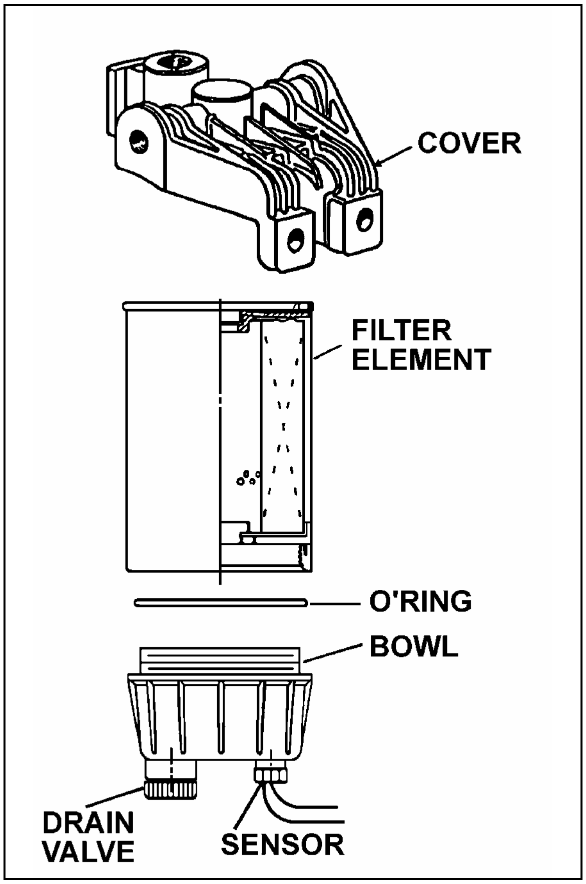


FIGURE 3: FUEL FILTER/WATER SEPARATOR 03025

3. Separate bowl from filter element. 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.
5. Screw new filter element onto bowl snugly by hand.

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

6. Lubricate filter seal with clean diesel fuel or motor oil.
7. Fill filter element/bowl assembly with clean diesel fuel and attach onto cover. Hand tighten an additional 1/3 to 1/2 turn after making full seal contact.
8. Open valves of the engine fuel supply line.
9. Run the engine and check for leaks.

⚠ CAUTION ⚠
If the 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.

4.2 FUEL FILTER SERVICING (PRIMARY AND 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. They are of a spin-on type and must be replaced every 12,500 miles (20 000 km) or once a year, whichever comes first. The primary fuel filter 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.

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 0.080" restriction fittings, the fuel pressure at the cylinder head inlet is 50-75 psi (345-577 kPa). Change the fuel filters whenever the inlet restriction at the fuel pump reaches 12 inches of mercury (42 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.

Change the filter cartridge(s) as follows:

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

1. Stop engine, shut off the engine fuel supply line valves (for valve location, See *"3. FUEL VALVES").* Unscrew and discard filters.
2. Fill new filter replacement cartridge(s) with clean fuel oil, about two thirds (2/3). Apply a thin coat of clean fuel oil on gasket.
3. Install new filters. Tighten until filter is snug against the gasket, with no side movement. Rotate an additional 1/2 turn by hand.
4. Open engine fuel supply line valves.

⚠ 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.

5. 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.

4.3 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 4).

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. Change filter when fuel level reaches the top of filter element (refer to figure 5).

Filter renewal:

1. Stop engine;
2. Drain fuel by opening the drain valve;
3. Untighten upper collar, remove cover;
4. Replace filter element;
5. Check O-Rings and components for wear;
6. Replace cover, hand tighten collar;
7. Pour fuel up to bottom of filter element through spin off cap located on top of cover.
8. Start engine, raise rpm for 2-3 minutes, hand tighten collar again.

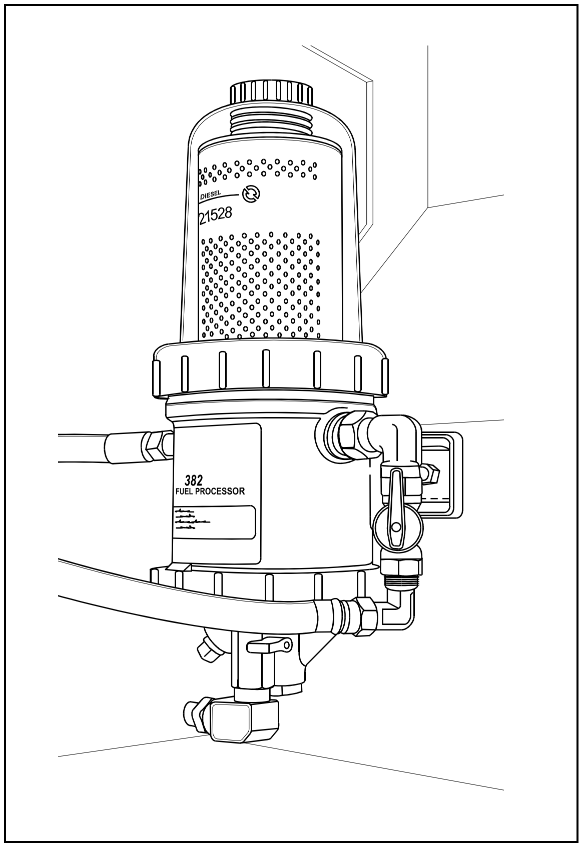


FIGURE 4: DAVCO FUEL PRO 382 FUEL FILTER 03032

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.

4.4 PREHEATER FUEL FILTER

The preheater fuel filter is located above the preheater, in the L.H. side rear service compartment. Replace the filter every 50,000 miles (80 000 km) or once a year, whichever comes first.

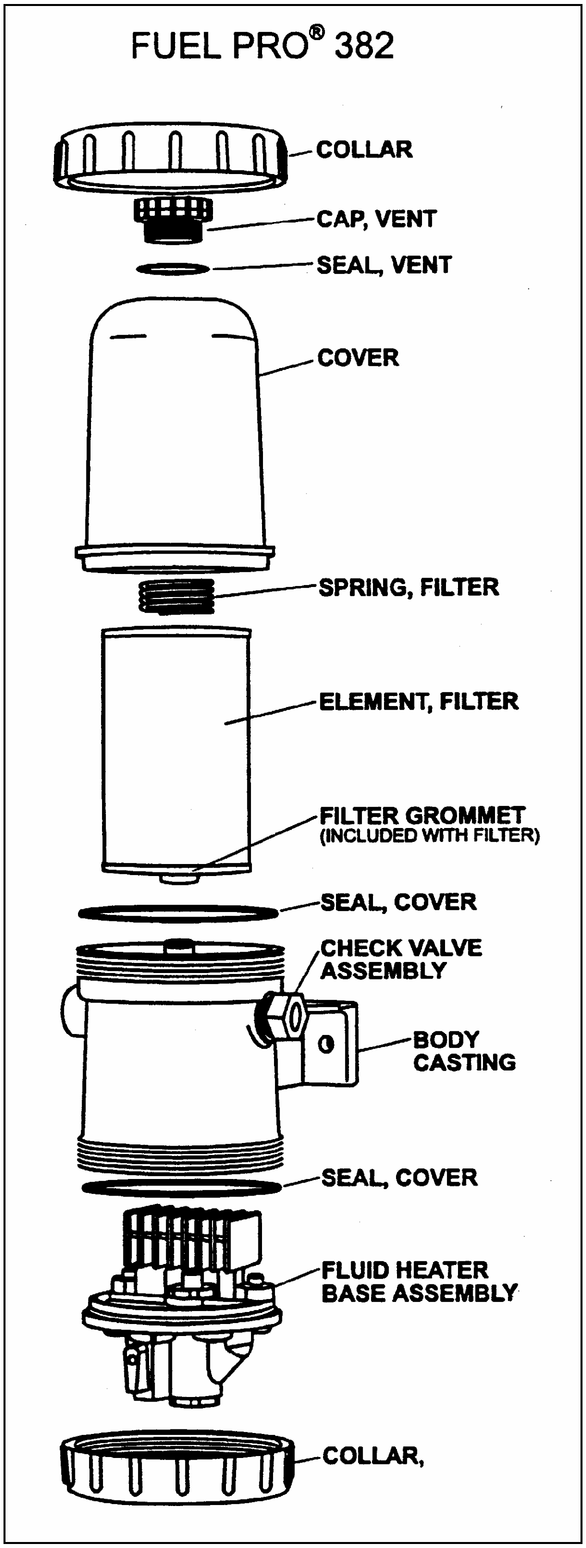


FIGURE 5: DAVCO FUEL PRO 382 EXPLODED VIEW 03034

5. FUEL TANK

All XL2 series vehicles are equipped with a high-density cross-link polyethylene fuel tank. XL2-45 coach has a capacity of 208 US gallons (787 liters). MTH 40 and MTH 45E fuel tanks have a total capacity of 250 US gallons (945 liters) while MTH 45 can be equipped with an optional 90 US gallons (341 Liters) auxiliary stainless steel tank forward of the standard 208 US gallons (787 liters) fuel tank. The main tank is located just forward of the rear baggage compartment, between the A/C condenser and evaporator. The auxiliary tank is located in the baggage compartment just forward of the main tank.

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(s).

5.1 TANK REMOVAL

⚠ WARNING ⚠

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.

NOTE

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(s).

For vehicles equipped with a transverse tank or an auxiliary tank, drain it as well since it is directly connected to the main tank.

NOTE
It is possible to drain both tanks through only one plug, but the other tank will not drain completely since the connecting hose is not on the bottom.

5.1.1 Main Fuel Tank

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.
5. Unscrew engine supply and return lines from fuel tank connection-panel, identify them for reinstallation.

NOTE
For vehicles equipped with a transverse tank or an auxiliary tank, the two hoses joining the tanks should be disconnected.

6. Disconnect electrical wiring from tank on connection plate.

⚠ WARNING ⚠
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.

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.

5.1.2 Auxiliary Fuel Tank (if so equipped)

1. Open the baggage compartment just forward of condenser compartment, disconnect the (2) hoses previously joining the tanks.
2. From underneath vehicle, unscrew the two (2) bolts retaining the tank strap (one on each side).
3. From inside the baggage compartment just forward of condenser compartment, slightly raise the strap and pull out auxiliary fuel tank using the same care as for the main fuel tank.

⚠ CAUTION ⚠
Protective cushions or rags should be placed on the baggage compartment floor to prevent it from being scratched by the fuel tank during removal.

5.1.3 Transverse Fuel Tank

1. The transverse fuel tank must be removed from R.H. side. The stainless steel panel must be removed by first removing the adhesive.
2. From underneath the vehicle, unscrew the bolt on left and right hand side securing the tank foot. Unscrew the two screws at the center of the tank then disconnect the two hoses previously joining the tanks.
3. Unscrew clamps retaining L.H. side filler tube to the fuel tank, then disconnect tube and remove it.
4. Unscrew clamps retaining R.H. side filler tube to fuel tank and filler neck. Disconnect tube and remove it.
5. Remove plastic molded panel from inside baggage compartment located forward of A/C & Heating compartment.
6. Slide the tank out carefully.

5.2 TANK INSTALLATION

To install Main, Auxiliary and Transverse Fuel Tanks, simply reverse the *"Tank Removal"* procedure.

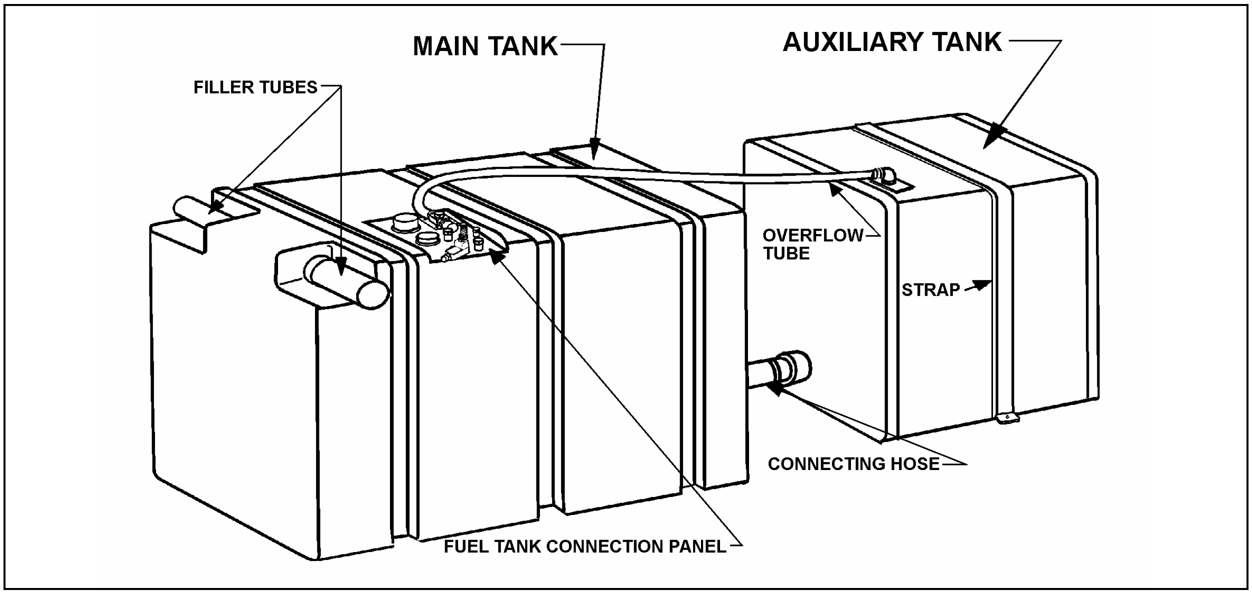


FIGURE 6: 208 US GAL. MAIN FUEL TANK (XL2-45) & 90 US GAL. AUXILIARY FUEL TANK (OPTIONAL) (MTH 45) 03028

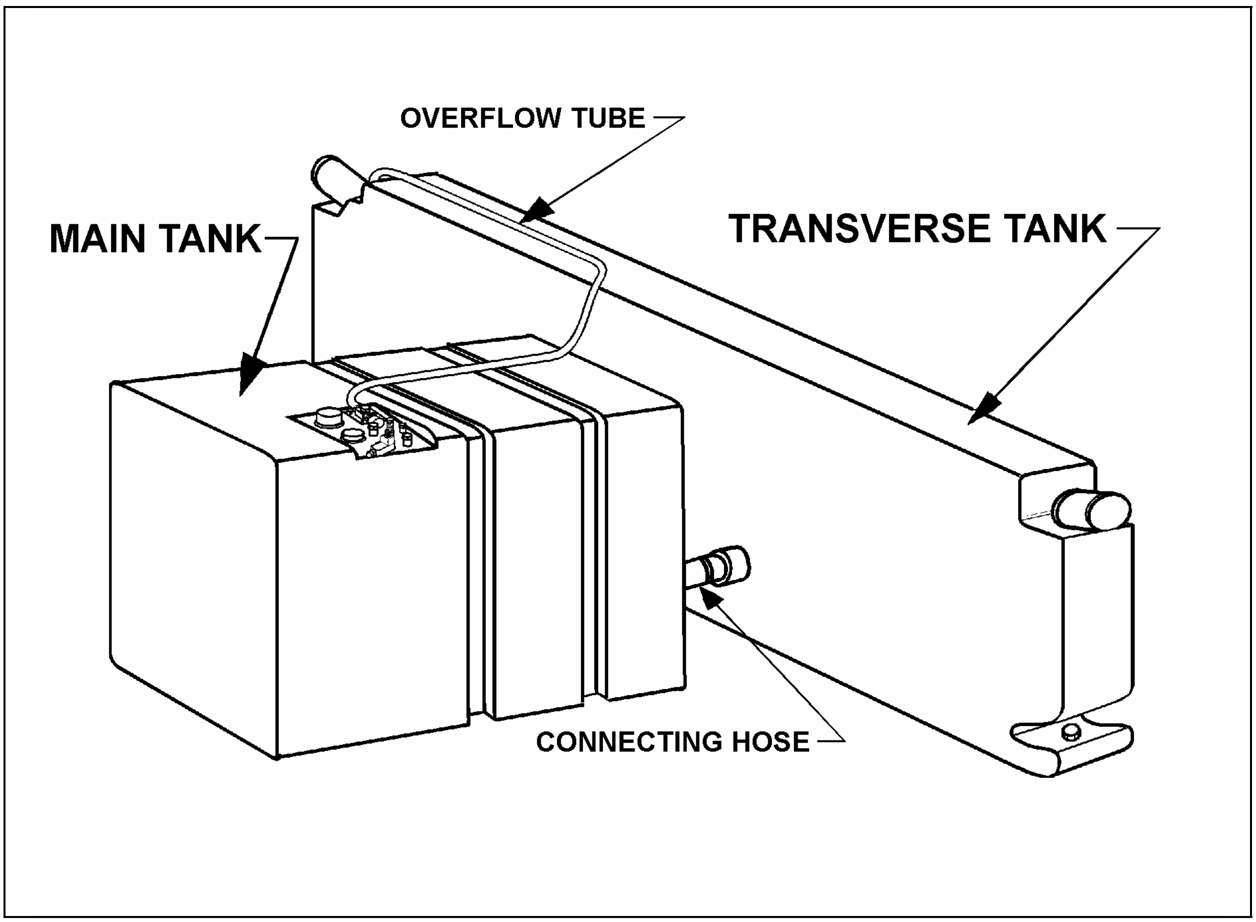


FIGURE 7: 250 US GALLONS FUEL TANKS (MAIN TANK & TRANSVERSE FUEL TANK) (MTH 40 & MTH 45E) 03029

5.3 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.

> ⚠ WARNING ⚠
>
> **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.**

5.4 POLYETHYLENE FUEL TANK REPAIR

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

> ⚠ WARNING ⚠
>
> **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 (Prévost #5001244) into anchor nut (Prévost #500331).
5. Place assembly in drill hole. Tighten screw by 10 complete turns. Refer to Fig. 8.
6. Apply sealant on head plug (Prévost #507300) and seal hole with the head plug.

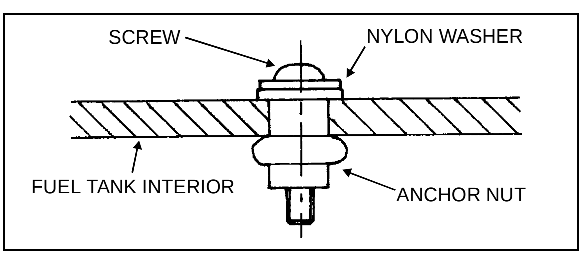


FIGURE 8: FUEL TANK REPAIR 03014

6. PRIMING FUEL SYSTEM

The problem with restarting a diesel engine that has run out of fuel, is that after the fuel is exhausted from the tank, it is pumped from the primary fuel filter or the fuel filter/water separator (if vehicle is so equipped), and sometimes partially removed from the secondary filter. This results in an insufficient fuel supply to sustain engine firing. The primary fuel filter or fuel filter/water separator and secondary filter must be free of air in order for the systems to provide adequate fuel for the injectors. When the engine runs out of fuel, the following operations must be performed before restarting:

Fill fuel tank with the recommended fuel oil. If only partial filling is possible, add a minimum of 10 gallons (38 liters) of fuel.

* If the vehicle is equipped with a Fuel Pro 382 fuel filter/water separation, pour fuel through spin on cap as per "4.3 DAVCO FUEL PRO 382".
* If the vehicle is equipped with an optional priming pump **(**see Figure 9).

Press the priming switch, located in the engine compartment rear junction box just below the switches and cables. Start the engine and check for leaks.

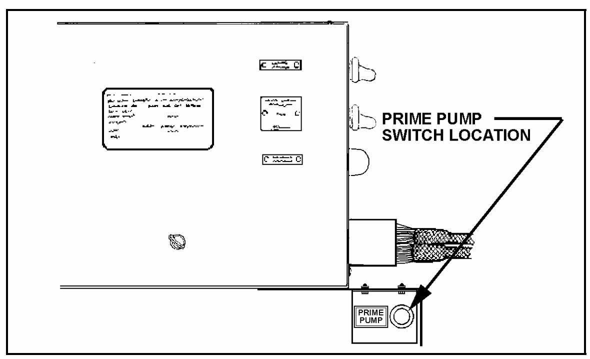


FIGURE 9: PRIME PUMP SWITCH LOCATION 01037

If the vehicle is not equipped with a priming pump:

1. Unscrew the cap on the priming valve located on the secondary filter;
2. Direct fuel under pressure 25 psi (172 kPa) to the priming valve using a quick coupling;
3. Start the engine and check for leaks.

7. FUEL PUMP INSTALLATION

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

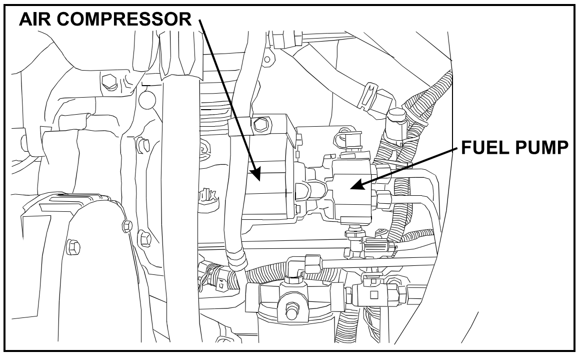


FIGURE 10: FUEL PUMP LOCATION

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 Locktite 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.

8. FUEL OIL 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 fuel oil should meet ASTM designation D 975. Grade 1-D is recommended, however grade 2-D is acceptable.

NOTE
These fuel grades are very similar to grade DF-1 or DF-2 of Federal Specifications VV-F-800. For detailed fuel recommendations, refer to publication "Engine Requirements-Lubricating Oil, Fuel, and Filters" #7SE270 available from Detroit Diesel Distributors.

9. 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).

9.1 PRE-CLEANER SERVICING

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.

9.2 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.

9.3 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.

9.4 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.

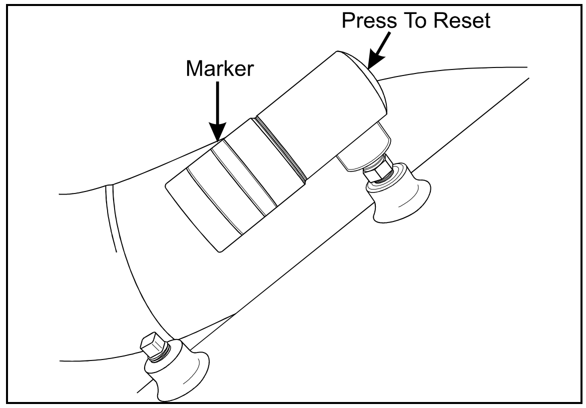


FIGURE 11: RESTRICTION INDICATOR 01052

10. FUEL COOLER

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 it is located just in front of the coolant radiator (Fig. 13).

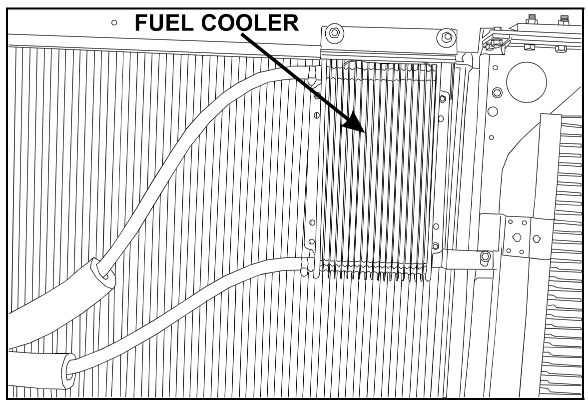


FIGURE 12: FUEL COOLER LOCATION 03054

11. 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.

11.1 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.

11.2 POTENTIOMETER REPLACEMENT

1. Disconnect cable harness connector.

⚠ 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. Loosen the two screws and remove potentiometer. Retain for re-assembly.
3. Discard potentiometer (Fig. 13).
4. 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. 13) and tighten just enough to secure potentiometer lightly. Tighten screws to 10 - 20 Lbf-in (1.5 - .2 Nm).
5. 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.

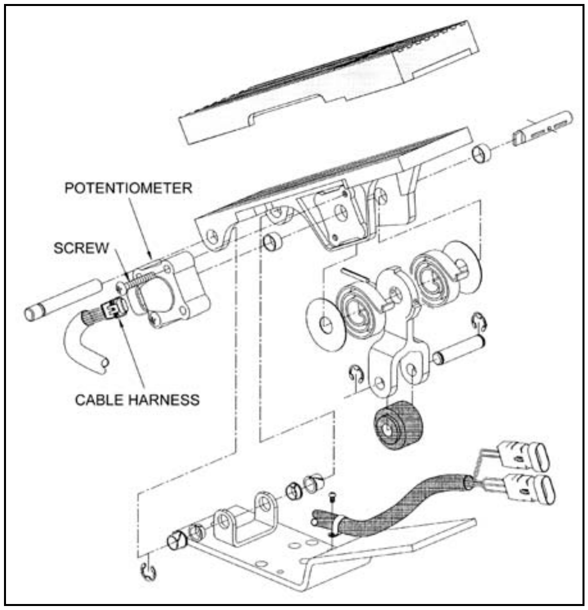


FIGURE 13: ELECTRONIC FOOT PEDAL ASSEMBLY 03035

12. SPECIFICATIONS

Davco FuelPro 382 Fuel Filter / Water Separator Element

Supplier number 23521528
Prévost number 531437

Primary Fuel Filter / Water Separator (optional)

(May be used instead of primary filter (never use with a primary filter).
Make .... Racor
Type .... Spin-on

ELEMENT
Supplier number .... S 3202
Prévost number 531390

BOWL
Supplier number RK30051
Prévost number 531389

DRAIN VALVE AND SEAL
Supplier number RK30058
Prévost number 531397

O-RING
Supplier number RK30076
Prévost number 531398

PROBE/WATER SENSOR
Supplier number RK21069
Prévost number 531391

Primary Fuel Filter

Make .... AC
Type .... Spin-on
Filter No. T-915D
Service Part No. 25014274
Prévost number 510137
OR
Service Part No (Type with Water Separator) 23512317
Prévost number 531407
Element torque .... 1/2 turn after gasket contact

Secondary Fuel Filter

Make .... AC
Type .... Spin-on
Filter No. T-916D
Service Part No. 25014342
Prévost number 510128
Element torque .... 1/2 turn after gasket contact

Fuel tank(s) Capacity (ies)

Standard (XL2-45 & MTH 45) .... 208 US gallons (787 liters)
Standard (MTH 40 & MTH 45E) .... 250 US gallons (945 liters)
Optional (MTH 45) .... 90 US gallons (341 liters)

Air Cleaner

Make .... Nelson
Prevost Number 530206
Service Part No 7182 8N
Supplier number (element cartridge) 70337N
Prévost number (element cartridge) 530197

Air Cleaner Restriction Indicator

Make .... Donaldson
Model RBX00-2220
Indicates .... at 20" (508 mm) of water
Prévost number 530161

Preheater Fuel Filter

Make .... Webasto
Supplier number 603.359
Prévost number 871037

Fuel Cooler

Make .... Berendsen
Supplier number DB-1240
Prévost number 950109

SECTION 04: EXHAUST SYSTEM

CONTENTS

ILLUSTRATIONS

1. DESCRIPTION

The muffler is rubber mounted on the vehicle frame. This feature reduces the transmission of vibrations to the muffler thus resulting in extended life of muffler, brackets and other components.

2. MAINTENANCE

The exhaust system should be inspected periodically for restrictions and leaks. The exhaust systems are shown on figures 1 & 2 (fig. 1 = XL2-40 & 45E and fig. 2 = XL2-45). Restrictions such as kinked or crimped pipes result in excessive back pressure that can lead to increased fuel consumption, power loss, and possible damage to engine combustion chamber components. Exhaust leaks are commonly the result of loose clamp bolts, corroded pipes, or a punctured muffler. In addition to objectionable noise, a leaking exhaust system could allow toxic gases to enter the vehicle. Inspect the exhaust system as follows:

* At vehicle inspection intervals ;
* Whenever a change is noticed in the sound of the exhaust system ; 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.

⚠ WARNING ⚠
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.

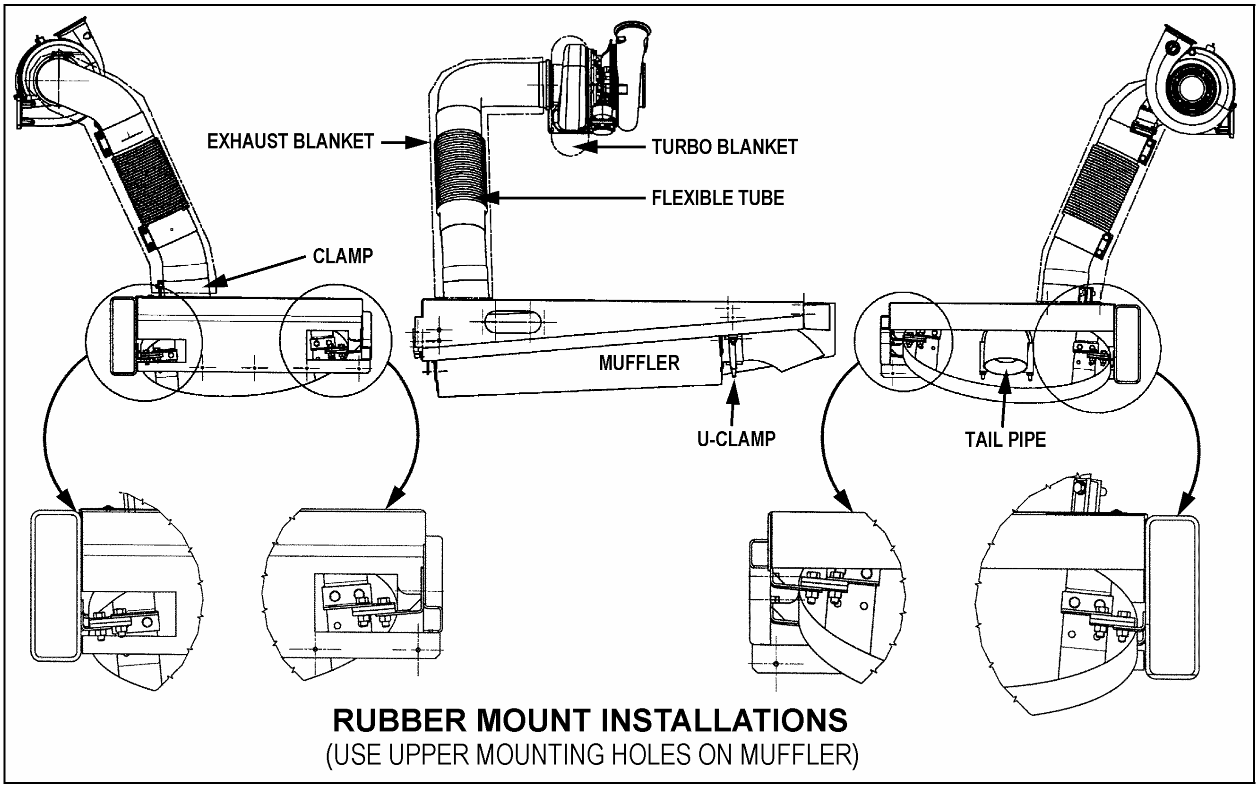


FIGURE 1: EXHAUST SYSTEM - XL2-40 & 45E (SHELL) INSTALLATION 04006

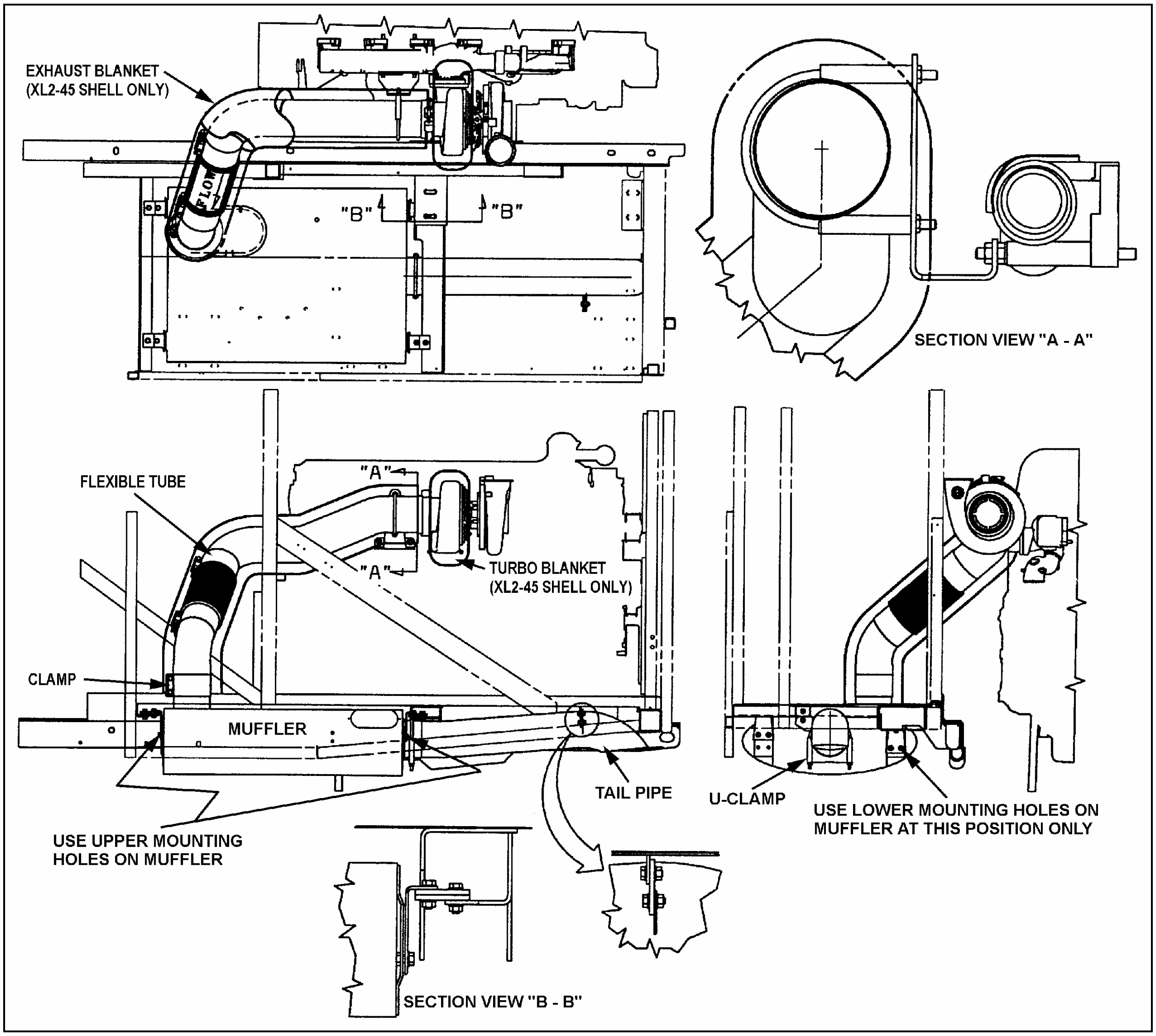


FIGURE 2: EXHAUST SYSTEM - XL2-45 (COACH & SHELL) INSTALLATION 04007

3. MUFFLER REMOVAL & INSTALLATION

⚠ WARNING ⚠

Make sure that muffler and components are cold before handling.

1. Remove bolts and clamps securing exhaust pipe bellows to the muffler.
2. Support the muffler from underneath vehicle.
3. Remove U-clamp retaining the tail pipe to the muffler.
4. Remove bolt holding the tail pipe to the frame bracket.
5. Remove the tail pipe.
6. Remove the fasteners holding the four rubber mounts to the frame brackets.
7. Remove the fasteners securing the rubber mounts to the muffler brackets.
8. Remove rubber mounts then muffler from underneath vehicle.
9. Remove parts which are attached to the muffler such as brackets and collar.
10. Inspect and replace parts if necessary. Reinstall parts on the new muffler.

For installation, reverse the removal procedure.

⚠ WARNING ⚠

Check connections for tightness and fasteners for proper assembly.

4. FLEXIBLE TUBE INSTALLATION

The flexible exhaust tube contains an inside rigid pipe. To allow appropriate flexibility for assembly, make sure that the rigid pipe is concentric to the flexible part.

To maintain the pipe centered at the time of installation, cardboard spacers must be inserted at four places at equal distance around tubing (Fig. 3). These spacers may be left in place and will deteriorate over time.

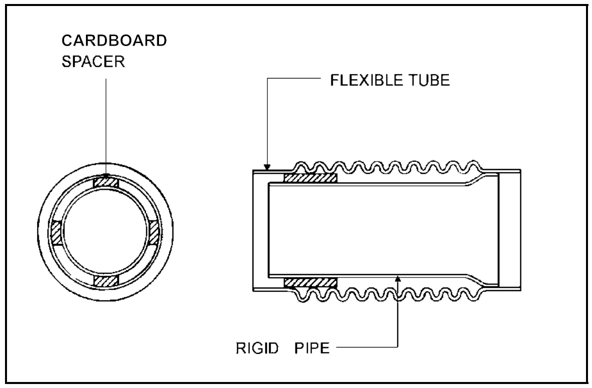


FIGURE 3: FLEXIBLE TUBE INSTALLATION 04003

5. HEAT BLANKETS (CONVERTED VEHICLES ONLY)

5.1 EXHAUST

5.1.1 Installation on XL2-45 Shells

1. Remove L.H. side tag axle wheel.
2. Locate splash guard panel located at rear of vehicle (behind L.H. side tag axle wheel), then remove, cover bellows and exhaust pipe with 2-piece blanket #040553 (Fig. 4). Use velcro to secure blanket in place.

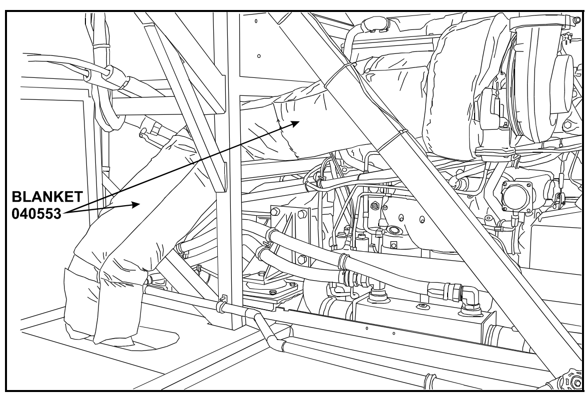


FIGURE 4: EXHAUST BLANKET INSTALLATION 04009

3. Install the turbo blanket as described further in this section.

5.1.2 Installation on XL2-40 & XL2-45E Shells

1. Remove L.H. side tag axle wheel.
2. Locate splash guard panel located at rear of vehicle (behind L.H. side tag axle wheel), then remove, cover bellows and exhaust pipe with 2-piece blanket #040565. Refer to figure 4 showing installation on XL2-45 shells. Use velcro to secure blanket in place.
3. Install the turbo blanket as described further in this section.

5.2 TURBO (ALL SHELLS)

Install turbo blanket #040557, then cover turbine housing (Fig. 5). Use velcro to secure blanket in place.

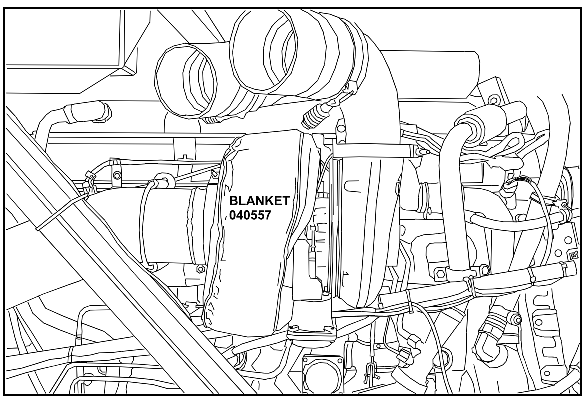


FIGURE 5: TURBO BLANKET INSTALLATION 04010

NOTE
The compressor housing does not require a blanket.

CONTENTS

ILLUSTRATIONS

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.

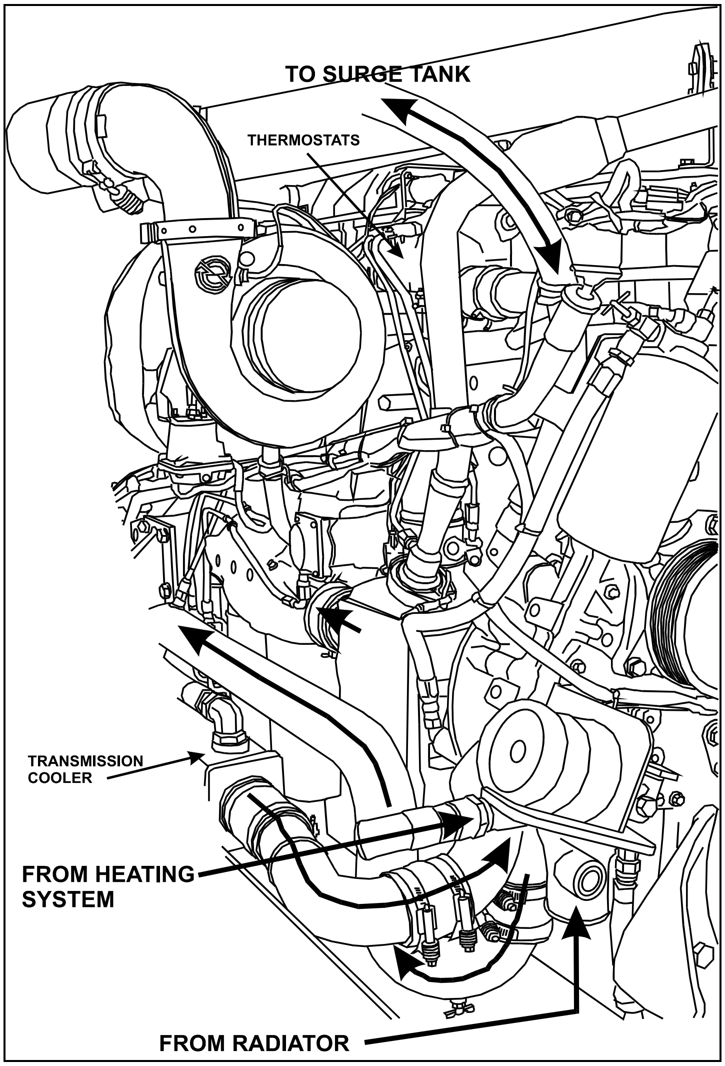


FIGURE 1: COOLING SYSTEM 05087

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.

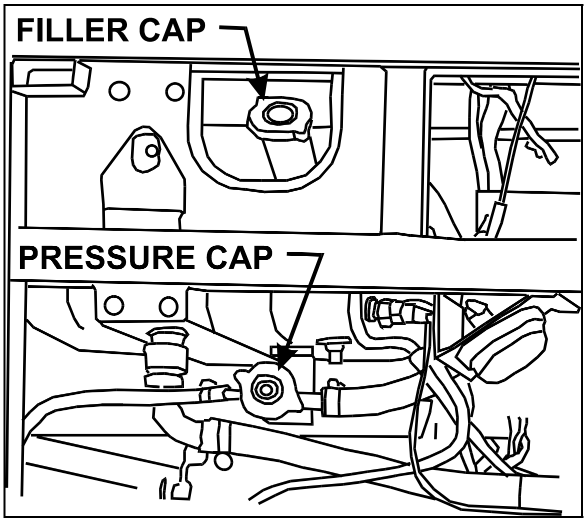


FIGURE 2: SURGE TANK - ENGINE COMP'T 05079

The cooling system is filled through a filler cap on the surge tank (Fig. 2). A pressure cap underneath 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. 2). Two thermostats are located in the housing attached to the right side of the cylinder head (Fig. 1). Furthermore, a water temperature sensor mounted on the cylinder head (radiator side) is also supplied for engine protection purposes.

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.

2. MAINTENANCE

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.
- Maintain the prescribed inhibitor strength levels as required. Coolant and inhibitor concentration must be checked at each 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 *"COOLANT FILTER"* in this section. If the vehicle is not equipped with a filter, add the recommended inhibitor concentration to the antifreeze/water solution.
- 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 maintenance 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.

Coolant must be discarded in an environmentally safe manner.

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 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 *"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.

- 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.

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

All hose clamps of 1 3/8" ID and over, used on the heating and cooling systems, are of the *"Constant-torque"* type. These two types of clamps are worm-driven, made of stainless steel, supplied with a spring or with a series of Belleville spring washers.

These clamps are designed to automatically adjust their 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.

3.1.1 1st Type

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 ¼" (6 mm) beyond the housing (Fig. 3).

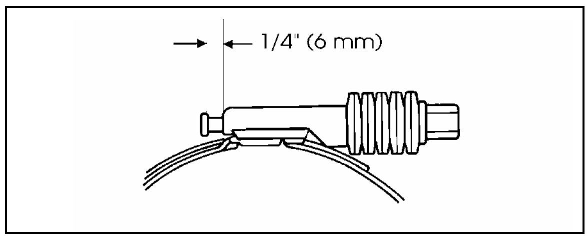


FIGURE 3: CONSTANT-TORQUE CLAMP 05037

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

Maintenance

The constant-torque clamps contain a *"Visual torque check" feature.* When the tip of the screw is extending ¼" (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.**

3.1.2 2nd Type

Installation

A torque wrench should be used for proper installation. The recommended torque is 10 lbf-ft (Fig. 4).

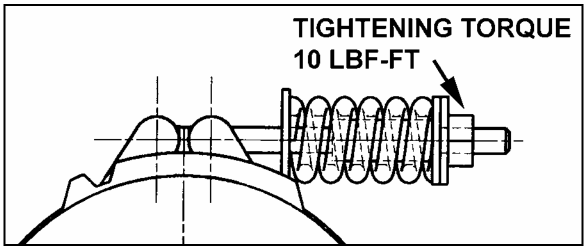


FIGURE 4: 4-INCH CONSTANT TORQUE CLAMP 05097

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

Maintenance

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.**

Constant-Torque Hose Clamp Replacement

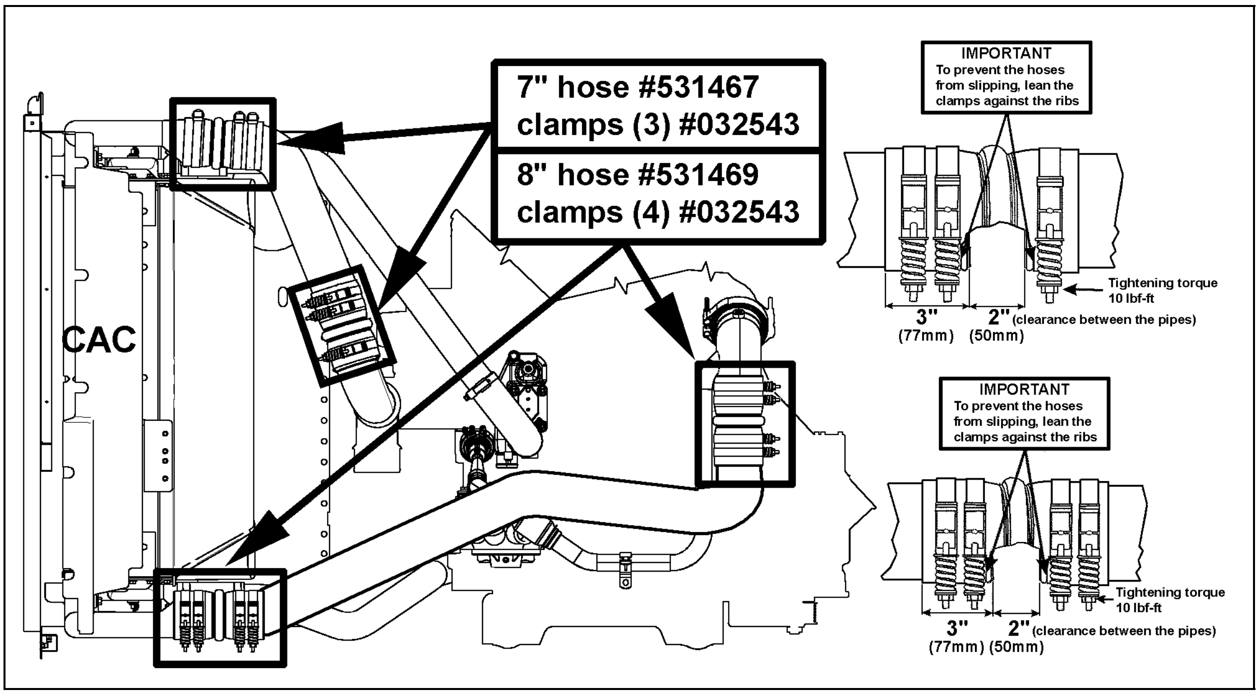


FIGURE 5: REPLACEMENT OF HOSES AND CLAMPS

4. COOLANT

4.1 COOLANT LEVEL VERIFICATION

Coolant level is correct when cold coolant is visible through the surge tank sight glass (Fig. 6). If coolant level is low, fill cooling system.

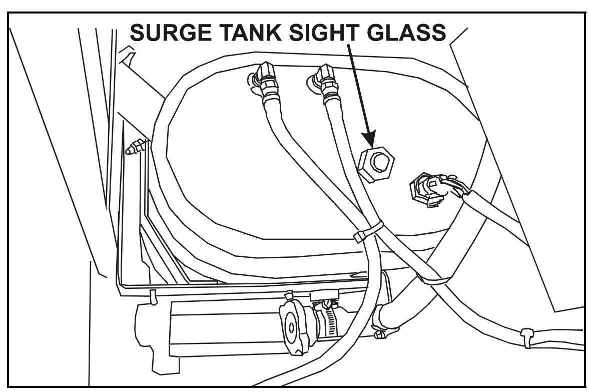


FIGURE 6: SURGE TANK SIGHT GLASS 05094

4.2 COOLANT LEVEL SENSOR

This warning device consists of a fluid level probe mounted on the surge tank. The probe sends a signal to the ECM 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 while the electronic module is mounted inside the rear electric junction box.

4.3 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.

4.4 COOLANT REQUIREMENTS

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.

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).

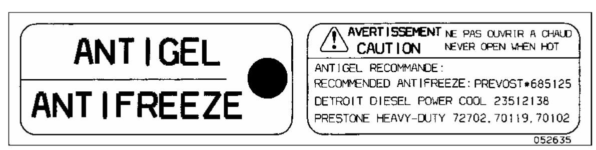
4.5 COOLING SYSTEM RECOMMENDATIONS

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.

Recommended phosphate free coolants: Detroit Diesel "DDC Power Cool" (P/N 23512138) or Prestone AF977 (bulk) Prevost #685125, 72702 (3.78 L), 70119 (205L), 70102 (4L).

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



4.6 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.

4.6.1 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:

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.

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)

4.7 COOLANT RECOMMENDATIONS

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.

⚠ 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.

4.7.1 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.

4.7.2 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.

4.7.3 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).

4.7.4 Vehicles With Coolant Filters

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

NOTE

The coolant filter contains inhibitors.

5. 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 XL2-40, XL2-45 & 45E MTH, one valve is located in the engine compartment, under the radiator fan gearbox (Fig. 7), another valve is located in the engine compartment behind splash guard panel at rear of vehicle (behind L.H. side tag axle wheel) (Fig. 8).

NOTE

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

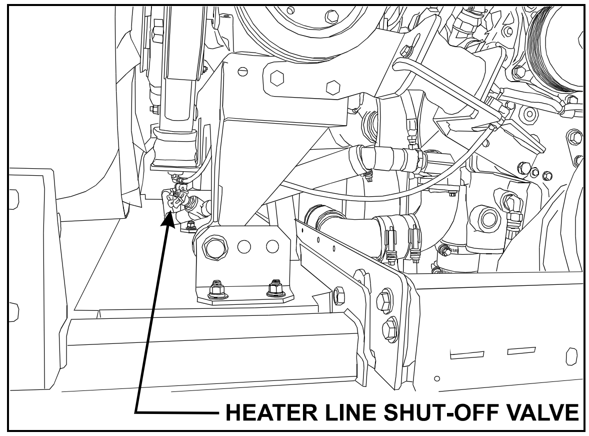


FIGURE 7: ENGINE COMPARTMENT 05078

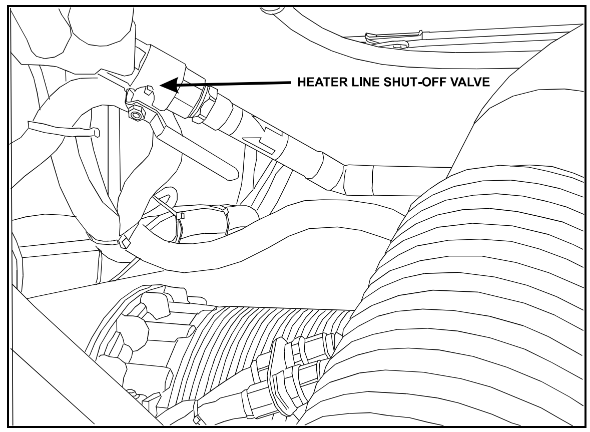


FIGURE 8: HEATER LINE SHUT-OFF VALVES 05067

On XL2-45 coaches, both valves are located in the engine compartment, behind splash guard panel at rear of vehicle (behind L.H. side tag axle wheel) (Fig. 9).

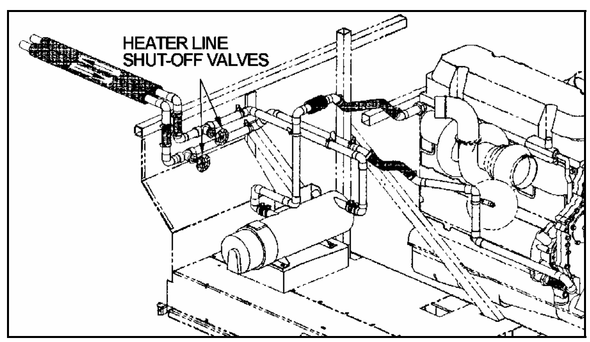


FIGURE 9: COACHES SHUT-OFF VALVES (TYP.) 01142

⚠ 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. Unscrew the surge tank pressure cap counterclockwise, ¼ turn to let air enter the system and permit the coolant to drain completely from system.

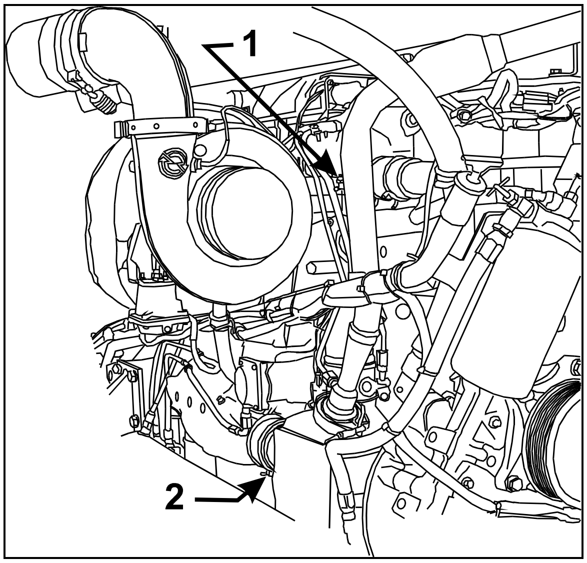


FIGURE 10: ENGINE COOLANT DRAIN COCKS 05088

3. Unscrew the water pump housing inlet line drain plug (Fig. 11).

4. Open drain cock at bottom of thermostat housing to drain the coolant trapped above the thermostats (1, Fig. 10).

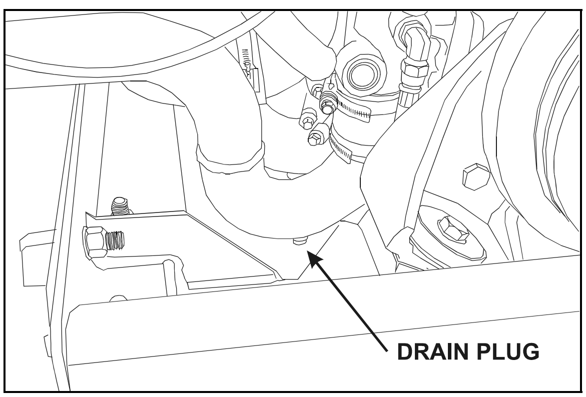


FIGURE 11: WATER PUMP DRAIN PLUG 05072

5. Open engine drain cock (2, Fig. 10).

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

To drain the entire system, do the previous steps while maintaining the shutoff valves in the open position; then follow the procedure under *“9.2 Draining Heating System”* in Section 22.

⚠ 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.**

6. 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. Refer to draining procedure for the location of draining points.

2. Refill cooling system from the surge tank filler cap inlet with a recommended ethylene glycol-based antifreeze and water solution of the required concentration. Add Detroit Diesel selected product cooling system inhibitors (if required).

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

NOTE
Make sure the vent line at top of thermostat housing is properly connected and not obstructed. The vent line (thermostat housing dome to radiator top tank) is required to ensure complete engine fill and proper venting of air in the system.

3. 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 light will flash

4. Stop engine and allow cooling.

5. 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 *"9.4 Bleeding Heating System".*

7. 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:

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

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

7.1 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.

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.

7.2 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.

8. 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 located beside the belt tensioning arm (Fig. 12).

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.

NOTE
If a coolant filter is to be installed on an engine already in service, drain and flush the cooling system before installing the filter.

To replace a filter:

1. Close the two filter shutoff cocks 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.
3. Clean the filter adapter with a clean, lint-free cloth.

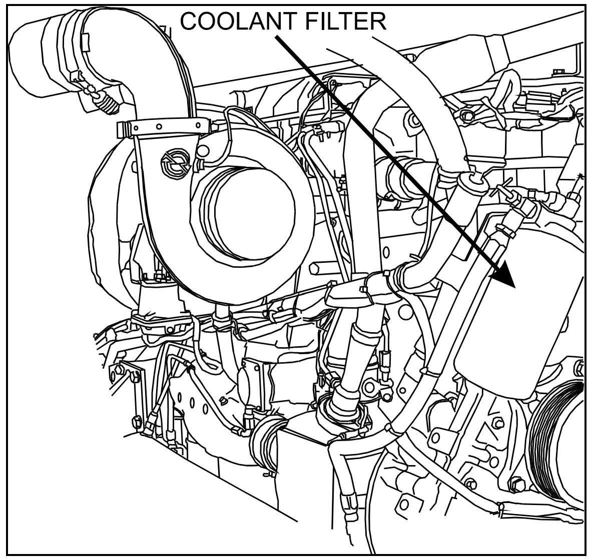


FIGURE 12: COOLANT FILTER 05089

4. Coat surface of gasket with oil, 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.

9. 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.

9.1 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.

10. VARIABLE SPEED RADIATOR FAN

The radiator fan has two thermostatically controlled speeds. The ECM controls the speed by comparing data from engine coolant temperature, charge air cooling temperature, engine oil temperature, A/C condenser temperature, transmission retarder state, manual switch to a set of calibration data. Once fan switches to a state, it stays at that state for 30 seconds long before changing, to reduce clutch cycling. The fan drive clutch is electromagnetic; the ECM 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:

- 190°F (87.5°C) Thermostat starts to open
- 192°F (89°C) Fan medium speed, descending, off
- 196°F (91°C) Fan medium speed, rising, on
- 199.5°F (93°C) Fan high speed, descending, off
- 203°F (95°C) Fan high speed, rising, on
- 205°F (96°C) Thermostats fully open

NOTE

In case of an electrical power failure: remove the bolt from the end of the shaft and screw it into the locking plate. This procedure will prevent engine from overheating by forcing fan rotation (Fig. 13).

On certain models, the mechanical locking device consists of two threaded bushings fixed on the pulley and two drilled metal plates fixed on the rotor. Use the two screws located on the face of the clutch to fasten the metal plates and the bushings (Fig.14).

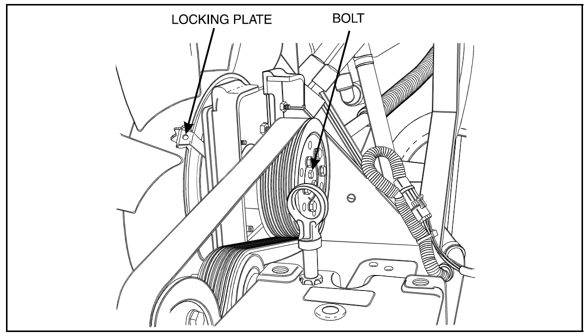


FIGURE 13: MECHANICAL LOCKING DEVICE 05061

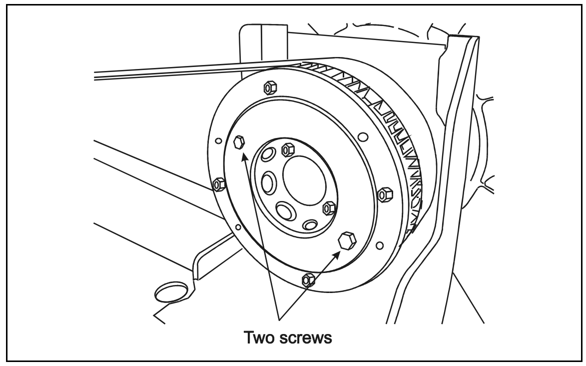


FIGURE 14: SCREWS LOCATION

10.1 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 add any fluids or lubricants to the fan driving mechanism.
5. Do not restrict fan rotation during engine operation for any reason.
6. Do not operate fan-driving mechanism with a damaged fan assembly. Replace a damaged fan as soon as the fault is noted.
7. Immediately investigate and correct any operator complaint involving driving mechanism or cooling system performance.
8. When questions arise, obtain answers before proceeding. Assistance is available through the authorized Field Sales distributor serving your area.

10.2 INSPECTION

> ⚠ **WARNING** ⚠
>
> **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 driving mechanism.
- Check coupling installation between fan blade assembly and gearbox.
- Visually inspect fan driving mechanism, fan blade assembly, shroud, radiator, and surrounding area for evidence of contact between rotating and non-rotating parts.
- Check fan transfer belt for fraying, cracking, and proper tension.
- Turn fan through at least 360° of rotation. It should turn smoothly with no resistance.

10.3 THERMOSTAT OPERATION

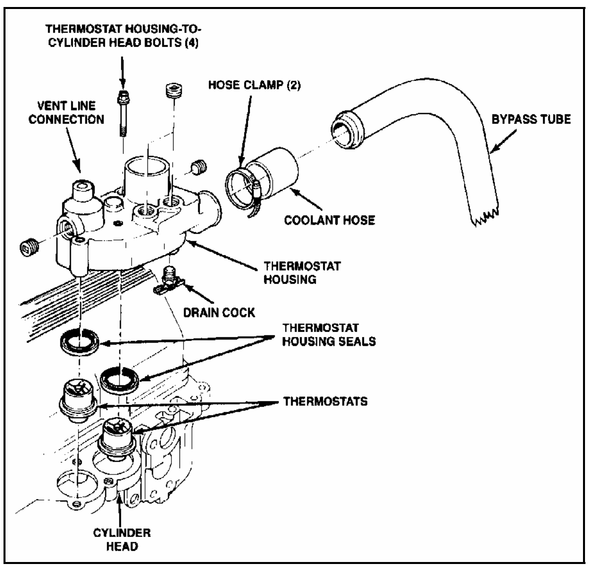


FIGURE 15: THERMOSTAT AND RELATED PARTS 05034

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. 15).

At coolant temperature below approximately 190°F (88°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 190°F (88°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 205-207°F (96-97°C) thermostat valves are fully open, the bypass system is blocked off and the coolant is directed through the radiator.

11. FAN GEARBOX

The radiator fan is belt driven from the engine crankshaft pulley through a standard gearbox, which is designed with two output shafts.

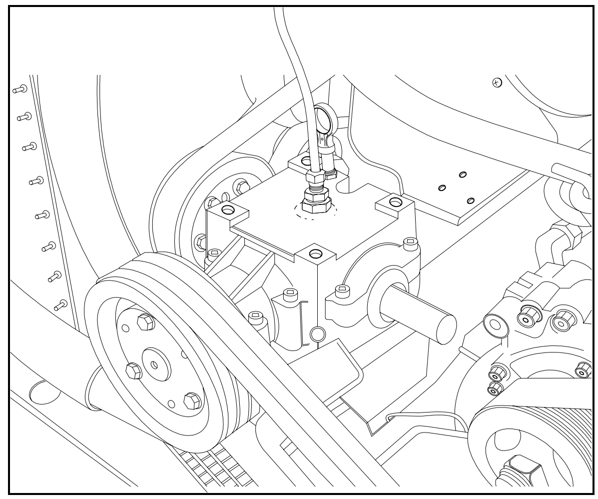


FIGURE 16: FAN GEARBOX 05062

11.1 MAINTENANCE

Change the gearbox oil at 3,000 miles (4,800 km) and subsequently every 50,000 miles (80,000-km) or once a year, whichever comes first.

11.2 OIL CHANGE

1. Stop engine and make sure that all engine safety precautions have been observed.
2. Remove the drain plug located underneath the gearbox case.
3. Drain gearbox.
4. Replace drain plug.
5. Remove the dipstick located on top of gearbox and wipe with a clean rag (Fig. 16).
6. Adjust level to ″Full″ mark using Mobil SHC 630 (Prévost #180217) synthetic oil.
7. Insert dipstick in gearbox case, then remove again to check mark.

8. Reinsert the dipstick.

12. RADIATOR FAN BELT REPLACEMENT

Locate the belt tensioner pressure-releasing valve (Fig. 17), then turn handle counter-clockwise in order to release pressure in belt tensioner air bellows, thus releasing tension on belts.

Remove existing belts (3″V″belts & 1 Poly) from fan assembly and replace with new ones.

Turn the pressure-releasing valve clockwise to its initial position to apply tension on the new belts.

NOTE
For proper operation of the belts, adjust the air bellows tensioner pressure regulating valve (located next to control valve) to 50 psi (345 kPa) for XL2 Coaches and to 45 psi (310 kPa) for XL2 MTH.

12.1 BELT TENSION ADJUSTMENT

The regulator is located in the engine compartment behind the belt tension pressure releasing valve panel. Turn the screw located under the regulator assembly to change the tension pressure. Check proper pressure using the pressure check valve (Fig. 17).

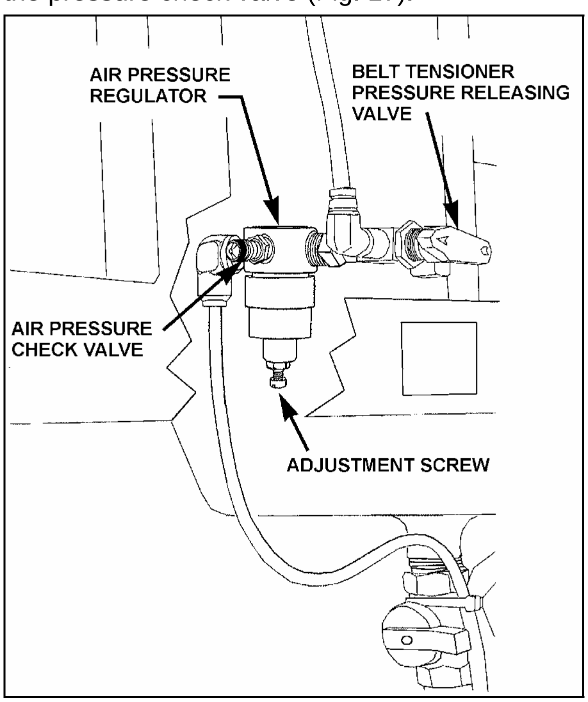


FIGURE 17: REGULATOR VALVE 12200

Use Belt Tension Gauge #68-2404 to measure tension of engine belts. For proper operation of air tensioners, adjust upper tensioning bracket to provide a ¼" (7 mm) gap between stopper and bracket under normal pressure of 50 psi - 345 kPa or 45 psi - 310 kPa. Refer to figure 18 for more information.

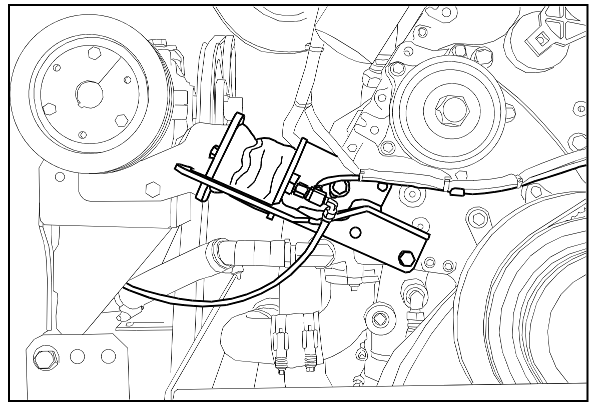


FIGURE 18: BELT TENSIONER 01059

13. FAN DRIVE ALIGNMENT

1. Install both attachment assembly plates (P/N 051779) (48, Fig. 19) through lower plating and secure with four spring nuts (P/N 500666), (70, Fig. 19). Then install one spacer (P/N 050705), (49, Fig. 19) on each spring nut at both anchoring locations (Fig. 19).
2. Center seat assembly in the fan shroud using the horizontal displacement of the fan driving mechanism support. Center with the slots in the floor at anchoring angle support (on some vehicles only). Vertical displacement of the fan clutch is made possible by slots at the base of the fan clutch (on some vehicles only) or by shimming with additional spacers at anchoring locations. Temporarily secure assembly with two nuts (P/N 500709), (74, Fig. 19) at both anchoring locations.

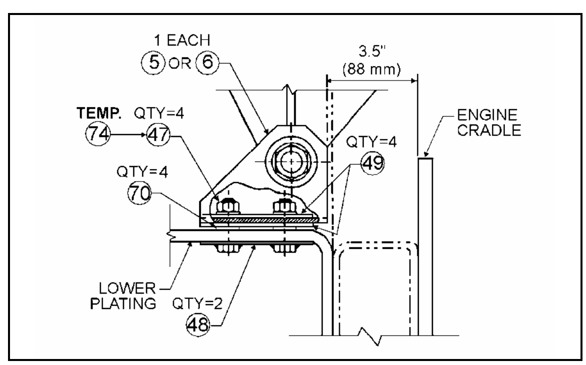


FIGURE 19: ANGLE SUPPORT 05014

⚠ CAUTION ⚠
Tilt fan and check for clearance.

3. Using a straight edge, align the 3"V"pulley on gearbox central shaft pulley with engine pulley, while taking pulleys outer edge thickness under consideration i.e. 3"V"pulley's outer edge is thicker than that of engine pulley's (Fig. 20).

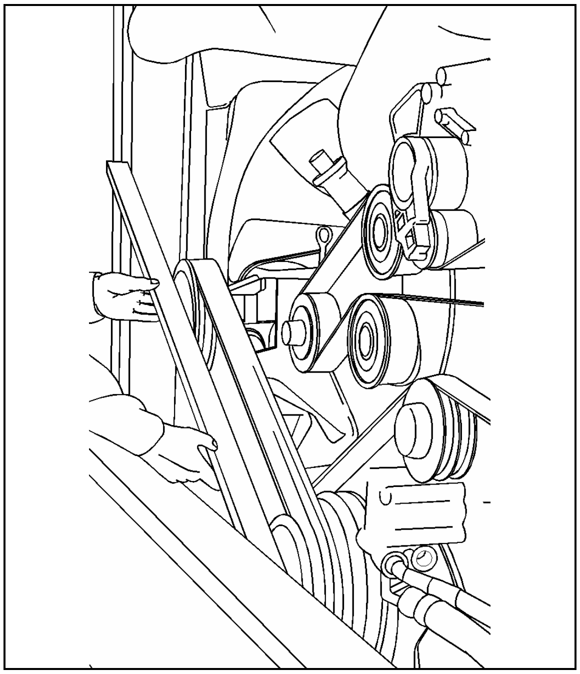


FIGURE 20: PULLEY ALIGNMENT 05064

4. Using a universal protractor, check 3"V" pulley's vertical angle with that of engine pulleys. If angles do not correspond, raise seat assembly by shimming with additional spacers (#49 - P/N 050705).

NOTE
Use a straight edge to measure engine pulley's vertical angle (Fig. 21).

5. Check alignments again (steps 2, 3 & 4) then replace temporary anchoring nuts (P/N 500709) (74, Fig. 19) with four nuts (P/N 500714) (47, Fig. 19) and tighten using a wrench.

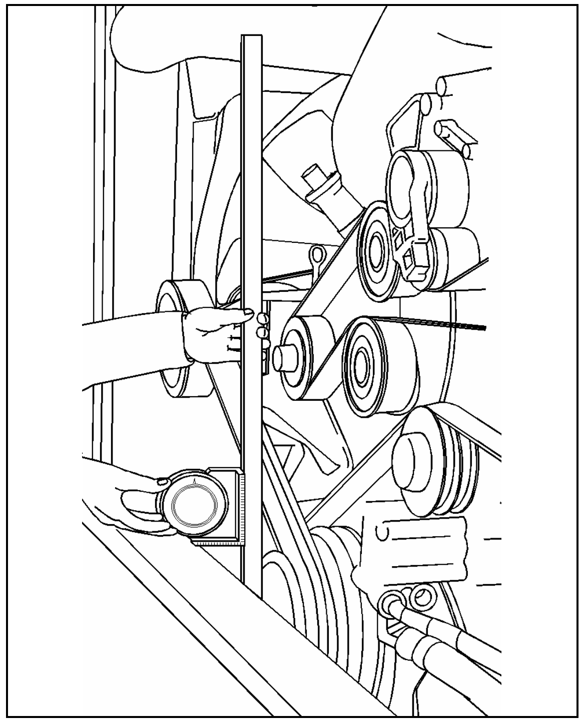


FIGURE 21: PULLEY VERTICAL ANGLE 05063

6. Align multi "V" pulley with fan pulley. Adjust the depth of the pulley on the gearbox shaft.
7. Set belt tensioner pressure regulating valve to 50 PSI - 345 kPa.

⚠ CAUTION ⚠
In order for tensioning system to work properly, adjust upper tensioning bracket to provide a ¼" (7 mm) gap between stopper and bracket. Otherwise, release tension on system and readjust distance using bolts securing upper tensioning bracket (Fig. 18).

.

14. SPECIFICATIONS

Cooling System Capacity (Approximation)

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

Thermostat

Number used.. 2
Start to open.. 186-193°F (86-89°C)
Fully open.. 207°F (97°C)

Radiator

Make.. Valeo
Location.. Rear L.H. side
<u>XL2 Coaches, W0 & WE MTH</u>
Supplier number.. 1040153
Prevost number.. 550820
<u>W5 MTH</u>
Supplier number.. 1040149
Prevost number.. 550819

Surge Tank Filler Cap

Make.. Stant
Model.. R3
Prevost number.. 052355

Pressure Cap

Make.. Stant
Pressure setting.. 14 psi (96.53 kPa)
Supplier number.. R12
Prevost number.. 550606

Fan Clutch

Make.. Linnig
Type.. 3 speed
<u>XL2 Buses</u>
Supplier number.. LA1.2.0118
Prevost number.. 550837
<u>XL2 MTH</u>
Supplier number.. LA1.2.0131Y
Prevost number.. 550839

Note: *The fan clutch is controlled by DDEC (not by thermoswitch).*

Fan Gearbox

Make.. Superior Gearbox
Ratio.. 1:1
Supplier number.. 411ACF-097-6
Prevost number.. 550789
Lubricating Oil.. MOBIL SHC 630
Prevost number (Oil).. 683666

Fan Belt (gearbox-fan)

Make .... Dayco
Type .... Poly-V
Qty 1

XL2 Coaches, W0 & WE XL2 MTH:

Supplier number .... 10-55”
Prevost number 506684

W5 XL2 MTH:

Supplier number 12 PK-2100
Prevost number 507627

Fan Belt (gearbox-motor)

Make .... Dayco
Type .... V belt
Qty 3

XL2 Coaches:

Supplier number AX-71
Prevost number 505522

W0 & WE XL2 MTH:

Supplier number AX-73
Prevost number 506691

W5 XL2 MTH:

Supplier number 3/BX-77
Prevost number 509822

Coolant

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

Corrosion Inhibitor and Coolant Stabilizer

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

Coolant Filter

Number used 1
Make .... Nalco
Type .... Spin-on

MAINTENANCE ELEMENT FILTER

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

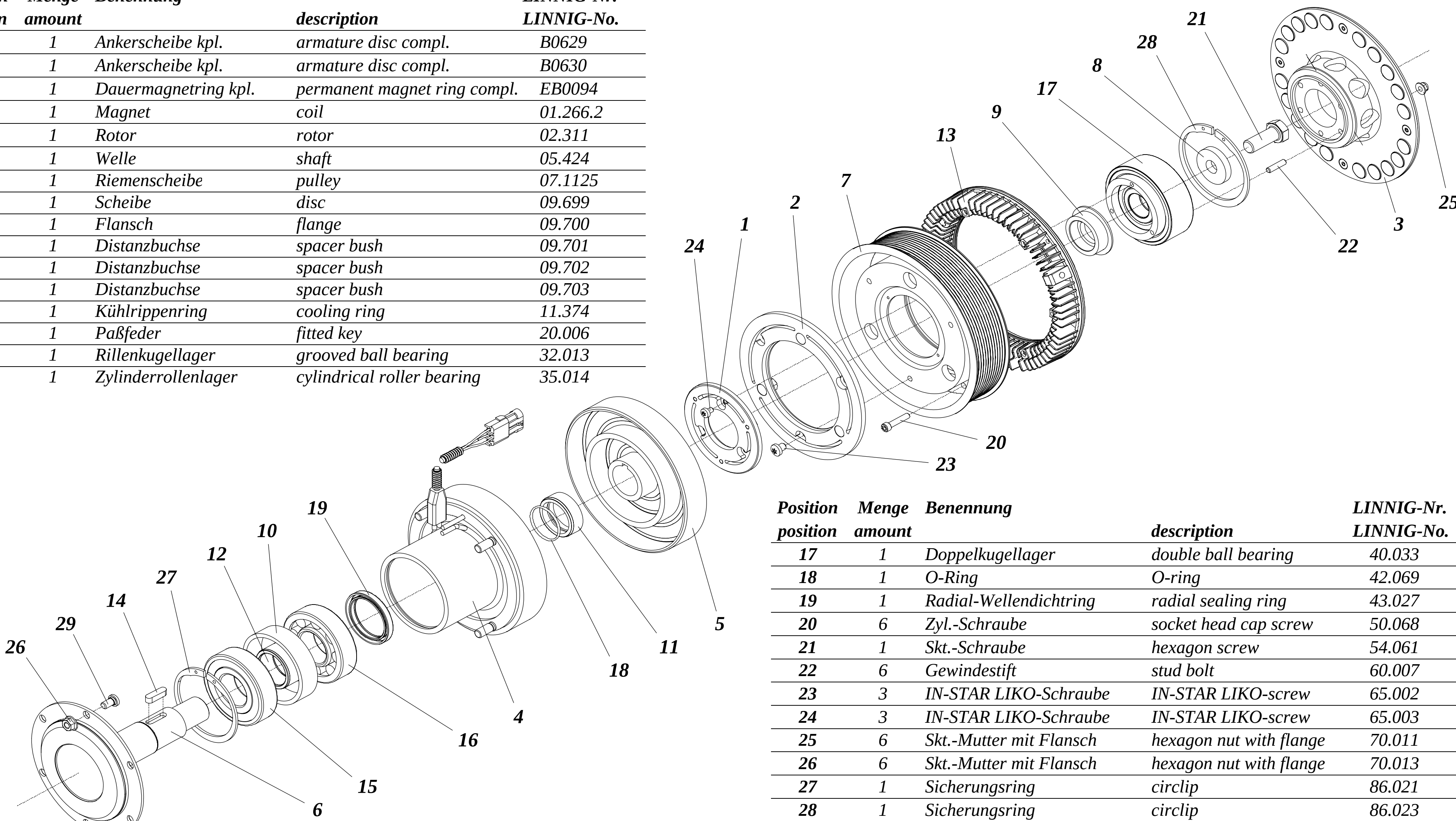
PRECHARGE ELEMENT FILTER

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

LINNIG
Antriebstechnik GmbH
Riedheimer Str.5
D - 88677 Markdorf

Ersatzteilliste / spare part list LA1.2.0131Y

Position *position*	**Menge** *amount*	**Benennung**	*description*	**LINNIG-Nr.** *LINNIG-No.*
1	1	*Ankerscheibe kpl.*	*armature disc compl.*	*B0629*
2	1	*Ankerscheibe kpl.*	*armature disc compl.*	*B0630*
3	1	*Dauermagnetring kpl.*	*permanent magnet ring compl.*	*EB0094*
4	1	*Magnet*	*coil*	*01.266.2*
5	1	*Rotor*	*rotor*	*02.311*
6	1	*Welle*	*shaft*	*05.424*
7	1	*Riemenscheibe*	*pulley*	*07.1125*
8	1	*Scheibe*	*disc*	*09.699*
9	1	*Flansch*	*flange*	*09.700*
10	1	*Distanzbuchse*	*spacer bush*	*09.701*
11	1	*Distanzbuchse*	*spacer bush*	*09.702*
12	1	*Distanzbuchse*	*spacer bush*	*09.703*
13	1	*Kühlrippenring*	*cooling ring*	*11.374*
14	1	*Paßfeder*	*fitted key*	*20.006*
15	1	*Rillenkugellager*	*grooved ball bearing*	*32.013*
16	1	*Zylinderrollenlager*	*cylindrical roller bearing*	*35.014*

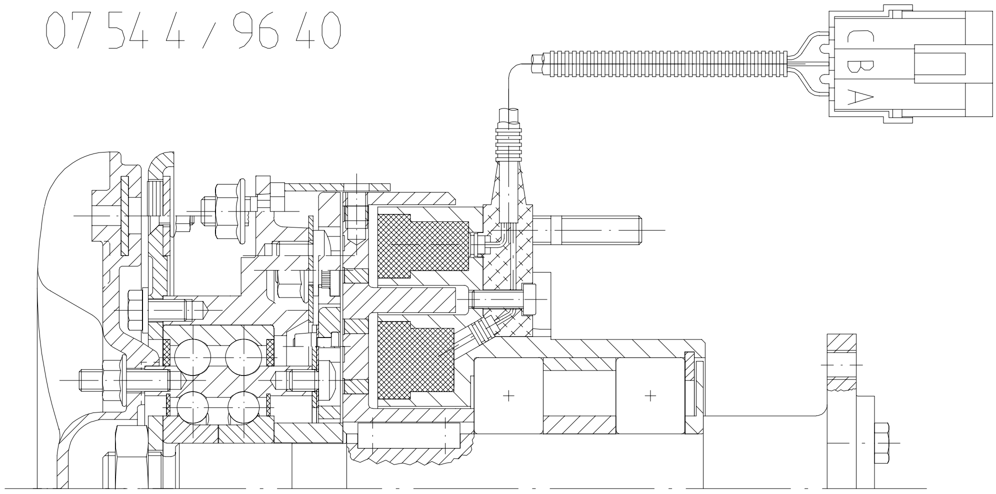


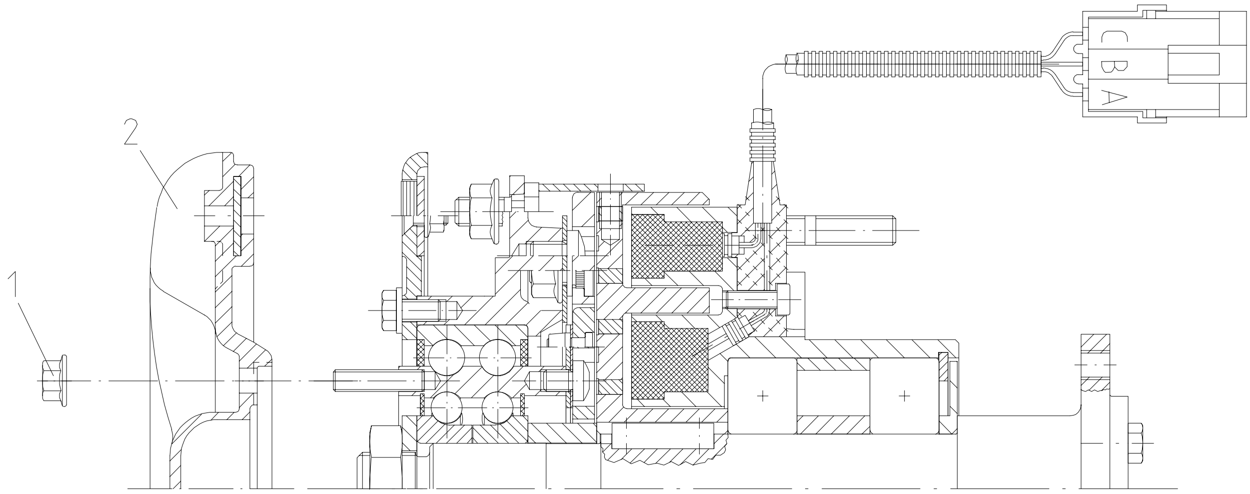
Position *position*	**Menge** *amount*	**Benennung**	*description*	**LINNIG-Nr.** *LINNIG-No.*
17	1	*Doppelkugellager*	*double ball bearing*	*40.033*
18	1	*O-Ring*	*O-ring*	*42.069*
19	1	*Radial-Wellendichtring*	*radial sealing ring*	*43.027*
20	6	*Zyl.-Schraube*	*socket head cap screw*	*50.068*
21	1	*Skt.-Schraube*	*hexagon screw*	*54.061*
22	6	*Gewindestift*	*stud bolt*	*60.007*
23	3	*IN-STAR LIKO-Schraube*	*IN-STAR LIKO-screw*	*65.002*
24	3	*IN-STAR LIKO-Schraube*	*IN-STAR LIKO-screw*	*65.003*
25	6	*Skt.-Mutter mit Flansch*	*hexagon nut with flange*	*70.011*
26	6	*Skt.-Mutter mit Flansch*	*hexagon nut with flange*	*70.013*
27	1	*Sicherungsring*	*circlip*	*86.021*
28	1	*Sicherungsring*	*circlip*	*86.023*
29	6	*Einpress-Gewindebolzen*	*press-in bolt*	*120.017*

Blatt 1/1 Ersteller: Metzner Stand: 15. Nov. 2002 Revision: A 142.182

Repair instructions
for LA1.2.0118Y and LA1.2.119Y

LINNIG
Antriebstechnik GmbH
Box 1430
88672 Markdorf
07 54 4 / 96 40





1) Loose hexagon head nut M6 (1).

2) Remove aluminium fan (2) by hand.
Mind the acceleration of the
permanent magnets.

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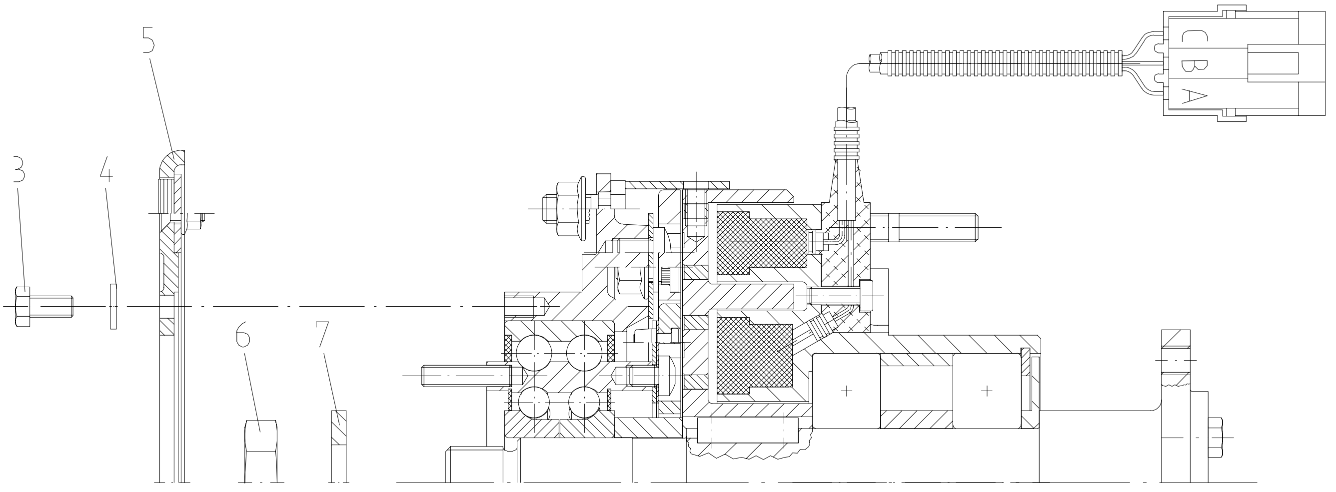
11.11.02
Meckes

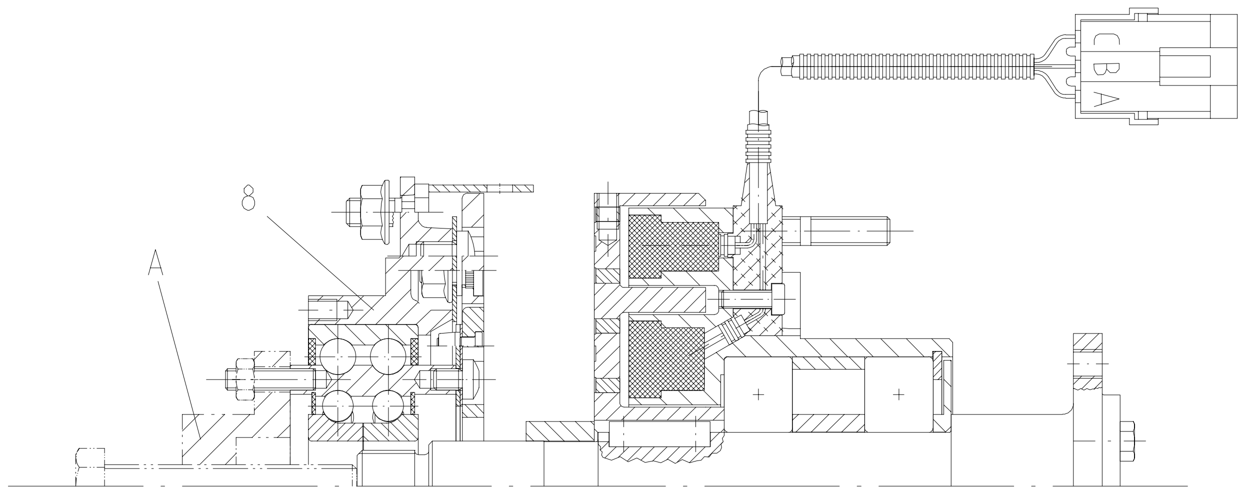


3) Loose hexagon head screw (3) and remove washers (4).

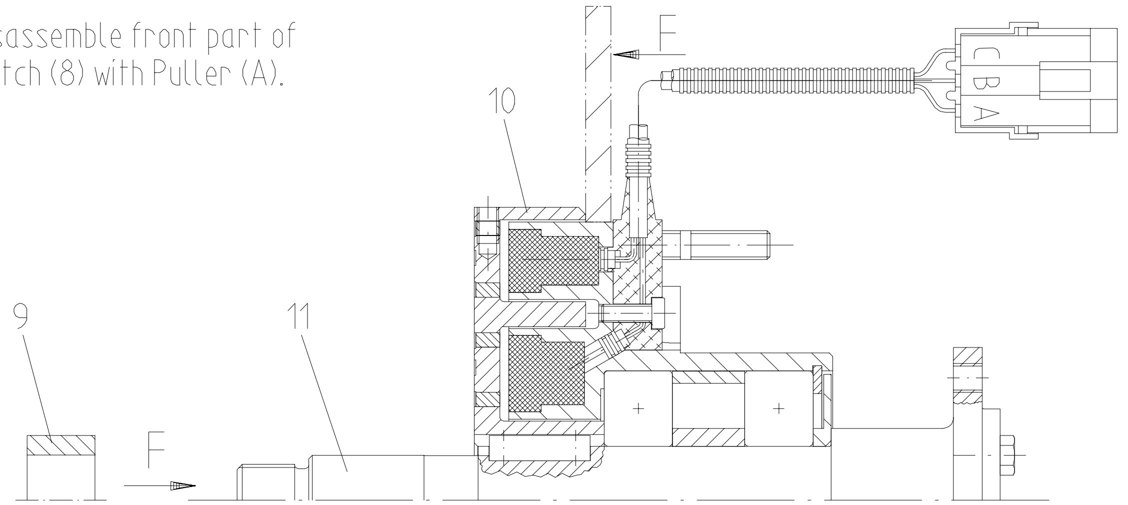
4) Dismantle the permanent magnet ring (5).

5) Remove fan.

6) Remove hexagon head nut M20×1.5 (6). Remove washer (7).



7) Disassemble front part of clutch (8) with Puller (A).

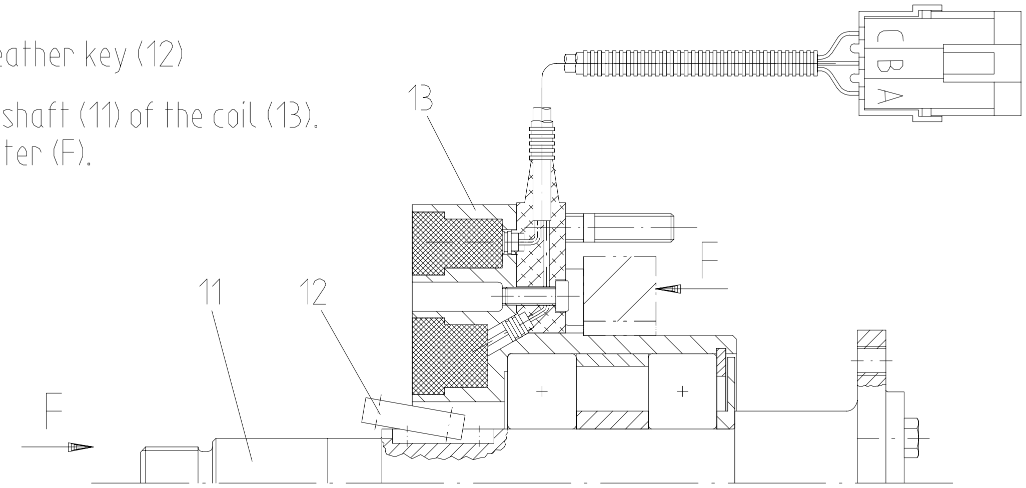


8) Remove spacer (9).

9) Press the shaft (11) of the rotor (10). Follow the letter (F).

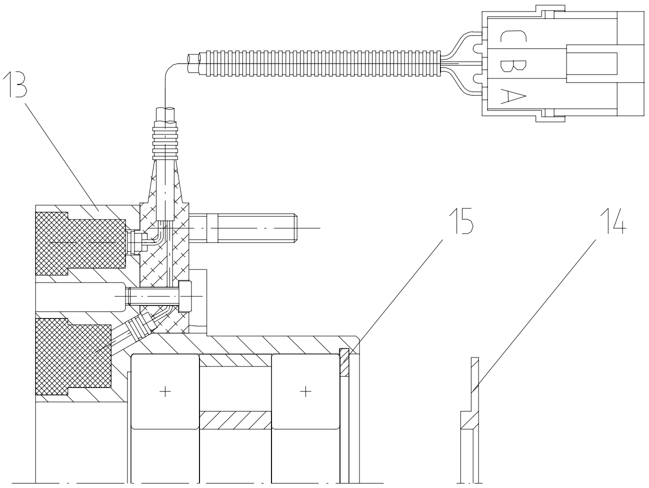
10) Remove feather key (12)

11) Press the shaft (11) of the coil (13).
Follow letter (F).



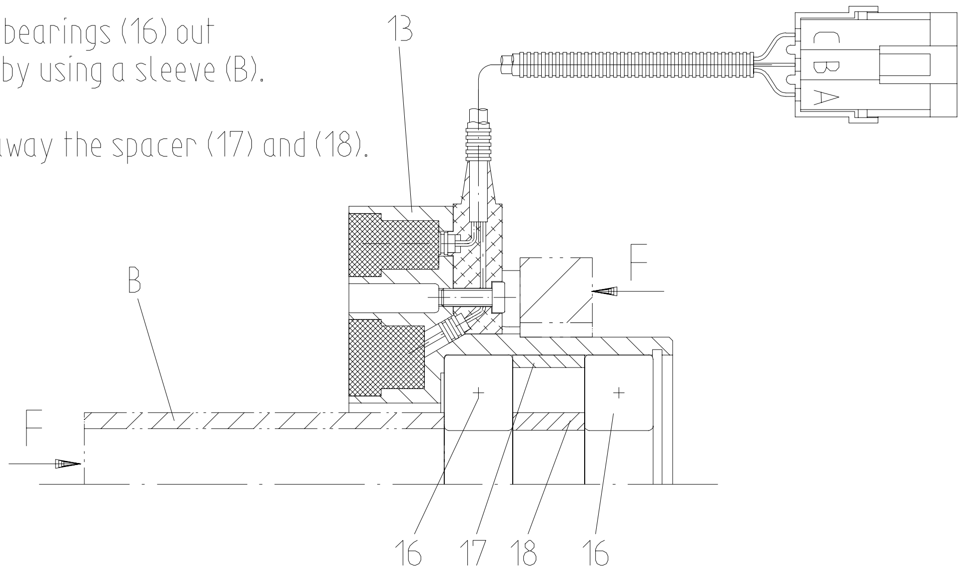
12) Remove gasket (14) from shaft.

13) Take out circlip (15) from coil (13).



14) Press the ball bearings (16) out
of the coil (13) by using a sleeve (B).

15) Don't through away the spacer (17) and (18).

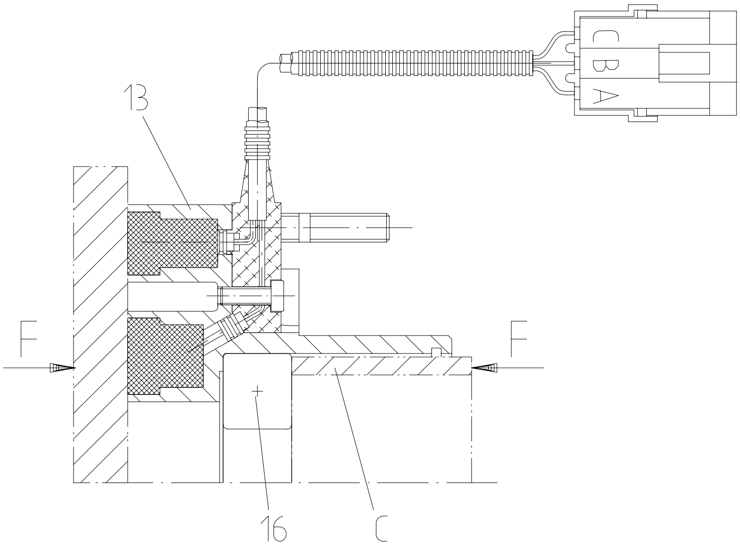


Renew the following parts
when reassemble the clutch:

clutch-front-part (8)	LINNIG No. EB0095
rotor (10)	LINNIG No. 02.264
2 × ball bearings (16)	LINNIG No. 32.005

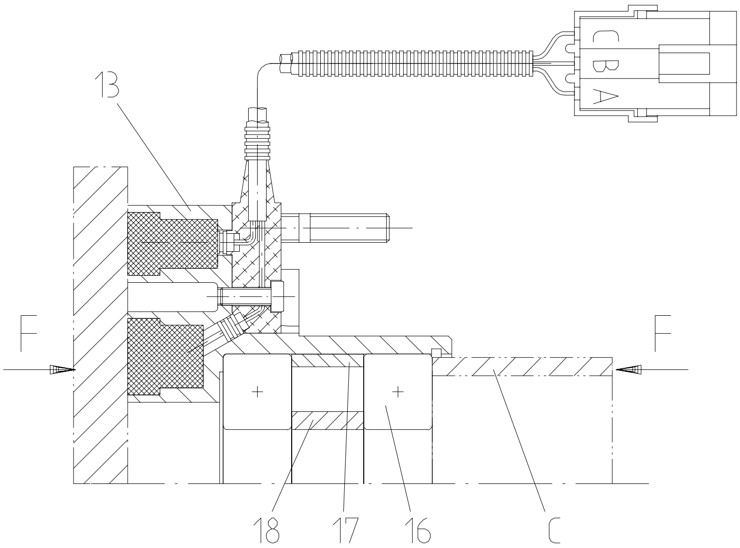
Assembly instruction

16) Press the ball bearing (16)
into the coil (13).
(Note: Press only the outer ring
of the bearing. See (F).

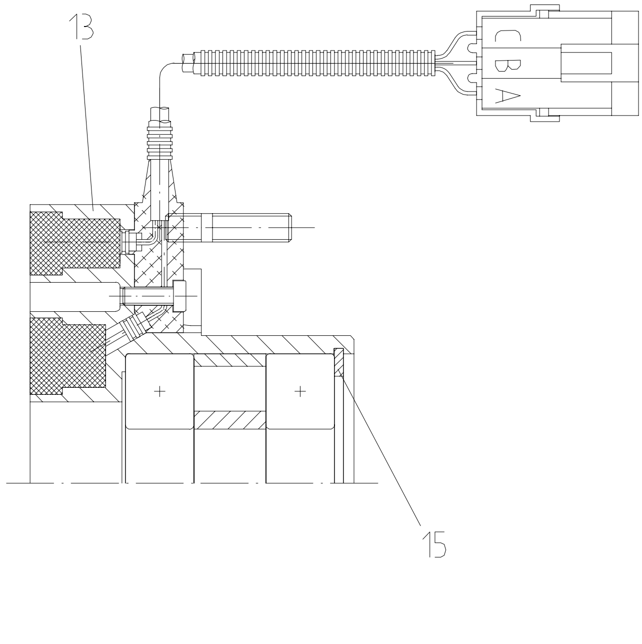


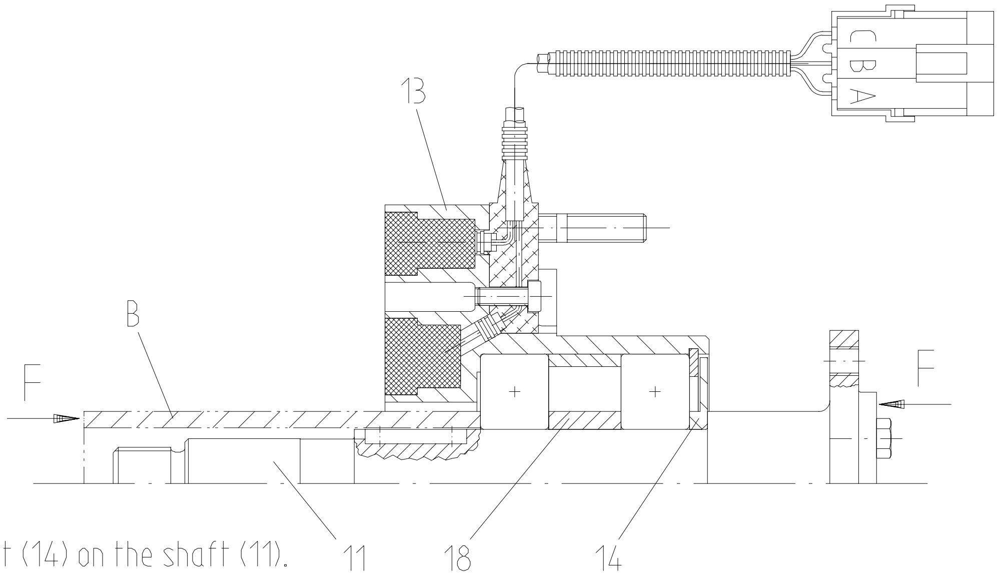
17) Insert spacer (17) and (18)
into the coil (13).

18) Press the ball bearing (16)
into the coil (13).
(Note: Press only on the
outer ring of the bearing.
See (F).



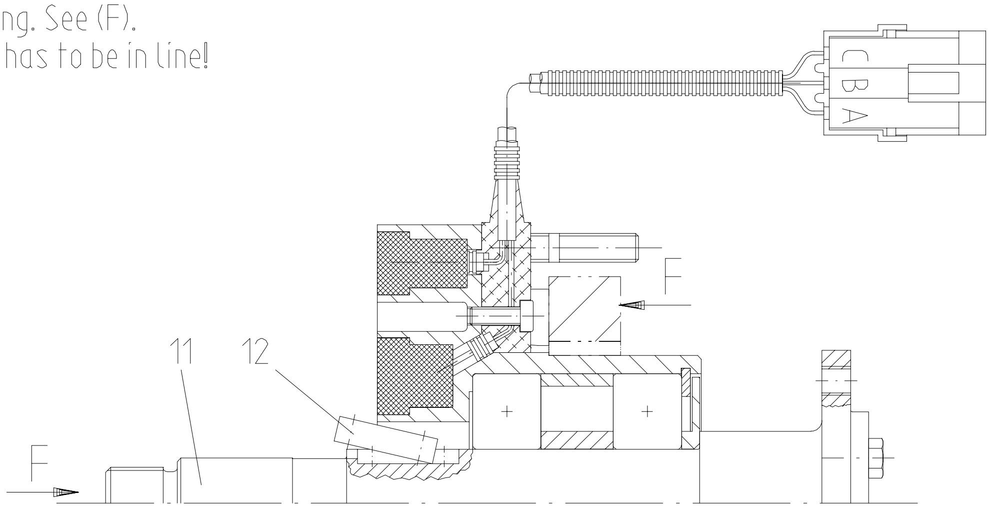
19) Replace circlip (15)
into the coil (13).



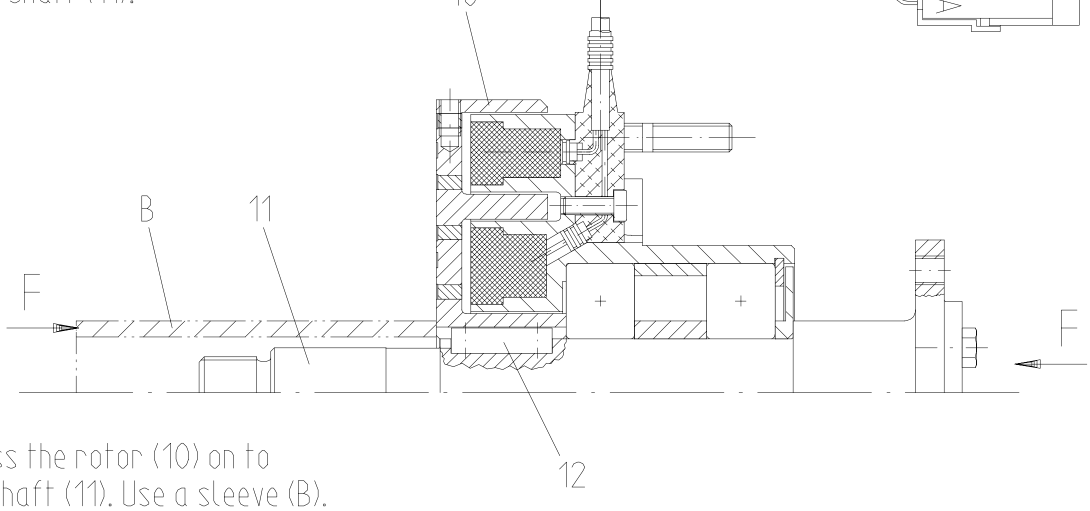


20) Push gasket (14) on the shaft (11).
(Take care for the right position)

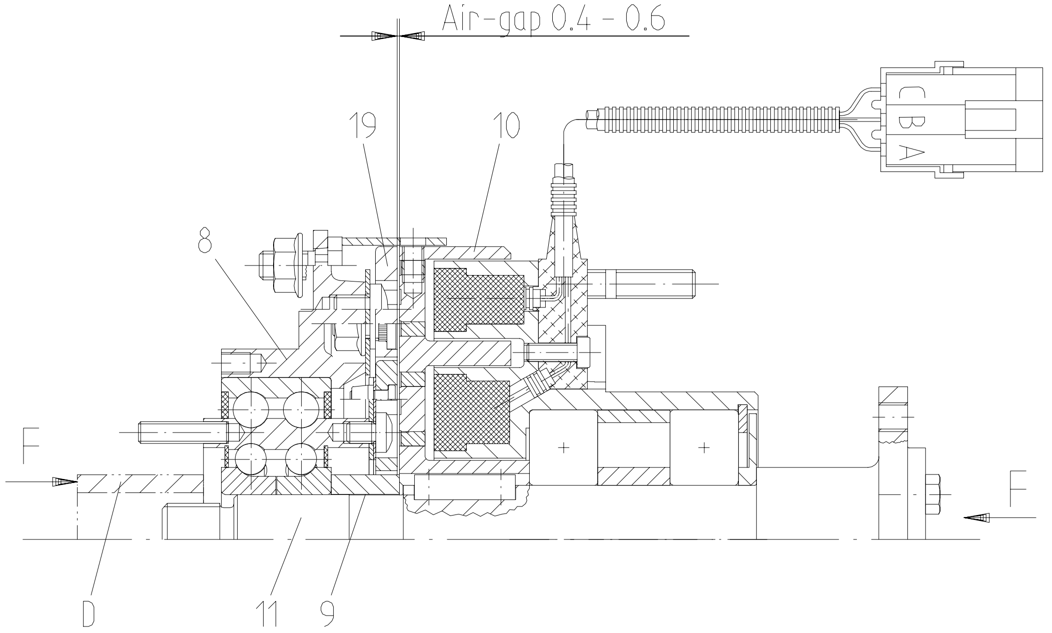
21) Press the coil (13) onto the shaft (11).
(Note: Press only the inner ring
of the bearing. See (F).
Spacer (18) has to be in line!



22) Insert feather key (12)
into shaft (11).



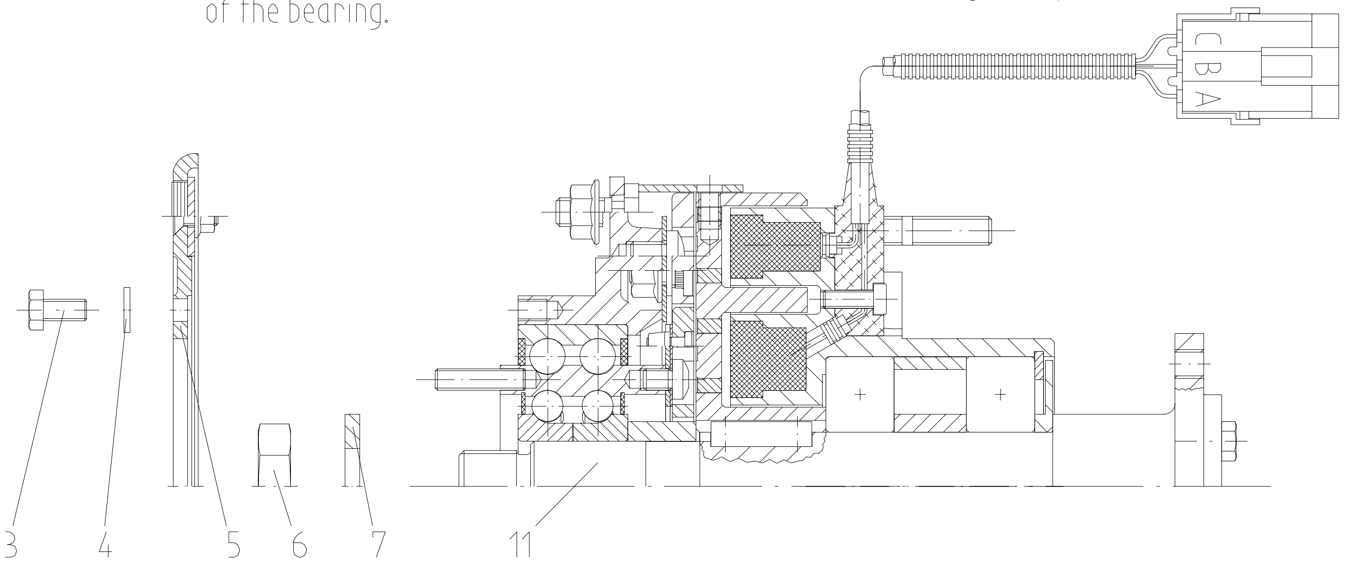
23) Press the rotor (10) on to
the shaft (11). Use a sleeve (B).
Look after the position of the feather key (12).



24) Push spacer (9) on to the shaft (11).

25) Press the clutch front part (8) with sleeve on to the shaft. Press only on the inner ring of the bearing.

26) Check the air-gap 0.4 - 0.6 mm between rotor (10) and core disc (19). If necessary put toleranced washers between bearing inner ring and spacer (9).



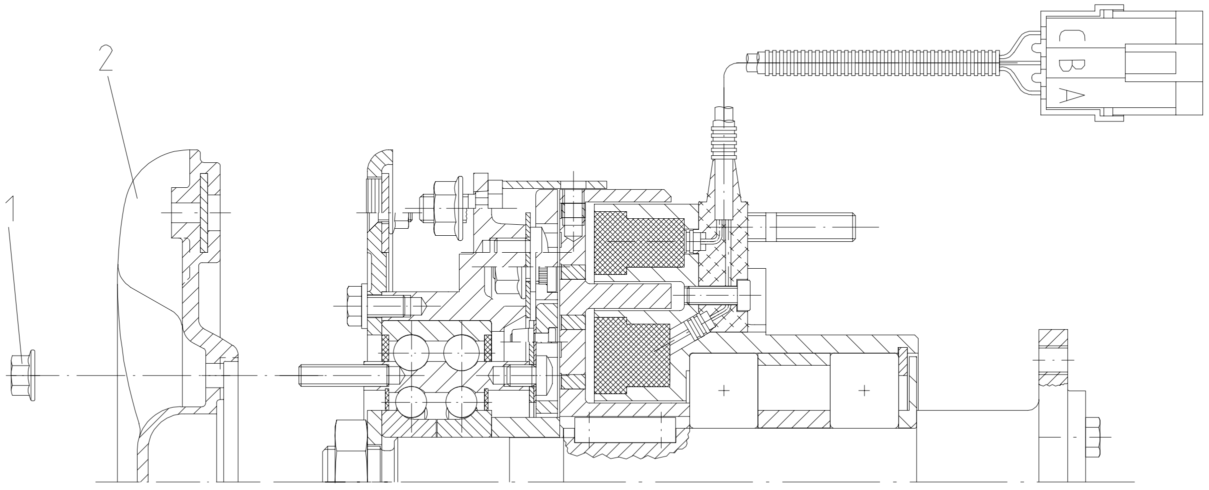
27) Push washer (7) on to the shaft (11).

28) Assemble hexagon head nut M20×1.5 (6). Torque Ma = 90 Nm Secure hexagon head nut with locking paint

29) Assemble fan.

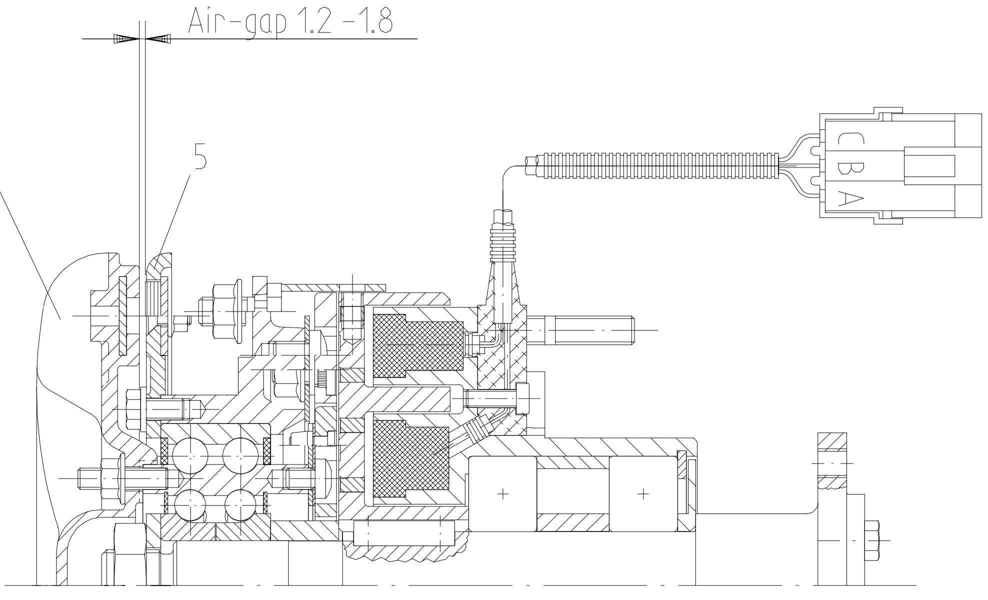
30) Assemble permanent magnet ring (5)

31) Bolt the permanent magnet ring (5) with three hexagon head screws M6×12-8.8 and washers (4) on to the clutch front part. Torque Ma = 10 Nm



32) Assemble aluminium fan (2).

33) Screw the aluminium fan (2)
on to the clutch front part
with hexagon head nut M6-8 (1).
Torque Ma = 10 Nm



34) Check air-gap 1.2 - 1.8 mm between
fan (2) and permanent magnet ring (5).

CONTENTS

ILLUSTRATIONS

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 “Delco” model 1150 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. One or two 24 volt self-rectified alternators are belt driven from the engine, and can be reached through the engine compartment door.

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.

1.1.1 Wiring Diagram Keys

Various symbols are used on the wiring diagrams to depict different types of electrical components. It is essential to become familiar with these symbols in order to understand the diagrams. The major symbols shown on the diagrams are identified under *"Wiring Diagram keys"* (page **K** of wiring diagrams).

1.1.2 Using Wiring Diagrams

Two 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 #56 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 CB #56, in the first column, you will find the page on which to find the corresponding diagram, in the second column the breaker ampere rating, and in the third column, the Prévost number. The other columns give you the location and the function of the breaker.

c) Refer to page 4, keeping in mind the function of the breaker, i.e. emergency exit lights.

d) When you have located *“emergency exit lights”,* follow the wiring until you come across CB #56 and its circuit.

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.

a) Refer to wiring diagram index and look for *“Sound system”.*

b) You will find on page 26 the components as well as the electric wiring, thus providing you with a complete understanding of this circuit.

1.1.3 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:

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.

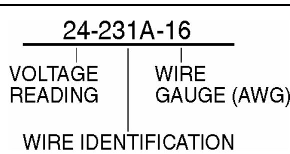


FIGURE 1: WIRE IDENTIFICATION 06048

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.

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.

⚠ WARNING ⚠

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 in the engine compartment, on R.H. side of the vehicle or in the main power depending on type of vehicle. The remaining breakers are located in the evaporator compartment, inside the A/C junction box.

CIRCUIT BREAKERS			
CB1	A/C Full Air	24 volts	200 amps
CB2	Hot Wire	12 volts	40 amps
CB3	Rear Junction Box	12 volts	70 amps
CB4	Front Junction Box	12 volts	90 amps
CB5	Hot Wire	24 volts	30 amps
CB6	Rear Junction Box	24 volts	90 amps
CB7	Front Junction Box	24 volts	90 amps
CB8	Condenser Fan Motor L.H.	24 volts	40 amps
CB9	Evaporator Fan Motor	24 volts	120 amps
CB11	Condenser Fan Motor R.H.	24 volts	40 amps

The smaller circuit breakers are accessible in the front service compartment and rear junction box. 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.

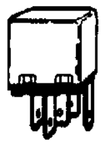
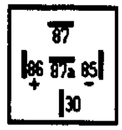
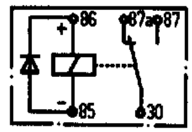
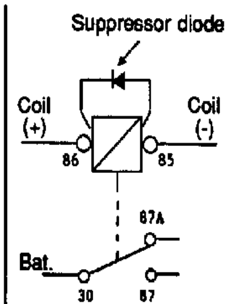
1.6 RELAYS

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.

Many systems on this vehicle are provided with control relays, which are all, located in or on the junction boxes, figure 2.

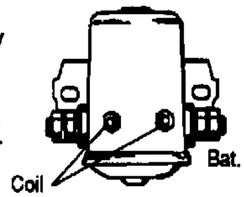
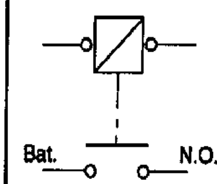
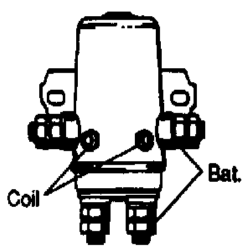
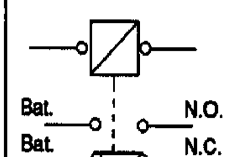
NOTE
Each relay is identified with “12V” or “24V” printed on its casing in order to identify the coil operating voltage.

⚠ CAUTION ⚠
The magnetic relays for the starting motor, evaporator and both condenser motors and condenser speed controls should have the 5/16" stud nuts torqued to 50 ± 5 lbf-in (5,5 ± 0,5 Nm).

	Configuration on base	Key printed on casing	Key used on wiring diageam	Example
Cubic relay (Steel or plastic casing) Type: S.P.D.T. 				R #5

NOTE: This relay is provided with an internal suppressor diode; never reverse wiring terminals #85 and 86 at base as a direct short circuit will result.

The relay coils connected to the alternator "relay terminal" should never be provided with a suppressor diode as the output current at this terminal is not rectified, thus rendering relay inoperative.

Magnetic relay (Round steel casing) Type: S.P.S.T. 	None	None		R #4
Magnetic relay (Round steel casing) Type: D.P.D.T. 	None	None		R #40

LEGEND

Bat.	**Battery**
N.O.	**Normally Open**
N.C.	**Normally Closed**
S.P.D.T.	**Single Pole Double Throw**
S.P.S.T.	**Single Pole Single Throw**
D.P.D.T.	**Double Pole Double Throw**

FIGURE 2: TYPES OF RELAYS 06050

2. XL2 COACHES ELECTRICAL COMPARTMENTS AND JUNCTION BOXES

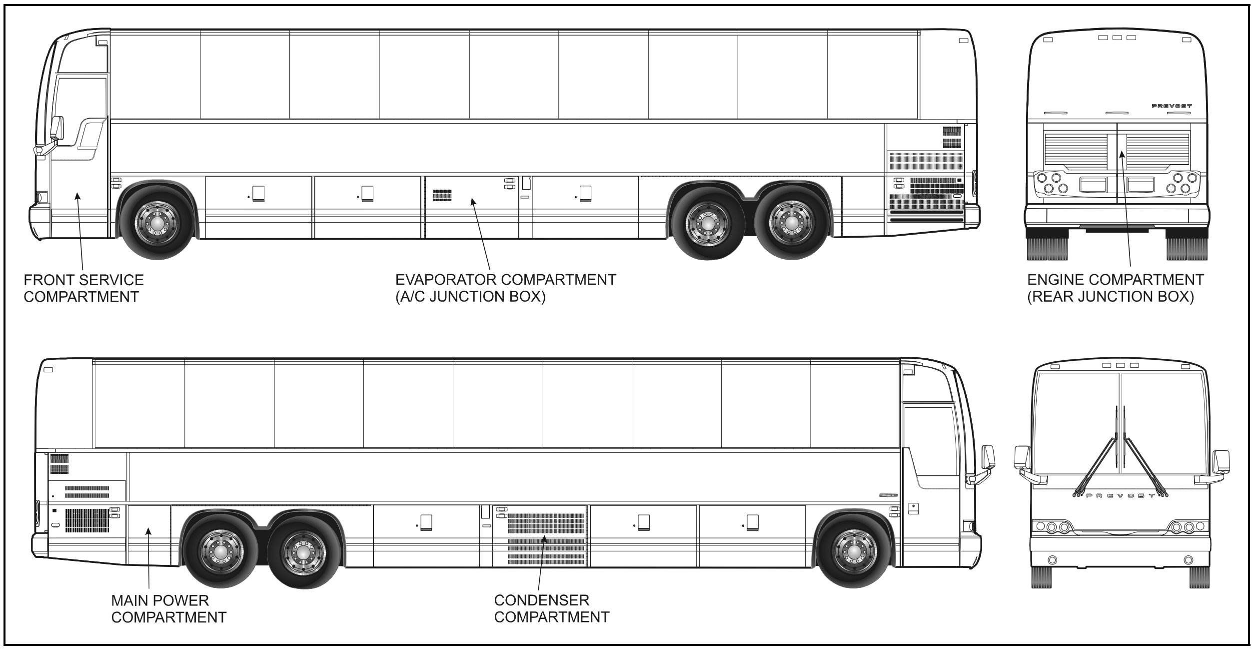


FIGURE 3: ELECTRICAL COMPARTMENT (XL2-45 COACH) 06541

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.

⚠ WARNING ⚠

Use VIC-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.

2.2 BOOSTER BLOCK

On XL2-45 coaches, booster block is located in the main power compartment (Fig. 4).

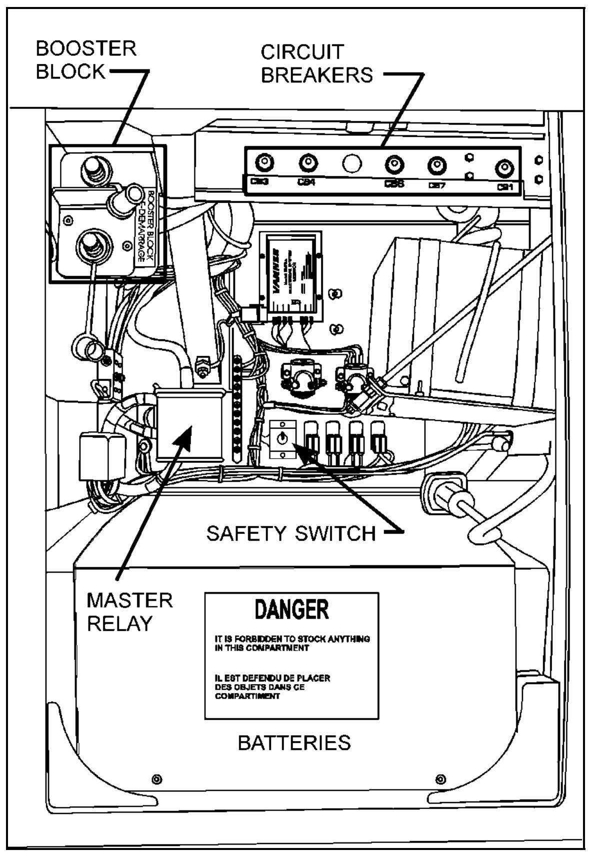


FIGURE 4: MAIN POWER COMPARTMENT (XL2-45) 06316

2.3 BATTERY SAFETY SWITCH

This switch disconnects both the 12 and 24 volts. This toggle switch is located in the main power compartment (XL2-45).

⚠ CAUTION ⚠
During repair or maintenance periods, set battery safety switch to the "OFF" position in order to avoid personal injury. This ensures that power is cut off even if master key switch is set to the “ON” position by mistake. When master key switch is set to the “OFF” position, electrical supply from the batteries is automatically cut off.

NOTE
When battery safety switch or master 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.

2.4 BATTERIES

The batteries are located in the main power compartment on the XL2-45 coach.

Electric Circuit Protection

Two types of cutoff mechanisms are installed to protect the vehicle's electrical system; fuses and manually-resettable circuit breakers. If an electrical device is inoperative, check the corresponding cutoff mechanism.

⚠ CAUTION ⚠
Never replace a fuse with a higher rated one because it will cause severe damage to the electric system.

2.5 CIRCUIT BREAKERS

Most of the manually-resettable circuit breakers are located in the: A/C junction box, rear junction box, front service compartment, and in the main power compartment. An identification decal is affixed on the inside face of each door.

XL2-45 coaches are equipped with eight (8) main breakers; they are installed in the main power compartment and in the A/C junction box in the evaporator compartment, they can be identified as follows (Fig. 4, 5, 6 and 7):

1. A/C full air (CB1) 200 A - 24 volts;
2. Front junction box (CB7) 90 A - 24 volts;
3. Rear junction box (CB6) 90 A - 24 volts;
4. Direct (CB4) 90 A - 12 volts;
5. Rear junction box (CB3) 70 A - 12 volts;
6. Condenser fan motor L.H. (CB8) 40 A - 24 volts;
7. Evaporator fan motor (CB9) 120 A - 24 volts;
8. Condenser fan motor R.H. (CB11)40 A - 24 volts.

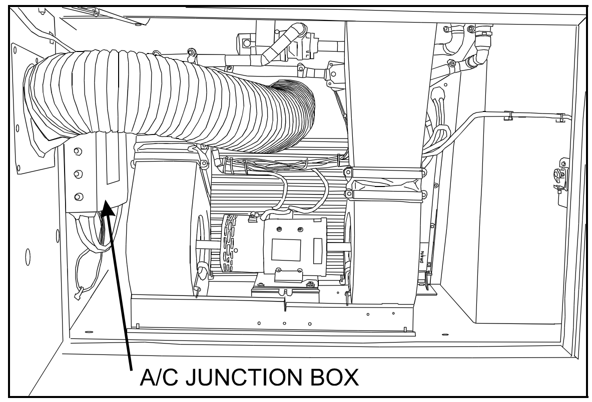


FIGURE 5: LOCATION OF A/C JUNCTION BOX IN EVAPORATOR COMPARTMENT 22244B

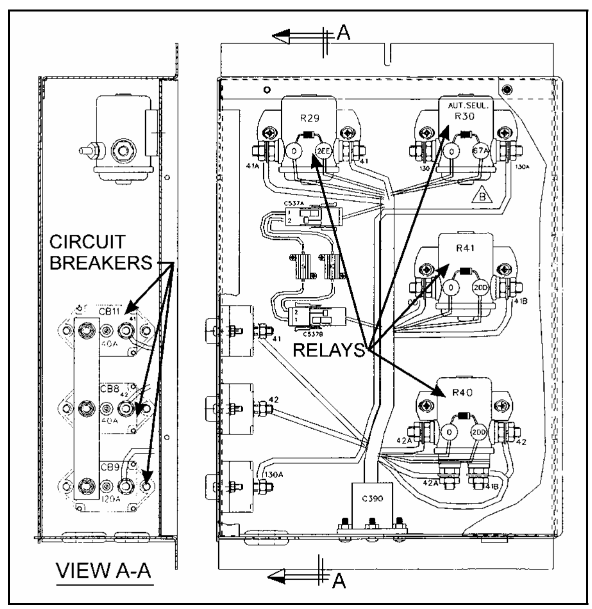


FIGURE 6: A/C JUNCTION BOX 06317

2.6 FRONT SERVICE COMPARTMENT

The front service compartment is located on L.H. side of vehicle, under the driver's window. It contains the following components (Fig. 7 and 8):

- relays;
- breakers;
- alternator module
- diodes;
- World Transmission ECU;
- Electronic control unit for ABS.

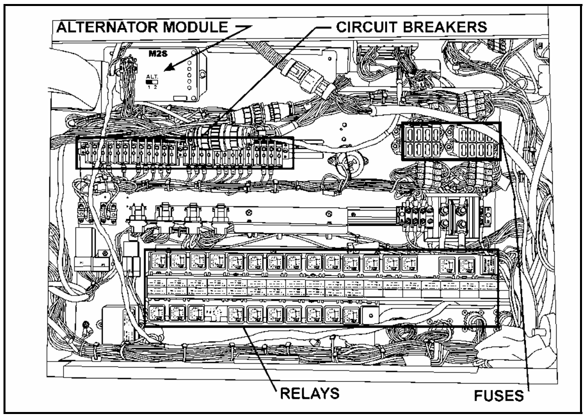


FIGURE 7: TOP SECTION OF FRONT SERVICE COMPARTMENT 06319

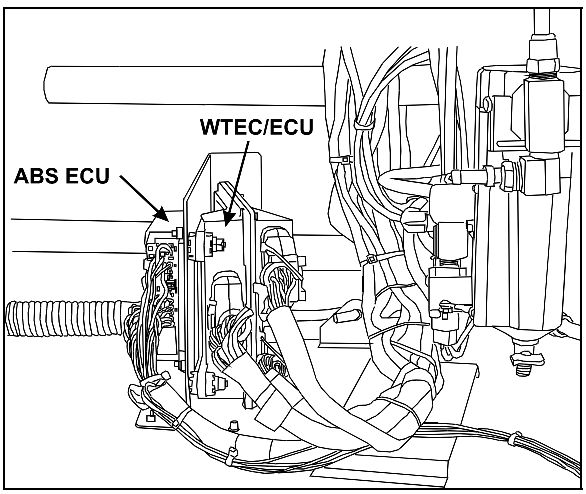


FIGURE 8: BOTTOM SECTION OF FRONT SERVICE COMPARTMENT 06394

DDR connector

To enhance troubleshooting and to allow interrogation of the ECU for valuable service information, a DDR (diagnostic data reader) can be used. To use it, plug the appropriate connector (not furnished by the manufacturer) in the terminal located in the rear junction box or the connector located on L.H. console (refer to fig. 9 and 11). You can also use your push-button shifter to perform certain maintenance operations (see Section 01, Engine, under paragraph "4. DDEC V Diagnostic codes").

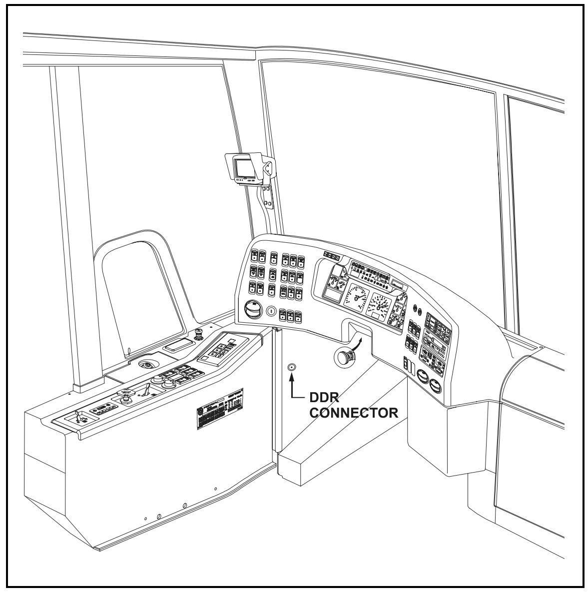


FIGURE 9: DDR CONNECTOR LOCATION IN DRIVER'S AREA 18558

2.6.1 L.H. Side of Front Baggage Compartment (Vehicle Equipped With Video System)

This compartment may contain the following components:

- protective screen (with video system);
- video inverter (with video system);
- Electronic system monitor.

Battery Equalizers

On XL2-45 coach the battery equalizers are located in the main power compartment (Fig. 4).

2.7 ENGINE COMPARTMENT (REAR JUNCTION BOX)

The rear junction box is located in the engine compartment. Switches are located on R.H. side of rear junction box (Fig.10):

- engine compartment light switch;
- starter selector switch;
- Rear start (push button switch).

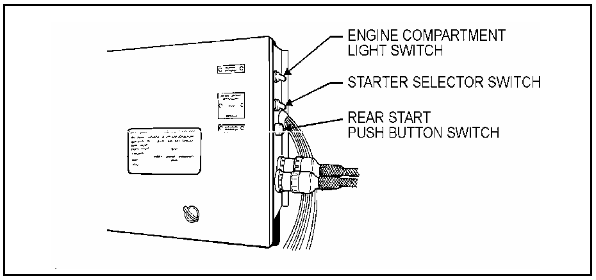


FIGURE 10: REAR JUNCTION BOX SWITCHES 01017

The rear junction box contains the following components (Fig. 11):

- relays;
- breakers;
- diodes;
- time delay relay;
- DDR connector.

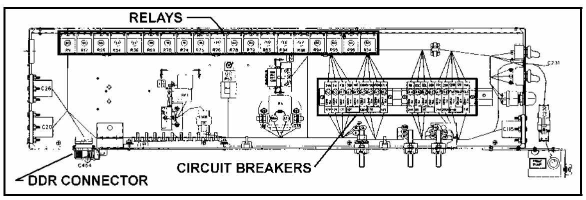


FIGURE 11: REAR JUNCTION BOX 06318

3. XL2 MOTORHOMES ELECTRICAL COMPARTMENTS AND JUNCTION BOXES

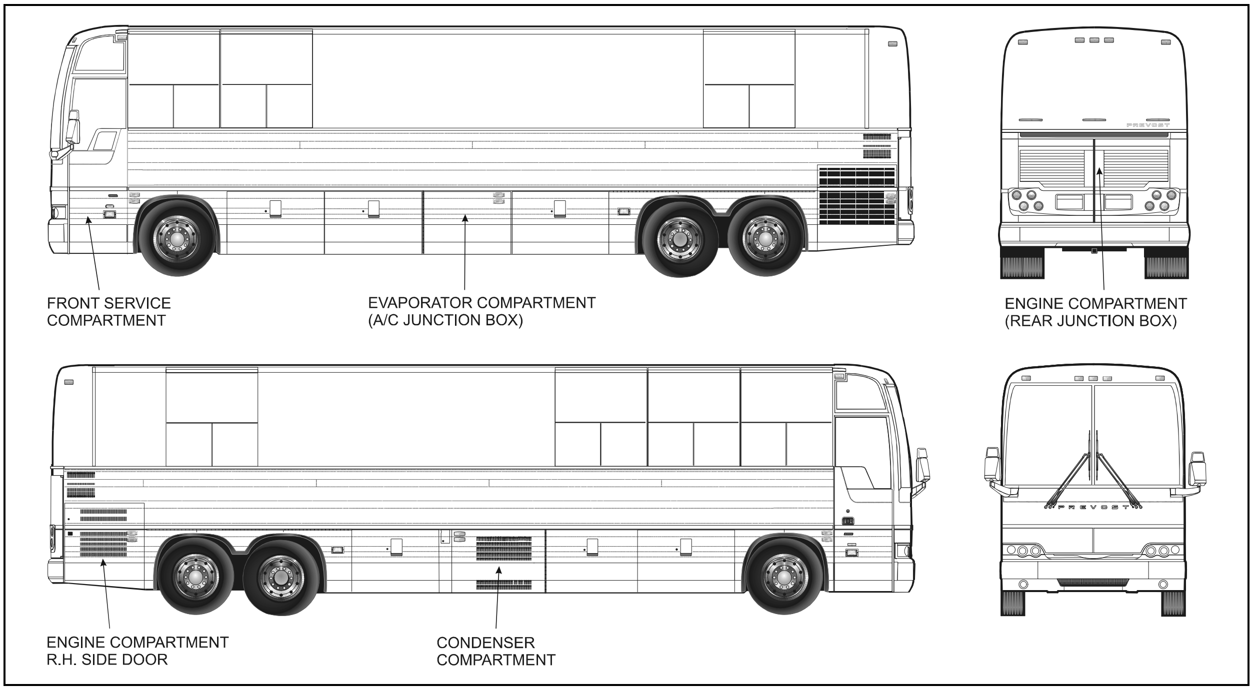


FIGURE 12: ELECTRICAL COMPARTMENTS (XL2-40 BUS SHELLS)
06543

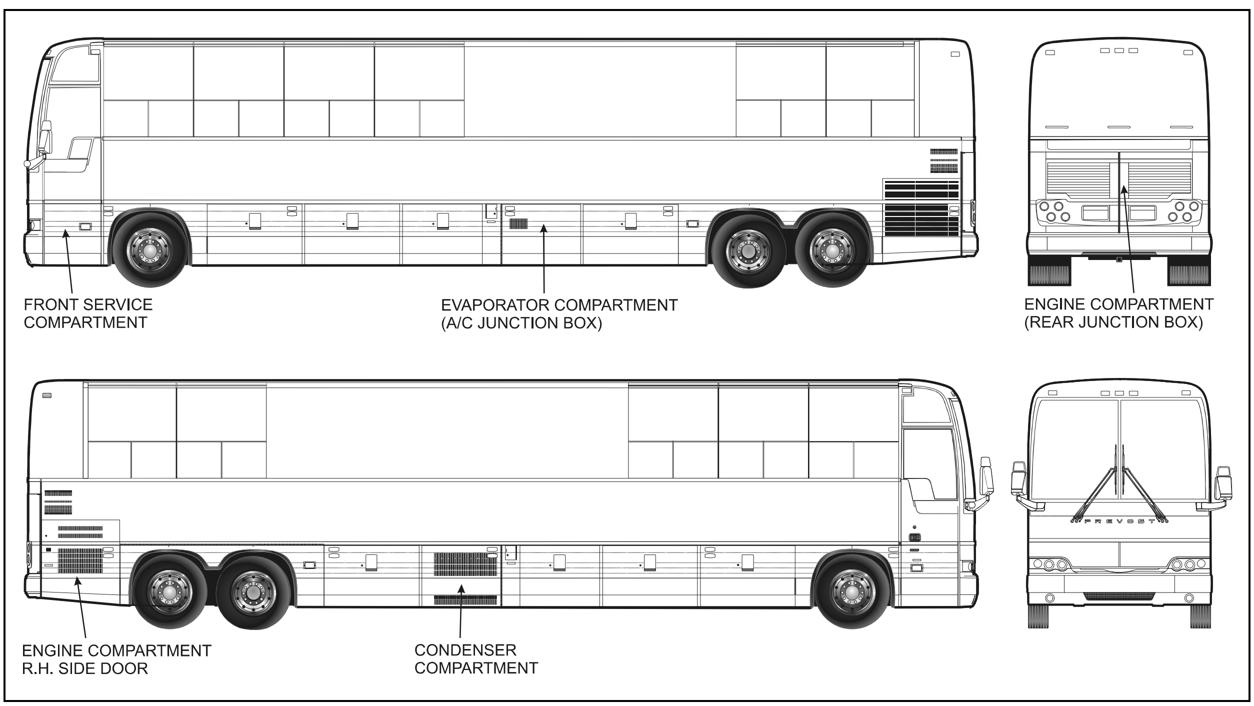


FIGURE 13: ELECTRICAL COMPARTMENTS (XL2-45E BUS SHELLS) 06545

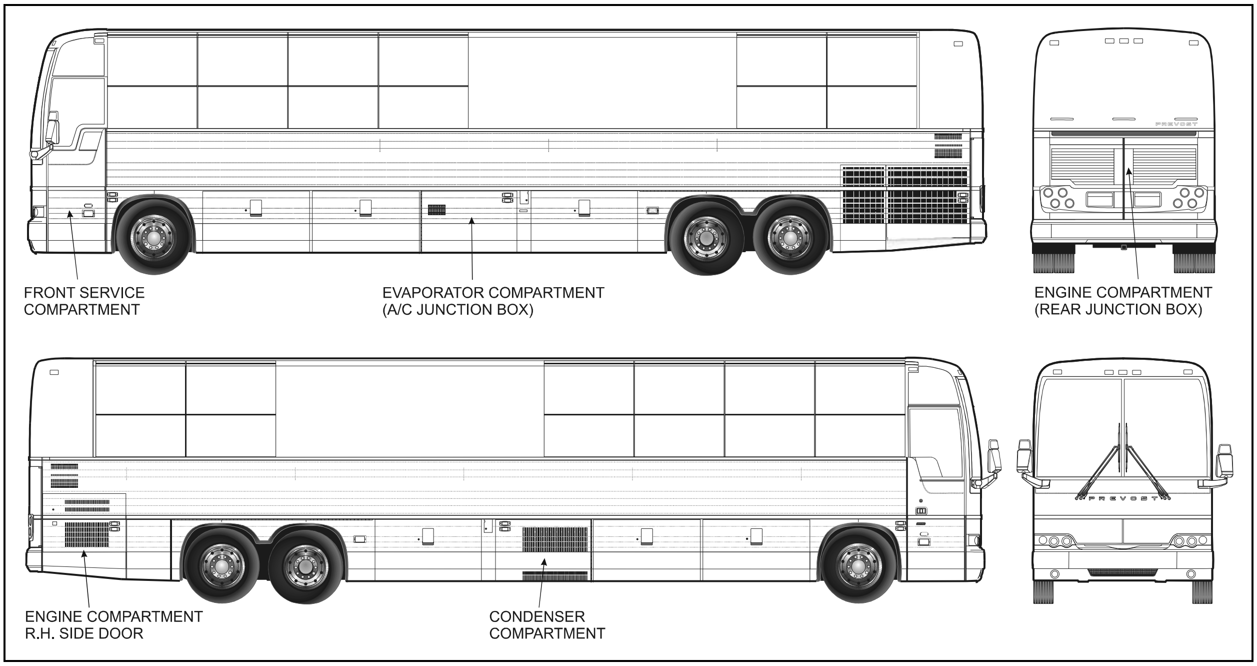


FIGURE 14: ELECTRICAL COMPARTMENTS (XL2-45 BUS SHELLS) 06542

3.1 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.

> ⚠ **WARNING** ⚠
>
> **Use VIC-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.**

3.2 BOOSTER BLOCK

On all XL2 MTH, booster block is located on the breaker panel in the engine compartment on the R.H. side and is accessible through engine R.H. side door (Fig. 15).

3.3 BATTERY SAFETY SWITCH

This switch disconnects both the 12 and 24 volts. This toggle switch is located on the breaker panel in the engine compartment on the R.H. side and is accessible through engine R.H. side door (Fig. 15).

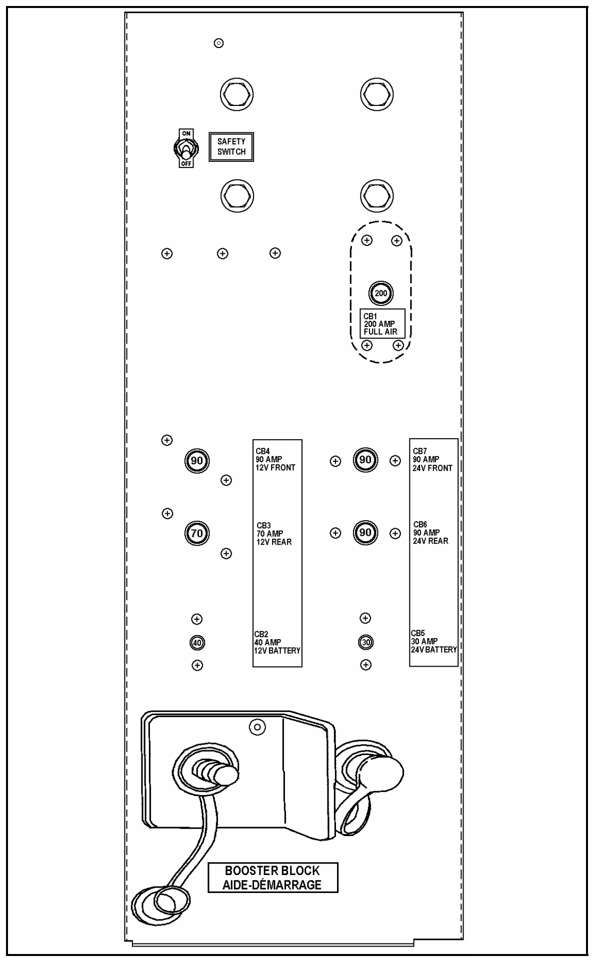


FIGURE 15: BREAKER PANEL 06508

⚠ **CAUTION** ⚠

During repair or maintenance periods, set battery safety switch to the "OFF" position in order to avoid personal injury. This ensures that power is cut off even if master key switch is set to the “ON” position by mistake. When master key switch is set to the “OFF” position, electrical supply from the batteries is automatically cut off.

NOTE

When battery safety switch or master 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.

3.4 BATTERIES

The batteries are located in the engine compartment R.H. side (Fig. 16). The battery arrangement may differ between vehicle types due to available space.

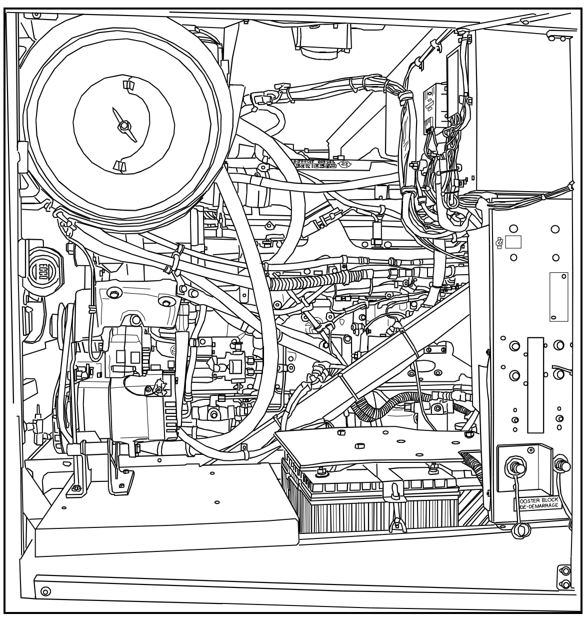


FIGURE 16: ENGINE COMPARTMENT R.H. SIDE 18513

Electric Circuit Protection

Two types of cutoff mechanisms are installed to protect the vehicle's electrical system; fuses and manually-resettable circuit breakers. If an electrical device is inoperative, check the corresponding cutoff mechanism.

⚠ **CAUTION** ⚠

Never replace a fuse with a higher rated one because it will cause severe damage to the electric system.

3.5 CIRCUIT BREAKERS

Most of the manually-resettable circuit breakers are located in the: A/C junction box, rear junction box, front service compartment and in the engine compartment R.H. side. An identification decal is affixed on the inside face of each door.

MTH XL2-40, XL2-45E and XL2-45 may be equipped with ten (10) main breakers; six (6) of which are standard and four (4) are supplied only on vehicles equipped with central A/C system. CB2 to CB7 breakers are standard and CB1, CB8, CB9 and CB11 breakers are optional.

On all vehicles, breakers CB1 to CB7 are installed on breaker panel in engine compartment R.H. side (Fig. 15 & 16). They are accessible through engine R.H. side door and can be identified as follows:

1. A/C full air (CB1) 200 A - 24 volts;
2. Front junction box (CB7) 90 A - 24 volts;
3. Rear junction box (CB6) 90 A - 24 volts;
4. Direct (CB4) 90 A - 12 volts;
5. Rear junction box (CB3) 70 A - 12 volts;
6. Battery CB2) 40 A - 12 volts;
7. Battery (CB5) 30 A - 24 volts;

On all vehicles equipped with central A/C, breakers CB8, CB9 and CB11 are installed in the A/C junction box in the evaporator compartment (Fig. 17 and 18), and are identified as follows:

1. Condenser fan motor L.H. (CB8) 40 A - 24 volts;
2. Evaporator fan motor (CB9) 120 A - 24 volts;
3. Condenser fan motor R.H. (CB11)40 A - 24 volts.

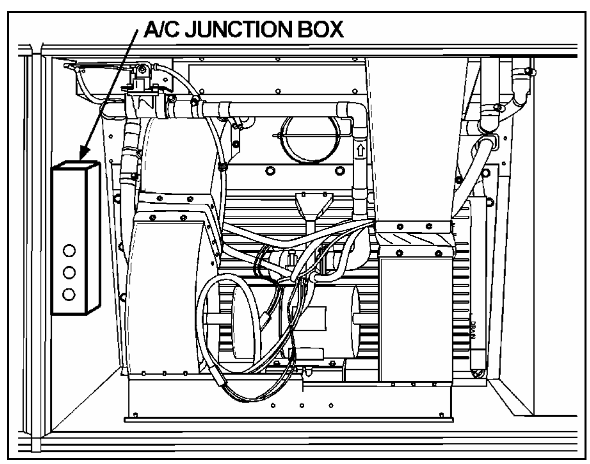


FIGURE 17: LOCATION OF A/C JUNCTION BOX IN EVAPORATOR COMPARTMENT 22178F

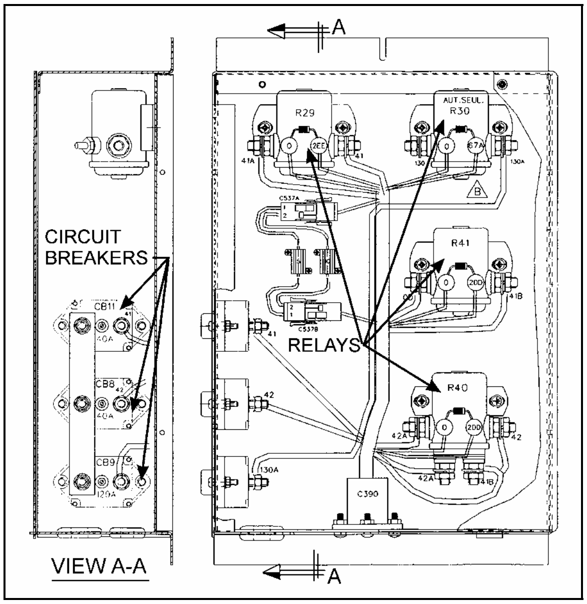


FIGURE 18: A/C JUNCTION BOX 06317

3.6 FRONT SERVICE COMPARTMENT

The front service compartment is located on L.H. side of vehicle, under the driver's window. It contains the following components (Fig. 19 and 20):

- relays;
- breakers;
- alternator module
- diodes;
- World Transmission ECU;
- Electronic control unit for ABS.

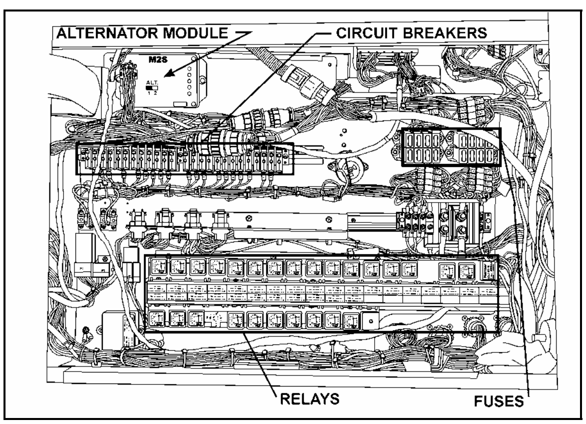


FIGURE 19: TOP SECTION OF FRONT SERVICE COMPARTMENT 06319

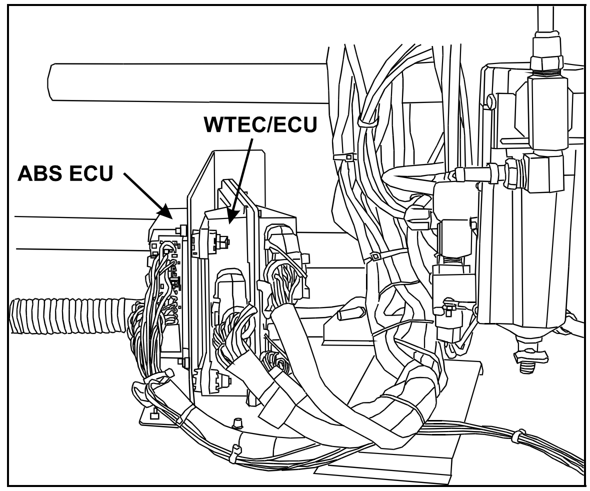


FIGURE 20: BOTTOM SECTION OF FRONT SERVICE COMPARTMENT 06394

DDR connector

To enhance troubleshooting and to allow interrogation of the ECU for valuable service information, a DDR (diagnostic data reader) can be used. To use it, plug the appropriate connector (not furnished by the manufacturer) in the terminal located in the rear junction box or the connector located on L.H. console (refer to fig. 21 and 23). You can also use your push-button shifter to perform certain maintenance operations (see Section 01, Engine, under paragraph "4. DDEC V Diagnostic codes").

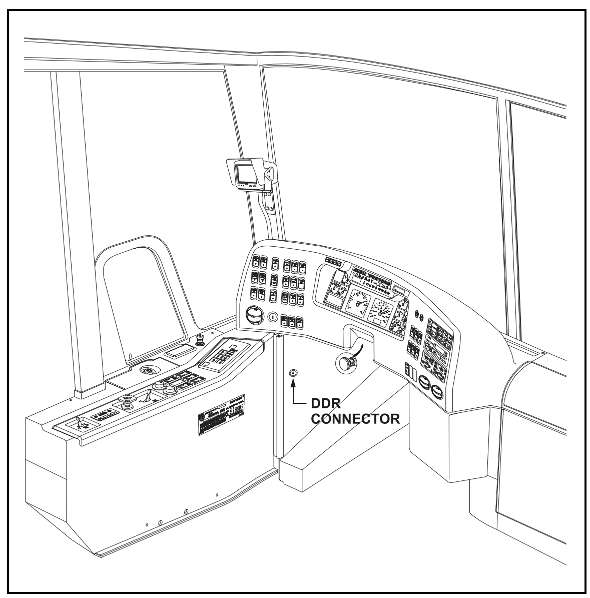


FIGURE 21: DDR CONNECTOR LOCATION IN DRIVER'S AREA 18558

3.7 ENGINE COMPARTMENT (REAR JUNCTION BOX)

The rear junction box is located in the engine compartment. Switches are located on R.H. side of rear junction box (Fig.22):

- engine compartment light switch;
- starter selector switch;
- Rear start (push button switch).

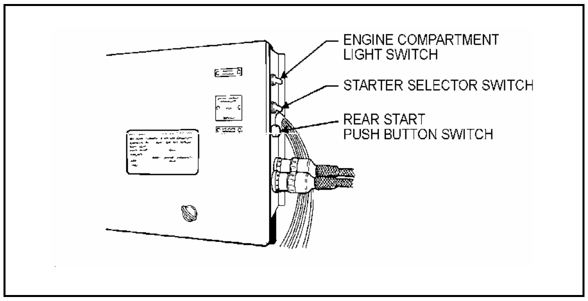


FIGURE 22: REAR JUNCTION BOX SWITCHES 01017

The rear junction box contains the following components (Fig. 23):

- relays;
- breakers;
- diodes;
- time delay relay;
- DDR connector.

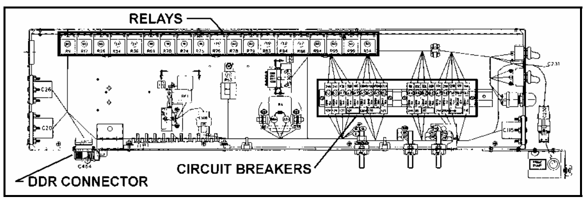


FIGURE 23: REAR JUNCTION BOX 06318

4. BATTERIES

The vehicle is provided with four (4) maintenance-free 12 volt heavy-duty batteries connected in series-parallel (Fig. 24). 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.

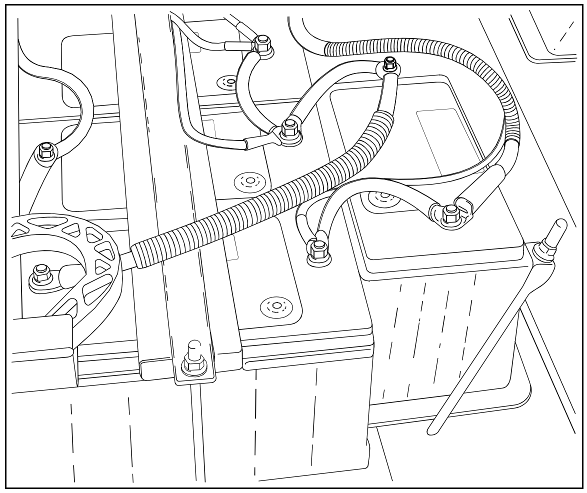


FIGURE 24: BATTERIES (TYPICAL) 06343

The vents require keeping the battery in an upright position to prevent electrolyte leakage. Tipping the battery beyond a 45^{O} 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^{O} when carrying or installing the battery.

NOTE

Evidence of electrolyte leakage does not necessarily mean the battery is defective.

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.

⚠ WARNING ⚠

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.

4.1 BATTERY REMOVAL AND INSTALLATION

4.1.1 XL2-45 Coach

The batteries are located in the main power compartment.

1. Remove the two screws at the bottom of the plastic protective cover, and then unscrew the two quarter turn nuts to remove the protective cover (Fig. 4)

⚠ WARNING ⚠
To prevent possible electric shocks or sparking, the battery master switch should be in the "Off" position before disconnecting cables from the batteries (see paragraph "2.3 Battery master switch").

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.

When reinstalling batteries, battery connections must be tightened to 13-15 lbf-ft (18-20) Nm) and the nut on top of sliding tray to 45-55 lbf-in (5-6 Nm). A torque wrench is required to ensure an accurate tightening torque.

⚠ WARNING ⚠
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.

4.1.2 XL2-40, XL2-45E and XL2 45 Bus Shells

The batteries are located in the engine compartment R.H. side (Fig. 16).

1. Remove the tree (3) plastic protective cover retaining bolts. Remove the plastic protective cover.
2. Remove the support retaining bolt.

⚠ WARNING ⚠
To prevent possible electric shocks or sparking, the 12 and 24 volts battery master switch should be in the "Off" position before disconnecting cables from the batteries (see paragraph "3.3 Battery Master Switch").

3. Remove the support (if necessary, remove battery cables). To remove battery cables, unscrew terminal nuts and remove cables.
4. Remove battery cables from defective batteries.

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.

5. Remove defective batteries.
6. Installation is the reverse of removal.

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.

When reinstalling batteries, battery connections must be tightened to 13-15 lbf-ft (18-20) Nm) and the nut on top of sliding tray to 45-55 lbf-in (5-6 Nm). A torque wrench is required to ensure an accurate tightening torque.

⚠ WARNING ⚠

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.

4.2 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^oF (-18^oC)
- Cold cranking (amps): 745 @ -20^oF (-29^oC)
- Weight (filled): 59 lb (26,7 kg)

The reserve capacity is defined as the number of minutes a new, fully charged battery at 80^oF ($26{,}6^oC$) 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^oF (-18^oC) 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.

4.3 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. 25).

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.

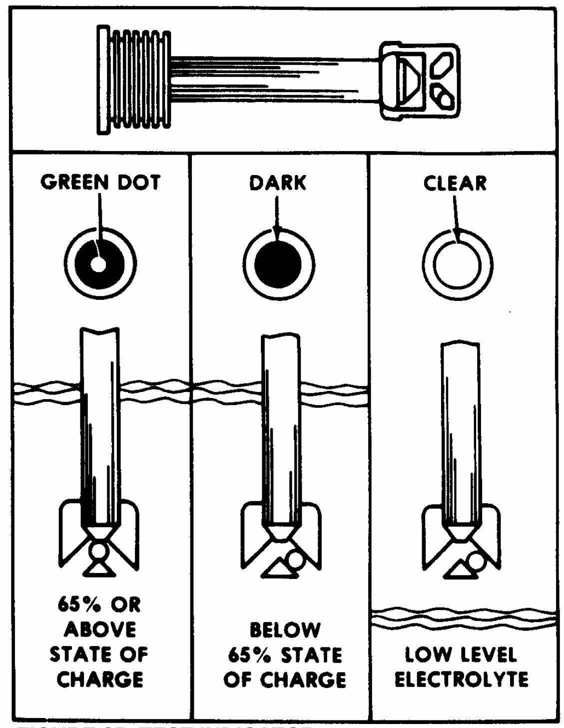


FIGURE 25: TEST INDICATOR 06096

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.**

4.3.1 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.

4.3.2 Removing Surface Charge

Disconnect cables from the battery and attach alligator clamps to the contact lead pad on the battery as shown in figure 27. Connect a 300 ampere load across the terminal for 15 seconds to remove surface charge from the battery.

4.3.3 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 26.

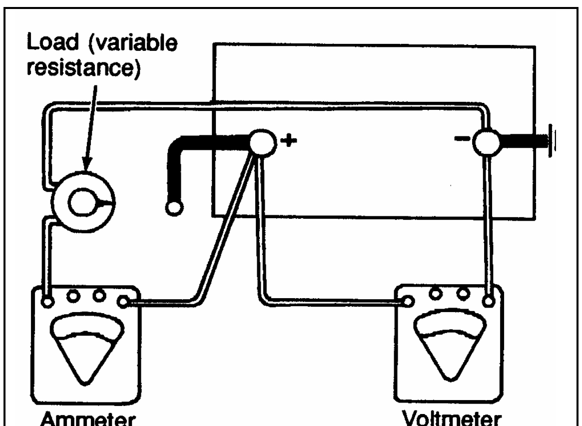


FIGURE 26: LOAD TEST 06064

⚠ **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 70ºF (21ºC) and above. For temperatures below 70ºF (21ºC), refer to the following *"Voltage and Temperature Chart"*.

Voltage and Temperature Chart

Ambient Temperature	Minimum Voltage
70ºF (21ºC) and above	9.6
60ºF (16ºC)	9.5
50ºF (10ºC)	9.4
40ºF (4ºC)	9.3
30ºF (-1ºC)	9.1
20ºF (-7ºC)	8.9
10ºF (-12ºC)	8.7
0ºF (-18ºC)	8.5

NOTE

The accuracy of this test procedure is dependent upon close adherence to the proper load, time and temperature specifications.

4.3.4 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:

⚠ **WARNING** ⚠

To prevent the engine from starting, the DDEC engine circuits, which are protected by breakers (CB-19, CB-20 and CB-21) located in the rear junction box, must be deenergized during these tests; afterward, depress black button to close circuit.

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 70ºF (21ºC), 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.

⚠ WARNING ⚠
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.**

4.4 BATTERY CHARGING

⚠ WARNING ⚠

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.**
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 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.**

The alligator clamps of the tester or charger must be placed between the terminal nuts and the lead pads of the terminal studs (Fig. 27) after the vehicle cables are detached. The alligator clamps should make firm contact with the lead pads.

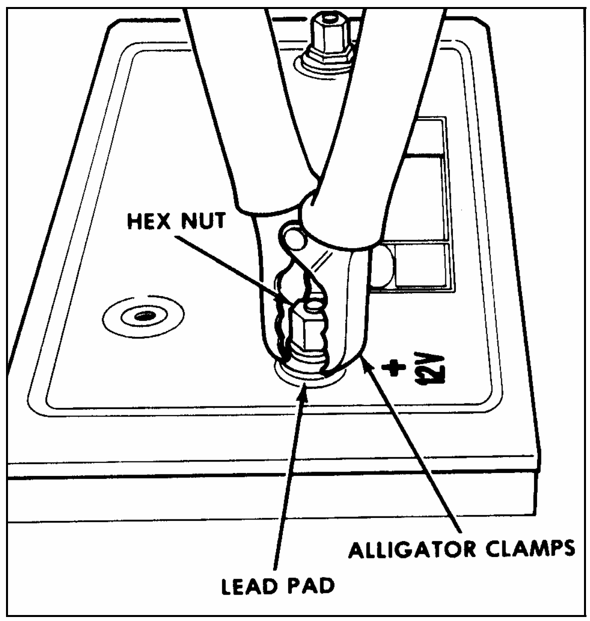


FIGURE 27: ALLIGATOR CLAMPS AND BATTERY 06065

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.

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 125ºF (52ºC)). If spewing or violent gassing of electrolyte occurs or battery temperature exceeds 125ºF (52ºC), 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.

4.4.1 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.

4.4.2 Emergency Jump Starting With Auxiliary (Booster) Battery.

⚠ WARNING ⚠
Do not jump start vehicles equipped with maintenance-free batteries if the test indicator is light yellow.

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.

⚠ WARNING ⚠
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.**

⚠ WARNING ⚠

Follow the procedure exactly as outlined hereafter. Avoid making sparks.

1. Wear eye protection and remove rings, watches with metal bands and other metal jewelry.
2. 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:
3. 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 in the main power compartment or in the engine compartment R.H. side (refer to fig. 4 and 15).
4. 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.
5. 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.
6. 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.
7. When removing the jumper cables, perform the above procedure exactly in reverse order, and replace protective caps on booster block terminals.

⚠ WARNING ⚠

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.

4.5 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.

4.6 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.

4.7 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.

5. ELECTRICAL SYSTEM MONITOR

This vehicle is equipped with an electronic device that monitors and detects abnormal alternator, voltage regulator, battery banks or battery equalizers conditions. The monitor is installed in the main power compartment (XL2-45) (refer to fig. 4), or in the engine compartment R.H. side (MTH). The *"Battery balance"* and *"Battery Hi/Lo"* warning lamps connected to this module are mounted in the dashboard (refer to *"Operator's Manual"* for location). If a malfunction should occur, the monitor sends a signal to the driver through the warning light of the malfunctioning component. If the *"Battery Hi/Lo"* warning 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 "Battery Hi/Lo" warning 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.

5.1 TELLTALE LIGHT DEFINITIONS

Battery Hi/Lo

Voltmeter drops below 24 V dc

- Check alternator output.
- Check voltage regulator.
- Check battery connections.
- Check battery cells.
- Check battery equalizer connections.

Voltmeter exceeds 30 V dc

- Check alternator output.
- Check voltage regulator.
- 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).
   - Check battery equalizer connections.
   - Check equalizer cables for proper gauge.

- Check battery connections.

2. Demand for 12 volt power exceeding rated amperage output of battery equalizers causing batteries to go out of balance.

   - Reduce 12 volt load or install additional battery equalizer(s).

“Battery” Warning Light

This warning light is not controlled by the electronic monitor, but by the "R" terminal of the alternator using the normally-closed contact of relay R-33. If a voltage drop should occur in the charging system, the *“Battery”* telltale light will immediately illuminate to warn the driver. The *“Battery Hi/Lo”* telltale light will illuminate if voltage drops below 24 V dc.

Refer to heading *"Diagnosis of Charging System Problems"* later in this section, to determine weather the alternator or the voltage regulator is defective. Should the *"Battery"* telltale light illuminate while the 24 volt voltmeter keeps on giving a normal reading and the *"Battery Hi/Lo"* telltale light does not illuminate, the relay R-33 or its wiring is probably defective.

⚠ CAUTION ⚠
Relay R-33 should never be replaced with a relay provided with a suppressor diode on its coil as the output current (between 12 and 14 volts) at the alternator "R" terminal is not rectified, thus rendering the relay inoperative.

NOTE
When the "Battery" warning light illuminates, the "A/C & Heating" system shuts off in order to prevent battery discharge.

6. BOSCH ALTERNATOR

One or two 24 volt 140 amp., self regulated, belt driven, air-cooled BOSCH alternators may be used in the 24 volt electrical system (instead of the DELCO 24 volt 270 amp. alternator).

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.

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.

NOTE
Use Polyrex EM grease (684922) when repacking the bearings. Grease comes in 14.1 oz (400gr) cartridges.

Refer to Bosh T1 Alternator Maintenance Manual Annexed at the end of this section.

6.1 TWIN BOSCH ALTERNATORS INSTALLATION

If the alternators needed to be removed, reinstall as follows. Refer to figure 28 for installation and to figure 29 for tightening specifications:

1. Install alternator mounting bracket (1, figure 28) 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 alternators to the bracket using the three inch bolt at the top of the upper alternator (2, fig 28) and flanged bolts at the other mounting bosses (3 and 4, figure 28). Tighten the bolts in the sliding sleeves (4, figure 28) last as they will adjust to prevent breaking the alternator mounting bosses upon final tightening. Repeat for the second alternator;
3. On the drive shafts of both alternators, install key, pulley, spring washer and nut. Tighten to 220 Lbf-ft (300 Nm);

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 (5, fig. 28) using three flanged bolts. Do not tighten the adjustment bolts on the snubber until after final tightening;
5. Install the compressor belt idler pulley (6, fig. 28) 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.

7. DELCO ALTERNATOR

The 24 volt charging system consists of a belt driven, oil-cooled, brushless alternator, a 24 volt voltage regulator, an alternator relay and a 12 volt system that includes a 12 volt, 100 amp equalizer. The components used in this system are described under the applicable headings hereafter.

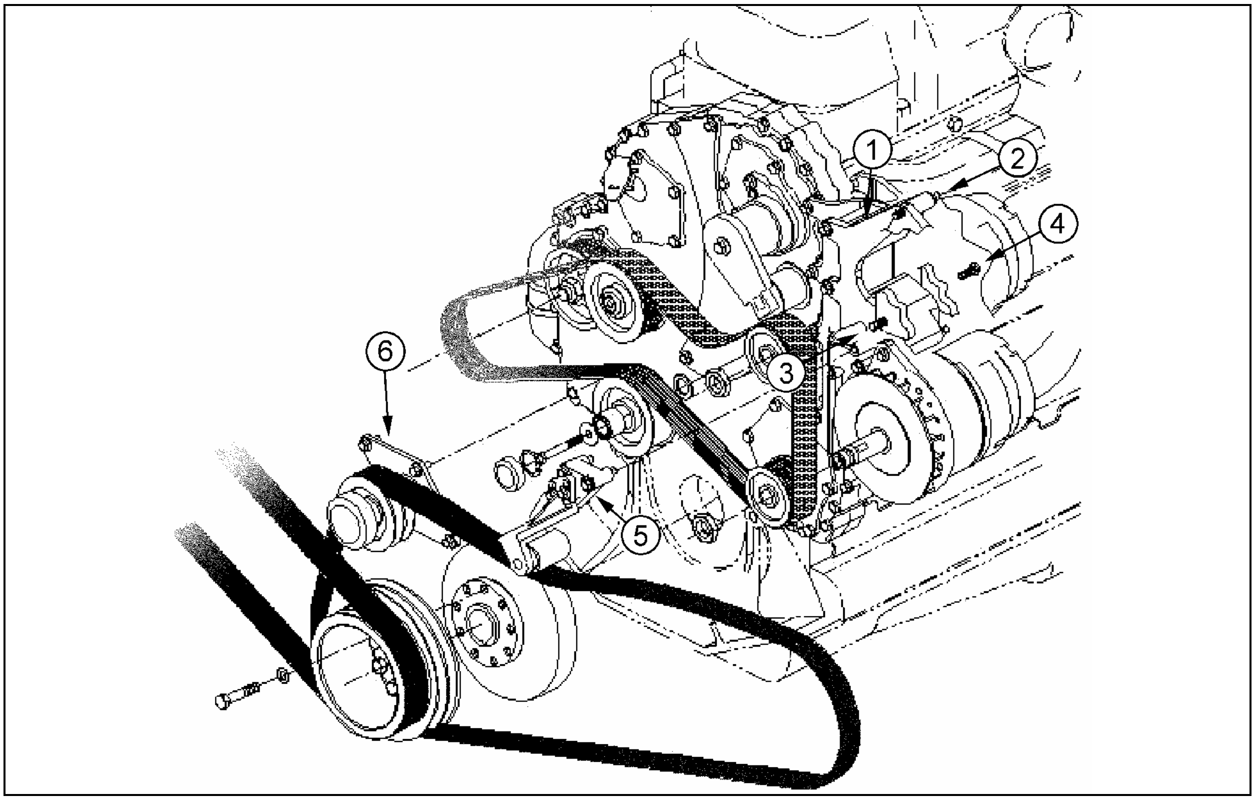


FIGURE 28: TWIN BOSCH ALTERNATORS INSTALLATION

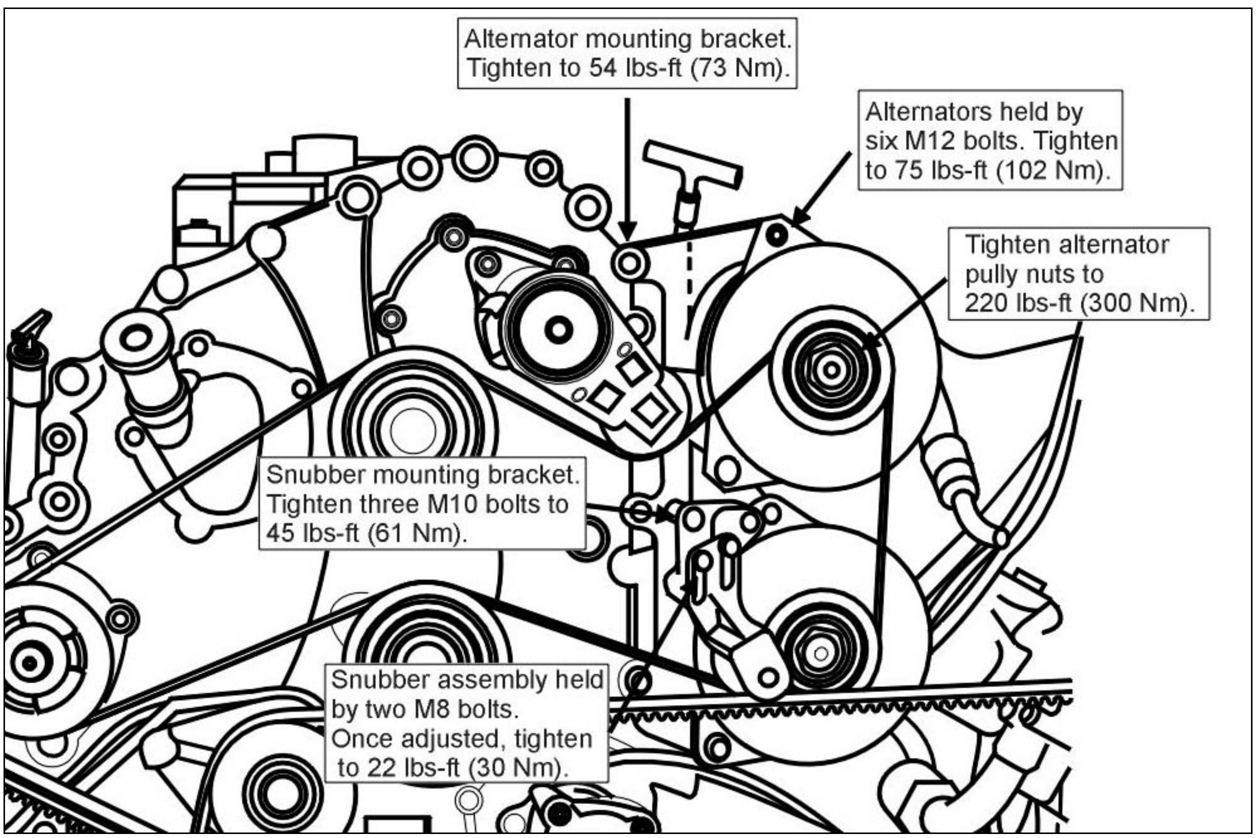


FIGURE 29: ALTERNATORS AND ACCESSORIES MOUNTING TORQUES

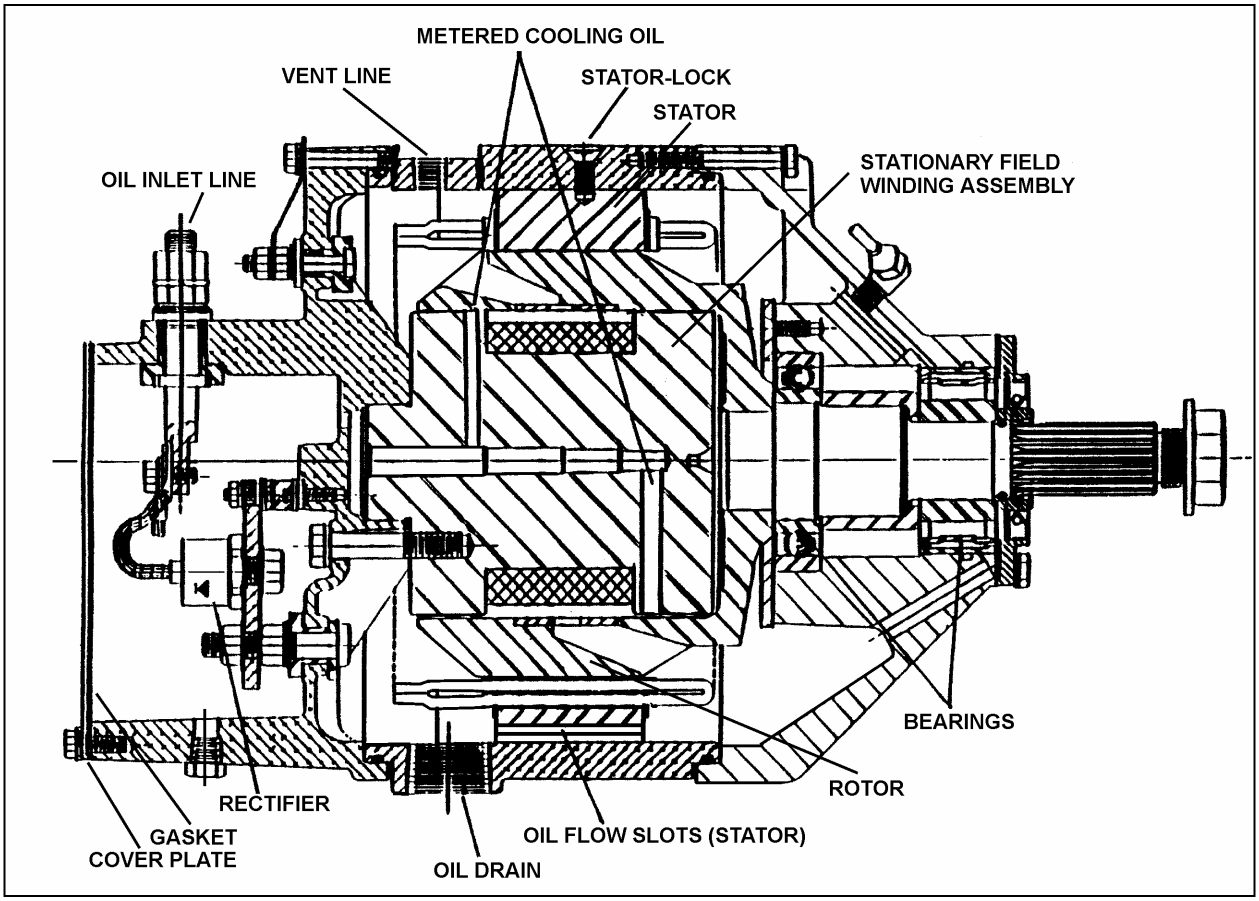


FIGURE 30: 50DN DELCO ALTERNATOR SECTIONAL VIEW 06493

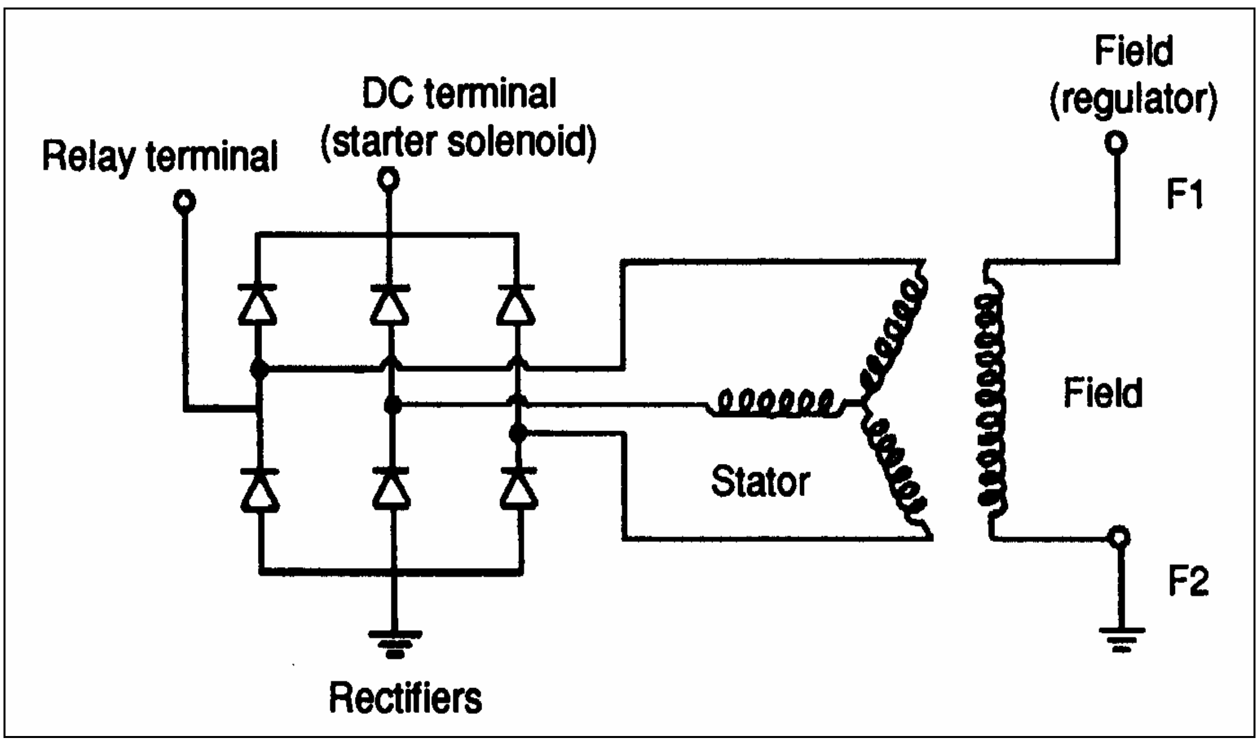


FIGURE 31: ALTERNATOR WIRING DIAGRAM (DELCO) 06067

This oil-cooled alternator is self rectifying. All current carrying members, windings, built-in diodes, and field coils are stationary. The only moving component is the rotor. The alternator is a totally-enclosed unit, cooled and lubricated by engine oil. The oil inlet is on the diode end cover. The oil drains back into the engine crankcase through the drive end frame and drive adapter housing.

This alternator should never be operated with the oil supply line disconnected. A continuous flow of engine oil through the alternator lubricates the bearings and cools the assembly. Four terminals are used on this alternator: the DC output terminal, two field terminals, and a 12 volt relay terminal. The alternator output voltage is regulated by a separate 24 volt regulator that controls the alternator field current (Fig. 30 and 31).

⚠ CAUTION ⚠

The electrical system is NEGATIVE GROUNDED. Connecting the batteries or a battery charger with the positive terminal grounded will endanger the alternator diodes and vehicle wiring by a high current flow. Burned wiring harnesses and burned "open" diodes will result. Always ensure that the alternator and battery polarities are matched prior to installation. THE ALTENATOR WILL NOT REVERSE TO ACCEPT INVERSE POLARITY. Also, do not ground or short across any of the alternator or regulator terminals.

⚠ CAUTION ⚠

Since there are no brushes, slip rings, or rubbing seals, the alternator requires no periodic maintenance other than the following:

1. **Check alternator-to-engine mounting bolts for looseness and tighten to the proper torque.**
2. **Check all electrical connections for tightness and corrosion. Clean and tighten connections as necessary. Be sure wiring insulation is in good condition and that all wiring is securely clipped to prevent chafing of the insulation.**
3. **With the engine running, listen for noise and check the alternator for vibration. If the alternator is noisy or vibrates excessively, it should be removed for inspection and repair.**
4. **Ensure that battery terminals are clean and tight**

NOTE

The relay coils connected to the alternator "relay terminal" SHOULD NEVER BE PROVIDED WITH A SUPPRESSOR DIODE as the output current at this terminal is not rectified, thus rendering relay inoperative.

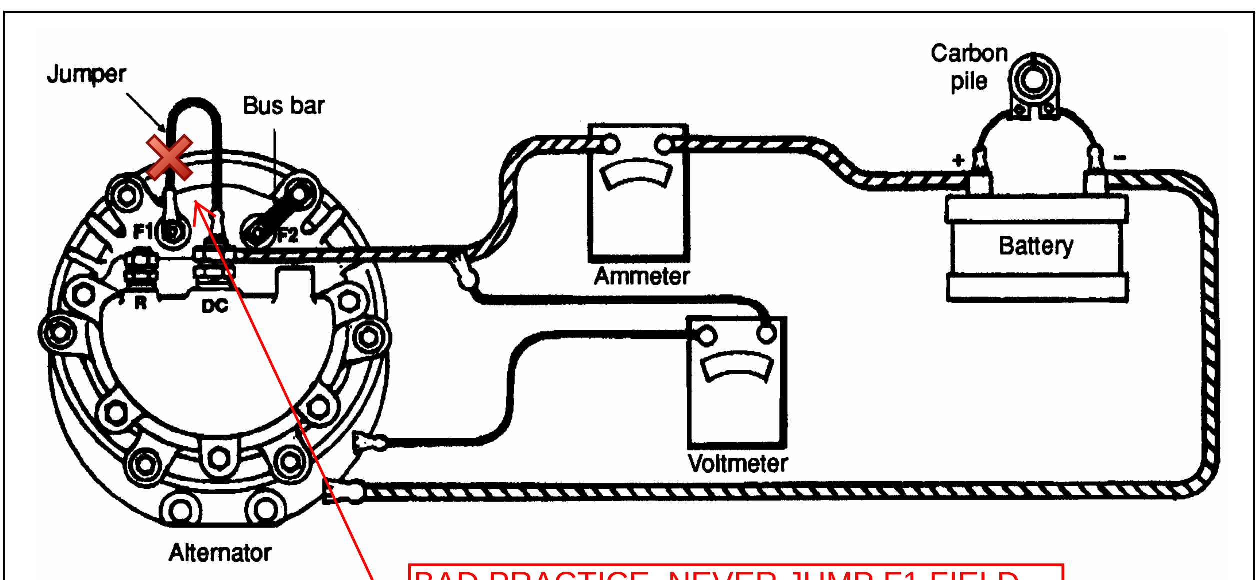


FIGURE 32: CONNECTIONS FOR CHECK

BAD PRACTICE. NEVER JUMP F1 FIELD TERMINAL TO DC(+) TERMINAL

06068

8. CHARGING SYSTEM TROUBLESHOOTING

The troubleshooting of the charging system is made easier by the use of a 12 and a 24 volt voltmeter, "*Battery*", *"Battery balance"* and *"Battery Hi/Lo"* telltale lights mounted in the dashboard (for location refer to the *"Operator's Manual"*). The definition of each warning light is explained under the "ELECTRICAL SYSTEM MONITOR"

8.1 ALTERNATOR OR VOLTAGE REGULATOR

[redacted]

⚠ [redacted] ⚠
[redacted]

[redacted]

8.2 ALTERNATOR DIAGNOSIS

⚠ CAUTION ⚠
Before checking the alternator, set the battery master switch to the OFF position.

It is not necessary to disassemble completely the alternator to make electrical checks. All electrical checks are made at the diode end of the assembly without having to remove the rotor, drive end frame or bearing. If the electrical components are not defective but bearing replacement is necessary, this can be done at the drive end without having to disassemble the diode end of the unit.

The components in the alternator that require electrical checks are the field winding, the six diodes, and the stator winding.

8.2.1 Diode Checks

Each diode may be checked for shorts and opens as follows:

1. Ensure the battery master switch is set to the "OFF" position.
2. Remove the pipe plug from underneath the end housing to drain the oil in the rectifier engine oil supply.
3. Remove the cap screws (7) and lock washers that attach the diode end cover to the end housing. Remove the end cover from the end housing.

NOTE
Do not operate the alternator unless this unit is completely reassembled.

4. Remove seal from the end housing, detach and remove "DC" and relay terminals, stud, insulating sleeves and O-rings.
5. Disconnect all diode flexible leads; i.e. three from the output terminal stud and three from the diode supports. See figure 33 for more details.

Each diode may be checked for short or open circuits with an ohmmeter.

NOTE
The ohmmeter polarity may be determined by connecting its leads to the voltmeter leads. The voltmeter will read up-scale when the negative leads are connected together and the positive leads are connected together. The polarity of the voltmeter leads may be determined by connecting the leads to the identified terminals on a battery.

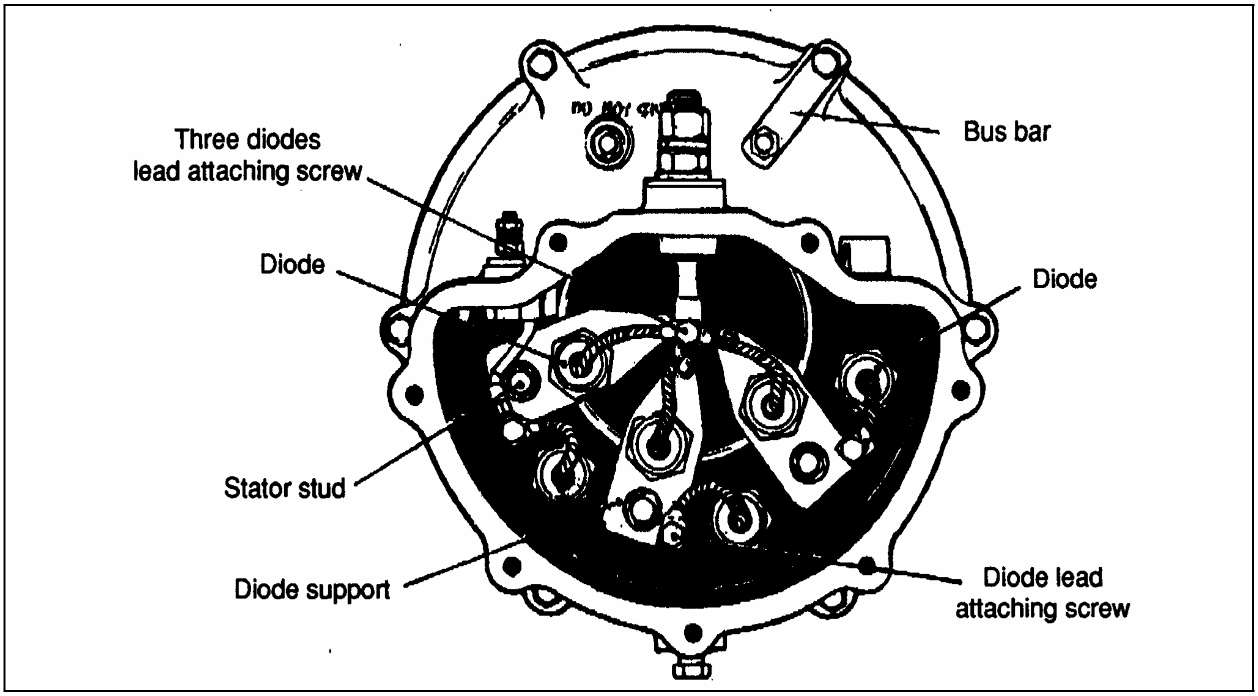


FIGURE 33: VIEW OF RECTIFIER END FRAME WITH COVER REMOVED 06069

NOTE

Use an ohmmeter with a single 1.5 volts cell. Most accurate reading will be determined when the 300 ohms value is calibrated to the center one-third of the scale. DO NOT USE high voltage, such as a 110 volts test lamp to check diodes.

To check diodes mounted in the supports for short fields, connect the positive ohmmeter lead to each diode lead and the ohmmeter negative lead to each support as shown in "A", "B", and "C" of figure 34. To check diodes mounted in the end frame for shorts, connect the ohmmeter positive lead to each diode lead and the ohmmeter negative lead to the end frame as shown in parts "D", "E", "F". The ohmmeter readings may vary considerably when checking diodes for shorts, but if the reading is 300 ohms or less, the diode is probably defective and should be replaced. A diode that reads 300 ohms or less will allow excessive reverse current from the battery. Replace defective diodes as explained later in this section.

To check the diodes mounted in the diode supports for open fields, connect the ohmmeter negative lead to each diode lead and the ohmmeter positive lead to each support as shown in parts “A”, “B”, and “C” of figure 35. To check the diodes mounted in end frame for shorts, connect the ohmmeter negative lead to each diode lead and the ohmmeter positive lead to the end frame as shown in parts “D”, “E” and “F”. An infinite resistance reading indicates an open diode. Diodes can be replaced by following the procedure outlined under DIODE REPLACEMENT”.

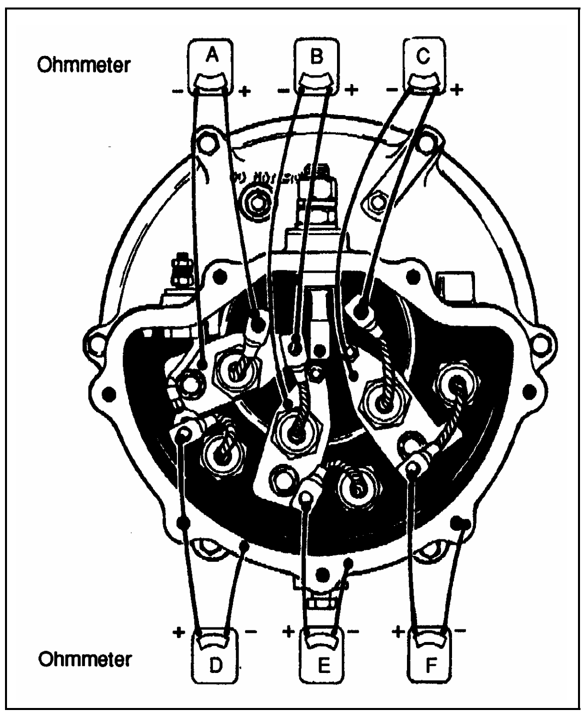


FIGURE 34: DIODE TESTING 06070

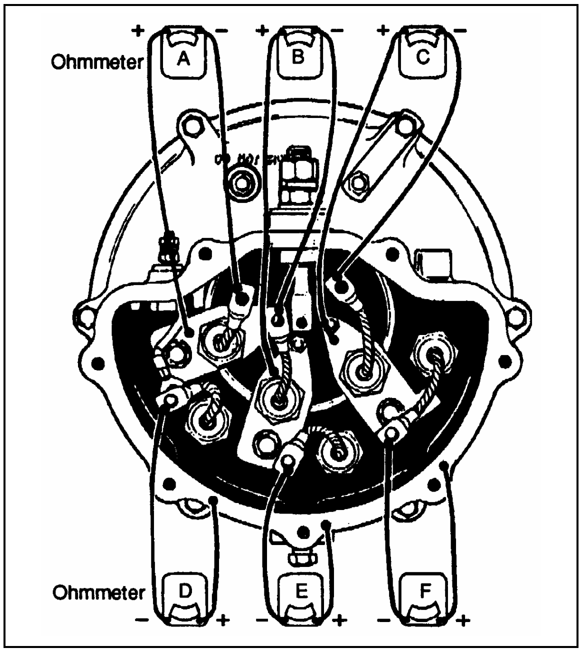


FIGURE 35: DIODE TESTING 06071

When reinstalling diodes, torque to 9-11 lbf-ft (12-15 Nm). Re-stake next to the threads in an arbor press with a 1/8 inch (3,2 mm) round punch. Press the punch with gradual pressure. Do not strike as the shock may damage the diodes.

8.2.2 Field Winding Check

The field winding may be checked for shorts and opens with an ohmmeter. To check the field winding, connect the ohmmeter to field terminal and to ground. A resistance reading above normal indicates an open, and a reading less than normal indicates a short field. The normal resistance value is 3.0 to 3.3 ohms at 80°F (27°C). An alternate method of checking is to place a battery of specified voltage, and an ammeter in series with the field winding. The current should register 7.2 to 8.3 amperes at 24 volts. Coil resistance is approximately 3.1 ohms. Amperage readings, other than the above, indicate an open, grounded, or shorted field. A defective field coil can be replaced by removing the end frame on which the field terminal is located and then removing the four field coil mounting screws. See FIELD REPLACEMENT" for a detailed procedure.

8.2.3 Stator Winding Check

The stator winding may be checked for open and short fields with an ohmmeter as follows:

Open Fields

Connect the ohmmeter leads to two pairs of diode supports as shown in parts "A", "B", and "C" of figure 36. Correct polarity of the leads must be observed. The ohmmeter should indicate a low resistance. If an infinite or a high resistance is measured in either one or both checks, the stator windings are open.

Ground

To check the stator windings for ground, connect an ohmmeter to the diode support and diode end frame as shown in part "C" of figure 36. The ohmmeter should indicate a very high or infinite resistance. If zero or a very low resistance is measured, the windings are grounded.

Shorts

The stator windings are difficult to check for shorts without finely calibrated laboratory test equipment due to the very low resistance values of the windings. However, if all other alternator checks are satisfactory, yet the unit fails to perform to specifications, shorted stator windings are probable.

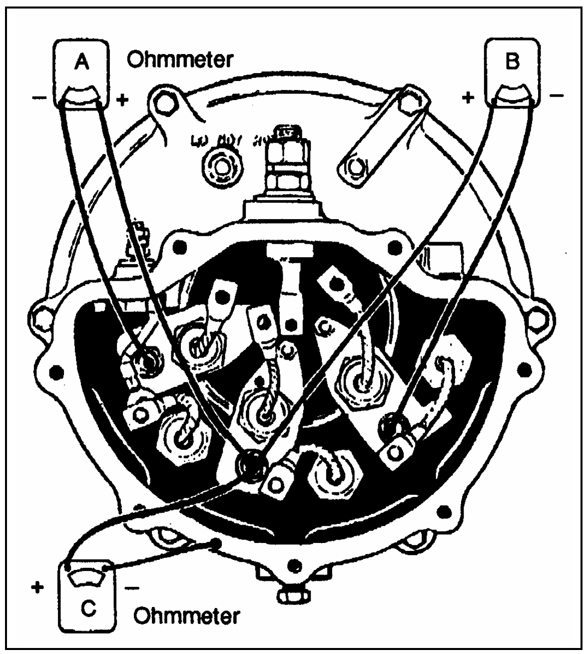


FIGURE 36: STATOR WINDING TEST 06072

8.3 DIODE REPLACEMENT

The following replacement procedures are based on the assumption that the diode end cover is still off and diode leads were disconnected as explained earlier in this section.

NOTE
When replacing a diode, make sure it is designed for a negative ground system. The diode can be identified by the symbol stamped on the diode case. The arrow must point toward the diode flexible lead.

To replace the three diodes that are mounted in the supports attached to the stator lead studs, it is necessary to remove the diode and support assembly. The two outer diode and support assemblies are identical and can be installed on either side. The center unit has a different support, with 2 inches (50,8 mm) between the mounting hole centers.

NOTE
The outer supports are provided with 2 ¼" (57,15 mm) center holes.

8.3.1 Diode Replacement (in Support)

1. Remove nut with lock washer attaching the diode support to the stator lead stud.
2. Remove nut, lock washer, and flat washer attaching support to the small stud in the end frame.
3. Remove the diode and support assembly. Then remove insert from small hole in support or from small stud in the end frame.
4. Remove nut and flat washer from diode mounting stud, and then remove diode from the support.
5. Place a new diode in the support and install a flat washer and nut on the diode mounting stud. Hold the diode with a wrench placed over flats on the diode, while tightening nut on the mounting stud to a torque of 160-180 lbf-in (18-20 Nm).
6. Place diode and support assembly over the stator lead stud and the small mounting stud. Place insert over small stud inside the hole in the support. Install flat washer, lock washer, and nut on the small stud, and tighten to a torque of 22-25 lbf-in (2-3 Nm). Install nut with lock washer on stator lead stud and tighten firmly.

8.3.2 Diode Replacement (in End Frame)

To remove diode, use a thin 1 inch open end wrench on flats of the diode case to unscrew diode from the end frame. Thread the new diode into the end frame and tighten to a torque of 160-180 lbf-in (18-20 Nm). If no other parts are to be replaced, refer to “DIODE END COVER INSTALLATION” in this section.

8.4 FIELD REMOVAL

1. Remove three diode and support assemblies from the end frame to provide access to the lower field to end frame bolts (2).
2. Remove nut with lock washer and flat washer from three stator lead studs.
3. Remove the six bolts and lock washers attaching the diode end frame to the stator frame.
4. Separate the end frame from the stator frame, and remove the end frame and field assembly from the rotor while pushing the stator lead studs out of the end frame.
5. Remove nut, lock washer, flat washer, and insulating washer which secure the field lead terminal stud in the end frame. Push the stud out of the end frame.
6. Remove field terminal stud insulating bushing and seal from the end frame. Remove insulating sleeve from the field terminal stud.
7. Remove the four bolts and lock washers attaching the field to the end frame.
8. To separate the field from the end frame, install four 3/8-24 x 3 inch bolts in place of the 3/8-24 x 2 inch bolts removed in step 7. Thread bolts in to even heights. Support the end frame in an arbor press. Then, using a suitable press plate to exert pressure on all four bolt heads, press the field out of the end frame.

8.5 FIELD INSTALLATION

1. Position the field assembly on the end frame. Insert four 3/8-24 x 3 inch bolts through the end frame and thread into the field to keep holes aligned.
2. Support the end frame on an arbor press bed so that the diodes will not be damaged, and press the field into the end frame. Press in until shoulder on field coil bottoms against the end frame.
3. Remove the four guide bolts. Install four 3/8-24 x 2 inch bolts, using new lock washers to attach the field to the end frame. Tighten bolts securely.

4. Place insulating sleeve in inner side of the field terminal stud hole in the end frame, and insert the terminal stud through the sleeve. Place two O-rings and insulating bushing over the terminal stud and push into hole in the end frame. Install insulating washer, flat washer, toothed lock washer, and nut on terminal stud. Tighten firmly.
5. Install each stator lead stud in the end frame as follows: Place insulating washer over the stud and insert the stud through the end frame. Place the insulating bushing over the stud and position in end frame hole. Install flat washer, lock washer, and nut on the stud. Tighten firmly.
6. Install three diode and support assemblies on the end frame as previously directed under “DIODE REPLACEMENT”.
7. Install a new seal in notch around end of the stator frame. Insert field into the rotor and position the end frame against the stator frame. Attach end frame to the stator frame with six bolts and lock washers. Tighten bolts firmly.
8. If no other parts require replacement, refer to "DIODE END COVER INSTALLATION" in this section to complete the assembly.

8.6 STATOR REPLACEMENT

If tests performed under “Stator Winding Checks” earlier in this section indicated an open circuit or short in the stator, the stator and frame assembly must be replaced.

8.6.1 Removal

1. Remove diode end frame and field assembly as previously directed in steps 1 through 4 under “Field Removal”.
2. Remove the six bolts and lock washers attaching the stator frame to the drive end frame.
3. Separate the stator frame from the drive end frame and remove the stator frame from the end frame and rotor.

8.6.2 Soldering Stator Terminal Leads

1. Using a wire brush, thoroughly clean the wire and terminal.
2. Silver solder the stator lead to the terminal using a torch.
3. Thoroughly clean the silver solder connection with a wire brush.
4. Using a high grade energized rosin flux, coat the silver soldered connection with a 80-20 tin-lead solder or pure tin solder to prevent deterioration of the silver solder by engine oil.

NOTE
The silver solder will provide the required mechanical strength, which will not be affected by temperature. The tin-lead solder will protect the silver solder connection from deterioration by engine oil.

8.6.3 Installation

1. Position new seal in notch around the drive end of the stator frame.
2. Position the stator and frame assembly over the rotor against the drive end frame. Attach the stator frame to the drive end frame with six bolts and lock washers. Tighten bolts firmly.
3. Install diode end frame and field assembly as directed in steps 5, 6 and 7 under “installation”.
4. Install rectifier end cover as directed later.

8.7 DIODE END COVER INSTALLATION

1. Make sure all diodes are properly installed and securely tightened. Leads from diodes threaded into the end frame must be securely attached to the diode supports. The relay terminal lead must also be attached to the left diode support.
2. Connect leads from the three diodes mounted in supports to the output terminal stud. Tighten the attachment screw firmly. Place insulating bushing over relay terminal stud.
3. Place a new seal in the diode end frame.
4. With the end cover in place against the end frame, install the cap screws and lock washers. Tighten the cap screws evenly and firmly.
5. Make sure the drain plug is installed in bottom of the end cover and securely tightened.

8.8 ALTERNATOR REMOVAL (DELCO)

1. Place *"Starter Selector Switch"* in engine compartment to the *"OFF"* position.
2. Place the battery master switch to the "OFF" position.
3. Remove alternator drive belt (see "ALTERNATOR DRIVE BELT").

NOTE
When reinstalling drive belt, it is important to set the belt tension correctly. (Refer to the appropriate heading later in this section).

4. Scratch off protective sealer from electrical connections (relay, field and positive terminals). Refer to figure 37.

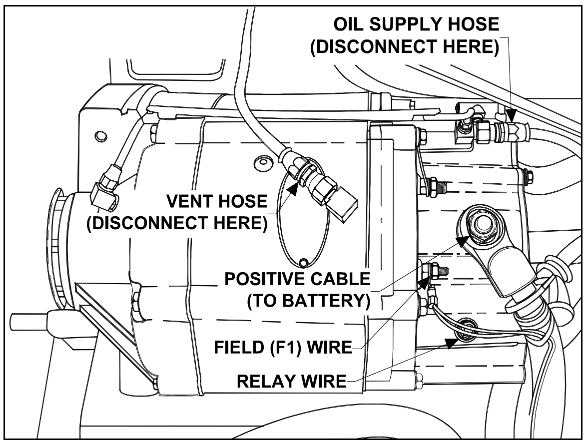


FIGURE 37: ALTERNATOR (HOSES AND WIRES) 06341

NOTE
After reconnecting electrical wires, it is important to cover terminals with protective sealer (Prévost #680745).

5. Disconnect wire #25 from the relay terminal, wire #107 from the field "F1" terminal and disconnect battery cable from the positive "+" terminal on the diode end cover. Tag wires removed to ease identification at time of installation. Refer to figure 37.
6. Disconnect oil supply line and vent hose from top of alternator (Fig. 37) and tape lines to prevent entry of foreign matter. Disconnect oil drain hose from bottom of alternator (Fig. 38) and tape line to prevent entry of foreign matter.
7. Remove the four bolts and lock washers fixing the alternator (refer to fig. 38).

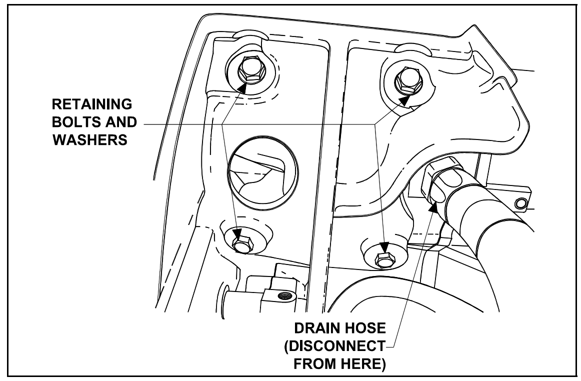


FIGURE 38: ALTERNATOR RETAINING BOLTS AND WASHERS 06350

⚠ WARNING ⚠
Alternator weights approximately 154 lbs (70 kg). Another person is required to take the alternator out of the engine compartment.

8.8.1 Disassembly of Alternator

After diode, field and stator winding checks, the alternator can be disassembled to repair a faulty component, such as field or stator, or to proceed with bearing or rotor replacement. Perform the following steps to disassemble the alternator:

1. Remove nuts and washers from "DC" terminal on diode end frame.
2. Separate the diode cover plate from the diode end frame by removing the mounting screws.
3. Remove the washer, nut and lock washer attaching the diode supports to the end frame, the three screws connecting the diode leads to the diode supports, and the three nuts which attach the stator studs to the diode supports.
4. Separate the diode support assemblies from the diode end frame, and the three nuts that connect the studs to the diode end frame.
5. Mark the position of the drive end frame and diode frame with respect to the stator assembly so that the parts can be reassembled in the same position.
6. Detach the diode end frame and field assembly from the stator assembly by removing the attachment screws.
7. Separate the field assembly from the diode end frame by removing the four attachment screws.

8. Separate the rotor assembly and drive end frame from the stator assembly by removing the attaching screws.
9. Remove the shaft nut and washer, and the pulley. Press the rotor shaft out of the drive end frame.
10. Remove the retainer plate and pull the bearings from the drive end frame.

8.8.2 Alternator Cleaning and Inspection

Whenever the alternator is disassembled, it should be cleaned and inspected.

Cleaning

If sludge has accumulated on the stator, a light mineral oil should be used to clean it.

Inspection

When the alternator has been disassembled to the extent that the stator is exposed, the stator should be checked for the following:

a) Adequate varnish.
b) Proper spacing of conductors so that “near shorts” do not exist.
c) Proper phase lead placement.
d) Strong conductor and cross-over welds

8.8.3 Bearing or Rotor Replacement

Whenever the rotor and drive end frame are disassembled for any reason, the single-row ball bearing must be replaced with a new one due to the probability of damage during disassembly.

Removal and Disassembly

1. If the pulley was not removed from the rotor shaft at time of alternator removal, remove the nut and flat washer from the shaft and pull the pulley off the shaft.
2. Remove the six bolts and lock washers attaching the drive end frame to the stator frame. Separate the drive end frame from the stator frame. Remove the drive end frame and support assembly.
3. Support the drive end frame in an arbor press so that the rotor can be pressed down out of the end frame. Using a suitable adapter against the end of the rotor shaft that will pass through the inner race of the double-row ball bearing, press the rotor down out of the end frame and bearings. Since the single-row bearing outer race is held in the end frame by the retainer plate, and the inner race is a press fit on to the rotor shaft, the bearing will probably be damaged when the shaft is pressed out and need to be replaced with a new part.
4. Remove the six screws attaching the bearing retainer plate to the drive end frame. Remove the retainer plate, the single-row bearing and the bearing spacer from the end frame.
5. Support the drive end frame in an arbor press with the double-row bearing down, so that the bearing can be pressed down out of the end frame. Using a suitable driver that will exert a force on the bearing outer race, press the bearing out of the end frame.
6. Remove the rubber bearing clamp from groove in the end frame.

Assembly and Installation

1. Install a new single-row ball bearing into inner side of the drive end frame. Install the bearing retainer plate and attach with six screws. Stake screws in place after tightening.
2. Position the rubber bearing clamp in the groove in bearing bore of the drive end frame. Lubricate the clamp to permit the bearing to be pressed in without dislodging or damaging the clamp.
3. Position the rotor in an arbor press with the shaft end up. Install the drive end frame and single-row bearing assembly over the rotor shaft. Using a driver over the rotor shaft, which will exert a force on the bearing inner race, press the bearing onto the shaft until it bottoms against the rotor.
4. Install bearing spacer over the rotor shaft. Position the double-row bearing over the rotor shaft at end frame bore. Using an adapter that will exert a force on both the inner and outer races of the bearing, press the bearing onto the shaft and into the end frame until the inner race bottoms against the bearing spacer.
5. Place a new seal around the drive end of the stator frame.
6. Insert the rotor between the stator and field, and position the drive end frame against the stator frame. Attach the end frame to the stator frame with six bolts and lock washers. Tighten the bolts to a torque of 5 to 5.4 lbf-ft (6-7 Nm).

⚠ CAUTION ⚠

When replacing the alternator on the vehicle, ensure that an alternator with the proper drive ratio is used. Installation of an alternator with any other drive ratio will result in severe and costly damage to the alternator and engine.

8.8.4 Alternator Reassembly

Reassembly is the reverse of disassembly.

NOTE

When tightening the outside nut on the "DC" output terminal, torque the nut to 30- 35 lbf-ft (41-47 Nm). The lower nut should be supported while doing so.

When reinstalling diodes, tighten to a torque of 9-11 lbf-ft (12-15 Nm).

8.8.5 Output check

When removed from the engine, the alternator may be checked without circulating oil on a test bench, providing the output is limited to 100 amperes or less. The alternator may be bench tested without circulating oil at outputs exceeding 100 amperes, as long as the period of operation is limited to less than 15 seconds.

⚠ CAUTION ⚠

Operating the alternator at outputs greater than 100 amperes without adequate oil circulation for periods exceeding 15 seconds, will cause the alternator to overheat, resulting in damage to the winding and diodes.

If the alternator is to be operated at an output greater than 100 amperes for longer than 15 seconds, circulating oil must be provided. SAE 30 engine oil must be applied to the connection on the diode end cover at a pressure of 35 psi and at a temperature of 60^{o}F to 220^{o}F (16^{o}C to 104^{o}C). This will provide an oil flow of about one gallon per minute.

To check the alternator on a test bench, make electrical connections as shown in figure 32. Make sure the negative battery terminal is connected to the alternator frame.

8.9 ALTERNATOR DRIVE BELT

Removal

1. Insert a ¾'' socket drive into the tensioning arm opening (Fig. 39).
2. Twist the tensioning arm to slacken belt.
3. Remove belt.

Installation

Installation of the alternator drive belt is the reverse of removal.

8.9.1 Adjustment

Correct belt tension is required to maximize belt life. The tensioning arm maintains proper belt tension, no adjustment is required.

Check for wear and proper tension every 6,250 miles (10 000 km) or twice a year, whichever comes first.

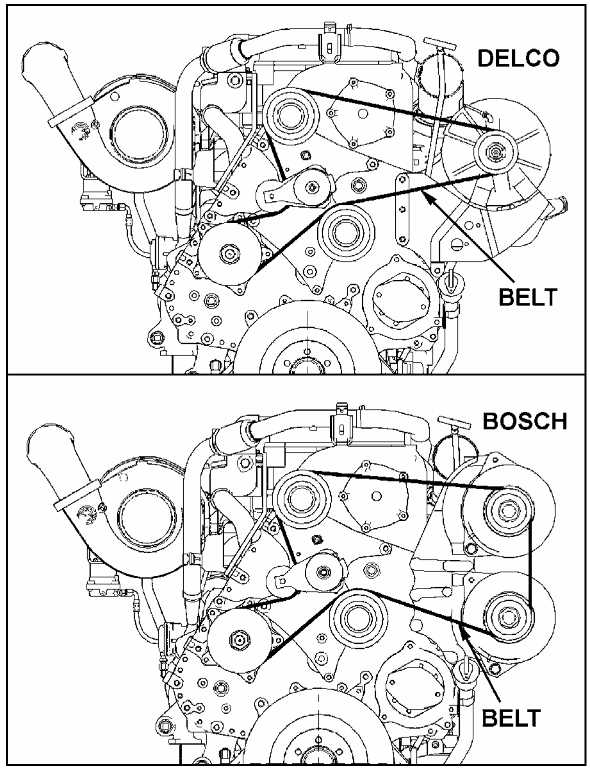


FIGURE 39: ALTERNATOR DRIVE BELT 06509

9. VOLTAGE REGULATOR (DELCO)

The 24 volt regulator used with Delco alternator is located in the engine compartment R.H. side (MTH).

The transistor regulator illustrated in figure 40 is an assembly mainly consisting of diodes, capacitors, resistors and transistors. These components are mounted on a printed circuit panel board to form a completely static unit containing no moving parts. Regulators of this type have only four terminals which are identified "GND." (ground), "FLD" (field) "BAT" (battery) and "IGN" (ignition).

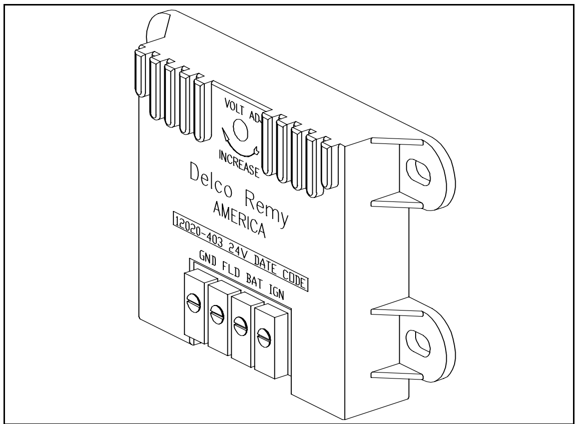


FIGURE 40: VOLTAGE REGULATOR 06408

The regulator components work together to limit the alternator voltage to the preset value by controlling the alternator field current. This is the only function that the regulator performs in the charging system.

The voltage at which the alternator operates is determined by the regulator adjustment. Once adjusted, the alternator voltage remains constant. The regulator is unaffected by length of service, changes in temperature, or changes in alternator output and speed.

A typical wiring diagram of a negative ground system is illustrated in figure 41. This diagram shows only the basic charging system components. It does not show any components such as the control relays. Refer to *"Charging system"* wiring diagram, in *"Wiring diagrams"* for the electric circuits and connections.

Voltage regulator maintenance

The voltage regulator is a service-free electronic unit. When it fails, it should be replaced. The following procedure must be used:

⚠ CAUTION ⚠
Set the battery master switch to the "OFF" position.

- Open the engine compartment R.H. side door in order to get access to the voltage regulator;
- Unscrew the electrical cable connectors;
- Unscrew the voltage regulator unit;
- Install a new voltage regulator by reversing the procedure.

NOTE
For information about BOSCH alternator and voltage regulator, refer to technical publication "Repair and Testing Instructions for T1 Alternator 0120 689 552".

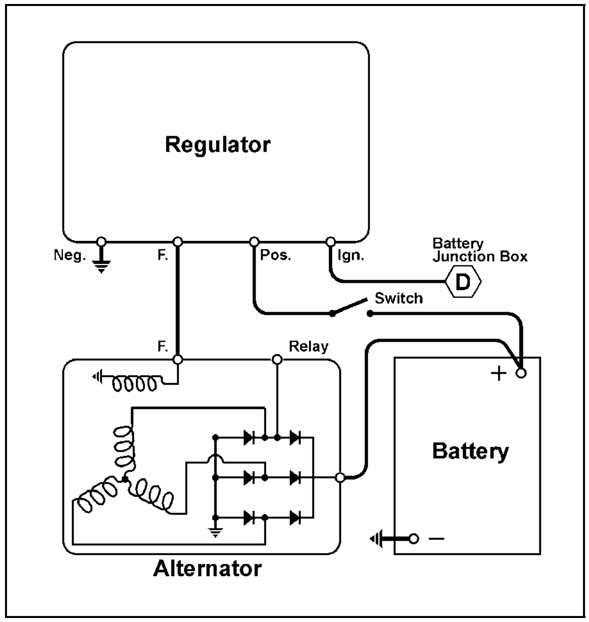


FIGURE 41: TYPICAL WIRING DIAGRAM OF A NEGATIVE GROUND SYSTEM 06415

9.1 TROUBLESHOOTING PROCEDURES

Trouble in the electrical system will usually be indicated by one of two conditions: an undercharged or an overcharged battery. Either condition can result from an improper voltage regulator setting:

Checking Battery Voltage

The absence of gas production during the continuous appearance of the green dot in the battery's built-in hydrometer indicates that the voltage setting is satisfactory. Check the following conditions:

Checking Voltage Regulator Setting

1. To check the voltage setting, connect a voltmeter across the "POS" and "NEG" terminals on the regulator, and an ammeter to the "C" terminal on the alternator. Refer to figure 42.
2. Operate the engine at approximately 1000 rpm (about 2300 alternator rpm), with accessories on, to obtain an alternator output of 20-200 amperes.
3. Note the voltage setting. It should be steady at 27.5 volts.
4. If not, the desired setting can be obtained by removing the plug from the voltage regulator cover and slightly turning the adjusting screw inside the regulator. Turn the adjusting screw clockwise to increase the voltage setting or counterclockwise to decrease it. See figure 43 for details.

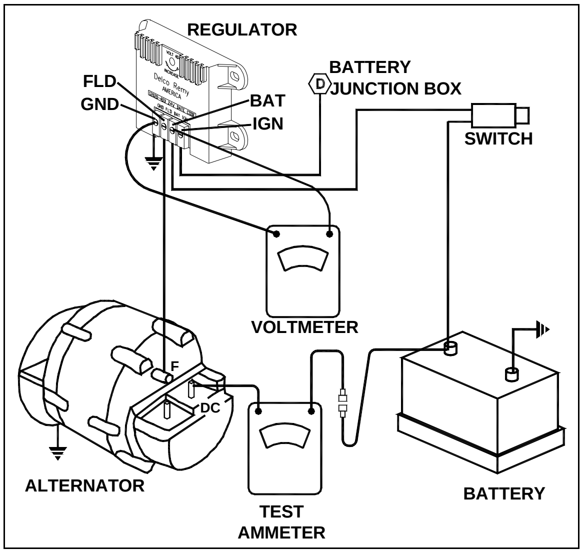


FIGURE 42: REGULATOR VOLTAGE SETTING 06416

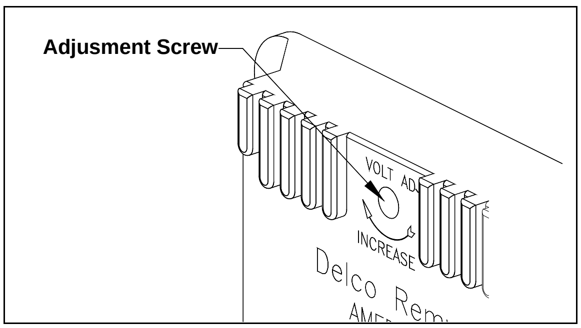


FIGURE 43: ADJUSTING REGULATOR VOLTAGE SETTING 06418

NOTE
If regulator voltage cannot be adjusted to the specified setting, remove the regulator and repair or replace it as necessary.

9.1.1 Undercharged Battery

If the voltage setting is steady and reasonably close to the specified value and the battery is undercharged, raise the setting by 0.3 volt, then check for an improved battery condition over a minimum service period of 48 hours. If the voltage cannot be adjusted to the desired value, the alternator should be checked as follows:

1. Stop alternator, turn off all accessories and disconnect battery ground cable.
2. Disconnect all leads from the regulator and from the alternator field. **Do not allow leads to touch ground.**
3. Connect a voltmeter and an ammeter in the circuit at the alternator "DC" terminal.
4. Connect a jumper lead from the alternator "DC" terminal to the alternator field terminal.

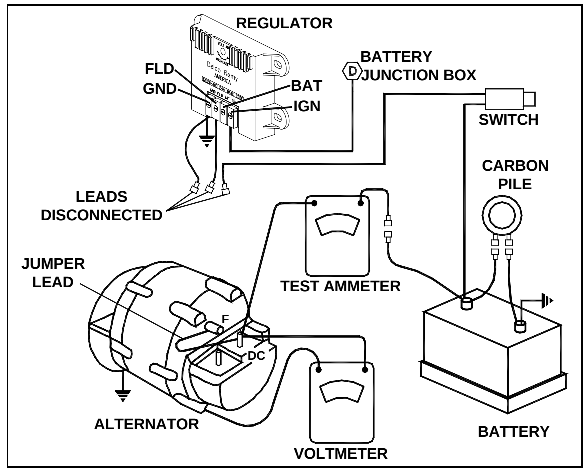


FIGURE 44: REGULATOR VOLTAGE TEST (UNDERCHARGED BATTERY) 06417

5. Connect a carbon pile resistor load across the battery. Turn to the *"Off"* position.
6. See figure 44 for wiring connections.
7. Reconnect battery ground cable
8. Turn on all vehicle accessories.
9. Operate alternator and adjust carbon pile resistor load as required to check for rated output as given in Delco-Remy Service Bulletin 1G-187 or 1G-188.
10. Check the alternator field winding as follows: Disconnect the lead from the field terminal and connect an ohmmeter from the field terminal to ground. A resistance reading above normal indicates an open field, and a resistance reading less than normal indicates a shorted or grounded field. The normal resistance can be calculated by dividing the voltage by the field current published in Delco-Remy Service Bulletin 1G-186, 1G-187, or 1G-188. The normal resistance value should be at or near midscale on the ohmmeter for accuracy. An alternate method of checking is to connect a battery of specified voltage and an ammeter in series with the field winding, and compare readings with published specifications in Delco-Remy Service Bulletin 1G-186, 1G-187, or 1G-188. An alternator is defective if it does not produce rated output or if field windings are faulty. If the alternator provides rated output, and field windings check satisfactorily, the regulator should be checked as covered under "Regulator Checks".

9.1.2 Overcharged Battery

If the voltage setting as checked above is steady and reasonably close to the specified value, lower the setting by 0.3 volt and check for an improved battery condition over a minimum service period of 48 hours. If the voltage cannot be adjusted to the desired value, proceed as follows: where the alternator field is grounded internally in the alternator as shown in figure 41 a shorted or grounded field or a defective regulator can cause an overcharged battery. The field winding can be checked as covered in paragraph “Undercharged Battery”. If the field winding is found to be correct, the alternator is not defective, and the regulator should be checked as covered under “Regulator Checks”.

9.2 REGULATOR CHECKS

Separate the cover from the base, and remove the panel assembly from the cover. Carefully note the location of all washers and lock washers.

The component parts are keyed to figure 41. Before making electrical checks, visually inspect the components and make sure all soldered connections are secure. Various electrical checks with an ohmmeter can be made to determine which components are defective.

The ohmmeter **must** be accurate, and should be a scale-type meter with a 1.5 or 3 volt cell. Most digital ohmmeters cannot be used to check semiconductors. However, some digital ohmmeters are specially designed to test semiconductors and can be used to test components in the regulator. Consult the ohmmeter’s manufacturer for specifications concerning the capabilities of the ohmmeter.

It is important that all of the following checks be made. If a defective part is found, replace it before proceeding with the remaining checks. Be sure to make all the checks since more than one component may be defective.

A defective regulator can be repaired according to the following methods:

A) By changing the printed circuit board in the regulator. Unscrew the retaining screws on the printed circuit and remove it. Install a new printed circuit board. This method is the most commonly used.

B) By removing any retaining screws involved and unsoldering the connections. When resoldering, limit solder time to a minimum as excessive heat may damage the printed circuit board and component parts. However good soldered connections are essential for satisfactory operation. A resin core 63% tin 37% lead solder with a 360°F (182°C) melting point is recommended along with a soldering iron rated at 50 watts or less. Use extreme care to avoid overheating. Before checking the printed circuit board, remove transistor TR1, which must be checked separately. Connect the ohmmeter as shown in figure 45, and then reverse the ohmmeter leads to obtain two readings on the same component. Use the middle scale on scale-type meters on which the 300 ohm value should be within or nearly within, the middle third of scale.

Capacitors C1 and C2 = The ohmmeter should read high and low on each capacitor. If not, replace capacitor.

Diodes D1, D2 and D3 = Each diode should give one high and one low reading. If not, replace diode.

Resistor R2 = Turn voltage adjustment screw (identified in figure 43) with ohmmeter connecting each way. Reading should change as slotted screw is turned. If not, replace R2.

Transistor TR1 = See figure 45. Use the low scale. Each of the three checks should read low and high. If not, replace TR1.

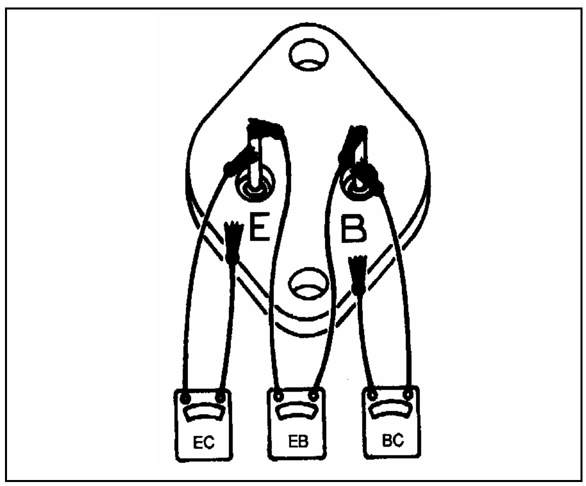


FIGURE 45: CHECKING TRANSISTOR TR1 06081

Transistor TR2 = Change the ohmmeter to use the low scale. EB should read low and high. BC should read low and high. EC should both read high. If not, replace TR2. See figure 46.

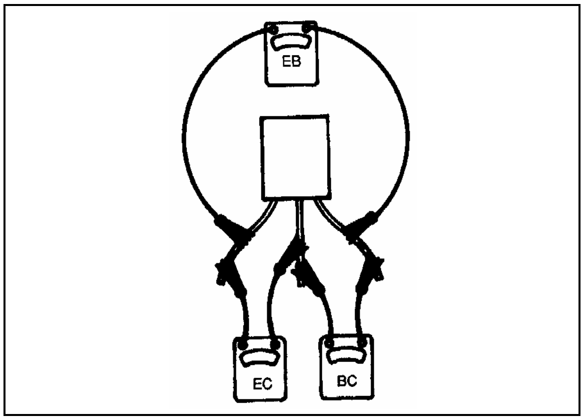


FIGURE 46: CHECKING TRANSISTOR TR2 06081

9.3 ADJUSTING VOLTAGE

After repair, the regulator must be adjusted to the desired voltage setting. Follow the procedure under "Checking Voltage Regulator Setting". Slowly turn the adjusting screw full range and observe the voltmeter to ensure that the voltage is being controlled, then, while still turning, slowly adjust to the desired setting.

10. BATTERY EQUALIZER

VoltMaster Battery Equalizer Owner's Manual (100 amps) is annexed at the end of this section.
Refer to "Electrical Compartments and Junction Box" in this section, for location.

11. 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** ⚠

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.

12. 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. 47). 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.

12.1 MAINTENANCE

This heater is non-serviceable except for the cord, and if faulty, must be replaced as a unit.

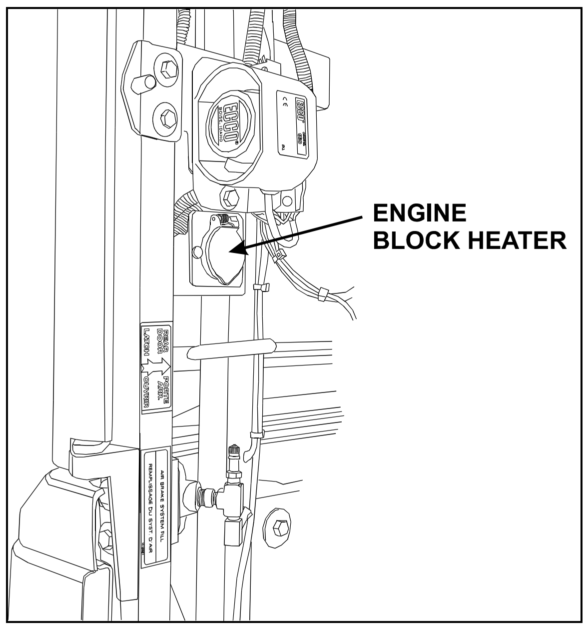


FIGURE 47: ELECTRIC HEATER PLUG LOCATION 18354

13. 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.

13.1 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 13.1.6.

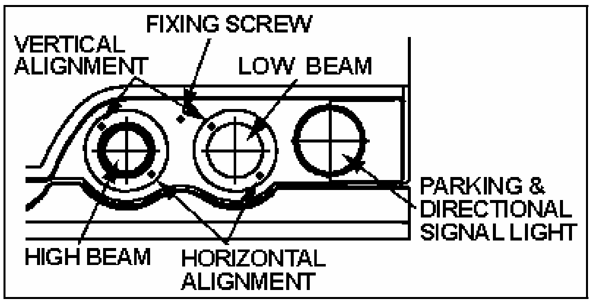


FIGURE 48: HEADLIGHT ASSEMBLY 06546

13.1.1 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.

13.1.2 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. 48). There is no adjustment for focus since the module is set for proper focus during manufacturing assembly.

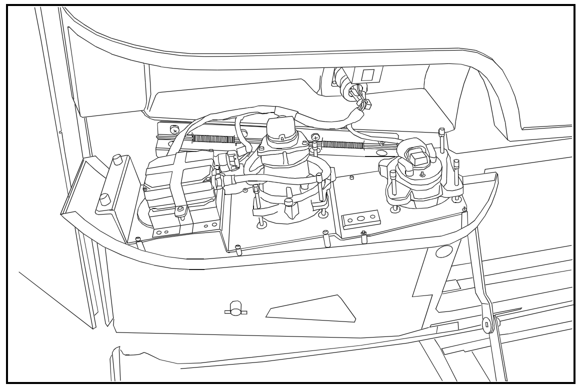


FIGURE 49: OPENING HEADLIGHT ASSEMBLY 06547

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.

13.1.3 Headlight Adjustment

The following is a general procedure for headlight adjustment using mechanical equipment, such as a *"Hoopy 100" Aligner.* If your mechanical equipment is different, refer to the manufacturer's instruction manual.

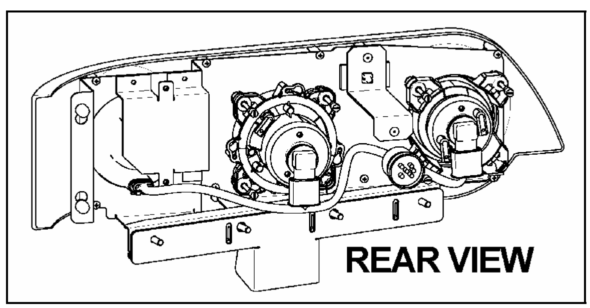


FIGURE 50: HEADLIGHT ASSEMBLY REAR VIEW 06548

Setting aligner according to slope

1. Park vehicle on a level floor.

2. Set the support rail (Prévost #29261) down (Fig. 51). Using shims, adjust its level to stabilize it.

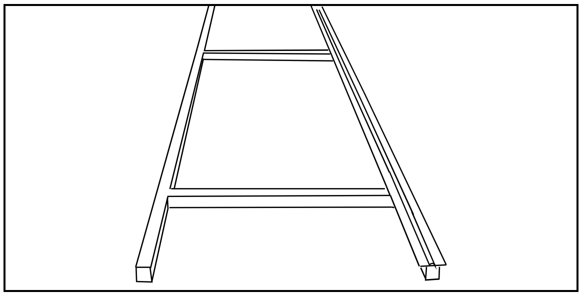


FIGURE 51: SUPPORT RAIL INSTALLATION 06501

3. Install jigs #29263 and #29262 onto the support rail. Position the support rail so that both stops are centered between the two beams (Fig. 52). Mark the position for future reference.

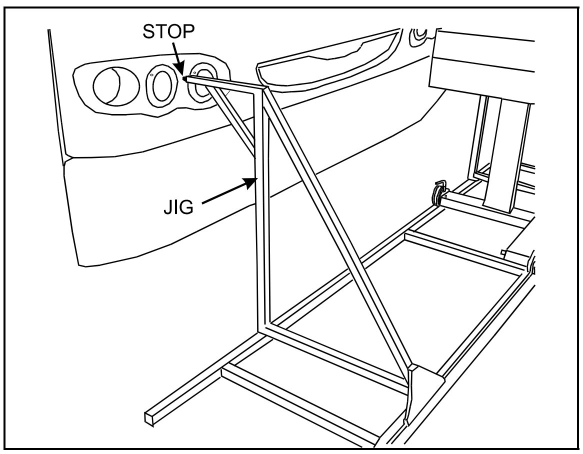


FIGURE 52: INSTALLATION OF JIGS 06499

NOTE
The stops will position the support rail between 16-24 inches of vehicle.

4. Remove the jigs.
5. Install *"Hoopy 100" Aligner* onto support rail (Fig. 53).
6. Using an Allen key on the front wheel, level Hoopy 100 aligner until spirit level bubble is centered (Fig. 54 and 55).
7. Install a calibration fixture in the axis of front axle wheel and one in the axis of rear axle wheel (Fig. 56).
8. Adjust mirrors so that lines are perfectly aligned.
9. Record reading.

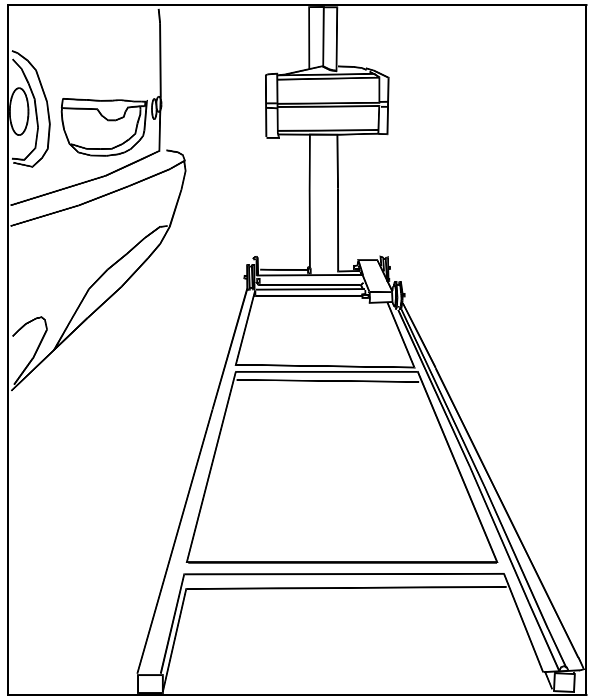


FIGURE 53: INSTALLATION OF HOOPY 100 ALIGNER 06496

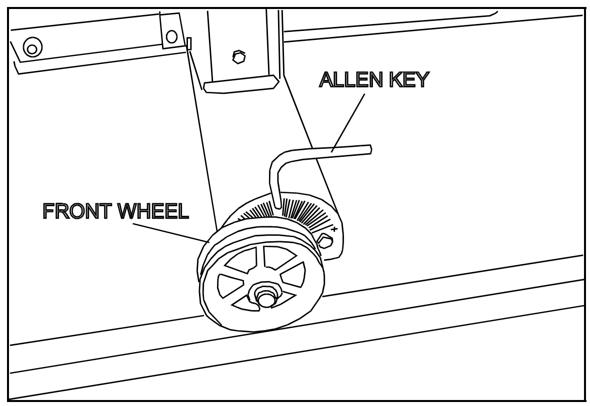


FIGURE 54: ADJUSTING HOOPY 100 LEVEL 06498

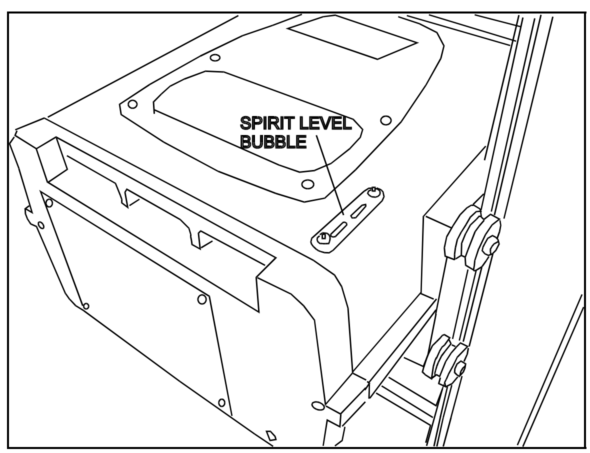


FIGURE 55: SPIRIT LEVEL 06500

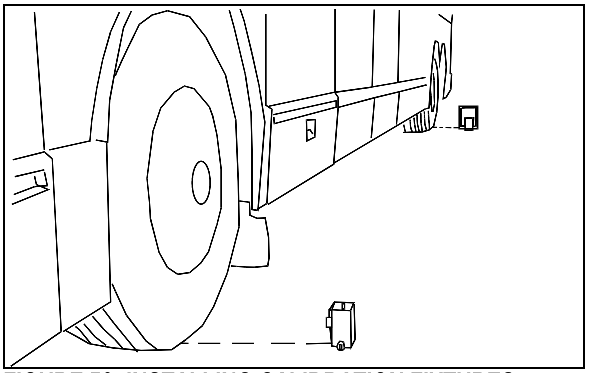


FIGURE 56: INSTALLING CALIBRATION FIXTURES 06497

NOTE
The floor level reading must be added to the aligner reading to ensure a precise alignment.

10. Transfer positive (+) or negative (-) reading of calibration fixtures to the front wheel of Hoopy 100 aligner. Add this reading to Hoopy 100 aligner level reading.
    * eg – level: 0.2, mirrors: 0.1 = 0.3
    * eg – level: -0.2, mirrors: 0.1 = 0.1

NOTE
If vehicle remains stationary during the headlight alignment procedure, it is not necessary to check floor slope each time.

Headlight Alignment

⚠ CAUTION ⚠
This mechanical equipment must be calibrated by metrology before initial set-up or after major overhaul. Calibration must be performed annually.

1. Set the support rail (Prévost #29261) down (Fig. 51). Using shims, adjust its level to stabilize it. Use previous reference marks to ensure proper positioning.
2. Make sure that headlight assembly fixing screw is properly fastened (Fig. 48).

NOTE
Make sure that the vehicle is at proper height (suspension) and that air pressure is above 90 psi.

3. Install *"Hoopy 100" Aligner* onto support rail (Fig. 53). Turn aligner ON.

⚠ CAUTION ⚠
Vehicle must be parked at the same location each time. If location is changed for any reason, floor slope alignment and aligner leveling must be redone. Refer to "Setting aligner according to slope".

NOTE
If aligner indicates LOW BATT, battery must be charged for 12 hours.

Low Beam Adjustment

1. Turn ON low beam lights.
2. Press ALIGN TO LAMP and move aligner in front of first beam.

NOTE
If beam is offset, a LOW CANDLES message will appear. Using vertical and horizontal alignment screws, adjust beam as needed (fig. 48).

3. Adjust aligner height (move aligner sideways if needed) so that XX appears in the aligner sight. Lock aligner side handle.
4. Open Hoopy 100 aligner door.
5. Press AIM LAMP down; press a second time so that LOW ADJUST appears in the sight. Arrows indicate in which direction to adjust the beam using the vertical and horizontal adjustment screws. Perform this adjustment until XX appears in the sight.
6. Aligner will reset after 5 minutes.
7. Repeat for other low beam light.

High Beam Adjustment

1. Turn ON high beam lights.
2. Press ALIGN TO LAMP and move aligner in front of first beam.
3. Adjust aligner height (move aligner sideways if needed) so that XX appears in the aligner sight. Lock aligner side handle.
4. Open Hoopy 100 aligner door.
5. Press AIM LAMP down; press a second time so that HIGH ADJUST appears in the sight. Arrows indicate in which direction to adjust the beam using the vertical and horizontal adjustment screws. Perform this adjustment until XX appears in the sight.
6. Aligner will reset after 5 minutes.
7. Repeat for other high beam light.
8. Store equipment away in a safe place.

If proper mechanical equipment is not available, perform adjustments as described hereafter:

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 ½ 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. 57).
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 table1.

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

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. 58).
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. 59).

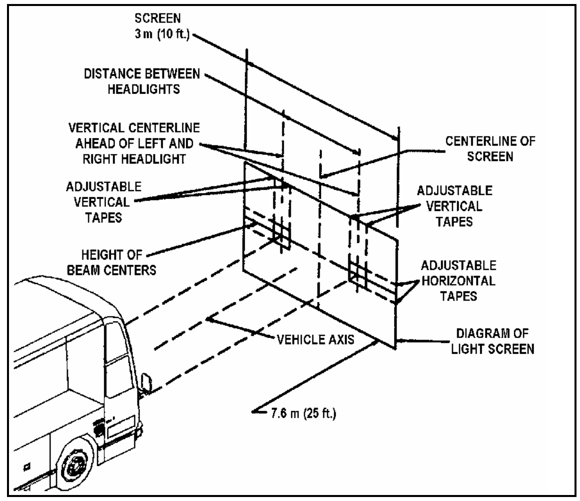


FIGURE 57: ALIGNMENT OF HEADLIGHT AIMING SCREEN 06502

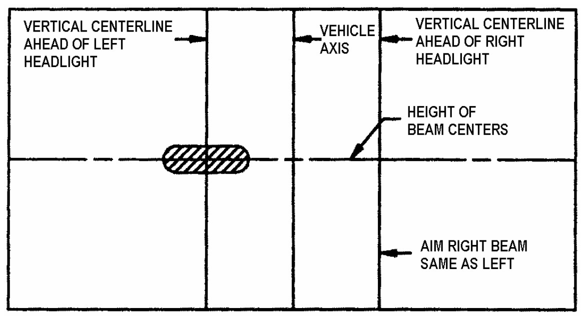


FIGURE 58: HIGH-INTENSITY ZONE (SHADED AREA) OF A PROPERLY AIMED UPPER BEAM ON THE AIMING SCREEN 7.6 M (25FT) IN FRONT OF VEHICLE 06503

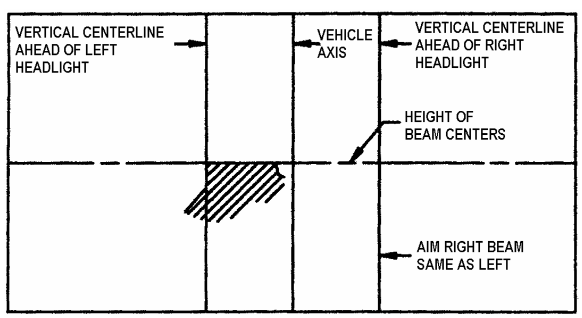


FIGURE 59: HIGH-INTENSITY ZONE (SHADED AREA) OF A PROPERLY AIMED LOWER BEAM ON THE AIMING SCREEN 7.6 M (25FT) IN FRONT OF VEHICLE 06504

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. 60).

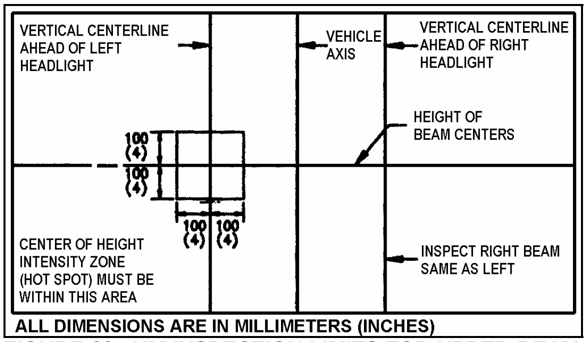


FIGURE 60: AIM INSPECTION LIMITS FOR UPPER-BEAM HEADLIGHTS 06505

8. 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. 61).

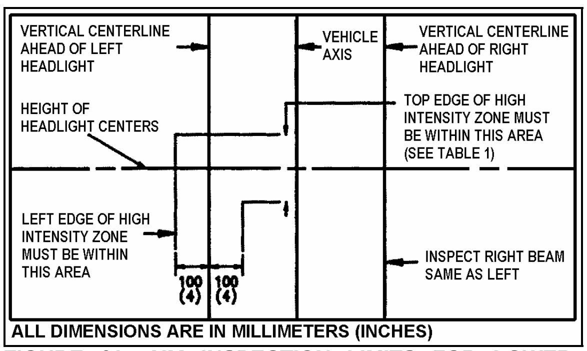


FIGURE 61: AIM INSPECTION LIMITS FOR LOWER-BEAM HEADLIGHTS 06506

13.1.4 Sealed-Beam Unit

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. 48 and 49).
3. Remove connector from headlight bulb.
4. Remove the bulb by pushing and rotating it out of the socket.
5. 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

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. 48 and 49).
3. Remove connector from headlight bulb.
4. Unfasten three metal clips attaching headlight unit to support.
5. Install new module and fasten metal clips.
6. Install wiring connector on back of new sealed beam unit.
7. 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.

8. 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.

13.1.5 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. 48 and 49).
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.

13.1.6 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.

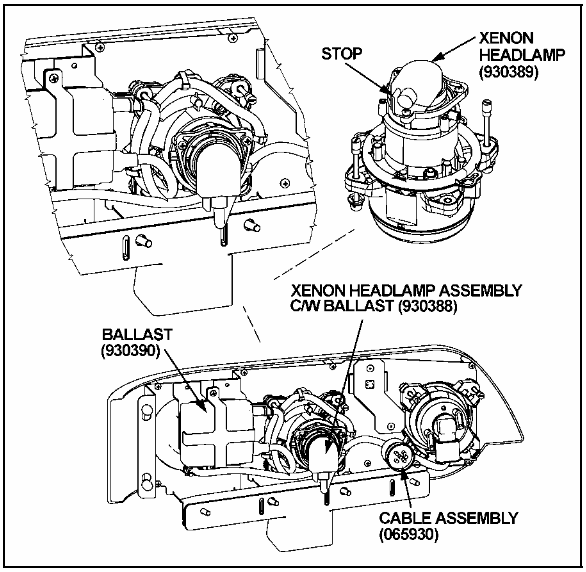


FIGURE 62: XENON HEADLAMP LOCATION 06549

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. 48 and 49).
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.

13.2 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.

13.2.1 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.

13.2.2 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.

13.3 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.

13.4 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.

13.4.1 Marker Light Removal and Replacement

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.

13.4.2 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.

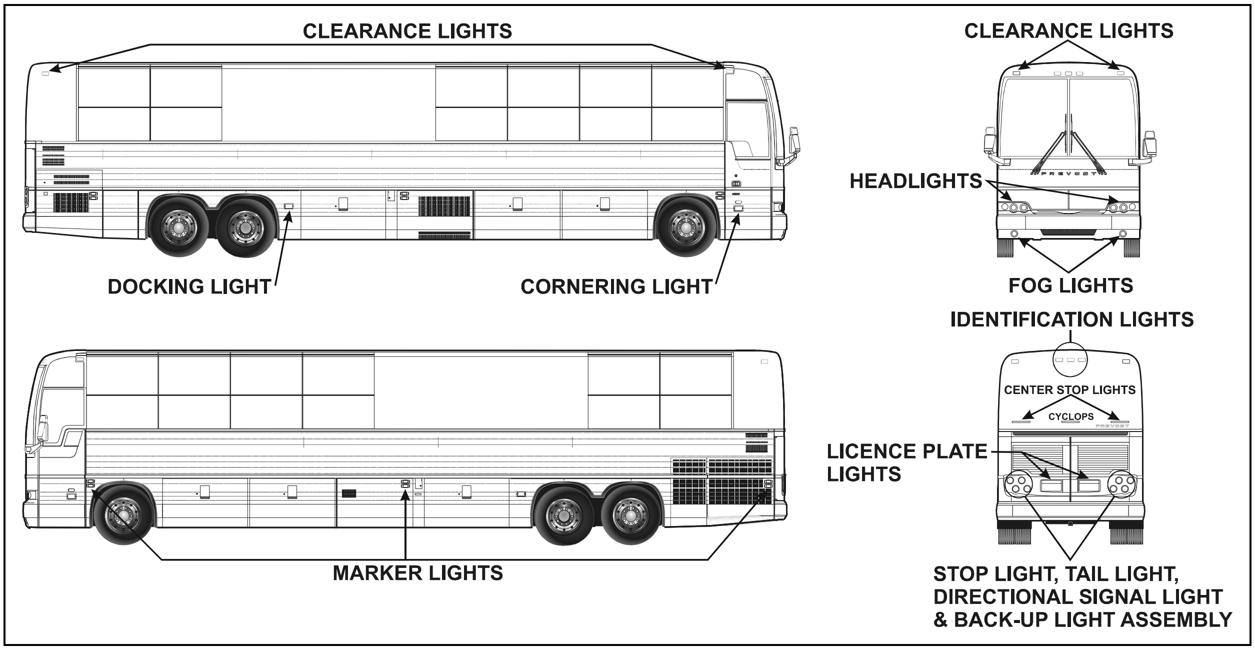


FIGURE 63: VARIOUS LIGHTS LOCATION 06544

13.5 DOCKING AND CORNERING LIGHTS

MTH vehicles are provided with two halogen sealed-beam units that serve as cornering lights. They are mounted on the vehicle as follows: one is mounted on the front L.H. side service compartment door, while the other is located on the entrance door on the R.H. side. The main function of these lights is to increase lateral visibility when turning a corner. These lights are energized simultaneously with the directional lights. A dashboard-mounted rocker switch may be actuated to cancel this system in special situations.

Two additional halogen sealed-beam units may be installed aft of the rear baggage compartment. These lights are used as docking lights and both will illuminate automatically when reverse range is selected to facilitate back-up or docking procedure. The cornering lights do not operate automatically when the reverse range is selected, but by means of a dashboard-mounted rocker switch. When the docking position is selected, the docking as well as the cornering lights illuminate.

13.5.1 Lamp Removal and Replacement

Both docking and cornering sealed-beam units can be changed in accordance with the following procedure:

1. Remove the two “Phillips” screws attaching the retaining ring.
2. Disconnect the light unit connection.
3. Remove the lamp.
4. Position new lamp.
5. Connect and position the light unit.
6. Finally, install the retaining ring.

13.6 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.

13.6.1 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.
6. Fasten the wing nut and securely close the bumper.

14. INTERIOR LIGHTING EQUIPEMENT

14.1 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.

14.1.1 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. 64).

NOTE
Switches are lighted by the use of LED. When lighting on a switch fails, replace defective switch as a unit.

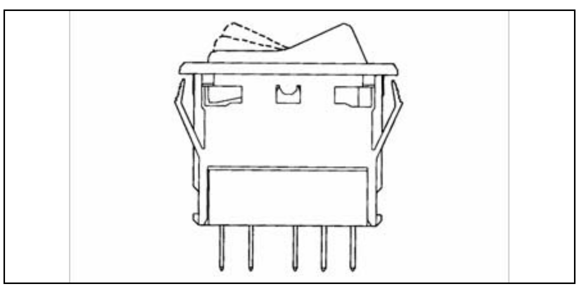


FIGURE 64: SWITCH 06321

14.1.2 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.

14.1.3 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.

14.2 STEPWELL LIGHTS (COACHES ONLY)

Two Stepwell lights are illuminated when the door opening system is activated.

14.2.1 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.

14.3 LAVATORY NIGHT-LIGHT

The lavatory night-light is illuminated as soon as the ignition switch is set to the *"ON"* position.

14.3.1 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

14.4 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.

14.4.1 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 ⚠
Do not touch halogen bulbs with bare hands as natural oils on skin will shorten bulb life span.

14.5 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.

14.5.1 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. 58).

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.

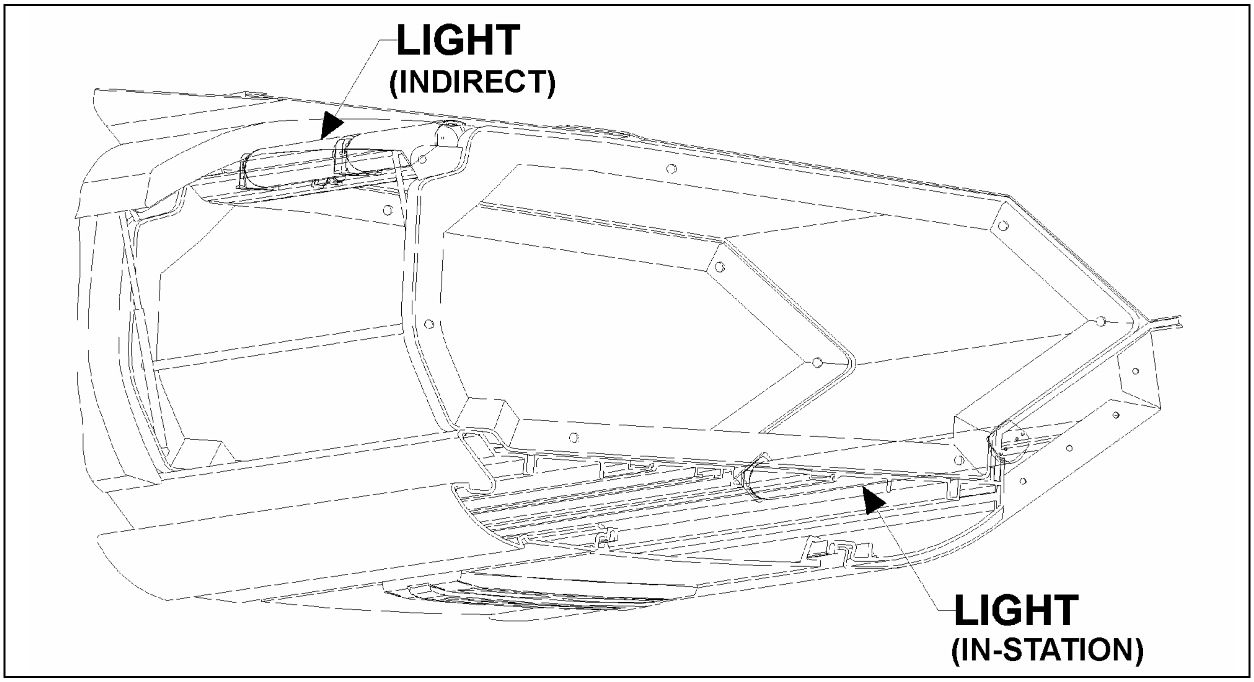


FIGURE 65: PARCEL RACK LIGHTING 06419

14.5.2 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 ⚠
The lens is fragile. Be very careful when removing and handling.

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.

14.5.3 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.

14.6 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.

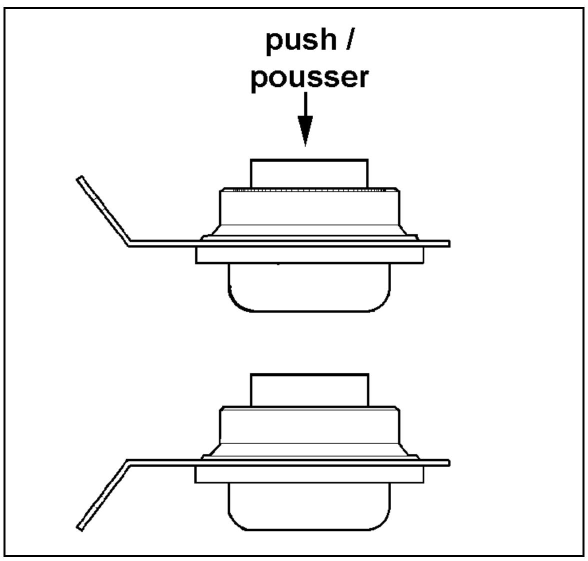


FIGURE 66: ENGINE COMPARTMENT LIGHT

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.

14.7 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.

15. 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

LIGHT BULB DATA					
APPLICATION	**PREVOST PART NO.**	**TRADE OR SAE NUMBER**	**WATTS OR CANDLE POWER**	**VOLTS**	**QTY**
EXTERIOR LIGHTING					
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.	562907	---	---	---	1
Step light (Coaches)	562278	6429	10 W	24	2
Lavatory	830176	Q20MR16	20 W	12	1
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	563260	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

16. 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)

Electrical system monitor

Make .... Vanner
Model EM-70
Input .... 24 V dc
System high .... Greater than 30 V dc
System low .... Less than 24 V dc
Trip level .... + 0.75 V dc
Prévost Number 562058

Alternator

Make .... Delco Remy
Model Number 1117702
Series 50DN
Type 600

Field current at 80°F (27°C)
-Amperes .... 7.2 – 8.0
-Volts 24

Hot output

-Amperes .... 270 at 80°F (27°C) ambient

-Volts 28

-Approximate rpm 3000

Ground .... negative

Prévost number 561723

Regulator

Make.. Delco-Remy
Model Number..
Type .... Transistor
Voltage adjustment .... External screw
Prévost number.. 562775

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.. 60-100D
Amperes.. 100 amps
Prévost Number 563334

Starter

Make..Mitsubishi Electric Corporation (MELCO)
Model Number..M009T82479
Type 105P70
Voltage 24
Prévost Number 510752

No-load test
-Volts 23.5
-Max. current draw ....125 amperes
-Min. rpm ....3000 rpm

Starter solenoid

Make..Mitsubishi Electric Corporation (MELCO)
Model Number.. 1115557
Pull In Voltage ....16 volts max.

Mitsubishi Electric Corporation (MELCO)

STARTER MOTORS (105P70)

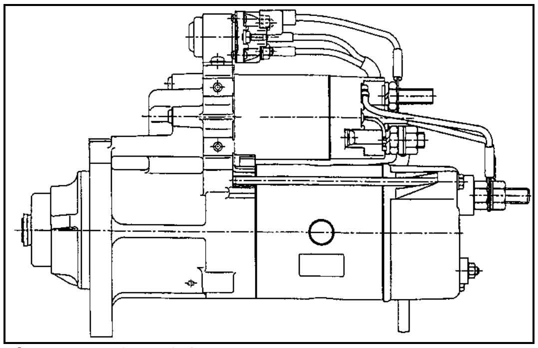


Figure 1 - 105P70 STARTER

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.

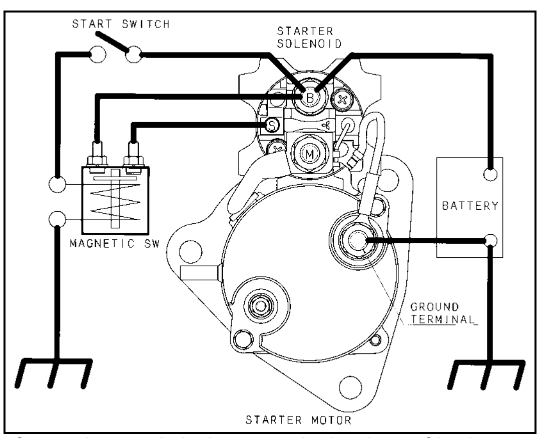


Figure 2 - BASIC STARTING CIRCUIT (GROUND-FLOAT TYPE)

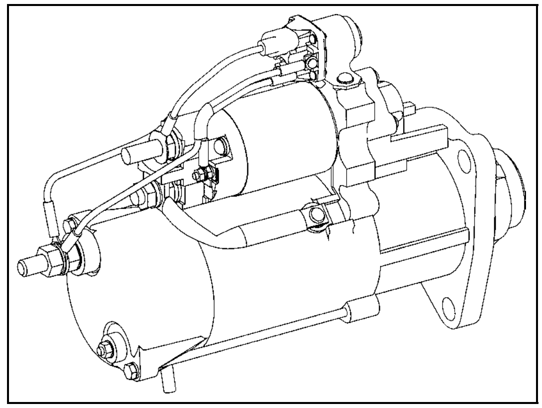


Figure 2 shows the circuit diagram for the 105P70 Ground-float type (sometimes referred to as Insulated or Isolated Ground).

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.

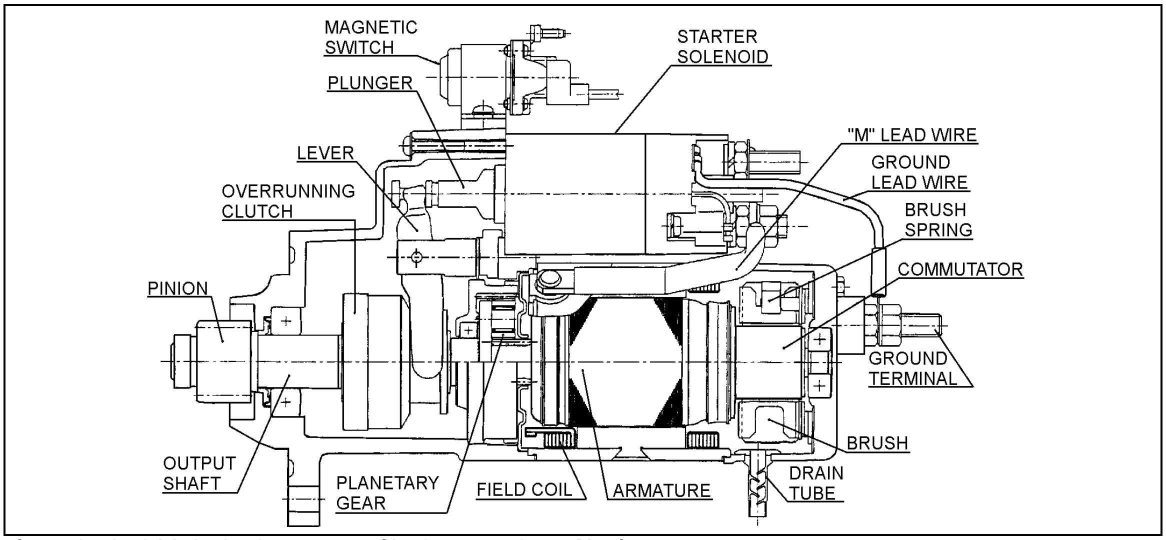


Figure 3 - CROSS-SECTIONAL VIEW (GROUND-FLOAT TYPE)

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-shorted, or the pinion sliding area may be clogged.

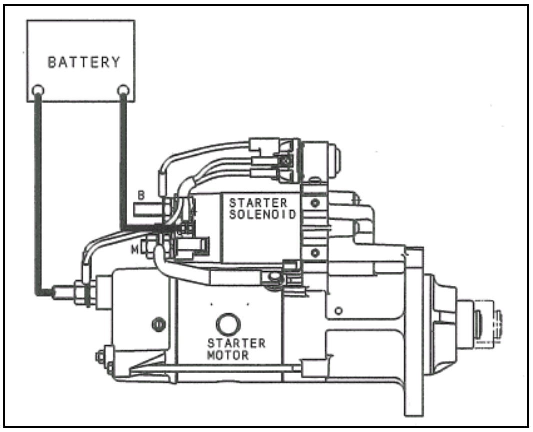


Figure 4 - TESTING PINION MOVEMENT AND PULL-IN WINDINGS (GROUND-FLOAT TYPE)

For the starter switch coils, refer to the switch circuit diagrams for the ground-wire type (ground-float type) shown in figures 5.

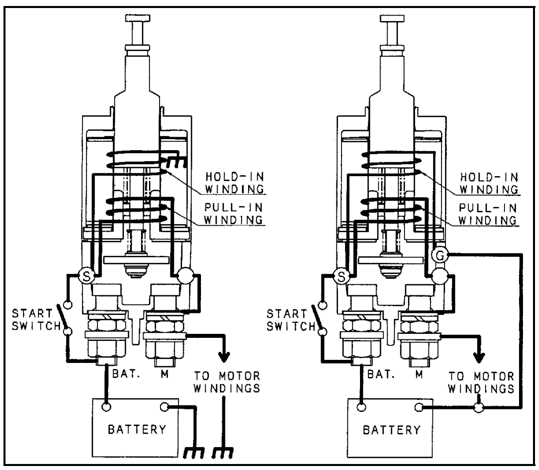


Figure 5 - SOLENOID CIRCUIT (GROUND-FLOAT TYPE)

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-shorted.

* M-terminal nut tightening torque: 20 to 30 N·m

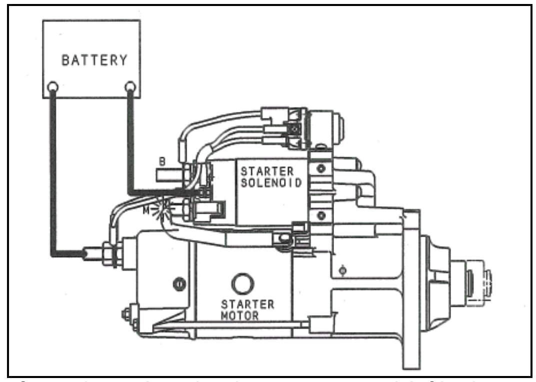


Figure 6 - TESTING HOLD-IN WINDINGS (GROUND-FLOAT TYPE)

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.*

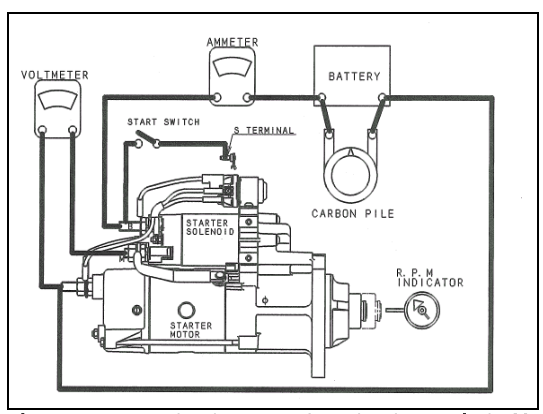


Figure 7 - NO-LOAD TEST CIRCUIT (BODY-GROUND TYPE)

* 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.

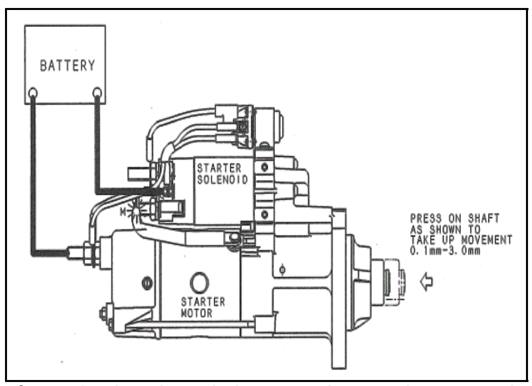


Figure 8 - CHECKING OUTPUT SHAFT CLEARANCE (GROUND-FLOAT TYPE)

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

Table of contents

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 and 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 μF (microfarad)
Load current less than/equal to 10A	27.6 … 28.4 V (volts, regulated)
Damping Resistance	3.1 … 3.5 kΩ (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.

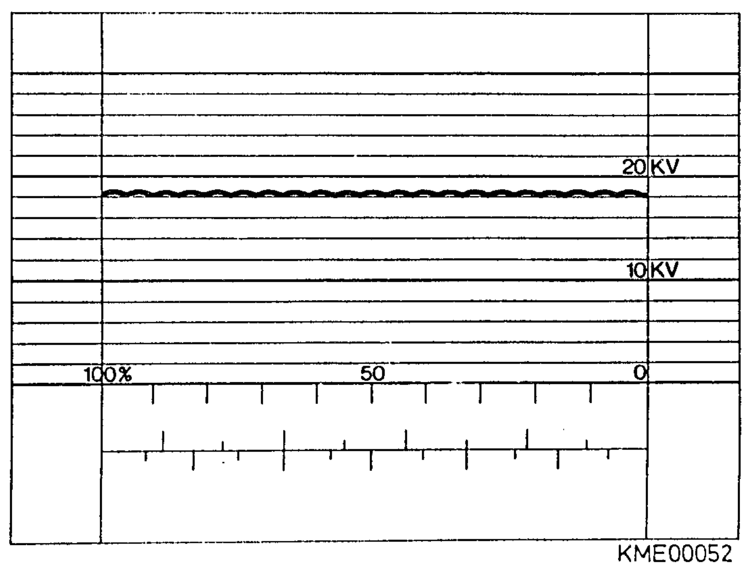


Figure 1 Normal Oscilloscope Pattern

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.

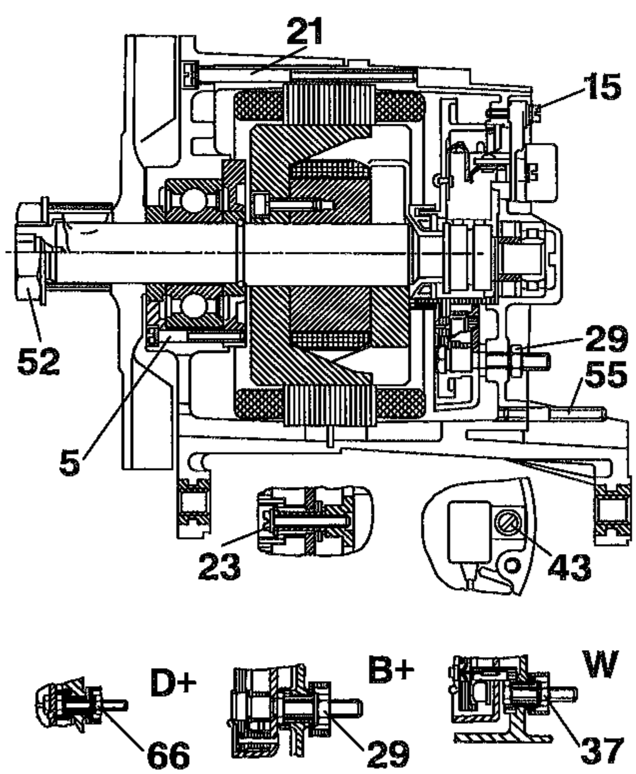


Figure 2 Fastener Torque Chart

4 Alternator Schematic

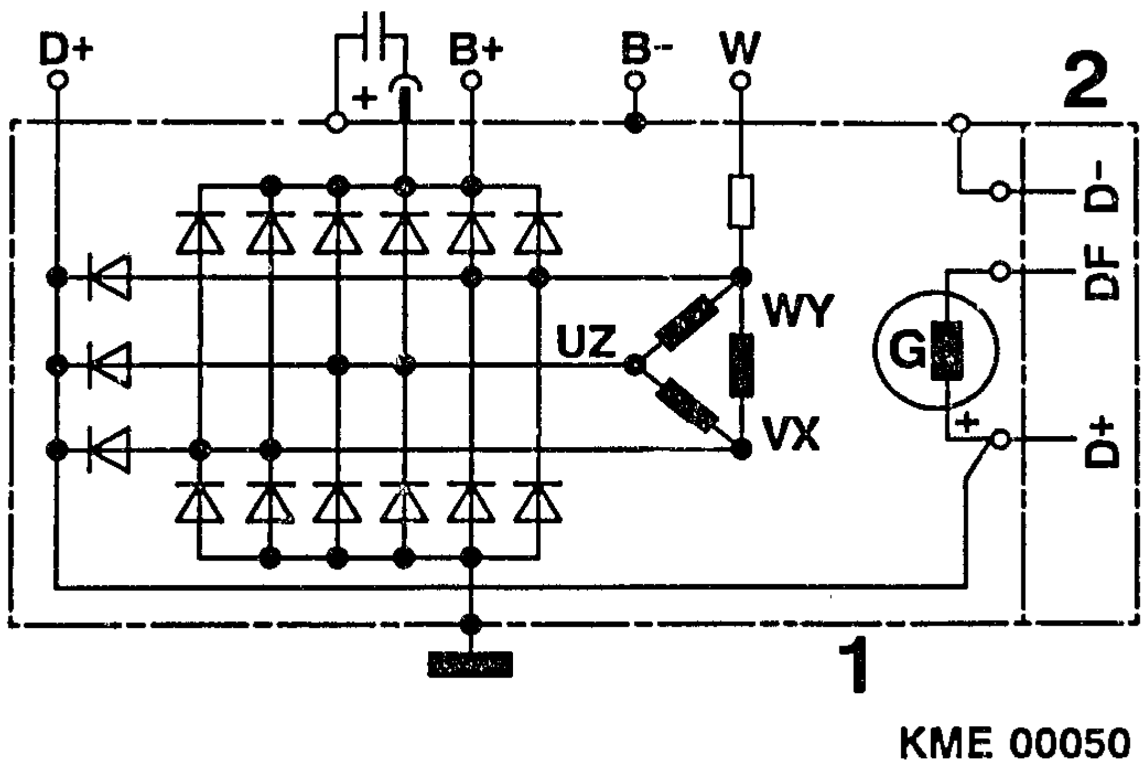


Figure 3 Alternator/Voltage Regulator Schematic

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

Rated current in amps measured at 6000 rpm

Rated current in amps measured at 1500 rpm

Alternator Voltage

Direction of Rotation

(→) Or R	Clockwise
(←) Or L	Counter Clockwise
(↔) Or RL	Multidirectional

1	Claw Pole Alternator
2	Salient Pole Alternator
3	Windingless Rotor Alternator

Outer Diameter of Alternator

G	100 … 109 mm
K	120 … 129 mm
N	130 … 139 mm
T	170 … 199 mm
U	more than 200 mm

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 and 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 *Note: 2 Required*	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) *Note: 4 required*	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

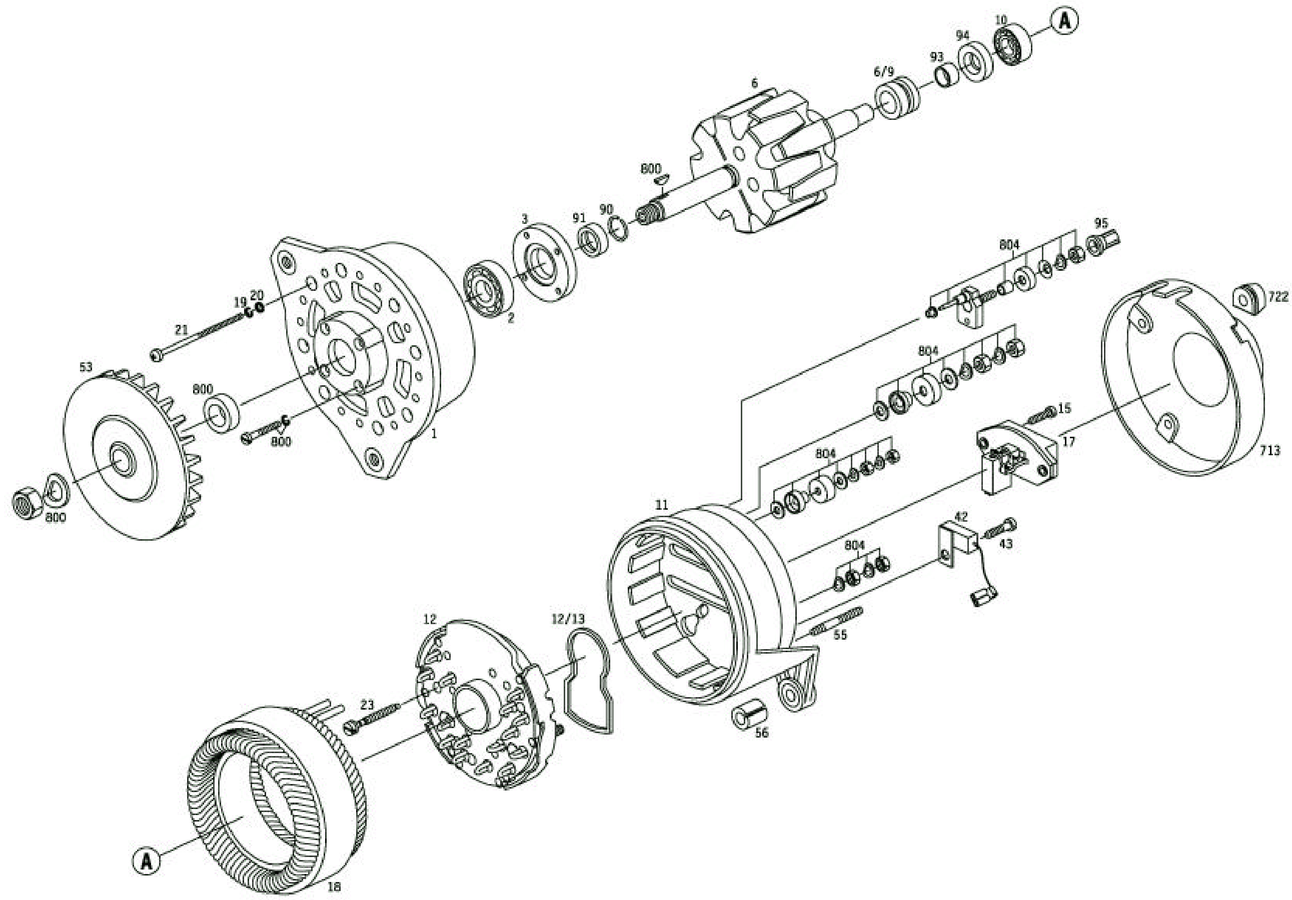


Figure 4 Alternator Exploded View

Item	Designation	Item	Designation
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)

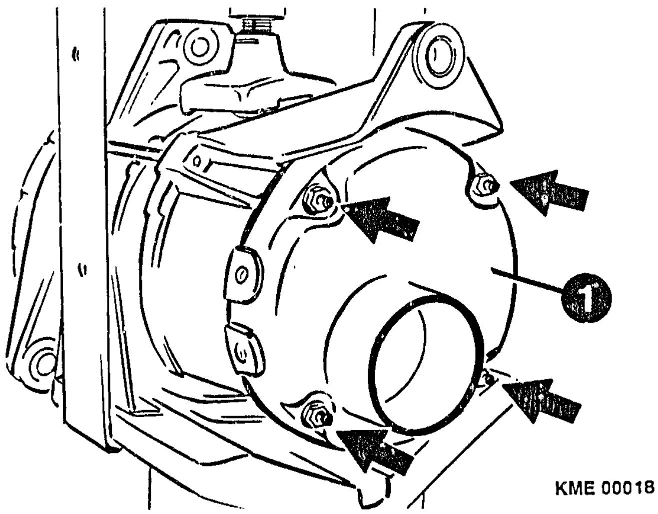


Figure 5 Air Intake Cover Removal (1)

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.

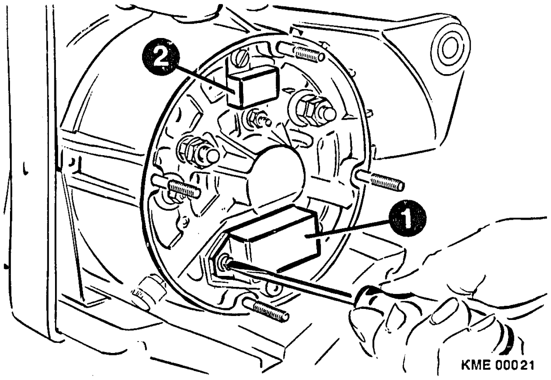


Figure 6 Voltage Regulator (1) and Suppression Capacitor (2)

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)

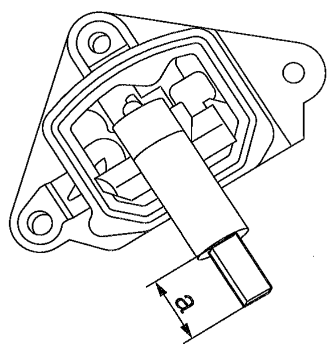


Figure 7 Brush Length Measurement

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)

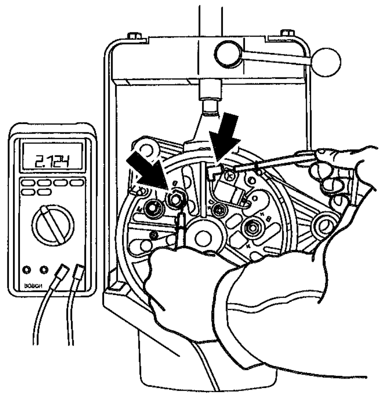


Figure 8 Testing of Suppression Capacitor

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.

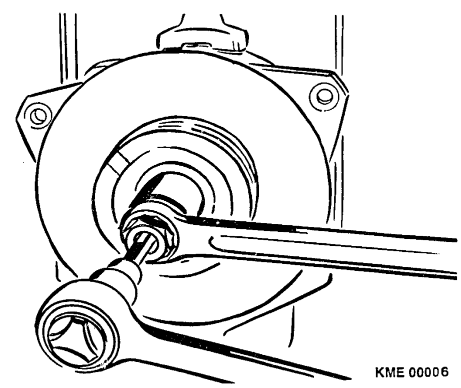


Figure 9 Pulley and Fan Removal

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 realigning 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)

2. Slide the drive end shield and rotor out of the collector end shield.

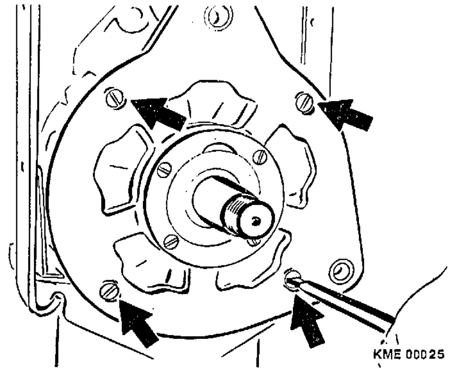


Figure 10 Drive End Shield Removal

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.

1. With the rectifier assembly still installed in the collector end shield, testing of the rectifier is to be performed.

   a. Using tester WPG 012.00 (Bosch Number 0 684 201 200) (Figure 11)

   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.

   ii) 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.

   iii) 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.

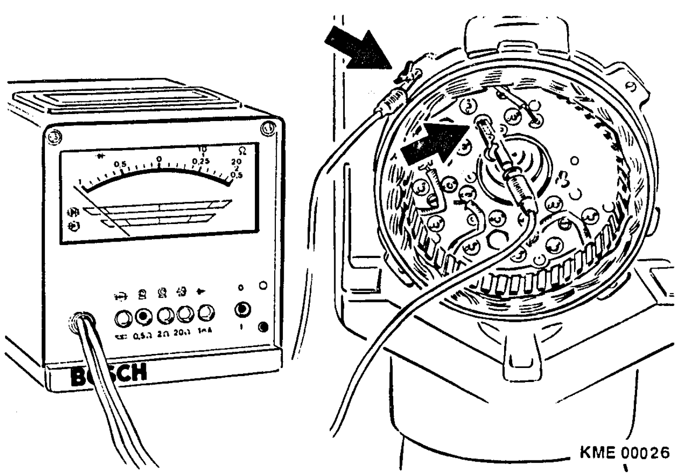


Figure 11 Testing of Rectifier Assembly

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)

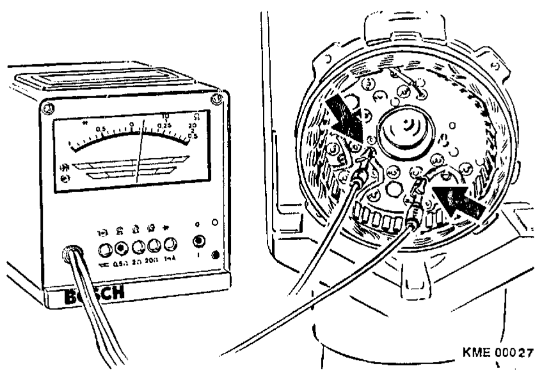


Figure 12 Stator Resistance Testing

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.

4. 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.

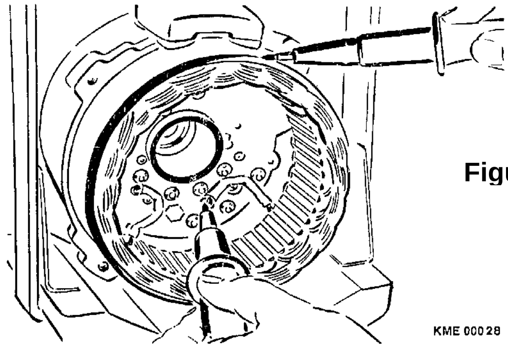


Figure 13 Stator Insulation Testing

9.8 Rectifier Assembly Removal

1. Loosen and remove the three screws that hold the rectifier to the collector end shield. (Figure 14)
2. Unsolder the W terminal from the rectifier assembly.

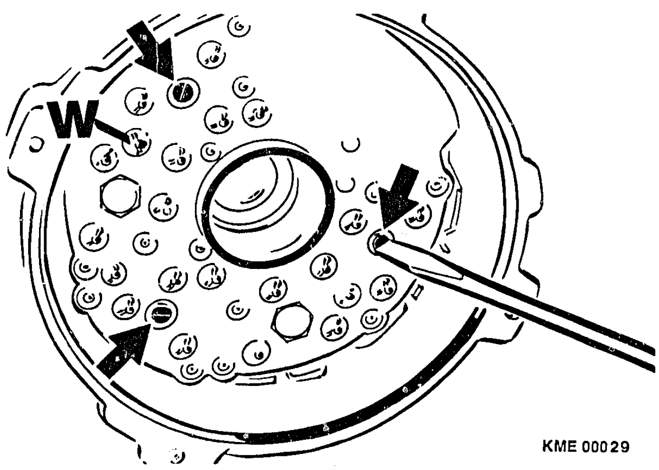


Figure 14 Rectifier Assembly Removal

3. 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.

4. 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)

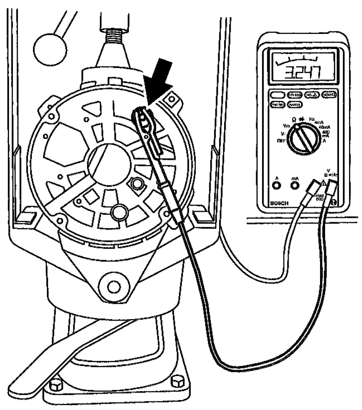


Figure 15 Testing of W Terminal Dampening Resistor

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)

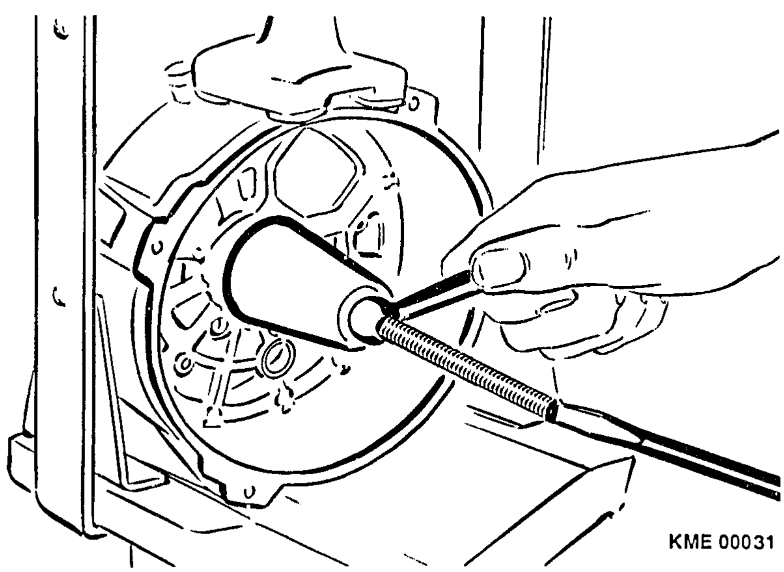


Figure 16 Bearing and Seal Removal

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.

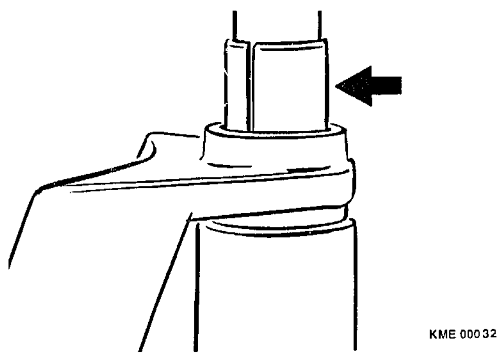


Figure 17 Sliding Bushing Removal

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.

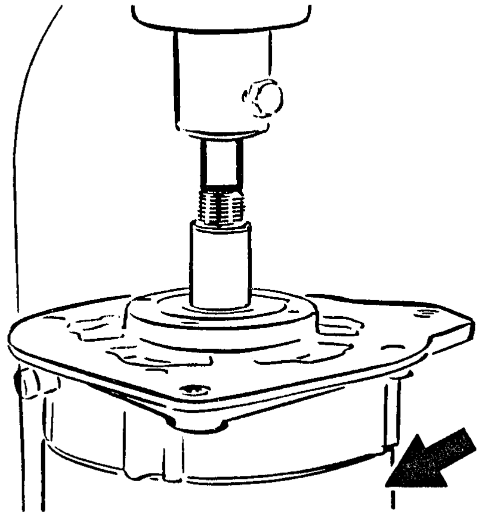


Figure 18 Pressing out Rotor

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.

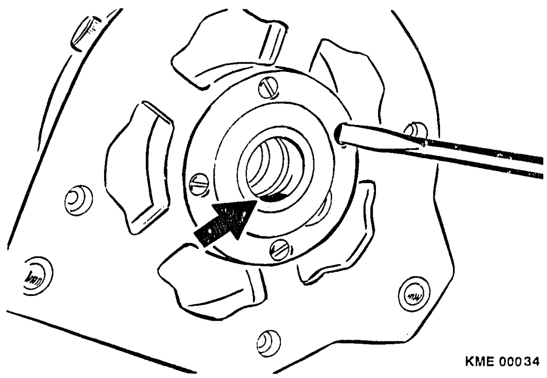


Figure 19 Drive End Bearing Removal

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.

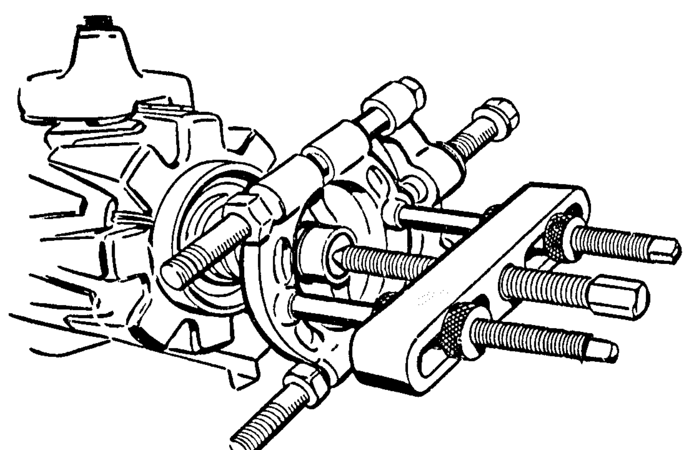


Figure 20 Inner Bearing Race Removal

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 . (Figure 21)

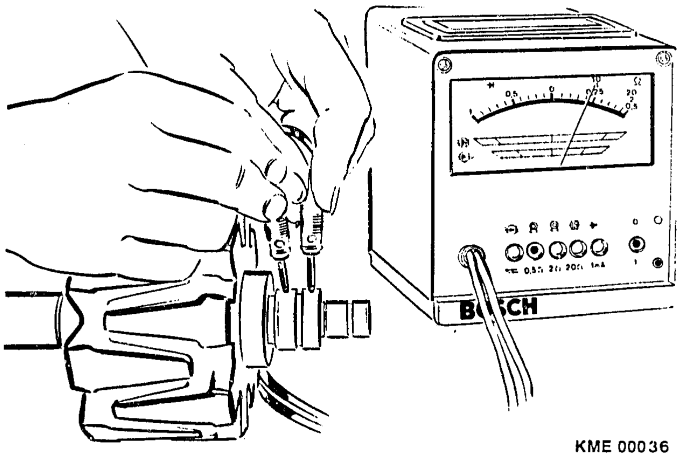


Figure 21 Rotor Resistance Testing

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)

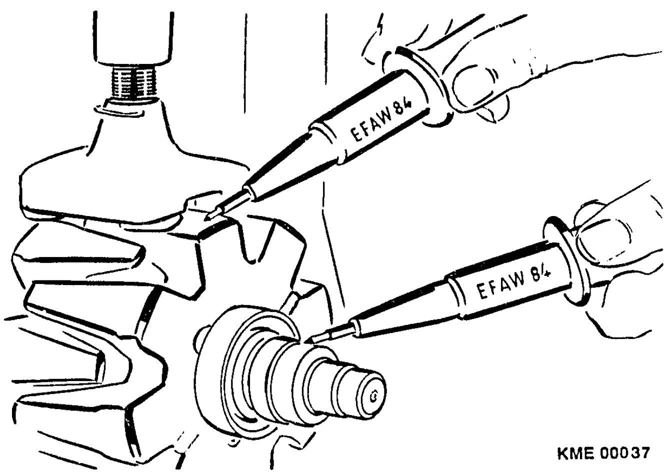


Figure 22 Rotor Insulation Testing

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.

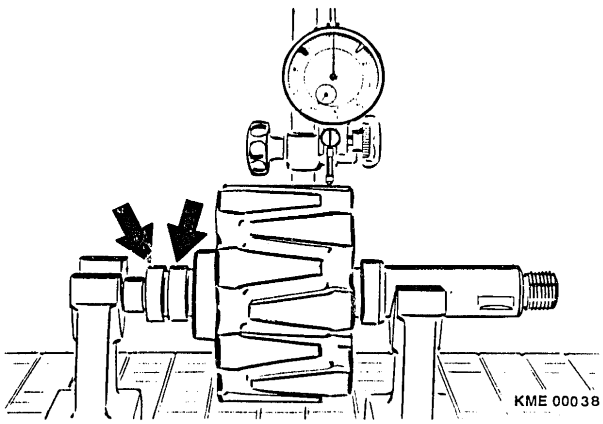


Figure 23 Rotor Concentricity Measurement

   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)

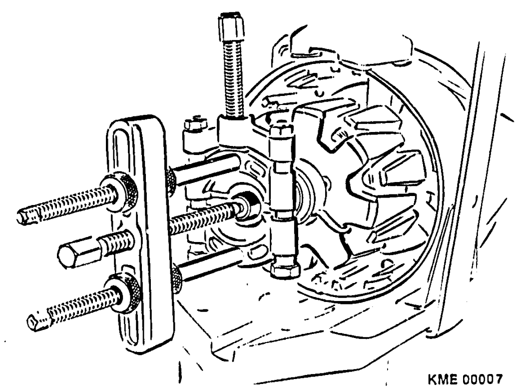


Figure 24 Collector Ring Removal

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)

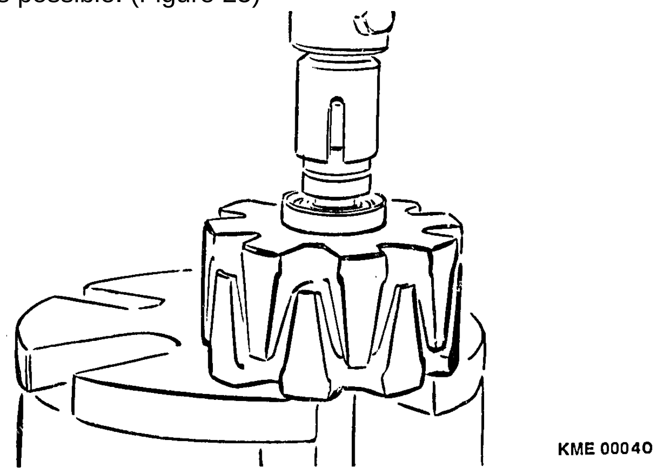


Figure 25 Pressing on Collector Rings

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)

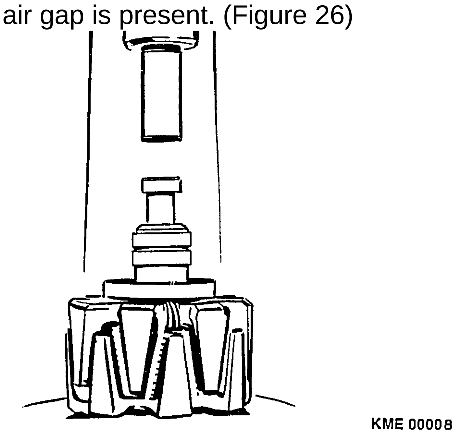


Figure 26 Spacer Ring Installation

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)

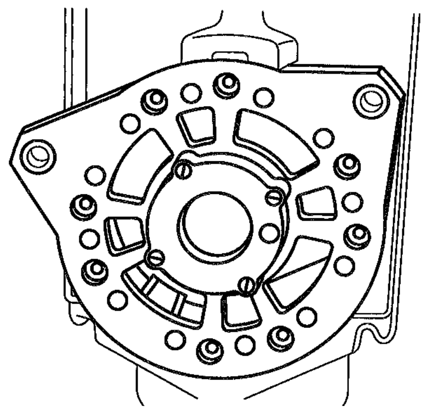


Figure 27 Drive End Bearing Retaining Screws

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.

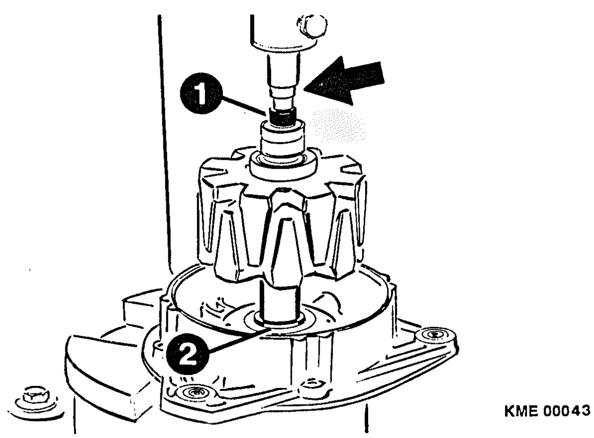


Figure 28 Installing Rotor into Drive End Shield
(1) Tool KDLJ 6018 (2) Support Ring

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.

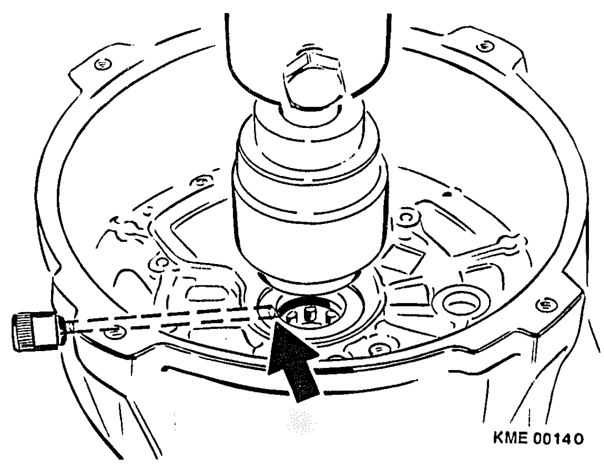


Figure 29 Installation of Bearing and Seal

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)

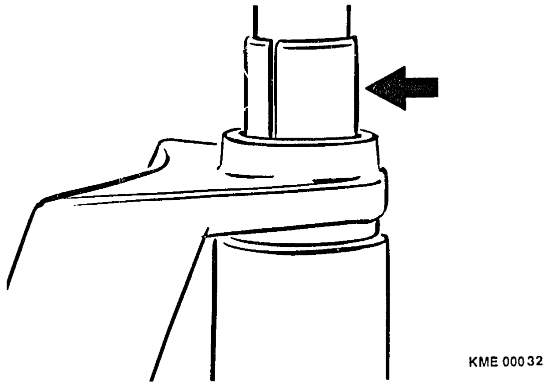


Figure 30 Sliding Bushing Installation

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)

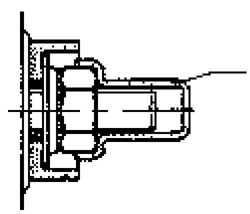


Figure 31 Terminal W Insulator, Washer, Nut and Cap

10.4 Rectifier Assembly

1. Place flat washer and insulator (a) onto terminal B+ and D+ studs of the rectifier assembly. (Figure 32)

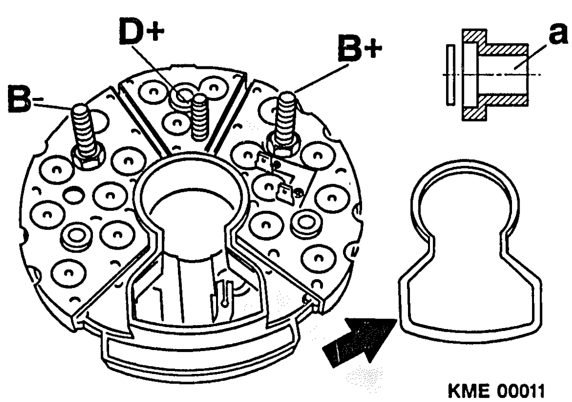


Figure 32 Rectifier Insulators and Seal

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.

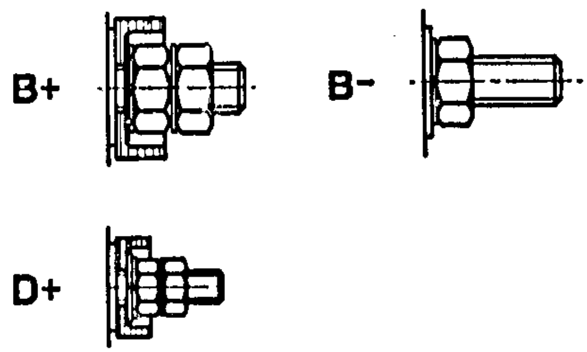


Figure 33 Terminal B+, B- and D+ Assembly

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)

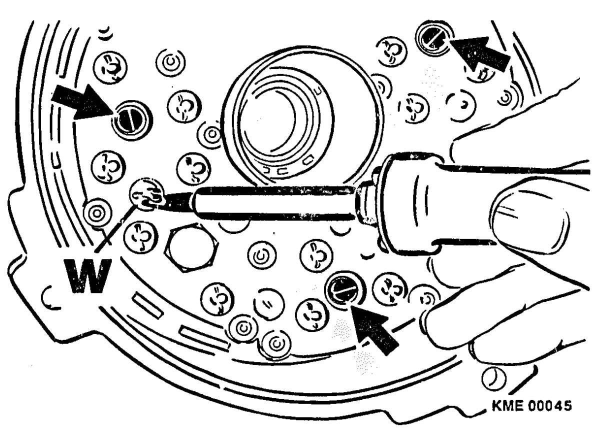


Figure 34 Rectifier Mounting and Soldering of Terminal W

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)

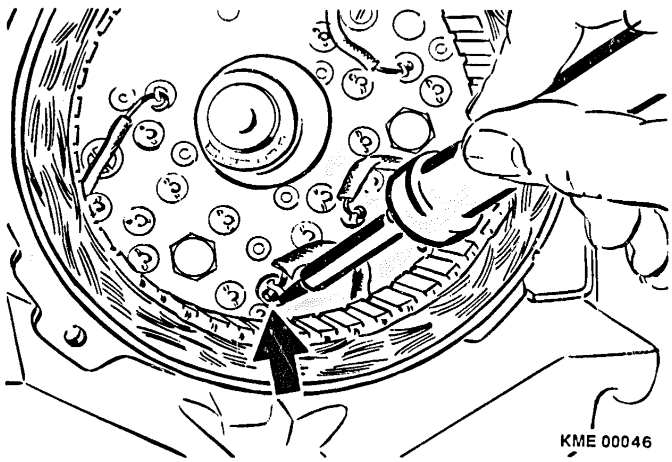


Figure 35 Soldering of Stator Leads

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.

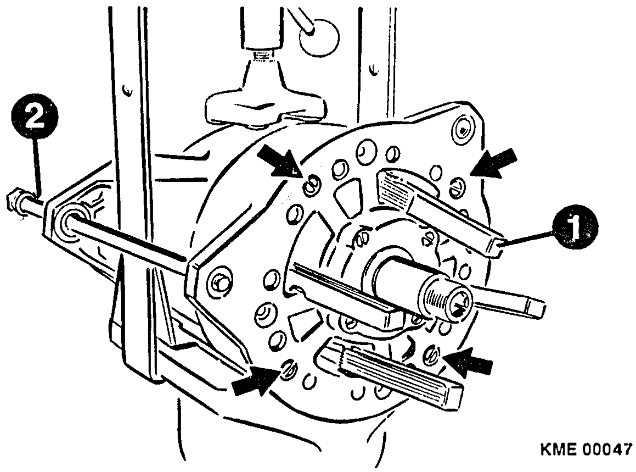


Figure 36 Drive End Shield, Stator and Collector End Shield Assembly
(1) Feeler Gauge (2) Tool KDLJ 6015

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)

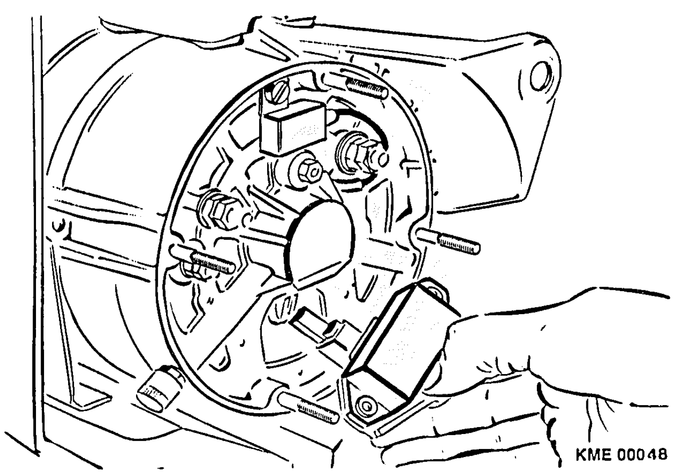


Figure 37 Regulator Installation

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)

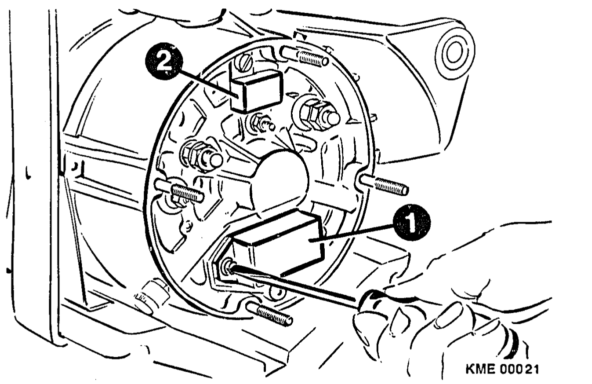


Figure 38 Capacitor Installation
(1) Voltage Regulator (2)

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.

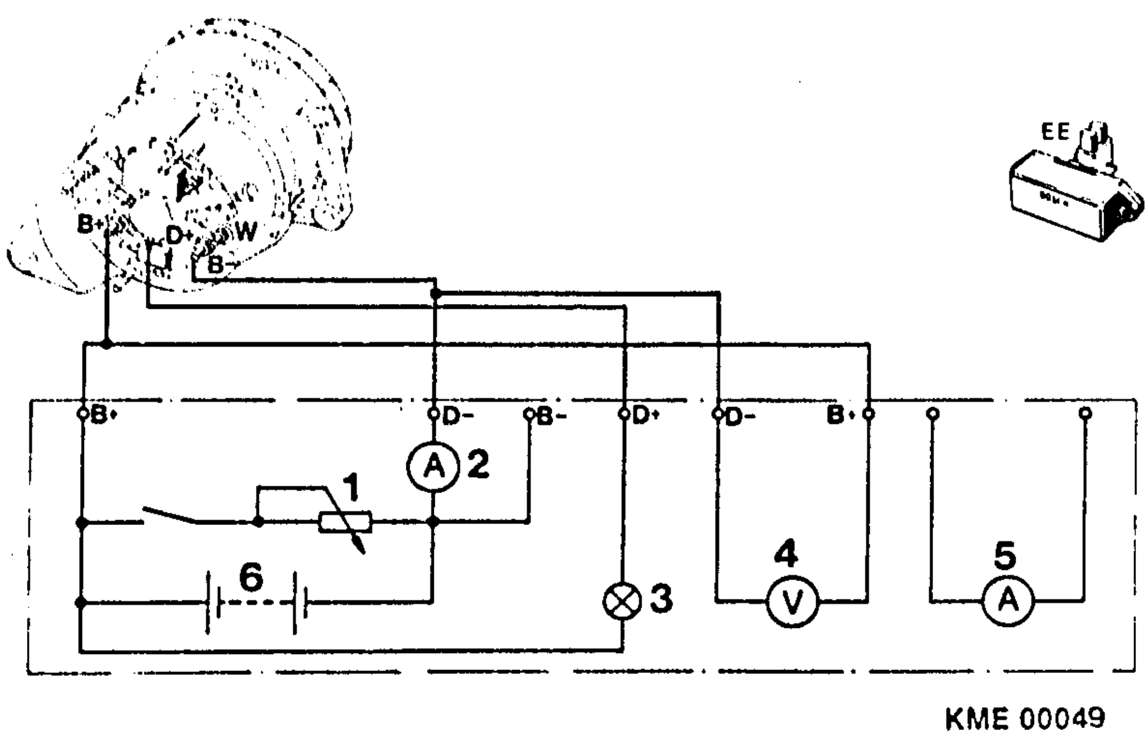


Figure 39 Alternator Test Bench Hook-up Schematic

(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.

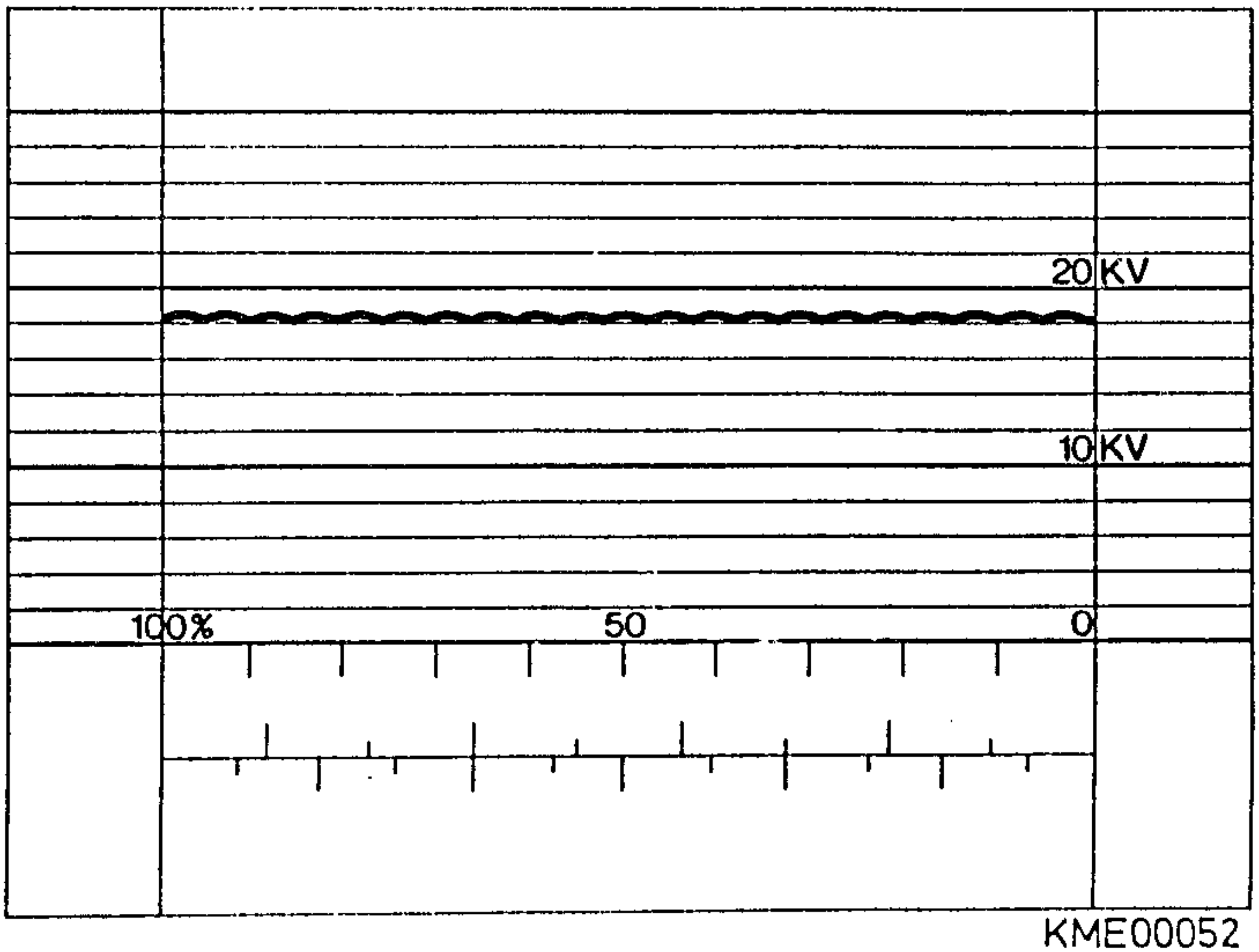


Figure 40 Normal Pattern

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.

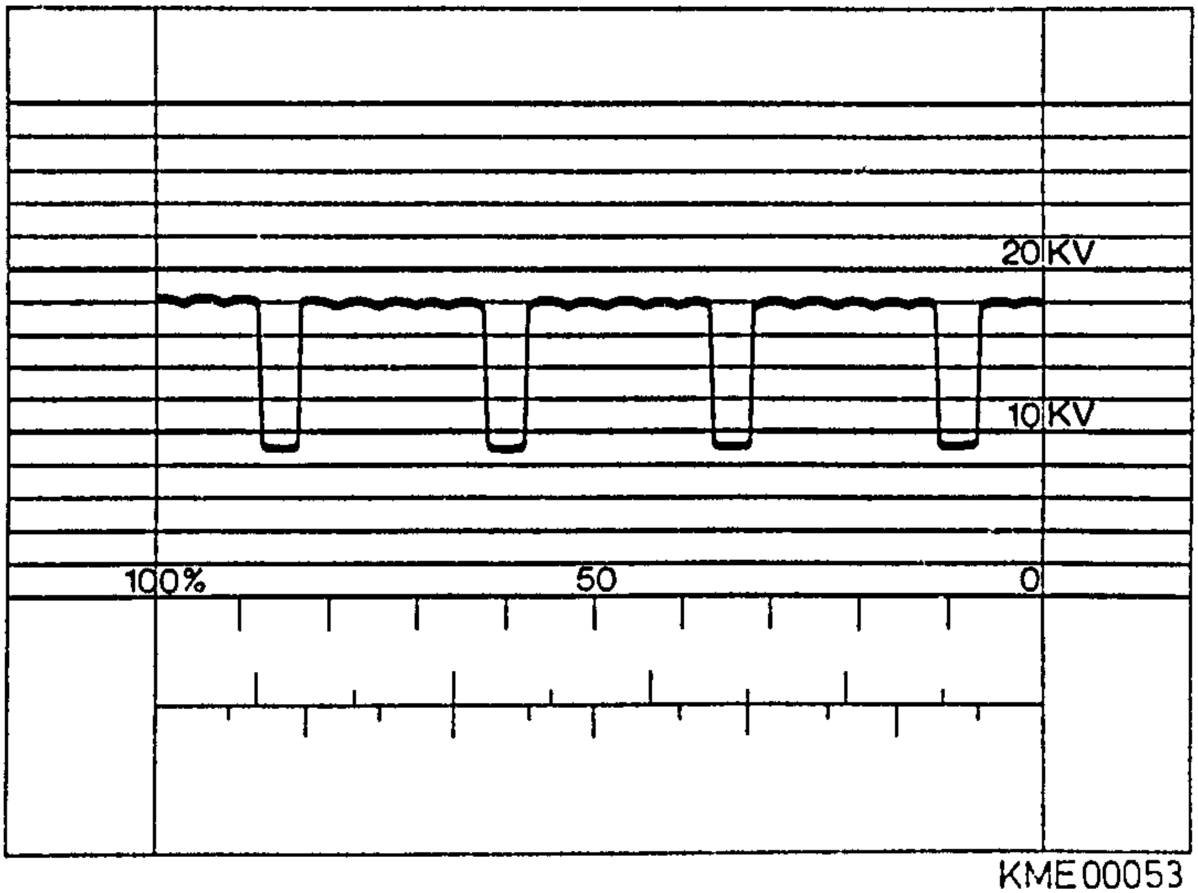


Figure 41 Open Exciter Diode

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.

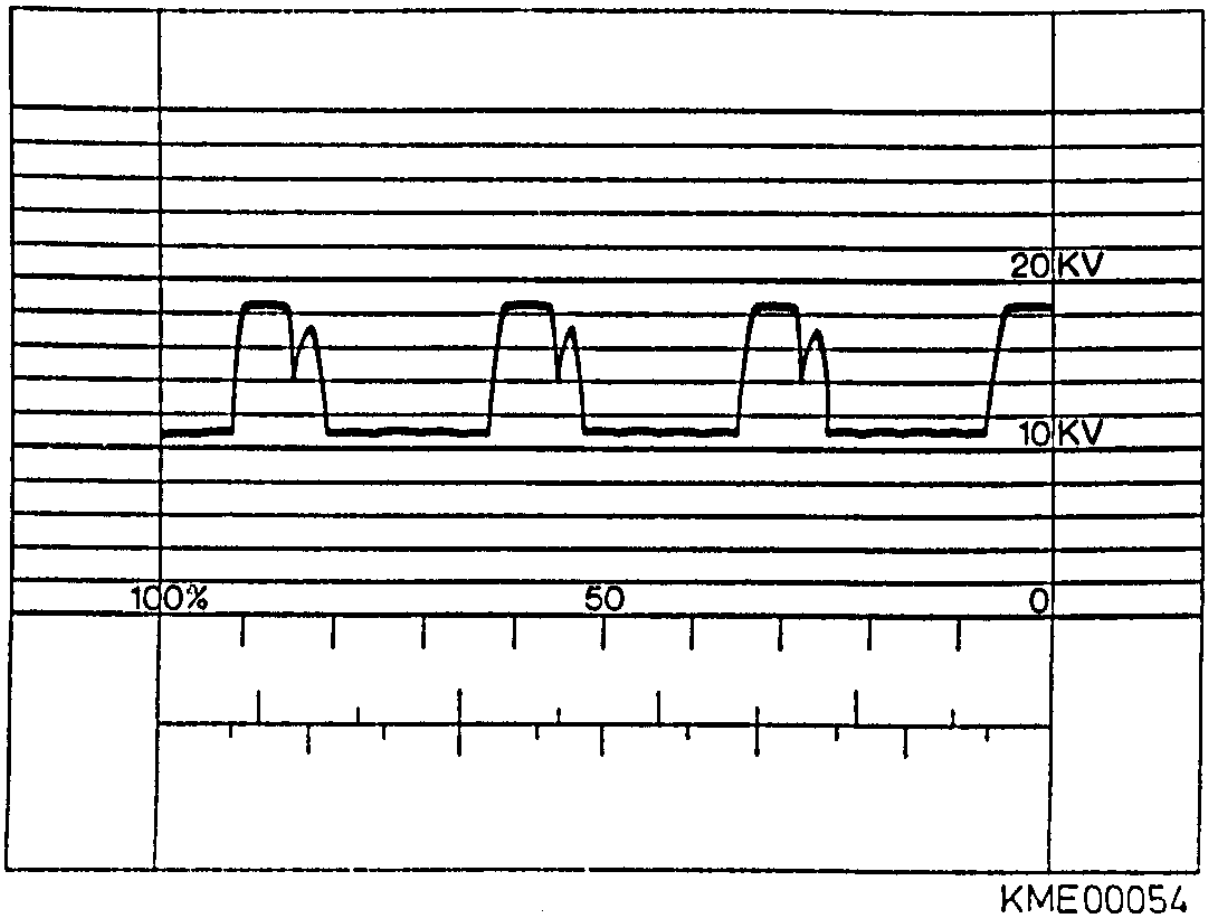


Figure 42 Open Positive Rectifier Diode

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.

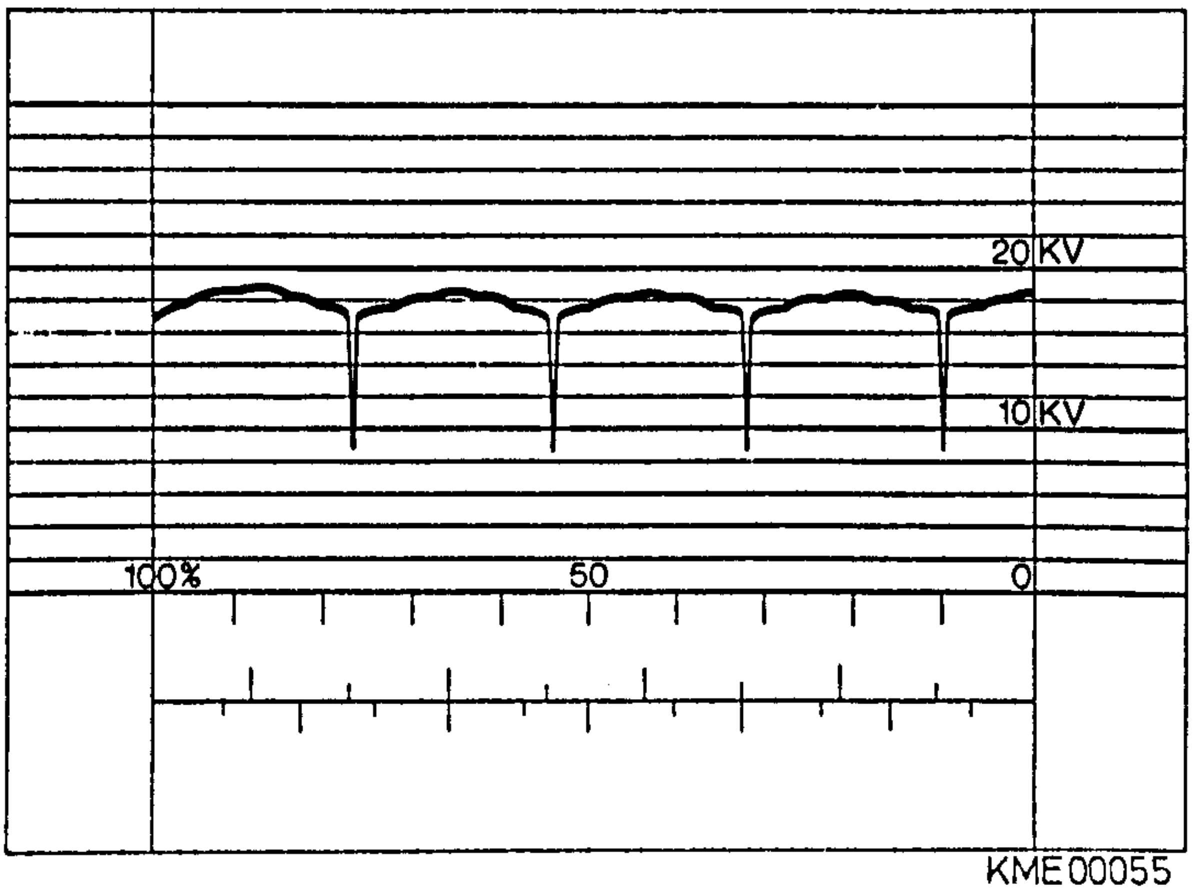


Figure 43 Open Negative Rectifier Diode

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.

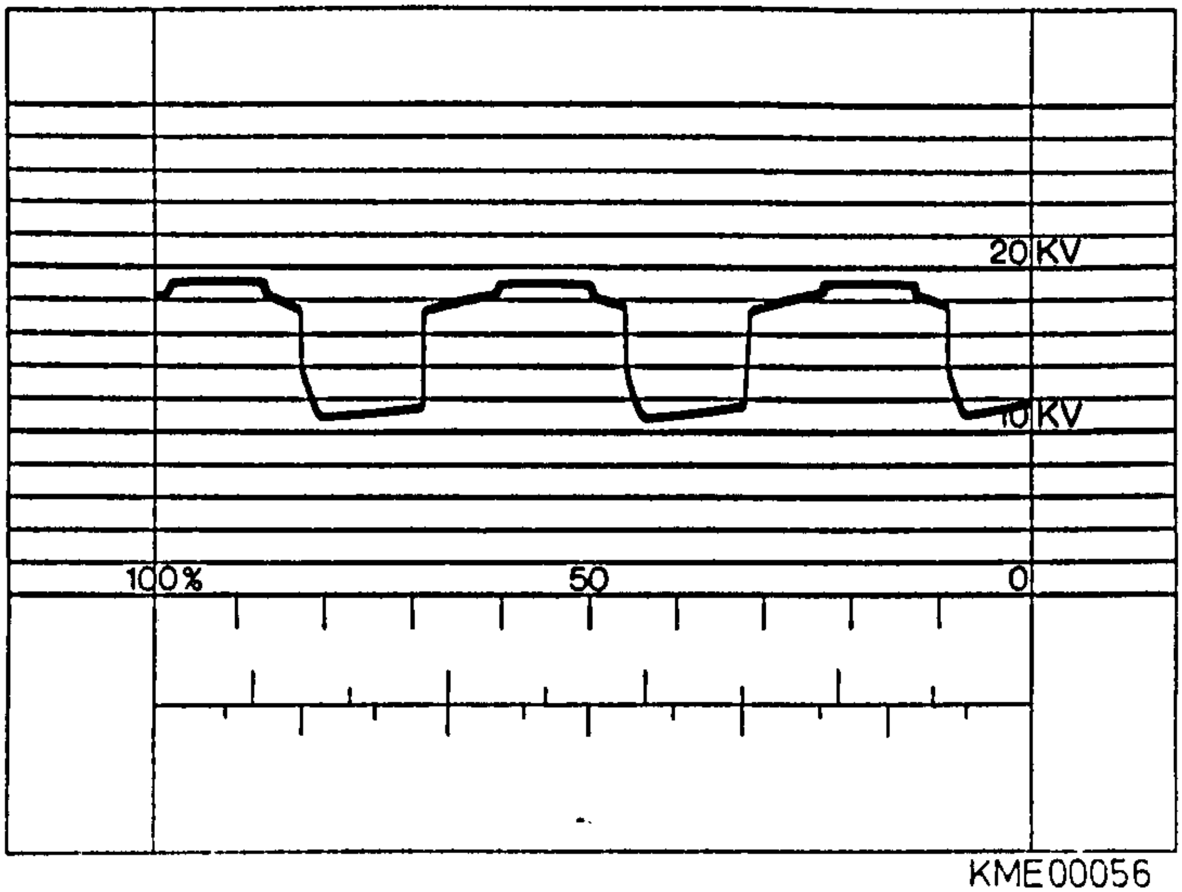


Figure 44 Shorted Exciter Diode

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.

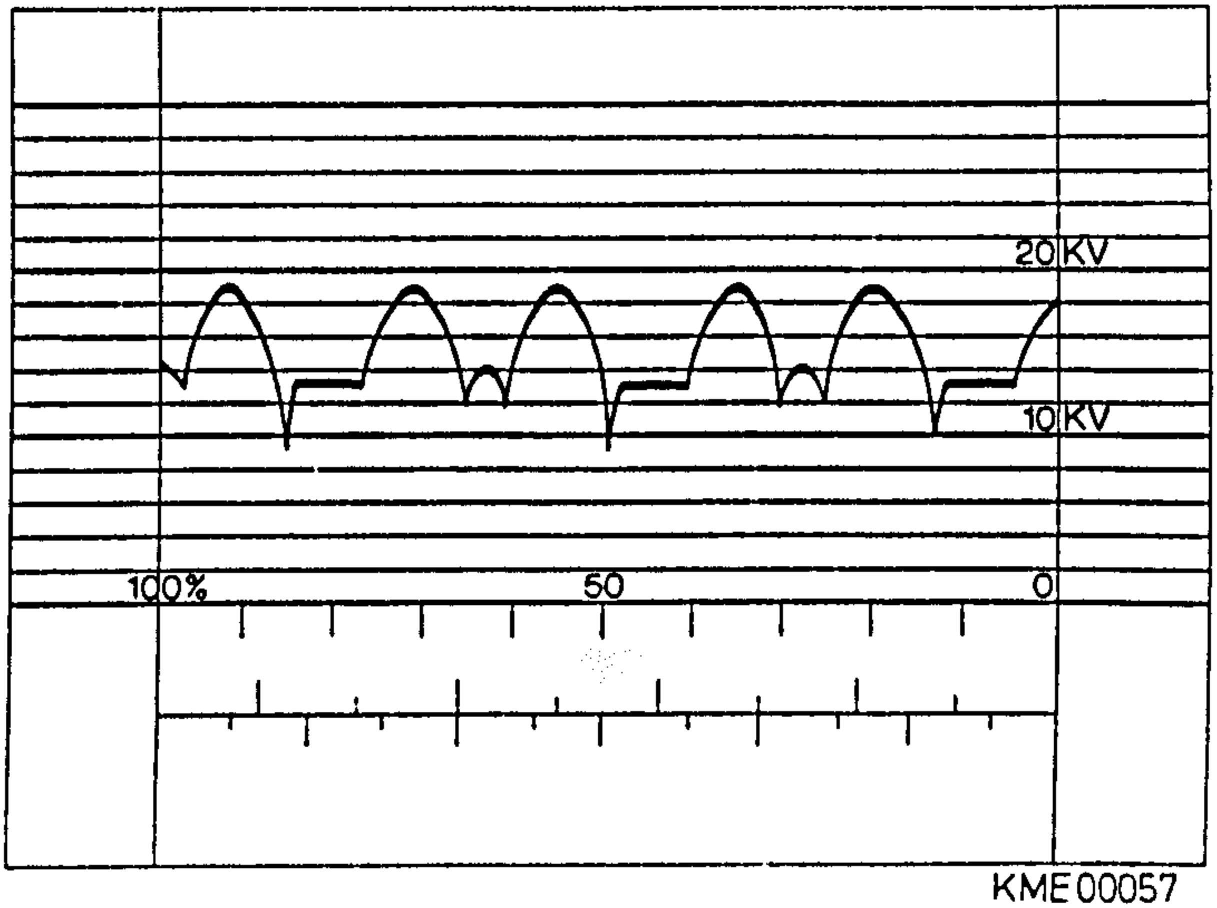


Figure 45 Shorted Positive Rectifier Diode

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.

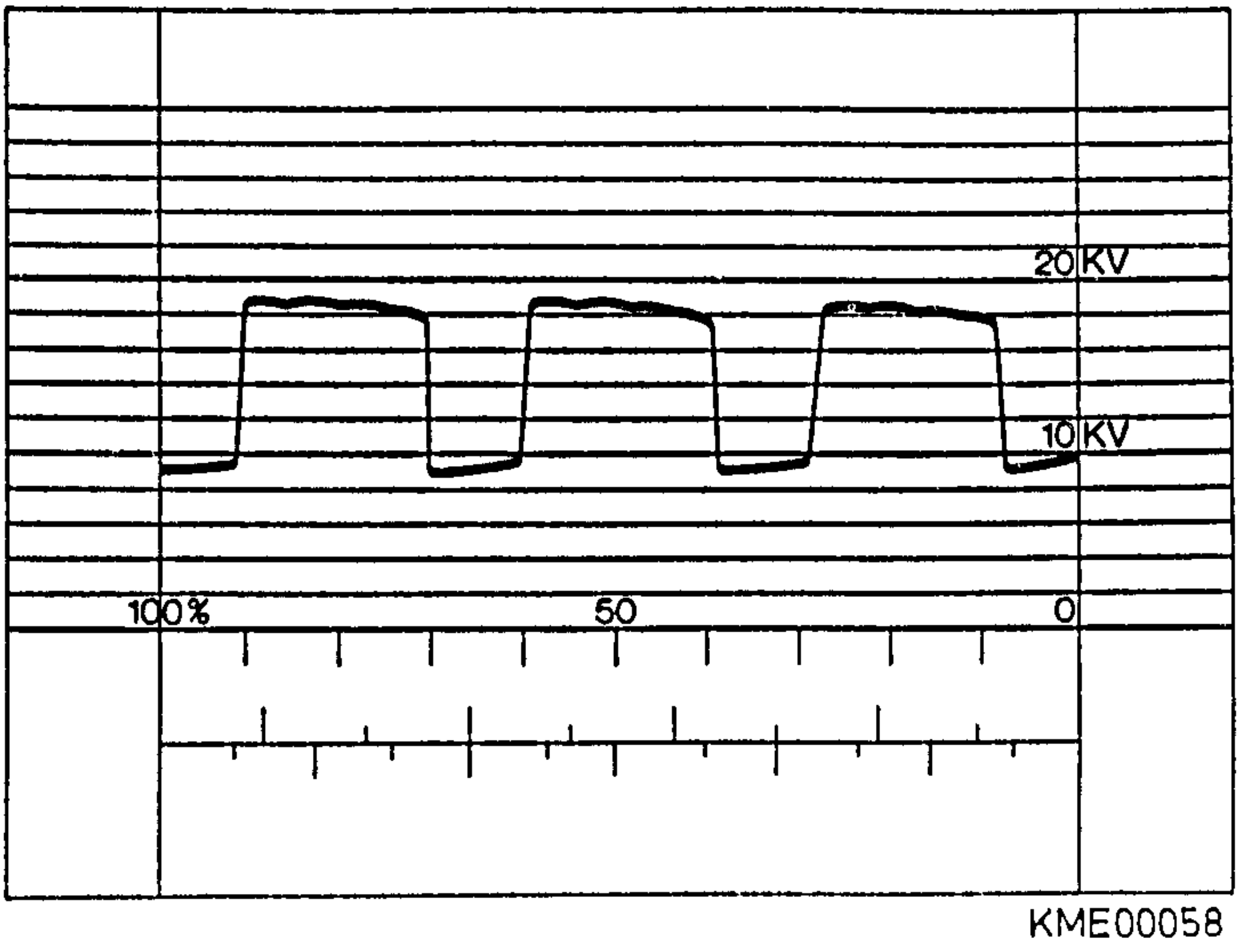


Figure 46 Shorted Negative Rectifier Diode

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.

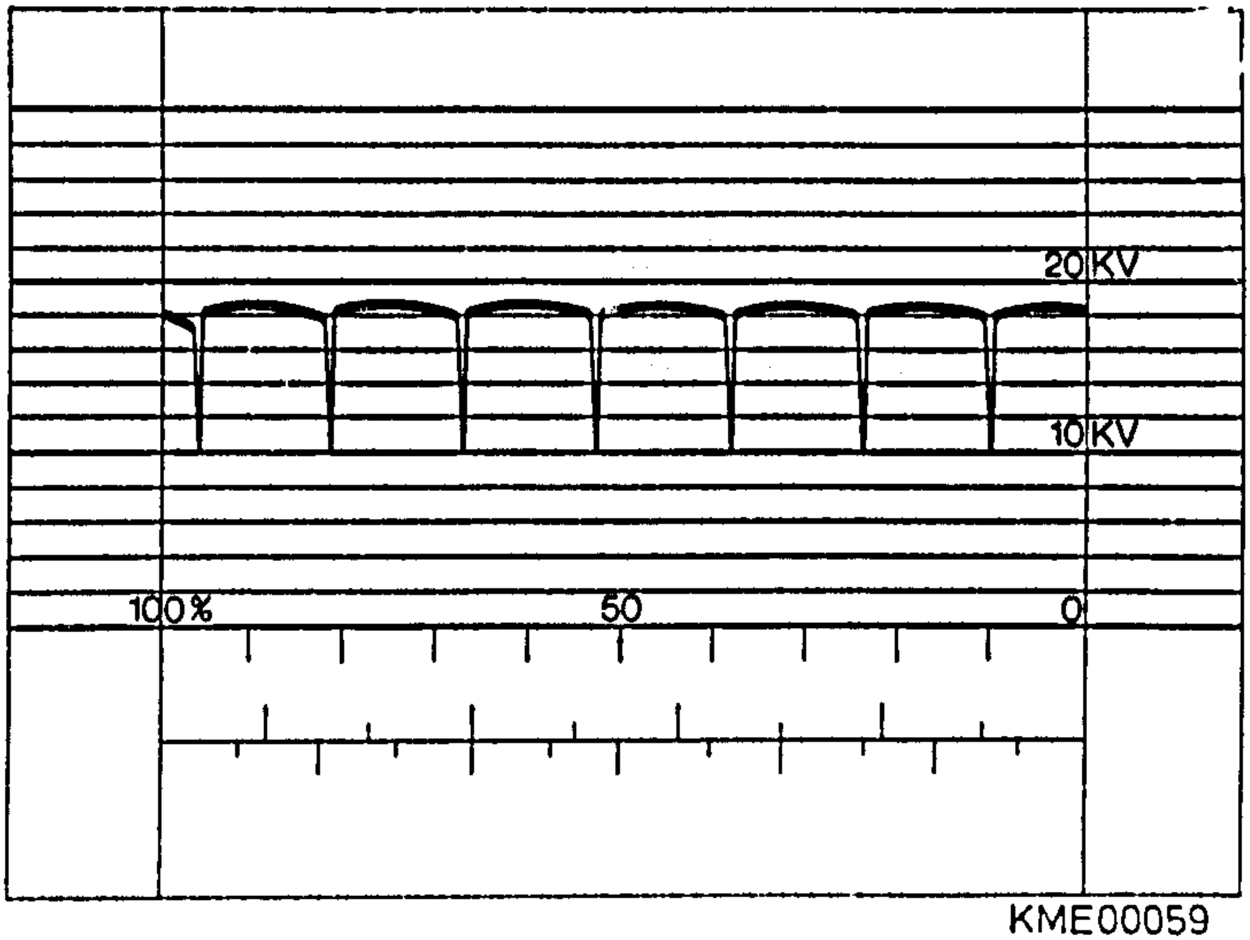
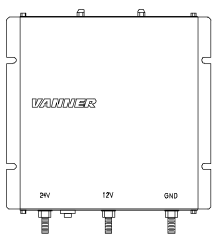
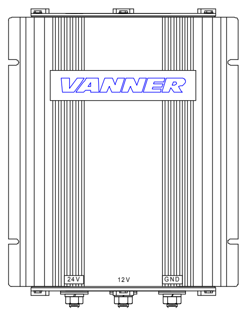
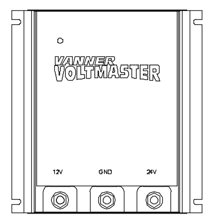


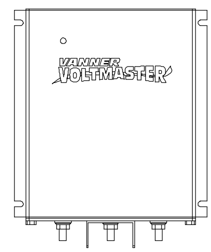
Figure 47 Open Stator Phase

VoltMaster Battery Equalizer









Family 1	Family 2	Family 3	Family 4	Family 5
60-10B	60-100C	60-60	65-60	66-60
60-20A	60-100D	60-60M	65-60M	66-80
60-50A	60-100E	60-80	65-80	66-100
60-50E		60-100	65-100	
60-50M				

Table of Contents

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.

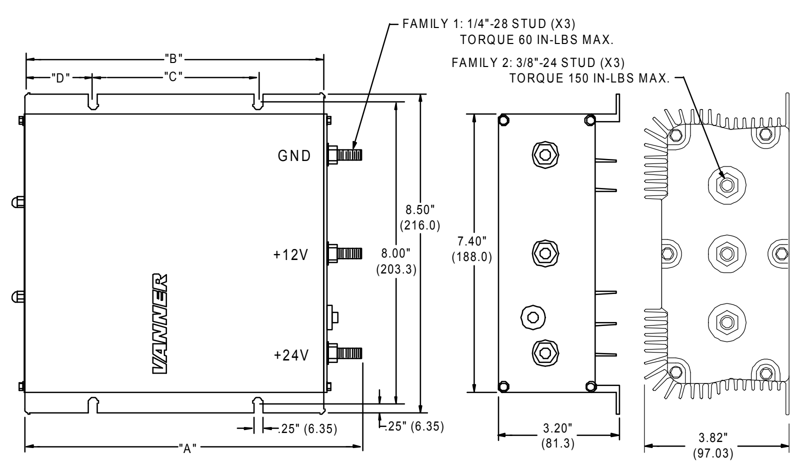
NOTE: The Vanner ***VoltMaster*** Battery Equalizer is an extremely reliable device and, when installed according to the instructions, will provide reliable operation for an indefinite period of time. However, if a system abnormality should develop that would cause a Battery Equalizer malfunction, damage 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			

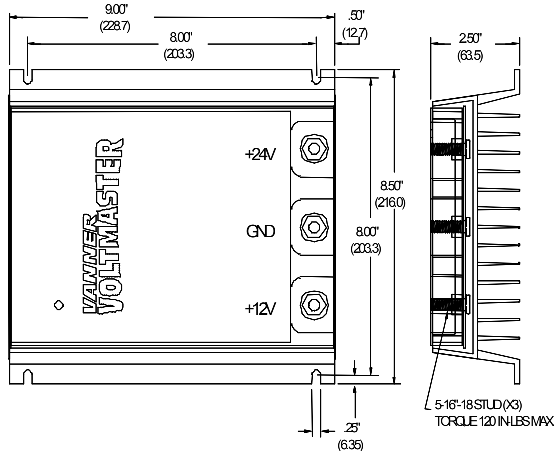
Unlisted models: Model 60-60M and 65-60M have built-in EM-70 Electrical System Voltage Monitor. Model 60-50M is a 60-50A with built-in EM-70. Model 60-50E is a 60-50A with weather resistant gasket. Model 60-100C is an early 60-100E. Model 60-100D is a 60-100C with circuit breakers instead of internal 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

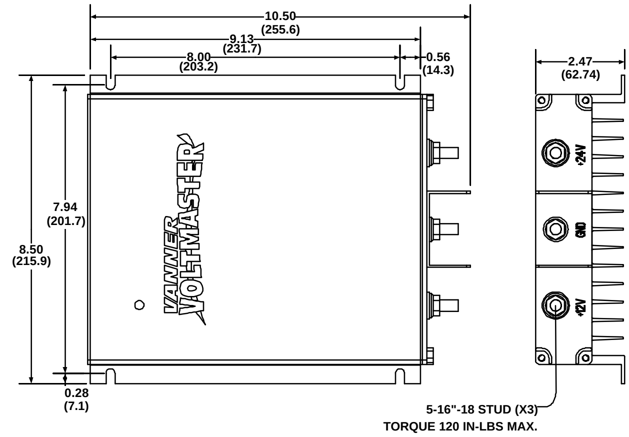


Model	"A"	"B"	"C"	"D"
60-10B	4.25 (107.9)	3.00 (76.3)	2.00 (50.80)	0.50 (12.7)
60-20A	9.38 (238.2)	8.00 (203.2)	4.50 (114.3)	1.75 (44.4)
60-50A	13.38 (339.8)	12.00 (304.8)	8.00 (203.2)	2.00 (50.8)
60-100C	13.46 (341.88)	12.00 (304.8)	8.00 (203.2)	2.00 (50.8)

Family 3 Equalizer Dimensions



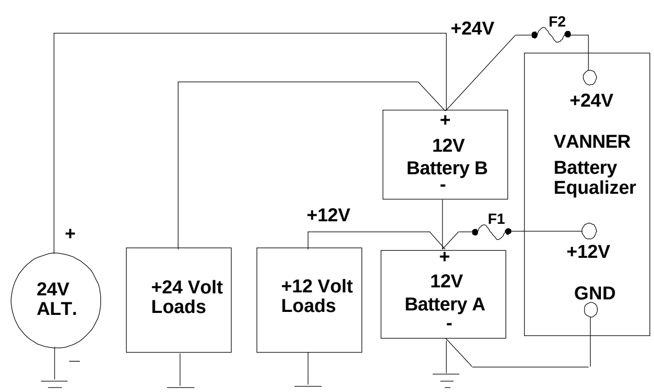
Family 4 and Family 5 Dimensions



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 resetable 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.

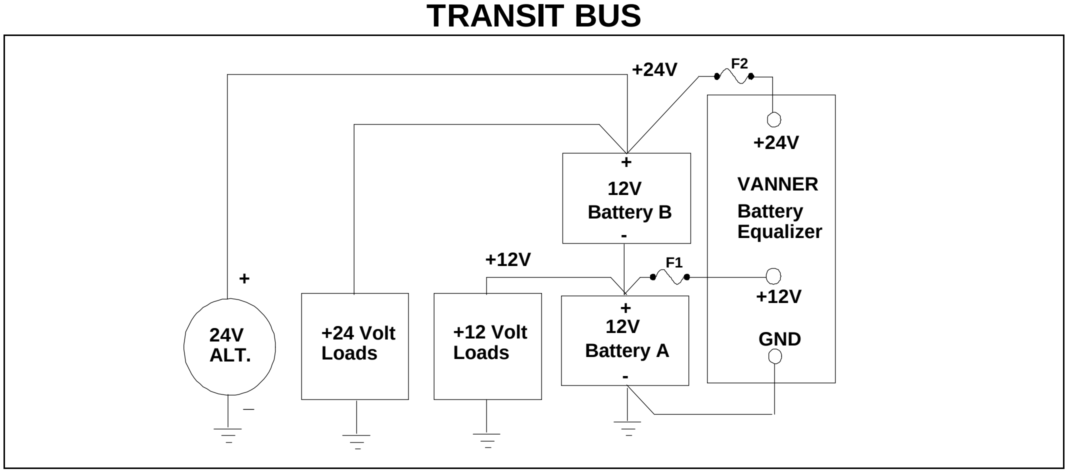
Scenario #2 - Both 24 volt and 12 volt loads present, alternator is OFF. The Battery Equalizer will insure that both batteries will discharge at the same rate even if different loads are present.

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.

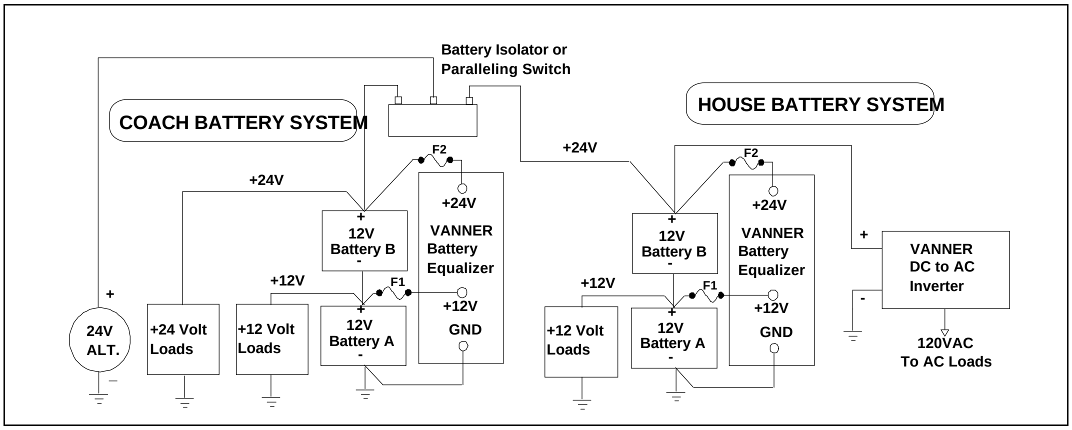
Typical Applications

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.

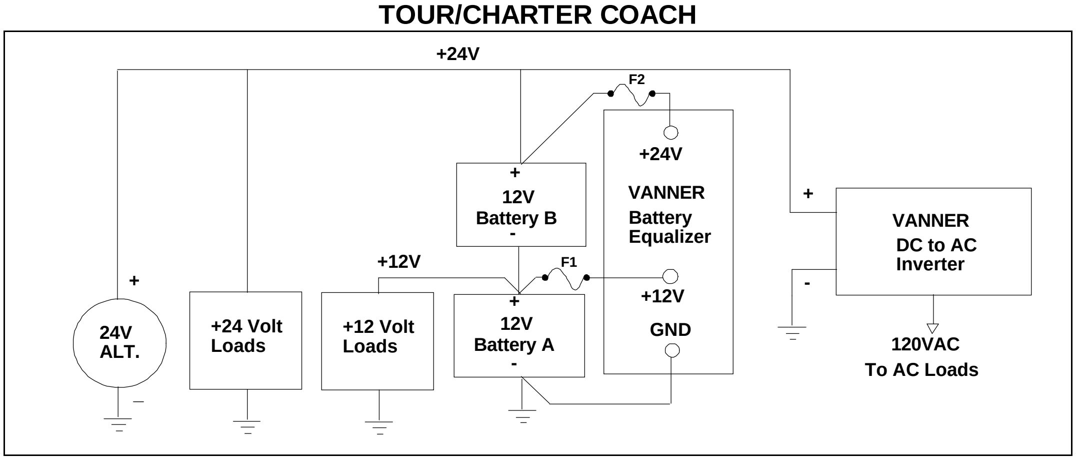
TRANSIT BUS



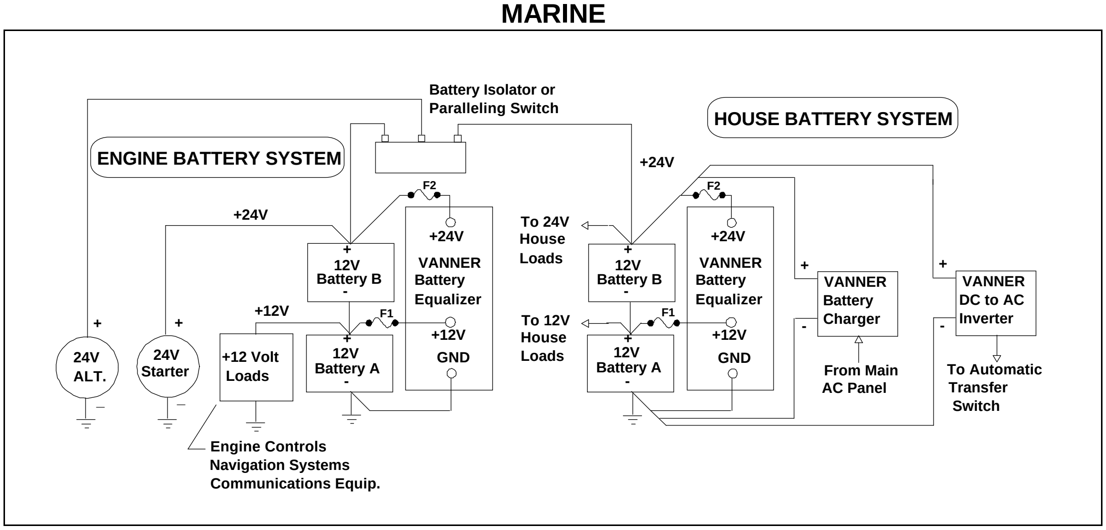
PRIVATE COACH



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.

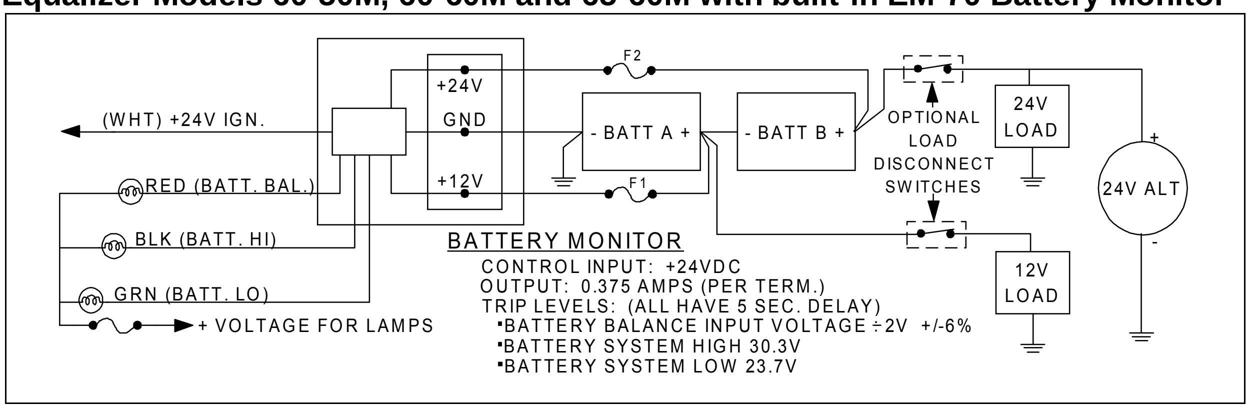
Caution: This equipment employs components that tend to produce arcs and sparks. To prevent fire or explosion, do not install in compartments containing batteries or flammable materials. Safety goggles should always be worn when working near batteries

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.

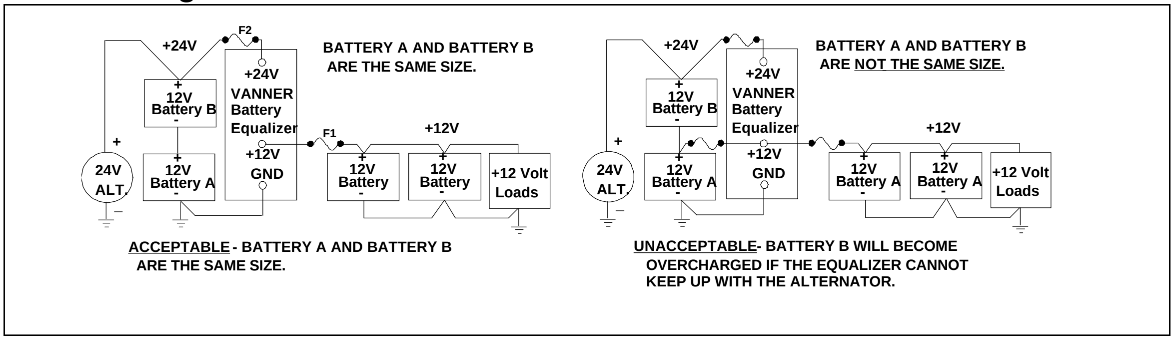
Wiring Sequence– To prevent reverse polarity damage on Family 1 and Family 2 models when connecting/disconnecting battery terminals: ALWAYS 1) Remove Equalizer ground terminal first, and 2) Replace Equalizer ground terminal last. The wiring sequence is not an issue with Family 3 or 4 models.

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 ÷ 2). Each ground signal is rated 0.375 amps and should be protected by a 1 amp fuse.

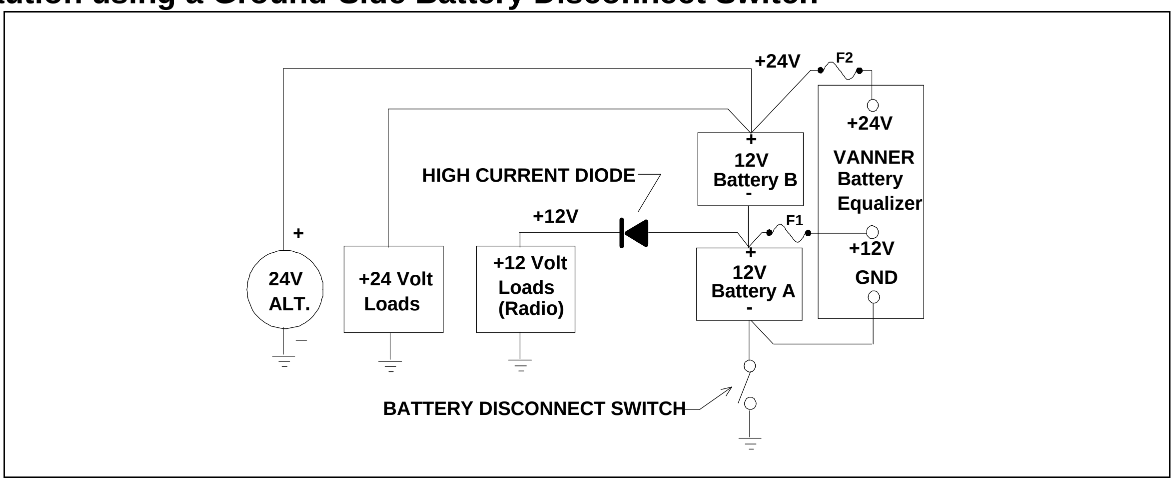
Caution adding 12volt batteries



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 sensitive12 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 71º or 75º C, use wire rated at least 90º 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 80º C.						
		60-10	60-20	60-50	60-60 65-60 66-60	60-80 65-80 66-80	60-100 65-100 66-100	2 x 60-100 2 X 65-100 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.

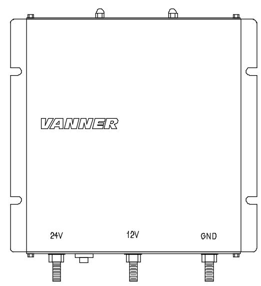
Equipment Required

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 breaker is 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.

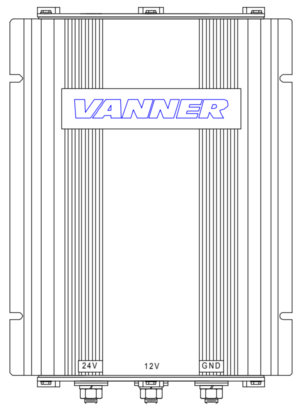
A3) Too small of wire or bad connections will allow the Battery balance to be less than optimum. Voltage loss in wire from the battery's +24 volt terminal to the Battery Equalizer's +24 volt terminal should be 0.05 VDC maximum; from the battery's +12 volt terminal to the Battery Equalizer's +12 volt 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:

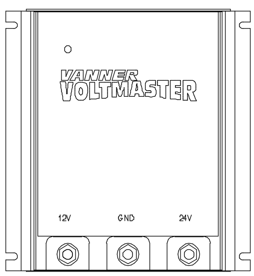
1. Remove Equalizer Ground terminal first.
2. Replace Equalizer Ground terminal last.

Family 2 Battery Equalizer Test Procedure:

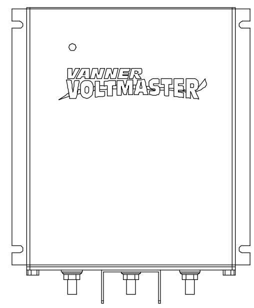
1. With the coach engine and vehicle loads OFF measure the voltage of Battery A. Replace or recharge Battery A if less than 11.5 volts.
2. Start the engine and turn ON a 12 volt load such as headlights.
3. Measure the input voltage between the +24 and GND posts of the equalizer. This voltage should be 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.		

<u>Overload Condition</u> 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.

<u>Trouble Shooting an Engine No-Start Situation</u>

<u>Situation:</u>
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.

<u>Cause:</u>
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.

<u>Solution:</u>
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.

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ELECTRONIC MONITOR EM-70D
Owner's Manual

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.

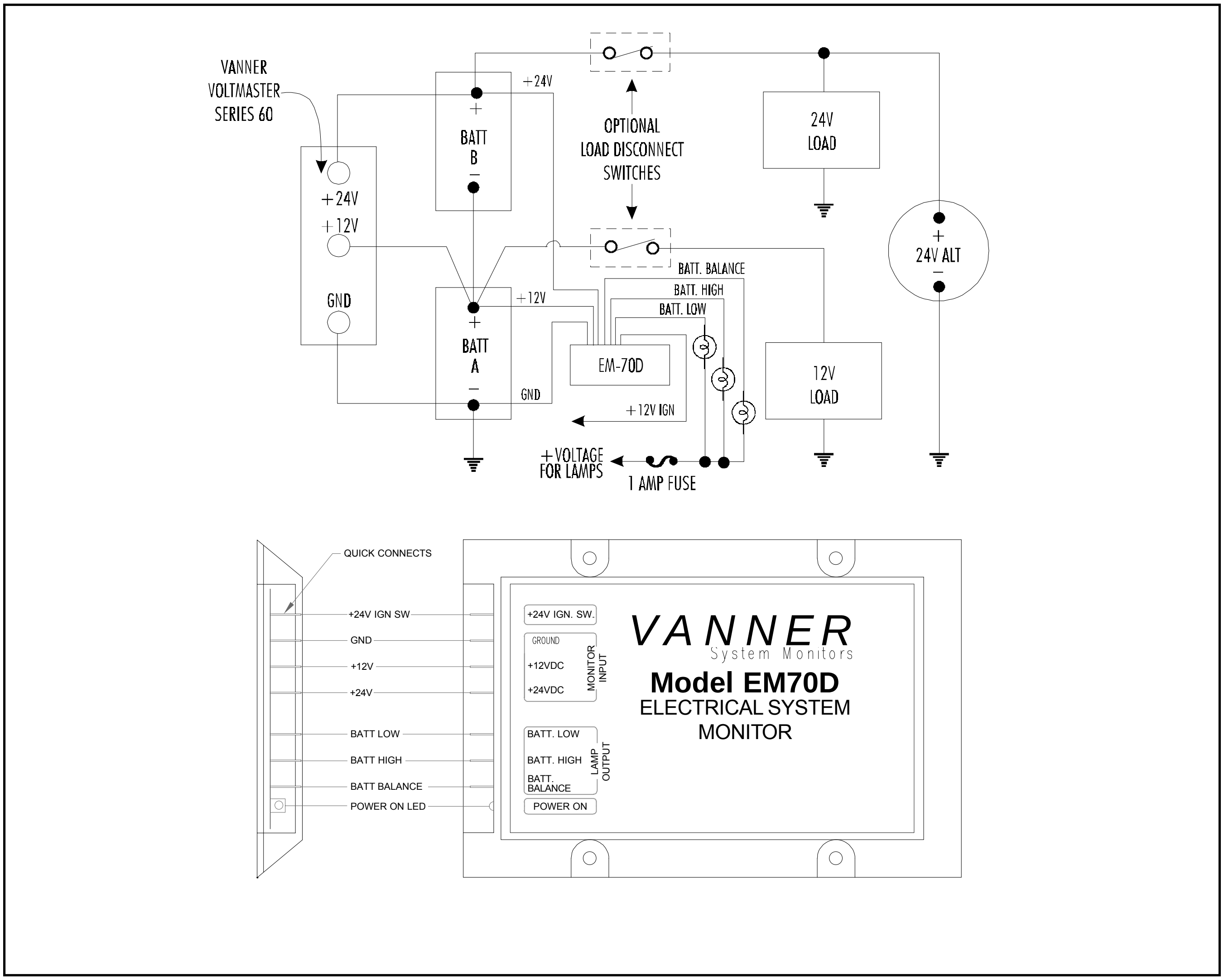
INSTALLATION

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 $\frac{\text{INPUT}}{2} + 6\%$ OR less than $\frac{\text{INPUT}}{2} - 6\%$
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

1. Battery voltage drops below 24 VDC
   - Check alternator output
   - Check alternator regulator
   - Check battery connections
   - Check battery cells
   - Check Battery Equalizer connections

BATTERY HIGH

1. Battery voltage exceeds 30 VDC
   - Check alternator output
   - Check alternator regulator
   - Check battery connections

BATTERY BALANCE

1. 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

2. 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

3. 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.

VANNER POWER GROUP

800- AC POWER

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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 occurance of incorrect information. We will however, update the manual as soon as we get new information and distribute revised versions to all parties concerned.

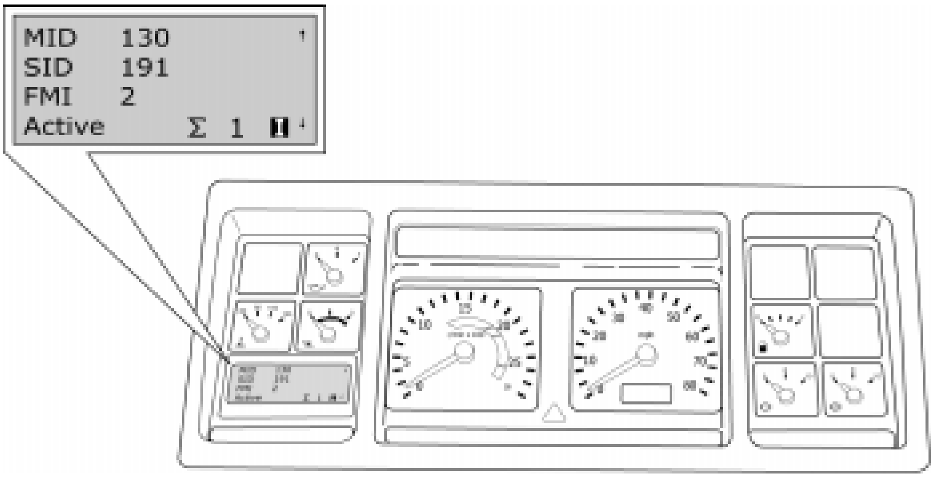
Table of contents

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.

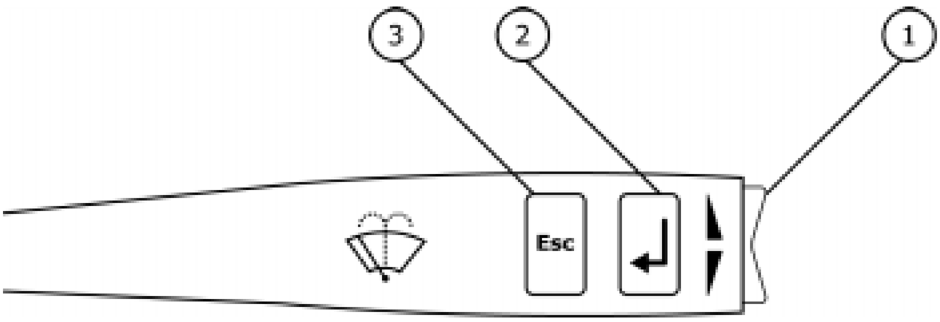
2. The instrument display

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

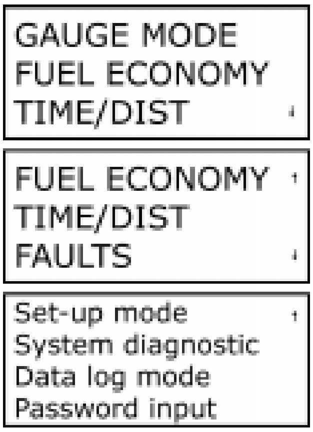
Using the the windscreen wiper handle at the right of the steeringwheel makes it possible to display the error at the lower left corner of the BIC. The errors can be displayed in numerical form and with help of the fault code table in this manual you can draw conclusions of what may have caused the errors.



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.

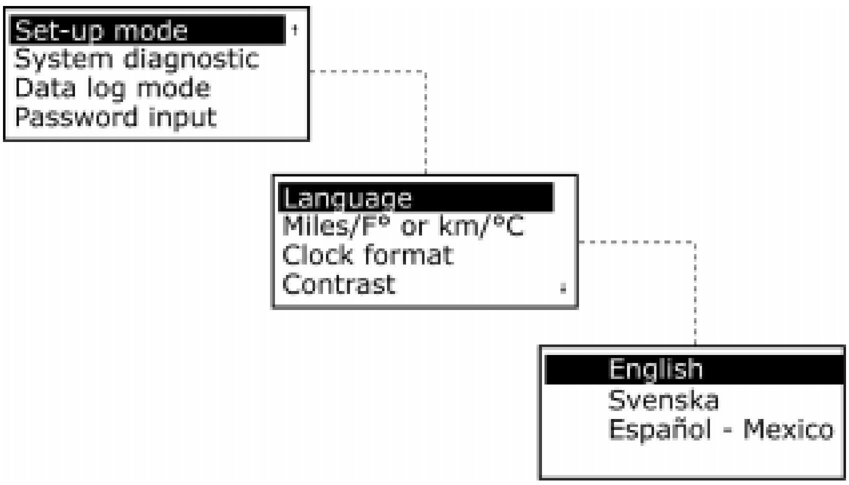
4. Display menus

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.



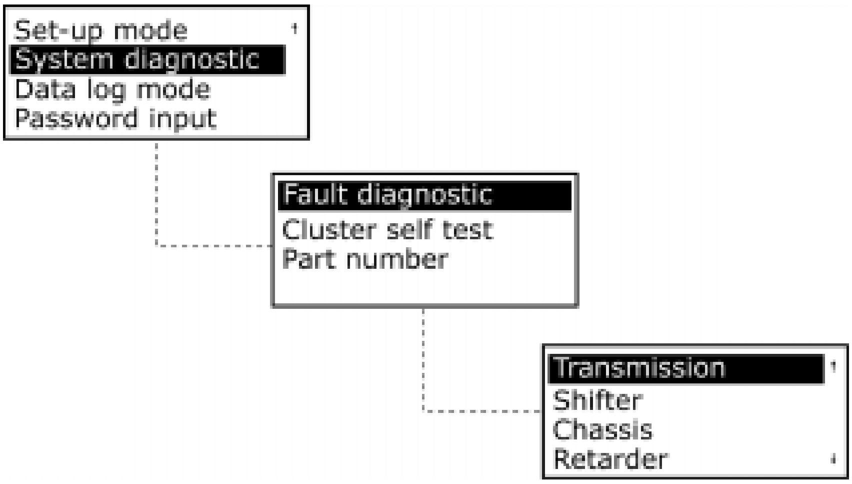
5. Setting the display language

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 alreadey highlighted. Press the "Return" button again to enter the choices of languages, select "English" and press the "Return" button once more.



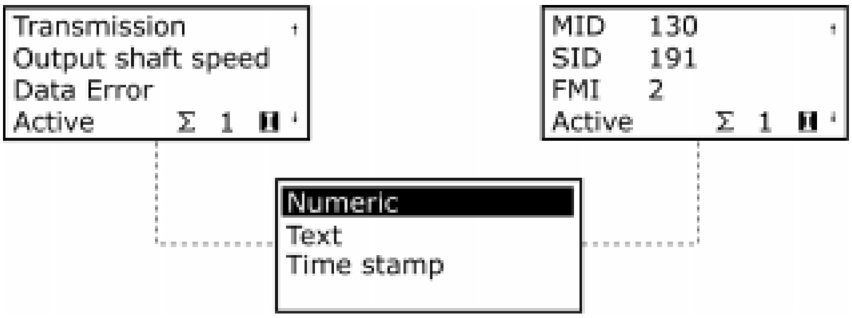
6. Read fault codes from ECU

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 dipsplay 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.
	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.

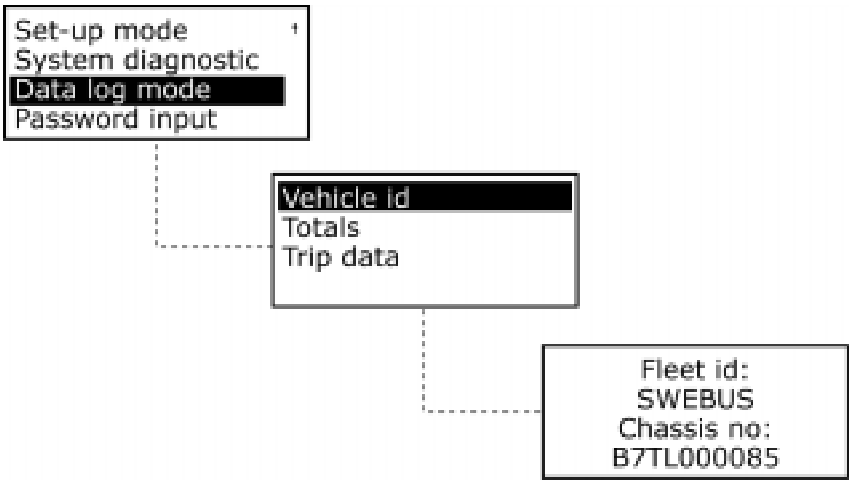
SAE-standard	
FMI	**SAE-text**
0	Data valid, but above normal operating range.
1	Data valid, but under normal operating range.
2	Intermittent or incorrect data.
3	Abnormally high voltage or short circuit to higher voltage.
4	Abnormally low voltage or short circuit to lower voltage.
5	Abnormally low current 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

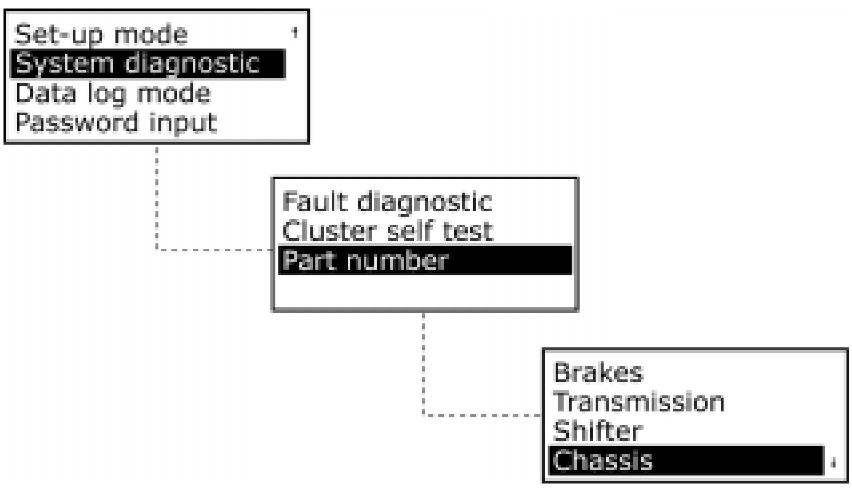
The VIC (Vehicle Identification Card) is a card that comes with every new bus that identifies the chassis number for the bus and the HW/SW id for each control unit.

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” buton on the windscreen wiper handle. The fleet id and the chassis number should occur on the display.

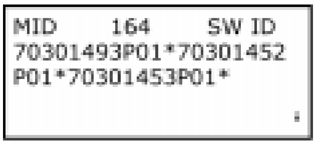


8. Comparing HW/SW id with the VIC

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.



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

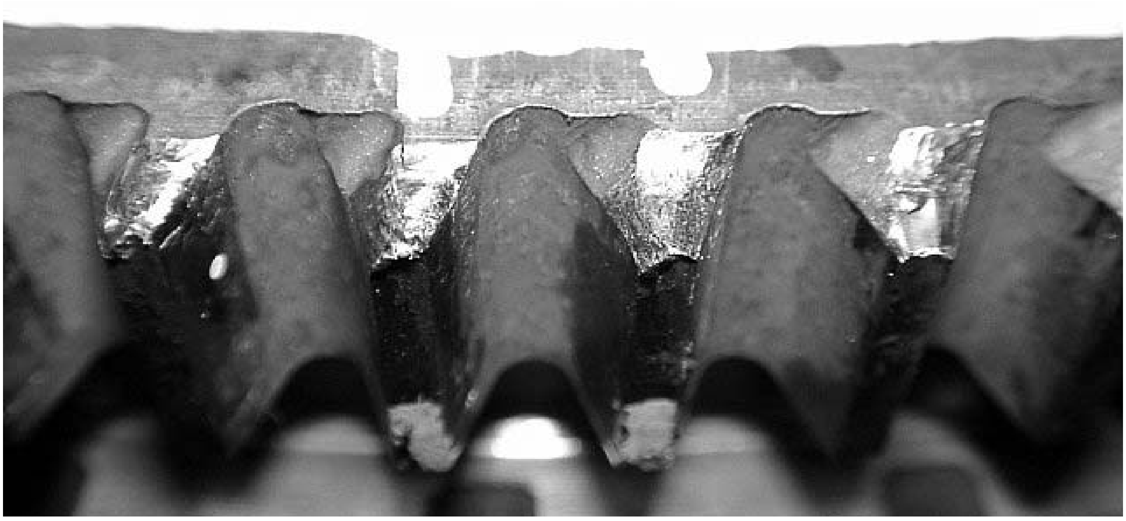
Code	Description
35	Internal fault concerning: ROM (CRC check). EEPROM (data record)
36	2/2-way valve fault
37	Non-plausibility of brake pedal operation
38	Pressure sensor fault
41	Time-out > 500ms press signal (VECU)
42	Time-out > 500ms ABS-signal (J1939)
43	J 1939 link "bus off".

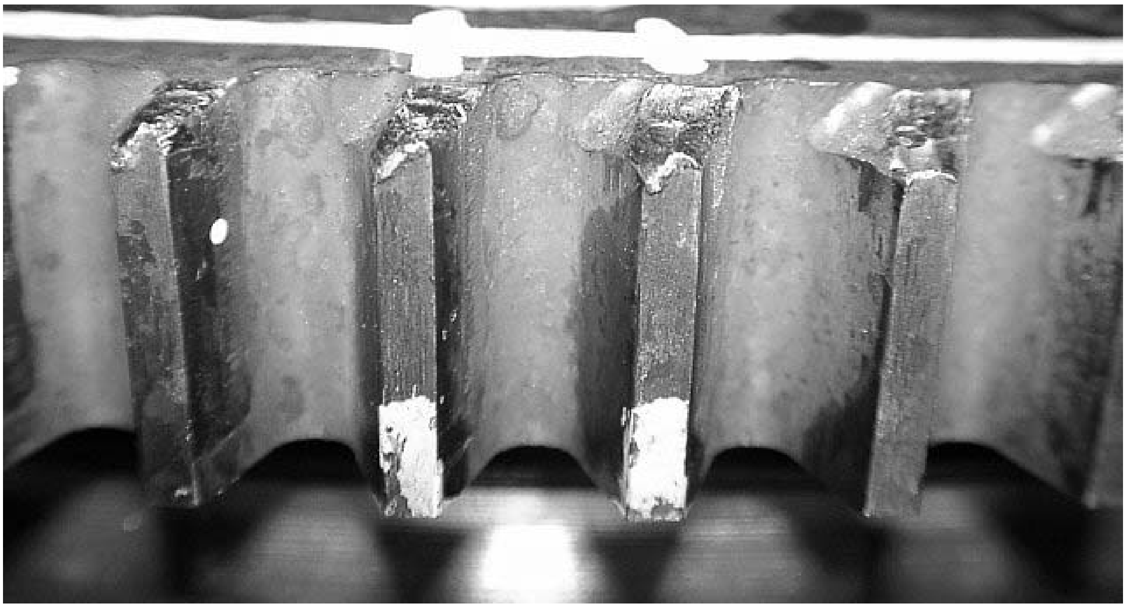
18. Fault codes, VECU (MID 144)

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

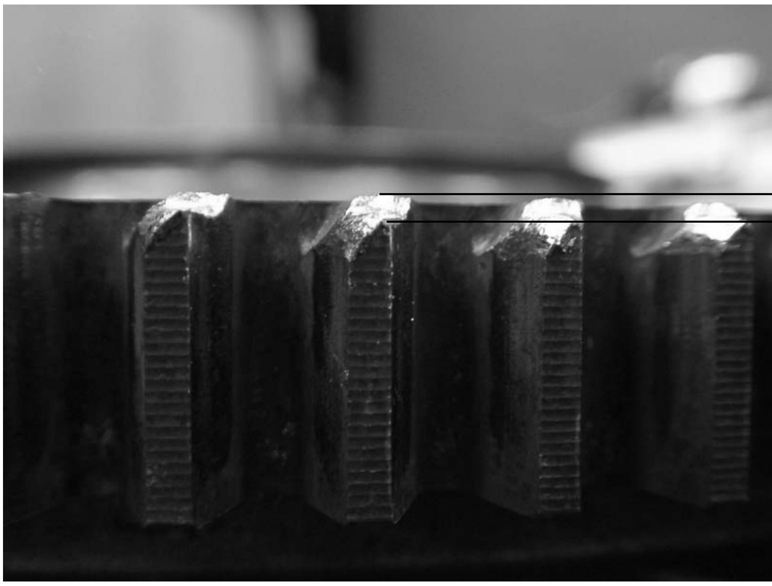
(Sample of Maximum Ring Gear Wear /Damaged)





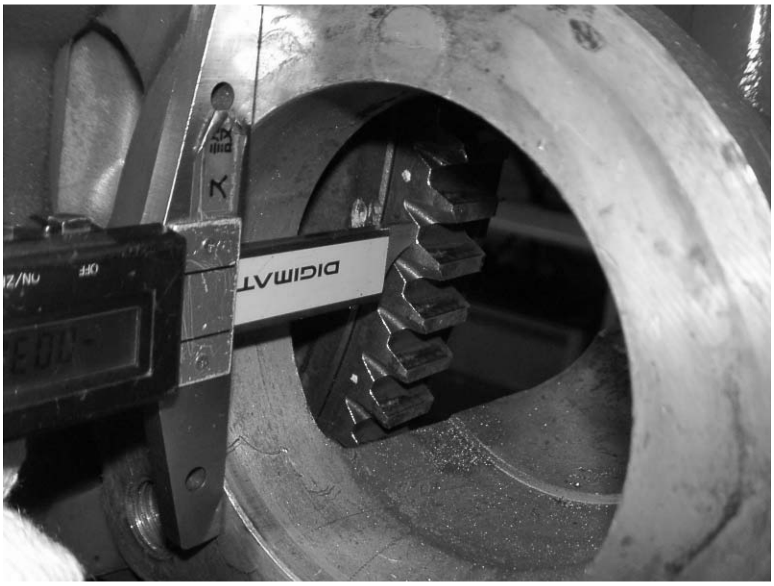
Please refer to the above photos and please replace the ring gear which has similar level of damage as these. See the next page for the method to measure the depth of the damage.

(Depth of wear / damage on ring gear)



Less than 0.5mm

(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

SECTION 07: TRANSMISSION

CONTENTS

ILLUSTRATIONS

1. DESCRIPTION

XL2 Series vehicles may be provided with either an Allison World automatic transmission or a ZF-AsTronic transmission.

1.1 ALLISON AUTOMATIC TRANSMISSION

The B500(R) World Transmission has 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.

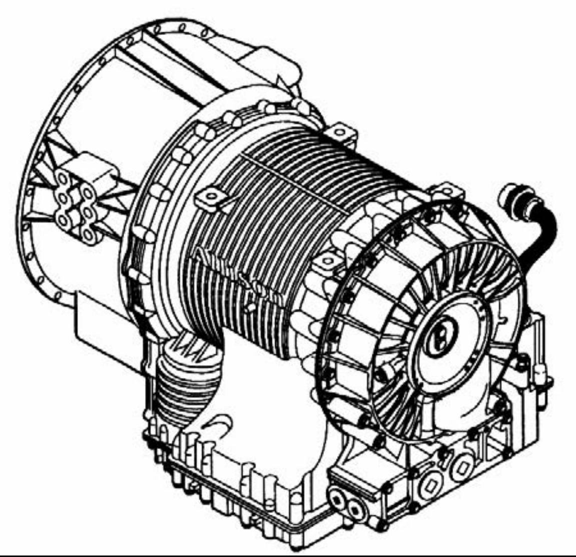


FIGURE 1: WORLD TRANSMISSION 07075

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. Four-digit trouble codes greatly reduce the time it takes to pinpoint potential problems. (Refer to heading *"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.

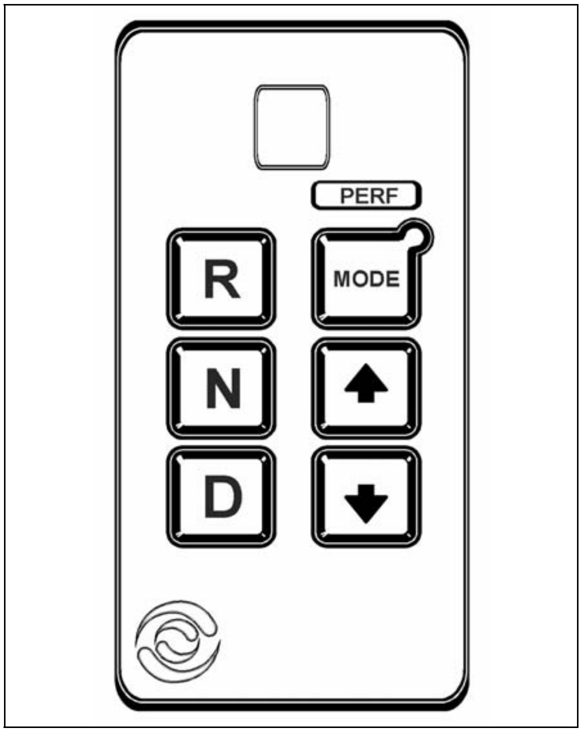


FIGURE 2: WORLD TRANSMISSION CONTROL PAD 07025

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.

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.

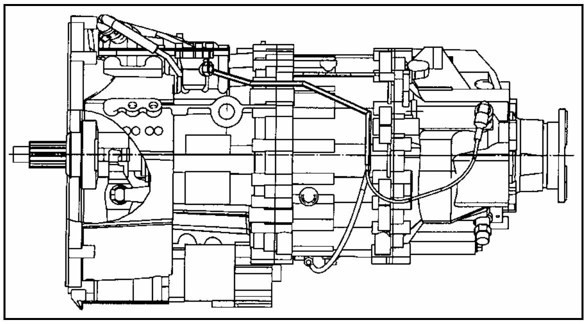


FIGURE 3: ZF-ASTRONIC TRANSMISSION 07078

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 WORLD 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).

To check the transmission oil level, a cold check and a hot check must be performed. A cold check must be made between 60ºF (16ºC) and 140ºF (60ºC). The transmission oil temperature gauge indicates the operating temperature; it is located in the MCD dashboard integrated Liquid Crystal Display and can be viewed when selecting the Gauge Mode (refer to ''Operator's Manual'' for added information).

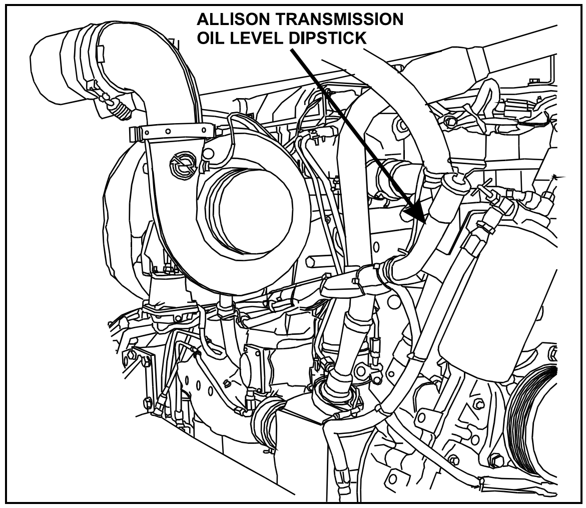


FIGURE 4: OIL LEVEL DIPSTICK (AUTO. TRANS.) 07033

NOTE
Perform the cold check first to verify the transmission oil level before performing the hot check.

The hot check can be performed when the transmission oil reaches the normal operating temperature of 160ºF (71ºC) to 200ºF (93ºC).

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 in accordance with the following procedures and record any abnormal level on your *"Maintenance Records".*

⚠ WARNING ⚠

When checking the oil level, be sure that the parking brake and/or emergency brakes are set and properly engaged, and the wheels are choked. 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.**

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.

3.1.1 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.

2. Run the engine for at least one minute. 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. Finally shift to Neutral (N) and allow the engine to idle (500 - 800 rpm).
3. While the engine is running, remove the dipstick from the tube and wipe it clean (Figs. 5 & 6).

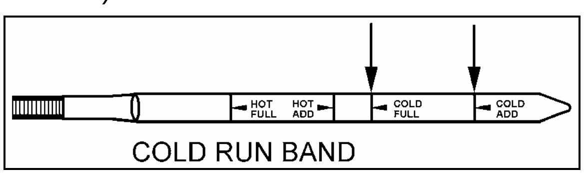


FIGURE 5: COLD CHECK 07050

4. Insert the dipstick into the tube and then remove, checking the oil level reading (Fig. 5). Repeat the check procedure to verify the reading. If the oil reading is within the "Cold Run" band, the level is satisfactory for operating the transmission until the oil is hot enough to perform a "Hot Run" check. If the oil reading is not within the "Cold Run" band, add or drain oil as necessary to bring the level within the "Cold Run" band.
5. Perform a **Hot Check** at the first opportunity after the normal operating temperature of 160ºF (71ºC) to 200ºF (93ºC) is attained.

⚠ CAUTION ⚠

An accurate fluid level check cannot be made unless the engine is idling (500-800 rpm) in Neutral, the transmission fluid is at the proper temperature, and the vehicle is on a level surface.

3.1.2 Hot Check

⚠ CAUTION ⚠

The oil must be hot to ensure an accurate check for this procedure. The oil level rises as temperature increases.

1. Operate the transmission in Drive (D) range until normal operating temperature is reached 160ºF (71ºC) to 200ºF (93ºC).
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. While the engine is running, remove the dipstick from the tube and wipe it clean.
4. Insert the dipstick into the tube and then remove, checking the oil level reading. Repeat the check procedure to verify the reading.

The safe operating level is anywhere within the "Hot Run" band on the dipstick (Fig. 6).

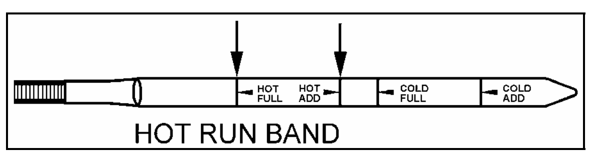


FIGURE 6: HOT CHECK 07049

If the oil level is not within the "Hot Run" band, add or drain oil as necessary to bring the oil level within the band.

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 automatic system of verification via the shift selector has priority over the Hot Check.

3.1.3 Readout of the Oil Level Sensor

The optional Oil Level Sensor (OLS) is designed to measure transmission oil level only when the following combination of operating conditions exists:

1. Engine must be at idle;
2. **NEUTRAL** must be selected;
3. Zero output speed;
4. Transmission oil must be within a "normal" temperature band (160-250°F; 70-120°C), and;
5. Once the first four (4) conditions are met, there must be a "waiting" period (approx. 2 min., to facilitate consistent oil drainback) before oil level measurement begins.

To enter OLS readout mode (after meeting the conditions noted above), simultaneously press the UPSHIFT and DOWNSHIFT arrows on the shifter. If the five (5) conditions noted above are present, the display will immediately enter the reading mode. If the "waiting" period has not elapsed, the left digit of the display will become a "chasing" digit and the right digit will count down from (8) to (1) until the waiting period is complete.

After attaining the reading mode, the display will flash *"OL-OK"*, *"LO-01"*, *"HI-02"*, etc., where the suffix *"01"* or *"02"* indicates the volume of oil (in quarts) either low or high.

At any time in this sequence, simultaneously pressing the UPSHIFT and DOWNSHIFT arrows directs the ECU to enter the transmission diagnostic mode as described under *"10. Troubleshooting"* in this section.
D, N, or R may also be selected on the shifter at any time - the OLS mode will abort and normal transmission will commence. Shifts are not inhibited.

Oil Level Sensor (OLS) Codes

CODE	CAUSE OF CODE
OL-OK	Oil Level Is Correct
LO-01	One Quart Low
LO-02	Two Quarts Low
HI-01	One Quart High
HI-02	Two Quarts High
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

3.1.4 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.

3.1.5 Oil Recommendations

Hydraulic oils used in the transmission have an important influence on transmission reliability and durability. In order of preference Castrol TranSynd Synthetic Fluid, DEXRON-III/VI, MIL-L-2104D, and type C-4 oils (Allison approved SAE 10W or SAE 30) are recommended. Type C-4 oil is the only oil approved for use in off-highway applications. Use type SAE 30 where ambient temperature is consistently above 86ºF (30ºC). Some DEXRON-III/VI oils are also qualified as type C-4 oils and may be used in off-highway applications. However, a DEXRON-III/VI fluid which is not qualified type C-4 oil must never be used in off-highway applications. Consult your local Allison dealer or distributor to determine if DEXRON-III/VI oil is also qualified type C-4 oil.
Before using type C-4 oils, consult the vehicle manufacturer to ensure that materials used in tubes, hoses, seals, etc., are compatible with type C-4 oils. Also, consult your local Allison dealer or distributor to determine if the oil you have selected is approved type C-4 oil. Ford Motor Company specification oils M2C33-F, M2C138-CJ and M2C166-H may be used and may be intermixed with DEXRON-III/VI oil.

OIL SPECIFICATIONS AND AMBIENT TEMPERATURE OPERATING CONDITIONS	
Oil type	Ambient temperature
MIL-L-2104D, DEXRON-III/VI, TranSynd TES 295, C-4	120ºF (48ºC) to -25ºF (-32ºC)
MIL-L-46167	-25ºF (-32ºC) to -60ºF (-51ºC)

The use of an arctic preheat kit is recommended at temperatures below -25ºF (-32ºC). If a preheat kit is not available, the ECU will restrict full operation until the sump temperature is increased. The chart below shows the temperature ranges in which the transmission will operate. It should be noted that at lower sump temperature, the transmission's operation may be restricted.

Transmission Oil Temperature	"DO NOT SHIFT" Light	Operation
Below -26ºF (-32ºC)	ON	Neutral only
-24ºF (-31ºC) to +19ºF (-7ºC)	OFF	Start with neutral and reverse, normal upshifts
+20ºF (-6ºC) to 260ºF (126ºC)	OFF	Full operation in all ranges
Above 260ºF (126ºC)	ON	Inhibits 5th and 6th ranges

3.1.6 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.

3.1.7 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.

3.1.8 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 (Non-TranSynd™/Non-TES 295/Mixture)

Coaches or MTH equipped with retarder				Coaches or MTH without retarder			
Fluid	Filters			Fluid	Filters		
	Main: Initial Break-in 5,000 miles (8,000 km)	Internal	Lube/ Auxiliary		Main: Initial Break-in 5,000 miles (8,000 km)	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

TABLE 2: Recommended Fluid and Filter Change Intervals (TranSynd™/TES 295 Approved Fluid)
2 inch Control Module (1.75 approximately) – Requires filter kit P/N 29540493

Coaches or MTH equipped with retarder				Coaches or MTH without retarder			
Fluid	Filters			Fluid	Filters		
	Main: Initial Break-in 5,000 miles (8,000 km)	Internal	Lube/ Auxiliary		Main: Initial Break-in 5,000 miles (8,000 km)	Internal	Lube/ Auxiliary
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

3.1.9 Oil and Filter Change

Allison transmissions are now factory fill with 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 and 2"* for oil and filter change intervals. More frequent changes may be required when operations are subject to high levels of contamination or overheating.

The procedure for changing the transmission oil and oil filters is as follows:

Drain

1. The transmission should be at an operating temperature of 160ºF (71ºC) to 200ºF (93ºC) 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

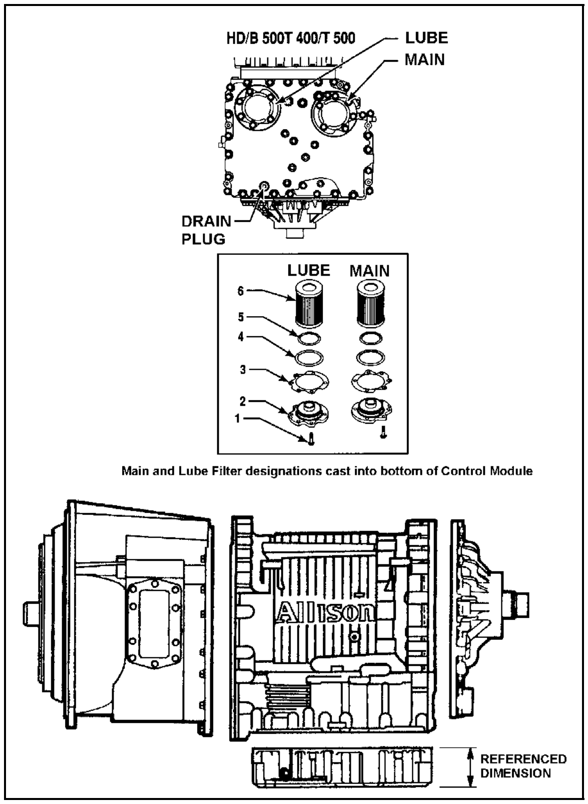


FIGURE 7: DRAIN PLUG AND FILTERS 07074

Refill

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 previously described procedure. The refill amount is less than the initial filling because some of the oil remains in the external circuits and transmission cavities.

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 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, 180^0 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.

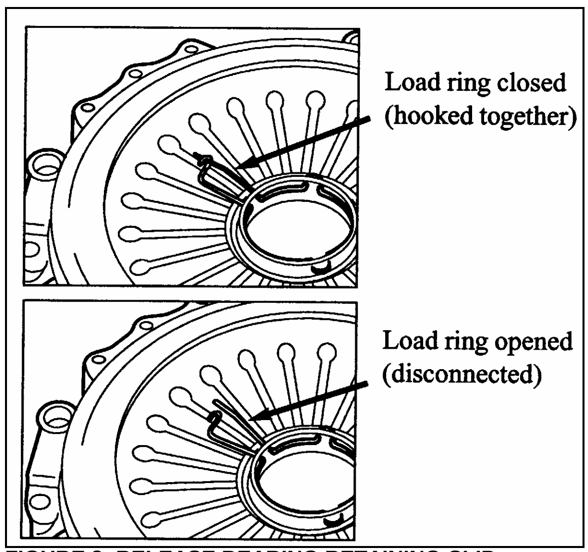


FIGURE 8: RELEASE BEARING RETAINING CLIP 07112

- Install the Clutch Actuator inspection cover.
- The clutch/transmission installation is now complete.

4. INSTALLATION OF ZF OR ALLISON TRANSMISSION BRACKETS

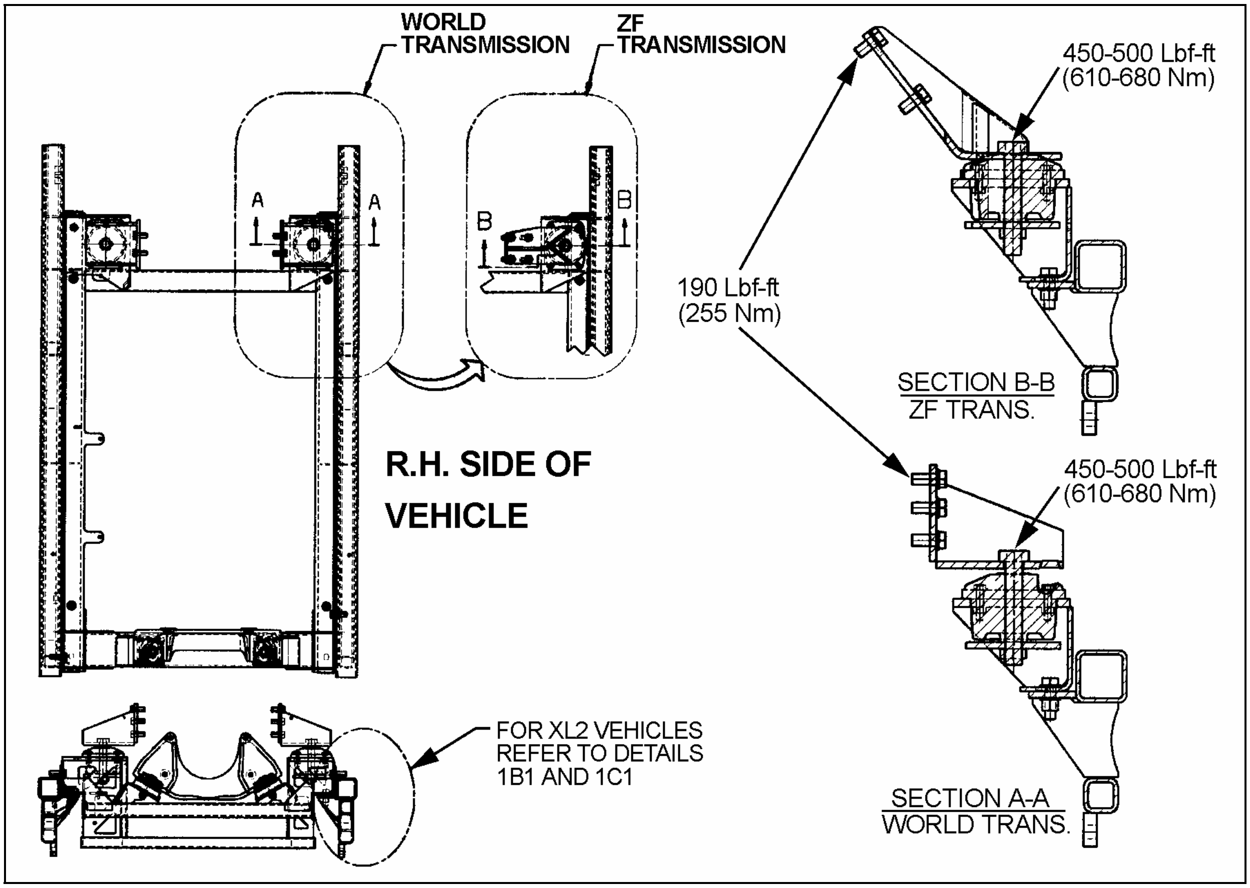


FIGURE 9: ZF OR ALLISON TRANSMISSION BRACKETS 07115

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 *"3.2.9 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.
14. 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. 11).

⚠ CAUTION ⚠
Do not rotate alternator shaft clockwise to avoid removing tension on belt.

15. Remove the 12 screws retaining the torque converter housing to the flywheel housing.

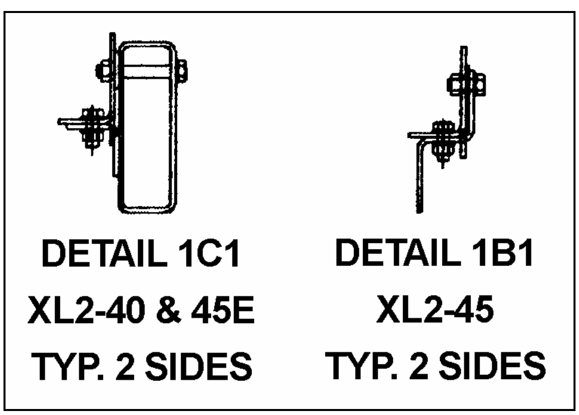


FIGURE 10: DETAILS FOR XL2 VEHICLES 07116

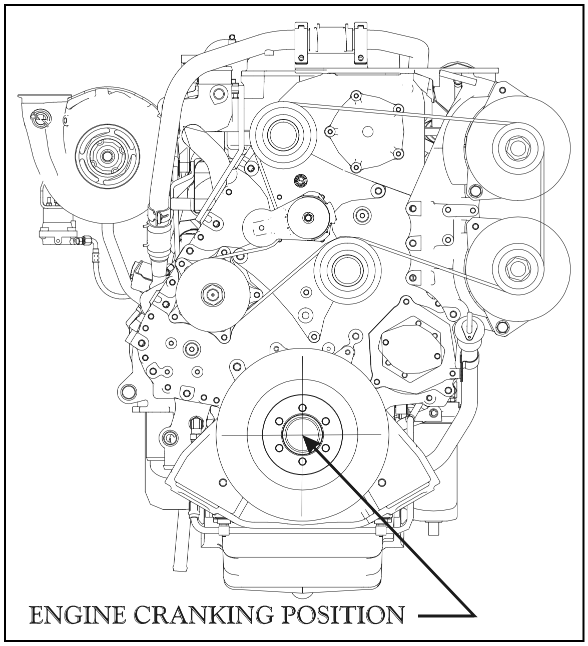


FIGURE 11: ENGINE CRANKING POSITION 01153

⚠ CAUTION ⚠
Make sure transmission-to-engine alignment is maintained when removing screws to avoid damaging torque converter housing.

16. Remove the transmission rubber mount above transmission by removing the nut, bolt and washer over the rubber and its support. Remove the bracket from transmission (only if the vehicle is equipped with a retarder).
17. Slowly pull transmission straight out to clear the engine.
18. Remove the transmission.

6. TRANSMISSION OIL COOLER REMOVAL

6.1 TRANSMISSION WITHOUT RETARDER

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. 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.

⚠ 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.

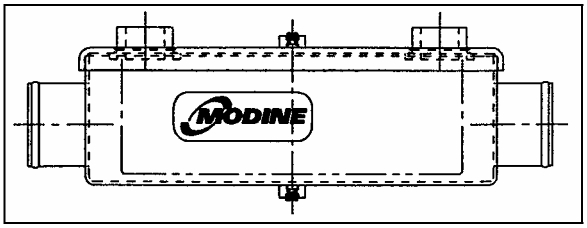


FIGURE 12: MODINE OIL COOLER 07072

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.

6.2 TRANSMISSION WITH RETARDER

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.

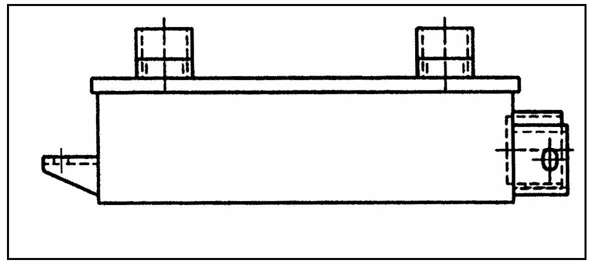


FIGURE 13: COOLER WITH RETARDER 07073

6. Reinstall transmission oil cooler by using reverse procedure.

7. CLEANING AND INSPECTION OF THE TRANSMISSION

7.1 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.

7.1.1 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).

1. With the access plug removed, align one of the 12 attaching screw holes in the flexible plate with the access opening (starter side).
2. Place the transmission on a transmission jack.
3. Install a headless guide bolt into one of the 12 threaded holes for flexible plate attaching screws in the flywheel.
4. Lubricate the flywheel center pilot boss with molybdenum disulfide grease (Molycote G, or equivalent).
5. 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.

⚠ WARNING ⚠
Severe damages and/or personal injury can occur if transmission is not adequately supported.

6. 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.

7. 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).

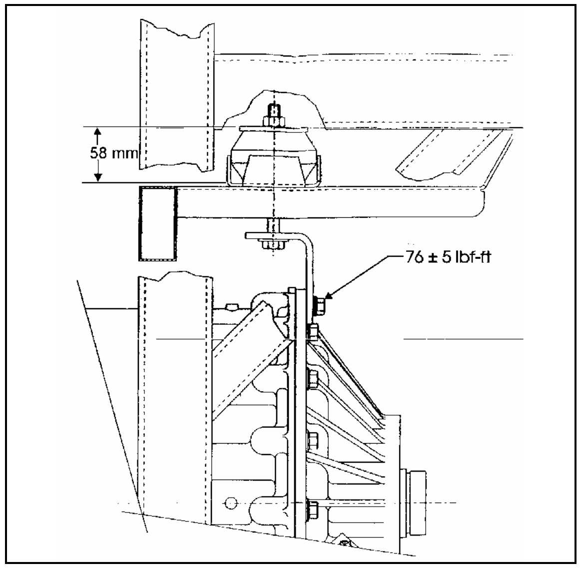


FIGURE 14: NUT TOLERANCE 07014

8. 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). Place a wrench on the crankshaft pulley attaching screw to turn the converter to gain access to the threaded holes.
9. Reinstall the access plug.
10. If the vehicle is equipped with a retarder; install the bracket on the transmission and tighten the bolt to 71-81 lbf-ft (96-110 Nm). Install the transmission rubber mount between the rubber support and the frame with a bolt, nut and washer. Tighten the nut until the tolerance of 58 ± 2 mm is met (Fig. 14).
11. Remove jack from under transmission.
12. Connect all sensors.
13. Connect the main wiring harness.
14. Connect the air supply line (steel-braided hose) to the retarder control valve (if applicable).

15. Connect the two transmission oil cooler hoses as they were previously.
16. Reinstall clamps and brackets, and replace locking ties previously removed during removal procedure.
17. Install propeller shaft and its safety guard. Refer to Section 09, *"PROPELLER SHAFT".*
18. Install transmission dipstick and filler tube.
19. Install cross member under transmission.
20. Install engine splash guards.
21. 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 at back of engine compartment, on R.H. side (Fig. 15) or in the R.H. side rear service compartment.
22. 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.

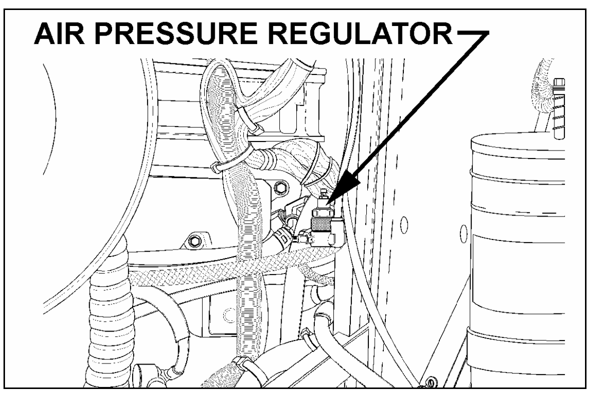


FIGURE 15: AIR PRESSURE REGULATOR (TYPICAL) 07037

9. ALLISON TRANSMISSION PRINCIPLES OF OPERATION

Refer to *"Allison Transmission, MD Series, Principles of Operation, SA 2454".*

10. TROUBLESHOOTING

10.1 ALLISON AUTOMATIC TRANSMISSION

Refer to “Allison Transmission, MD Series, Troubleshooting Manual, SA 2158A”.

10.1.1 WTEC/Electronic Control Unit

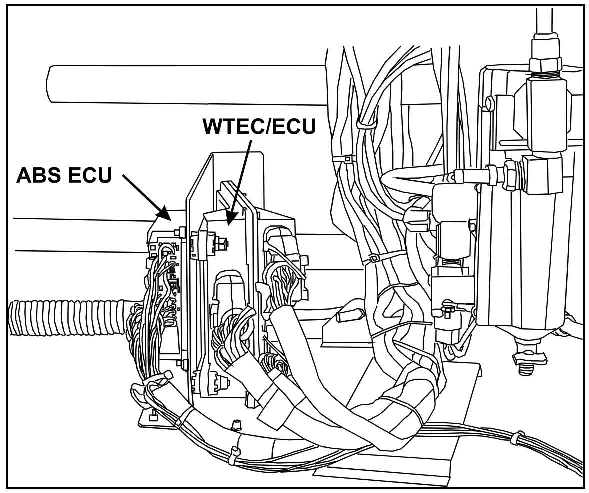


FIGURE 16: WTEC / ELECTRONIC CONTROL UNIT 07075

The ''World'' automatic transmission has a new Electronic Control Unit (ECU) which involves specific diagnostic incident codes. The ECU transmission unit is located in the coach front service compartment.

WTEC/ECU Replacement

The automatic transmission ECU is a non-serviceable electronic device. When it fails, it must be replaced using the following procedure:

- Open the coach front service compartment in order to get access to the ECU;
- Remove the electrical cable connectors;
- Unscrew the WTEC/ECU unit;
- Replace by reversing the procedure.

⚠ CAUTION ⚠

Place the battery master switch to the ‘’OFF’’ position.

10.1.2 WTEC/Troubleshooting

For complete information about WTEC /Troubleshooting, refer to ‘’Allison Transmission, MD Series, Troubleshooting Manual, SA2978’’ March 1997, pages D-9 and D-10.

10.1.3 Diagnostic Code Memory

Diagnostic codes are logged in a list in memory (sometimes referred to as the queue), positioning the most recently occurring code first and containing up to five codes. The codes contained in the list have the information recorded as shown in the chart below. Access to the code list position, main code, sub code and active indicator is available through either the shifter display or the Pro-Link Diagnostic Data Reader (DDR). Access to the ignition cycle counter and event counter is obtained through the DDR only.

Code List Position	Main Code	Sub Code	Active Indicator	Ignition Cycle Counter	Event Counter
d1	21	12	YES	00	10
d2	41	12	YES	00	04
d3	23	12	NO	08	02
d4	34	12	NO	13	01
d5	56	11	NO	22	02
Displayed on shifter display and DDR			YES= ACTIVE= "MODE ON"	Ignition cycle counter and event counter are not available on shifter display	

NOTE

All information is available with a diagnostic tool (DDR).

The following paragraphs define the different parts of the code list.

Code List Position

The position (1 through 5) which a code occupies in the code list in memory. Positions are shown as "d1" (Diagnostic Code #1) through "d5."

Main Code

The general condition or area of fault detected by ECU.

Sub Code

The specific area or condition under the main code in which the condition was detected.

Active Indicator

Will be turned "On" when a fault condition is active (shifter will display "MODE ON" or the DDR will display "YES"). Will be set to "Off" when conditions exist to indicate fault condition is gone.

Ignition Cycle Counter

Used to clear diagnostic codes that are inactive from the code list in memory. A counter is incremented each time a normal ECU power down occurs following clearing of the Active Indicator. A code will be cleared from the list when the counter exceeds 25.

Event Counter

Used to count the number of occurrences of a diagnostic code that occurs prior to the incident being cleared from the code list. The most recent code will be in position "d1". If the most recent code is one which is already in the code list, that code will be moved to position "d1", the Active Indicator will be turned "On" (shifter will display "MODE ON" or the DDR will display "YES"), the Ignition Cycle Counter is cleared and "1" is added to the Event Counter.

Clearing the Active Indicator and code Records from the Code List in Memory

If the conditions causing a diagnostic code to be set are cleared, the Active Indicator can be manually cleared by holding the "MODE" button down continuously for 3 seconds until a tone is heard from the shifter.

To clear code records from the list, hold the "MODE" button down continuously for ten seconds until a second tone sounds. All diagnostic records in the list that are not active will then be cleared and the remaining records will be moved up the list.

Code Reading and Code Clearing Procedures

Diagnostic codes can be read and cleared by two methods: by using the Pro-Link 9000 DDR plugged in the receptacle located on L.H. lateral console (Shells)/L.H. side control panel (Coaches) or by using the shifter display. The use of the Pro-Link 9000 DDR is described in the instruction manual supplied with each tool. The method for reading and clearing codes described in this section refers only to entering of the Diagnostic Display Mode by the proper button selection.

The Diagnostic Display Mode may be entered for viewing of codes at any speed. Codes can only be cleared when the output speed = 0 and no output speed sensor failure is active.
The following descriptions explain how to use the shifter to read and clear codes.

10.1.4 Reading Codes

1. Enter the diagnostic display mode by pressing the "⬆" and "⬇" (upshift and downshift arrows) buttons at the same time on the pushbutton shifter.

NOTE
If a "DO NOT SHIFT" condition is present at this time, the lever should be in the same position as it was at the time of code detection. If not, this shifter tone will sound continuously.

NOTE
If an Oil Level Sensor (OLS) is present, the oil level will be displayed first. Diagnostic code display is achieved by depressing the UPSHIFT and DOWNSHIFT arrows or display MODE button a second time.

2. Read the first code in the first of five code positions on the digital display of the shifter. For example, we will read code 25 11 in the first position. The display will change every two seconds as follows:
   a. Code list position --"d1";
   b. Main code --"25";
   c. Sub code --"11"; and
   d. Display will repeat cycle of a., b. and c, above.
3. Press the "MODE" button momentarily to view the second position (d2) in the same way as 2. above.
4. To view the third, fourth and fifth positions (d3, d4 and d5), momentarily press the "MODE" button as explained above.
5. Pressing the "MODE" button momentarily after the fifth position is displayed will cause the sequence of code positions to start over with the first position.
6. Any code that is active will be indicated by the "MODE ON" indicator (Active Indicator) being turned on while in that code position (while in the normal operation).
7. Any code position in the list which does not have a diagnostic code logged will display "- -" for both the main and sub code displays. All positions after a code codes.

10.1.5 Clearing Codes

1. Clearing of the active indicator is automatically done at ECU power down on all but code 69 34.
2. Some codes will clear the active indicator automatically when the condition causing the code is no longer detected by the ECU (see Diagnostic Code List and Description, page 7 - 22).
3. Manual clearing is possible while in the diagnostic display mode and after the condition causing the code is corrected (output speed must be zero).

a. To clear all active indicators, hold the "MODE" button down continuously for 3 seconds until the shifter tone sounds for 0.5 seconds.

b. Release the "MODE" button to return to normal operating mode. If the condition causing the code was not active at the time, the active indicator will turn off.

⚠ CAUTION ⚠

If clearing a code while locked in a Forward or Reverse position (fail-to-range), the transmission will still be in Drive or Reverse when the clearing procedure is completed. Neutral must be selected manually.

Exiting the Diagnostic Display Mode

The diagnostic display mode can be exited by any of the following procedures:

1. Press the "⬆" and "⬇" (upshift and downshift) buttons at the same time on the pushbutton shifter.
2. Press any range button, "D", "N" or "R", on the pushbutton shifter (the shift will be commanded if it is not inhibited by an active code).
3. Do nothing and wait until the calibrated time (approximately 10 minutes) has passed and the system automatically returns to the normal operating mode.
4. Turn off power to the ECU (turn off the vehicle at the ignition switch).
5. After the clearing of a code, the active indicator procedure described above has been performed.

Clearing Records from the Code List in Memory

If the requirements for Manual Clearing the Active Indicator have been satisfied, and the "MODE" button is held down continuously for ten seconds while in the display mode until a tone sounds, then all diagnostic records in the code list that are not active will be cleared and the remaining records will be moved up in the code list.

Abbreviations found in the Code Chart

The following responses are used throughout the following chart to command safe operation when diagnostic codes are set.

1. **DNS** (**D**o **N**ot **S**hift) Response

   a. Turn off lockup clutch and inhibit lockup operation.

   b. Inhibit all shifts.

   c. Turn on the *DO NOT SHIFT* light.

   d. Pulse the tone generator for 8 seconds when the condition is first detected.

   e. Blank the select digit in the display.

   f. Ignore any range selection inputs and disable the button feedback tone for the pushbutton shifter.

2. **SOL OFF** (**Sol**enoid **Off**) Response

   All solenoids are commanded off (turning solenoids "A" and "B" off electrically causes them to be on hydraulically).

3. **RPR** (**R**eturn to **P**revious **R**ange) Response

   When the ratio or C3 pressure switch tests associated with a shift are not passed, the ECU commands the same range as commanded at the beginning of the shift.

4. **NNC** (**N**eutral **N**o **C**lutches) Response

   When certain ratio or C3 pressure switch tests are not passed, the ECU commands a neutral condition with no clutches applied.

Diagnostic code list and description

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
12	12	Oil level, low	No	No upshift above a calibration range
12	23	Oil level, high	No	No upshift above a calibration range
13	12	ECU input voltage, low	Yes	DNS, SOL OFF (Hydraulic default)
13	13	ECU input voltage, medium low	No	None: Shift adaptive feature will not function.
13	23	ECU input voltage, high	Yes	DNS, SOL OFF (Hydraulic default)
14	12	Oil level sensor, low	No	None
14	23	Oil level sensor, high	No	None
21	12	Throttle position sensor, low	No	Use Throttle default value
21	23	Throttle position sensor, high	No	Use Throttle default value
22	14	Engine speed sensor reasonableness test	No	Use default engine speed
22	15	Turbine speed sensor reasonableness test	Yes	DNS, Lock in current range
22	16	Output speed sensor reasonableness or rapid decel test	Yes	DNS, Lock in current range
23	12	Primary Shifter or RSI Link Fault	No	Hold in last valid direction
23	13	Primary Shifter Mode Function Fault	No	Mode change not permitted
23	14	Secondary Shifter or RSI Link Fault	No	Hold in last valid direction
23	15	Secondary Shifter Mode Function Fault	No	Mode change not permitted
24	12	Sump oil temperature, cold	Yes	DNS
24	23	Sump oil temperature, hot	No	No upshifts above a calibration range
25	00	Output speed reasonableness test, detected at 0 speed, (L)	Yes	DNS, Lock in current range (L)
25	11	Output speed reasonableness test, detected at 0 speed, (1st)	Yes	DNS, Lock in current range (1st)
25	22	Output speed reasonableness test, detected at 0 speed 2nd	Yes	DNS, Lock in current range (2nd)

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
25	33	Output speed reasonableness test, detected at 0 speed, 3rd	Yes	DNS, Lock in current range (3rd)
25	44	Output speed reasonableness test, detected at 0 speed, 4th	Yes	DNS, Lock in current range (4th)
25	55	Output speed reasonableness test, detected at 0 speed, 5th	Yes	DNS, Lock in current range (5th)
25	66	Output speed reasonableness test, detected at 0 speed, 6th	Yes	DNS, Lock in current range (6th)
25	77	Output speed reasonableness test, detected at 0 speed, R	Yes	DNS, Lock in current range (R)
32	00	C3 pressure switch open, L range	Yes	DNS, Lock in current range (L)
32	33	C3 pressure switch open, 3rd range	Yes	DNS, Lock in current range (3rd)
32	55	C3 pressure switch open, 5th range	Yes	DNS, Lock in current range (5th)
32	77	C3 pressure switch open, R range	Yes	DNS, Lock in current range (R)
33	12	Sump oil temperature sensor, low	No	Use default value of 200° F (93° C)
33	23	Sump oil temperature sensor, high	No	Use default value of 200° F (93° C)
34	12	EEPROM, factory cal. compatibility number wrong	Yes	DNS, SOL OFF (Hydraulic default)
34	13	EEPROM, factory calibration block checksum	Yes	DNS, SOL OFF (Hydraulic default)
34	14	EEPROM, Power Off Block checksum	Yes	Use previous location, or factory calibration and reset adaptive
34	15	EEPROM, Diagnostic Queue Block Checksum	Yes	Use previous location, or clear diagnostic queue
34	16	EEPROM, Real Time Block Checksum	Yes	DNS, SOL OFF (Hydraulic default)
35	00	Power interruption (Code set after power restored)	No	NONE (Hydraulic default during interruption)
35	16	Real Time EEPROM Write Interruption	Yes	DNS, SOL OFF (Hydraulic default)
36	00	Hardware/Software not compatible	Yes	DNS, SOL OFF (Hydraulic default)

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
41	12	Open or short to ground, A solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
41	13	Open or short to ground, B solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
41	14	Open or short to ground, C solenoid circuit	Yes	DNS. SOL OFF (Hydraulic default)
41	15	Open or short to ground, D solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
41	16	Open or short to ground, E solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
41	21	Open or short to ground, F solenoid circuit	No	Lock-up inhibited
41	22	Open or short to ground, G solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
41	23	Open or short to ground, H solenoid circuit	No	Retarder allowed, differential lock inhibited
41	24	Open or short to ground, J solenoid circuit	No	Low and 1st inhibited
41	25	Open or short to ground, K solenoid circuit	No	K solenoid operation inhibited
41	26	Open or short to ground, N solenoid circuit	No	Low and 1st inhibited
42	12	Short to battery, A solenoid circuit	Yes	DNS, Lock in a range
42	13	Short to battery, B solenoid circuit	Yes	DNS, Lock in a range
42	14	Short to battery, C solenoid circuit	Yes	DNS, Lock in a range
42	15	Short to battery, D solenoid circuit	Yes	DNS, Lock in a range
42	16	Short to battery, E solenoid circuit	Yes	DNS, Lock in a range
42	21	Short to battery, F solenoid circuit	No	Lock-up inhibited
42	22	Short to battery, G solenoid circuit	Yes	DNS, Lock in a range
42	23	Short to battery, H solenoid circuit	No	Retarder allowed, differential lock inhibited

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
42	24	Short to battery, J solenoid circuit	No	Low and 1st inhibited
42	25	Short to battery, K solenoid circuit	No	K solenoid operation inhibited
42	26	Short to battery, N solenoid circuit	No	Low and 1st inhibited
43	21	Low side driver, F solenoid circuit	No	Lock-up inhibited
43	25	Low side driver, K solenoid circuit	No	K solenoid operation inhibited
43	26	Low side driver, N solenoid circuit	No	Low and 1st inhibited
44	12	Short to ground, A solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
44	13	Short to ground, B solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
44	14	Short to ground, C solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
44	15	Short to ground, D solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
44	16	Short to ground, E solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
44	21	Short to ground, F solenoid circuit	No	Lock-up inhibited
44	22	Short to ground, G solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
44	23	Short to ground, H solenoid circuit	No	Retarder allowed. differential lock inhibited
44	24	Short to ground, J solenoid circuit	No	Low and 1st inhibited
44	25	Short to ground, K solenoid circuit	No	K solenoid operation inhibited
44	26	Short to ground, N solenoid circuit	No	Low and 1st inhibited
45	12	Open circuit, A solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
45	13	Open circuit, B solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
45	14	Open circuit, C solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
45	15	Open circuit, D solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
45	16	Open circuit, E solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
45	21	Open circuit, F solenoid circuit	No	Lock-up inhibited
45	22	Open circuit, G solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
45	23	Open circuit, H solenoid circuit	No	Retarder allowed differential lock inhibited
45	24	Open circuit, J solenoid circuit	No	Low and 1st inhibited
45	25	Open circuit, K solenoid circuit	No	K solenoid operation inhibited
45	26	Open circuit, N solenoid circuit	No	Low and 1st inhibited
51	10	Offgoing ratio test (during shift), 1 to L	Yes	Low and 1st inhibited
51	12	Offgoing ratio test (during shift), 1 to 2	Yes	DNS, RPR
51	21	Offgoing ratio test (during shift), 2 to 1	Yes	DNS, RPR
51	23	Offgoing ratio test (during shift), 2 to 3	Yes	DNS, RPR
51	43	Offgoing ratio test (during shift), 4 to 3	Yes	DNS, RPR
51	45	Offgoing ratio test (during shift), 4 to 5	Yes	DNS, RPR
51	65	Offgoing ratio test (during shift), 6 to 5	Yes	DNS, RPR
52	01	Offgoing C3PS test (during shift), L to 1	Yes	DNS, RPR
52	08	Offgoing C3PS test (during shift), L to N1	Yes	DNS, NNC

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
52	32	Offgoing C3PS test (during shift), 3 to 2	Yes	DNS, RPR
52	34	Offgoing C3PS test (during shift), 3 to 4	Yes	DNS, RPR
52	54	Offgoing C3PS test (during shift), 5 to 4	Yes	DNS, RPR
52	56	Offgoing C3PS test (during shift), 5 to 6	Yes	DNS, RPR
52	71	Offgoing C3PS test (during shift), R to 1	Yes	DNS, NNC
52	72	Offgoing C3PS test (during shift), R to 2	Yes	DNS, NNC
52	78	Offgoing C3PS test (during shift), R to N1	Yes	DNS, NNC
52	79	Offgoing C3PS test (during shift), R to 2 (R to NNC to 2)	Yes	DNS, NNC
52	99	Offgoing C3PS test (during shift), N3 to N2	Yes	DNS, RPR
53	08	Offgoing speed test (during shift), L to N1	Yes	DNS, NNC
53	18	Offgoing speed test (during shift), 1 to N1	Yes	DNS, NNC
53	28	Offgoing speed test (during shift), 2 to N1	Yes	DNS, NNC
53	29	Offgoing speed test (during shift), 2 to N2	Yes	DNS, RPR
53	38	Offgoing speed test (during shift), 3 to N1	Yes	DNS, NNC
53	39	Offgoing speed test (during shift), 3 to N3	Yes	DNS, RPR
53	48	Offgoing speed test (during shift), 4 to N1	Yes	DNS, NNC
53	49	Offgoing speed test (during shift), 4 to N3	Yes	DNS, RPR
53	58	Offgoing speed test (during shift), 5 to N1	Yes	DNS, NNC

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
53	59	Offgoing speed test (during shift), 5 to N3	Yes	DNS, RPR
53	68	Offgoing speed test (during shift), 6 to N1	Yes	DNS, NNC
53	69	Offgoing speed test (during shift), 6 to N4	Yes	DNS, RPR
53	78	Offgoing speed test (during shift), R to N1	Yes	DNS, NNC
53	99	Offgoing speed test (during shift), N2 to N3 or N3 to N2	Yes	DNS, RPR
54	01	Oncoming ratio test (after shift), L to 1	Yes	DNS, RPR
54	07	Oncoming ratio test (after shift), L to R	Yes	DNS, NNC
54	10	Oncoming ratio test (after shift), 1 to L	Yes	DNS, RPR
54	12	Oncoming ratio test (after shift), 1 to 2	Yes	DNS, RPR
54	17	Oncoming ratio test (after shift), 1 to R	Yes	DNS, NNC
54	21	Oncoming ratio test (after shift), 2 to 1	Yes	DNS, RPR
54	23	Oncoming ratio test (after shift), 2 to 3	Yes	DNS, RPR
54	27	Oncoming ratio test (after shift), 2 to R	Yes	DNS, NNC
54	32	Oncoming ratio test (after shift), 3 to 2	Yes	DNS, RPR
54	34	Oncoming ratio test (after shift), 3 to 4	Yes	DNS, RPR
54	43	Oncoming ratio test (after shift), 4 to 3	Yes	DNS, RPR
54	45	Oncoming ratio test (after shift), 4 to 5	Yes	DNS, RPR or SOL OFF (Hydraulic default)
54	54	Oncoming ratio test (after shift), 5 to 4	Yes	DNS,RPR

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
54	56	Oncoming ratio test (after shift), 5 to 6	Yes	DNS,RPR
54	65	Oncoming ratio test (after shift), 6 to 5	Yes	DNS,RPR
54	70	Oncoming ratio test (after shift), R to L	Yes	DNS,NNC
54	71	Oncoming ratio test (after shift), R to 1	Yes	DNS,NNC
54	72	Oncoming ratio test (after shift), R to 2	Yes	DNS,NNC
54	80	Oncoming ratio test (after shift), N1 to L	Yes	DNS,RPR
54	81	Oncoming ratio test (after shift), N1 to 1	Yes	DNS,RPR
54	82	Oncoming ratio test (after shift), N1 to 2	Yes	DNS,RPR
54	83	Oncoming ratio test (after shift), N1 to 3	Yes	DNS,RPR
54	85	Oncoming ratio test (after shift), N1 to 5	Yes	DNS,RPR
54	86	Oncoming ratio test (after shift), Nl to 6	Yes	DNS, RPR
54	92	Oncoming ratio test (after shift), R to 2 (R to NNC to 2)	Yes	DNS, NNC
54	92	Oncoming ratio test (after shift), N1 to 2 (N1 to NNC to 2)	Yes	DNS, RPR
54	92	Oncoming ratio test (after shift), N2 to 2	Yes	DNS, RPR
54	93	Oncoming ratio test (after shift), N3 to 3	Yes	DNS, RPR
54	95	Oncoming ratio test (after shift), N3 to 5	Yes	DNS, RPR
54	96	Oncoming ratio test (after shift), N4 to 6	Yes	DNS, RPR
54	97	Oncoming ratio test (after shift), 2 to R (2 to NNC to R)	Yes	DNS, NNC

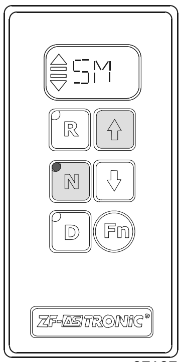
MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
55	17	Oncoming C3PS test (after shift), 1 to R	Yes	DNS, NNC
55	27	Oncoming C3PS test (after shift), 2 to R	Yes	DNS, NNC
55	80	Oncoming C3PS test (after shift), N1 to L	Yes	DNS, RPR
55	87	Oncoming C3PS test (after shift), N1 to R	Yes	DNS, RPR
55	97	Oncoming C3PS test (after shift), 2 to R or NVL to R (2 to NNC to R)	Yes	DNS, NNC
56	00	Range verification test, L	Yes	DNS, 1st, Low, or SOL OFF (Low)
56	11	Range verification test, 1st	Yes	DNS, 6th
56	22	Range verification test, 2nd	Yes	DNS, 6th or 5th
56	33	Range verification test, 3rd	Yes	DNS, 5th or SOL
56	44	Range verification test, 4th	Yes	DNS, 3rd or 5th
56	55	Range verification test, 5th	Yes	DNS, SOL OFF (5th) or 3rd
56	66	Range verification test, 6th	Yes	DNS, 5th, 3rd, or SOL OFF (3rd)
56	77	Range verification test, R	Yes	DNS, N2 or N3
57	11	Range verification C3PS test, 1st	Yes	DNS, SOL OFF (3rd)
57	22	Range verification C3PS test, 2nd	Yes	DNS, 3rd
57	44	Range verification C3PS test, 4th	Yes	DNS, 5th or SOL OFF (3rd)
57	66	Range verification C3PS test, 6th	Yes	SOL OFF (5th), DNS
57	88	Range verification C3PS test, N1	Yes	DNS, N3
57	99	Range verification C3PS test, N2 or N4	Yes	DNS, N3
61	00	Retarder oil temperature, hot	No	None
62	12	Retarder oil temperature sensor, low	No	None
62	23	Retarder oil temperature sensor, high	No	None
63	00	Special function input	No	Depends on special function
64	12	Retarder modulation request sensor, low	No	Retarder operation inhibited

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
64	23	Retarder modulation request sensor, high	No	Retarder operation inhibited
65	00	Engine rating too high	Yes	DNS
66	00	Serial communications interface fault	No	Use default throttle values
69	12	ECU, A solenoid driver open	Yes	DNS, SOL OFF (hydraulic default)
69	13	ECU, B solenoid driver open	Yes	DNS, SOL OFF (hydraulic default)
69	14	ECU, C solenoid driver open	Yes	DNS, SOL OFF (hydraulic default)
69	15	ECU, D solenoid driver open	Yes	DNS, SOL OFF (hydraulic default)
69	16	ECU, E solenoid driver open	Yes	DNS, SOL OFF (hydraulic default)
69	21	ECU, F solenoid driver open	No	Lock-up inhibited
69	22	ECU, G solenoid driver open	Yes	DNS, SOL OFF (Hydraulic default)
69	23	ECU, H solenoid driver open	No	Retarder allowed, differential lock inhibited
69	24	ECU, J solenoid driver open	No	Low and 1 st inhibited
69	25	ECU, K solenoid driver open	No	K solenoid operation inhibited
69	26	ECU, N solenoid driver open	No	Low and 1st inhibited
69	32	ECU, SPI communications link fault	No	Hold in last valid direction
69	33	ECU, Central Operating Processor (COP) time-out	Yes	Reset ECU, Shutdown ECU on 2nd occurrence (power loss: hydraulic defaults)
69	34	ECU, EEPROM write time-out	Yes	DNS, SOL OFF (Hydraulic default)
69	35	ECU, EEPROM checksum	Yes	Induce COP time-out (reset ECU)
69	36	ECU, RAM self test	Yes	Induce COP time-out (reset ECU)
69	41	ECU, I/O ASIC addressing test	Yes	Induce COP time-out (reset ECU)
0	35	Software, minor loop overrun	Yes	Induce COP time-out (reset ECU)

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
70	35	Software, illegal write to access $0000	Yes	Induce COP time-out (reset ECU)
70	35	Software, major loop overrun	Yes	Induce COP time-out (reset ECU)

11. ZF-ASTRONIC TRANSMISSION SYSTEM FAULTS AND ERROR MESSAGES

11.1 SYSTEM FAULTS (ERROR MESSAGES)



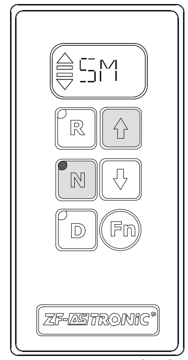
07107

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.

Calling up error numbers

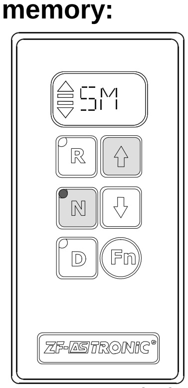


07107

- 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:



07107

- 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.

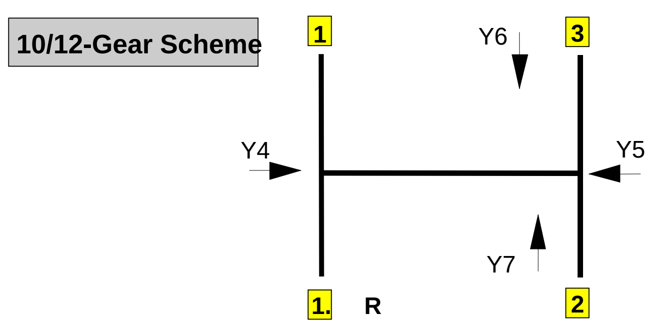
ERROR CODES

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)



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

ON MESSAGES CENTER DISPLAY (MCD) SAE-J1587 Codes	ON SHIFT SELECTOR DISPLAY	ISO CODES WITH TESTMAN TOOL	DESCRIPTION
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
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)

ON MESSAGES CENTER DISPLAY (MCD) SAE-J1587 Codes	ON SHIFT SELECTOR DISPLAY	ISO CODES WITH TESTMAN TOOL	DESCRIPTION
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)
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

ON MESSAGES CENTER DISPLAY (MCD) SAE-J1587 Codes	ON SHIFT SELECTOR DISPLAY	ISO CODES WITH TESTMAN TOOL	DESCRIPTION
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
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

ON MESSAGES CENTER DISPLAY (MCD) SAE-J1587 Codes	ON SHIFT SELECTOR DISPLAY	ISO CODES WITH TESTMAN TOOL	DESCRIPTION
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)
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

12. SPECIFICATIONS

ALLISON AUTOMATIC TRANSMISSION WITH OR WITHOUT RETARDER

XL2 Buses
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
XL2 MTH
Gross input power (maximum)....................525 HP (392 kW)
Gross input torque (maximum) ....1650 Lbf-ft (2237 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/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
Supplier number 29503829
Prévost number 57-1687

SECTION 09: PROPELLER SHAFT

CONTENTS

ILLUSTRATIONS

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".

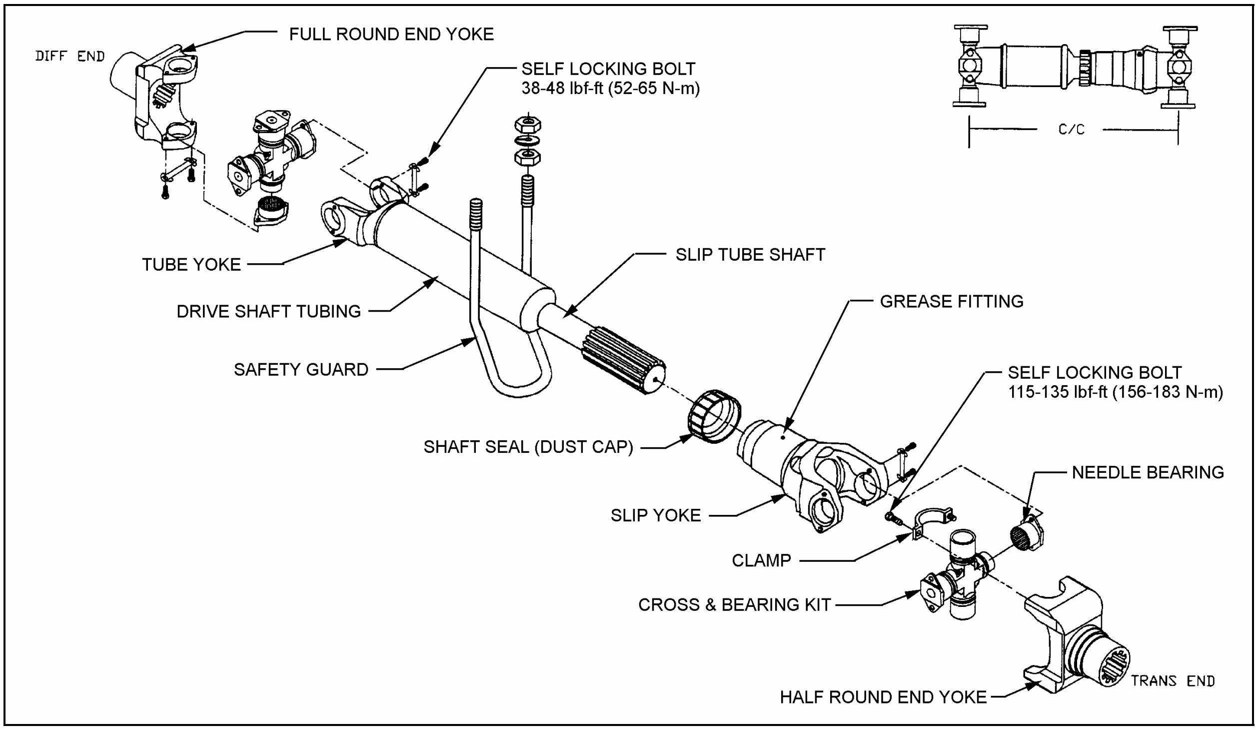


FIGURE 1: PROPELLER SHAFT ASSEMBLY 09002

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

VEHICLES EQUIPPED WITH ALLISON WORLD TRANSMISSION

XL2-45 COACHES AND W-45 MOTORHOMES

Make .... Hayes-Dana Inc.
Series 1810
Supplier number 819325-2200
Prevost number 580070

W-40 AND Y-45E MOTORHOMES

Make .... Hayes-Dana Inc.
Series 1810
Supplier number 819299-1
Prevost number 580075

XL2-45 COACHES EQUIPPED WITH ZF TRANSMISSION

Make .... Hayes-Dana Inc.
Series 1810
Supplier number 816688-1600
Prevost number 580080

Repair kits

Make .... Hayes-Dana Inc.
U-joint kit (tube yoke), Supplier number 5-281X
U-joint kit (tube yoke), Prevost number 580043
U-joint kit (slip yoke), Supplier number 5-510X
U-joint kit (slip yoke), Prevost number 580062
Cap and bolt kit, bolt torque 115-135 lbf•ft (156-183 N•m), Supplier number 6.5-70-18X
Cap and bolt kit, bolt torque 115-135 lbf•ft (156-183 N•m), Prevost number 580063
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 number 580071

Half Round End Yoke

Make .... Covington Detroit Diesel
Supplier number 29511516

NOTE
U-joint kits will come equipped with the serrated bolt and lock patch and will no longer contain a lock strap.

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.

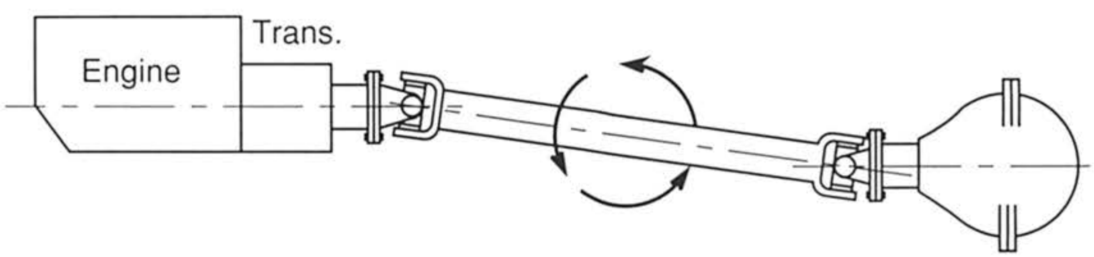
Experience with universal joint failures has shown that a significant majority are related to lubricating film breakdown. This may be caused by a lack of lubricant, inadequate lube quality for the application, inadequate initial lubrication or failure to lubricate properly and often enough.

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:

L.G.T. = N.E.T. x Trans L.G.R. x .85 (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.

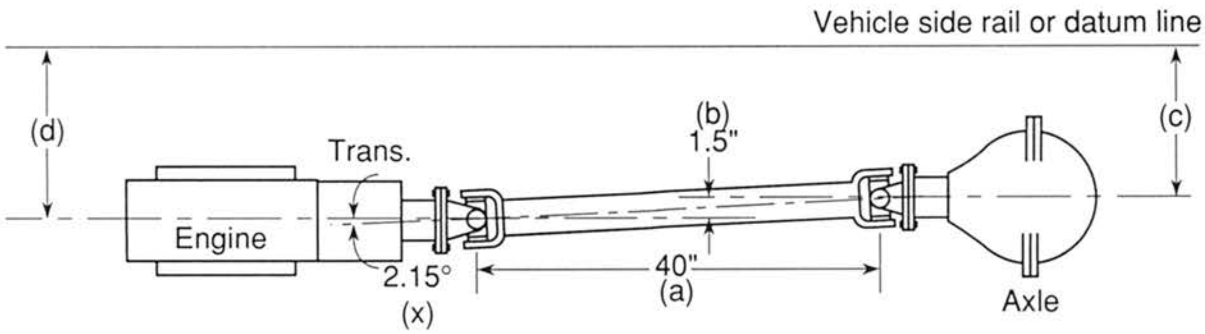
U-joint operating angles are probably the most common causes of driveline vibrations in vehicles that have been re-worked or in vehicles that have had auxiliary equipment installed.

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.

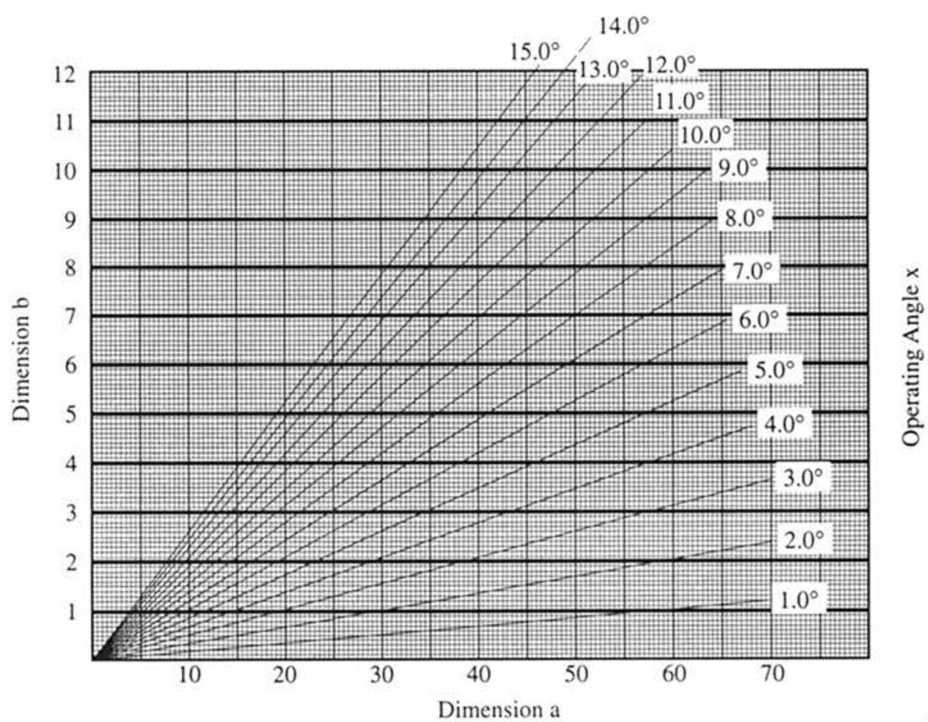
The TRUE OPERATING ANGLE of a U-joint is a combination of the angle that occurs in the top view and the angle that occurs in the side view.

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.

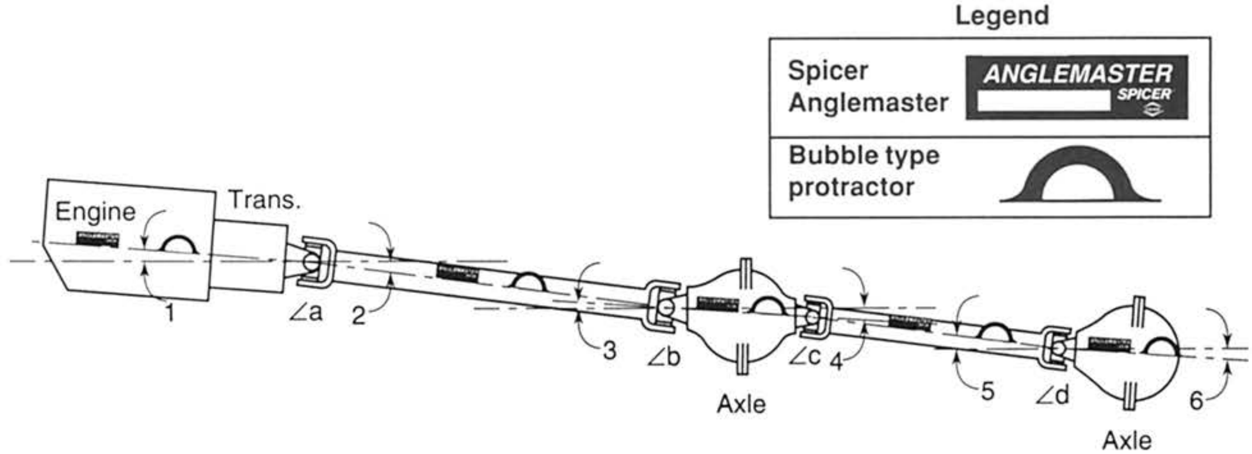


Example:

Where a = 40.0"
b = 1.5"
X = 2.15° operating angle

U-Joint Operating Angles

II. To determine operating angles in side view



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.

$\angle$ a = (2) - (1) = 7°00' - 4°30' = 2°30' (2.50°)
$\angle$ b = (2) - (3) = 7°00' - 4°00' = 3°00' (3.00°)
$\angle$ c = (5) - (4) = 7°00' - 4°00' = 3°00' (3.00°)
$\angle$ d = (5) - (6) = 7°00' - 4°15' = 2°45' (2.75°)

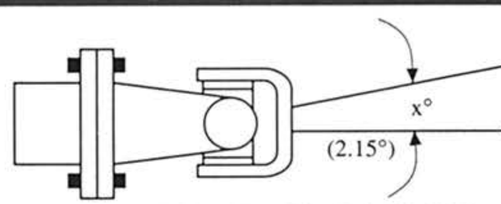
III. Calculating the True U-Joint Operating Angle

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:

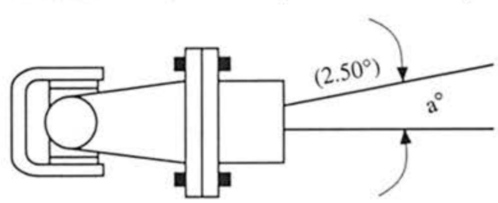
True operating angle = $\sqrt{x^{\circ 2} + a^{\circ 2}}$
Where x = 2.15° as determined by use of chart in Section I.

a = 2.5° as determined in Section II.

True operating angle = $\sqrt{2.15^2 + 2.5^2}$
= 3.297° or 3°18'



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

Probable Causes

Complaints	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	Yoke Lug Face Squareness	No U-Joint Operating Angle	Long Shaft with Loose U-Joint Thrust Fit and Unbalance	Roller Lock	Roller Skewing	Frettage Corrosion Due to Yoke Working Under Load	Galling (Adhesive Wear)	Slip Member Working in Extreme Extended	Excessive Loose O.D. Fit	Male Spline Head F	Exce
Low Mileage U-Joint Failure	1	1	1 6	1	1	2 11		4	5	1 4 6 7															
Repeat U-Joint Failure	1	1	1 6	1	1	2 11	13 3	4	5	1 4 6 7															
End Galling of Cross Trunnion and Bearing Cup								4			1 8 11	1 6	7	7	7										
Frettage (Also: False Brinelling, Wear Oxidation, Friction Oxidation, and Chaffing Fatigue)											1 8 11	1 5 6 8				10	18 22 25 26	11 13	11 12 13						
Bearing Race O.D. Seizure in Yoke Cross Holes																				9					
Slip Spline Seizures	1	1	1	1	1						8	1 6 8									1 6 5 8 14	15			5
Slip Spline Galling											8	1 6 8										15		16 17	5
Slip Spline O.D. Wear at Extremities and at 180°																						15	11 32	16 17	
Slip Spline Shaft or Tube Broken in Torsion																									5 19
Shaft Broken in Bending																									
Tube Split in Longitudinal Seam Weld																									
Tube Circle Weld Failure																									5 19
Yoke Broken in Hub																									5
Yoke Broke at Ear Tip																									
Broken Cross or Cups																									5
Needle Rollers Brinelled into Cups and Cross Trunnion																									5
Shaft Support Brg. Failure	11 32	11				11 32					11 32														
Shaft Support Rubber Insulator Failure																									
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.

...ded Position	...ad Engagement Length too Short for Application	Excessive Torque Load for U-Joints and Driveshaft Size	Improper Slip Spline Shaft Neck Heat Treatment	Inadequate Radius at Slip Spline Shaft Neck Runout — Stress Riser	Tube Size Inadequate	Defective or Worn Part	Driveshaft Too Long for Operating Speeds	Bending Fatigue Due to Secondary Couple Loads	Defective Circle Weld	Balance Weight Too Close To Circle Weld	Balance Weight Located in Apex of Weld Yoke Lug Area	Inadequate Hub and Radius For Application	Defective Forging or Casting	Mating Yoke Lug Interference at Full Jounce and Rebound	Excessive U-Bolt Torque on Retaining Nuts — Pinching Rollers	Inadequate Torque on Cap Screws Retaining Brg. Plate	Worn Universal Joints	Continuous Running U-Joint Angles — Too Large	Unequal U-Joint Angles	Driveshaft Balance and Straightness	Damaged Driveshaft Tube	Runout on Drive and Driven Support Shafts	Excessively Loose U-Joint for Operating Speed and Length	Loose O.D. Fit on Slip Spline	Drive Shaft Too Long for Speed — Operating in Critical	Driveshaft Weight Not Compatible with Eng. — Transmission Mounting	Driveshaft Yoke Phasing	Secondary Couple Load Reaction at Shaft Support Brg.	Torsional Excitation	Inertia Excitation	Shaft Support Brg. Misaligned — Interference with Slinger	Improper Shaft Length and Slip
															26																	
															26																	
			11	5 17	5 19	11																										
							18 19	4																								
						11																										
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																												4 21 33 34 35				
																													4 21			

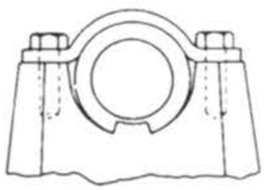
18. Install two piece driveshaft with shaft support bearing.
19. Use larger diameter tube.
20. Design limitation due to axle's or transmission shaft's requirement.
21. Shim drivetrain components to equalize U-joint angles.
22. Straighten and balance.
23. Check with transmission or axle manufacturer ...Replace shaft bearing.
24. Revise power plant mounting scheme.
25. Check U-joint flex effort for looseness.
26. Torque bearing retention to spec.
27. Use wide angle yokes.
28. Check installed length. Adjust driveshaft length to provide proper slip conditions.
29. Re-align mounting bracket to frame cross member and eliminate interference.
30. Replace U-joint kits.
31. Replace tube.
32. If normal wear...Replace.
33. Check O.E.M. maintenance manual or alignment arrows on slip yoke and male slip shaft for correct yoke phasing.
34. If 2 piece-3JT driveshafts...Adjust shaft lengths to 50-50 or 40-60 split.
35. Re-position shaft support bearing.

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.

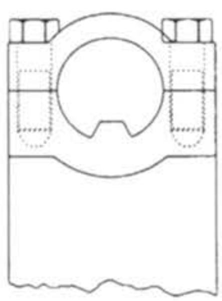
BEARING STRAP



WARNING: Bearing Strap Retaining Bolts Should **NOT** Be Reused.

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.

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

WARNING: Self Locking Bolts Should **NOT** Be Reused

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.

* 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: Bolt	Washer	Nut	Diameter, Thread, & Length Under Head	Recommended Torque
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.

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Drivetrain Service Division
P.O. Box 321
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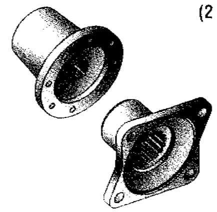
3119-5 DSD 4/94

SPICER® LIFE™ DRIVELINE COMPONENTS

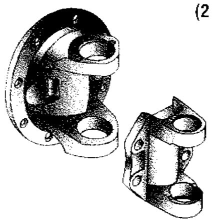
COMPANION FLANGE (1)

(2 STYLES)



FLANGE YOKE (2)

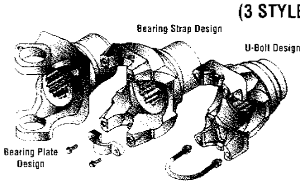
(2 STYLES)

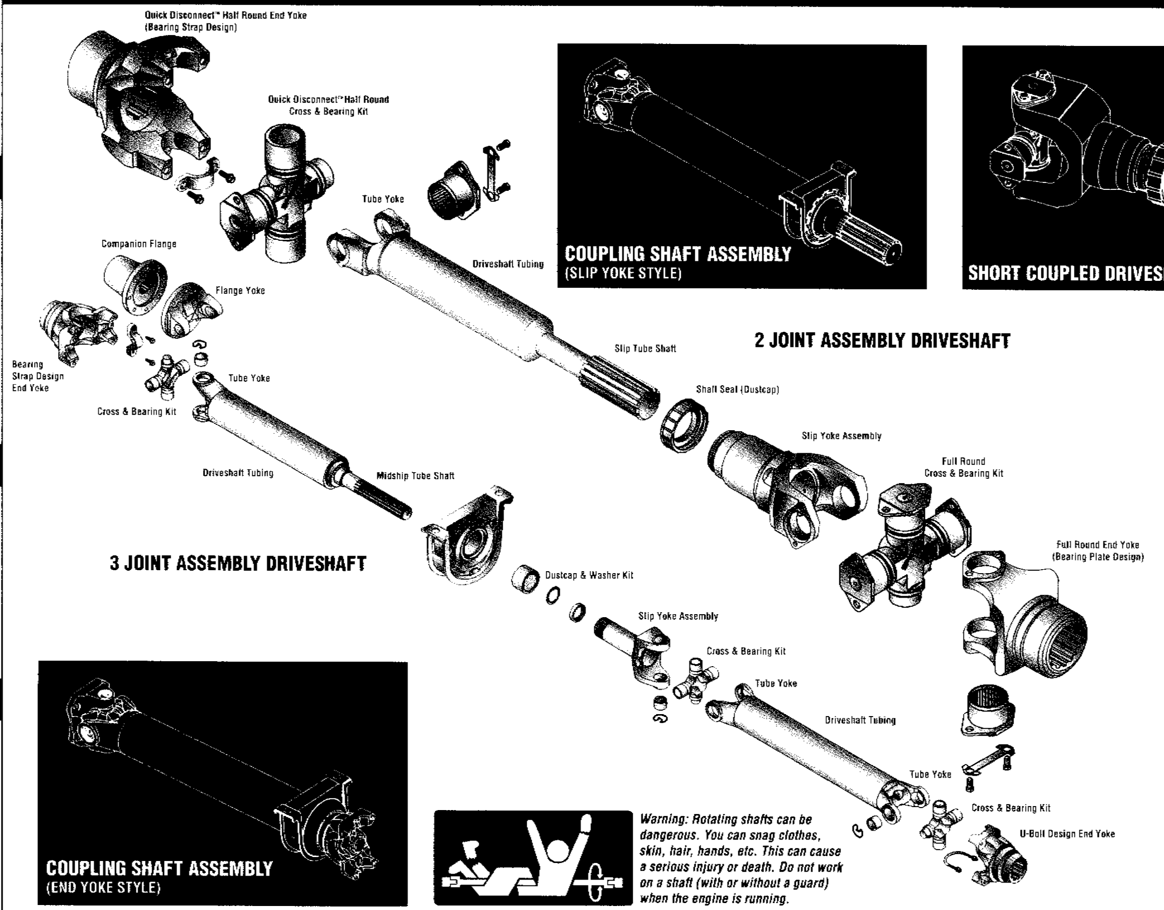


SLIP YOKE ASSEMBLY (3)

END YOKE (4)

(3 STYLES)





2 JOINT ASSEMBLY DRIVESHAFT

3 JOINT ASSEMBLY DRIVESHAFT

COUPLING SHAFT ASSEMBLY
(SLIP YOKE STYLE)

SHORT COUPLED DRIVESHAFT

COUPLING SHAFT ASSEMBLY
(END YOKE STYLE)

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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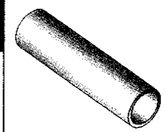
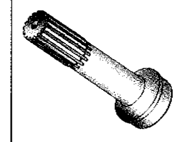
Bulletin J3211-2

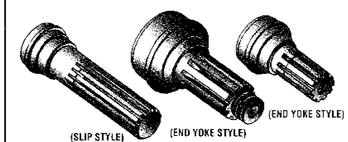
TUBING (30 or 32)



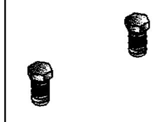
TUBE SHAFT (40-42)



MIDSHIP TUBE SHAFT (53-57)

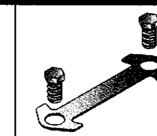


SERRATED BOLTS w/LOCK PATCH (73)



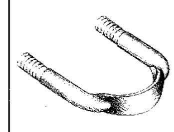
After Spring '94

LOCK STRAP (98)

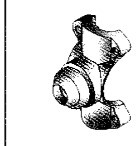


Pre-Spring '94

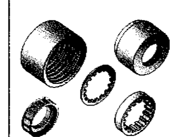
U-BOLT ASSEMBLY (94)



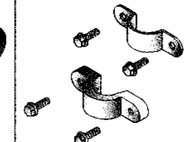
SOCKET YOKE (83)



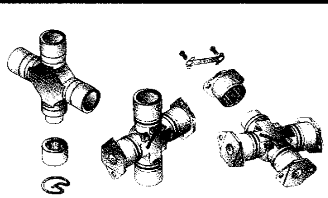
DUST CAP & WASHER KIT (VARIABLE PART NO.)



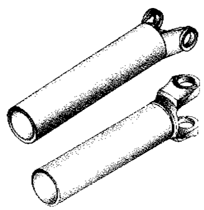
STRAP OR CAP & BOLT ASSEMBLY (70)



JOURNAL & BEARING KIT

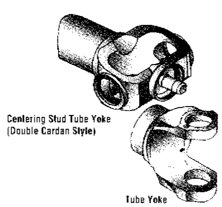


TUBE YOKE w/TUBE (27)

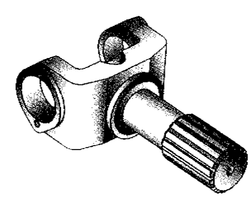


TUBE YOKE (28)

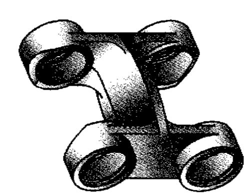
(2 STYLES)



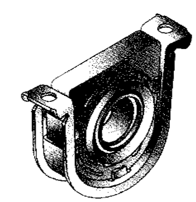
YOKE SHAFT (82)



CENTER YOKE (26)



SHAFT SUPPORT BEARING ASSEMBLY



SECTION 10: FRONT AXLE

CONTENTS

ILLUSTRATIONS

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.

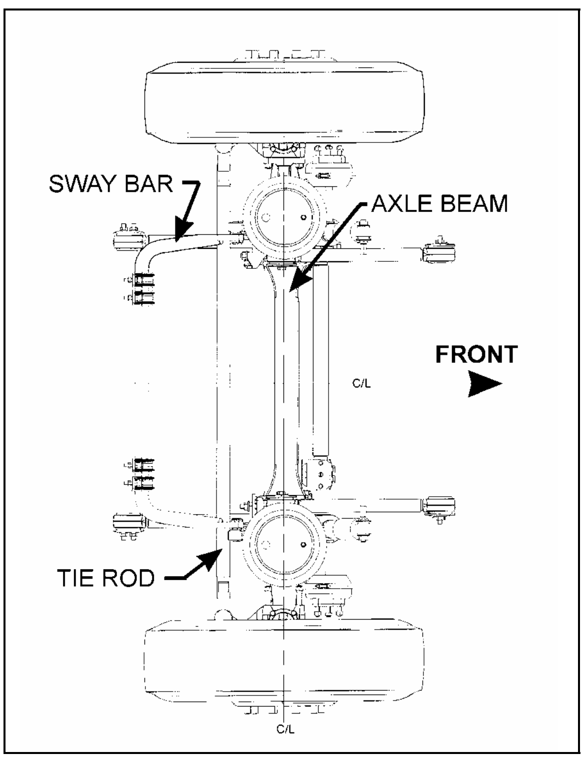


FIGURE 1: FRONT AXLE ASSEMBLY 10026

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.

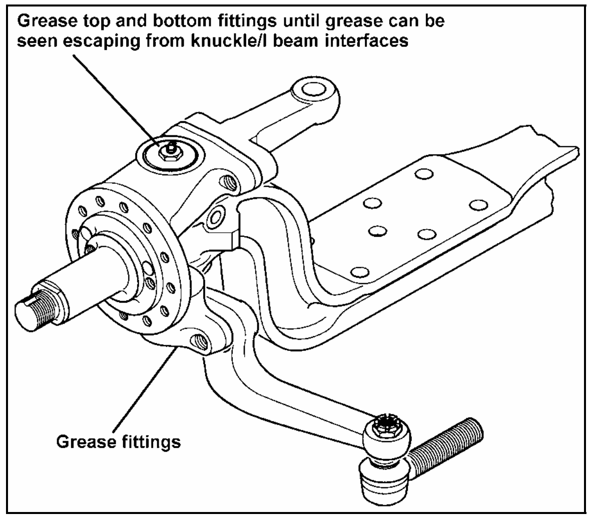


FIGURE 2: FRONT AXLE GREASING POINTS

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.

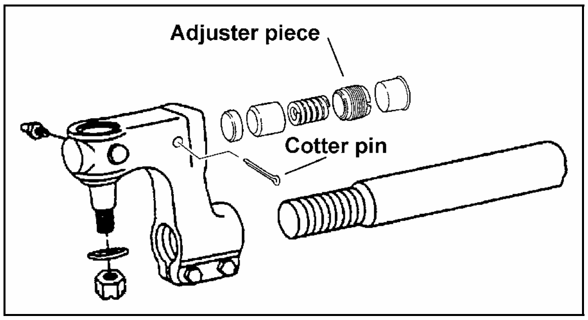


FIGURE 3: TIE ROD END PLAY ADJUSTMENT 10029

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.

⚠ WARNING ⚠

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.

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

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 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).

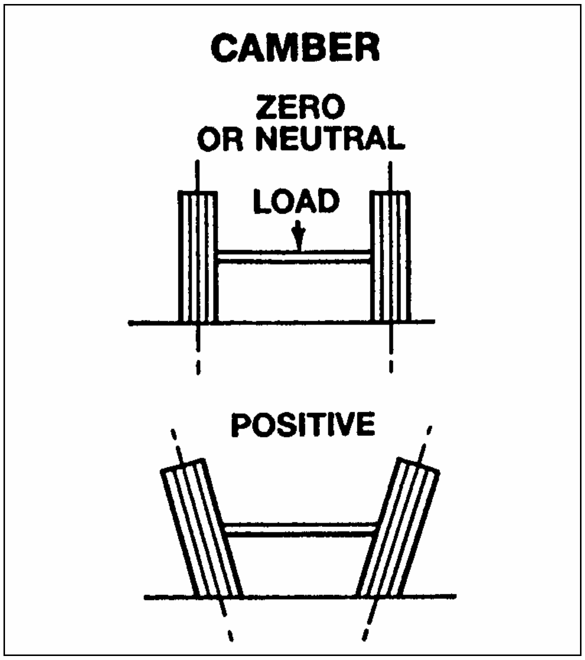


FIGURE 4: CAMBER 10006

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.

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.

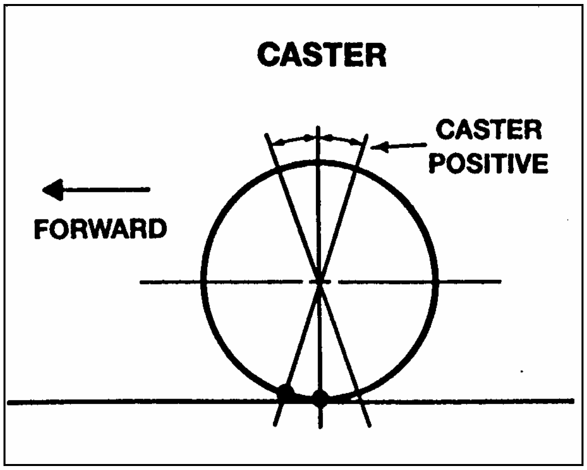


FIGURE 5: CASTER 10007

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 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.

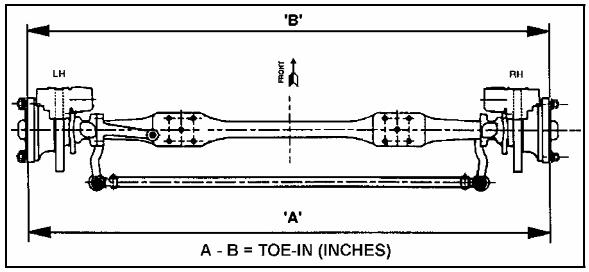


FIGURE 6: TOE-IN MEASUREMENTS

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.	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.	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.	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.	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.	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.	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.	1. Drag link fasteners tightened past specified torque. 2. Lack of lubrication or incorrect lubricant. 3. Power steering stops improperly adjusted.	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.	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.	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.	1. Caster not adjusted properly. 2. Wheels and/or tires out-of balance. 3. Worn steering stabilizer cylinder.	1. Adjust caster. 2. Balance or replace wheels and/or tires. 3. Replace steering stabilizer cylinder.

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

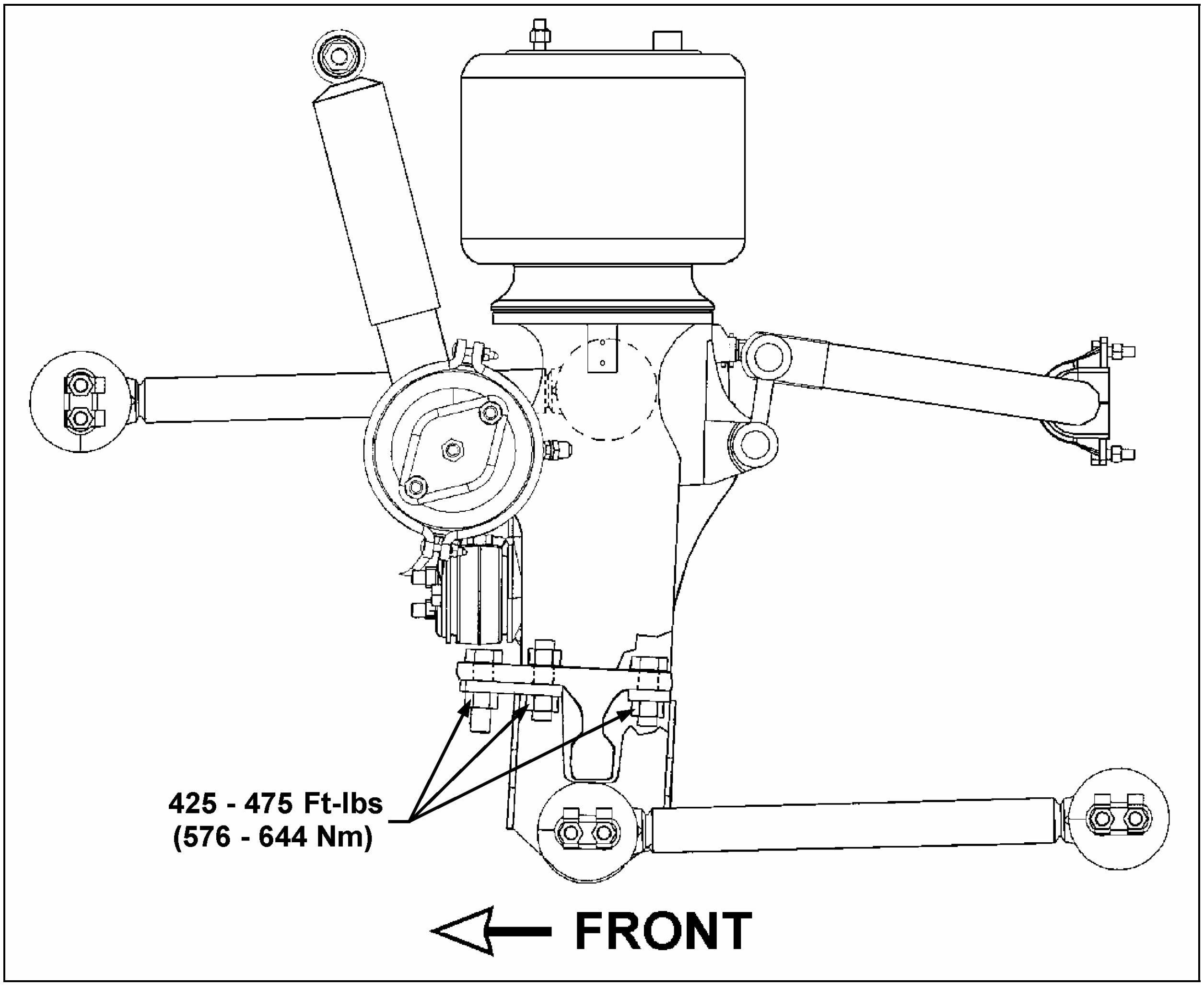


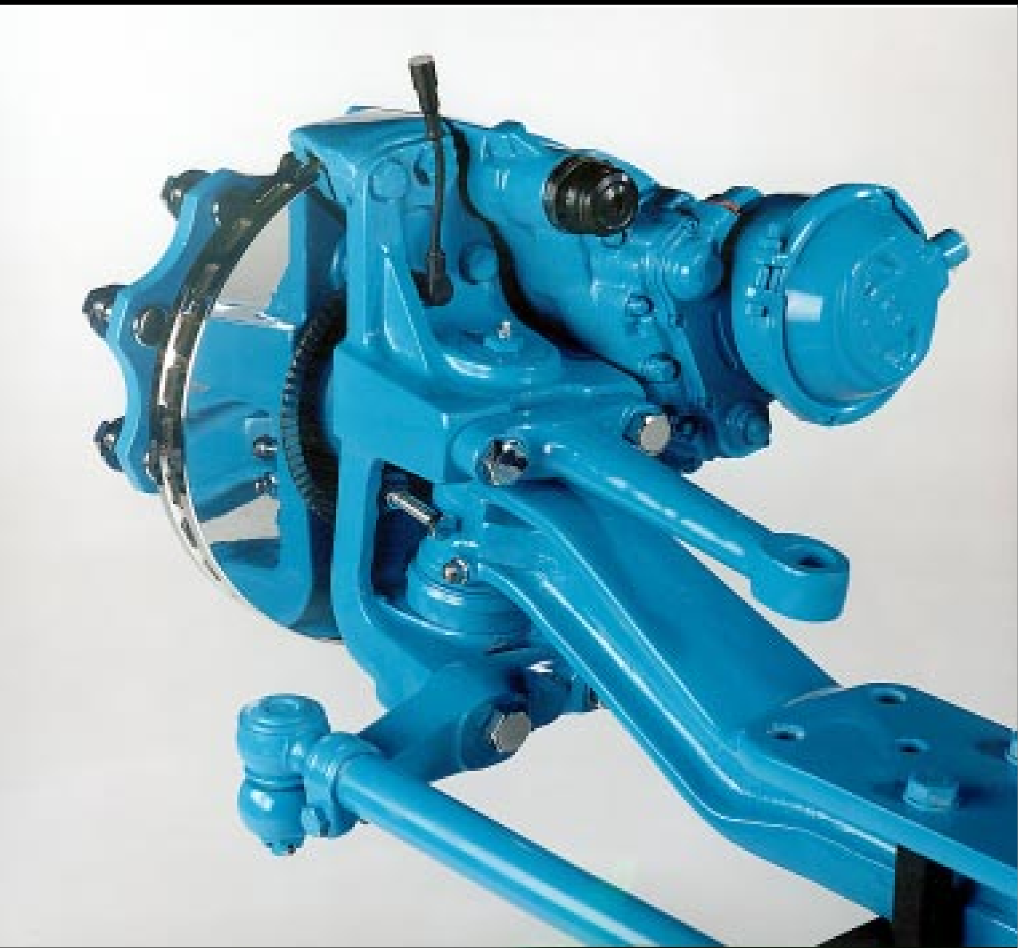
FIGURE 7: AIR BELLOWS MOUNTING SUPPORT AND AXLE 10030

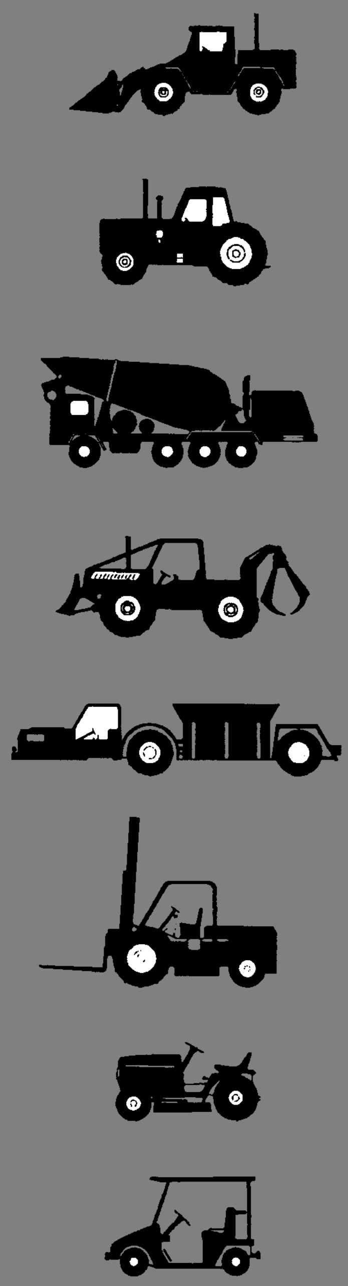
For more torque specifications, see 'Dana Spicer Maintenance Manual NDS Axles and Maintenance Manual Model NDS'' annexed at the end of this section.

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)	0.08	0.13	0.17

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

DANA

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 JEPORDISE 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
ABBEY 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 wordsrequire clarification; hence the following list:-

ENGLISH	U.S.A
SWIVEL	KNUCKLE
COTTER PIN	DRAW KEY
AXLE BED	I BEAM
STEERING LEVER	TIE ROD ARM
HUB NUT	SPINDLE NUT
SWIVEL STOP SCREW	STOP BOLT
TOP / BOTTOM CAP	KING PIN CAP
BUSHES	BUSHINGS
LUBRICATOR	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.

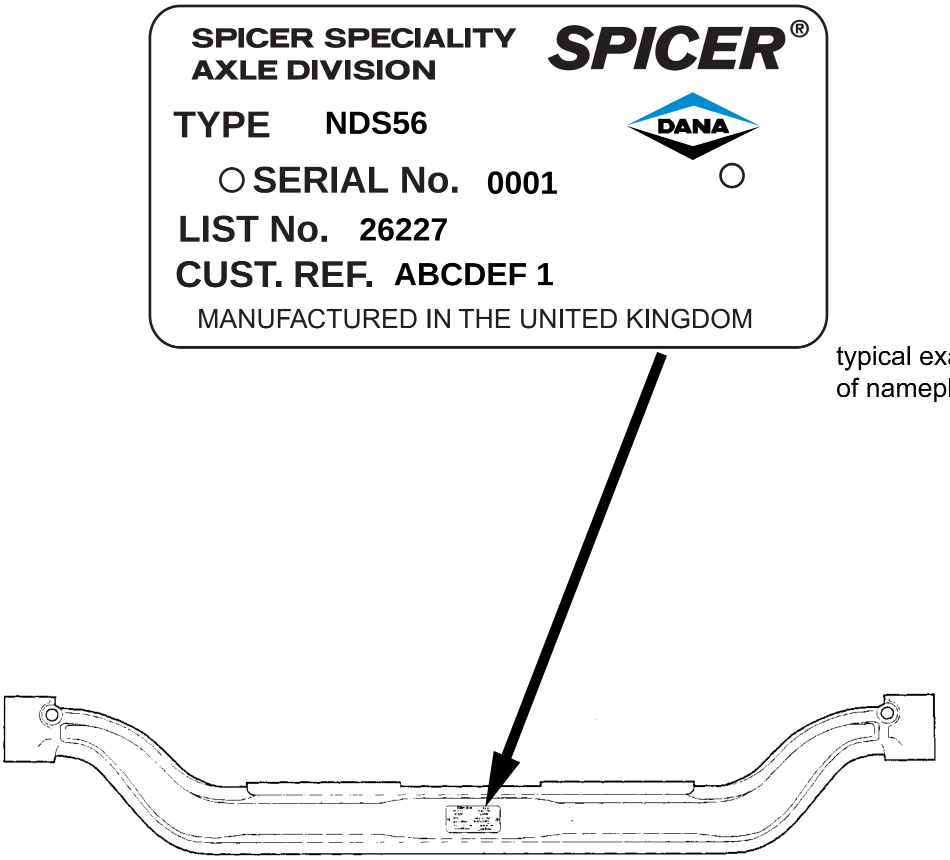
The items included in the spare parts section of this manual are currently available as service spare parts at the time of printing.
The part numbers and illustrations are provided specifically as a guide only.

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:-



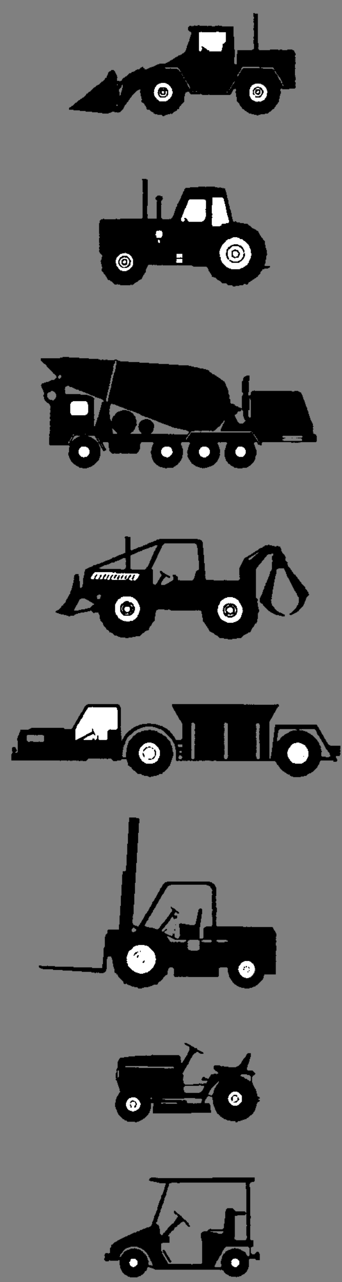
typical example
of nameplate

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
ABBEY 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

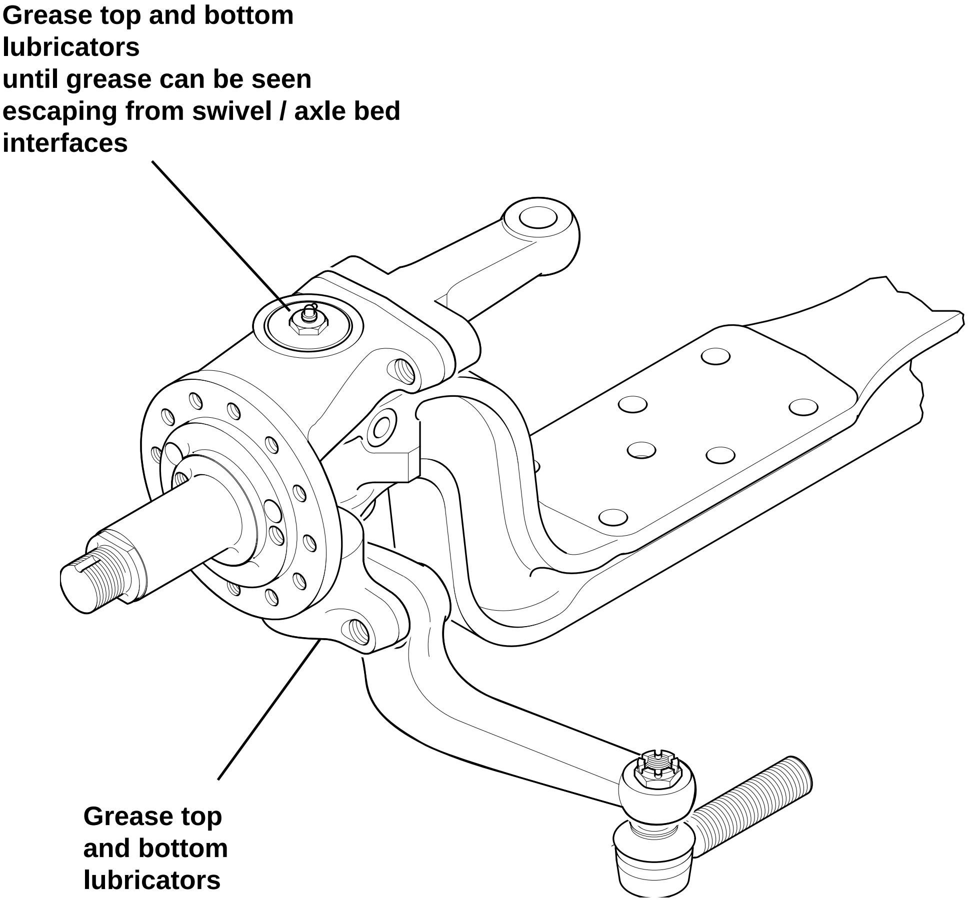
Page No.	Issue	Description / Alteration	Reason	Date
All	A	New Manual		Nov. 99
5	B	Mileage interval altered	Updated spec.	Mar.2000
9	B	Mileage interval altered	Updated spec.	Mar.2000
13	B	Tie rod torques added	New tie rod	Mar.2000
14	B	Tie rod torques added	New tie rod	Mar.2000
15	B	Air cylinder torques 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.



Greasing points
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 '

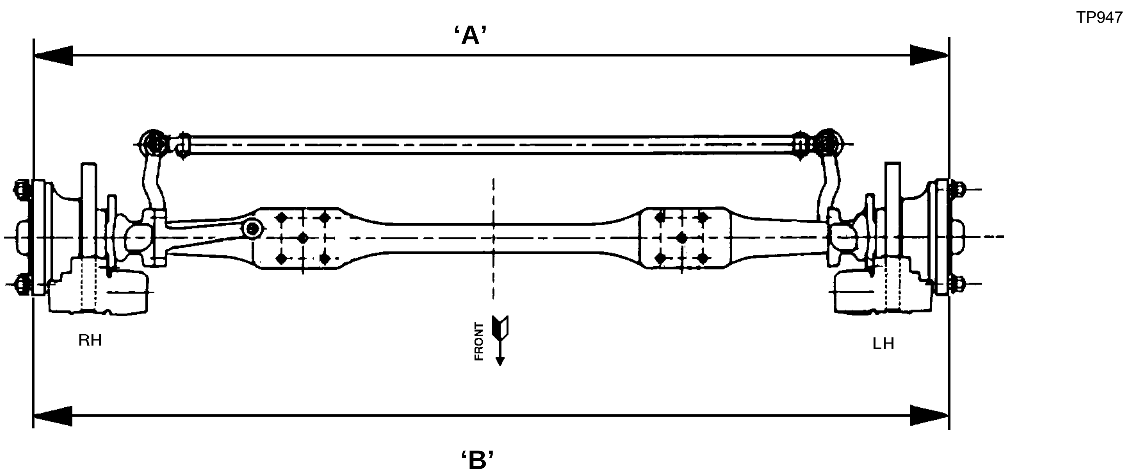
a) To preserve correct steering and avoid excessive tyre wear, tracking (or alignment) of front wheels should be checked periodically, as follows :-
Set front wheels in straight ahead position and at points level with wheel centre, measure distance over hubs / wheel rims, both in front and behind axle 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.



Measure dimensions 'A' and 'B' over hubs / wheel rims on horizontal centre line.
To give correct alignment ; dimension 'A' should be 0.0" to 0.04" (0 to1mm) greater than dimension 'B'.

Fig. No.2

2.3 Check condition of brake pads as described in relevant brake manufacturers service manual.

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).

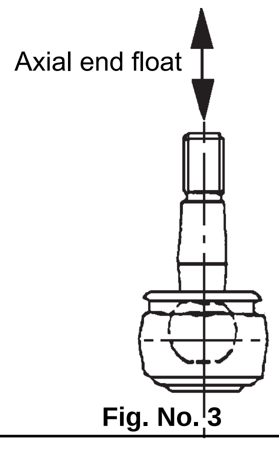


Fig. No. 3

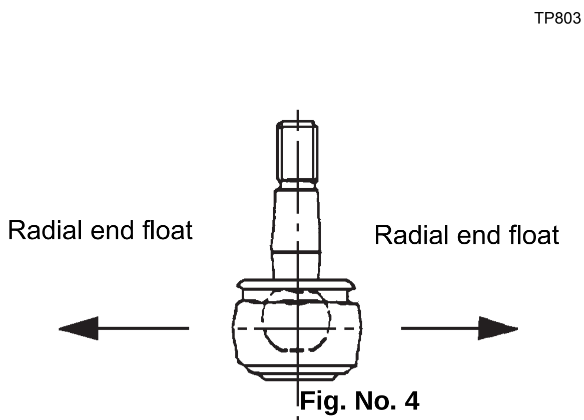


Fig. No. 4

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.

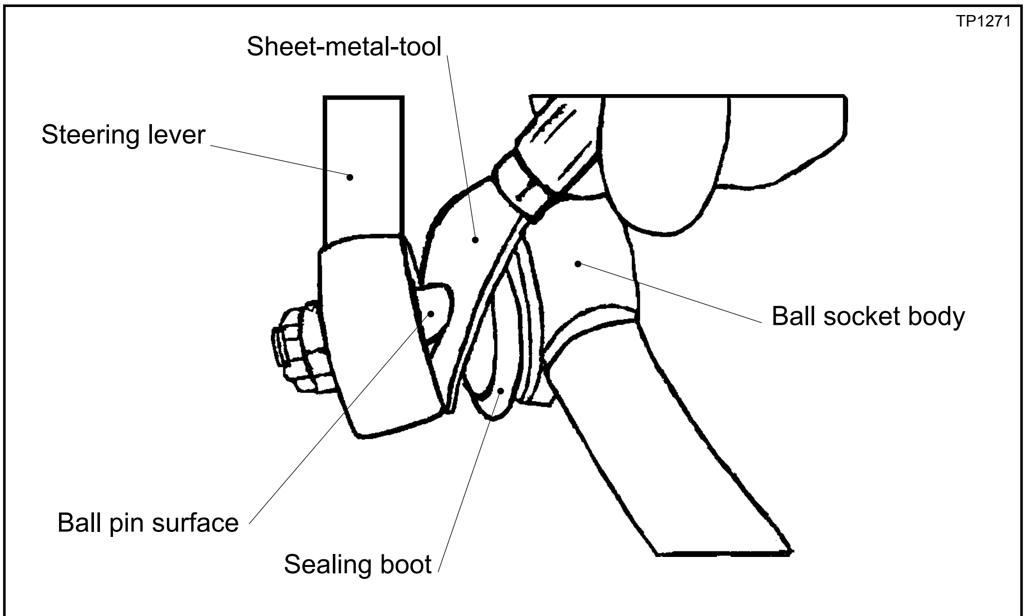


Fig. No. 5

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.

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 occured, 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 occuring.

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 continualy 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.

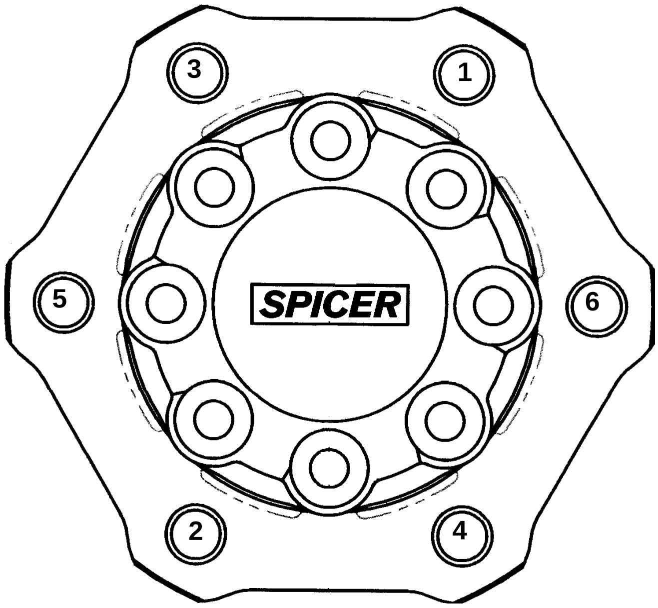
NOTE :-
FURTHER DETAILS ARE GIVEN IN BRITISH STANDARD CODE OF PRACTICE FOR THE SELECTION AND CARE OF TYRES AND WHEELS FOR COMMERCIAL VEHICLES:- BSAU50 : PART2 : SECTION 7A : 1995

3.2 PROTECTION OF SPIGOT WHEEL FIXING DIAMETERS AND PRESSURE SURFACES.

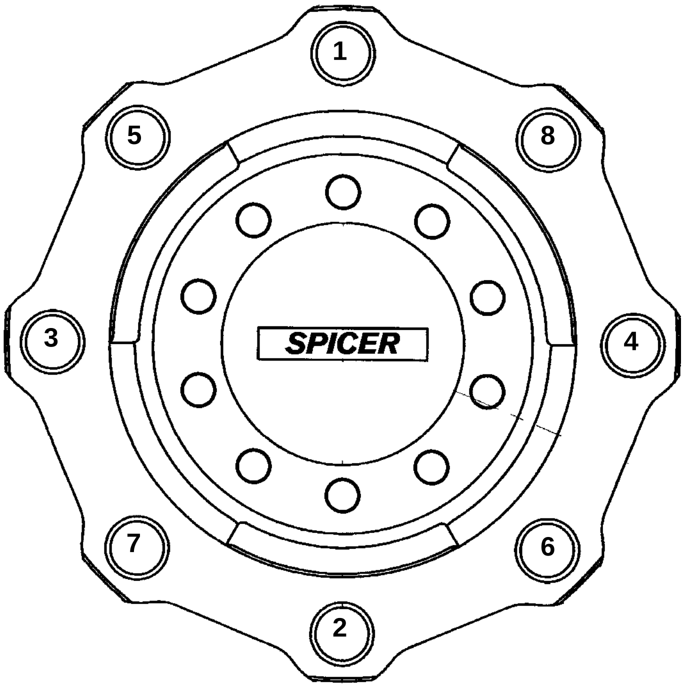
Although **Spicer Speciality Axles Division** apply an initial surface coating to wheel rim mating faces on spigot to stop rusting and facilitate easy removal of wheels. The application of P.B.C. grease such as 'Rocol Tufgear' or equivalent to wheel register is recommended.

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.

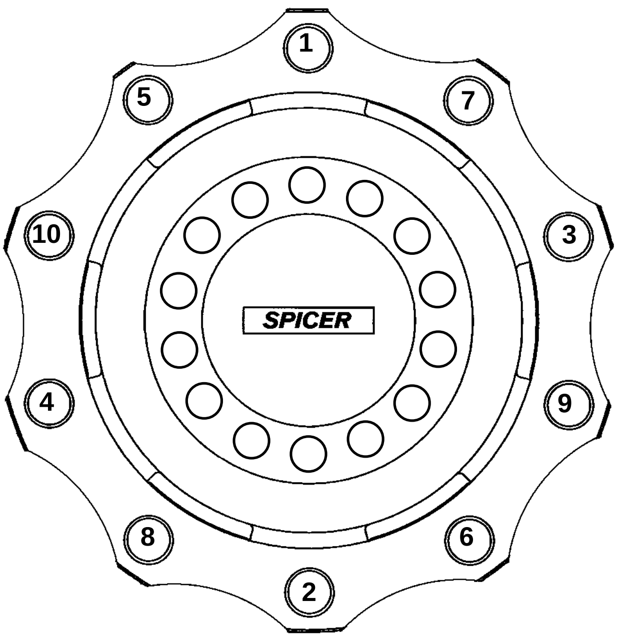
WHEELNUT TIGHTENING
TORQUE SEQUENCE
6 - STUD FIXING



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

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.

TP1627

Fig. 9

You should inspect for the following:-

- Heat checking
- Cracks
- Grooves - scoring
- Blue marks - Banding
- Polished discs

<u>Heat checking</u> can be light or heavy,

If **<u>light heat checking</u>** type cracks (fine and light) are found as shown in Fig.10 the disc can continue to be used.

If **<u>heavy heat checking</u>** type cracks (deep and wide) are found the disc **<u>must be replaced.</u>**

TP1628

Fig. 10

<u>Cracks</u> can be of 2 types **<u>Radial or Through.</u>**

If any **<u>radial</u>** cracks are found in the brake disc surface as shown in fig. 11. then the disc **<u>must be replaced.</u>**.

TP1629

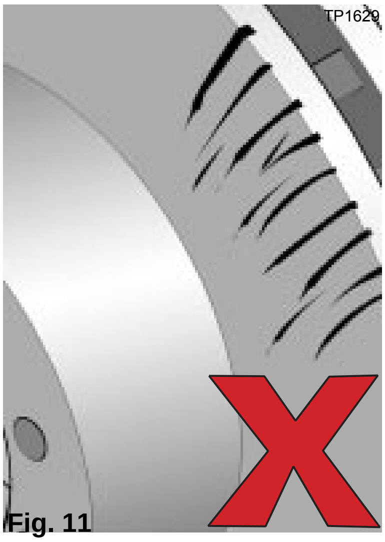


Fig. 11

If any **<u>Through</u>** cracks are found in the brake disc as shown in fig. 12. then the disc **<u>must be replaced.</u>**.

TP1630

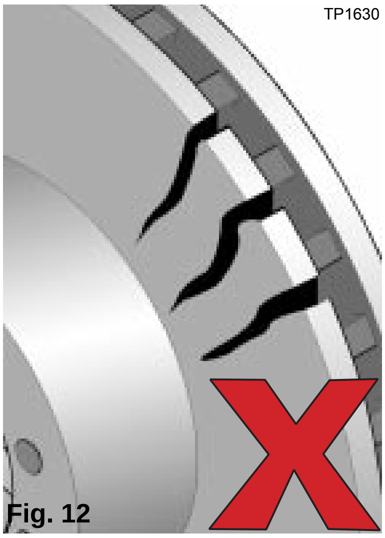


Fig. 12

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.

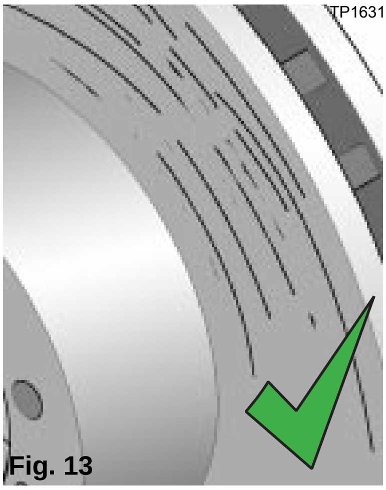


Fig. 13

If **Heavy** grooving is found as shown in Fig. 14 then the disc must be replaced.

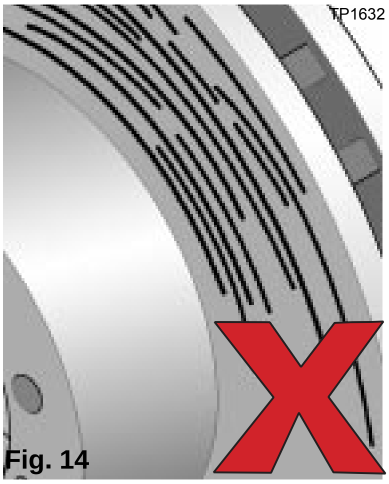


Fig. 14

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.

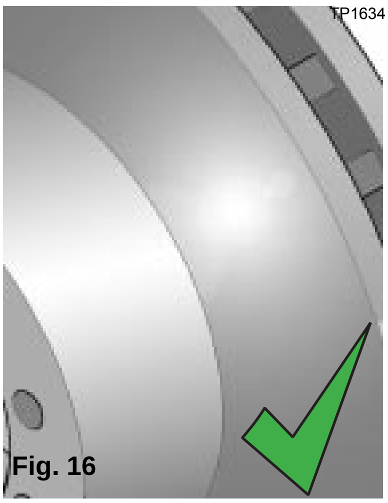
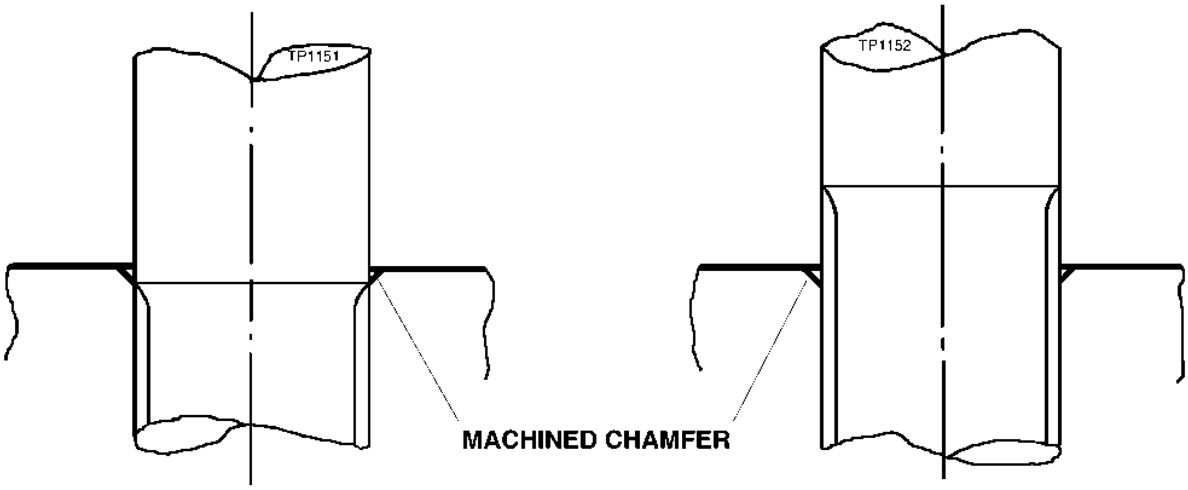


Fig. 16

SPICER SPECIALITY AXLE DIVISION

STANDARD STUDS - FITTED INTO MACHINED CHAMFERED HOLES

STUDS TO BE INSERTED UNTIL THREAD RUN-OUT LOCKS INTO PARENT METAL

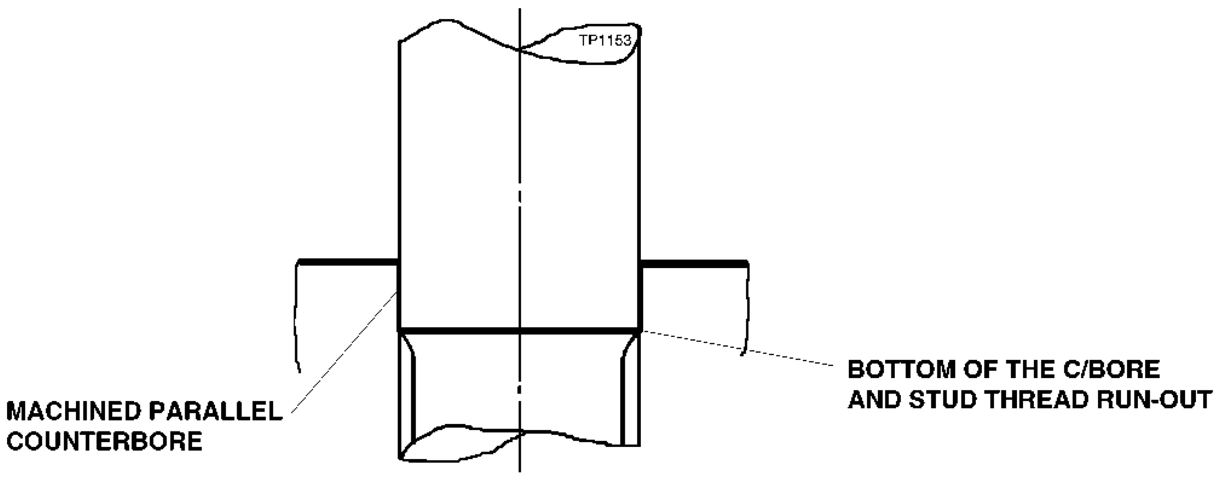


CORRECT   INCORRECT

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									

DISTRIBUTION Front Axle B.U. Drive Axle B. U. Production	STUD FITTING PROCEDURES	TD183/1 SHT 1 OF 1

SWIVEL / AXLE BED TIGHTENING TORQUES

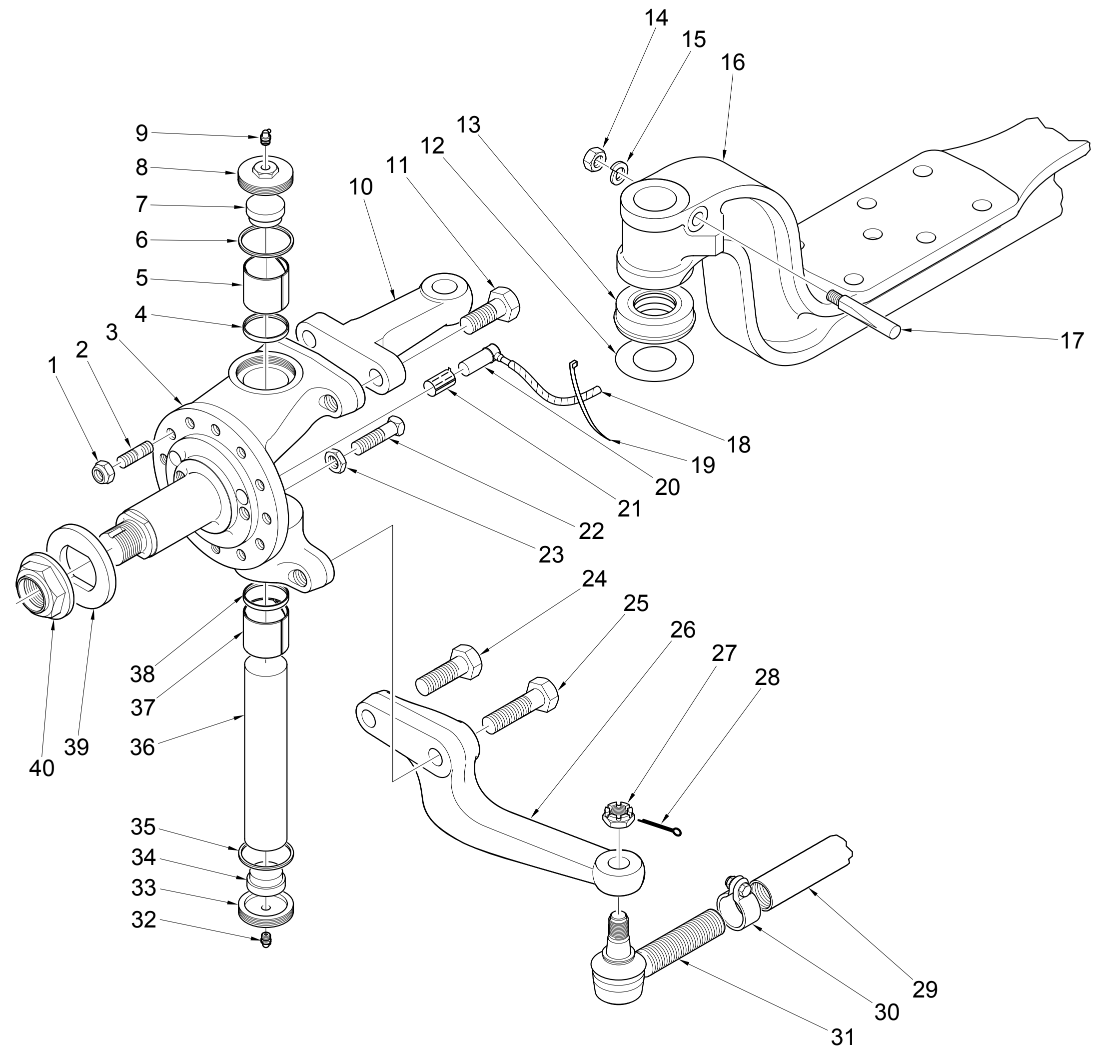


Fig.No.17

PART Nº	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

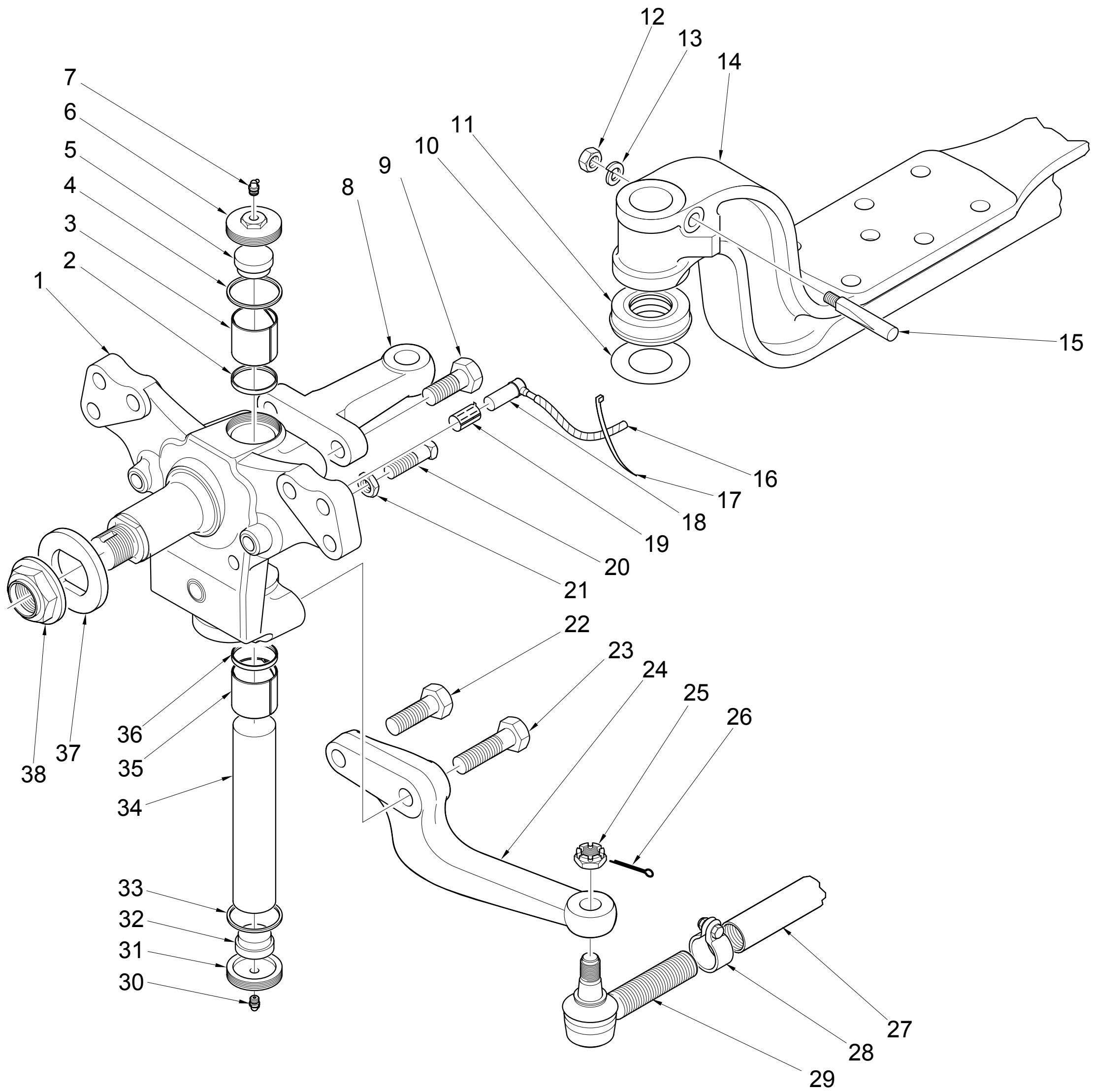


Fig.No.18

PART Nº	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

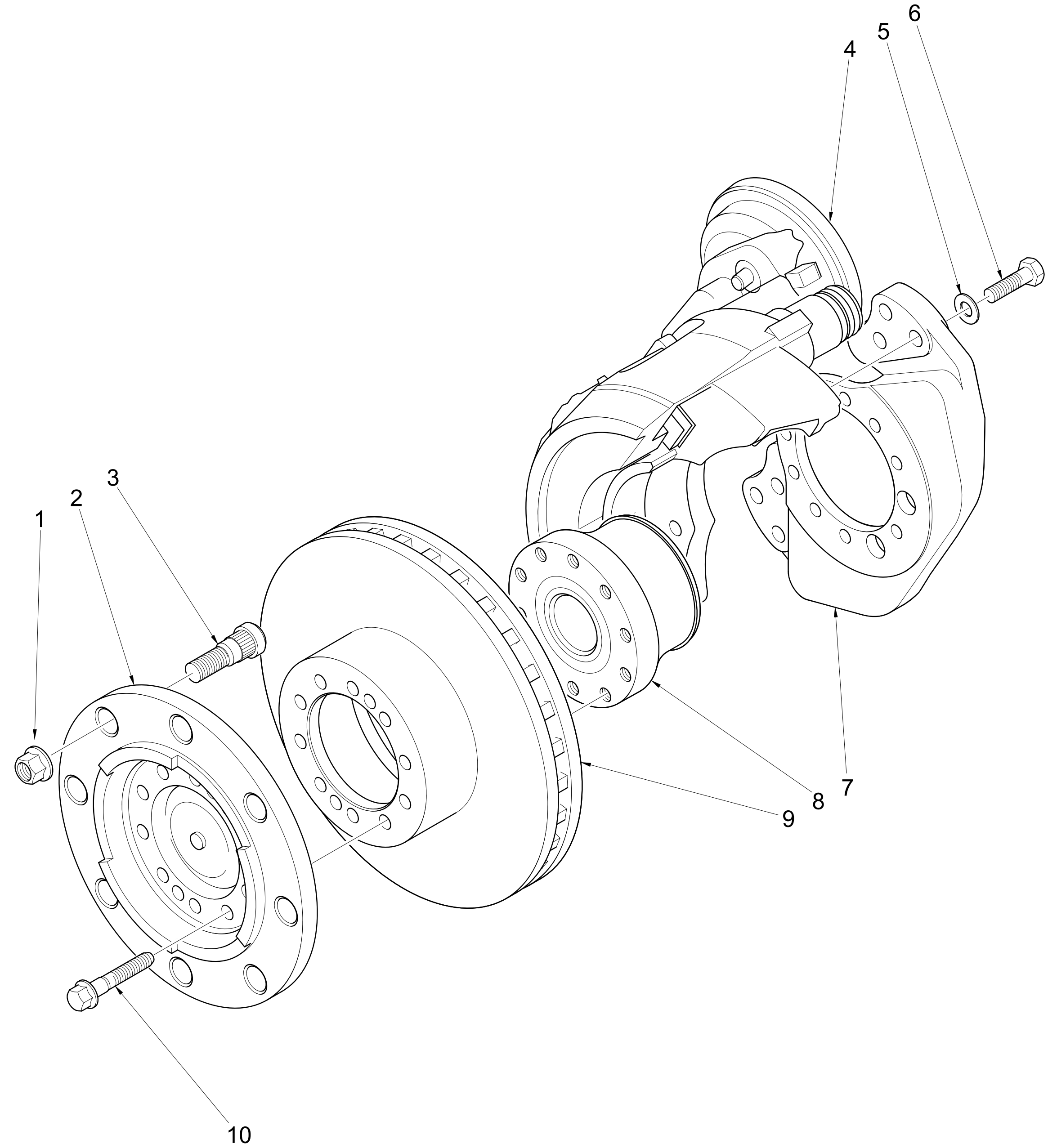


Fig.No.19

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

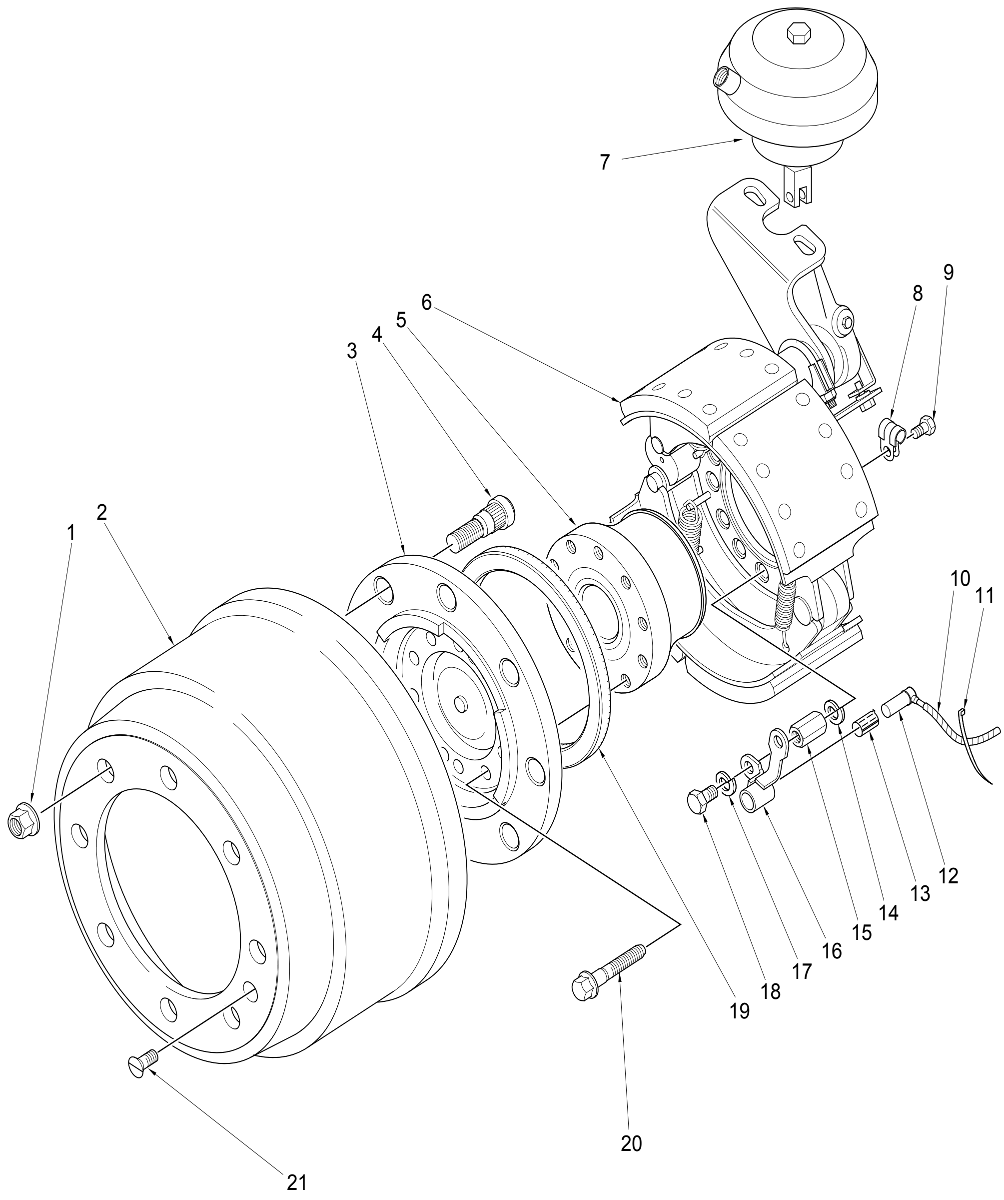


Fig.No.20

PART Nº	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

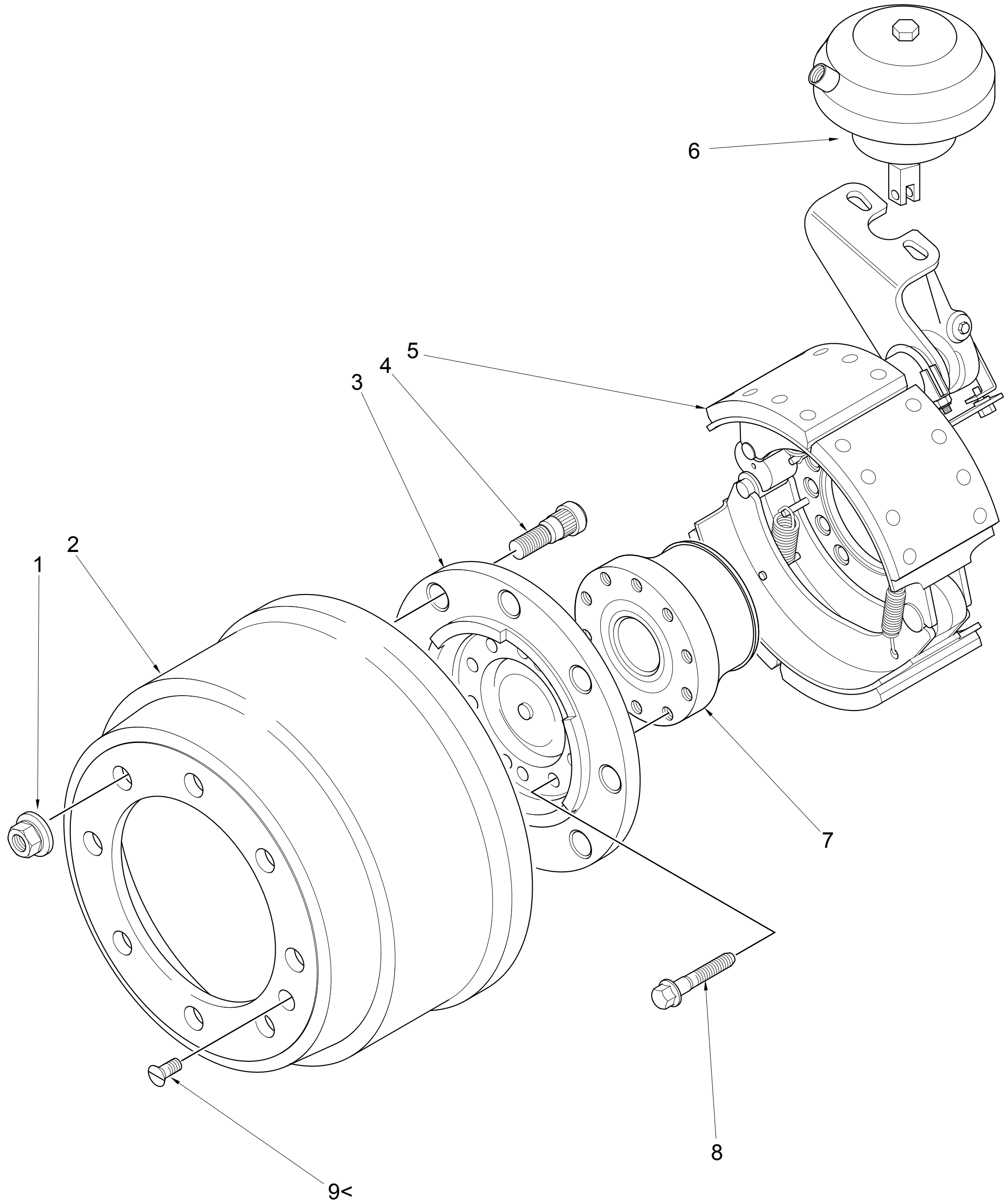


Fig.No.21

PART N^{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
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

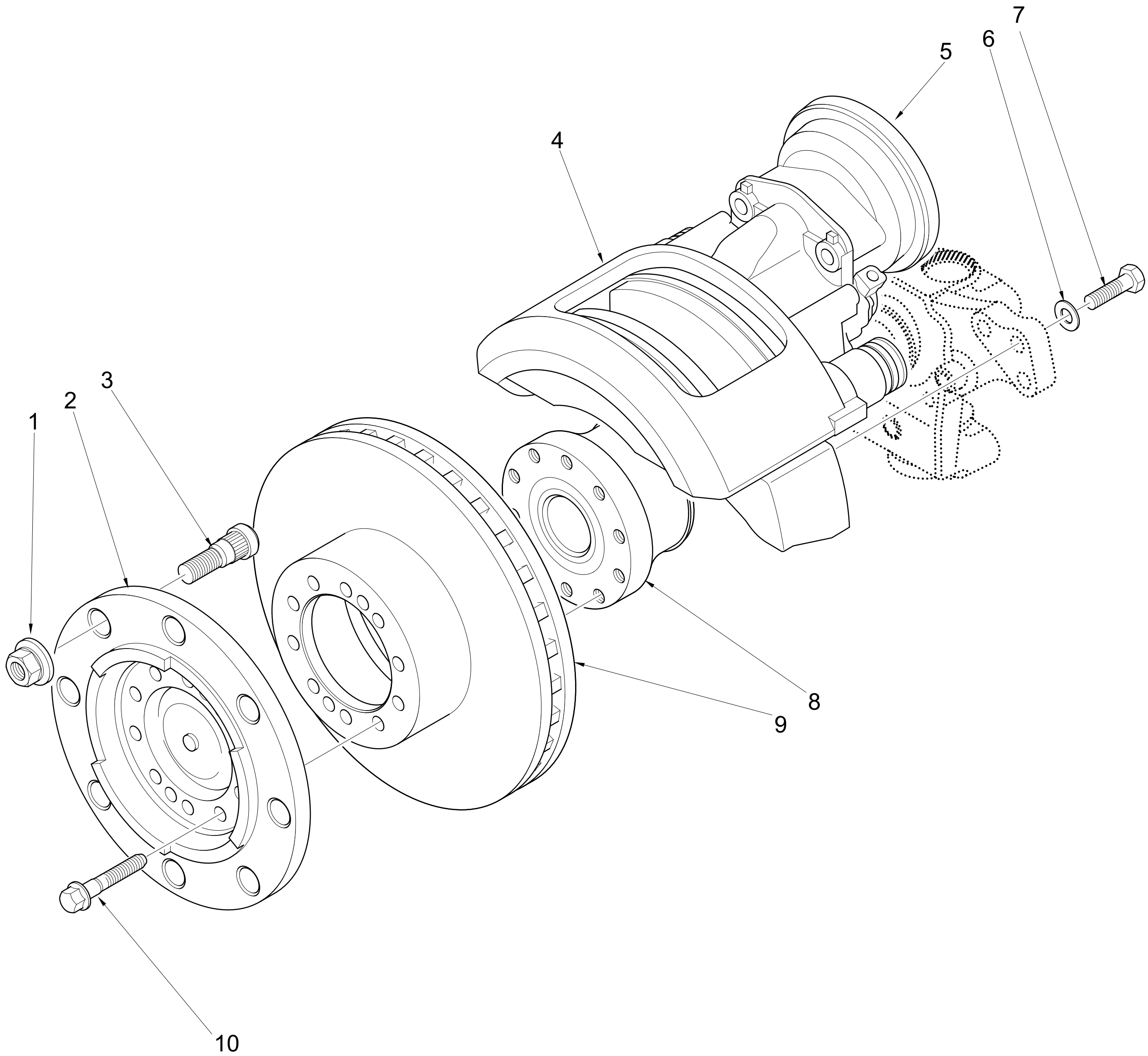


Fig.No.22

PART N°	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

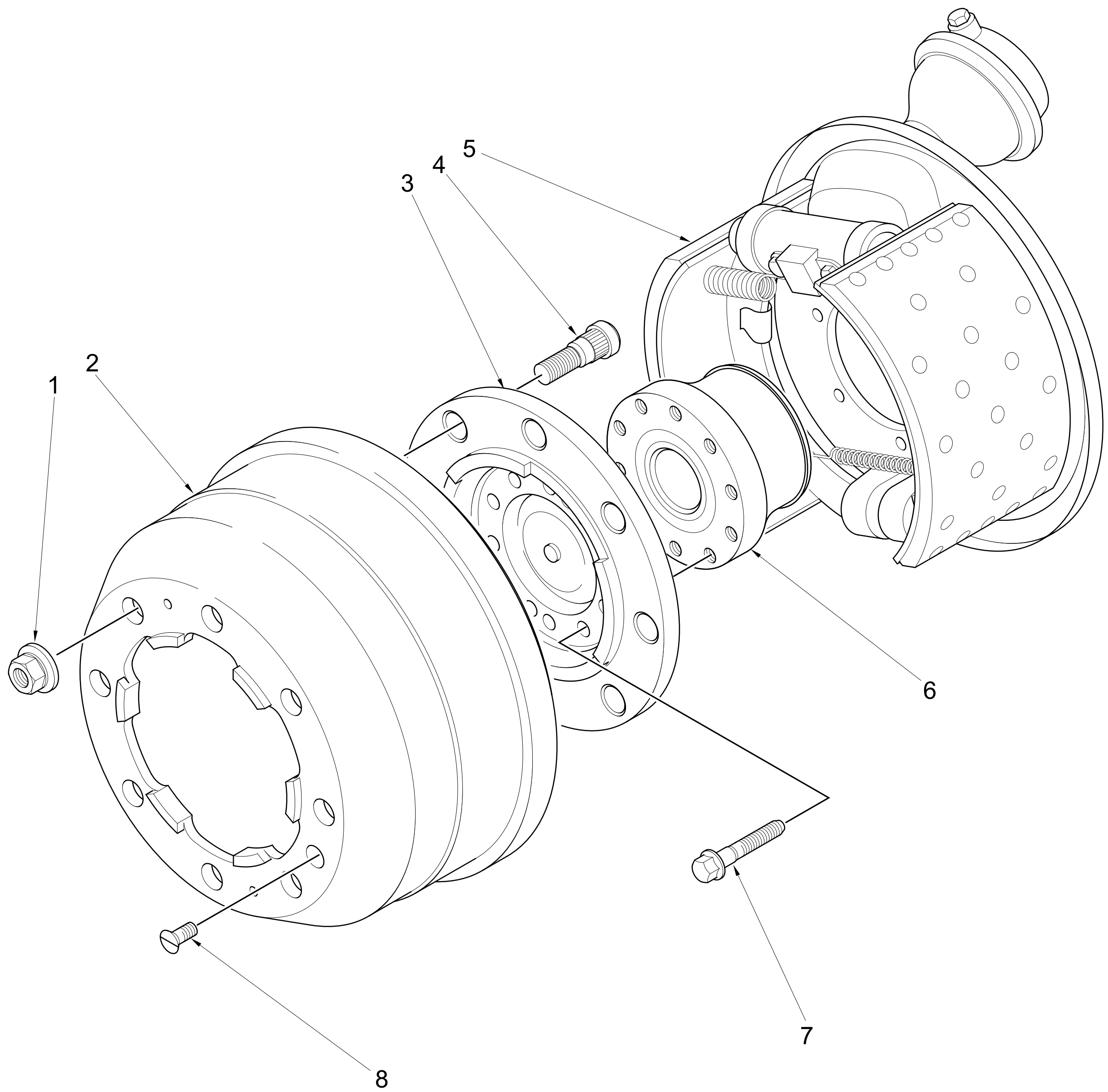


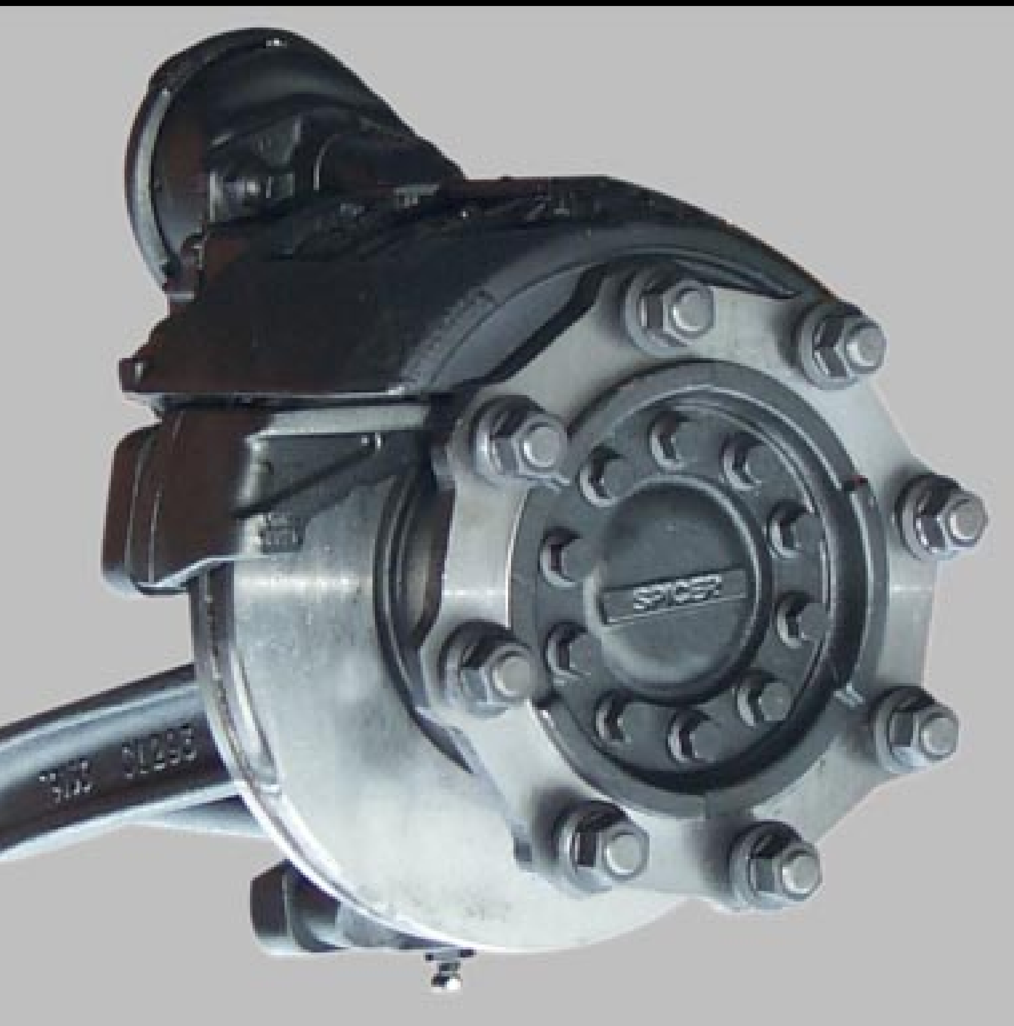
Fig.No.23

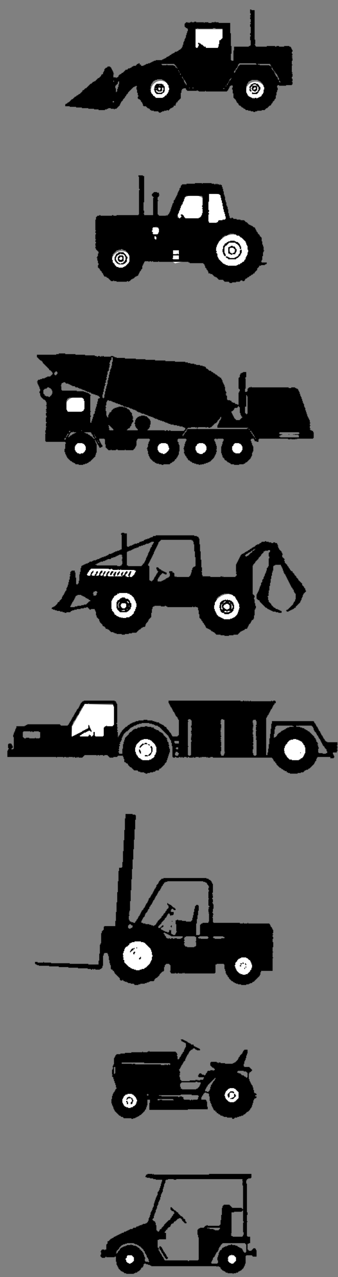
PART N^{O}	DESCRIPTION	TIGHTENING TORQUE	
1	Wheel nut M18 x 1.5	235 - 260 lbs.ft	318 - 352NM
	Wheel nut M20 x 1.5	285 - 315 lbs.ft	386 - 427NM
	Wheel nut M22 x 1.5	475 - 525 lbs.ft	644 - 712NM
7	Hub flange retaining bolt M14 x 1.5	174 - 192 lbs.ft	236 - 260NM
8	Brake drum retaining screw	26 - 32 lbs.ft	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	A	New Manual		Mar.2000
11	B	Page added all subsequent pages re numbered	Brake disc checking added	Oct.2000
7	C	Optimol Paste Added	To prevent fretting ECN 8695	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.

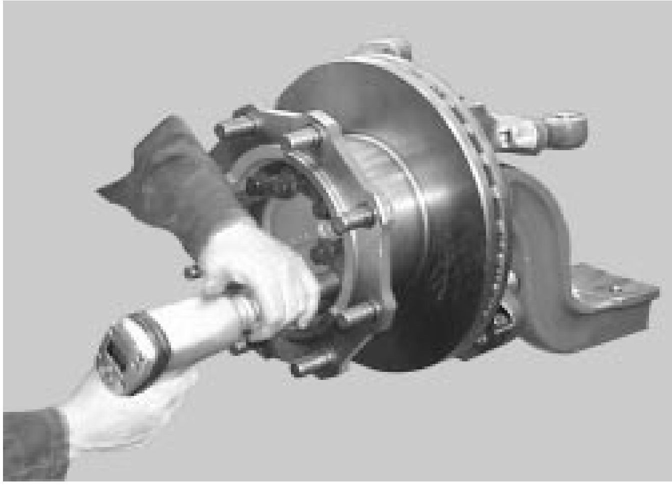
NOTE:-
BRAKE CALIPERS ARE HANDED!
SPICER SPECIALITY AXLE DIVISION RECOMMENDS MARKING CALIPERS WITH PAINT OR MARKER PEN TO FACILITATE CORRECT REFITTING

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

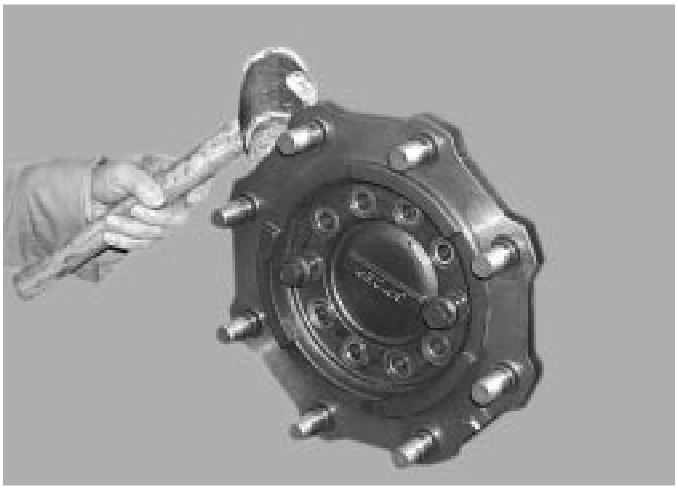


5. Loosen but do not remove hub flange bolts.

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

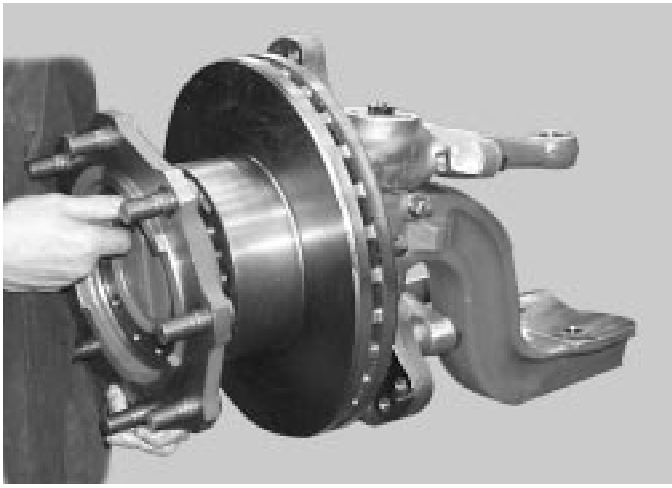


8. Gently tap hub flange outwards using a hide faced hammer.

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

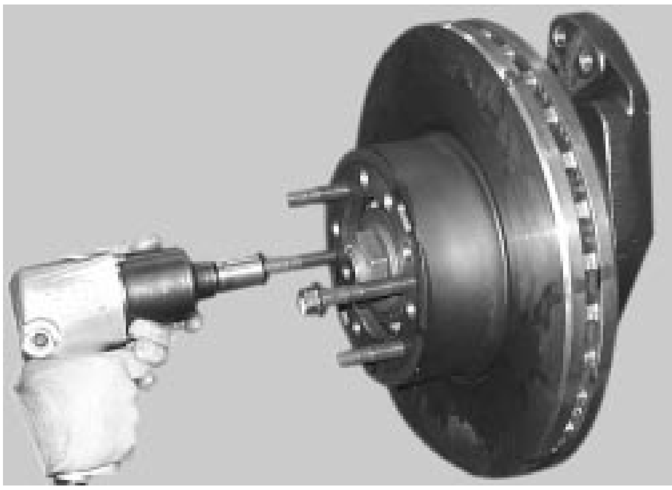
HUB END DISASSEMBLY

12. Once hub flange has been removed, insert two bolts into brake disc extraction holes

13. Tighten to free brake disc from hub bearing.

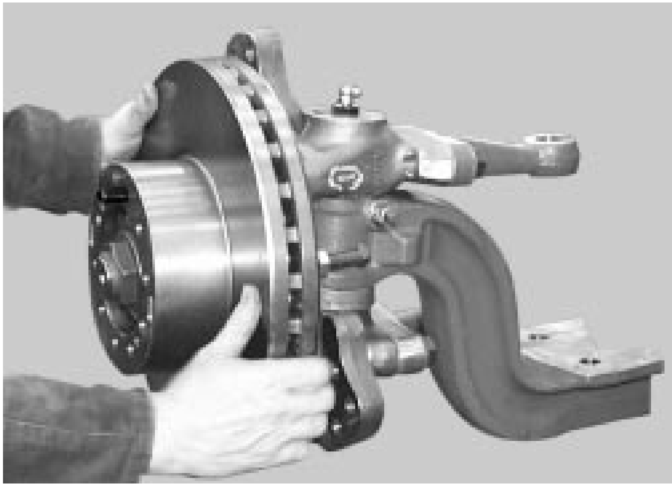
14. Support weight of brake disc and carefully slide along dummy studs to remove.

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:

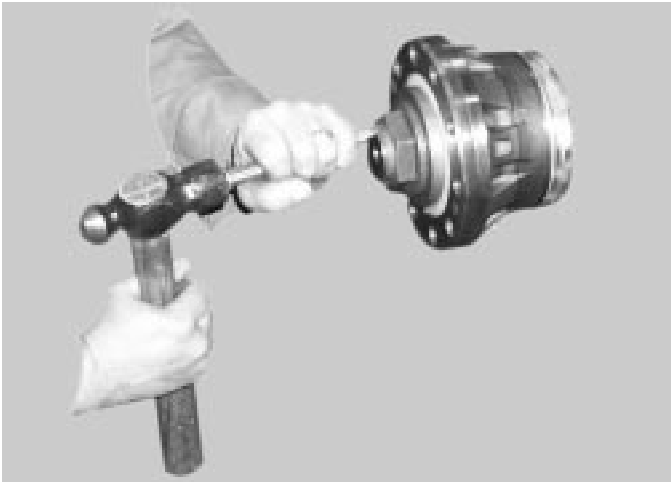
WARNING!
DO NOT ALLOW BRAKE DISC TO WEAR BELOW MINIMUM THICKNESS!



Brake disc type	Original thickness	Minimum thickness
SB5000	34MM	28MM
SB6000	45MM	37MM
SB7000	45MM	37MM

OVERHAUL PROCEDURES

HUB END DISASSEMBLY



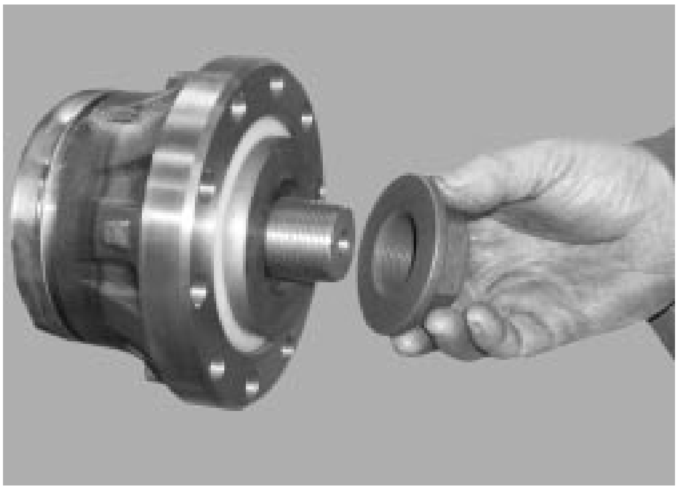
16. Using a small ended chisel, pry off the "staking" on the hub nut.

17. Remove hub nut and discard.

18. Remove bearing thrust washer.

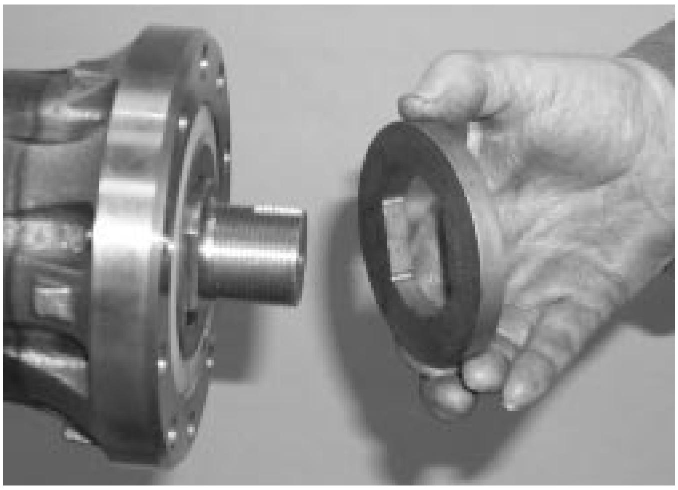
19. Fit bearing guide sleeve onto swivel thread. (See chart at front of swivel assembly)

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

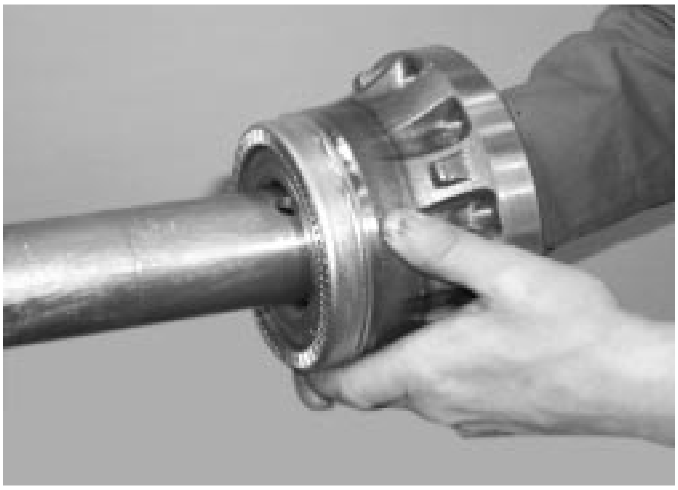
HUB END REASSEMBLY

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.

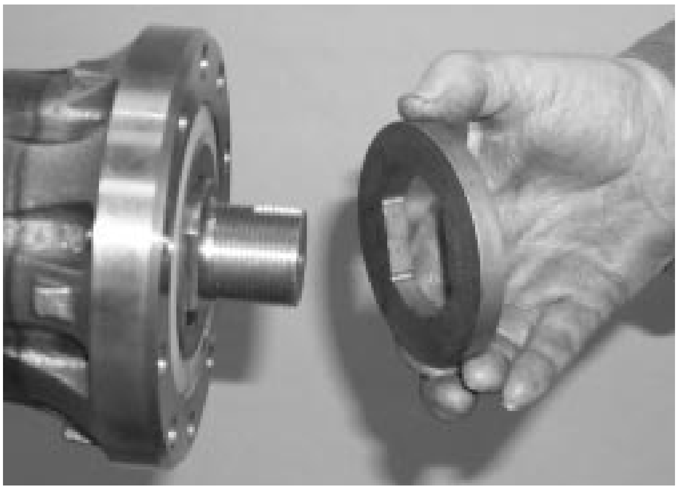
4. Offer new unitised bearing onto swivel stub.



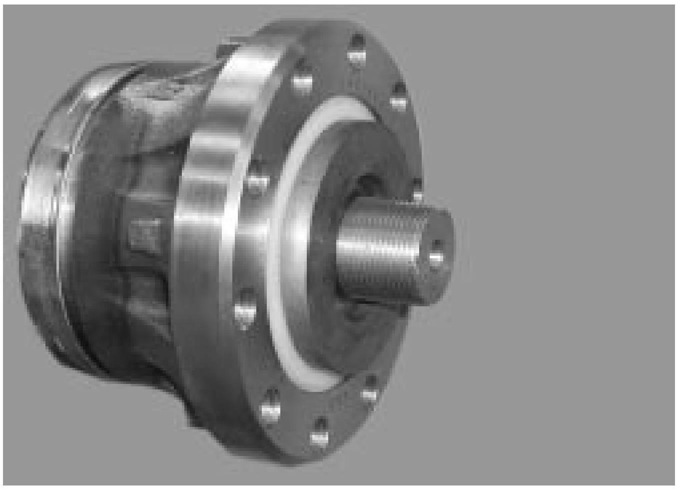
OVERHAUL PROCEDURES

HUB END REASSEMBLY CONTINUED

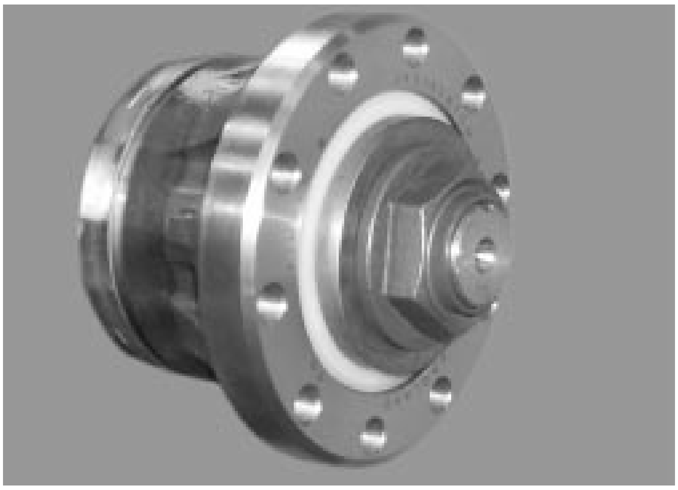
5. Place unitised hub bearing thrust washer onto axle stub.



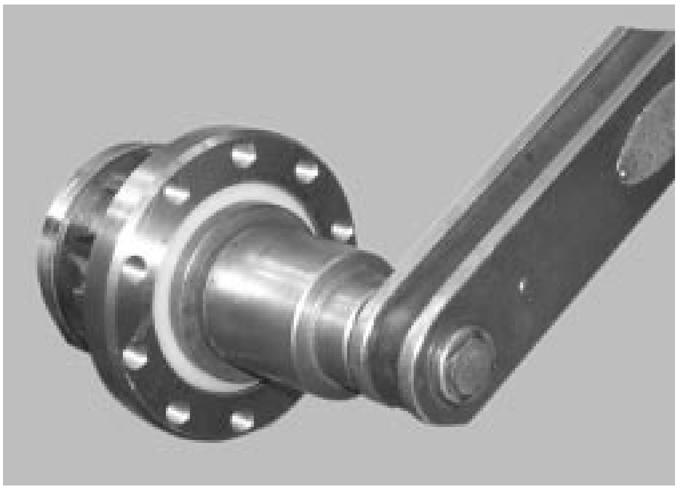
6. Fit hub nut.



7. Tighten to specified torque.

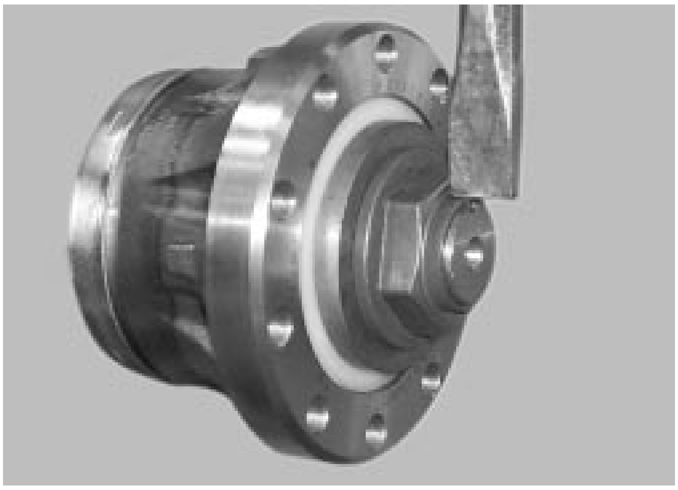


NOTE:-
ROTATE UNITISED HUB BEARING WHILST TIGHTENING.



OVERHAUL PROCEDURES

HUB END REASSEMBLY CONTINUED

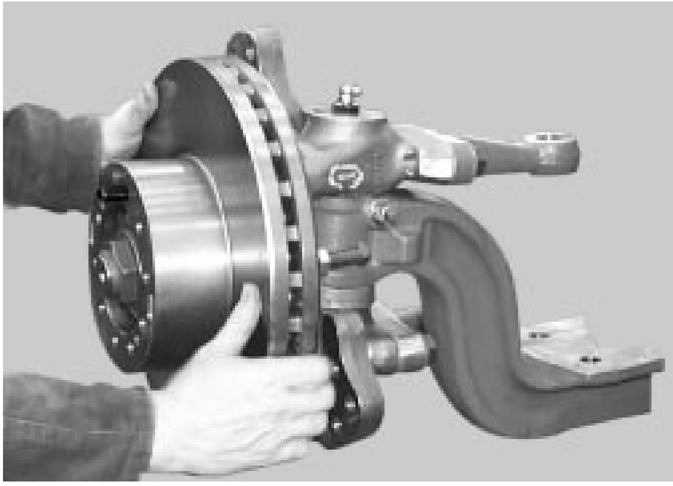


8. Stake the hub nut by deforming with a round nosed chisel.

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.)

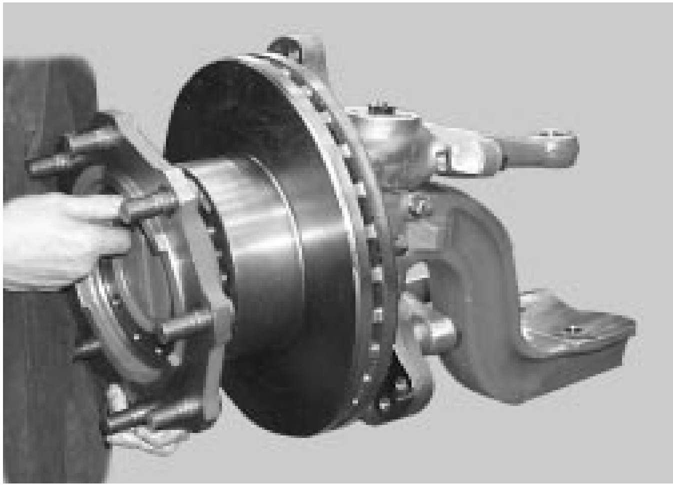
11. Remove the modified hub flange bolt at this point.



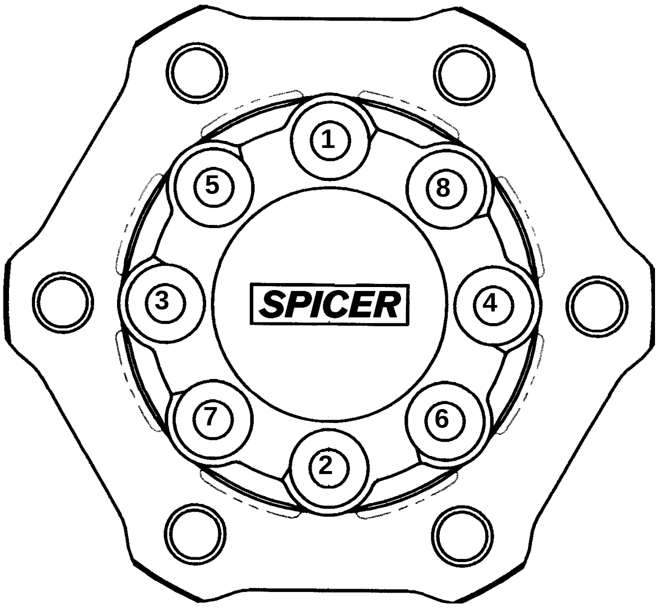
12. Carefully offer hub flange up to
brake disc / unitised hub bearing assembly and hold in position by inserting 1 - off hub flange bolt and tightening hand tight.

13. Insert remainder of hub flange bolts.

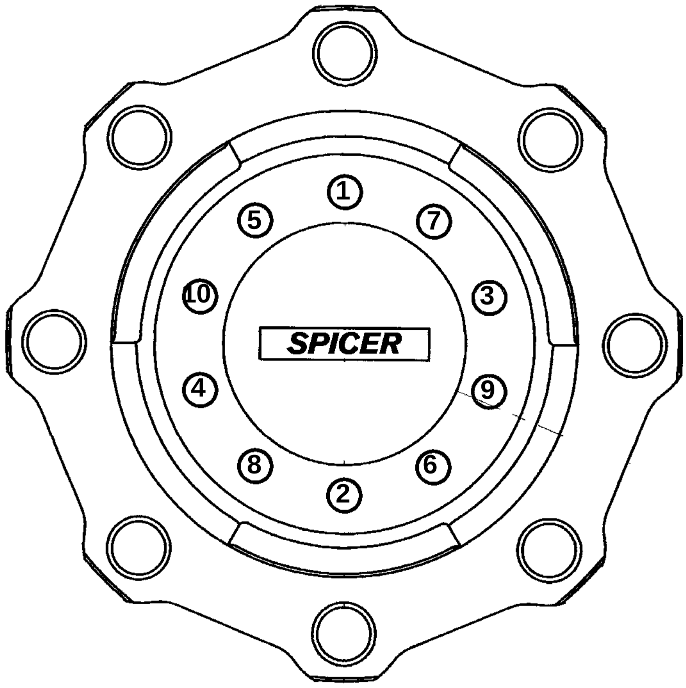
14. Tighten to correct torque using selection procedure as shown on following page.



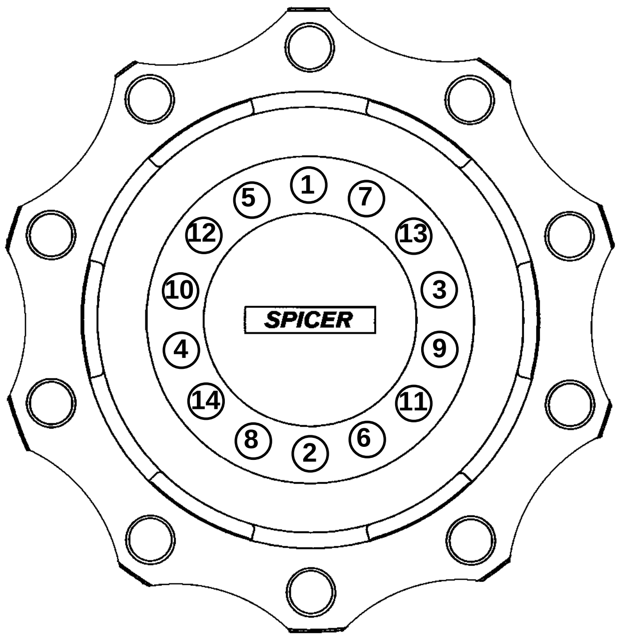
HUB FLANGE BOLT
TIGHTENING TORQUE SEQUENCE
FOR 8 BOLT FIXING



HUB FLANGE BOLT
TIGHTENING TORQUE SEQUENCE
FOR 10 BOLT FIXING

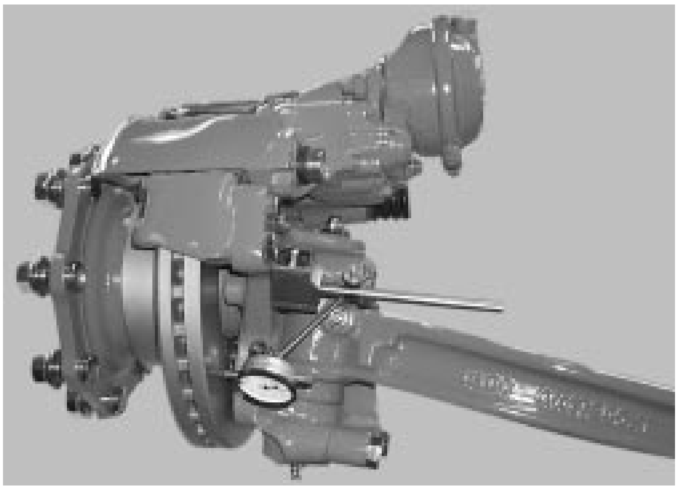


HUB FLANGE BOLT
TIGHTENING TORQUE SEQUENCE
FOR 14 BOLT FIXING



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 occured to the mounting faces, or that no dirt is present.

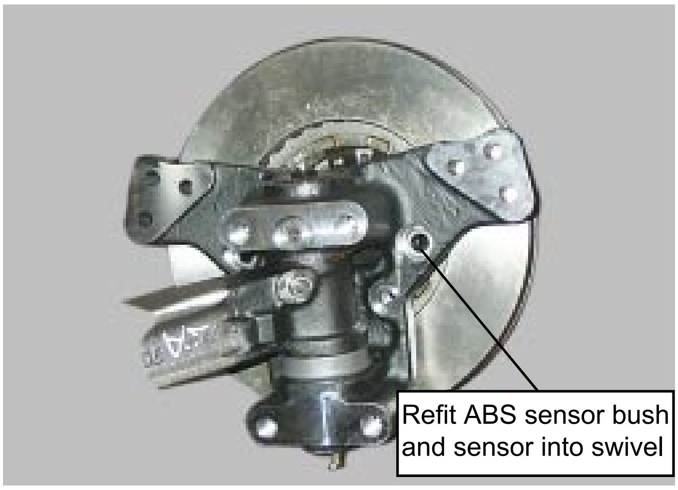
21. Remove any dirt found on the mounting faces and refit and re check disc.

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.

HUB END REASSEMBLY CONTINUED

26. Check A.B.S. sensor performance as follows :-

<u>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.</u>

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 ;

$$\boxed{RPM = \frac{60Hz}{z} \times 60 \text{ secs}}$$

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.

$$\boxed{\frac{Vmax}{Vmin} \leq 1.8}$$

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.

$$\boxed{\frac{Vmax}{Vmin} > 1.8}$$

e) The minimum reading must be greater than the voltage threshold (Vt) ie.

$$\boxed{Vmin. > Vt} \qquad \boxed{Vt. = 60mV}$$

If this is not the case, then the sendsor 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.

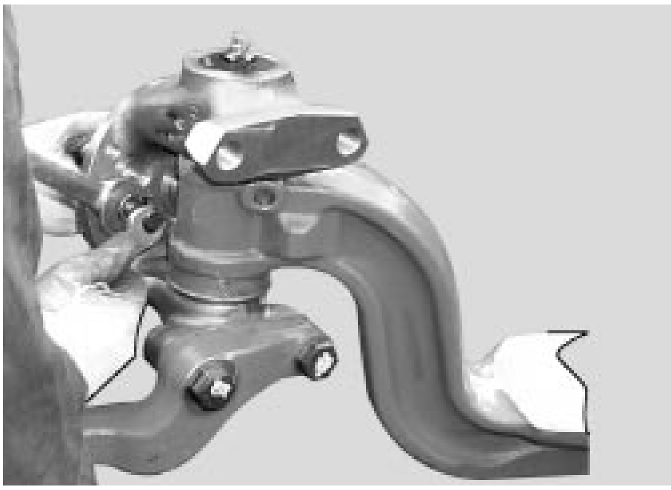
b) At a point level with wheel centre, measure distance over hubs / wheel rims, both in front and behind axle centre.

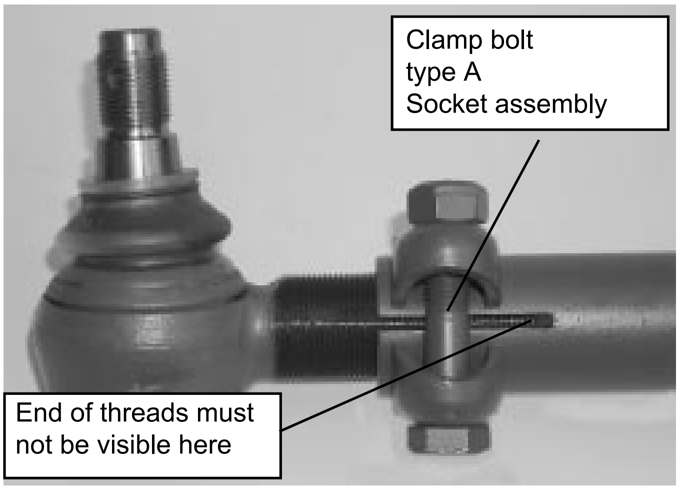
c) Front measurement ‘B’ should be 0.0" to 0.04" (0.0 to 1mm) **LESS** than rear measurement ‘A’.

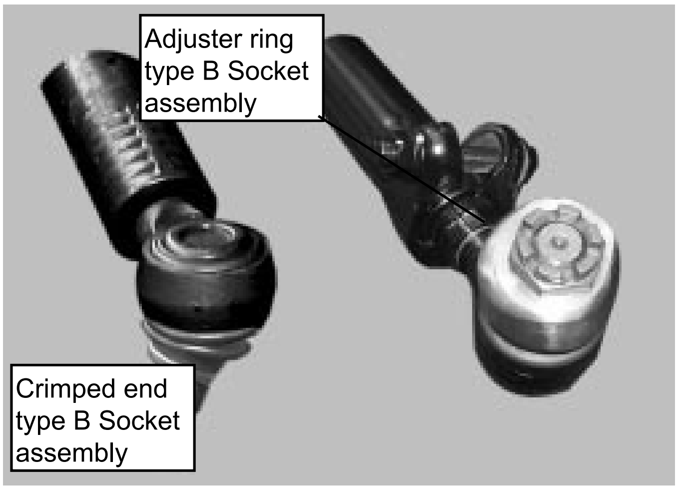
d) Any adjustment on type A socket and tie rod assemblies can be effected by slackening clamp bolts in ball sockets and rotating track rod tube.
For type B socket and tie rod assemblies, slacken the clamped end of the assembly and use the adjuster ring.

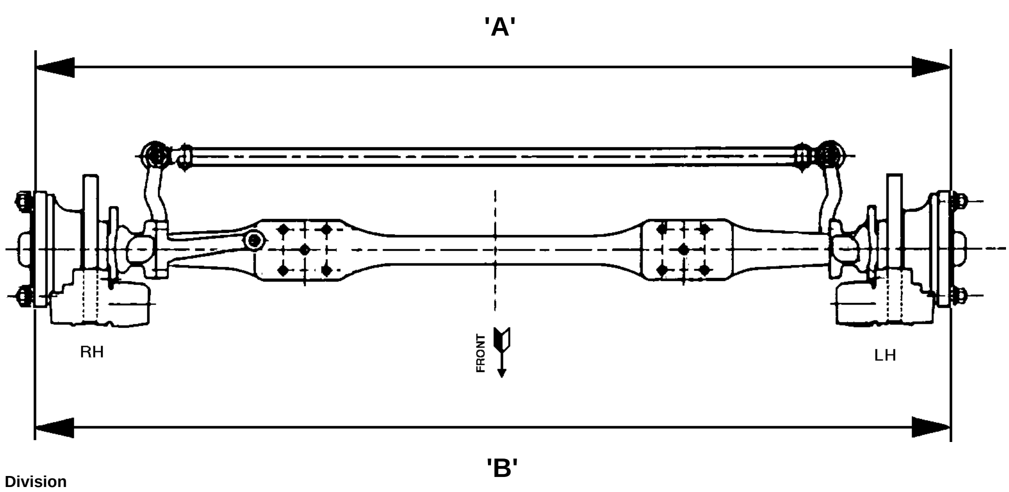
e) After adjustment, tighten clamp bolts to specified torque.

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









HUB END REASSEMBLY CONTINUED

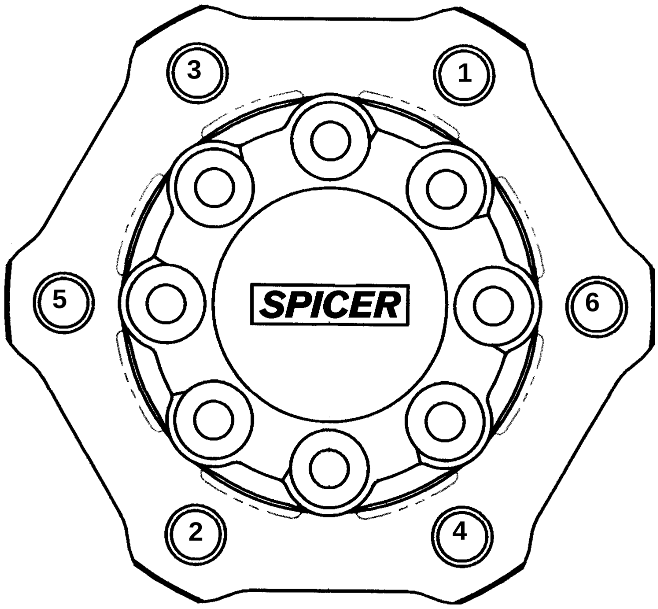
37. Re-connect brake to vehicle hydraulic system as recommended in brake manufacturer's manual.

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.

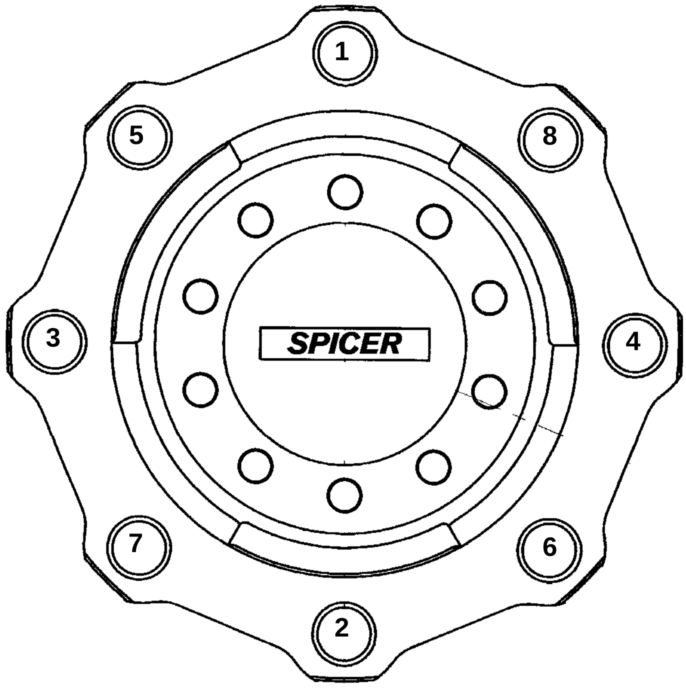
NOTE:-
INTERFACES MUST BE FREE FROM DIRT, INCLUDING BRAKE LINER MATERIAL DEBRIS, RUST AND PAINT. FAILURE TO KEEP INTERFACES CLEAN <u>CAN AND WILL</u> CAUSE WHEEL RIM TO DISTORT UPON TIGHTENING OF WHEEL NUTS
FOR FURTHER DETAILS SEE BS AU50 : part 2 : section 7A : 1995

39. Remove axle supports and lower vehicle to ground.

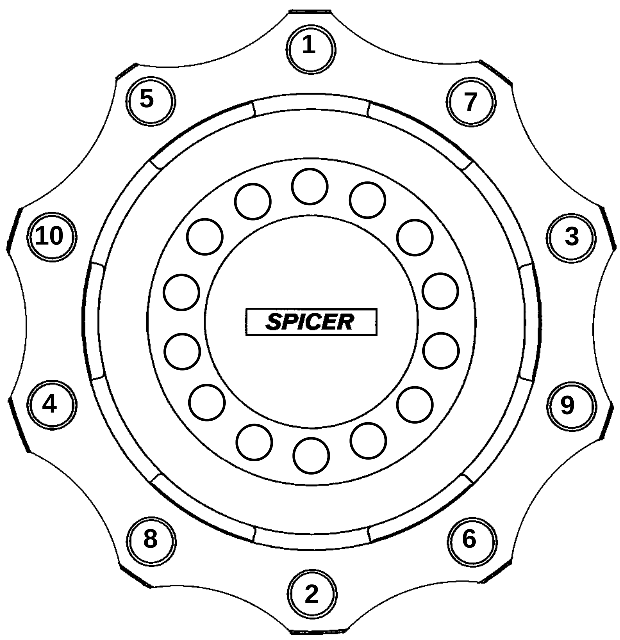
WHEELNUT TIGHTENING
TORQUE SEQUENCE
FOR 6 STUD FIXING



WHEELNUT TIGHTENING
TORQUE SEQUENCE
FOR 8 STUD FIXING



WHEELNUT TIGHTENING
TORQUE SEQUENCE
FOR 10 STUD FIXING

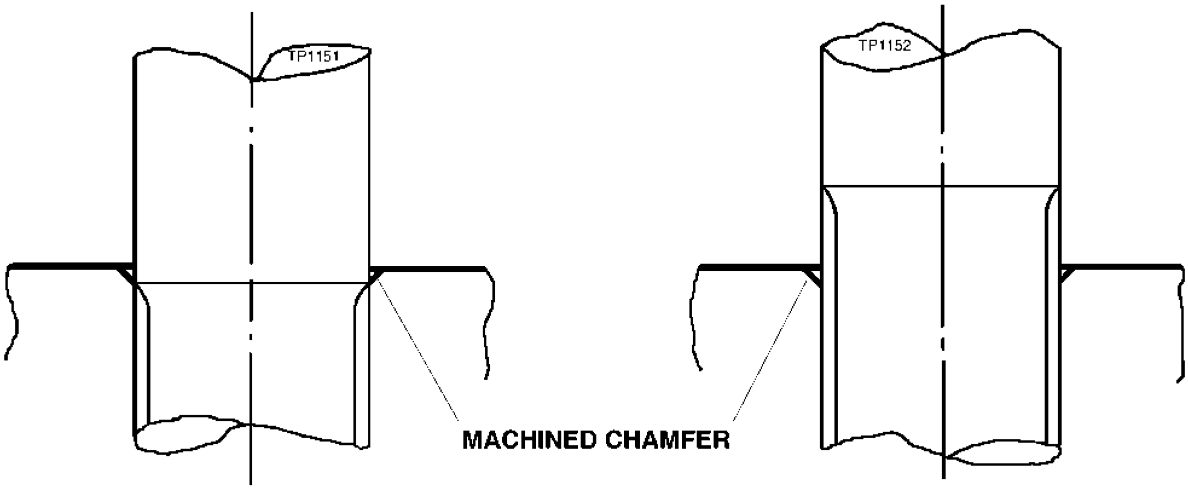


SPICER SPECIALITY AXLE DIVISION

TP1193

STANDARD STUDS - FITTED INTO MACHINED CHAMFERED HOLES

STUDS TO BE INSERTED UNTIL THREAD RUN-OUT LOCKS INTO PARENT METAL

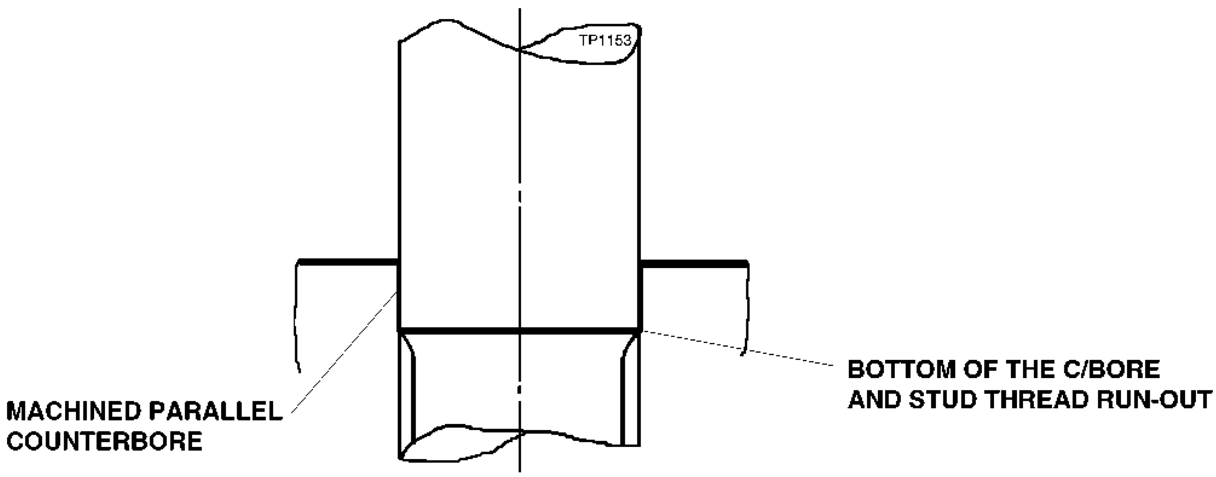


CORRECT INCORRECT

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



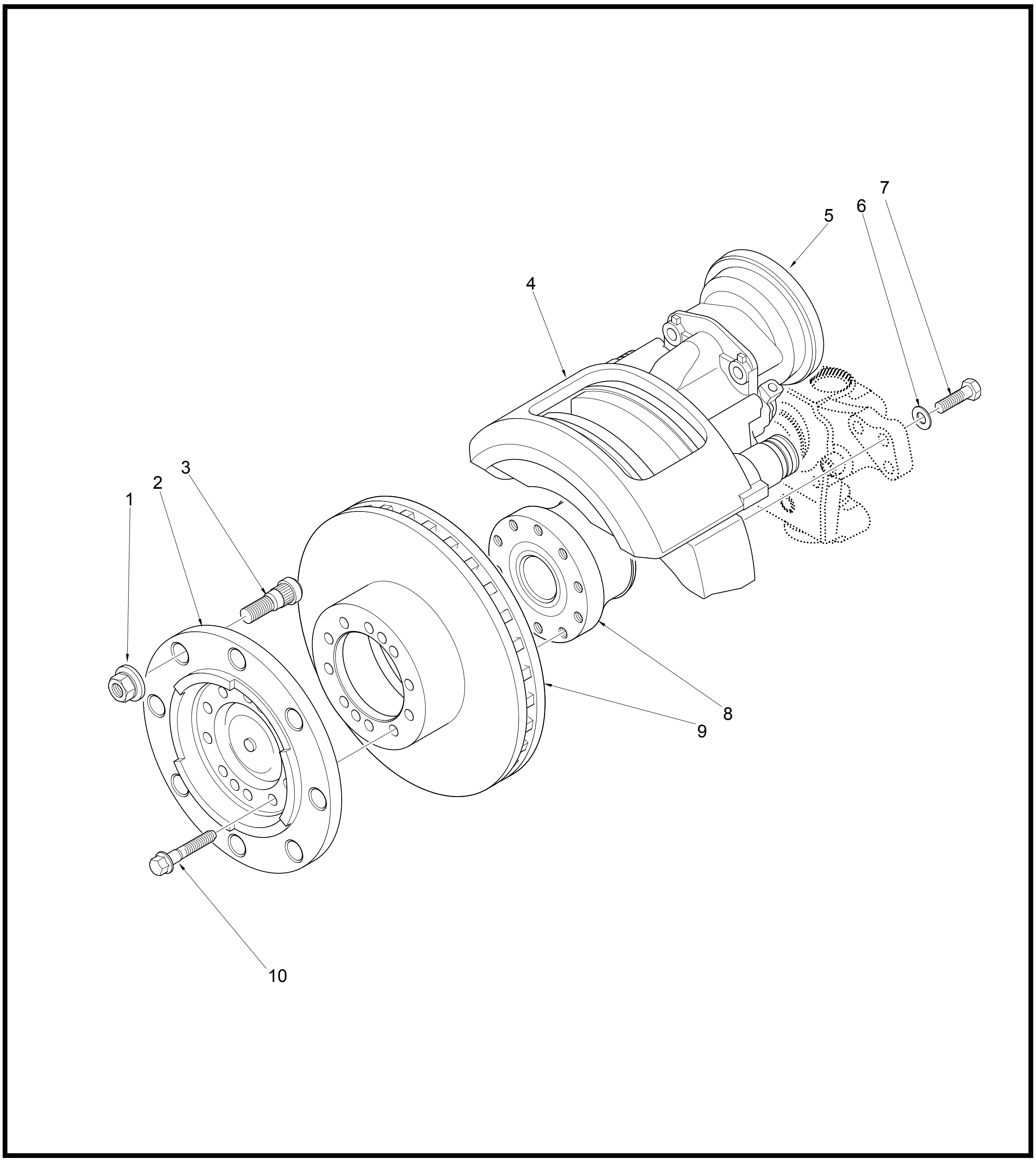
THIS SPECIFICATION IS FOR STUD FITTING ONLY ;
NUTS & SETSCREWS MUST BE TORQUED TO VALUE SPECIFIED

Alteration Numbers

ISSUE A									

DISTRIBUTION		
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
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
LEEDS LS5 3NF
ENGLAND
TEL (+44-113) 2584611 FAX (+44-113) 2586097

SECTION 11: REAR AXLES

CONTENTS

ILLUSTRATIONS

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.

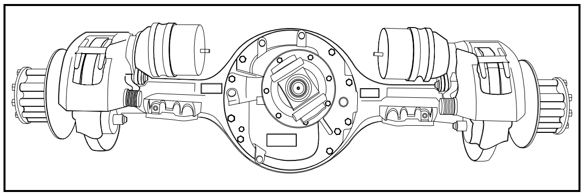


FIGURE 1: DRIVE AXLE 11019

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.

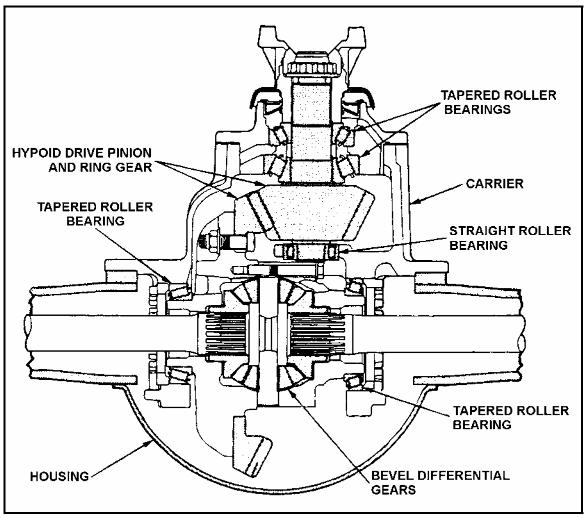


FIGURE 2: DIFFERENTIAL ASSEMBLY 11024

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.

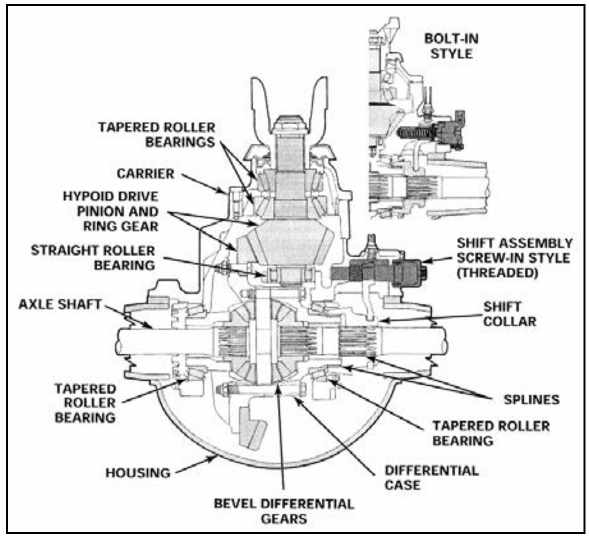


FIGURE 3: DRIVER-CONTROLLED DIFFERENTIAL LOCK

1.3 DRIVE AXLE LUBRICATION

Additional lubrication information is covered in the Meritor Product Information Letter *"Revised Lubricant Change Intervals"* annexed to this section.

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 25,000 miles (40 000 km) or according to the fleet maintenance interval, whichever comes first (Fig. 4).

Change differential oil and clean the breathers, magnetic fill and drain plugs, every 100,000 miles (160 000 km) or once a year, whichever comes first.

If using full synthetic gear oil, change differential oil and clean the breathers, magnetic fill and drain plugs, every 250,000 miles (400 000 km) or every four years, whichever comes first.

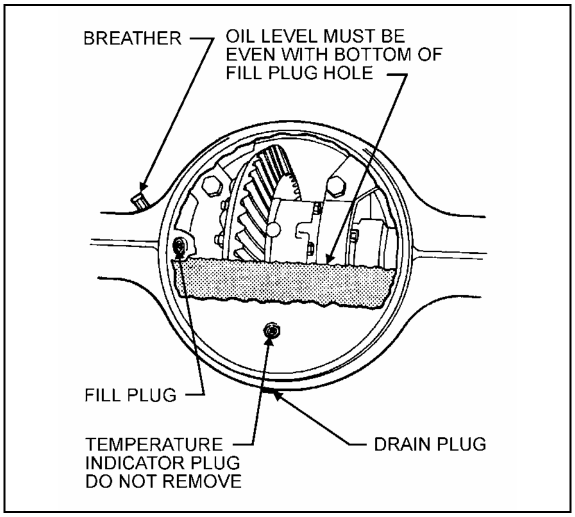


FIGURE 4: DIFFERENTIAL HOUSING BOWL 11007

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

⚠ WARNING ⚠
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 190ºF (88ºC) 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

⚠ WARNING ⚠
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 250ºF (120ºC).

6. Install and tighten the fill plug to 35-50 lbf-ft (48-67 Nm).

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".*

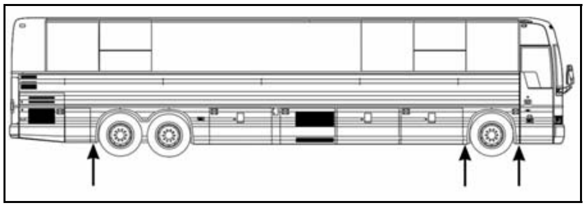


FIGURE 5: JACKING POINTS ON FRAME 11020

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).

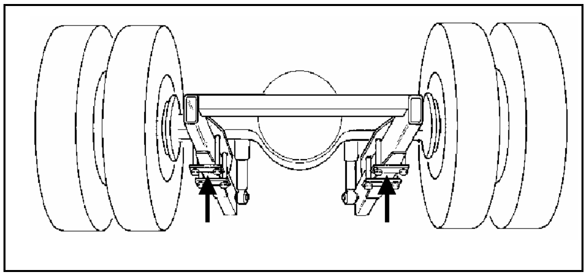


FIGURE 6: JACKING POINTS ON DRIVE AXLE H3B762

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.

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

1. Park vehicle on a level surface, then chock front vehicle wheels.
2. 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 ½ inch from ground. Secure in this position with safety stands, and release parking brake.
3. Install wheel mount sensors on front and drive axles (fig. 7). Adjust front axle according to appropriate specifications chart below.

NOTE
See reference numbers on wheel mount sensors (fig.7).

NOTE
Select axle specifications in the appropriate chart

FRONT AXLE VEHICLES EQUIPPED WITH I-BEAM FRONT AXLE			
Alignment / value	Minimum value	Nominal value	Maximum value
Right camber (degrees)	-0.250	0.125	0.375
Left camber (degrees)	-0.250	0.125	0.375
Right caster (degrees)	2	2.75	3.5
Left caster (degrees)	2	2.75	3.5
Total toe (degrees)	0.08	0.13	0.17

DRIVE AXLE ALIGNMENT

- With the system installed as for front axle alignment (fig.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

TAG AXLE ALIGNMENT

- Remove and reinstall all wheel mount sensors on the drive and tag axles (fig. 8);

NOTE
For an accurate alignment, the tag axle must be aligned with the drive axle.

NOTE
Reinstall wheel mount sensors as shown in figure 7. For example, the sensor from the right side of the front axle is mounted on the left side of the tag axle. For corresponding wheel mount sensor reference numbers, refer to figure 7.

- 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

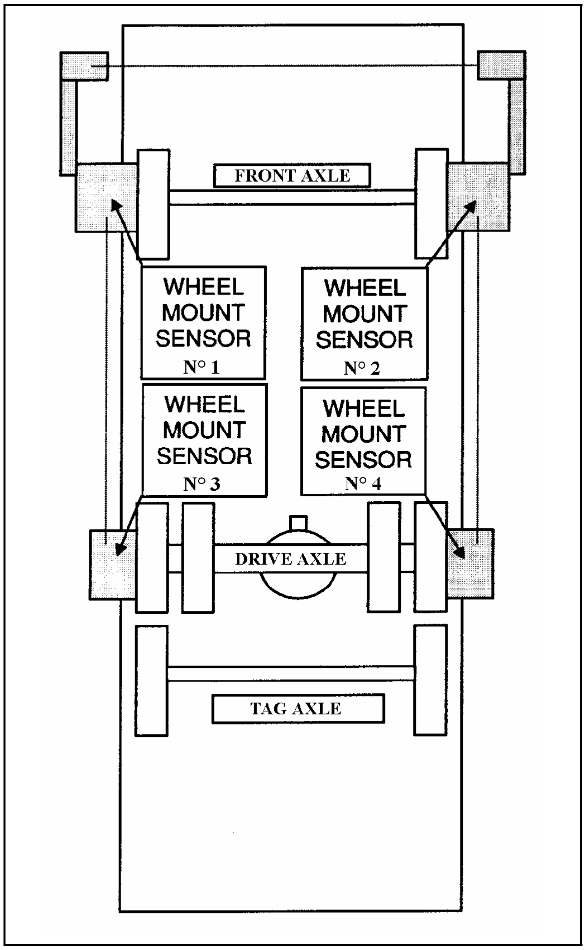


FIGURE 7: FRONT & DRIVE AXLE ALIGNMENT 11025

NOTE
Refer to Section 16, "Suspension", for proper torque tightening of the longitudinal radius rod support nuts.

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:

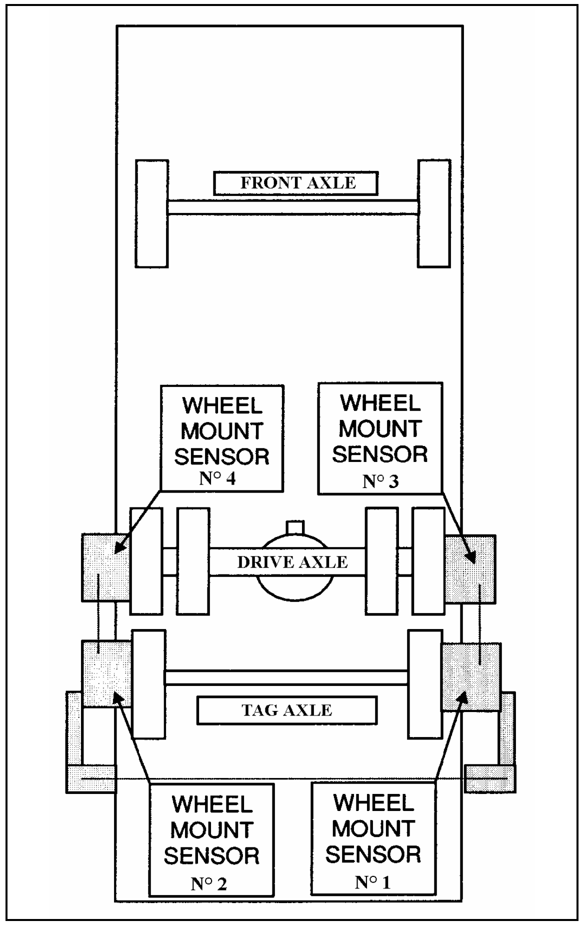


FIGURE 8: TAG AXLE ALIGNMENT 11026

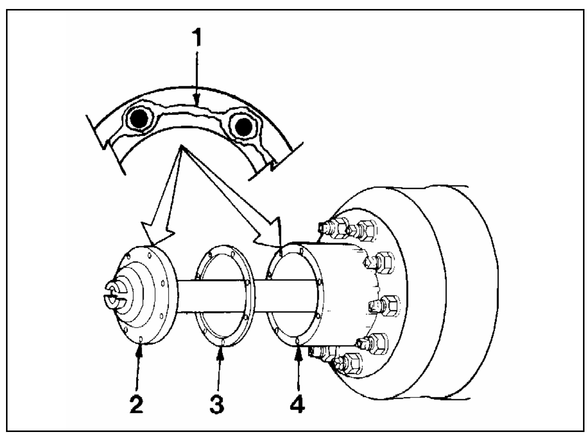


FIGURE 9: AXLE SHAFT INSTALLATION 11003

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, 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)

2. TAG AXLE

The tag axle is located behind the drive axle. It carries a single wheel and tire on each side. One optional system allows unloading of the tag axle air springs without raising the axle, while the other system enables unloading and raising of the tag axle (refer to the *"OPERATOR'S MANUAL"* for location of controls). Both these systems have 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.
2. Transferring extra weight and additional traction to the drive wheels on slippery surfaces.

⚠ CAUTION ⚠
Never exceed 30 mph (50 km/h) with tag axle up or unloaded and resume normal driving as soon as possible.

The tag axle service brakes operate only when the axle is in normal driving (loaded) position.

2.1 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 Section 10.

2.2 REMOVAL AND REINSTALLATION

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 10).

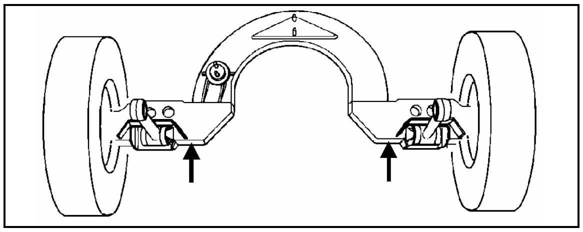


FIGURE 10: JACKING POINTS ON TAG AXLE 11023

4. Applies only to vehicles equipped with retractable tag axles: 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.

2.3 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.

3. SPECIFICATIONS

Drive Axle

Make .... Meritor
Drive track .... 76.7 inches (1 949 mm)
Gear type .... Hypoid
Axle type .... Full floating
Lube capacity .... 41 pints (19,3 liters)

Drive axle ratio

World Transmission

4.88:1 Standard
4.56:1 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

Make .... Prévost
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.
2135 W. Maple Rd.
Troy, MI 48084
www.arvinmeritor.com

PRODUCT INFORMATION LETTER # 427

DATE: January 2005

SUBJECT: REVISED LUBRICANT CHANGE INTERVALS

MODELS: ALL SINGLE, TANDEM AND TRIDEM DRIVE AXLES

Dear Customer,

This Product Information Letter supercedes ArvinMeritor PIL 415, which was published in May 2004.

The chart originally included with that publication has been revised to better define all vocational limitations.

Please use the *attached revised chart* for all lubrication interval direction.

Our Maintenance Manuals, and related Technical Publications will be revised to reflect the intervals shown on this chart.

ArvinMeritor continues to recommend a regular lubrication analysis program as part of any preventative maintenance program. In the ArvinMeritor Maintenance Manual Number 1 (Preventative Maintenance and Lubrication – Revision 11-03) pages 1 and 2 highlight the oil analysis guidelines for all drive axle differential oils.

The extended drain intervals for the transit bus vocation reflected in the attached revised chart are the result of extended field testing by ArvinMeritor and ExxonMobil.

We apologize for any confusion caused by the initial publications, and we believe the revised chart will clarify questions that may have been raised by it.

Thank you,

J.L. Malkowski
Director – Product Management
CVS Axles

B. Hicks
Senior Director - Engineering
CVS Axles & Drivelines

PRODUCT INFORMATION LETTER

PRODUCT INFORMATION LETTER

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 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 (8,000 Km), once a month, or the fleet maintenance interval, whichever comes first (1)
Petroleum-Based Oil Change on Axles with or without Pump and filter system	Every 100,000 miles (160,000 Km) or annually, whichever comes first	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 (2)	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 (3)
Filter Change on Axles with Pump and filter system	Every 100,000 miles (160,000 km)	Every 100,000 miles (160,000 km)	Every 100,000 miles (160,000 km)	Every 100,000 miles (160,000 km)

Notes:

(1) For continuous heavy-duty operation, check the oil level every 1,000 miles (1,600 km).

(2) These intervals apply to approved semi-synthetic and full synthetic oils only. For a list of approved extended-drain axle oils, refer to TP-9539, Approved Rear Drive Axle Lubricants.

(3) Change interval for TRANSIT BUS can be increased to **150,000 miles** or **3 years**, which ever comes first, contingent upon:

a) documented 10% fleet oil sampling with results below ArvinMeritor guidelines per MM #1,
b) minimum of 6 magnets in housing
(61163/ 71163 drive axles come standard with 6 magnets in housing),
c) use of approved extended drain interval lubricants per, TP-9539.
(Drive axles excluded are: RC-26-633/634 & RC-26/27-720)

SECTION 12: BRAKE AND AIR SYSTEM

CONTENTS

ILLUSTRATIONS

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 breaking 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 and tag axles are provided with spring-loaded emergency/parking brakes, which are applied automatically whenever the control valve supply pressure drops below 40 psi (275 kPa). The optional emergency/parking brake overrule system allows the driver to release spring brakes, and to move the vehicle to a safe parking place, such as in the case of a self-application of these brakes due to a drop in air pressure.

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).

Two additional air reservoirs may be installed on the vehicle: the kneeling air tank and emergency / parking brake overrule air tank.

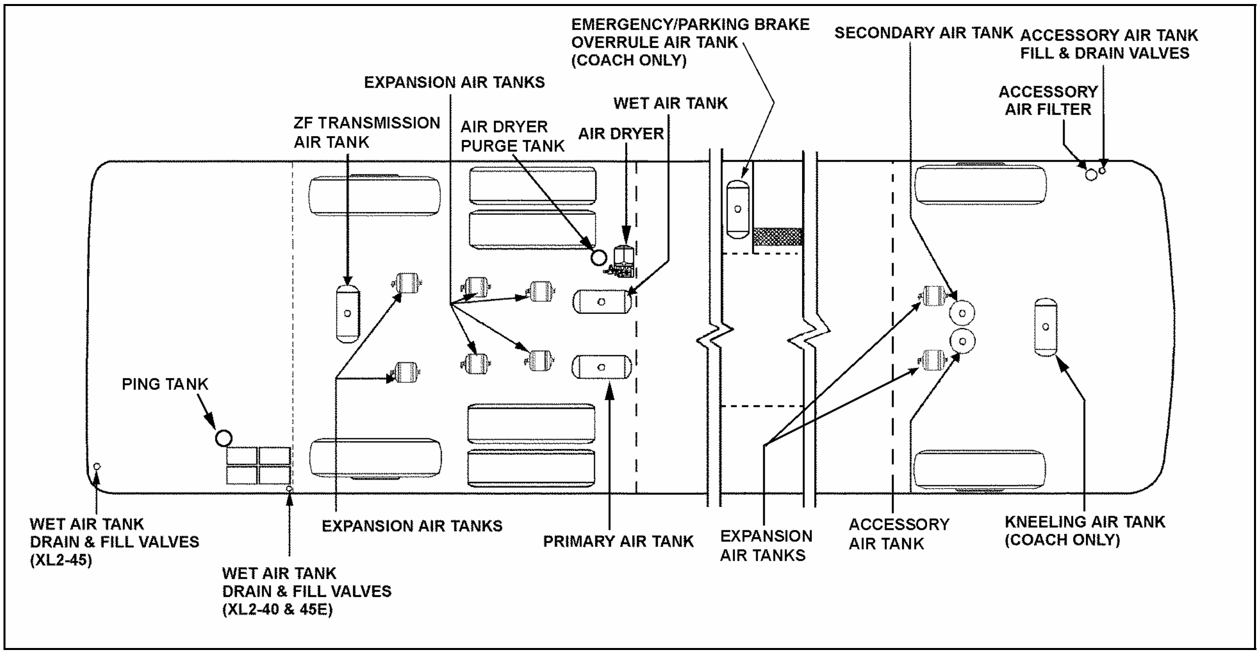


FIGURE 1: AIR RESERVOIRS LOCATION 24006

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.

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). It is recommended to purge the primary air tank every 12,500 miles (20 000 km) or once a year, whichever comes first.

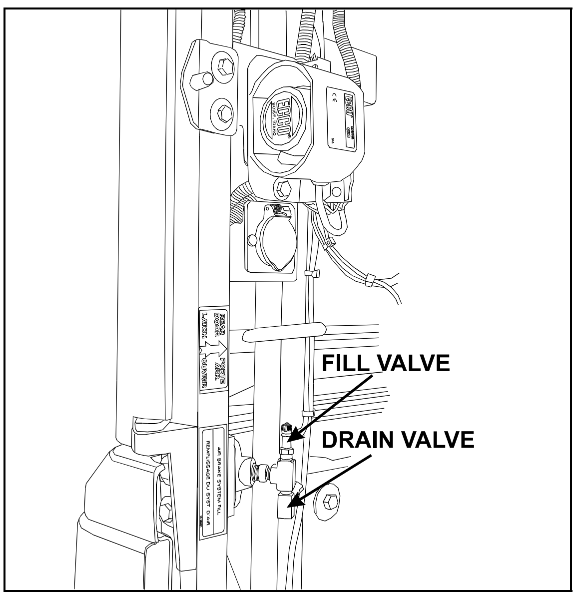


FIGURE 2: REAR VALVE LOCATION (TYPICAL) 12202

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).

Purge the reservoir by it's drain valve every 12,500 miles (20 000 km) or once a year, whichever comes first.

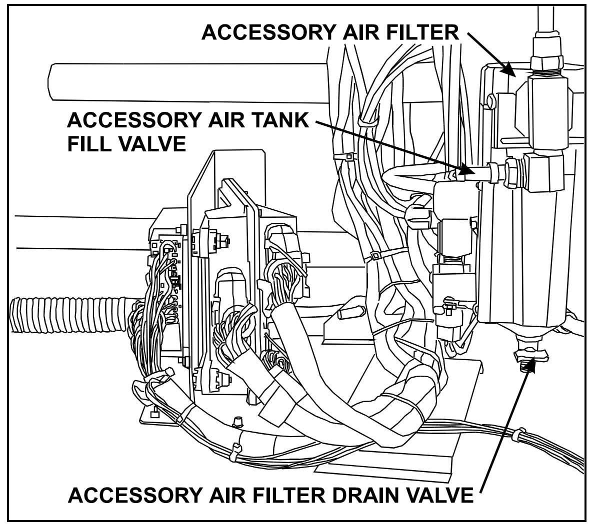


FIGURE 3: FRONT SERVICE COMPARTMENT 12201

3.1.4 Emergency/Parking Brake Overrule Air Tank

Installed on vehicles equipped with this option, this reservoir is located aft of the evaporator compartment (Fig. 1). 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.

3.1.5 Secondary Air Tank

This tank is located in the front wheelhousing, behind the steering axle (Fig. 1). 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.

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), 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 2.). It can be positioned close to the door hinge or 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. 3).

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

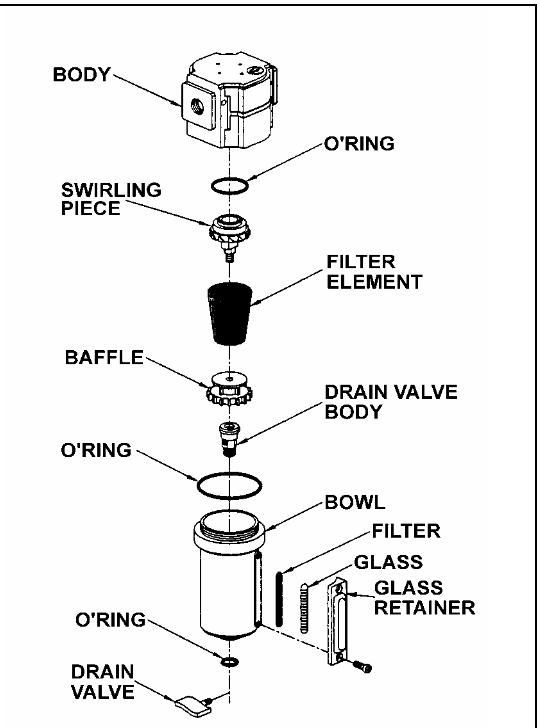


FIGURE 4: ACCESSORY AIR FILTER 12088

This filter is located inside the front service compartment (Fig. 3). 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. 4).

5.2 CLEANING

Clean filter body and bowl with a warm water and soap solution. Rinse thoroughly with clean 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" or "Owner'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

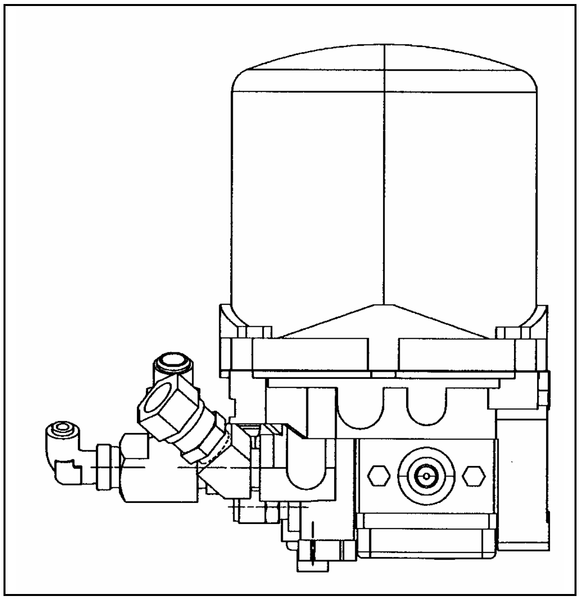


FIGURE 5: HALDEX AIR FILTER DRYER 12194

The air filter/dryer is located in front of rear wheelhousing above drive axle (Fig. 1 & 5). 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 over the battery assembly, close to the door hinge or close to the L.H. side of door opening depending on type of vehicle (Fig. 2). 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).

⚠ CAUTION ⚠

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.

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) for coaches, WE and W0 MTH and to 45 ± 2 psi (310 ± 15 kPa) for W5 MTH (Fig. 7).

The optional regulator is located 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 (coach, WE & W0) 45 (W5)	**series 60** 345 310
Retarder	80 ± 3	550 ± 20

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. 6). 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.

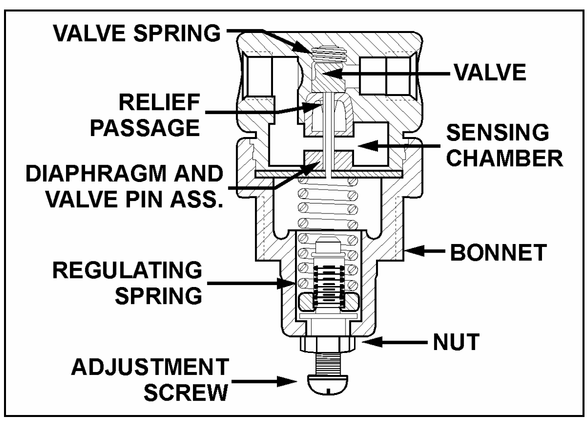


FIGURE 6: AIR PRESSURE REGULATING VALVE 12141B

9.2 PRESSURE SETTING PROCEDURE

Remove the dust cap from the pressure check valve (Fig. 7). Attach a pressure gauge at this port and check the pressure reading. If the pressure reading is incorrect, adjust as follows:

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.

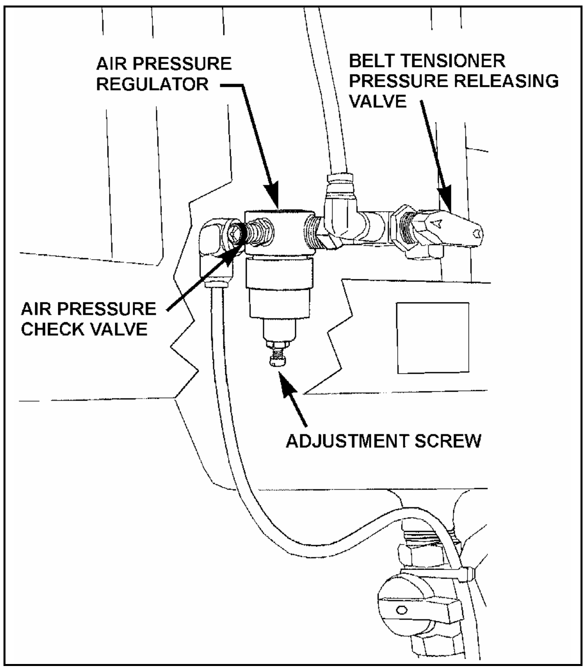


FIGURE 7: AIR PRESSURE REGULATOR 12200

10. AIR COMPRESSOR (BA-921)

The air compressor is located on starter side of the engine, on the rear of the engine gear case (Fig. 8). 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.

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.

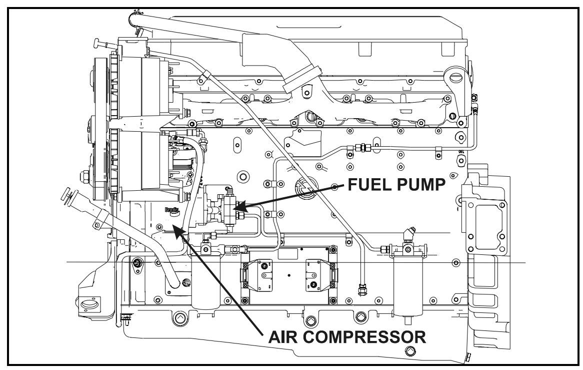


FIGURE 8: AIR COMPRESSOR LOCATION 03061

10.1 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.

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.

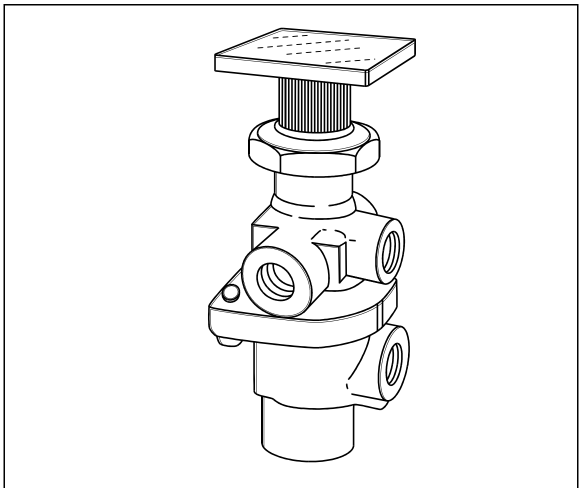


FIGURE 9: PP-1 12142

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. 9).
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.

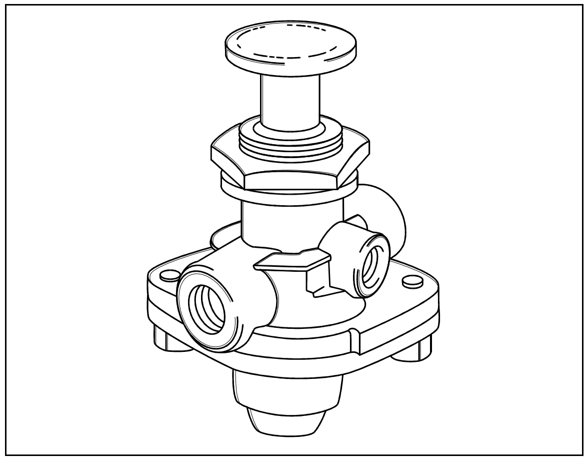


FIGURE 10: RD-3 12136

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.

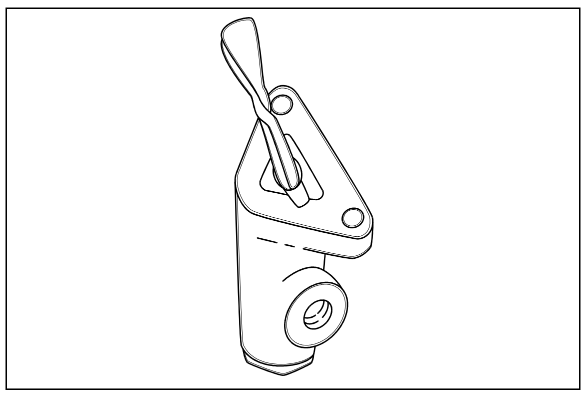


FIGURE 11: TW-1 12138

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. 12).

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^{o} brake pedal inclination (Fig. 12).
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.

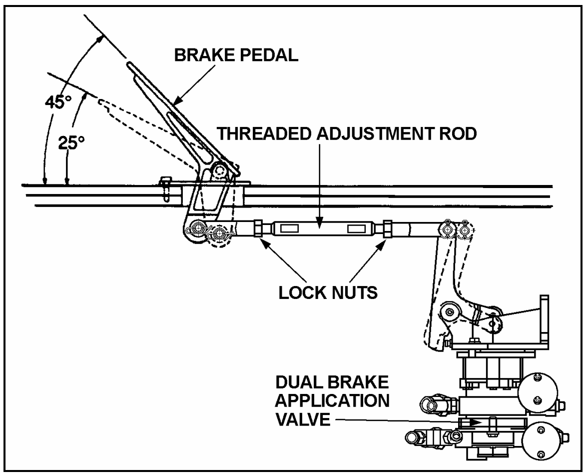


FIGURE 12: BRAKE PEDAL ADJUSTMENT 12208

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. 13), while the lower one (Bendix, SL-5) closes its contact at 4 psi (28 kPa) (Fig. 14). The switches are not serviceable items; if found defective, the complete unit must be replaced.

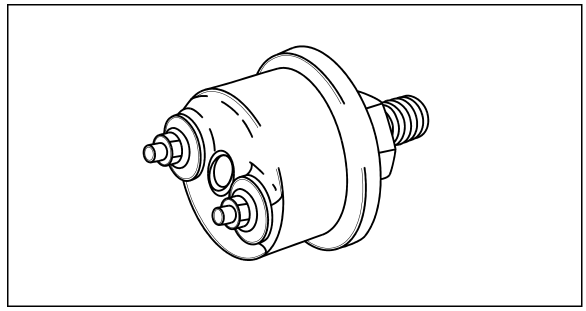


FIGURE 13: DELCO SWITCH 12139

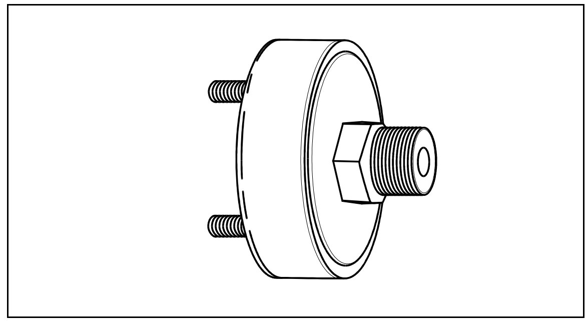


FIGURE 14: BENDIX SWITCH 12140

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.

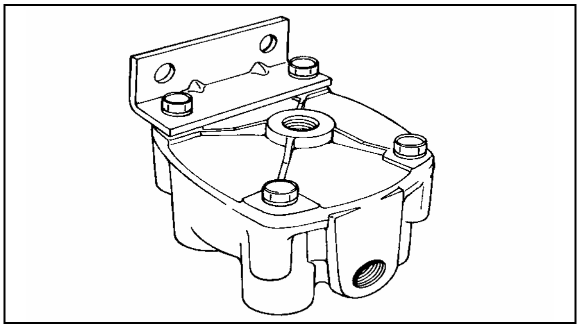


FIGURE 15: R-12 12074

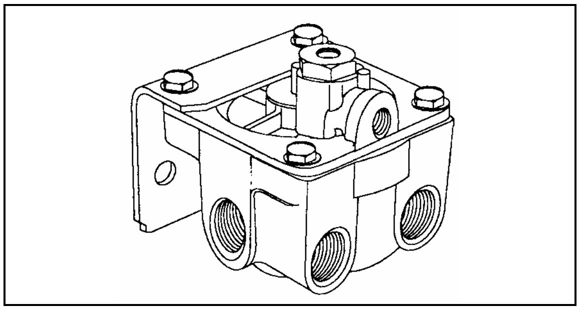


FIGURE 16: R-14 12207

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.

Maintenance and repair information on this valve is supplied in the applicable booklet annexed to this section under reference number SD-03-901.

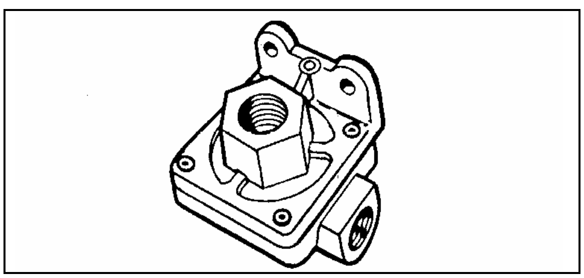


FIGURE 17: QR-1 12075

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.

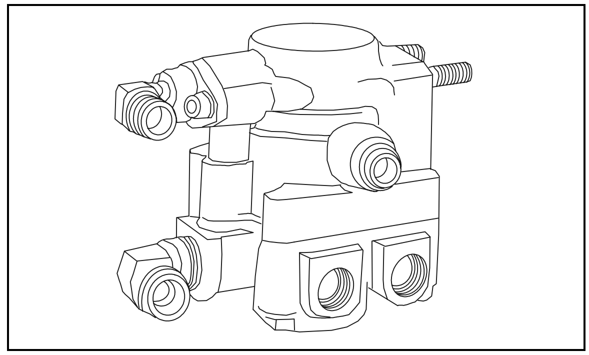


FIGURE 18: SR-7 12206

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. 19). 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.

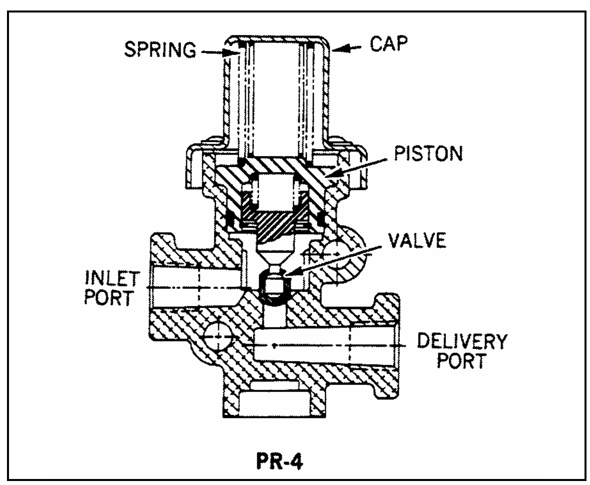


FIGURE 19: PR-4 12174

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 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. 20), 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).

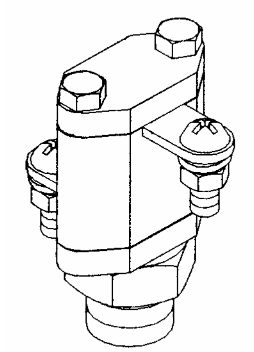


FIGURE 20: LP-3 12078

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.

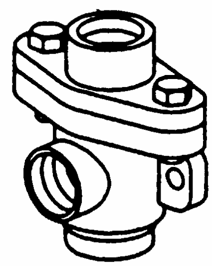


FIGURE 21: DC-4 12134

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.

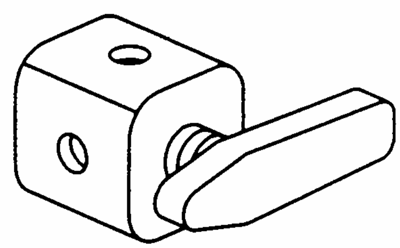


FIGURE 22: THREE-WAY VALVE 12186

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.
- 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 and tag axles, and will apply automatically if primary system pressure falls below 40 psi (276 kPa). The optional parking brake override system can cancel the parking brakes, enabling the driver to move the vehicle to a safe parking place. To operate this system, push down and hold the control knob located on the R.H. side of the driver’s seat (see *"Operator's Manual"* for more details).

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 may also be 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 SB7000 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 16 square inch effective area for service brake and a 16 square inch effective area for emergency/parking brakes. The *Knorr-Bremse SB7000* 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. 23). 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.

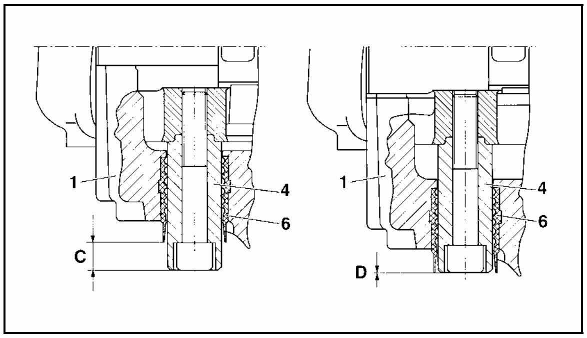


FIGURE 23: BRAKE PAD CHECK 12117

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. 24), push down retainer bar (11), pull out pin (44) and remove retainer bar. Push caliper toward actuator (center of vehicle) for maximum clearance.

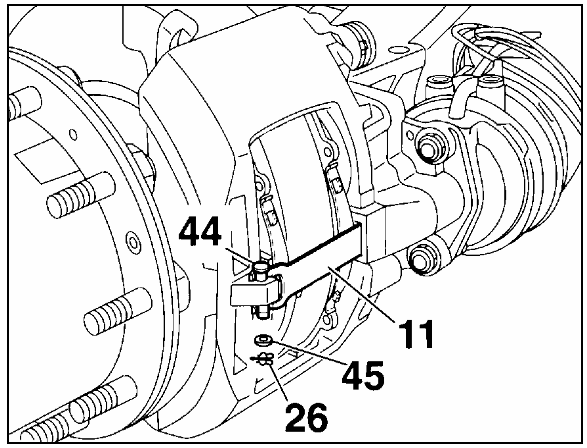


FIGURE 24: CLEARANCE INSPECTION 12119

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).

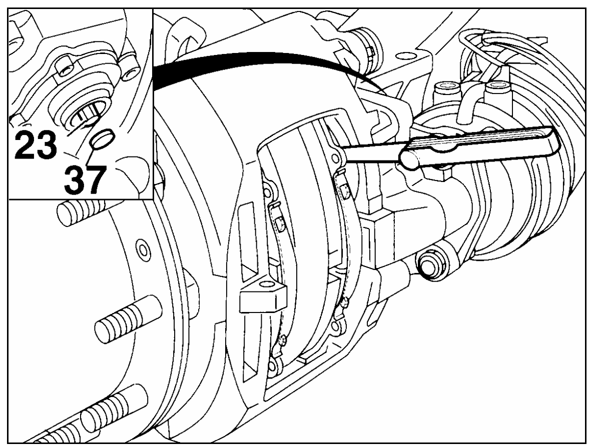


FIGURE 25: RUNNING CLEARANCE 12116

4. Checking the adjuster

WARNING
Use only a standard box wrench on the adjuster hexagonal pinion. Do not over-torque the pinion as overtorquing will damage the pinion.

a) Remove cap (37, Fig. 26).

b) Using a box wrench (8 mm), turn the adjuster pinion (23, Fig. 26) counterclock-wise 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. 26 and 27).

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.

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.

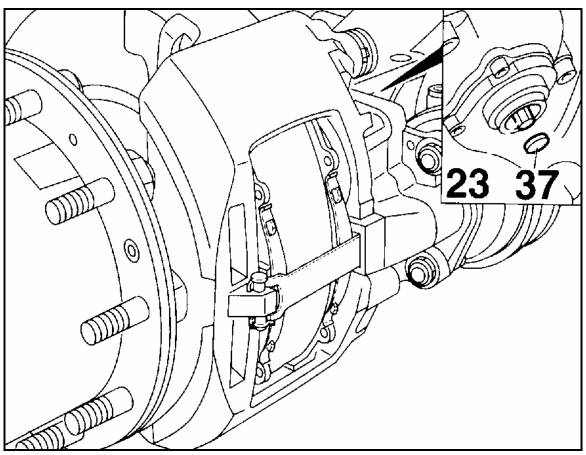


FIGURE 26: ADJUSTER PINION 12120

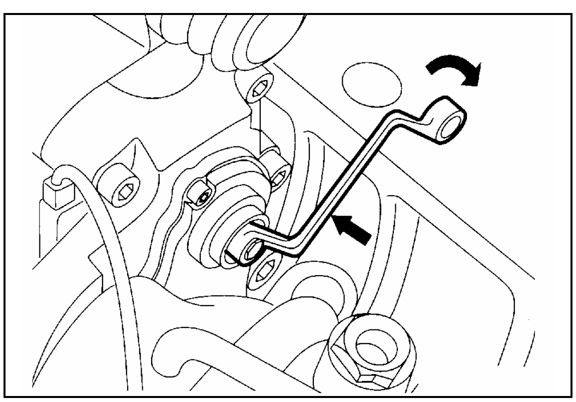


FIGURE 27: BOX WRENCH ON ADJUSTER PINION 12118

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 28. The movement in the axial direction should not exceed 2 mm (5/64").

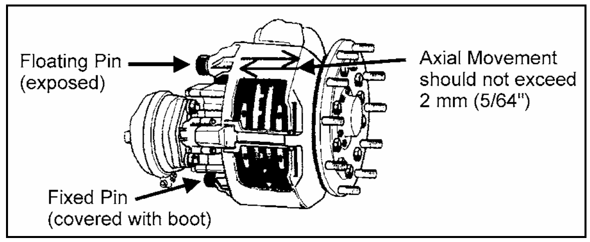


FIGURE 28: CALIPER AXIAL MOVEMENT 12132

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 29. When pads are in new thickness condition, the pin will be exposed (C) 19 mm (¾"). 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.

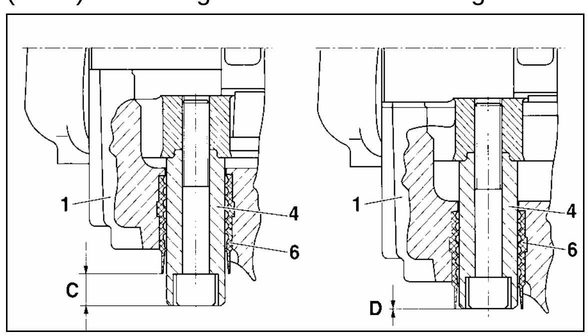


FIGURE 29: BRAKE PAD CHECK 12117

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.

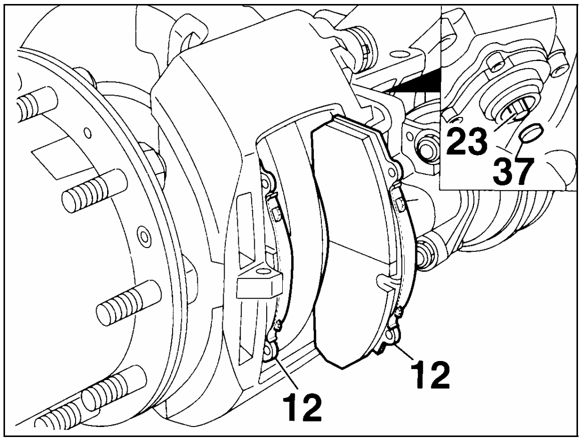


FIGURE 30: PAD REMOVAL 12111

27.1.5 Checking Pad Wear

Minimum friction material thickness is 2 mm (A, Fig. 31)

New friction material has a thickness of 21 mm (B, Fig. 31)

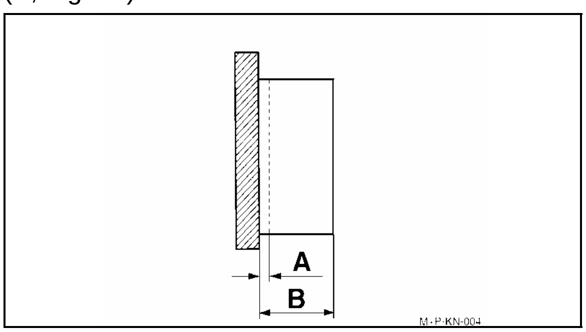


FIGURE 31: PAD WEAR 12112

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**.

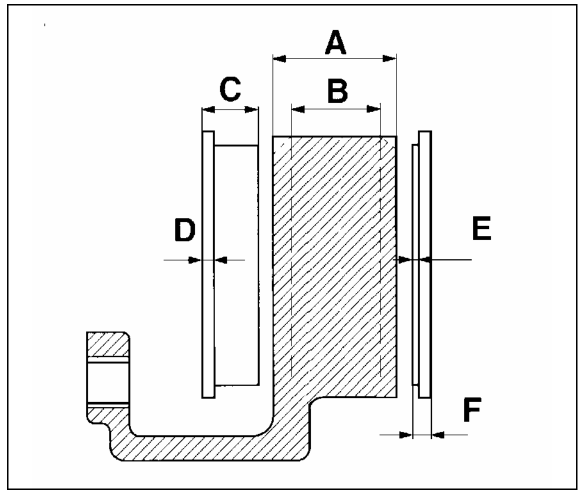


FIGURE 32: ROTOR AND PAD WEAR LIMITS 12113

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. 33):

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.

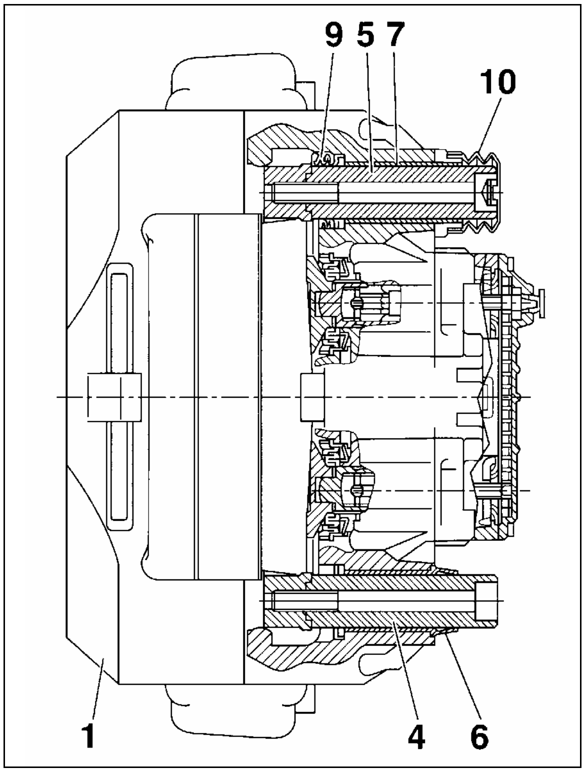


FIGURE 33: CALIPER GUIDANCE 12114

27.1.8 Checking the Tappet Boots

a) The rubber boots (13, Fig. 34) should show no damage, check the attachment.

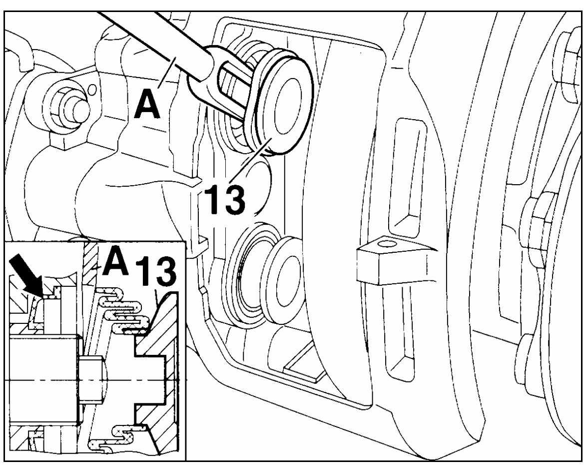


FIGURE 34: RUBBER BOOTS 12115

⚠ 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. 35) 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.

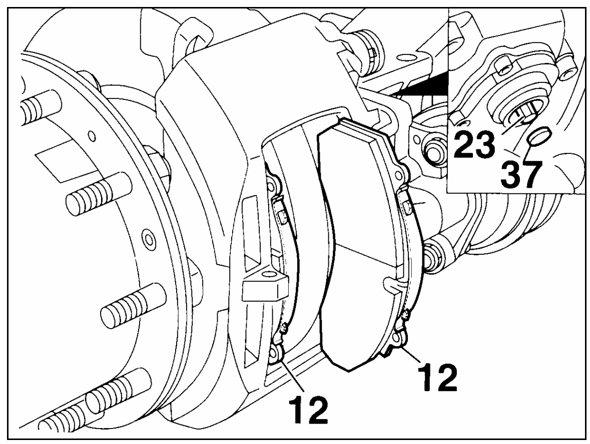


FIGURE 35: PAD INSTALLATION 12111

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. 36). 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. 36) 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.

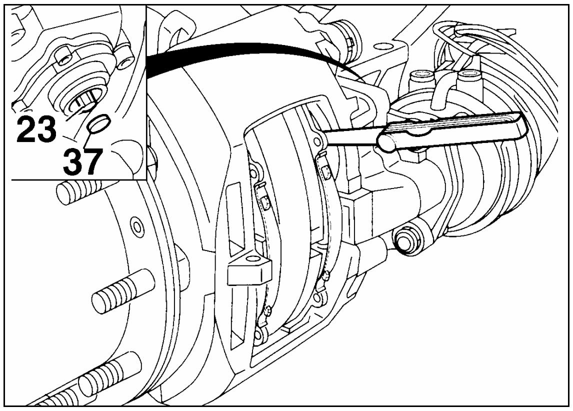


FIGURE 36: RUNNING CLEARANCE 12116

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. 37). 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.

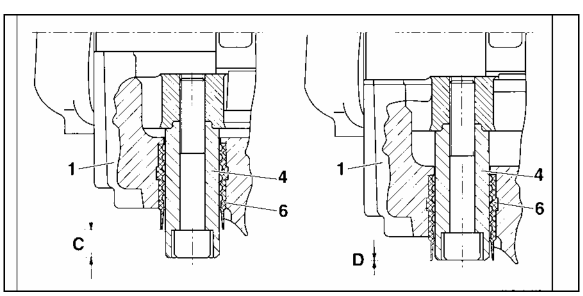


FIGURE 37: BRAKE PAD CHECK 12117

27.1.13 Torque specifications

For proper caliper maintenance, refer to the following figures.

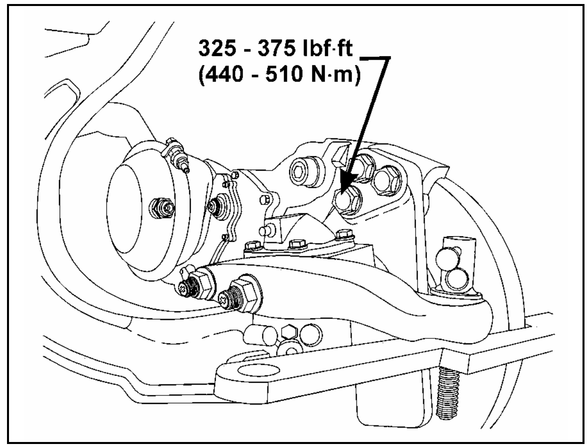


FIGURE 38: TORQUE SPECIFICATION 12145

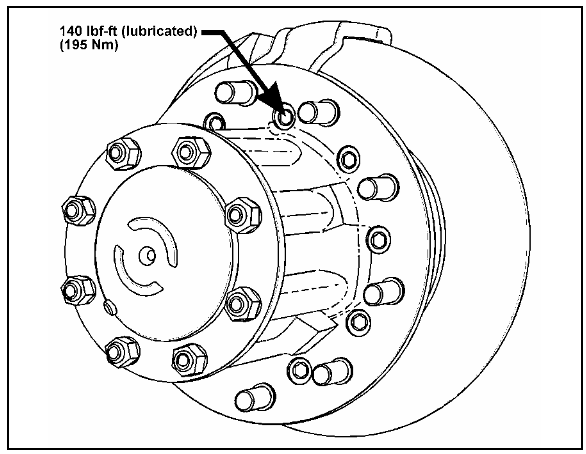


FIGURE 39: TORQUE SPECIFICATION 12149

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 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.

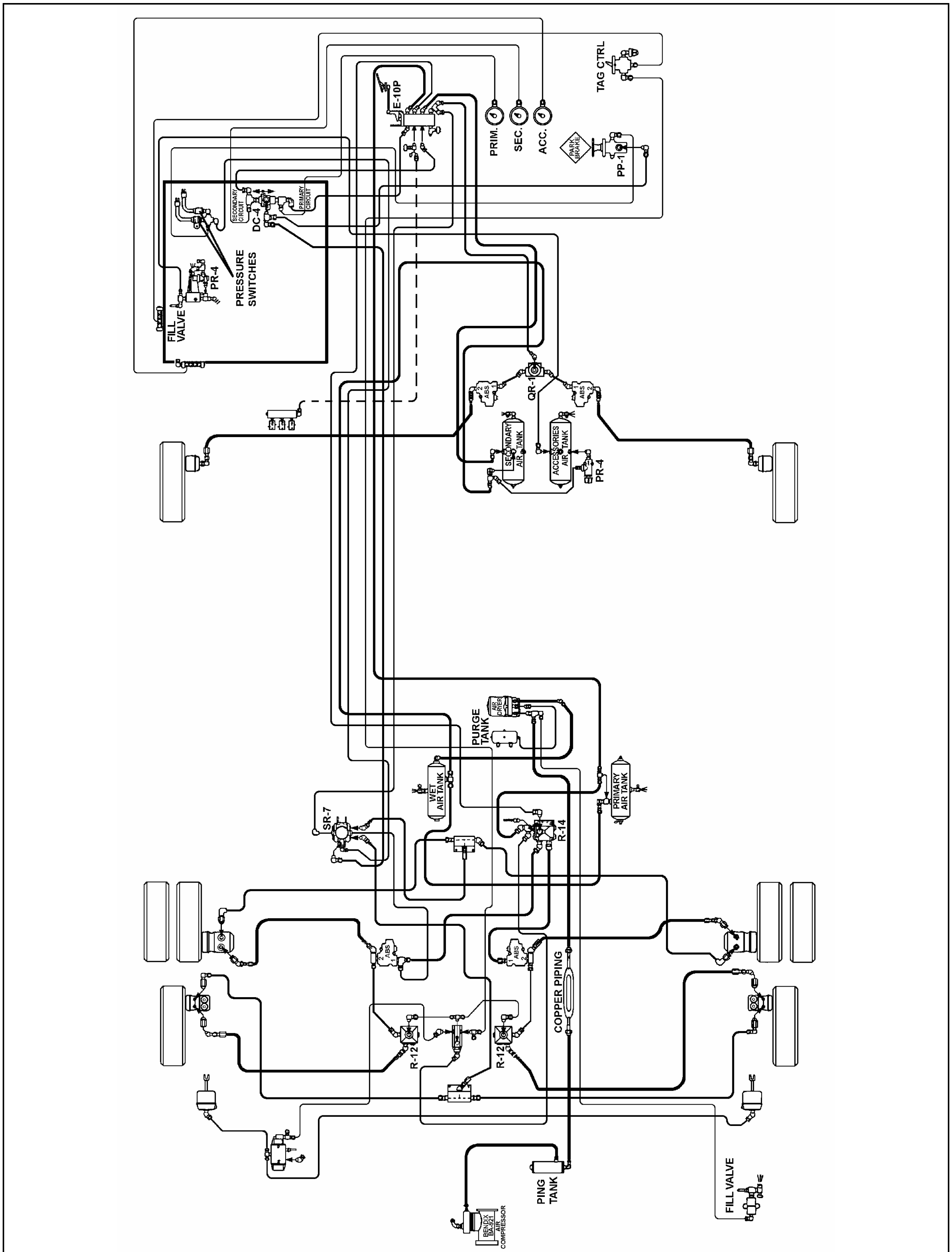


FIGURE 40: AIR-OPERATED BRAKING SYSTEM XL2

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 ±3 (847±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 dash-board.
3. Pressure drop should not be more than 4 psi (27 kPa) per minute.

For common corrections, refer to the following check list.

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.

30. BRAKE AIR CHAMBER

If this vehicle is equipped with *Knorr-Bremse SB7000* disc brakes on all axles, it also uses "Knorr-Bremse" brake chambers. The tag and 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 41 and 42.

The front axle brake air chambers are used only for service brake duty (Fig. 41).

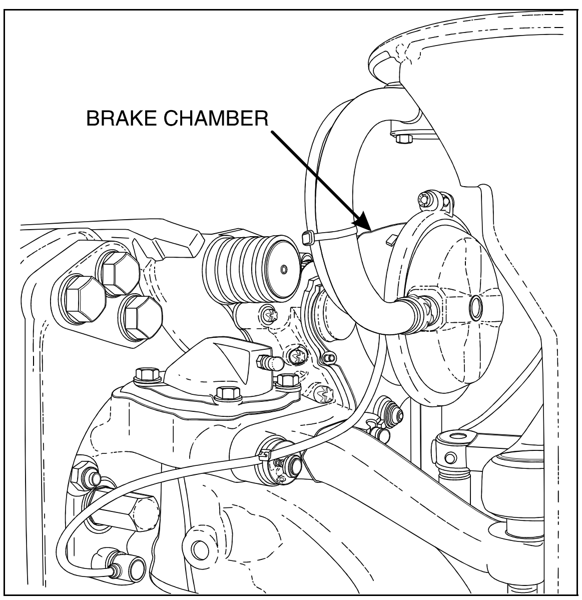


FIGURE 41: FRONT AXLE BRAKE AIR CHAMBER 12158

30.1 MAINTENANCE

Every 6,250 Miles (10 000 km) or twice a year, whichever comes first depending on type of operation:

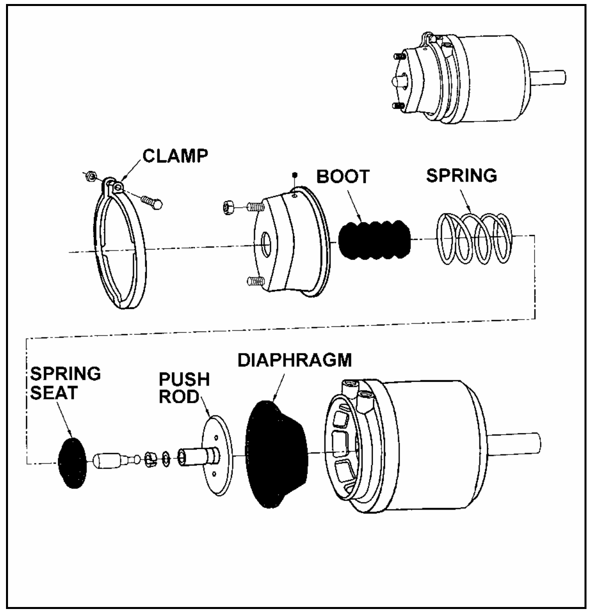


FIGURE 42: TAG AXLE BRAKE AIR CHAMBER 12126

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 airtighteness 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

WARNING
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, 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.

⚠ WARNING ⚠

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.

Tag Axle

1. Block the wheels to prevent the vehicle from moving.
2. Turn the release bolt counterclockwise to cage the power spring (approx. 2.5 inches (6 cm)). Repeat on the opposite side.
3. To manually reset the emergency/parking brake, turn the bolt clockwise.

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 and tag axles 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, 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

⚠ WARNING ⚠

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 and tag axles 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 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.

31.2.1 Electronic Control Unit (ECU)

This control unit is located in the front service compartment, (refer to figure 43 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.

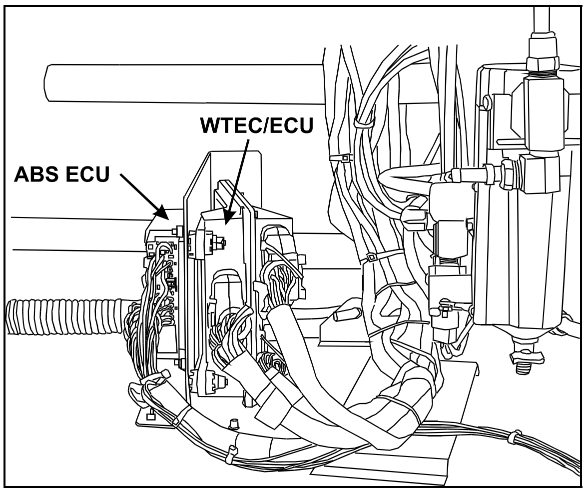


FIGURE 43: ABS ECU LOCATION 12147

Maintenance

No specific maintenance is required. The ECU is not serviceable. When found to be defective, replace.

⚠ CAUTION ⚠

In order to protect the ABS electronic control unit from voltage surges, always disconnect before performing any welding procedure on vehicle.

31.2.2 ABS Modulator Valve

This ABS system is equipped with four modulator valves, located between the brake chamber and the relay valve or quick release valve (Fig. 44). Note that there is only one solenoid valve controlling the drive and tag axle wheels on the same side (tag axle is slave to drive axle).

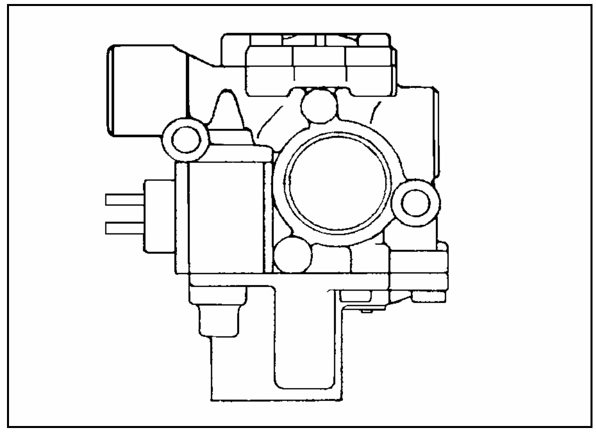


FIGURE 44: ABS MODULATOR VALVE 12084

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

No specific maintenance is required for the solenoid control valve.

31.2.3 Sensors

The sensors are mounted on the front and drive axle wheel hubs (Fig. 45). 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 proportionately. 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.

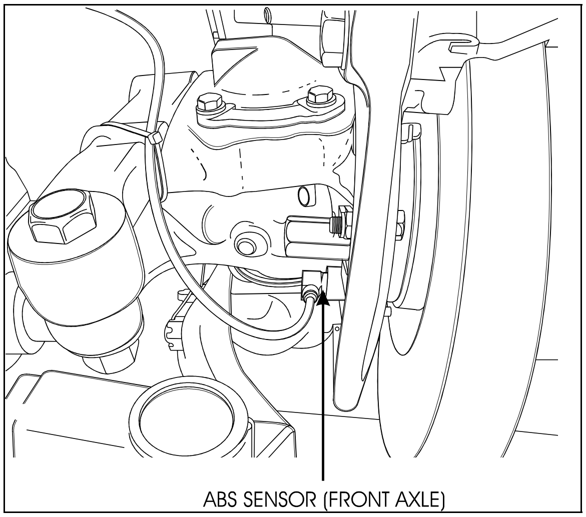


FIGURE 45: ABS SENSOR LOCATION 12153

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.

31.2.4 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.

31.2.5 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. 46).

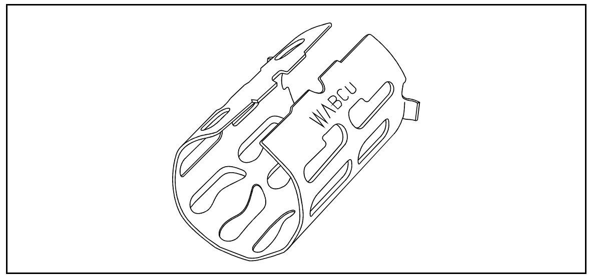


FIGURE 46: SPRING CLIP 12161

Maintenance

The spring clip requires no specific maintenance.

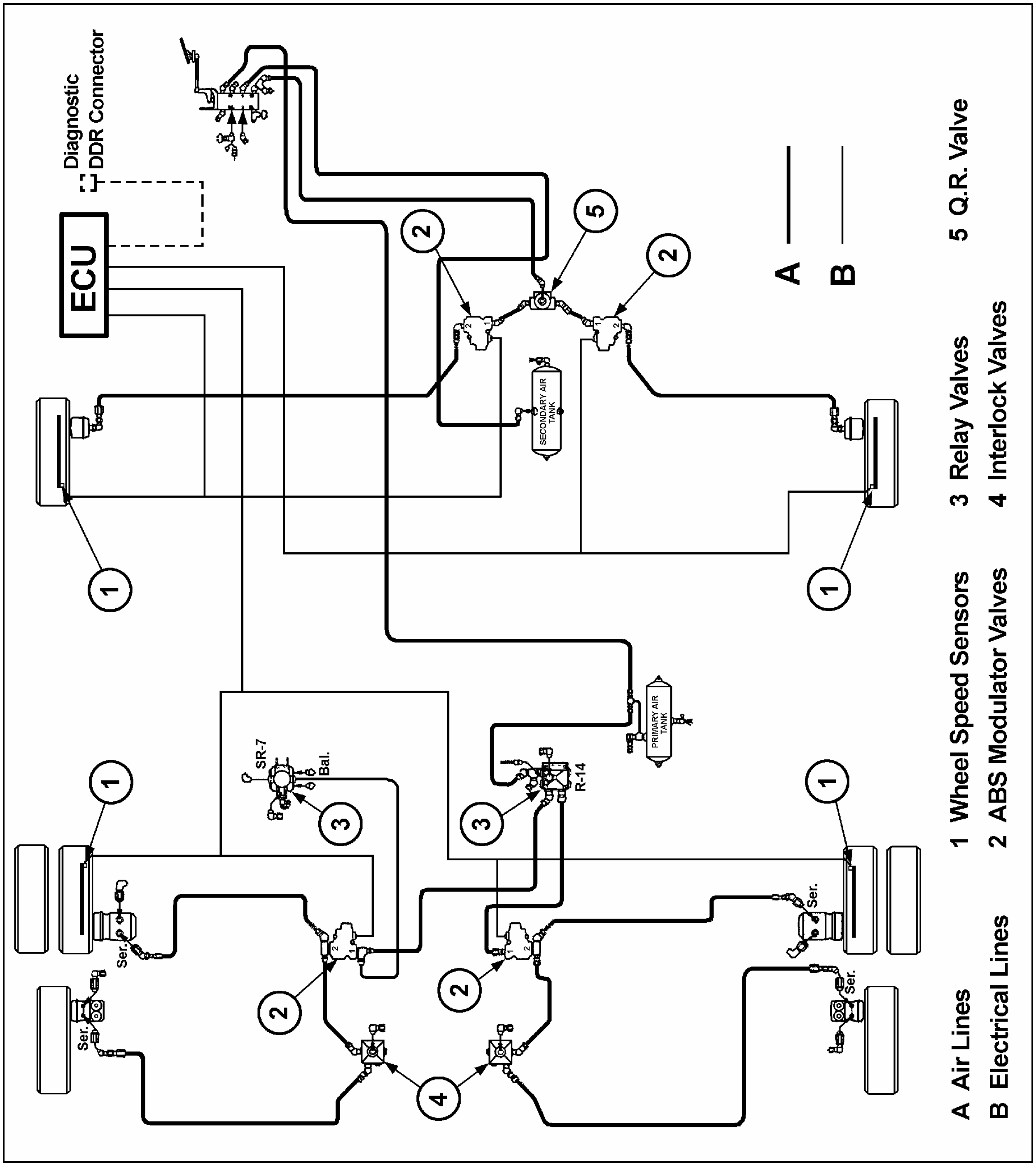


FIGURE 47: ABS 4S/4M CONFIGURATION

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).

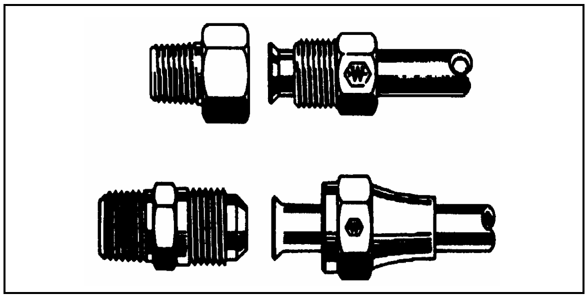


FIGURE 48: HOSE FITTINGS 12053

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

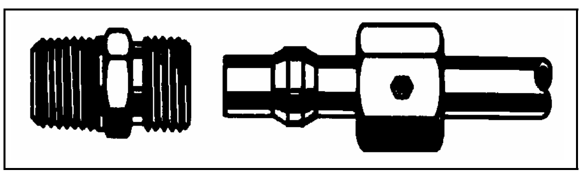


FIGURE 49: HOSE FITTING 12054

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

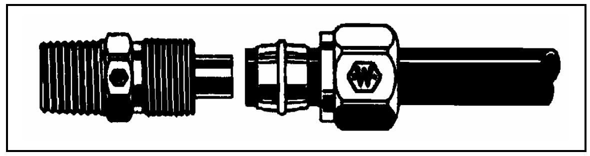


FIGURE 50: HOSE FITTING 12055

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

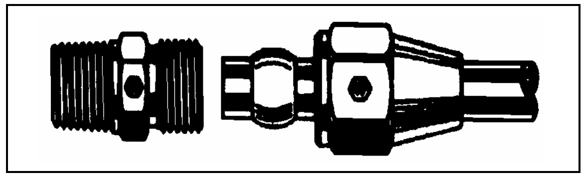


FIGURE 51: HOSE FITTING 12056

Pipe Tightening: All connections must be hand tightened. From that point, tighten a minimum of 2 ½ additional turns.

NOTE
Use Locktite (Prévost number 680098) pipe sealant to seal pipe thread.

33. SPECIFICATIONS

Air Compressor

Make..Bendix Westinghouse
Model..BA-921
Capacity (at 1250 rpm) ....15.7 cfm (0,445 m^3/min.)
Supplier number..801287
Prévost number..641990

BA-921 Service Kits

ST-4 Safety Valve

Supplier number..800534
Prévost number..641989

Series 60 Seal Kit

Supplier number..5012371
Prévost number..641988

Compressor Seal Kit

Supplier number..5008559
Prévost number..641987

Cylinder Head Gasket Kit

Supplier number..5008558
Prévost number..641986

Air Dryer

Make..Haldex
Model..AT-87192
Supplier number..108229
Prévost number..70303498
Desiccant cartridge Prévost number..3097369

Flip-Flop Control Valve

Make..Bendix Westinghouse
Model..TW-1
Type ....On-Off
Supplier number..229635
Prévost number..640136

Emergency/Parking Brake Control Valve

Make..Bendix Westinghouse
Model..PP-1
Automatic release pressure ....40 psi (275 kPa) nominal
Supplier number..287325
Prévost number..641128

Emergency/Parking Brake Overrule Control Valve

Make..Bendix Westinghouse
Model..RD-3
Supplier number..281481
Prévost number..640472

Dual Brake Application Valve

Make..Bendix Westinghouse
Model..E-10P
Supplier number..5006280
Prévost number..641856

Stoplight Switches

Make..Bendix Westinghouse
Model..SL-5
Contact close (ascending pressure)..4 psi and more (28 kPa)
Supplier number..286404
Prévost number..641462

Brake Relay Valves

Make..Bendix Westinghouse
Model..R-12
Supplier number..
Prévost number..

Brake Relay Valve

Make..Meritor Wabco
Model..R-14
Supplier number..
Prévost number..

Quick Release Valve

Make..Bendix Westinghouse
Model..QR-1
Supplier number..5001496
Prévost number..641429

Spring Brake Valve

Make..Bendix Westinghouse
Model..SR-7
Supplier number..
Prévost number..

Pressure Protection Valve

Make..Bendix Westinghouse
Model..PR-4
Nominal closing pressure..70 psi (482 kPa)
Supplier number..277226
Prévost number..641137

Shuttle-Type Double Check Valve

Make..Bendix Westinghouse
Model..DC-4
Supplier number..277988
Prévost number..641015

Low Pressure Indicators

Make..Bendix Westinghouse
Model..LP-3
Contact close..66 psi (455 kPa)
Supplier number..277227
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)
Supplier number..R06-2G7 RNKA
Prévost number..641472

Air Filter Element

Make......Norgren
Type ......With manual drain
Supplier number......F74G-345-004
Prévost number...... 641338

Front Axle Brake Chambers

Make......Knorr-Bremse
Type 24
Supplier number (R.H.) ......BS-3457 II 34671
Prévost number (R.H.) 641414
Supplier number (L.H.)......BS-3457 II 34670
Prévost number (L.H.)...... 641413

Drive Axle Brake Chambers

Make......Knorr-Bremse
Type ......24 as service -24 as emergency
Supplier number......II/35699/BS-9524
Prévost number...... 641432

Piggy Back (On Drive Brakes)

Make......Knorr-Bremse
Type ...... 24 as emergency
Supplier number......II/17567/0061
Prévost number...... 641433

Tag Axle Brake Chambers

Make......Knorr-Bremse
Type ......16 as service – 16 as emergency
Supplier number...... II/18224/V1-BS9396
Prévost number...... 641308

Piggy Back (On Tag Brakes)

Make......Knorr-Bremse
Type ...... 16 as emergency
Supplier number......II/18224/0061
Prévost number...... 641431

Brake Lining (All Axles)

Make......Knorr-Bremse
Supplier number......II 33976
Prévost number...... 611049
Prévost number...... 641226

ABS ANTILOCK BRAKING SYSTEM (if applicable)

ABS MODULATOR VALVE

Make...... Rockwell Wabco
Voltage ......24 V
Supplier number......472 195 006 0
Prévost number...... 641097

Sensor, Front Axle

Supplier number......441 032-572-0
Prévost number...... 641288

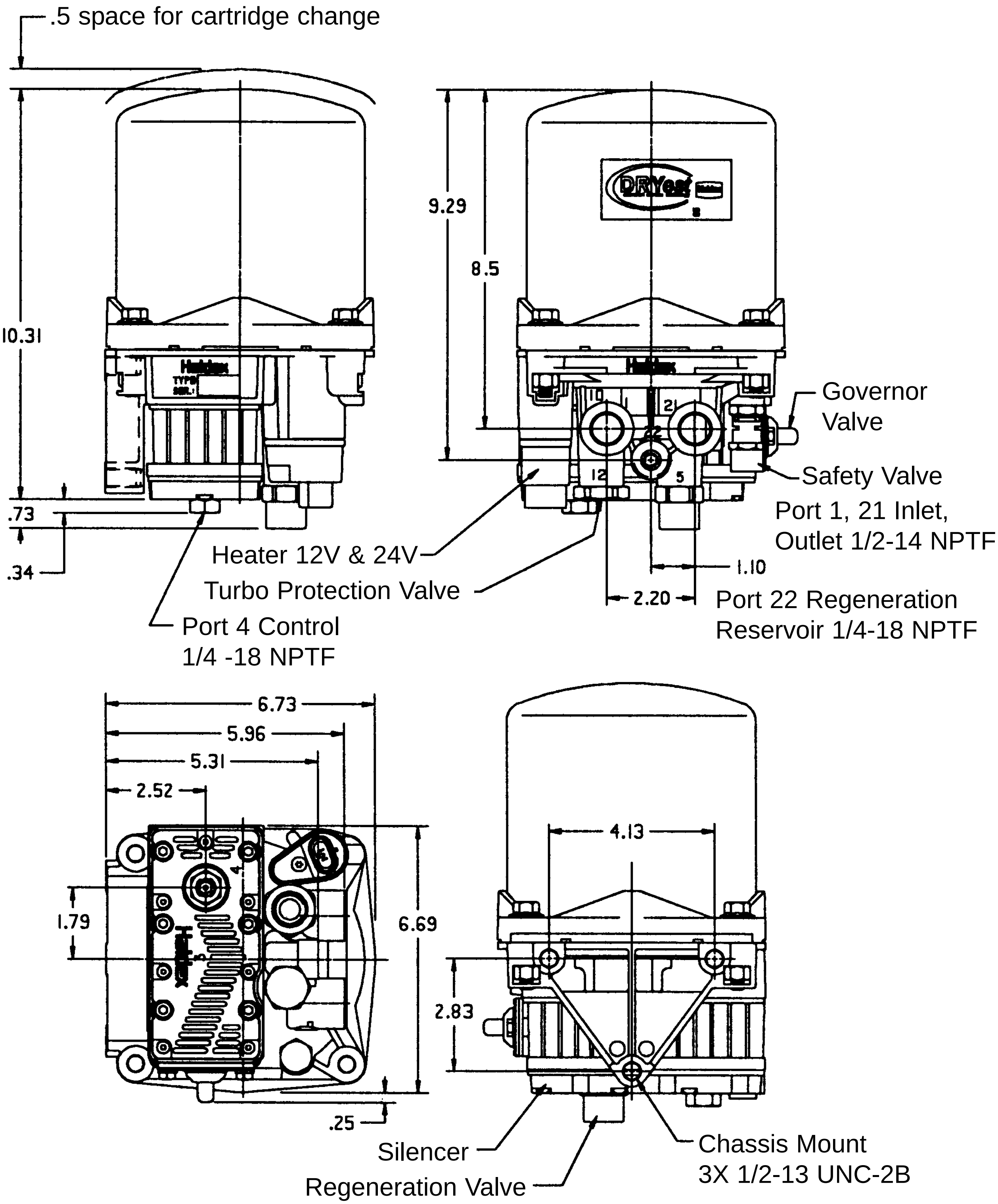
Sensor, Drive Axle (In Wheel End)

Supplier number......441 032-576-0
Prévost number...... 641095

Haldex

DRY*est* Air Dryer
Installation and Maintenance

L31166
9/02



The Haldex DRY*est* 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 DRY*est* are illustrated on the next page.

Application Schematics

FIG. 2.A. Standard System Regeneration with Integrated Governor

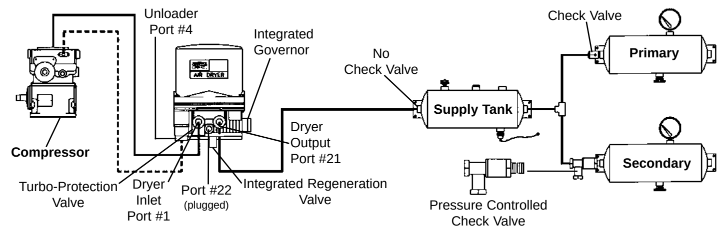


FIG. 2.B System Regeneration with External Governor

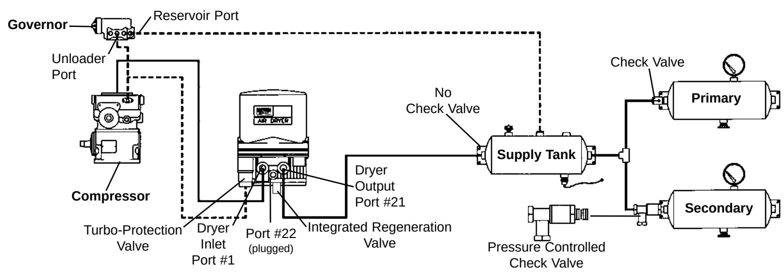


FIG. 2.C External Purge Tank Regeneration with Integrated Governor

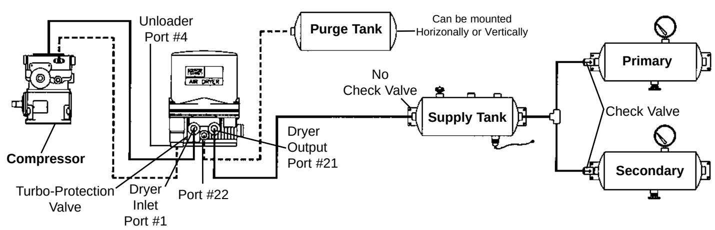


FIG. 2.D External Purge Tank Regeneration with External Governor

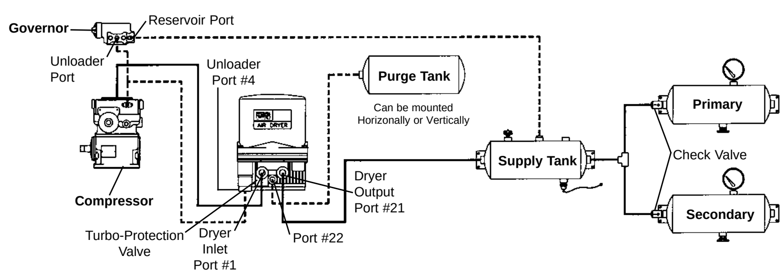


FIG. 2.E. Blow Thru: External Purge Tank with Integrated Governor

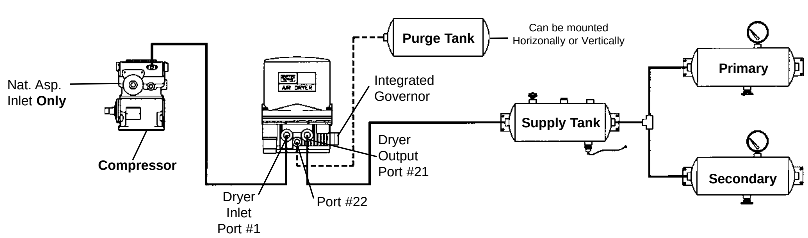
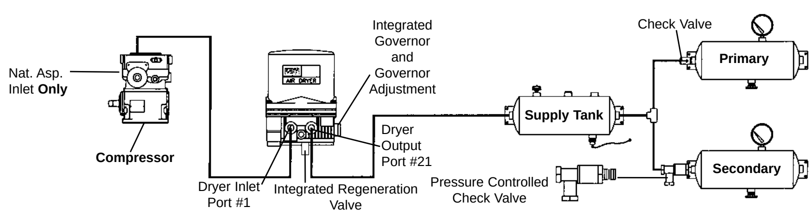


FIG. 2.F. Blow Thru: System Regeneration with Integrated Governor



Installing the DRY*est*

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 DRY*est* 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 DRY*est* 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 DRY*est* (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 DRY*est* Air Dryer discharge contaminates away from vehicle components, it will be necessary to purchase an air dryer with special hose fitting option.

Testing the DRY*est*

Before placing the vehicle in service, perform the following tests.

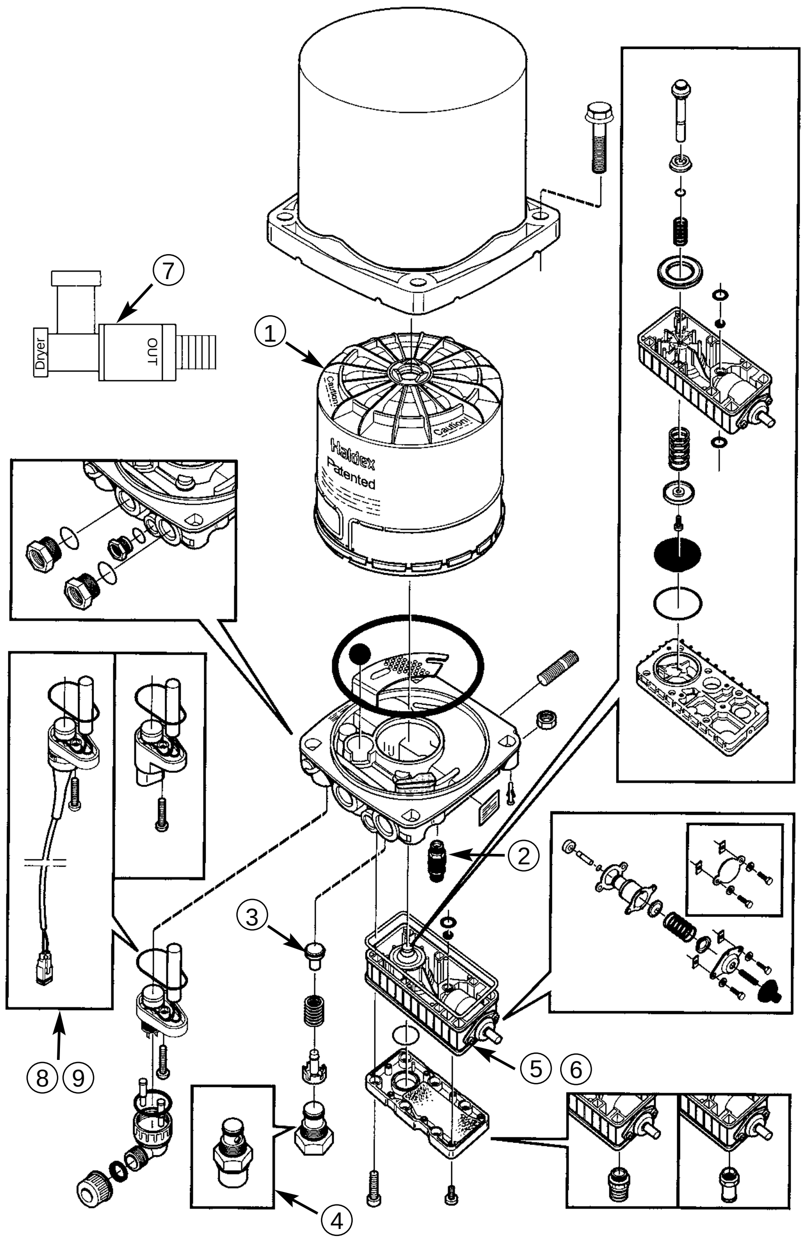
1. Close all reservoir drain cocks.
2. Build up system air pressure to governor cut-out and note that the air dryer purges with an audible exhaust of air. If system 2.E or 2.F is used, the purge will be followed by a steady pulsating flow of air indicating that the system is "unloaded" and is venting 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	1. Contaminants in desiccant. 2. Leaks in air system.	1. Change desiccant cartridge. Check compressor for excessive oil passage. 2. Tighten air connections, soap connection and recheck for leaks per Testing the DRY*est* section.
Constant exhaust of air at air dryer and not Blow-Thru Type	1. Defective dryer outlet check valve. 2. Dryer unloading valve not closing.	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	1. Excessive leaks in air system. 2. Defective dryer outlet check valve. 3. Undersize compressor, duty cycle of compressor should not exceed 25%.	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	1. Desiccant cartridge is plugged. 2. Ice block in dryer. 3. Excessive system pressure.	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	1. Air at inlet of dryer exceeds 170°F. 2. Duty cycle of compressor does not allow for sufficient time for desiccant regeneration.	1. Extend length of compressor discharge line; see Installing the DRY*est* 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	1. Air at inlet of dryer exceeds 170°F.	1. Extend length of compressor discharge line; see Installing the DRY*est* 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)

Haldex

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9/02 1M ART L31166

AlliedSignal
Bendix

Service Data

R-12 & R-14 RELAY VALVES

* FORMERLY SD-03-31

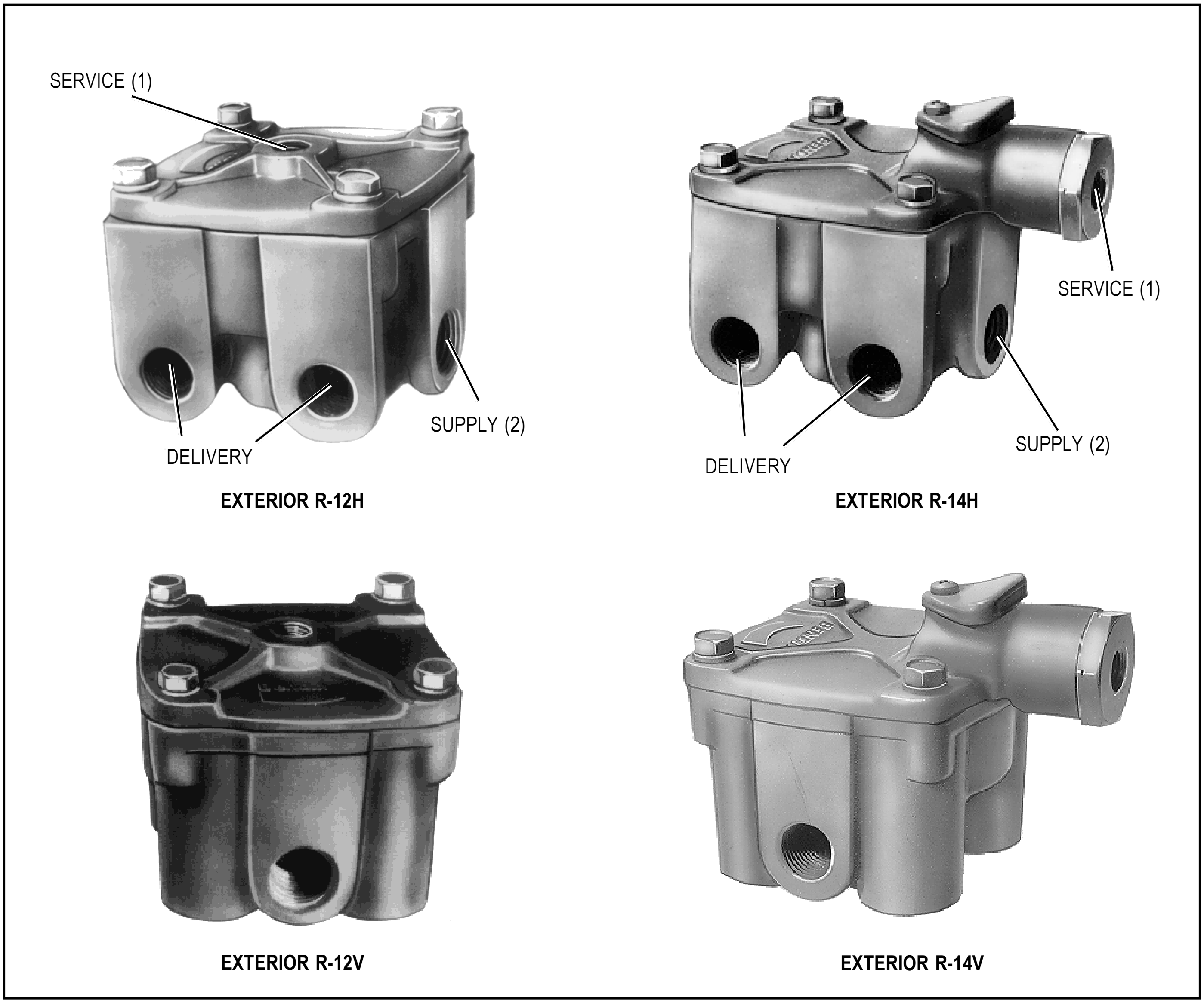


*FIGURE 1 - **EXTERIOR VIEWS***

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

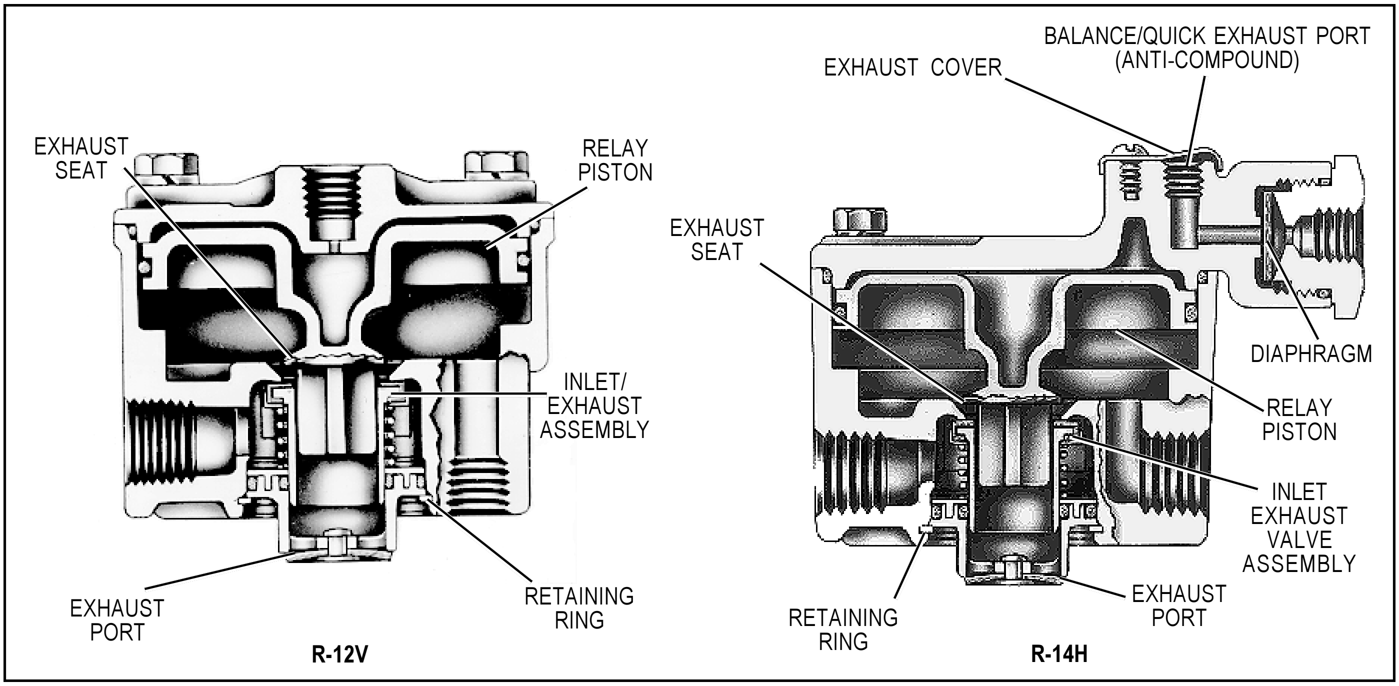


*FIGURE 2 - **SECTIONAL VIEWS***

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.

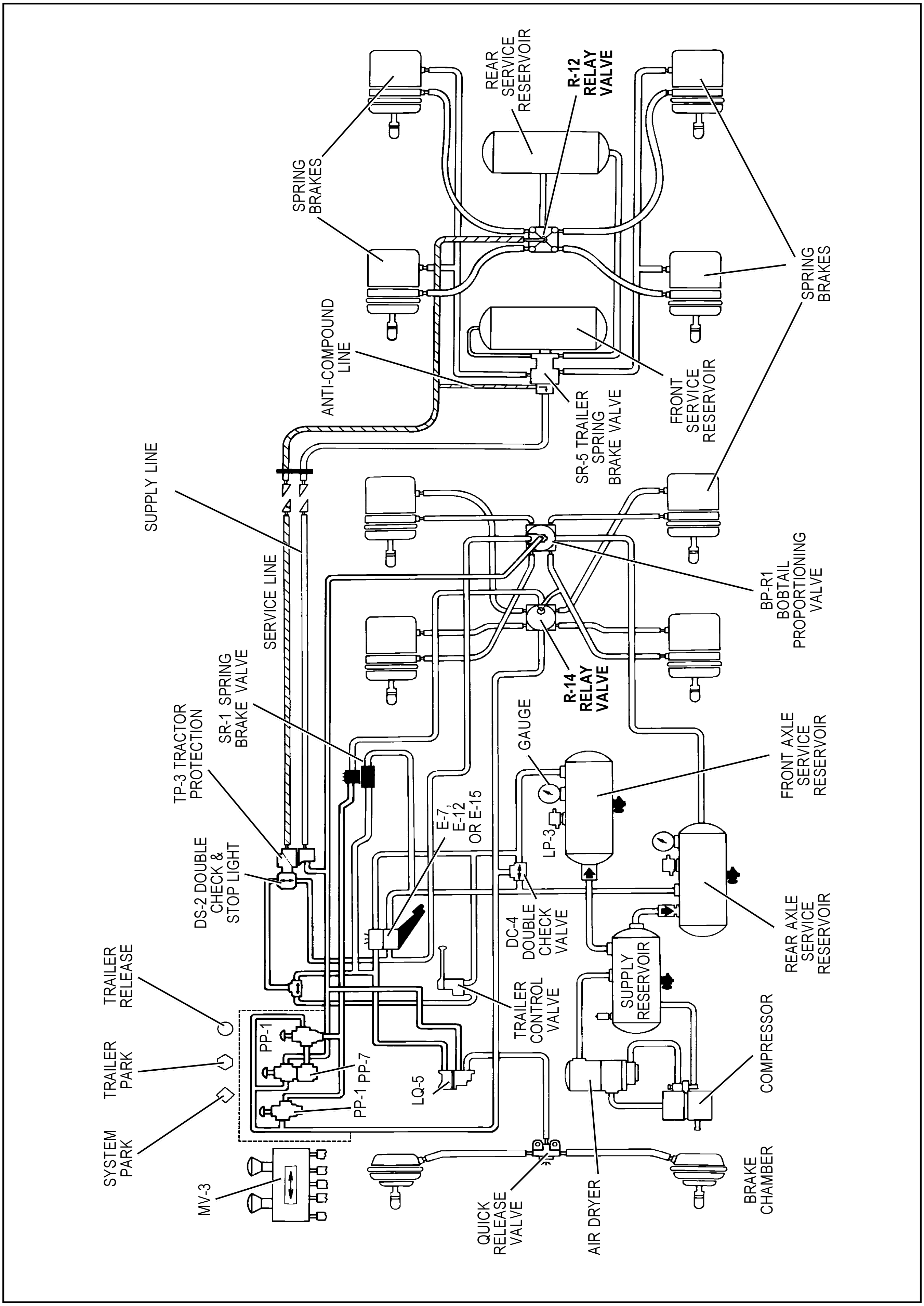


FIGURE 3 - TYPICAL PIPING SCHEMATIC

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 at tempted 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.**

AlliedSignal Bendix

Service Data

SD-03-2010*

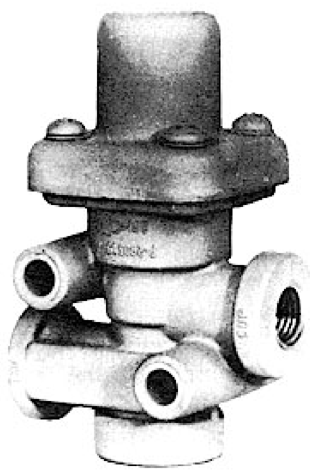
PRESSURE PROTECTION VALVES

*Formerly SD-03-55

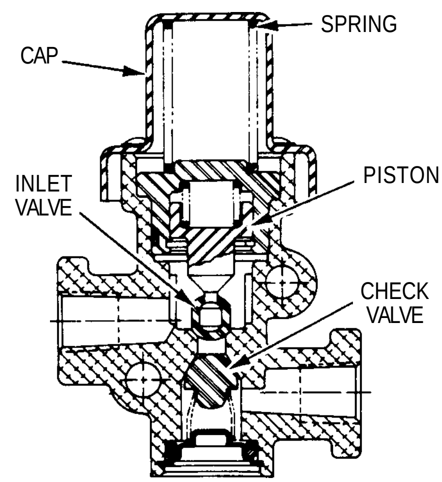
DESCRIPTION

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.

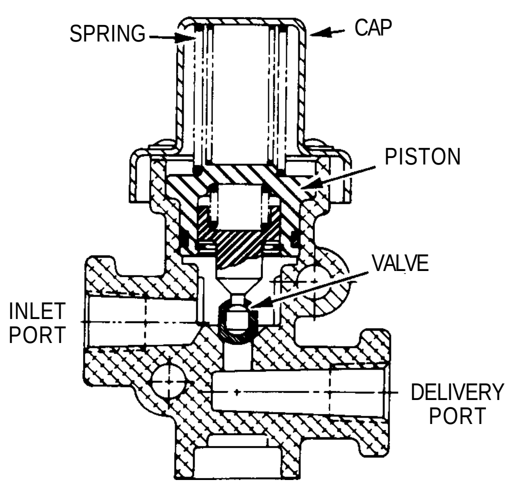
The PR-2 and PR-4 pressure protection valves have one 1/4" N.P.T.F. supply port and one 1/4" N.P.T.F. delivery port which are identified. Both valves are provided with two 9/32" mounting holes through the body. The closing pressure of the PR-2 is externally adjustable while the PR-4 has a fixed setting.



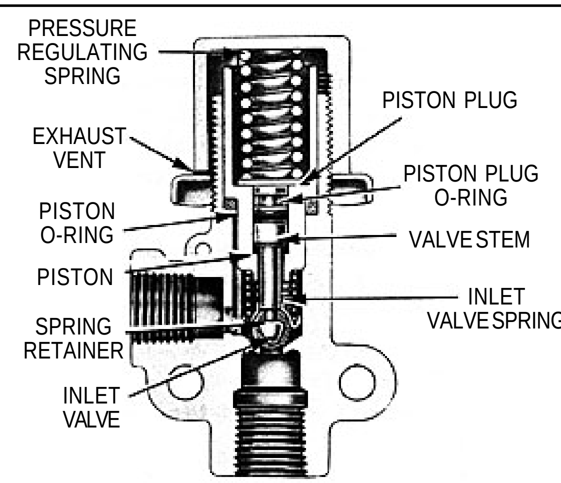
PR-3 OR PR-4



PR-3



PR-4



PR-2

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 if 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 permissable 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.

AlliedSignal
Bendix™

Service Data

SD-03-2202*

DOUBLE CHECK VALVES

*FORMERLY SD-03-67

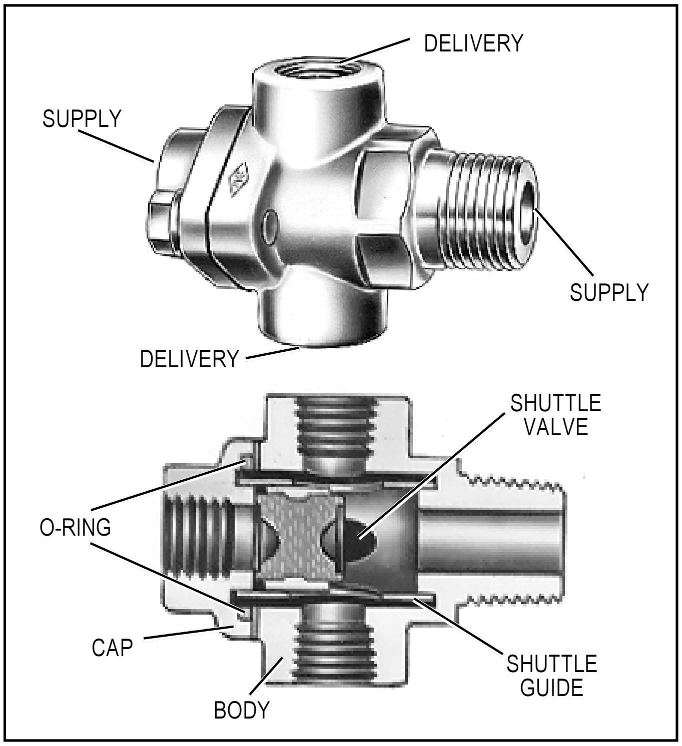


*FIGURE 1 - **DOUBLE CHECK VALVE (SHUTTLE TYPE)***

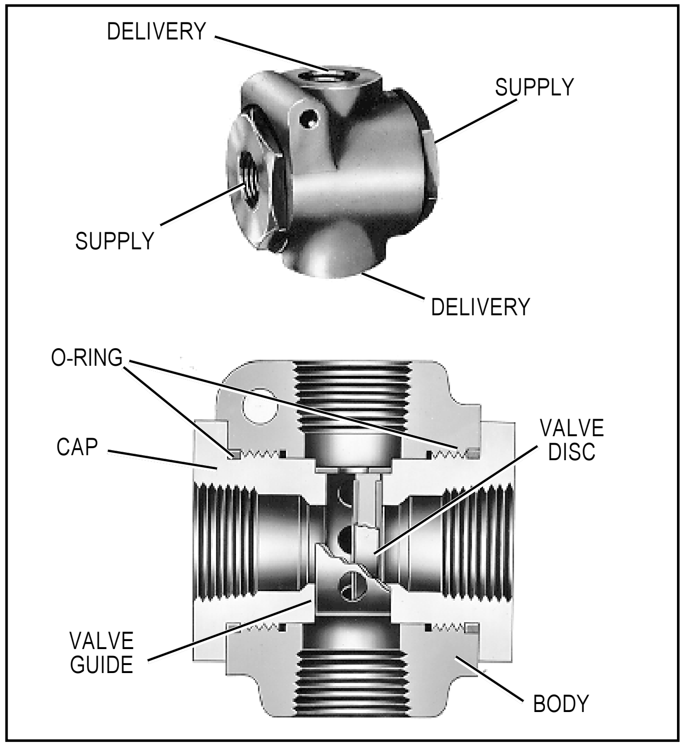


*FIGURE 2 - **DOUBLE CHECK VALVE (DISC TYPE)***

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.

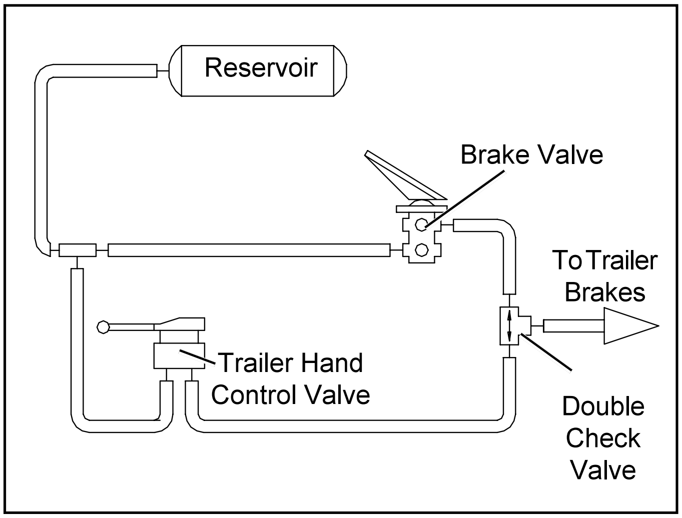


*FIGURE 3 - **DOUBLE CHECK VALVE: CONTROL OF SYSTEM FROM EITHER OF TWO CONTROL SOURCES***

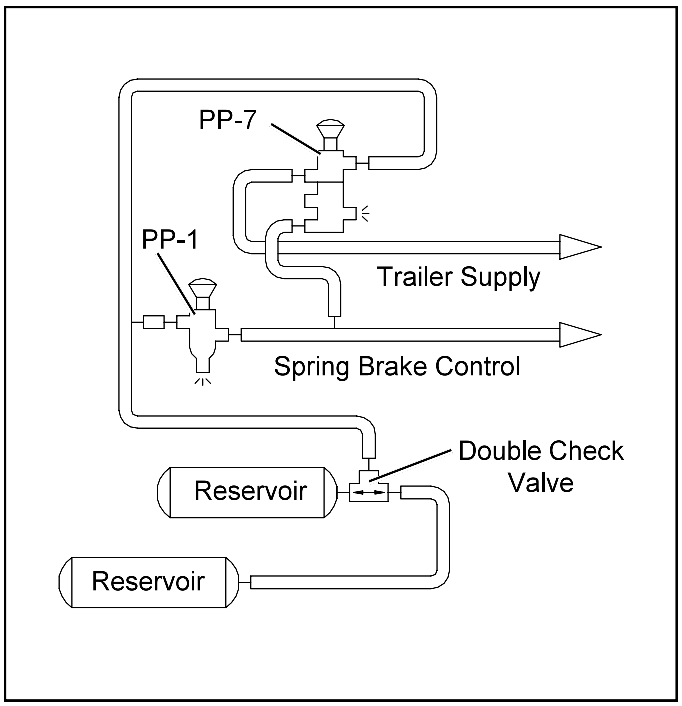


*FIGURE 4 - **DOUBLE CHECK VALVE: SYSTEM WITH TWO SUPPLY SOURCES***

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.**

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Service Data

SD-03-3602*

TW-1, TW-3, TW-4, TW-5 & TW-6 CONTROL VALVES

*Formerly SD-03-64

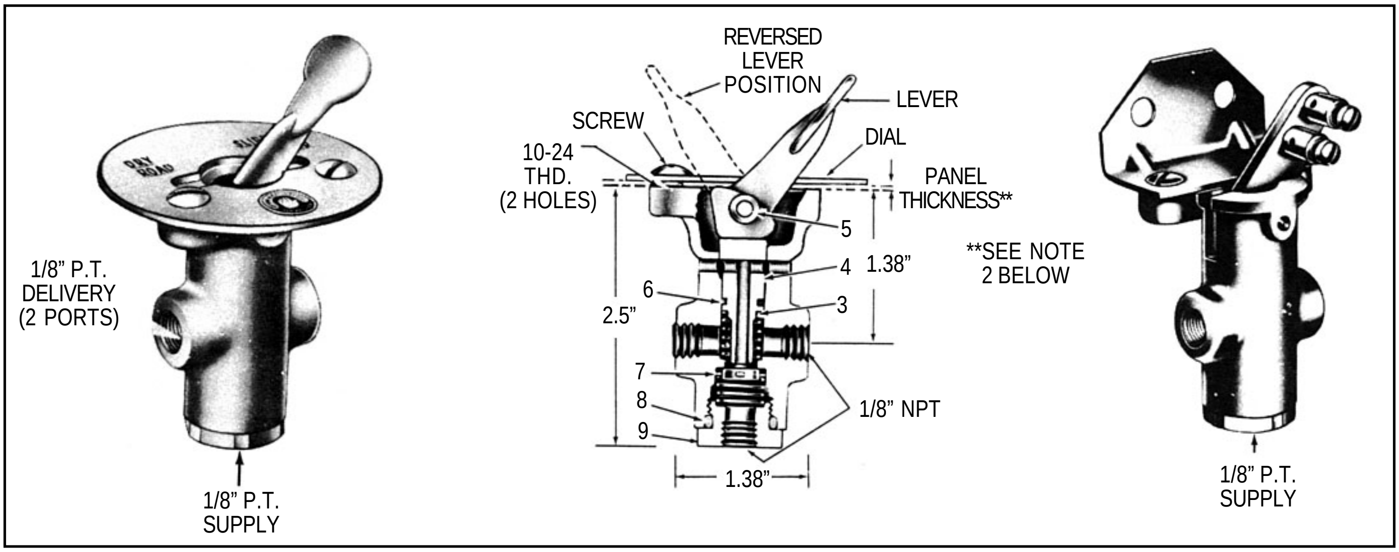

FIGURE 1 - TW-1

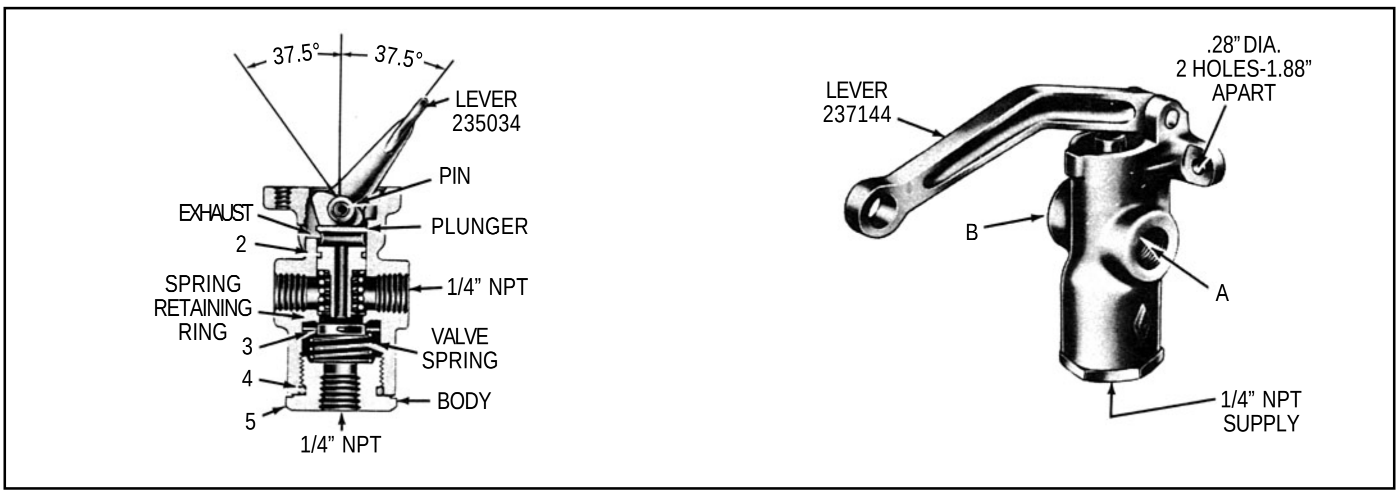

FIGURE 2 - TW-3

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.

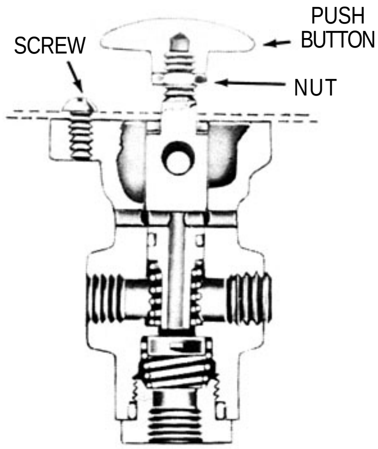

FIGURE 3 - TW-4

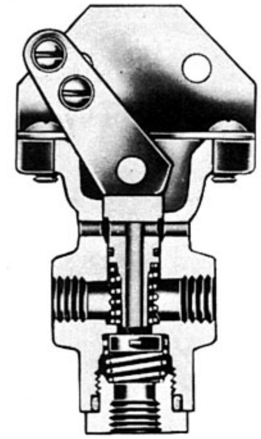

FIGURE 4 - TW-6

OPERATION

With air pressure a 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.

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 0-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.

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Service Data

SD-03-3611*

PUSH-PULL TYPE CONTROL VALVES: PP-1, PP-2, PP-5, PP-8, & RD-3

*FORMERLY SD-03-61

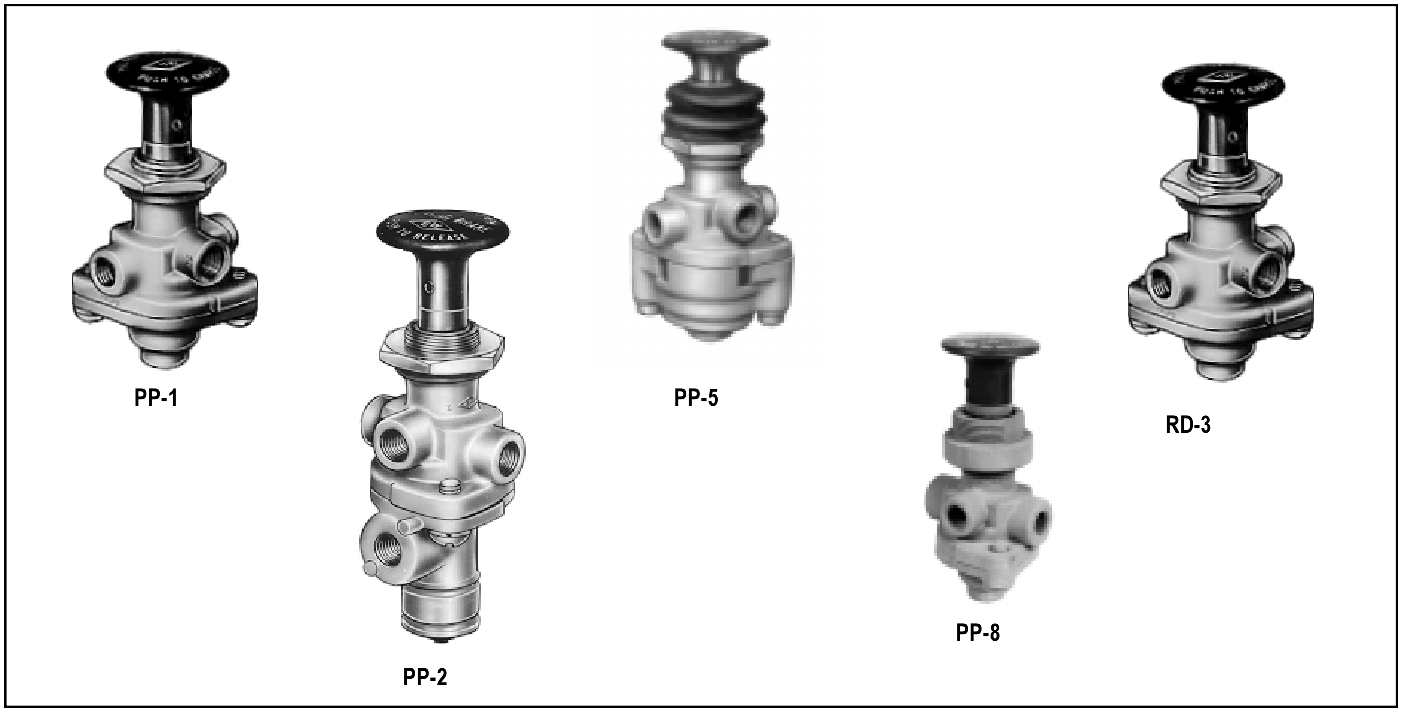


*FIGURE 1 - **PUSH-PULL TYPE CONTROL VALVES***

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.**

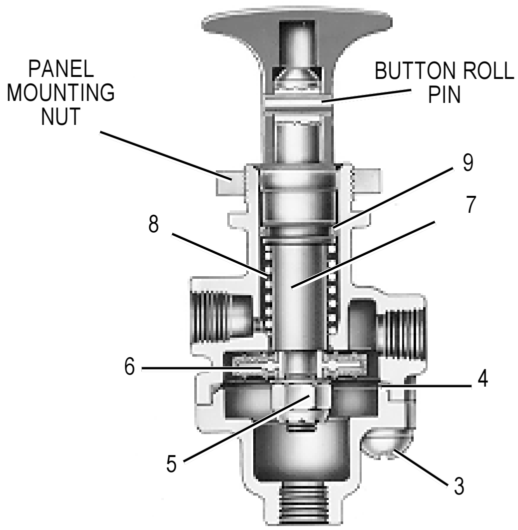


FIGURE 2 **PP-1**

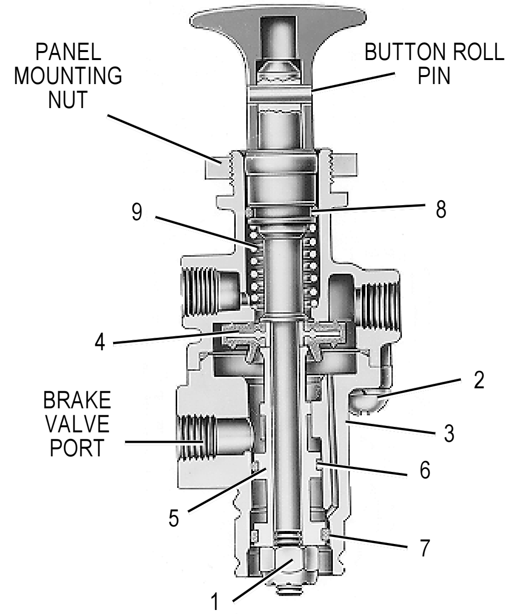
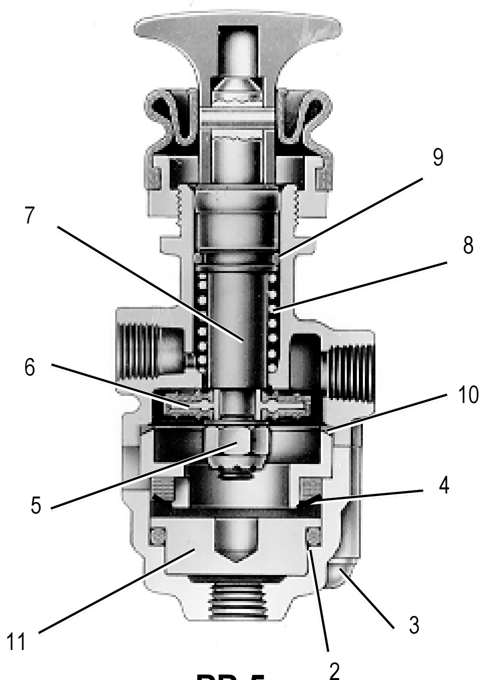
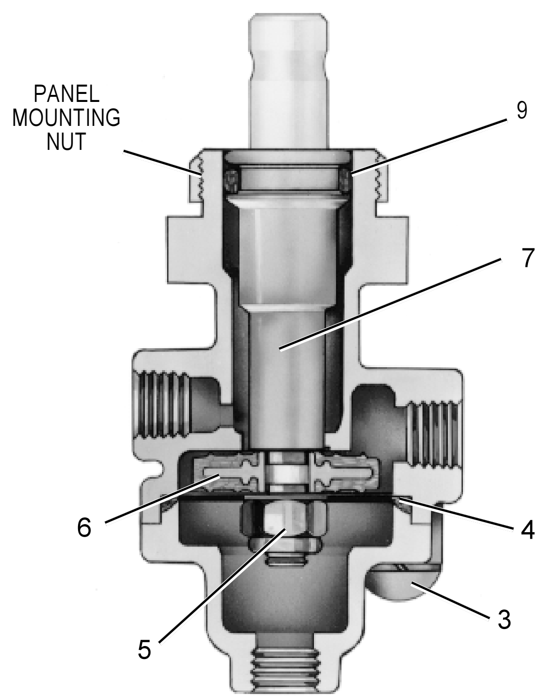


FIGURE 3 **PP-2**



PP-5

FIGURE 4

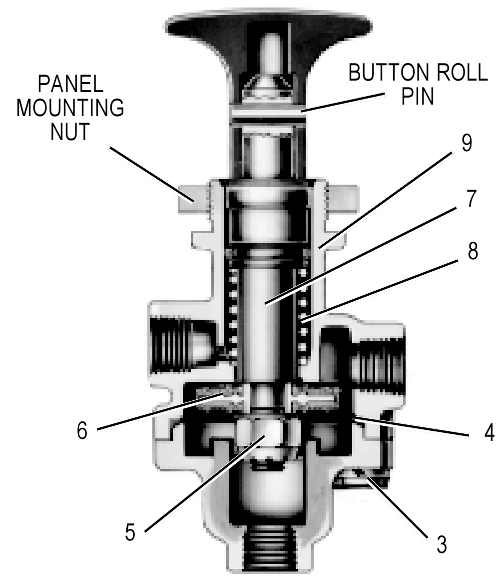


PP-8

FIGURE 5

3. **If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning <u>any</u> 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, <u>extreme caution</u> 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.



RD-3

FIGURE 6

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Service Data

E-8P & E-10P DUAL BRAKE VALVES

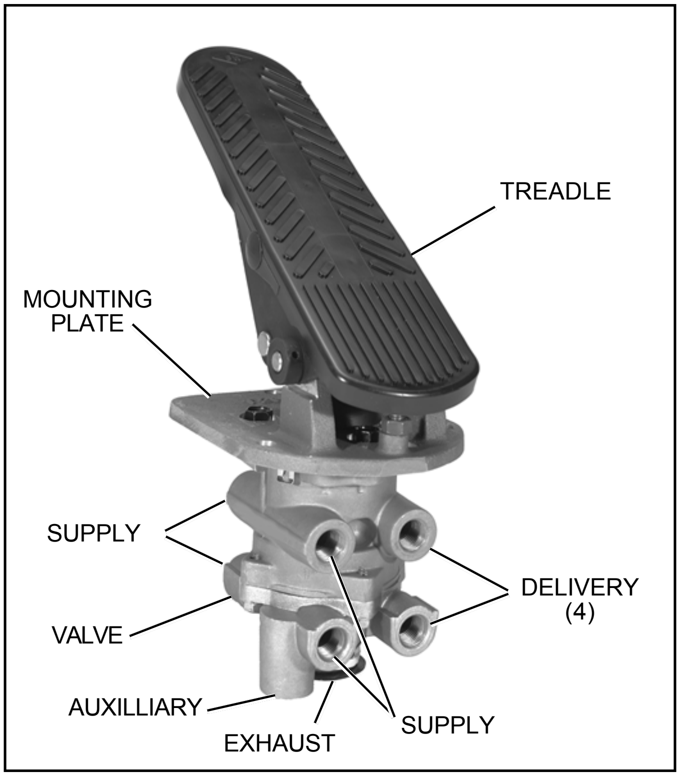

*FIGURE 1 - **E-8P***

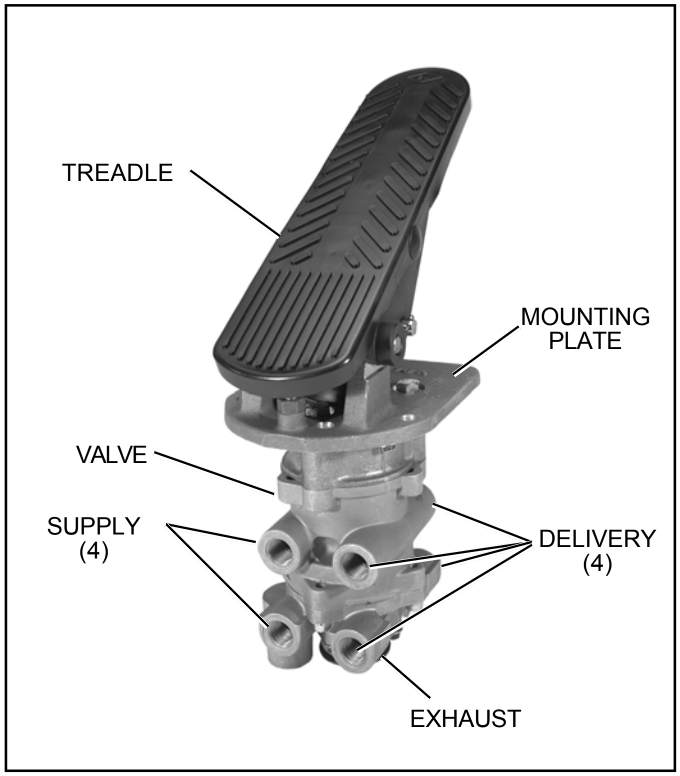

*FIGURE 2 - **E-10P***

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.

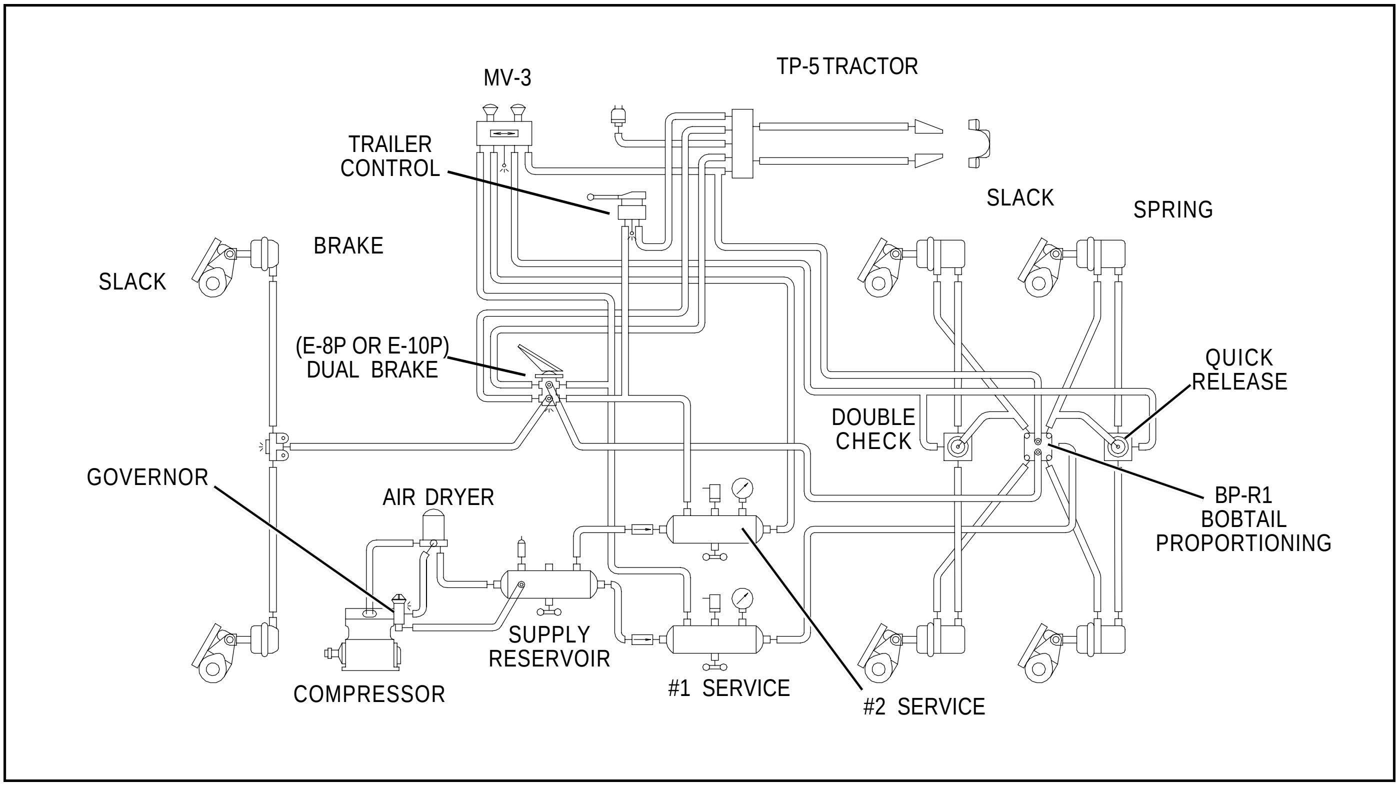

FIGURE 3 - ***TYPICAL PIPING SCHEMATIC***

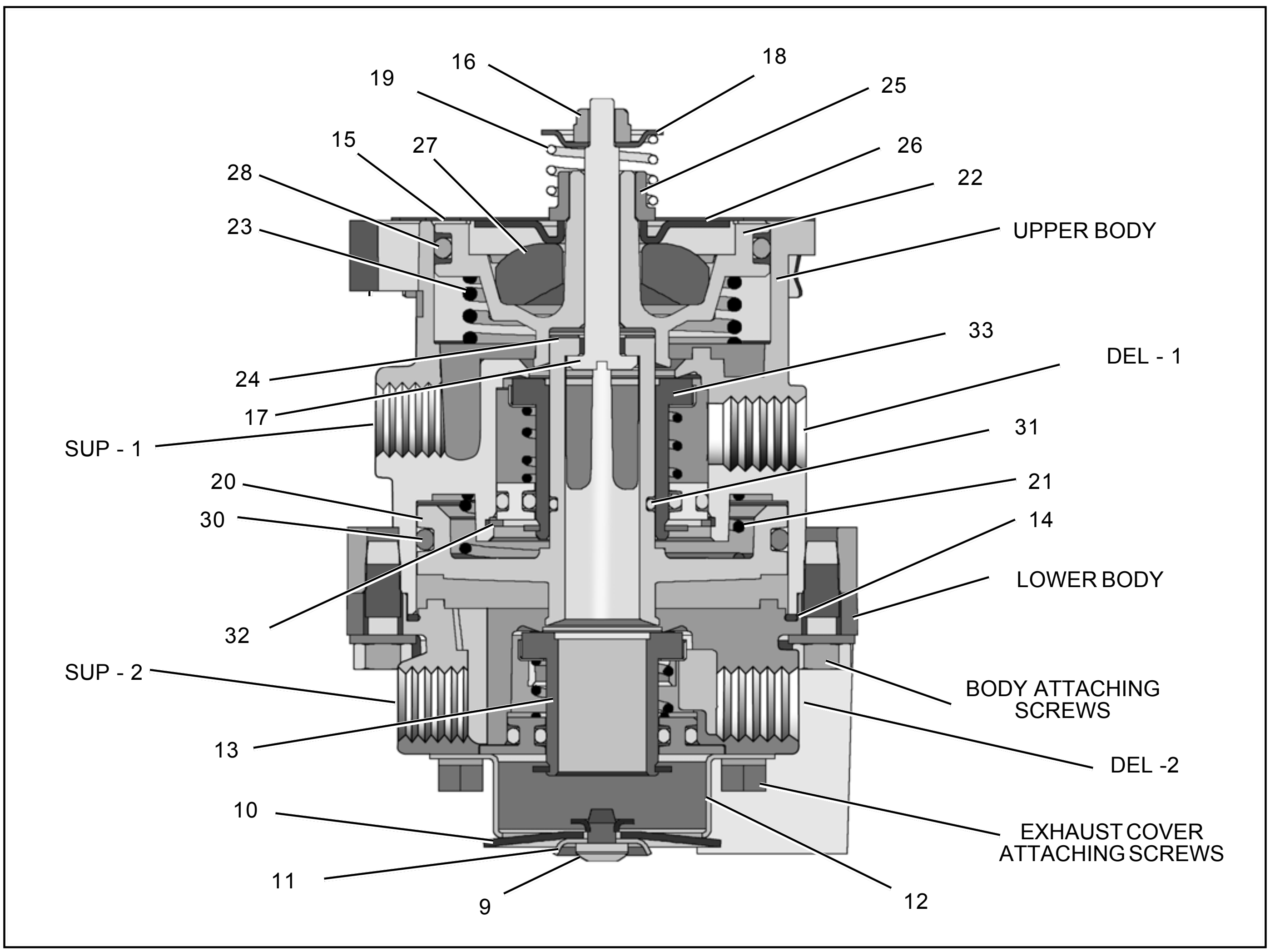

FIGURE 4 - ***E-8P SECTIONAL VIEW***

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).

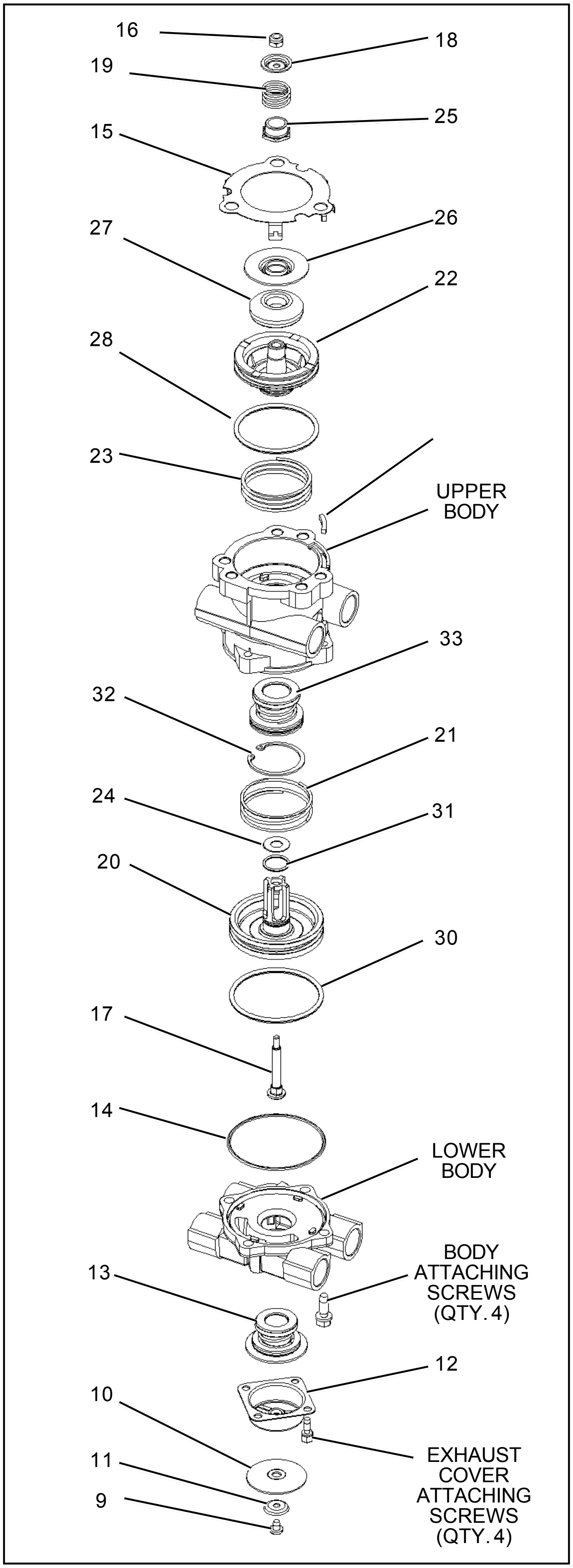

FIGURE 5 - ***E-8P BRAKE VALVE - EXPLODED VIEW***

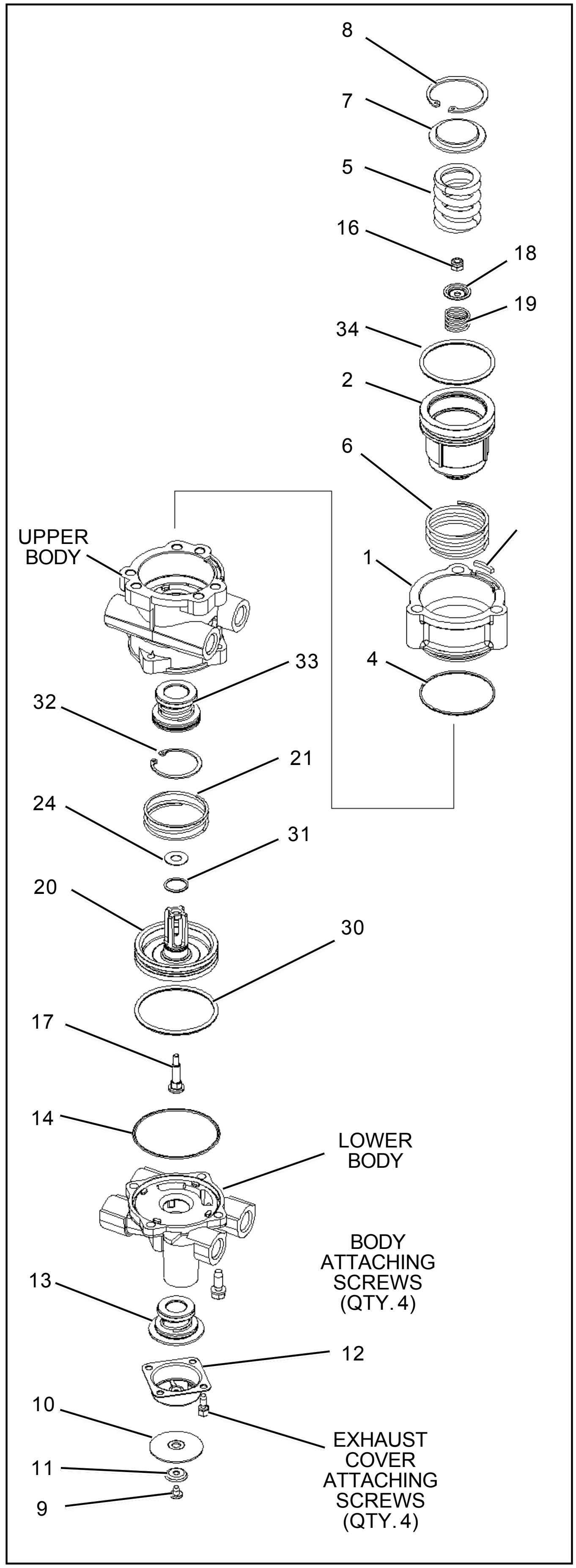

FIGURE 6 - ***E-10P BRAKE VALVE - EXPLODED VIEW***

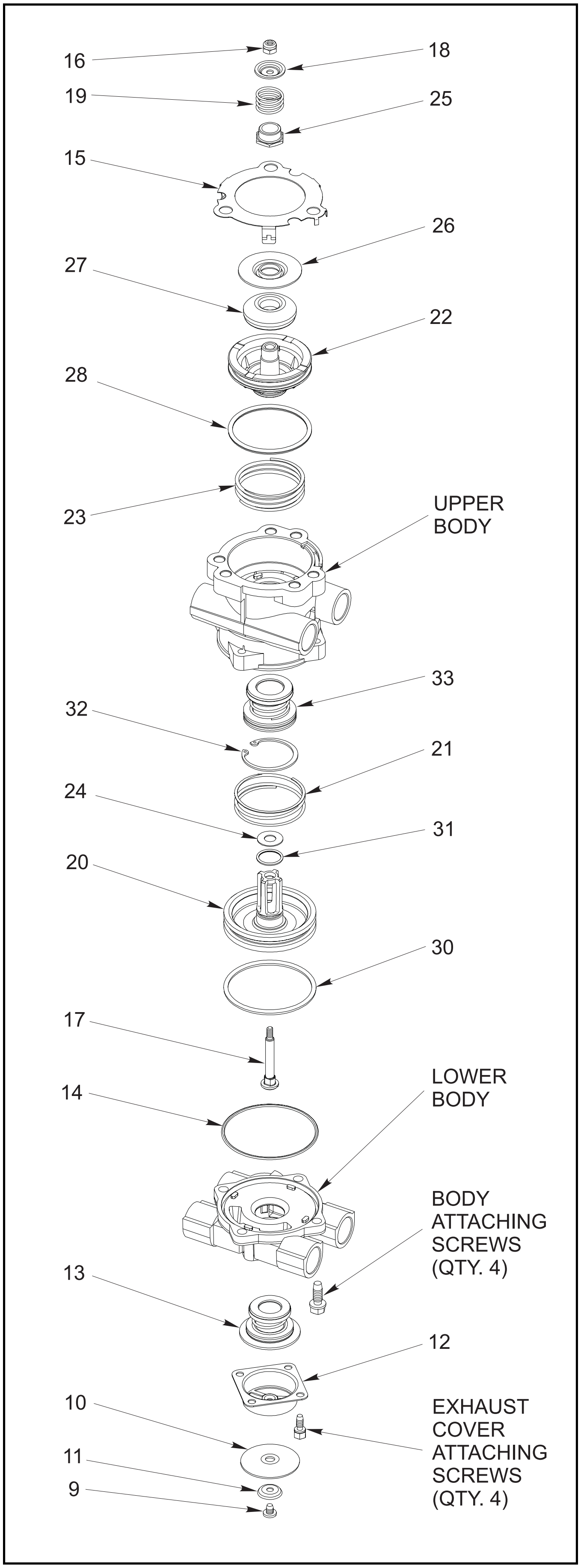

*FIGURE 5 - **E-8P BRAKE VALVE - EXPLODED VIEW***

*FIGURE 5 - **E-8P BRAKE VALVE - EXPLODED VIEW***

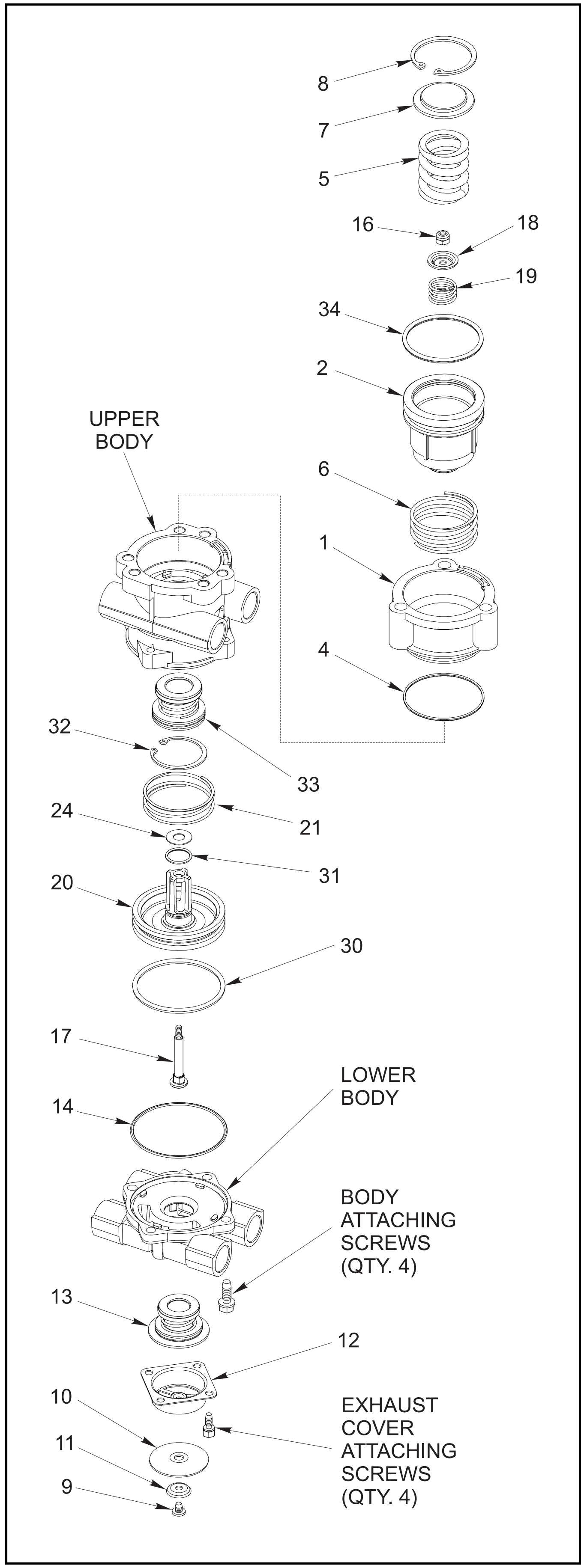

*FIGURE 6 - **E-10P BRAKE VALVE - EXPLODED VIEW***

*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.

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.
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).
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.**

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Service Data

SD-03-901*

QR AND QR-1 QUICK RELEASE VALVES

*Formerly SD-03-69

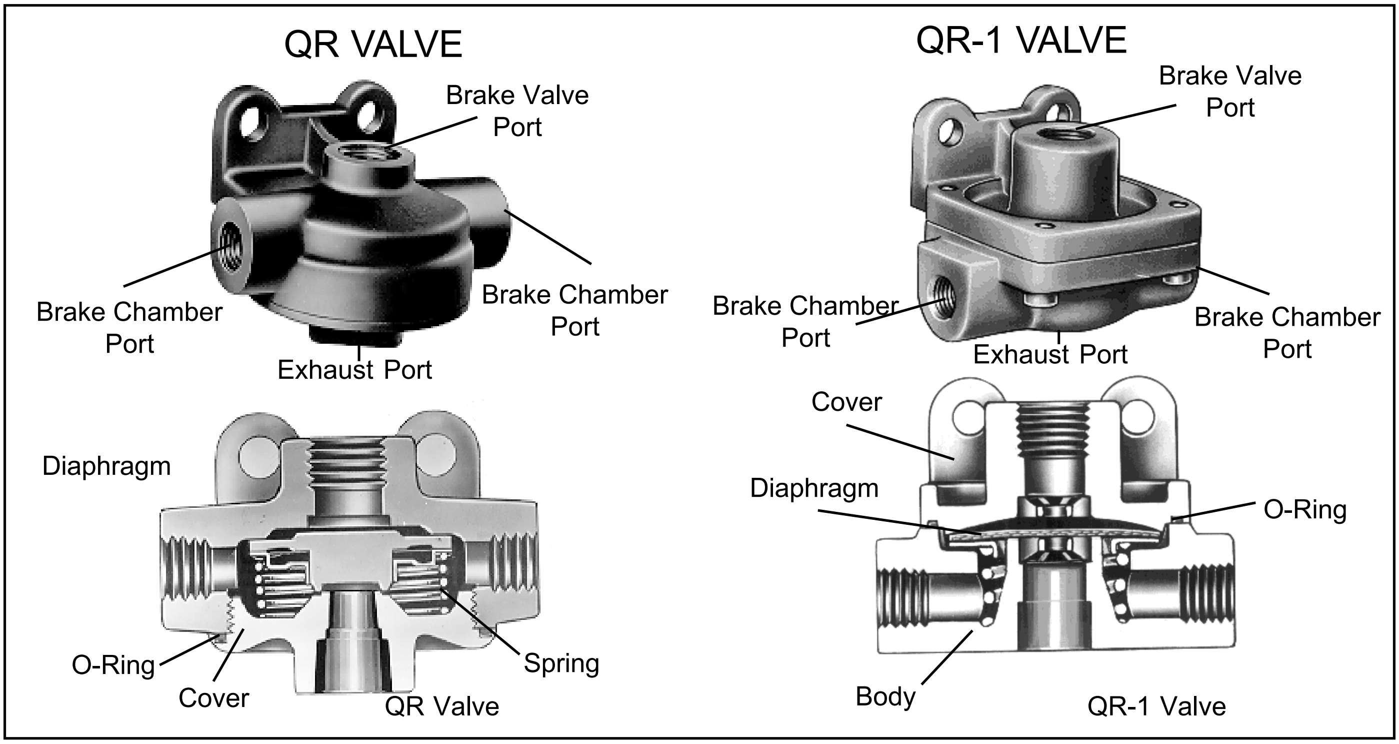

FIGURE 1

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.
c. 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.

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Service Data

SD-06-1600*

LOW PRESSURE INDICATORS

*Formerly SD-06-2

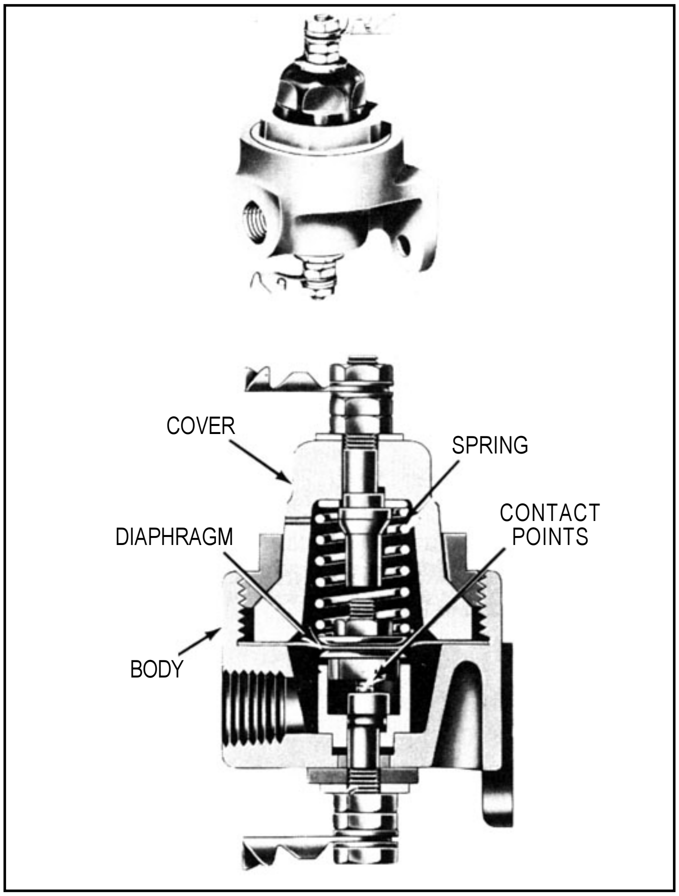


FIGURE 1 - LP-2

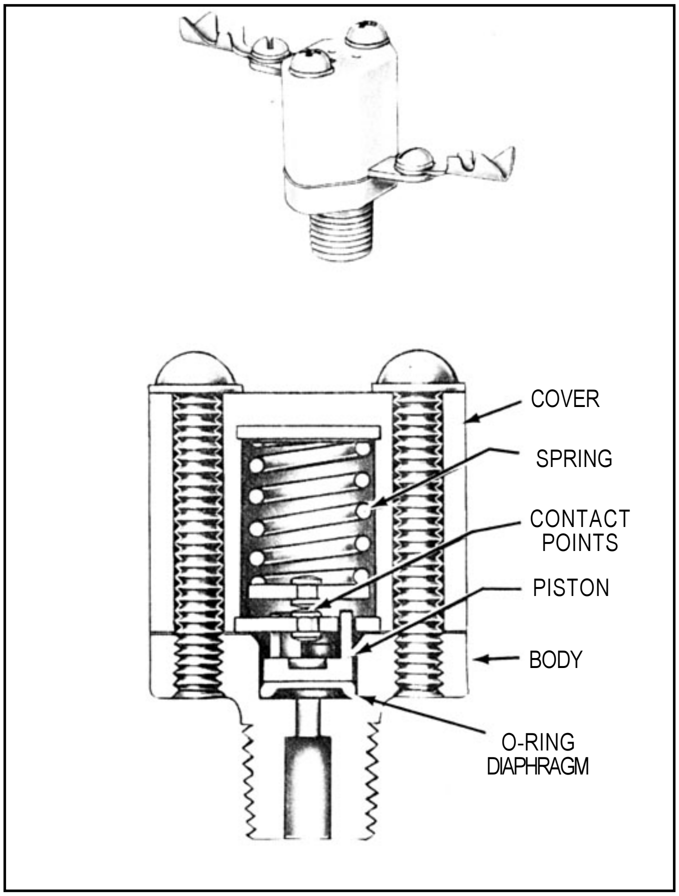


FIGURE 2 - LP-3

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 available with either one terminal or two. The single terminal unit utilizes a metallic gasket between body and case to ground the lower contract 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 <u>ANY</u> 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, <u>EXTREME CAUTION</u> 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.

Bendix™

Service Data

BA-921BENDIX AIR POWER COMPRESSOR

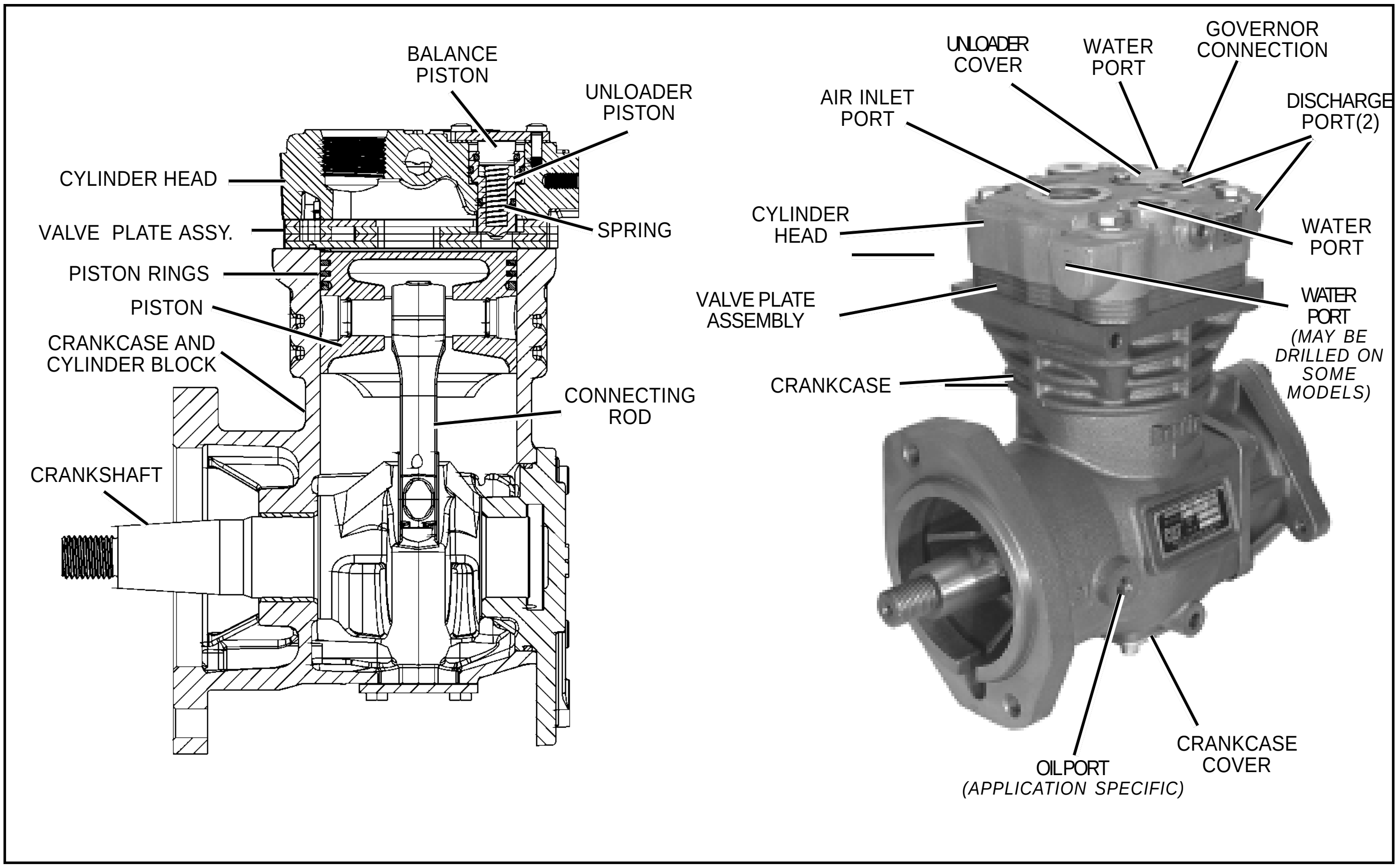


FIGURE 1 - BA-921 COMPRESSOR

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.

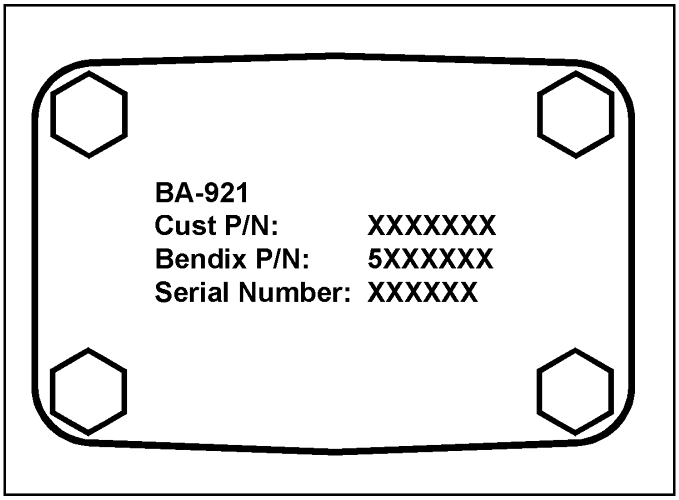


FIGURE 2 - BA-921 CRANKCASE COVER

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.

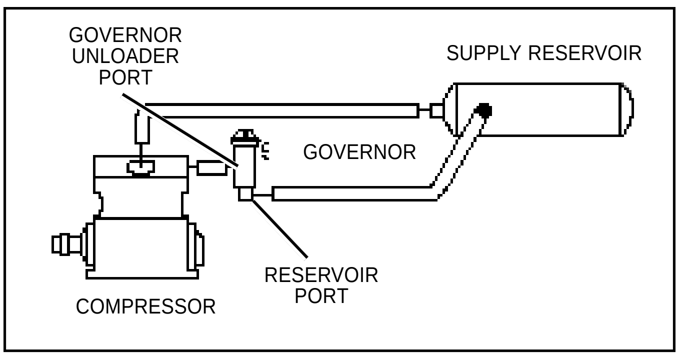


FIGURE 3 - BA-921 COMPRESSOR UNLOADER SYSTEM

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

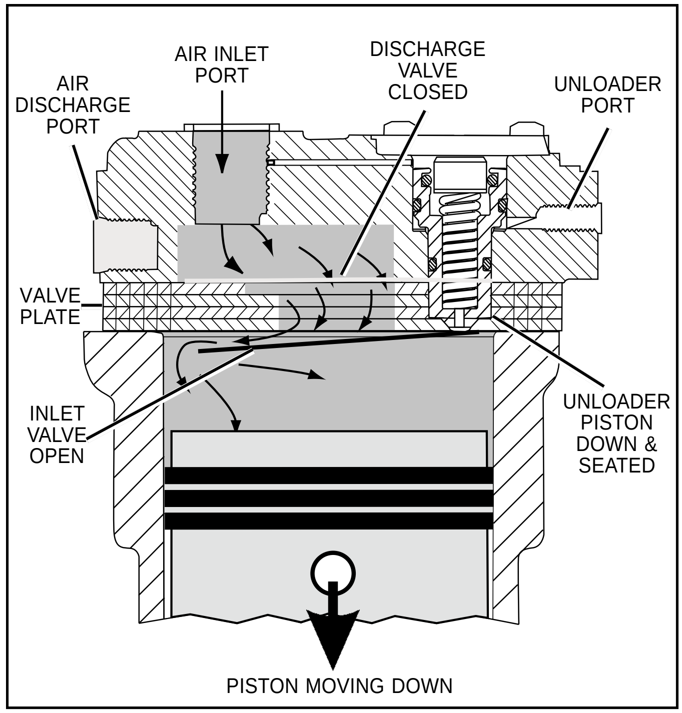


FIGURE 4 - OPERATIONAL-LOADED (INTAKE)

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.

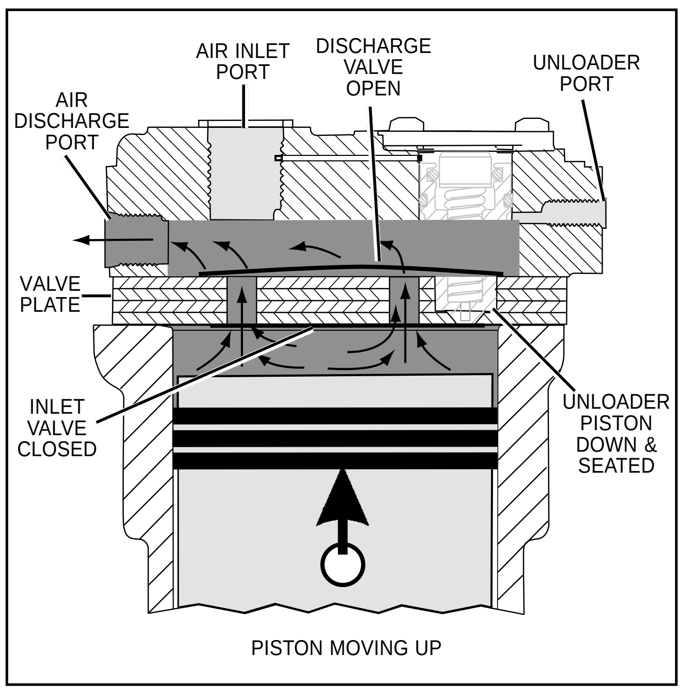


FIGURE 5 - OPERATIONAL-LOADED (COMPRESSION)

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

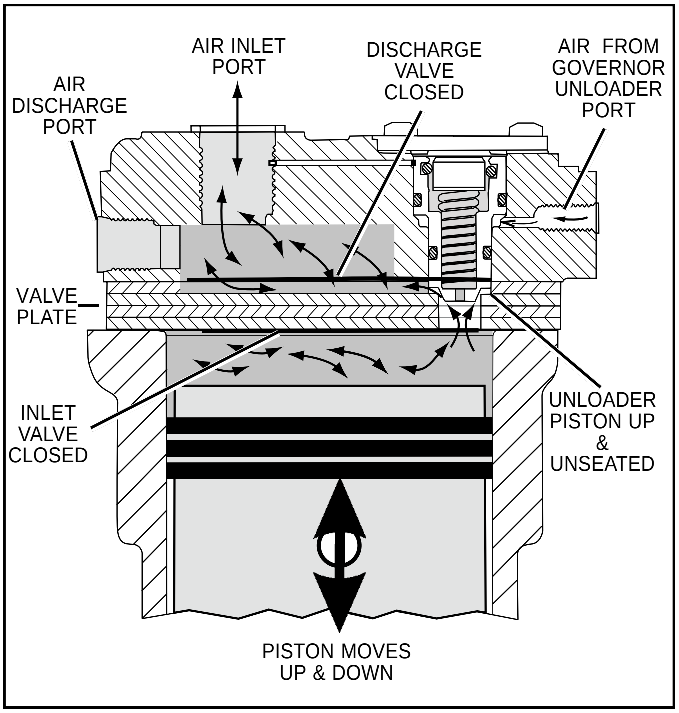


FIGURE 6 - OPERATIONAL-UNLOADED

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

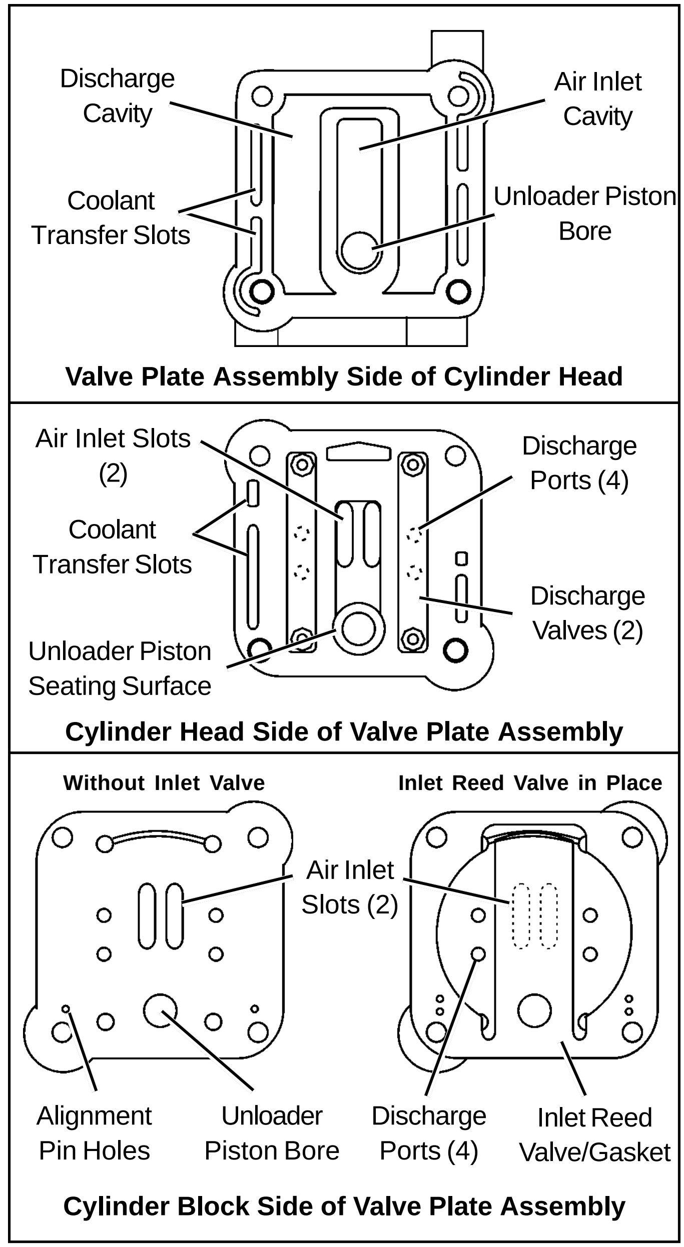


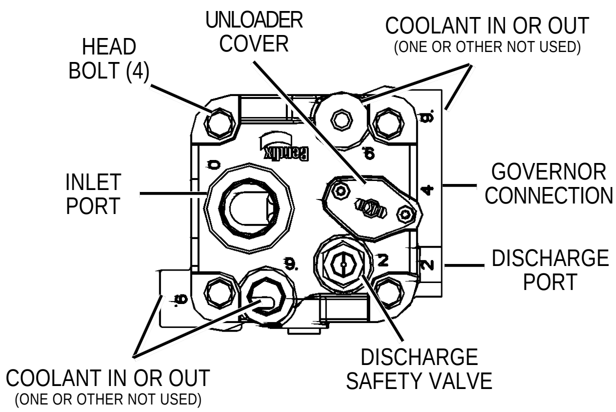
FIGURE 7 - CYLINDER HEAD AND VALVE PLATE ASSY.

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.



CYLINDER HEAD PORT IDENTIFICATION

The cylinder head connection ports are identified with cast in numerals as follows:

Atmospheric AIR IN	0
Compressed AIR OUT	2
Coolant IN or OUT	9
Governor Control	4

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 dyer, 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

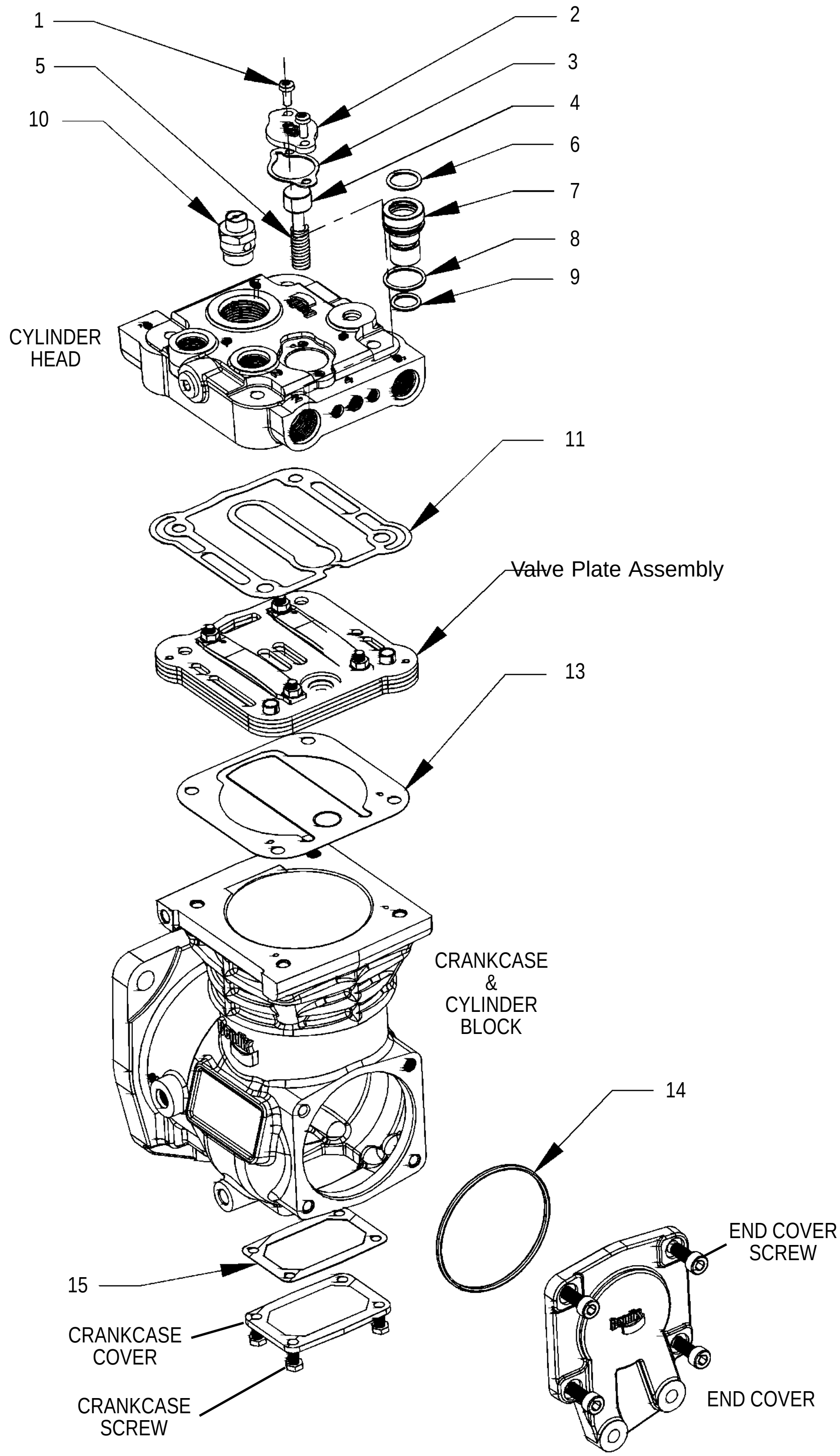
Remove the balance of road dirt and grease from the exterior of the compressor with a cleaning solvent. Mark the rear end cover or end cover adapter in relation to the crankcase. It is recommended but not specifically necessary to mark the relationship of the cylinder head to the valve plate assembly 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

4. Remove the balance piston (4) and its spring (5) from the cylinder head.
5. Remove the four hex head bolts and washers from the cylinder head.
6. 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.
7. Remove the metal reed valve/gasket (13).
8. 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).
9. 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

1. 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

1. Remove the four end cover cap screws that secure the rear end cover or end cover adapter to the crankcase.
2. 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

1. 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.
2. 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.
3. 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.
4. Check the threads in all cylinder head ports for galling. Minor chasing is permitted.
5. 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

1. Carefully inspect the cylinder head gasket surfaces for deep gouges and nicks. If detected, the compressor must be replaced.
2. 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.
3. 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

1. 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: $\frac{\text{12 Inch Pounds}}{12}$ = 1 Foot Pound

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

[1]Note: 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: 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 cool ant 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 as sure the proper antifreeze mixture reaches the compressor.
	C. Faulty compressor (porous castings).	C. If casting porosity is detected, replace the com-pressor.
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.

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Service Data

SD-03-9043

SR-7 SPRING BRAKE MODULATING VALVE

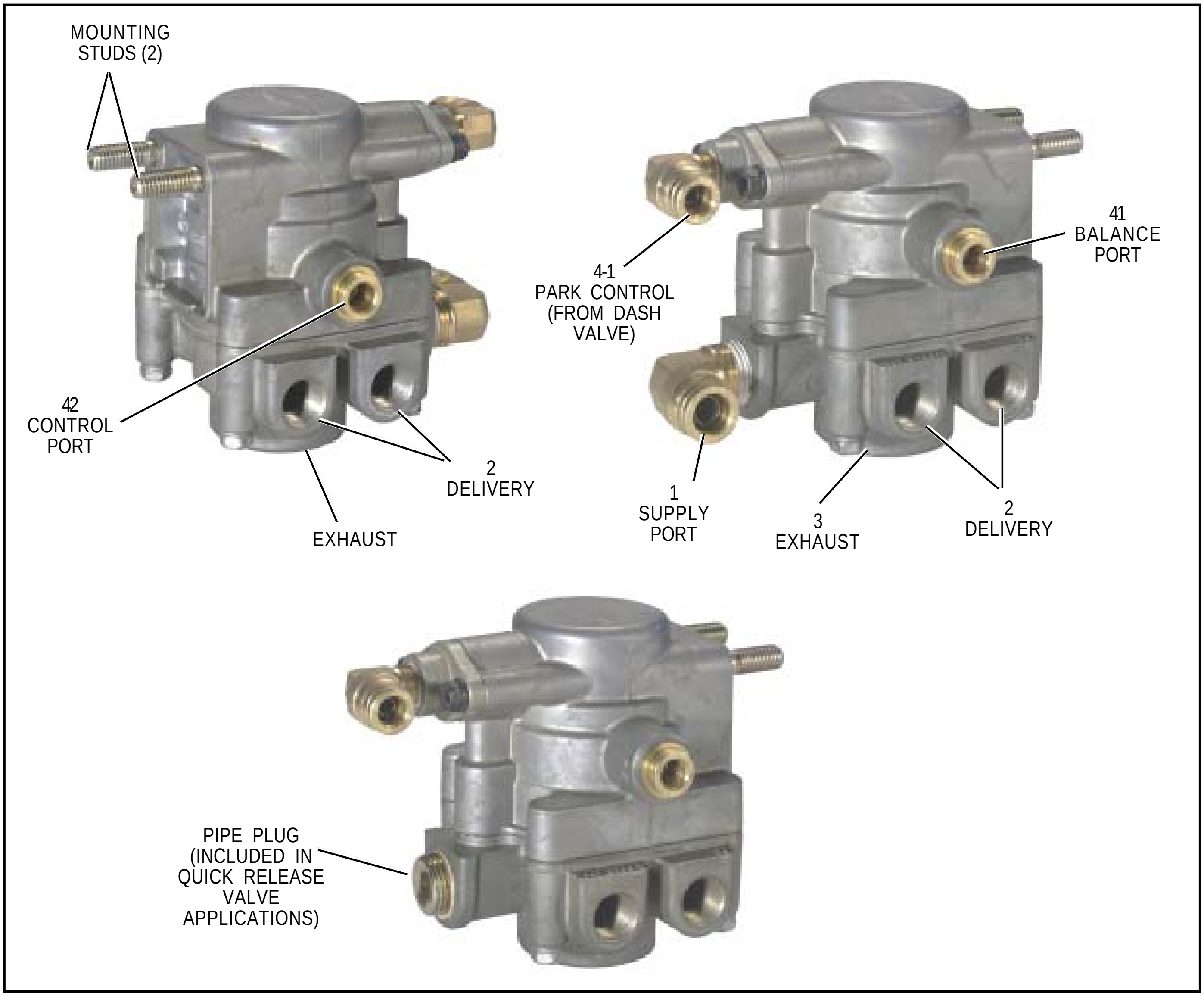


FIGURE 1 - EXTERIOR VIEW

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).

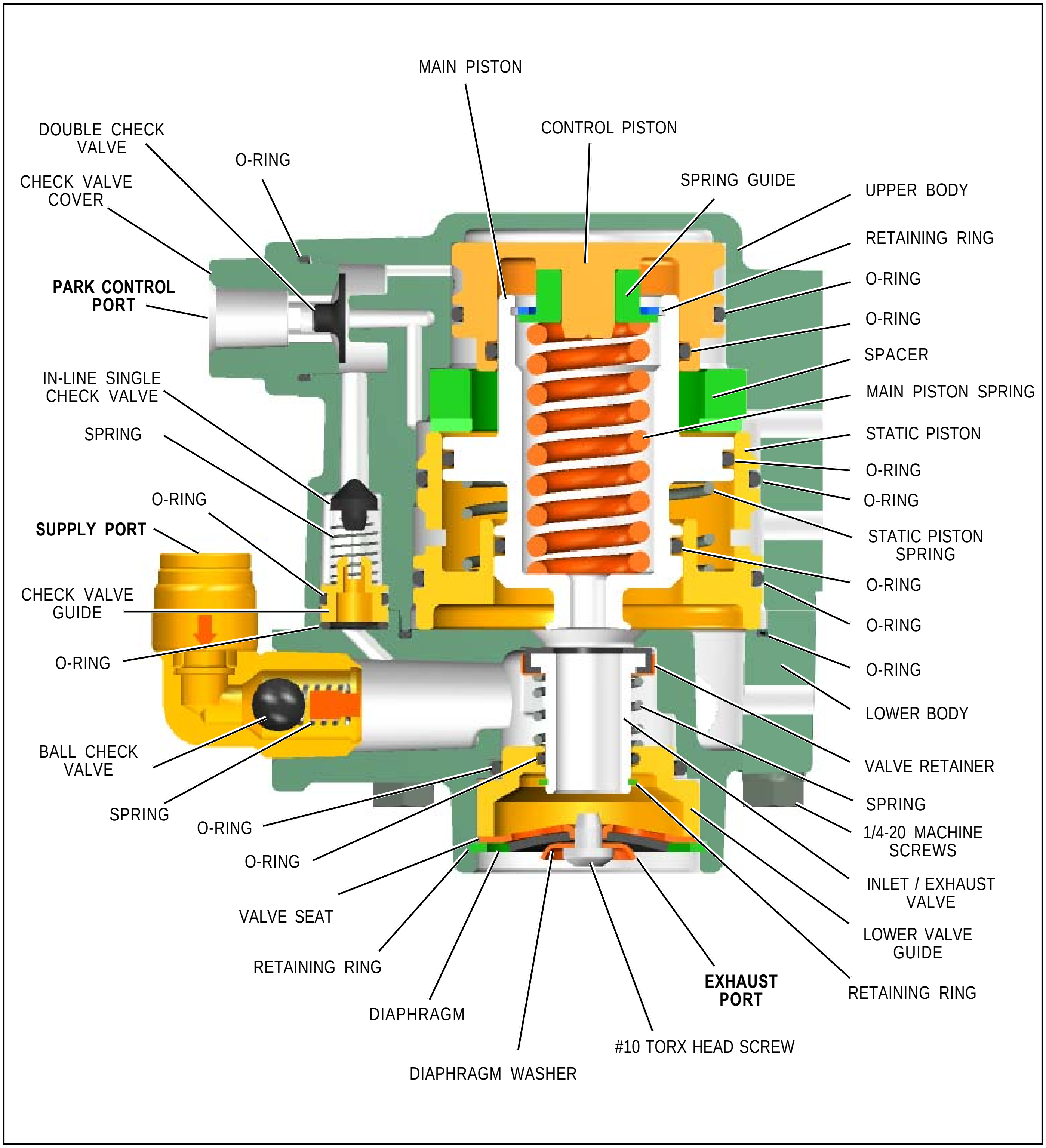


FIGURE 2 - SECTIONAL VIEW OF SR-7 USED IN RELAY VALVE APPLICATIONS

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.

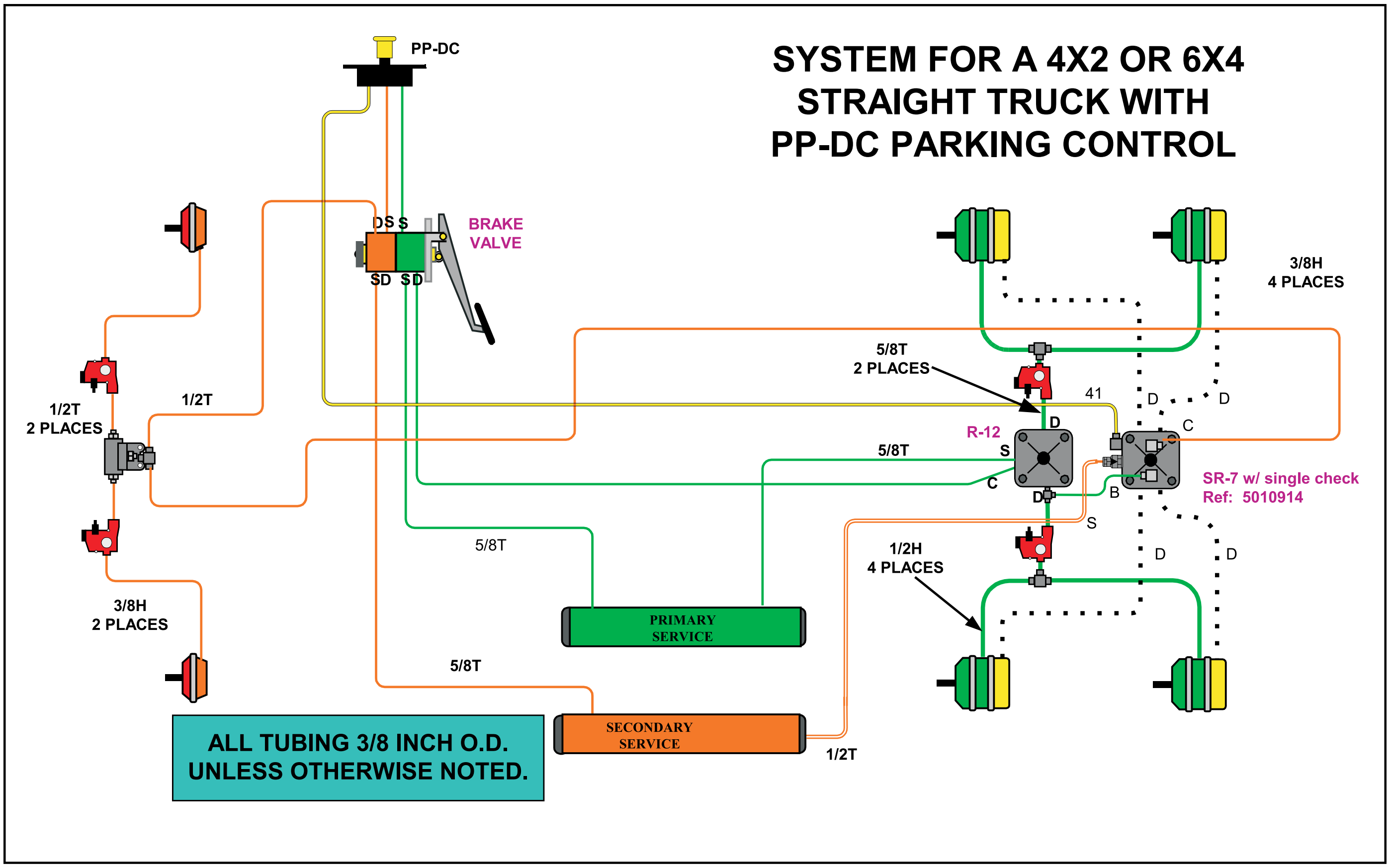


FIGURE 3 - SYSTEM SCHEMATIC WITH PP-DC PARK CONTROL

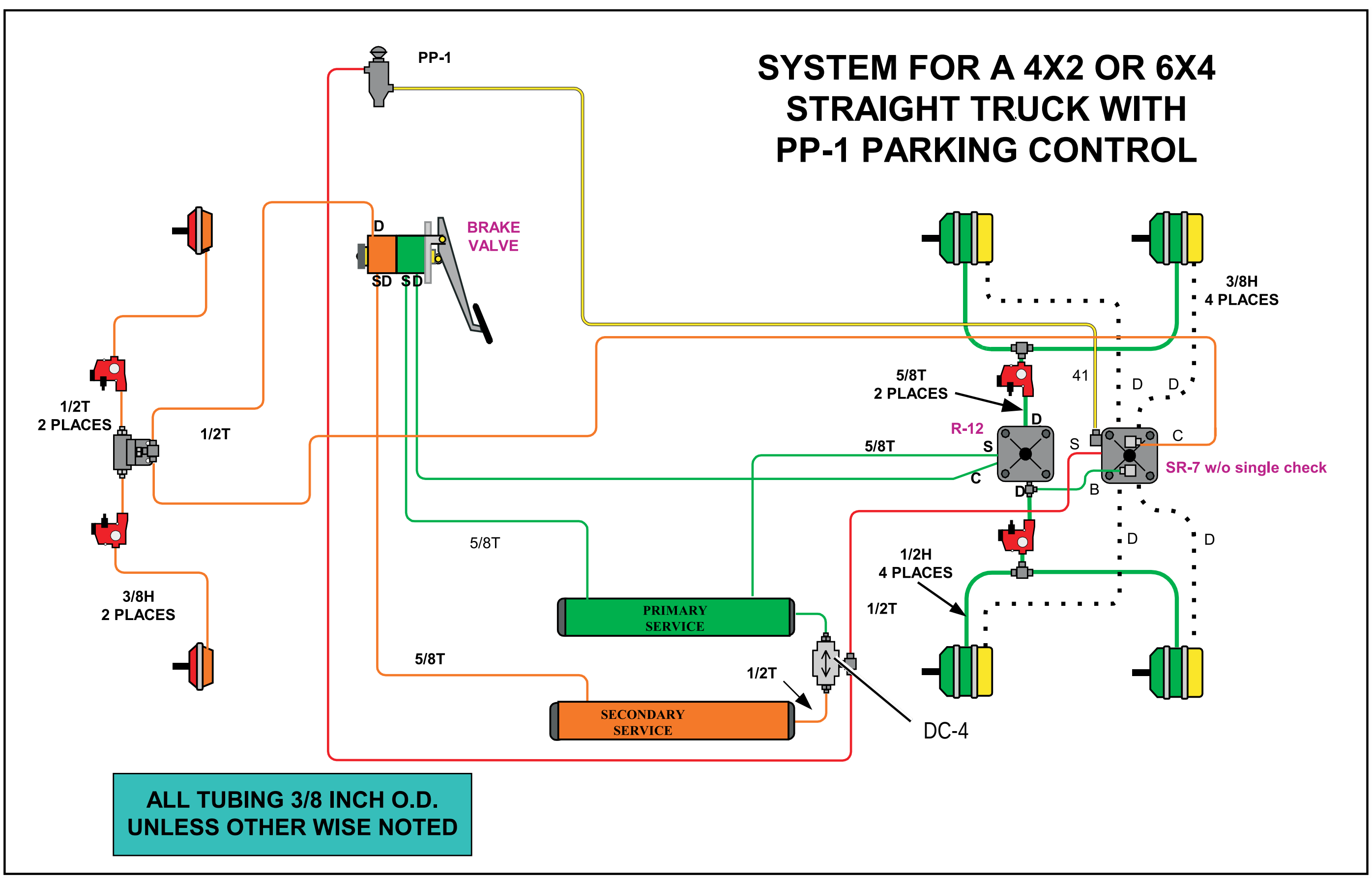


FIGURE 4 - SYSTEM SCHEMATIC WITH PP-1 PARK CONTROL AND DC-4 DOUBLE CHECK VALVE

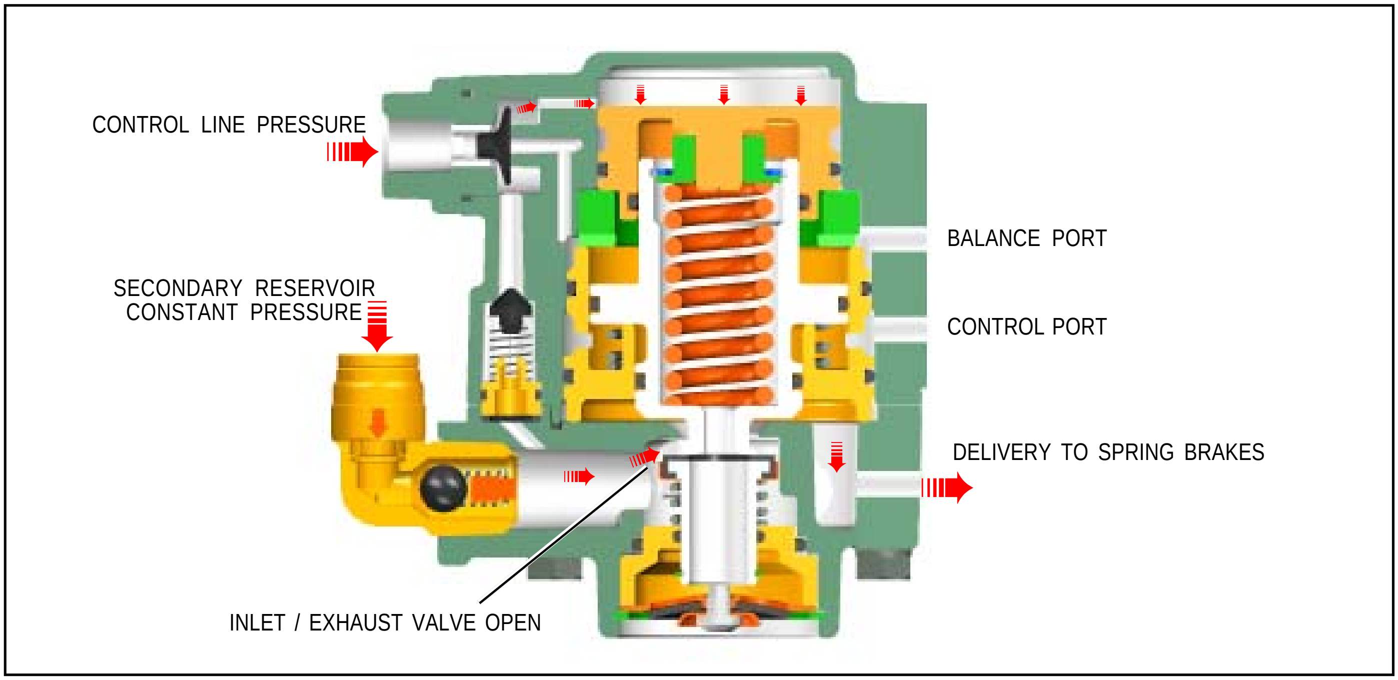


FIGURE 5 - CHARGING LESS THAN 107 PSI

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).

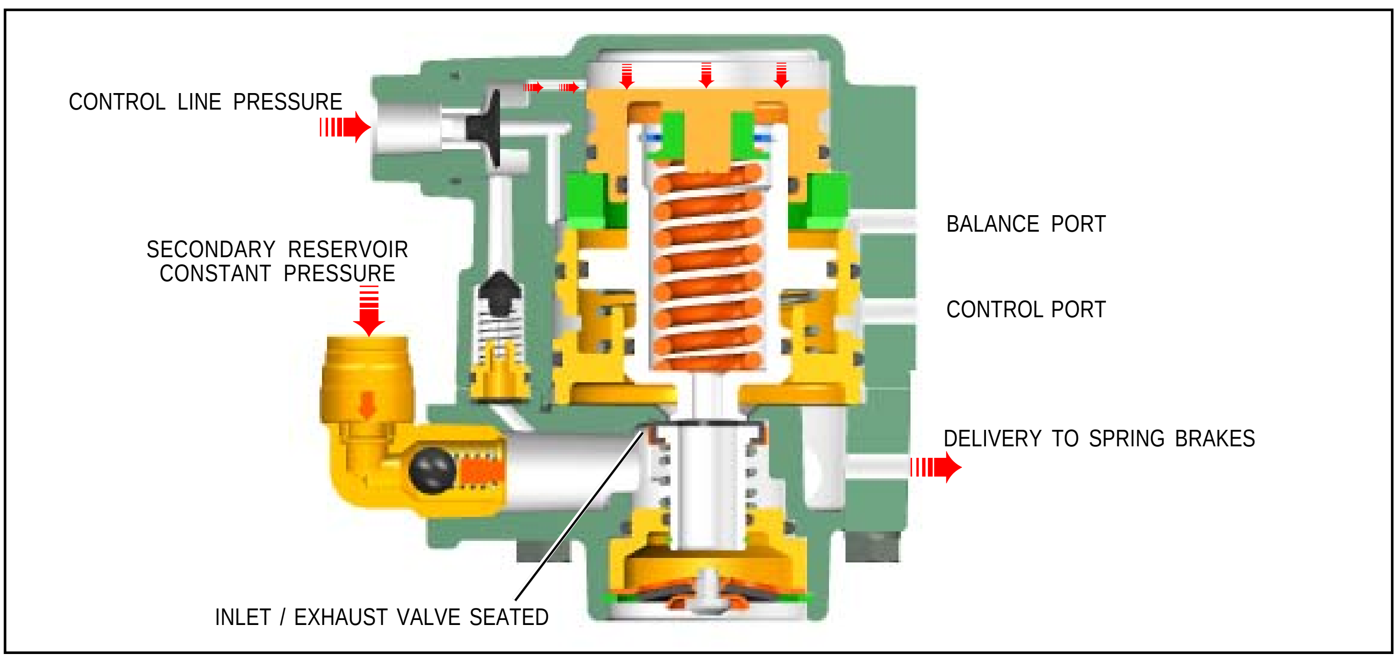


FIGURE 6 - CHARGING GREATER THAN 107 PSI

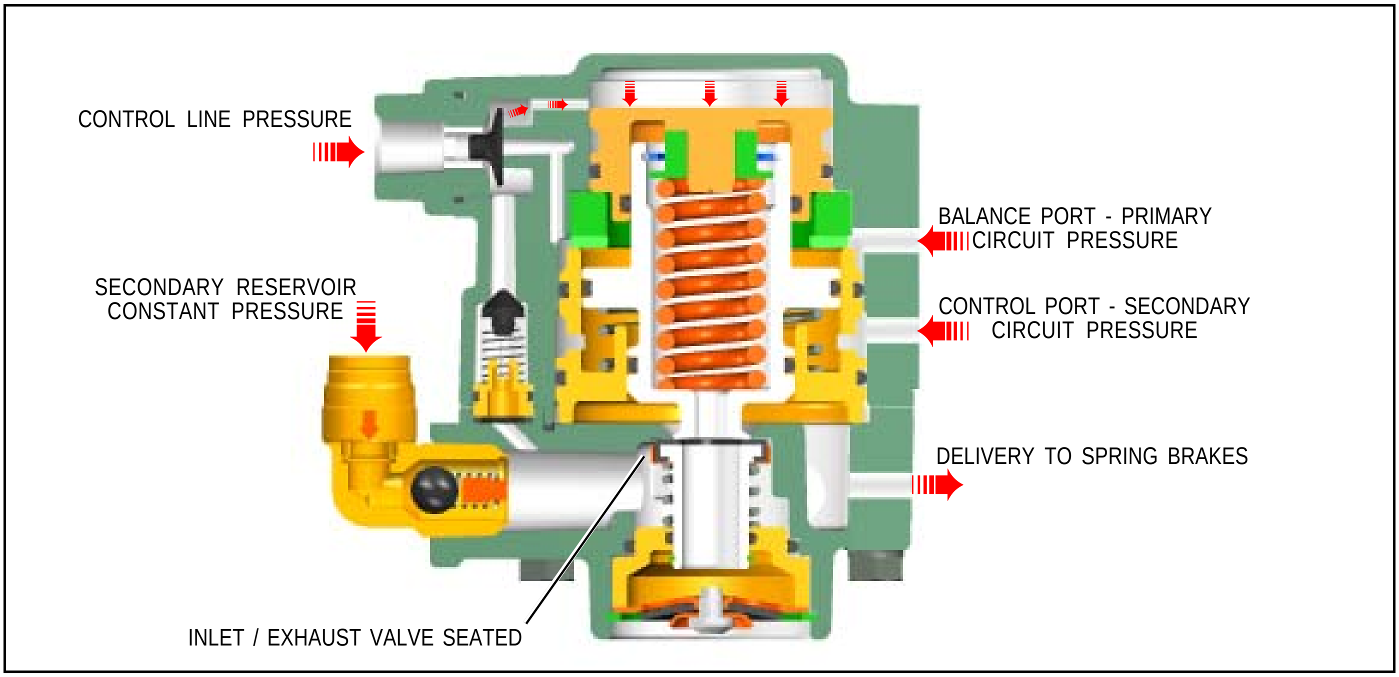


FIGURE 7 - NORMAL SERVICE APPLICATION

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.

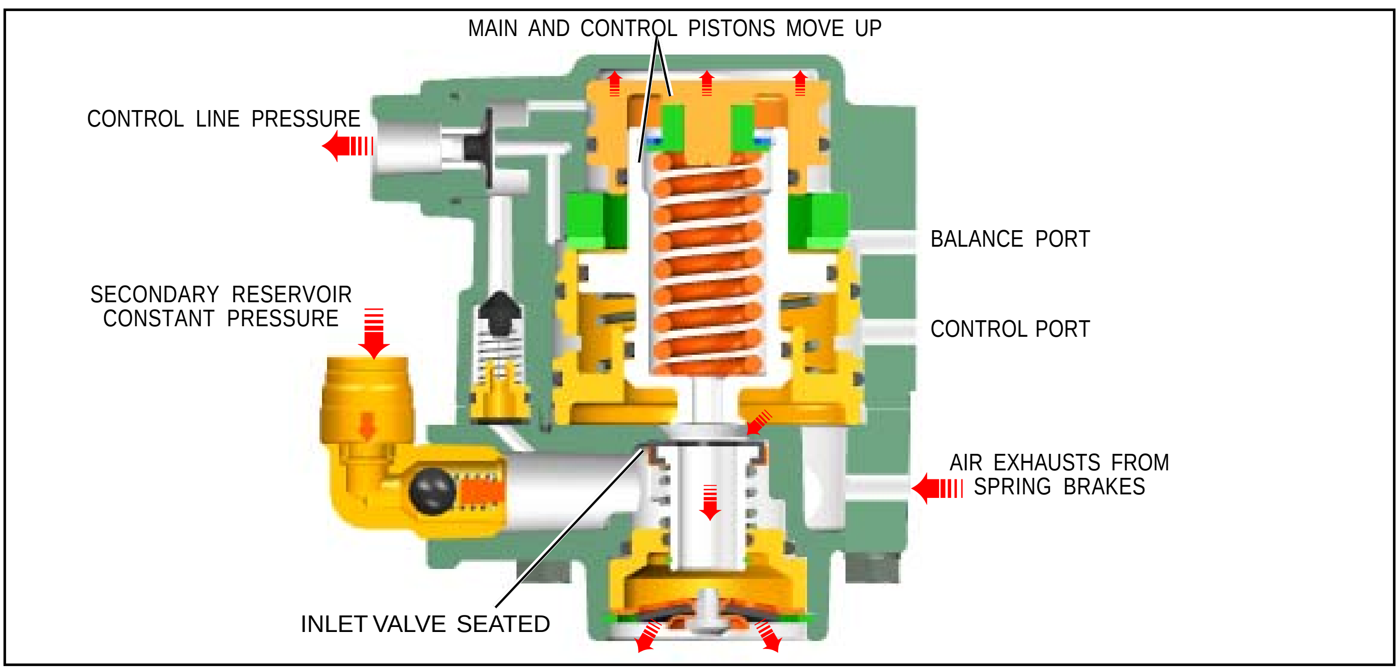


FIGURE 8 - PARKING

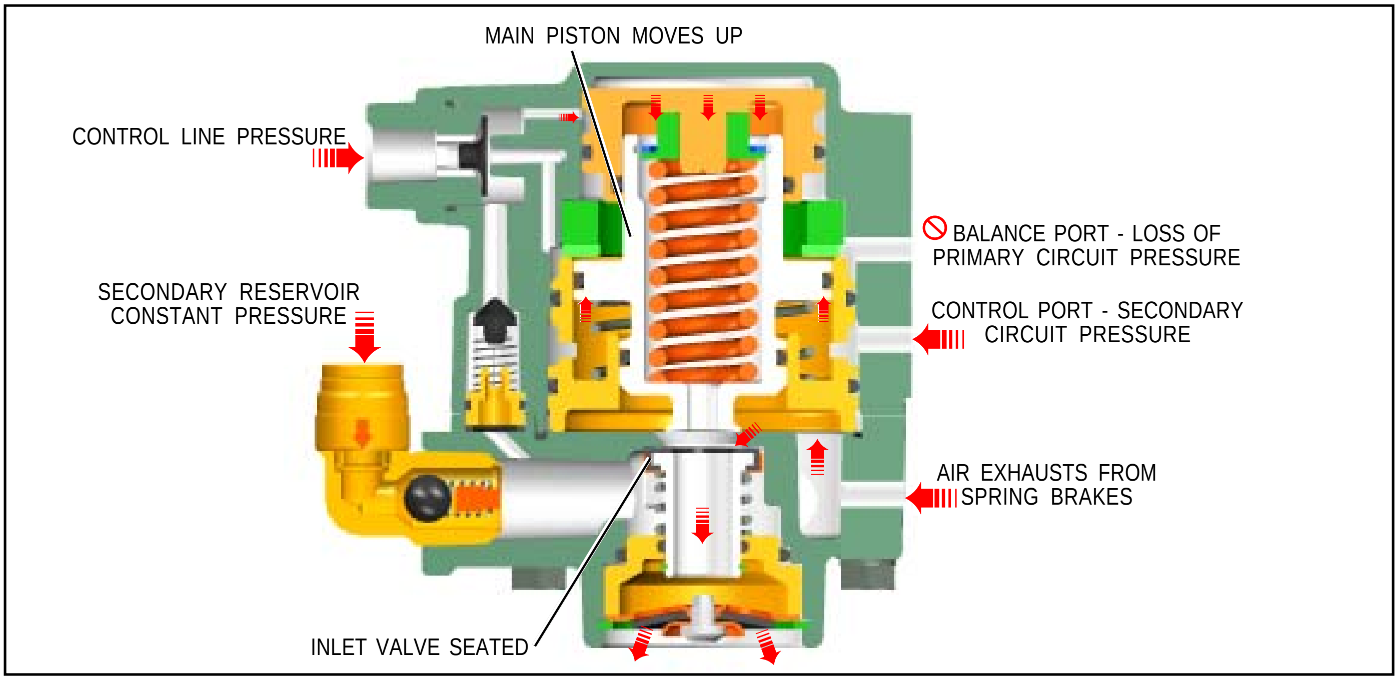


FIGURE 9 - SERVICE APPLICATION LOSS OF PRIMARY CIRCUIT

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.

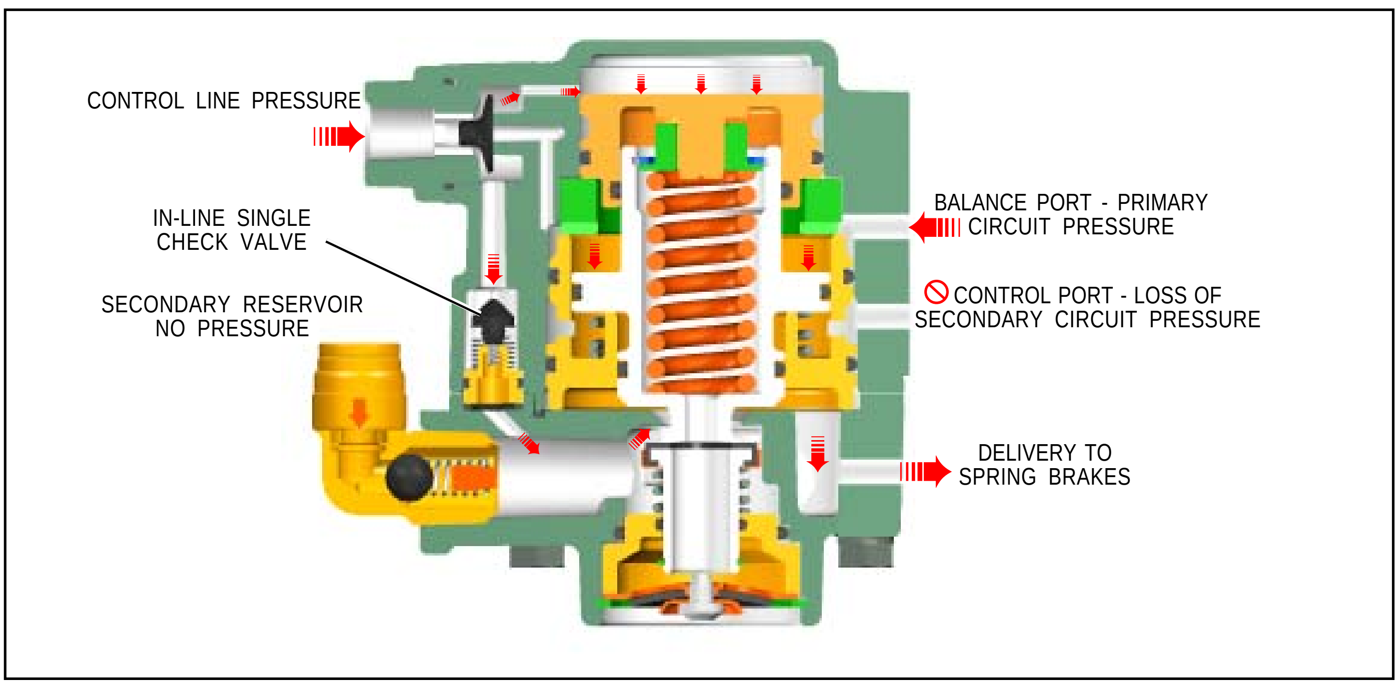


FIGURE 10 - SERVICE APPLICATION LOSS OF SECONDARY CIRCUIT

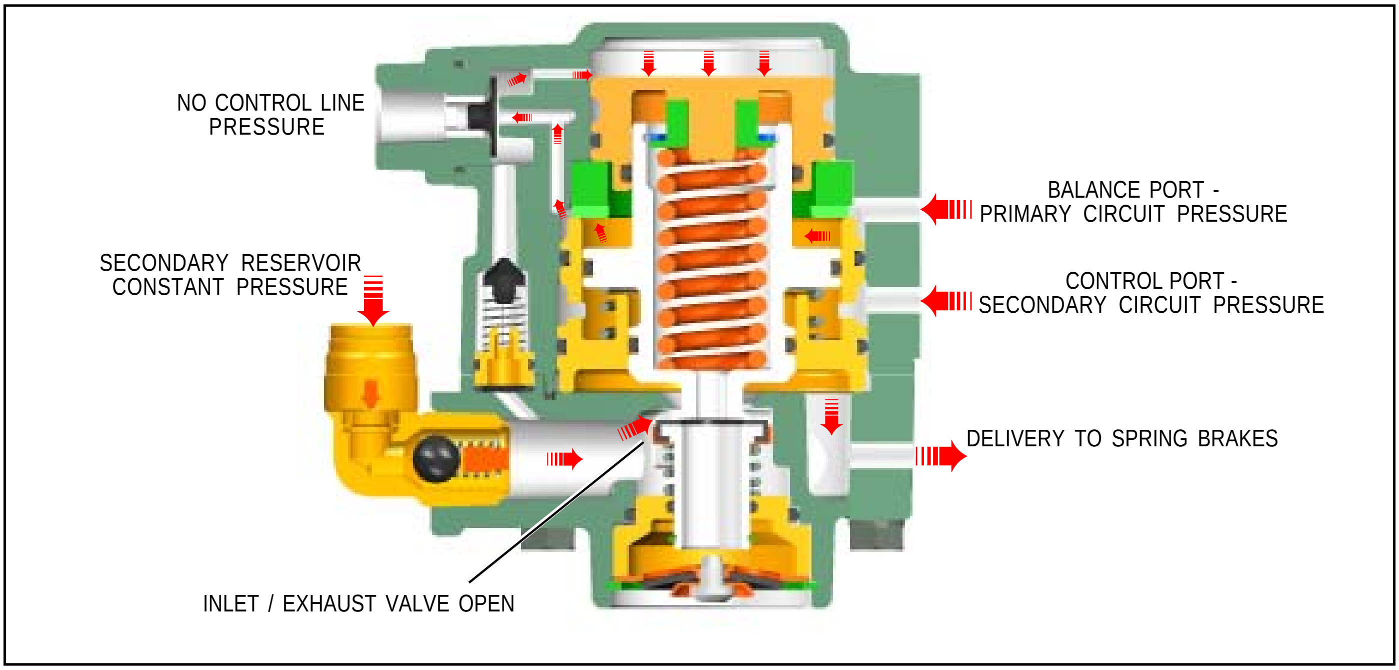


FIGURE 11 - ANTI-COMPOUNDING

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

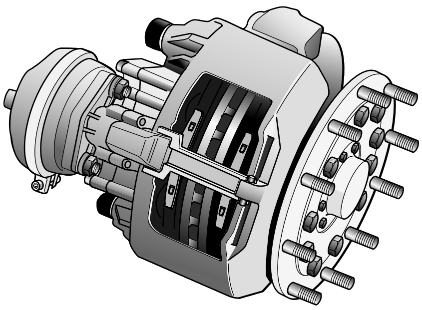
Perform operating and leakage tests as outlined in "Operating Tests" section.

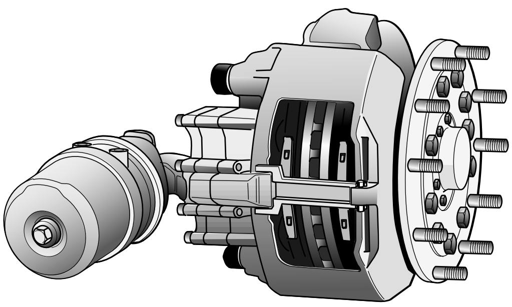
Service Manual

RA-SB0002-EN

Pneumatic Disc Brake

SB 6... / SB 7...
Axial- and Radial Disc Brake





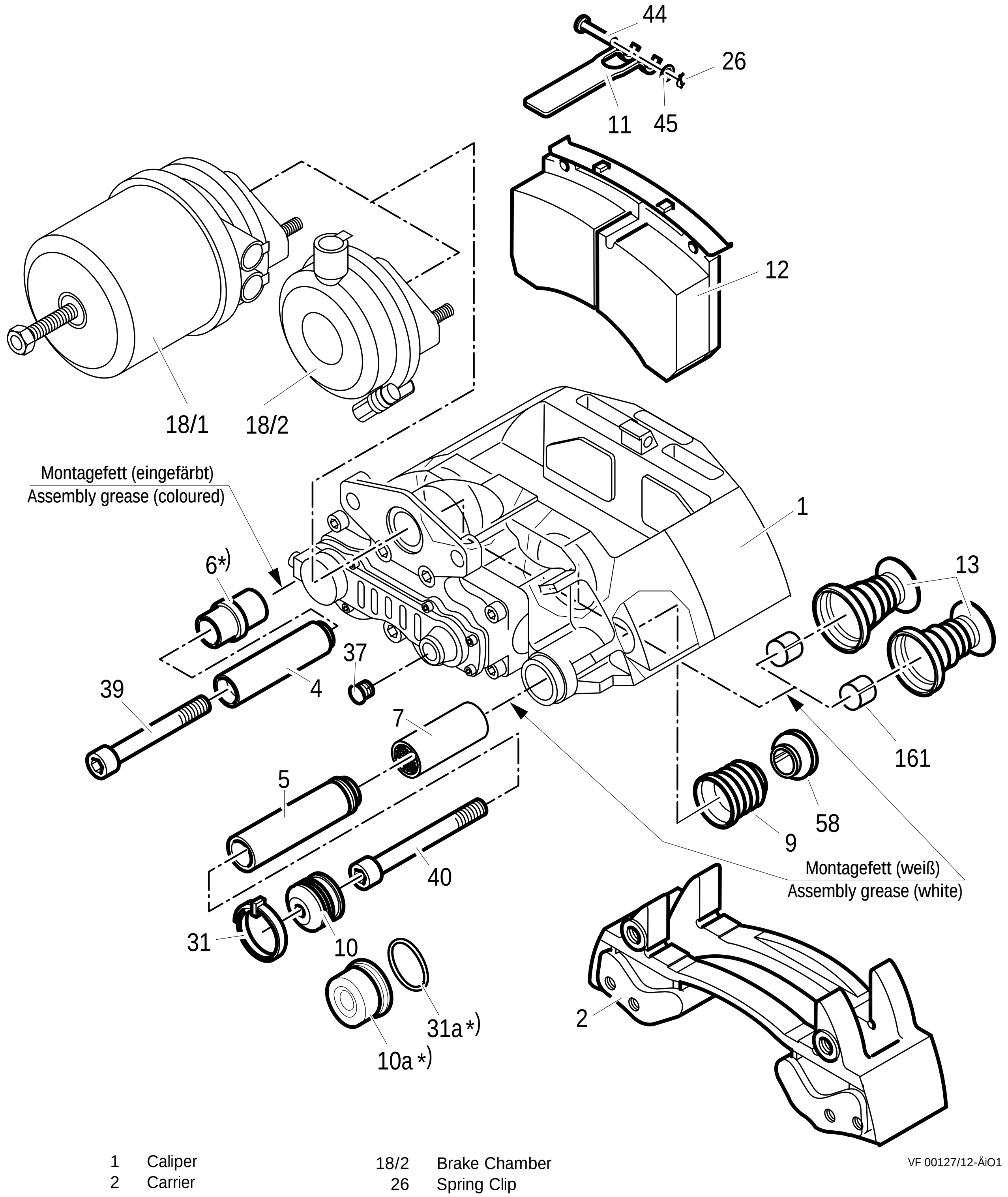
KNORR-BREMSE
Systems for Commercial Vehicles

Index

1 Overall view

1.1 Axial Disc Brake Components

(for Wear Indicatators Kits see 1.2.1)



1	Caliper
2	Carrier
4	Sleeve
5	Sleeve
6	Rubber Bush
7	Brass Bush
9	Inner Boot
10	Outer Boot
10a	Steel Cap
11	Pad Retainer
12	Pad
13	Tappet with Boot
18/1	Spring Brake
18/2	Brake Chamber
26	Spring Clip
31	Outer Boot Clip
31a	O-Ring
37	Adjuster Cap
39	Caliper Bolt
40	Caliper Bolt
44	Pad Retainer Pin
45	Washer
58	Ring
161	Tappet Bush

*) possible variants by items 10a & 31a

If short rubber bush (6) (sleeve ring is placed centrally), Caliper bolts (39) & (40) are identically

1.2 Axial Disc Brake Repair Kits

ATENTION!

Use only KNORR-BREMSE parts

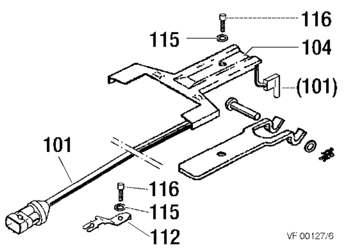
The following Repair Kits are available

Description	Contents	Association of Repair Kits to the Disc Brakes and Repair Kit's Order no.
Carrier Guide Kit	2, 4, 5, 31, 39, 40	see Disc Brake Product Catalogue (Part Number Y000875), also available as an electronic form (CD-ROM, http://www.Knorr-BremseSfN.com)
Carrier Guide Kit (Steel Cap)	2, 4, 5, 10a, 31a, 39, 40	
Wear Indicator Kit (per axle)	for variants see 1.2.1 with or without 104	
Guide Pins Kit	4-7, 9, 10, 31, 39, 40, 58	
Guide Pins Kit (Steel Cap)	4, 5, 6, 7, 9, 10a, 31a, 39, 40, 58	
Seal Kit for Guide Pins	9, 10, 31, 37, 58	
Tappet and Boot Kit (2 pcs)	13, 161	
Pad Set (per axle)	12, 26, 37, 44, 45	
Adjuster Cap (4 pcs)	37	
Pad Retainer Kit (per axle)	11, 26, 44, 45	
Pad Retainer Kit (per axle)	11, 26, 44, 45, 104, 115, 116	
Kit for Rubber Sleeve	4, 6, 39	
Outer Guide Seal Kit (10 pcs)	10, 31	
Repair Kit	5, 7, 9, 10a, 31a, 40, 58	
Kit for Steel Cap	10a, 31a	
Screw Kit for Steel Cap	10a, 31a, 39, 40	
Screw Kit for Outer Boot	10, 31, 39, 40	
Exchange Caliper r.h.	only in assembled condition	see Type plate on the Caliper
Exchange Caliper l.h.		

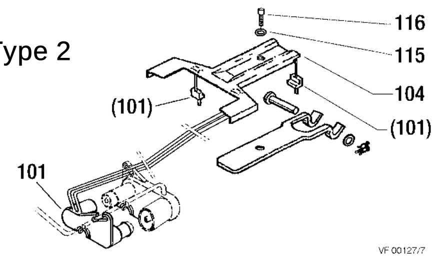
1.2.1 Axial Disc Brake Wear Indicator Kits

(Typical kits are shown below)

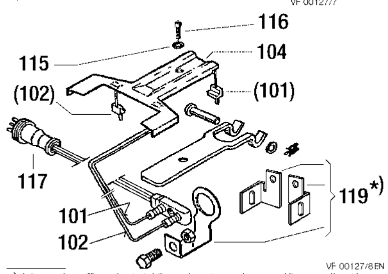
Type 1



Type 2

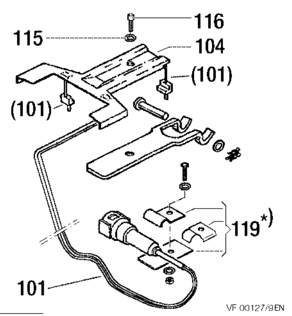


Type 3



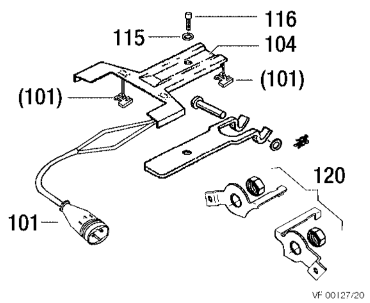
*) Mounting Bracket 119 varies to suit specific applications

Type 4



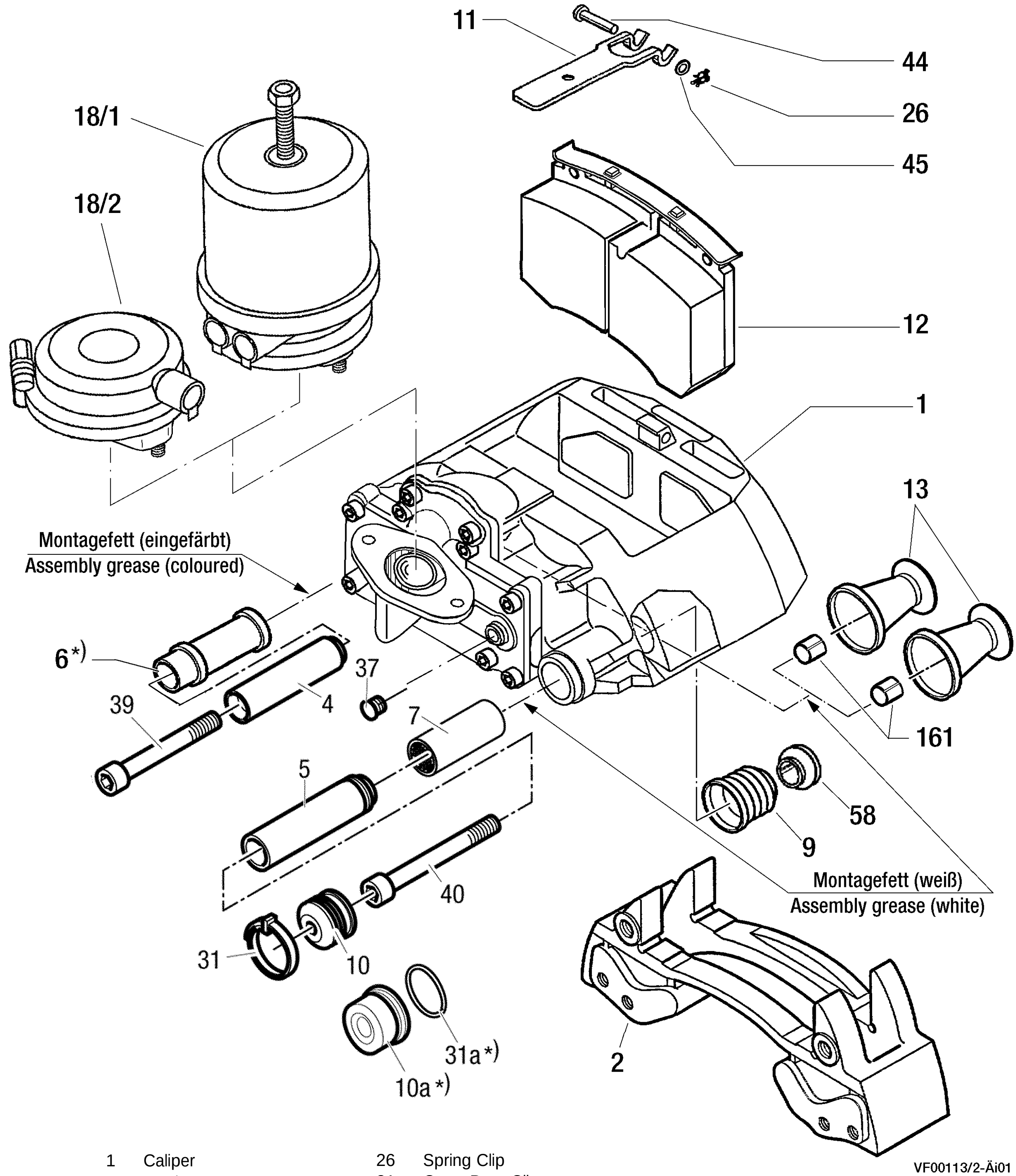
*) Mounting Bracket 119 varies to suit specific applications

Type 5



101	Sensor	115	Spring Washer
102	Sensor	116	Screw
104	Cable Protection Plate	117	Wear Indicator Cable
112	Clip	119	Bracket
		120	Bracket

1.3 Radial Disc Brake Components
(for Wear Indicator Kits see 1.4.1)



1	Caliper	26	Spring Clip
2	Carrier	31	Outer Boot Clip
4	Sleeve	31a	O-Ring
5	Sleeve	37	Adjuster Cap
6	Rubber Bush	39	Caliper Bolt
7	Brass Bush	40	Caliper Bolt
9	Inner Boot	44	Pad Retainer Pin
10	Outer Boot	45	Washer
10a	Steel Cap	58	Ring
11	Pad Retainer	161	Tappet Bush
12	Pad		
13	Tappet with Boot		
18/1	Spring Brake		
18/2	Brake Chamber		

*) possible variants by items 10a & 31a

If short rubber bush (6) (sleeve ring is placed centrally), Caliper bolts (39) & (40) are identically

1.4 Radial Disc Brake Repair Kits

ATENTION!

Use only KNORR-BREMSE parts

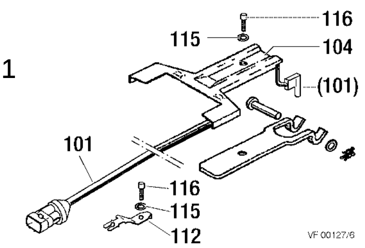
The following Repair Kits are available

Description	Contents	Association of Repair Kits to the Disc Brakes and Repair Kit's Order no.
Carrier Guide Kit	2, 4, 5, 31, 39, 40	see Disc Brake Product Catalogue (Part Number Y000875), also available as an electronic form (CD-ROM, http://www.Knorr-BremseSfN.com)
Carrier Guide Kit (Steel Cap)	2, 4, 5, 10a, 31a, 39, 40	
Wear Indicator Kit (per axle)	for variants see 1.2.1 with or without 104	
Guide Pins Kit	4-7, 9, 10, 31, 39, 40, 58	
Guide Pins Kit (Steel Cap)	4, 5, 6, 7, 9, 10a, 31a, 39, 40, 58	
Seal Kit for Guide Pins	9, 10, 31, 37, 58	
Tappet and Boot Kit (2 pcs)	13, 161	
Pad Set (per axle)	12, 26, 37, 44, 45	
Adjuster Cap (4 pcs)	37	
Pad Retainer Kit (per axle)	11, 26, 44, 45	
Pad Retainer Kit (per axle)	11, 26, 44, 45, 104, 115, 116	
Kit for Rubber Sleeve	4, 6, 39	
Outer Guide Seal Kit (10 pcs)	10, 31	
Repair Kit	5, 7, 9, 10a, 31a, 40, 58	
Kit for Steel Cap	10a, 31a	
Screw Kit for Steel Cap	10a, 31a, 39, 40	
Screw Kit for Outer Boot	10, 31, 39, 40	
Exchange Caliper r.h.	only in assembled condition	see Type plate on the Caliper
Exchange Caliper l.h.		

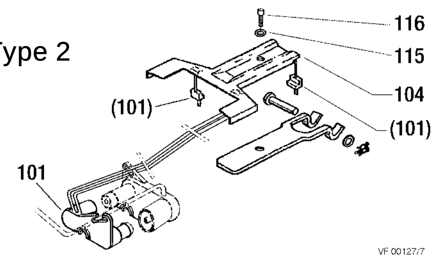
1.4.1 Radial Disc Brake Wear Indicator Kits

(Typical kits are shown below)

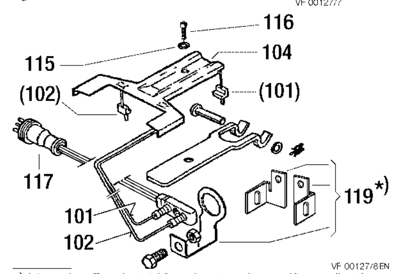
Type 1



Type 2

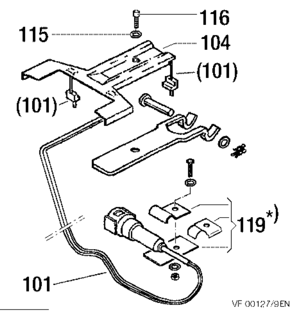


Type 3



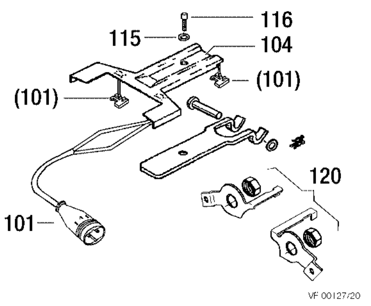
*) Mounting Bracket 119 varies to suit specific applications

Type 4



*) Mounting Bracket 119 varies to suit specific applications

Type 5



101	Sensor	115	Spring Washer
102	Sensor	116	Screw
104	Cable Protection Plate	117	Wear Indicator Cable
112	Clip	119	Bracket
		120	Bracket

1.5 Brake Discs

(for “Axial- and Radial Disc Brake”)

When replacing the Discs, please also refer to the instructions of the Vehicle Manufacturer.

This should also be done when fitting KNORR-Brake Discs.

When replacing Discs, please adhere to the recommended bolt tightening torques.

The use of non-approved Brake Discs will reduce levels of safety and invalidate warranty.

Brake Discs can be ordered through the Knorr-Aftermarket Organisation.

Detailed informations can be taken out from our Product Catalogue “Disc Brake“ (Part Number Y000875).
This is also available as an electronic form (CD-ROM, http://www.Knorr-BremseSfN.com).

2 General Information
(for “Axial- and Radial Disc Brake”)

2.1 Service Tools

Part Number	Description
II 19252	Press-In Tool for Tappet and Boot (13)
II 19253	Pull-In Tool for Inner Boot (9)
II 19254	Pull-In/Out Tool for Brass Bush (7)
II 32202	Wedged Fork for removal of Tappet and Boot (13)
II 36797	Grooving Tool for Brass Bush (7)
Z001105	Press in Tool for Steel Cap (10a)

Service tool kit ZB 9032 II 37951/004EX contains the above listed tools as well as this Service manual. The service video in English is available separately in the UK as Part No. KBP2060/1 and in other territories as RA-SB0002 EN.

2.2 Diagnostic Equipment

Part Number	Description
II 36695	**ZB 9031** Hand held device for checking Potentiometer function. (Also Pad + Disc wear when 13 pin chassis plug installed).
II 38691F	**ZB 9033** Chassis mounted device for measuring Pad + Disc wear

2.3 Lubrication

Part Number	Description	Colour	Application
II 14525	Renolit HLT2	White [2)]	Brass Bush (7)
II 32793	Syntheso GL EP1	Green [2)]	Rubber Bush (6)

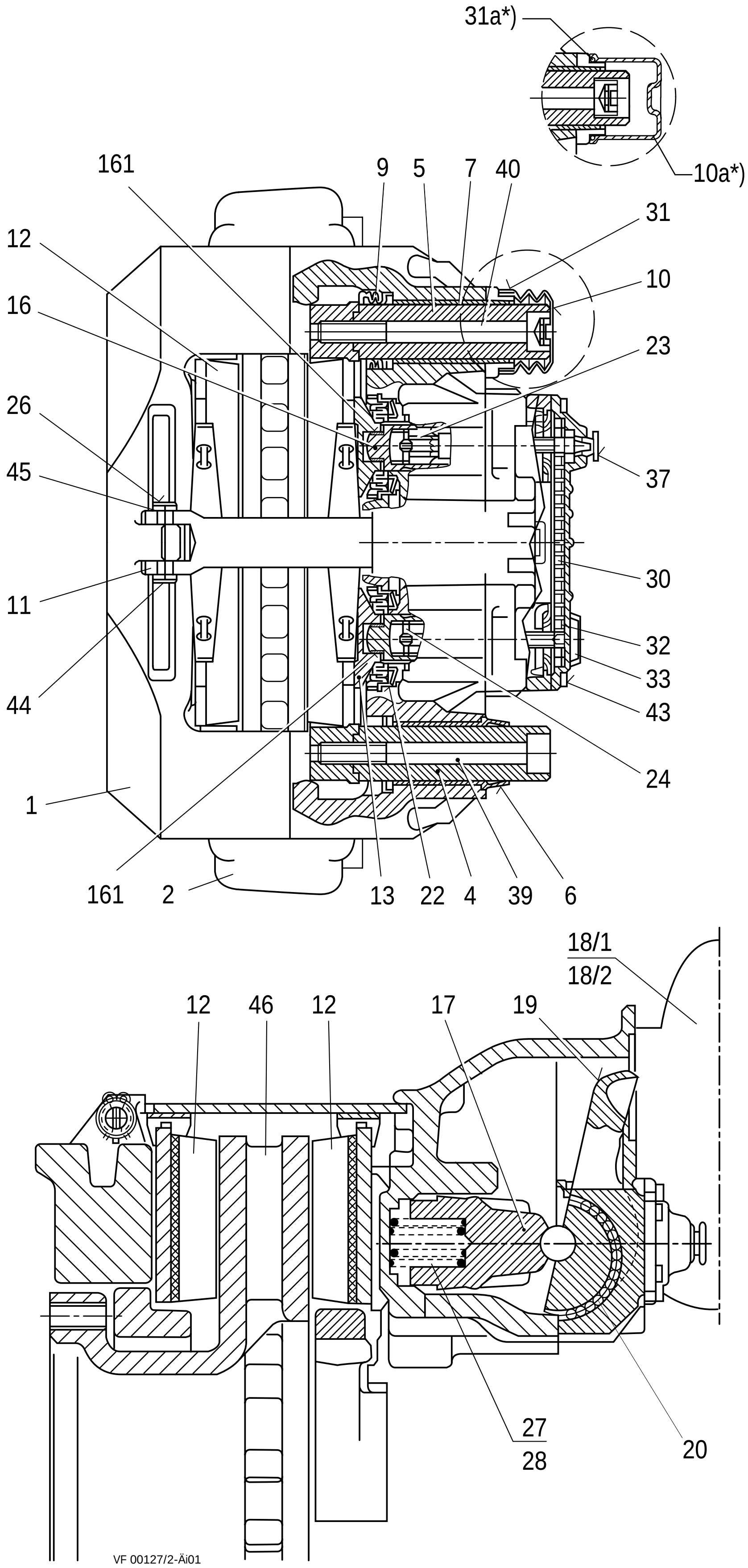
[2)] **Important Note:** The correct Grease MUST be used for each Bush!

2.4 Torque requirements

Item Number		Torque [Nm]	spanner size (mm)
39 + 40	Caliper Bolts M16x1,5 - 10.9	$285^{\pm 25}$	14
	Actuator Mounting Nuts M16x1,5	180^{+30}	24

3 Description and function

3.1 Axial Disc Brake Sectioned View



1	Caliper
2	Carrier
4	Sleeve
5	Sleeve
6	Rubber Bush
7	Brass Bush
9	Inner Boot
10	Outer Boot
10a	Steelcap
11	Pad Retainer
12	Pad
13	Tappet with Boot
16	Threaded Tube
17	Bridge
18/1	Spring Brake
18/2	Brake Chamber
19	Lever
20	Eccentric Bearing
22	Inner Seal Cap
23	Adjuster Unit
24	Turning Device
26	Spring Clip
27	Spring
28	Spring
30	Chain
31	Outer Boot Clip
31a	O-Ring
32	Chain Wheel
33	Wear Sensor
37	Adjuster Cap
39	Caliper Bolt
40	Caliper Bolt
44	Pad Retainer Pin
45	Washer
46	Disc
161	Tappet Bush

*) possible variants by items 10a & 31a

3.2 Description of operation
(Floating Caliper principle)

3.2.1 Brake actuation

During actuation, the Push Rod of the Actuator (18/1 or 18/2) moves the Lever (19). The input forces are transferred via the Eccentric Bearing (20) to the Bridge (17). The force is then distributed by the Bridge (17) and the two Threaded Tubes (16) to the Tappets (13) and finally to the inboard Pad (12).

After overcoming the running clearance between the Pads and the Disc, the reaction forces are transmitted to the outboard Pad (12). The clamping forces on the Pads (12) and the Disc (46) generate the braking force for the wheel.

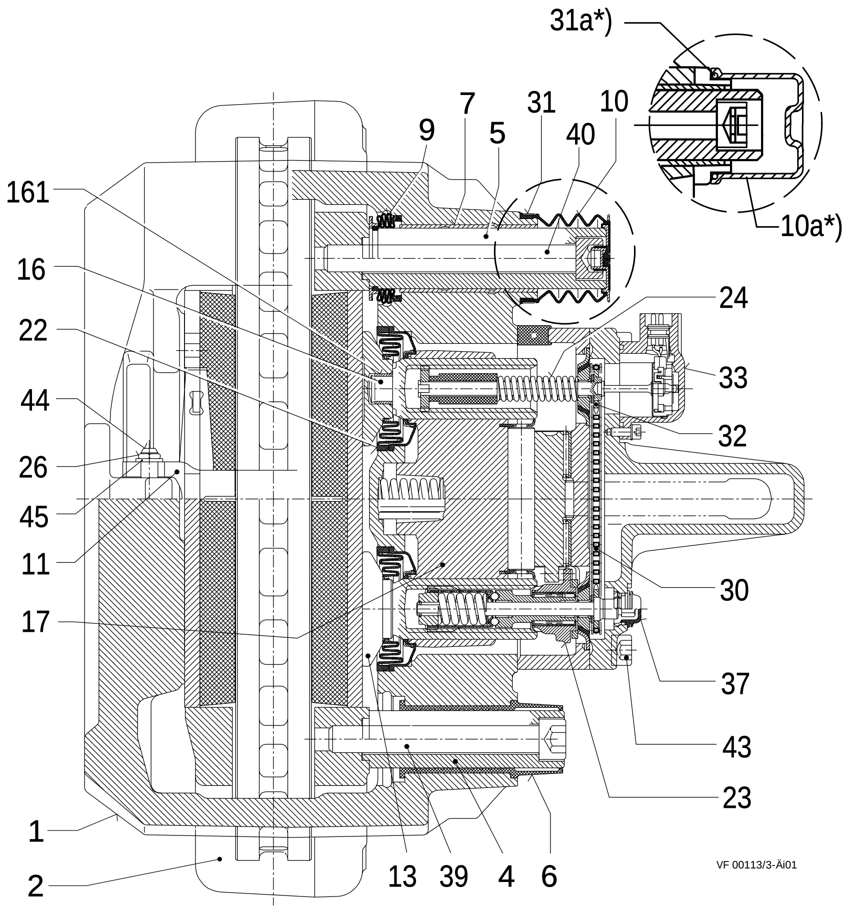
3.2.2. Brake release

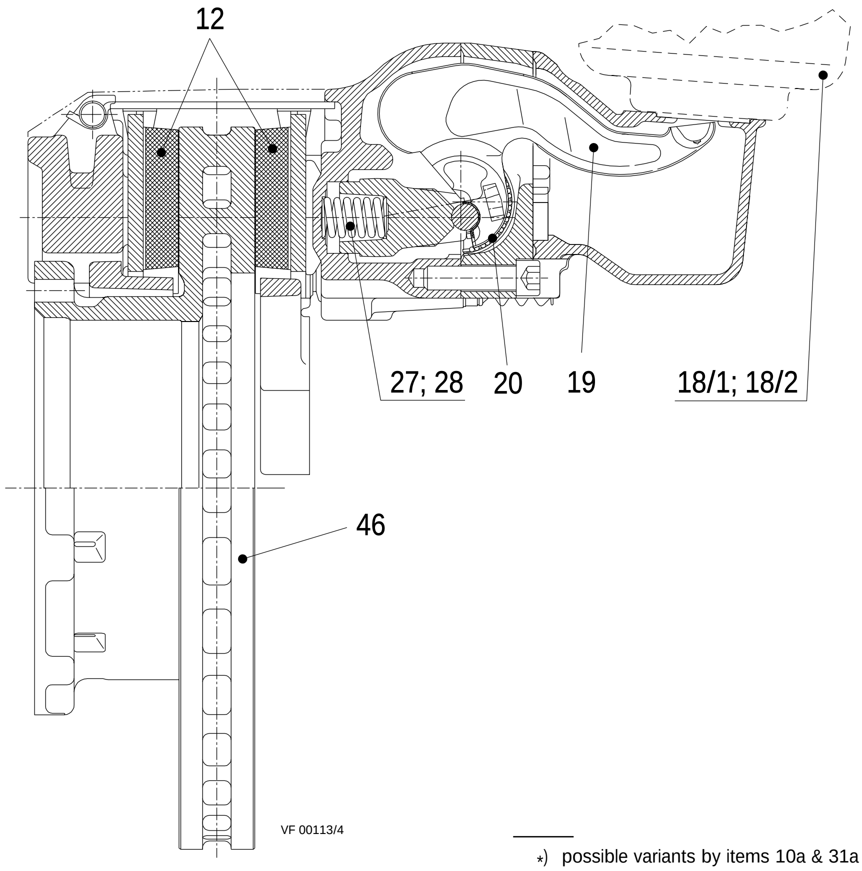
After releasing the air pressure, the two Return Springs (27/28) push the Bridge (17) and Lever (19) back to the start position; this ensures a running clearance between Pads and Disc is maintained.

3.2.3 Brake adjustment (automatic)

To ensure a constant running clearance between Disc and Pads, the brake is equipped with a low wearing, automatic adjuster mechanism.
The Adjuster (23) operates with every cycle of actuation due to the mechanical connection with Lever (19). As the Pads and Disc wear, the running clearance increases. The Adjuster (23) and Turning Device (24) turn the Threaded Tubes (16) by an amount necessary to compensate for this wear. The total running clearance (sum of clearance both sides of Disc) should be between 0.6 and 0.9 mm.; smaller clearances may lead to overheating problems.

3.3 Radial Disc Brake Sectioned View





1	Caliper
2	Carrier
4	Sleeve
5	Sleeve
6	Rubber Bush
7	Brass Bush
9	Inner Boot
10	Outer Boot
10a	Steelcap
11	Pad Retainer
12	Pad
13	Tappet with Boot
16	Threaded Tube
17	Bridge
18/1	Spring Brake
18/2	Brake Chamber
19	Lever
20	Eccentric Bearing
22	Inner Seal Cap
23	Adjuster Unit
24	Turning Device
26	Spring Clip
27	Spring
28	Spring
30	Chain
31	Outer Boot Clip
31a	O-Ring
32	Chain Wheel
33	Wear Sensor
37	Adjuster Cap
39	Caliper Bolt
40	Caliper Bolt
44	Pad Retainer Pin
45	Washer
46	Disc
161	Tappet Bush

*) possible variants by items 10a & 31a

3.4 Description of operation
(Floating Caliper principle)

3.4.1. Brake Actuation

During actuation, the Push Rod of the Actuator (18/1 or 18/2) moves the Lever (19). The input forces are transferred via the Eccentric Bearing (20) to the Bridge (17). The force is then distributed by the Bridge (17) and the two Threaded Tubes (16) to the Tappets (13) and finally to the inboard Pad (12).

After overcoming the running clearance between the Pads and Disc, the reaction forces are transmitted to the outboard Pad (12). The clamping forces on the Pads (12) and the Disc (46) generate the braking force for the wheel.

3.4.2. Brake release

After releasing the air pressure, the two Return Springs (27/28) push the Bridge (17) and Lever (19) back to the start position; this ensures a running clearance between Pads and Disc is maintained.

3.4.3 Brake adjustment (automatic)

To ensure a constant running clearance between Disc and Pads, the brake is equipped with a low wearing, automatic adjuster mechanism. The Adjuster (23) operates with every cycle of actuation due to the mechanical connection with Lever (19). As the Pads and Disc wear, the running clearance increases. The Adjuster (23) and Turning Device (24) turn the Threaded Tubes (16) by an amount necessary to compensate for this wear. The total running clearance (sum of clearance both sides of Disc) should be between 0.6 and 0.9 mm.; smaller clearances may lead to overheating problems.

4 Safety Instructions for service work
(for “Axial- and Radial Disc Brake”)

Please also refer to the relevant safety instructions for repair work on commercial vehicles, especially for jacking up and securing the vehicle.

Use only original KNORR-BREMSE parts.

WARNING!

Before starting repair work, ensure the service brake and parking brake are not applied and that the vehicle cannot roll away.

Please follow repair manual instructions and adhere to the wear limits of the Pads and the Discs - see Section 5.3.

Use only recommended tools - see Section 2.1.

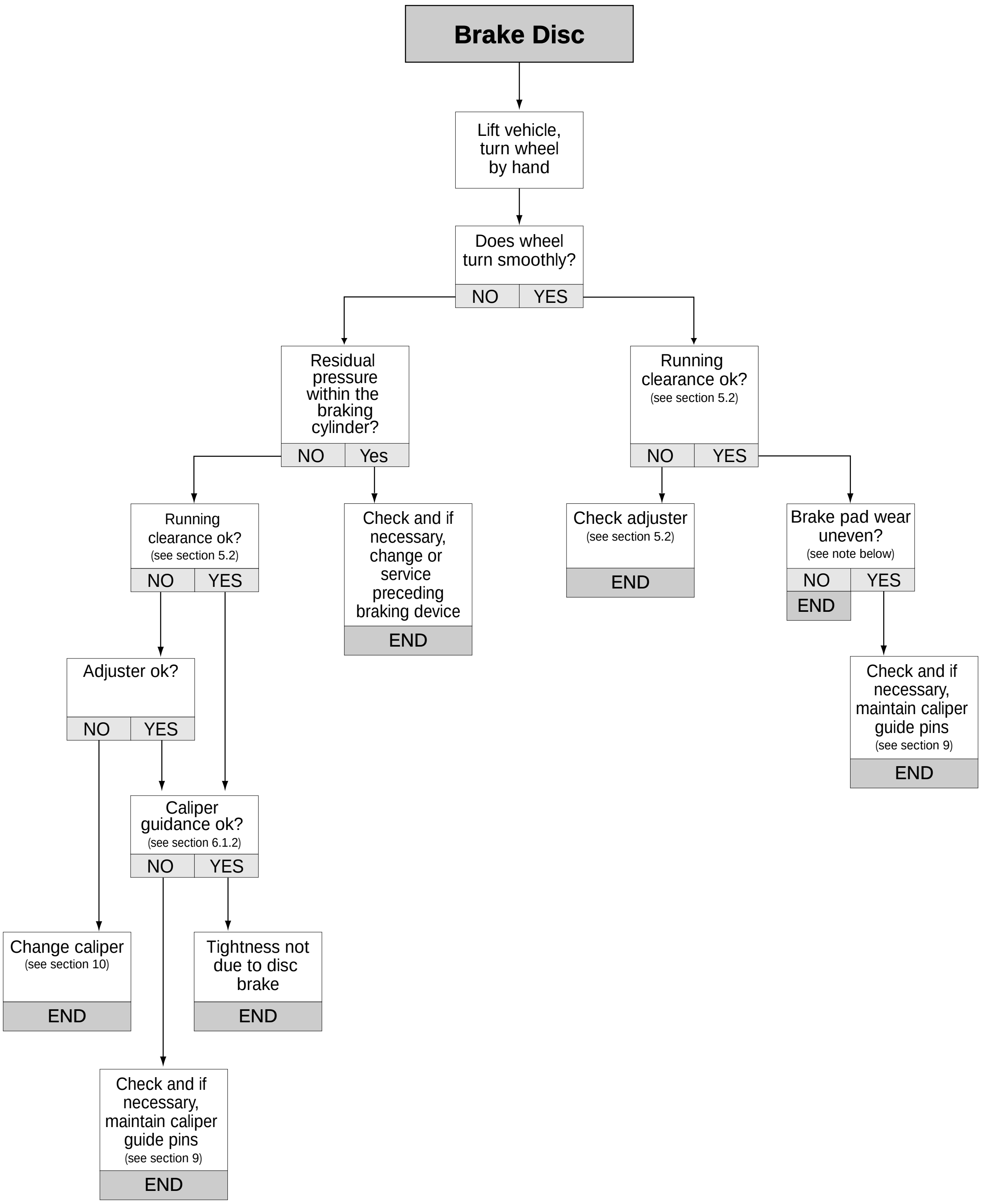
Tighten bolts and nuts to the recommended torque values - see Section 2.4.

After re-fitting the wheel according to the Vehicle Manufacturer’s recommendations, please ensure that there is sufficient clearance between the Tyre Inflation Valve, the Caliper and the wheel rim, to avoid damage to the Valve.

After service work:
Check the brake performance and the system behaviour on a rolling road or by actual road test.

5 Brake Testing
(for Axial- and Radial Disc Brake)

5.1 Fault finding procedure



Note: Difference between inboard and outboard pad < 5, and diagonal wear ≤ 2 mm

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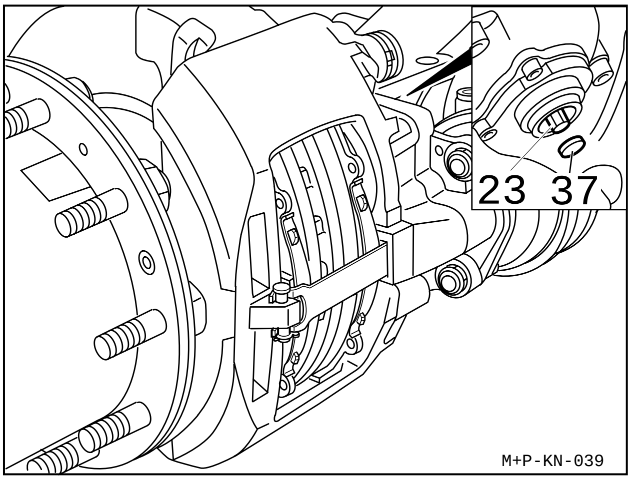
5.2 Adjuster check

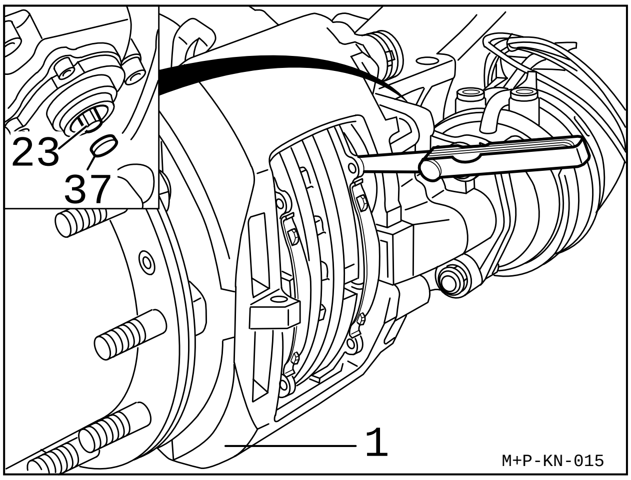
> ***WARNING!***
>
> *Before starting repair work, ensure the service brake and parking brake are not applied and that the vehicle cannot roll away.*



Remove wheel.

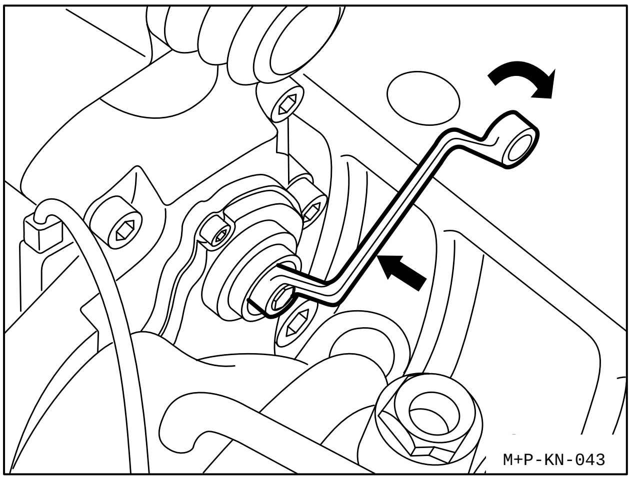
The caliper assemply should be pushed inboard on its guide pins. Using a suitable tool, press the inboard pad (12) away from the Tappets and check Tappet and inboard pad backplate - it should be between 0.5mm & 1.0mm. If the running clearance is too small or large, the adjuster may not be functioning correctly and should be checked as follows.

Remove Cap (37).



> ***WARNING!***
>
> *Do not overload or damage the Adjuster (23). Use only 8mm Ring Spanner or 1/4" drive Socket with a lever length no greater than 100mm.*
> ***DO NOT*** *use an Open Ended Spanner since this may damage the Adjuster shaft.*

The Adjuster should be turned counter-clockwise for 2 or 3 clicks (increasing running clearance).



> ***Attention!***
>
> *Make sure that the Ring Spanner or Socket can turn freely during following procedure.*

By applying the brake 5 - 10 times (about 2 Bar) the Spanner or Socket should turn clockwise in small increments if the Adjuster is functioning correctly (see notes below).

If Pads are not being changed, Cap (37) should be replaced having lightly greased it with Renolit HLT2 (available as part number II14525).

NOTE:
As the number of applications increases, incremental adjustment will decrease.

NOTE:
If the Spanner or Socket does not turn, turns only with the first application or turns forward and backward with every application, the automatic Adjuster has failed and the Caliper must be replaced.

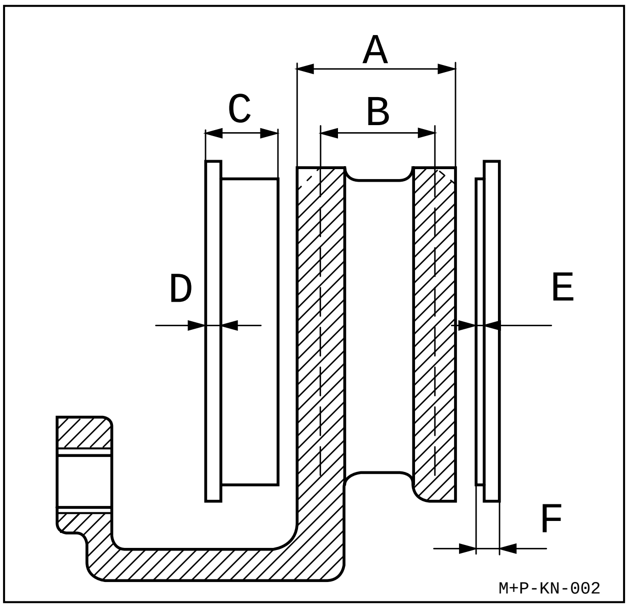
5.3 Wear Limits of Pads and Discs

WARNING!

For optimum safety, stay within the Disc and Pad Wear Limits

Pads

The thickness of the Pads must be checked regularly dependent on the usage of the vehicle.
The Pads should be checked corresponding to any legal requirements that may apply.
If no Wear Indicator has been connected this should be at least every 3 month.
If friction material is less than 2mm (see E), the Pads must be replaced.



Discs

Measure thickness at thinnest point. Avoid measuring near the edge of the disc as a burr may be present.

- A = Disc thickness (new condition) 45mm
- B = Disc thickness (worn) 37 mm, Disc must be replaced
- C = Overall thickness of Pad (new condition) 30mm
- D = Backplate 9mm
- E = Minimum thickness of friction material 2mm
- F = Minimum allowed thickness in worn condition for backplate and friction material 11mm (replacement of Pads necessary).

If wear dimension B $\leq$ 39 mm Disc should be renewed together with Pads.

Wear dimension B = 37mm must not decrease.

WARNING!

If these recommendation are ignored, there is a danger of brake failure

Check Disc at each change of Pads for grooves and cracks.
The diagram shows possible conditions of the surface.

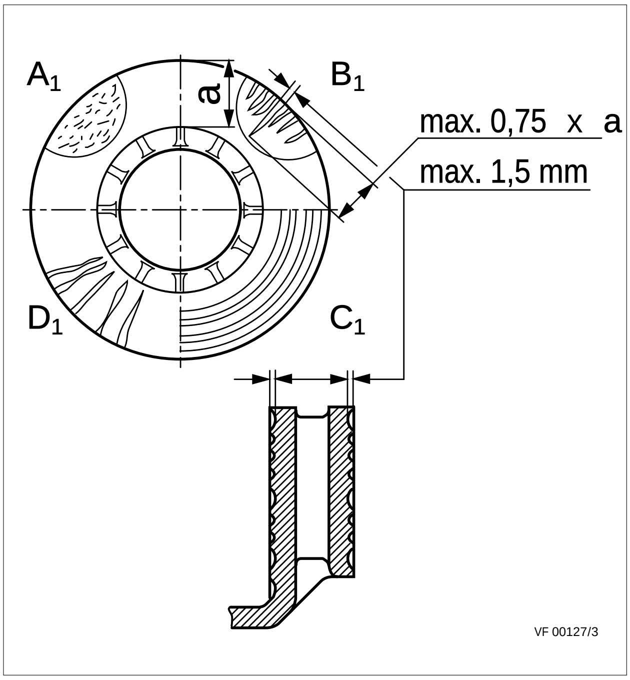
A_1 = Small cracks spread over the surface are allowed

B_1 = Cracks less than 1.5mm deep or wide, running in a Radial direction, are allowed

C_1 = Grooves (circumferencial) less than 1.5mm wide are allowed

D_1 = Cracks in the vanes are not allowed and the Disc MUST BE REPLACED.

a = Pad contact area



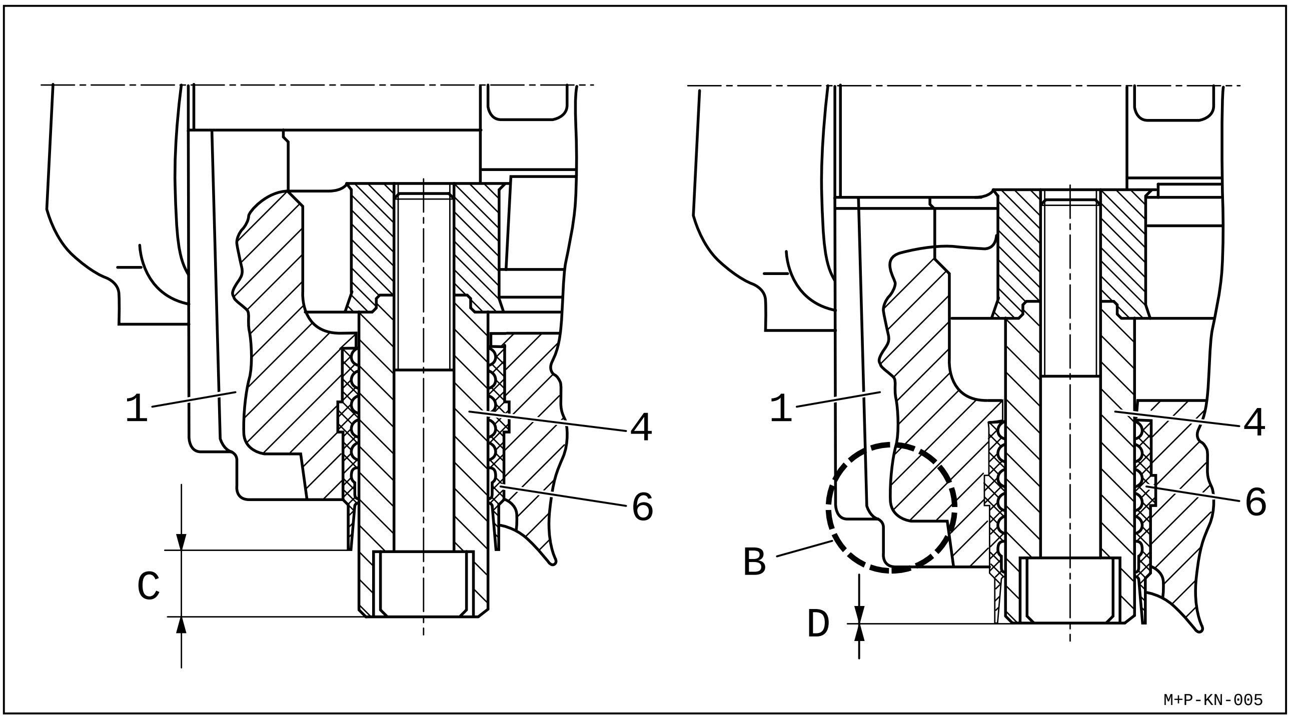
Note
In case of surface conditions A_1,-C_1, the Disc can continue to be used until the minimum thickness of 37mm is reached.

Knorr-Bremse Discs are normally service-free and grinding when changing Pads is not necessary. However, grinding could be useful, e.g. to increase the load-bearing surface of the Pads after severe grooving on the entire friction surface has occurred. To meet safety requirements, the minimum thickness after regrinding is > 39 mm.
In addition, the recommendation of the Vehicle Manufacturer MUST be followed.

WARNING!

If these recommendations are ignored, there is a danger of brake failure. If the Pads are worn down to the backplate or if Disc wear is excessive, brake performance will be severely affected and may be lost completely.

5.3.1 Brake Wear Check using Guide Pin (For all Axial and Radial Disc Brakes except those listed in Section 5.3.2 - These Callipers do not have the rib in position B (see also Section 5.3.2)



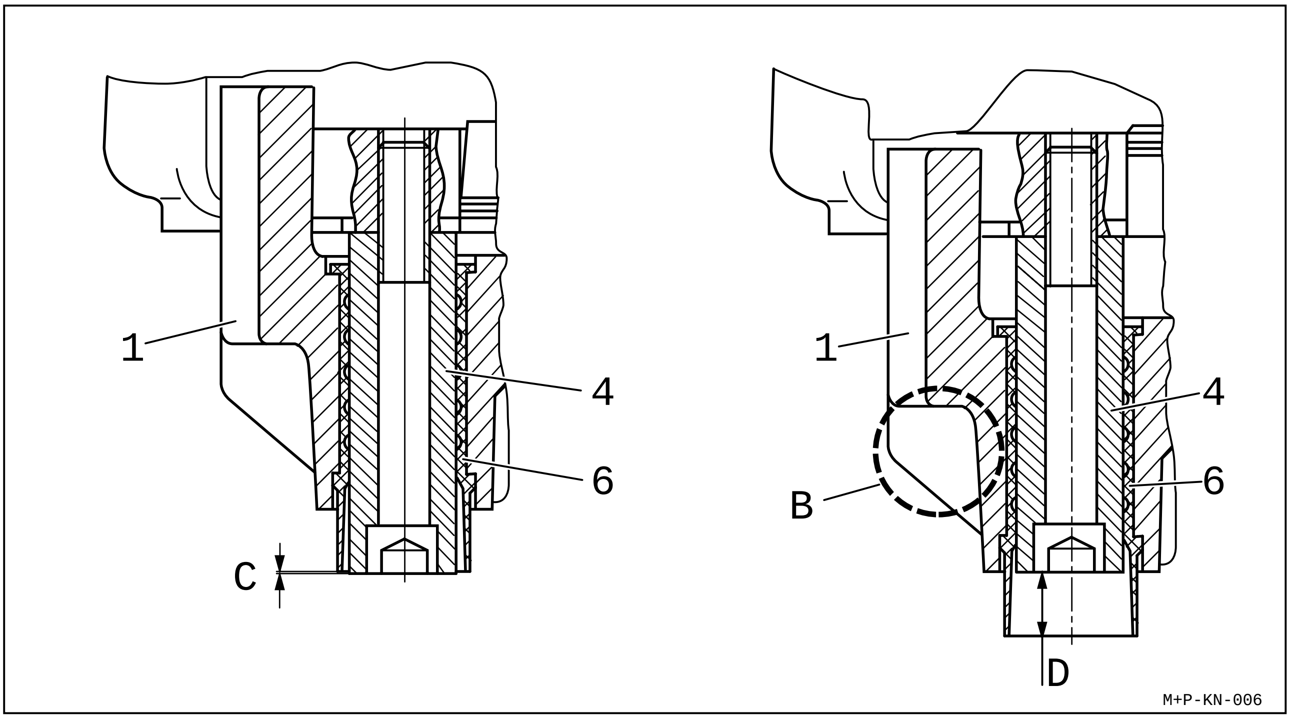
The condition of the Pads can be visually determined without removing the road wheel by noting the position of the Fixed Sleeve (4) in the Floating Caliper (1).

If dimension ‘C’ is less than 1mm, a more accurate check of the Pads and Disc must be made.

If necessary change the Pads - see Section 6

B = without rib (see also Section 5.3.2)
C = pin protrusion - shown in new condition
D = minimal pin protrusion - Pads and Disc must be checked with road wheel removed

5.3.2 Brake Wear Check using Guide Pin (Only for Axial Disc Brakes SB 7541, SB 7551 to SB 7629, SB 7639 and Radial Disc Brakes SB 7102, SB 7112, SB 7103, SB 7113, SB 7104, SB 7114, SB 7105, SB 7115, SB 7108, SB7118, SB 7109, SB 7119, SB 7120, SB 7130 - These Callipers do have the rib in position B (see also Section 5.3.1)



The condition of the Pads can be visually determined without removing the road wheel by noting the position of the Fixed Sleeve (4) in the Floating Caliper (1).

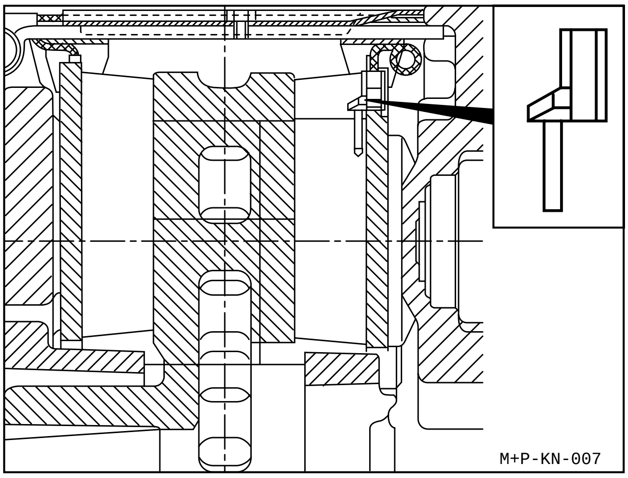
If the head of the Fixed Sleeve (4) is inside the Rubber Bush (6) by a dimension D greater than 18mm, then a more accurate check of the Pads and Disc must be made.

If necessary change the Pads - see Section 6.

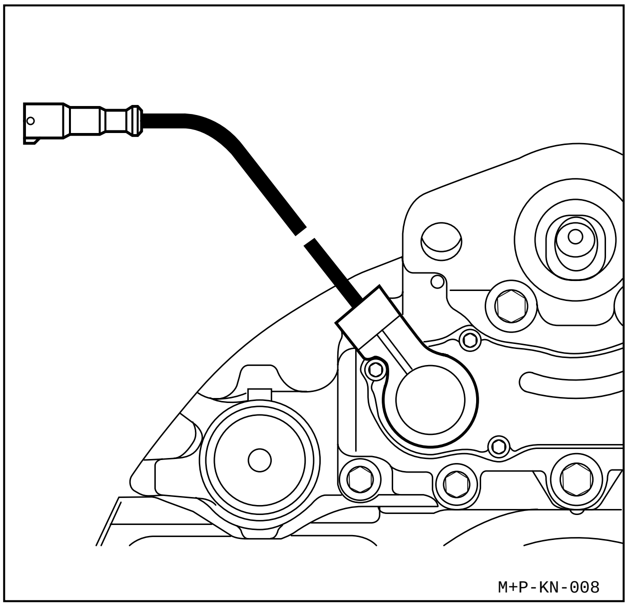
B = with rib (see also Section 5.3.1)
C = new condition
D = 18 mm or more, Pads and Disc must be checked with road wheel removed

5.3.3 Wear Indicators

Due to different Vehicle Manufacturer and vehicle types there are several types of Pad Wear Indicator used.



a) In - Pad Normally Closed Indicator - Circuit is broken when Pad Wear reaches limit.
b) In - Pad Normally Open Indicator - Circuit is made when Pad Wear reaches limit.



c) Wear Indicator using built in Potentiometer. This is available either as an on/off version or as a continuous signal version which can be linked to the vehicle's electronic monitoring systems.

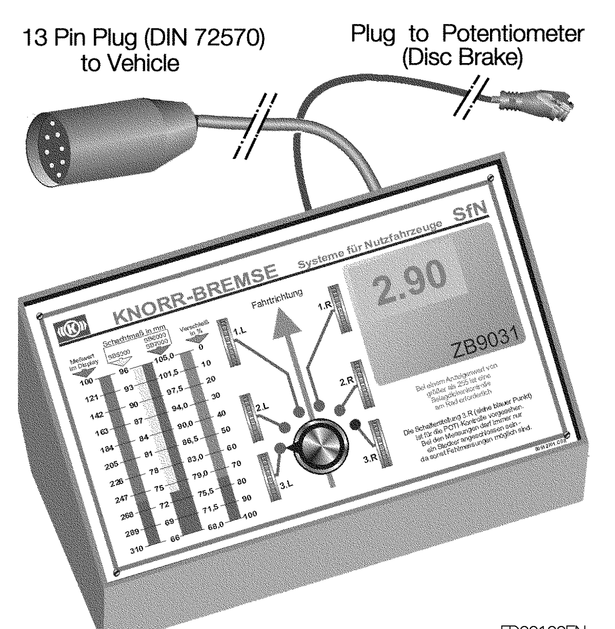
An optical or acoustic device may be linked to any of the above.

Important
Please also refer to specifications provided by the Vehicle Manufacturer

5.4 Knorr-Bremse Diagnostic Equipment

The Knorr-Bremse Diagnostic Unit **ZB 9031** is a hand held device suitable for vehicles that are fitted with Knorr-Bremse Disc Brakes using a continuous signal type of Wear Potentiometer.
The wear condition of each brake can be measured by connecting the device to a suitable 13 pin socket (DIN 72570) where fitted. This socket will have been connected to each sensor by the vehicle manufacturer.
The Diagnostic unit allows:
- Quick and simple wear check.
- A check of the potentiometer function.

A detailed instruction manual is included with each unit.



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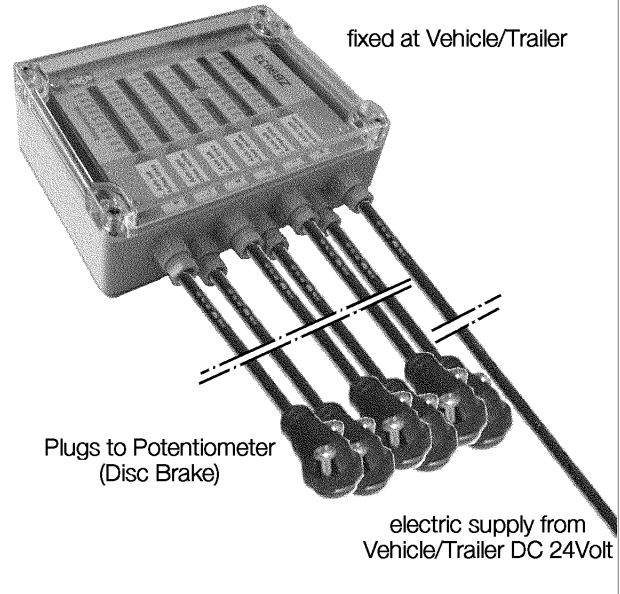
5.5 Knorr-Bremse Diagnostic Equipment

The Knorr-Bremse Wear Check Module **ZB 9033** is a chassis mounted device suitable for vehicles that are fitted with Knorr-Bremse Disc Brakes using a continuous signal type of Wear Potentiometer.
The module continuously monitors and displays the wear at each brake.
For vehicles without an automatic brake control system, particularly Trailer applications, the module allows for a quick and simple wear check.
The Wear Check Module allows:
- Up to 6 Brakes to be checked together.
- LED monitoring of each Brake condition.

A detailed instruction manual is included with each unit.



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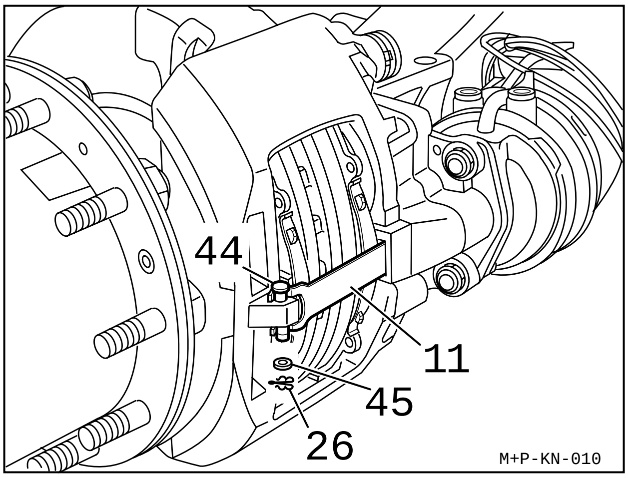
6 Pad replacement
(for “Axial- and Radial Disc Brake”)

WARNING!

Before starting repair work, ensure the service brake and parking brake are not applied and that the vehicle cannot roll away.

6.1 Pad removal



Take the wheel off (refer to Vehicle Manufacturer’s recommendations).

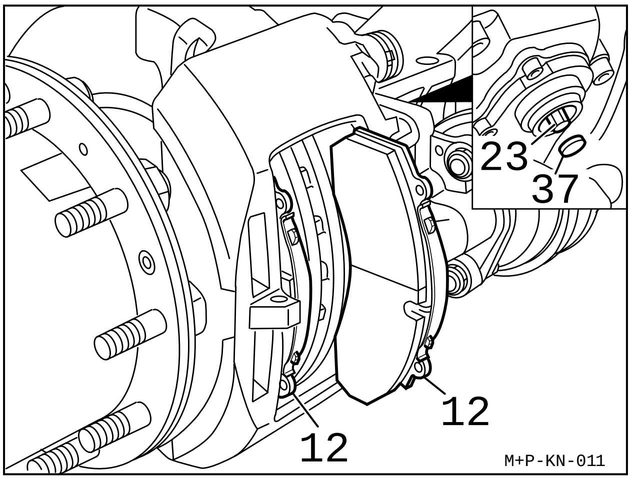
Remove Clip (26) and Washer (45), push down the Pad Retainer (11) and remove Pin (44).

If the Pad Retainer (11) is corroded, it should be replaced.

Important
Before removing Pads it is strongly recommended that the Adjuster mechanism is checked for correct operation. See Section (5.2)

WARNING!

Do not overload or damage the Adjuster (23). Use only 8mm Ring Spanner or 1/4” drive Socket with a lever length no greater than 100mm.
***DO NOT** use an Open Ended Spanner since this may damage the Adjuster shaft.*



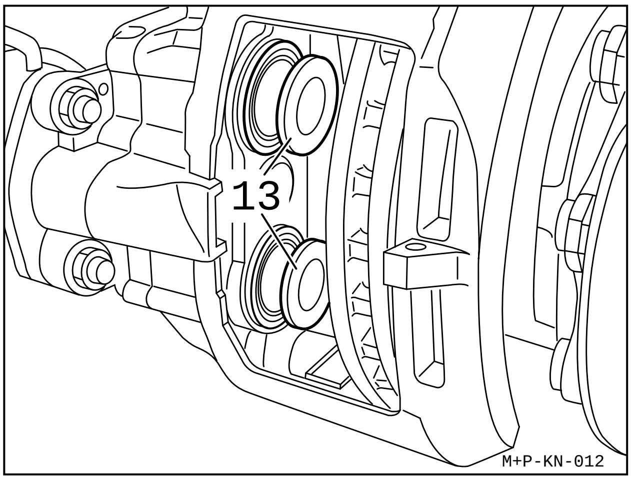
Remove Cap (37).

Turn the Adjuster counter-clockwise until Pads can be removed. A clicking noise will be heard during this procedure.

Push inboard Pad (12) toward Actuator.

Pull out both Pads (12).

6.1.1 Tappet Boot Check



The Adjuster (23) should be screwed clockwise until the boots are clearly visible.
The Boots should not show any damage.
Check the attachment of the Boots into the Caliper housing.

Important
Any ingress of water or dirt past the Tappet Boot will lead to corrosion and affect the function of the Actuation Mechanism and Adjuster Unit.

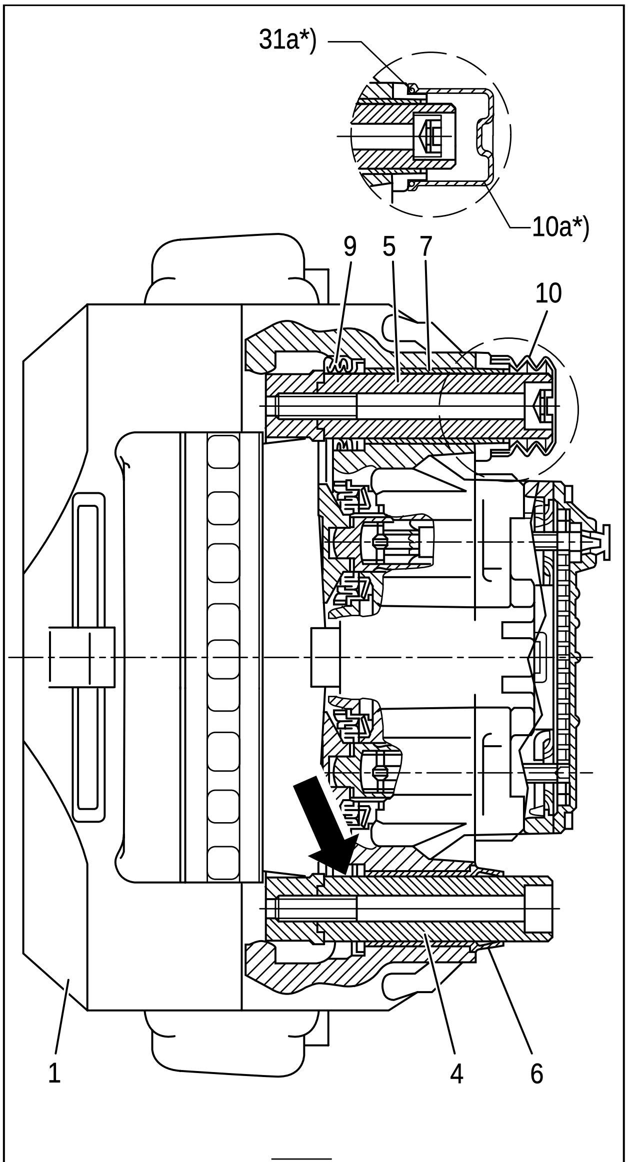
If damaged, the Boot and Tappet must be replaced (see Section 7).

6.1.2 Caliper guidance check

Following Pad removal (Section 6.1)

Using hand pressure only (no tools), the Caliper (1) must slide freely over the whole length of the Guide Pin arrangement >30mm.
During this operation the Sleeve (5) is sealed by the Boot (9) and Cap (10) or Steel Cap (10a) and O-Ring (31a). These must show no signs of damage. Check that these are correctly seated.

The Caliper may have to be re-sealed by using a suitable Kit (see page 5 or page 7).



6.2 Pad fitting

WARNING!

Pads must be changed as an axle set and NOT individually.
Use only Pads which are permitted by the vehicle manufacturer,axle manufacturer and brake manufacturer.
Failure to comply with this may invalidate the vehicle manufacturer's warranty

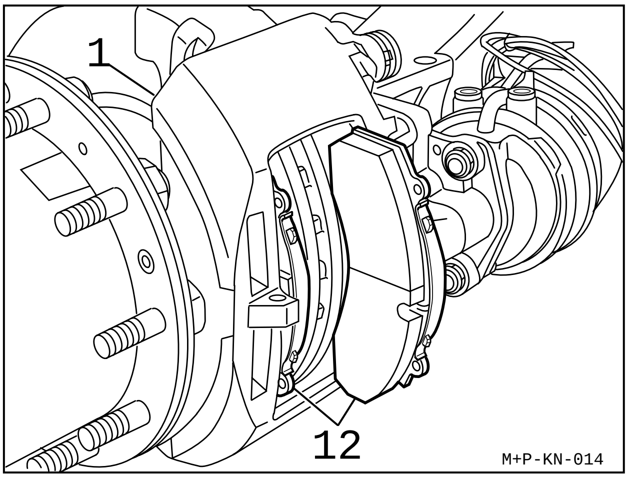
Note:
Before placing the Pads into the Carrier, the Adjuster (23) must be further de-adjusted by rotating it counter clockwise.

Clean the Pad abutments.

Push Caliper (1) outboard and fit the outboard Pad (12).

For fitting the inboard Pad (12) push Caliper (1) in the opposite direction.

If fitted, replace Wear Indicators and fittings / brackets etc. See page 5 or 7.



WARNING!

Do not overload or damage the Adjuster (23). Use only 8mm Ring Spanner or 1/4" drive Socket with a lever length no greater than 100mm.
***DO NOT** use an Open Ended Spanner since this may damage the Adjuster shaft.*

Rotate the Adjuster clockwise until the Pads come into contact with the Disc. Then turn back the Adjuster 2 clicks.

The hub should turn easily by hand after having applied and released the brake.

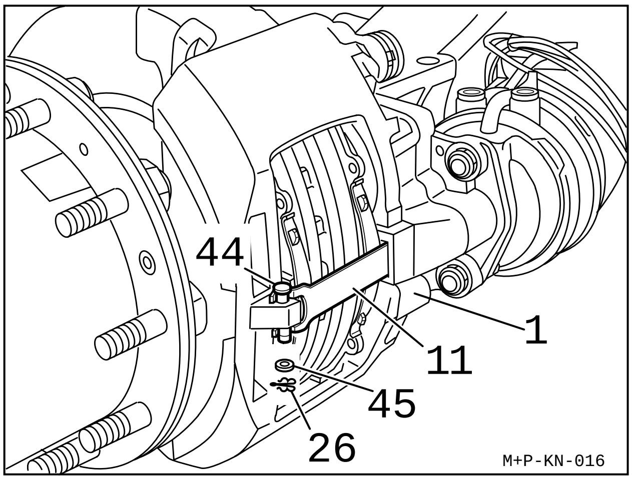
The Cap (37) must then be replaced having lightly greased it with Renolit HLT2 (available as part number II14525).

After setting the Pad Retainer (11) into the groove of the Caliper (1), it must be pushed in to enable the positioning of Pad Retainer Pin (44).

Fit washer (45) and Spring Clip (26) to the Pad Retainer Pin (44) (use only new parts).

Our recommendation is fitting Washer (45) and Spring Clip (26) pointing downwards (see diagram).

Wheel mounting (refer to Vehicle Manufacturer's recommentations).



IMPORTANT!

New Pads need bedding in. Heavy or long duration braking should initially be avoided.

7 Tappet with Boot replacement
(for "Axial- and Radial Disc Brake")

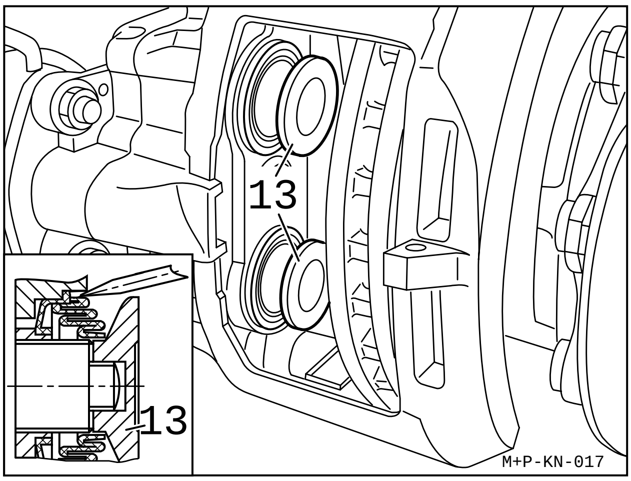
7.1 Tappet with Boot removal

Note:
It may be easier to remove the Caliper from the axle to replace the Tappets of the Caliper (see Section 10.1).

The Adjuster (23) must be screwed clockwise until the Boots can be reached.

If the Caliper has been removed from the vehicle care must be taken not to overrun the threads (see section 7.1.1).

To remove the Tappet Boot from the Caliper bore, a Screwdriver should be used to deform the Boot location ring - see diagram.



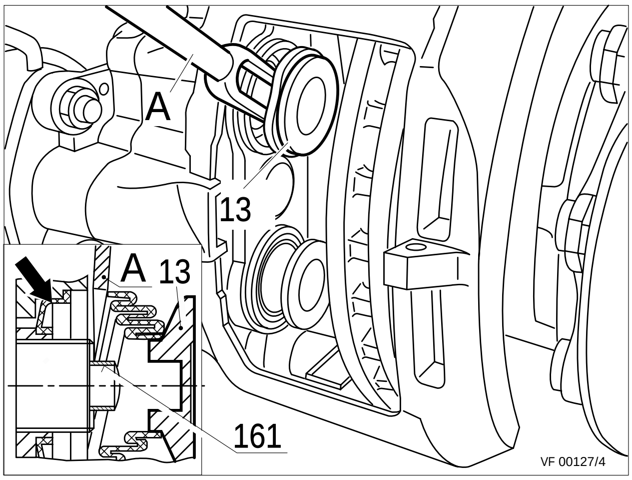
Warning!

Great care must be taken not to damage the Inner Seal since it is not a replacement item.

The Tappets (13) can be removed from the Threaded Tubes by using Wedge Fork A. (Order No. II32202).

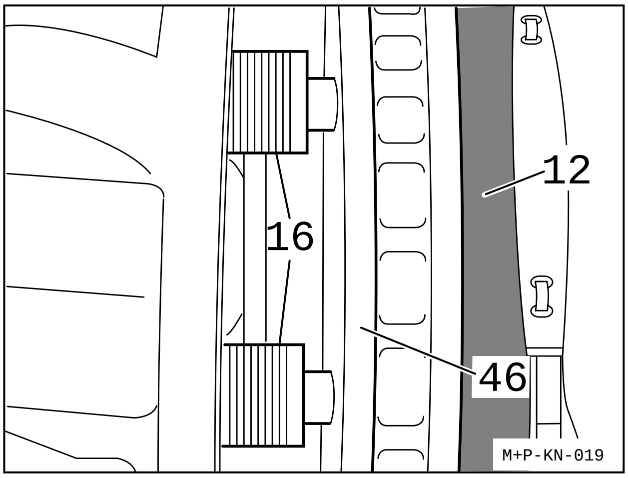
Remove the old Tappet Bush (116).

Check Inner Seal (arrow) and if damaged, the Caliper must be replaced .



7.1.1 Adjuster thread inspection

Place an unworn Pad (12) **into the outboard gap** to avoid overrunning of the Threaded Tubes.

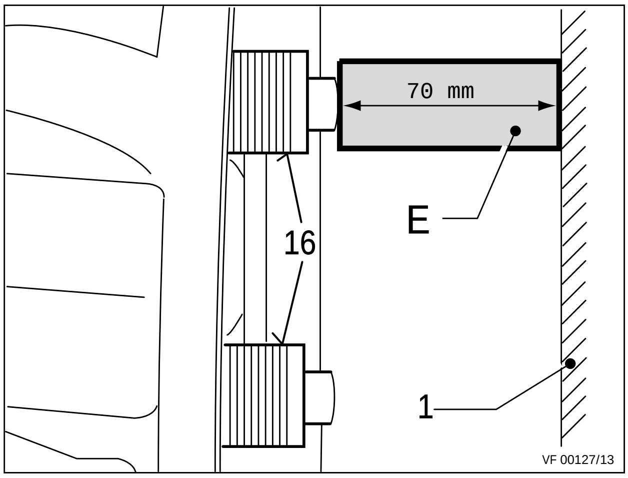


IMPORTANT!

Threaded Tubes should not overrun the inner thread of the Bridge.
The Caliper must be changed if synchronisation is lost.

For the inspection of the threads, the tubes must be screwed out (max. 30mm) by turning the Adjuster (23) clockwise.

If Caliper is not installed on axle, put a spacer E (length = 70mm) into the Caliper (1) to avoid overrunning of the Threaded Tubes (16) when screwing them out (see illustration opposite). During screwing, the threads can be checked for corrision damage.
In case of water ingress or corrosion, the Caliper must be replaced.



7.2 Tappet with Boot fitting

With Caliper fixed to axle:
Grease threads with RENOLIT HLT2 (Order No. II14525).

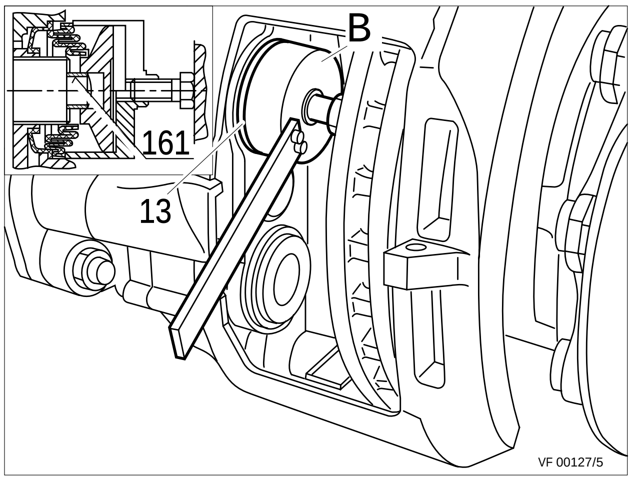
Screw back Threaded Tubes (16), by turning the Adjuster (23) counter-clockwise.

Place new Tappet Bush (161) onto the head of the Tube (16).

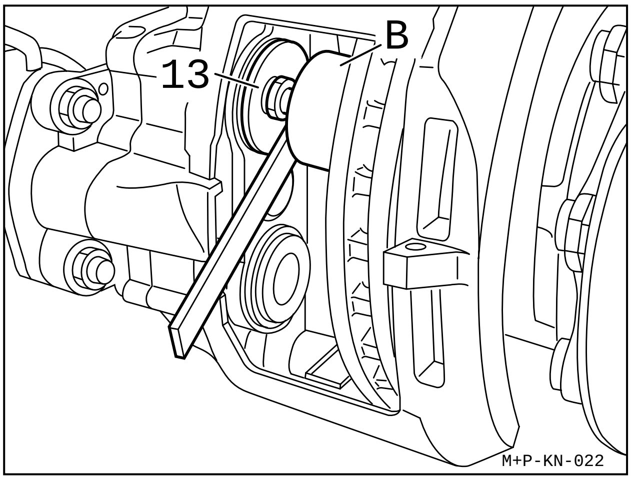
Sealing seat in the caliper for Tappet with Boot (13) must be clean and free of grease.

Place Tappet with Boot (13) onto the head of the Tube.

Use Push-In Tool with the short strut (B) (Order No II19252) for positioning and pressing-in the Boot (13).

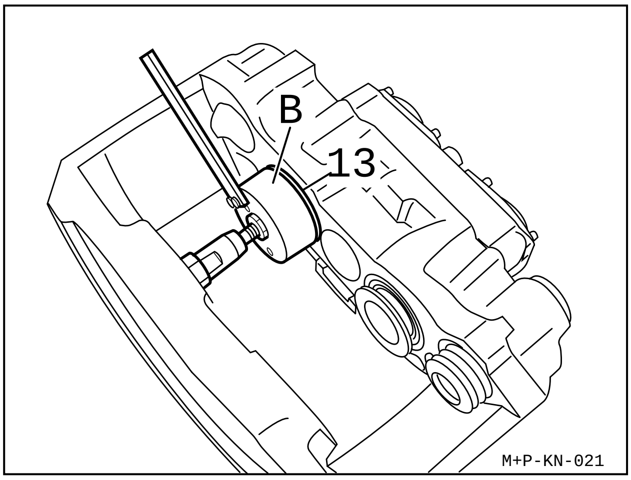


Using Tool B in reverse, the Tappet can be pressed on.



With Caliper not installed on axle
Grease threads with RENOLIT HLT2 (Order No. II14525).

Screw back Threaded Tubes (16), by turning the Adjuster (23) counter-clockwise.



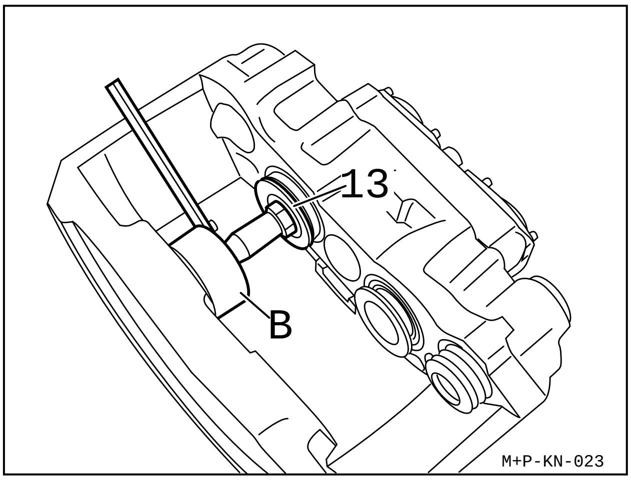
Sealing seat in the caliper for Tappet with Boot (13) must be clean and free of grease.

Place new Tappet Bush (161) onto the head of the Tube (16).

Place Tappet with Boot (13) onto the head of the Tube.

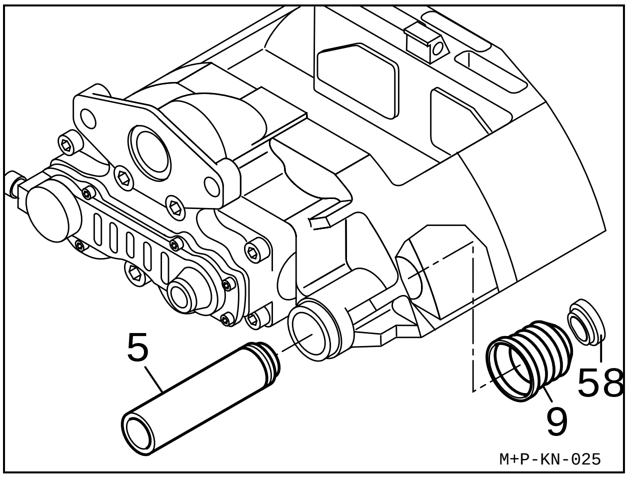
Use Push-In Tool with the long strut (B) (Order No II19252) for positioning and pressing-in the Boot (13).

Using the Tool (B) in reverse, the Tappet can be pressed on.



8 Caliper Suspension sealing

(Replacement of inner Boot (9))
(for the Axial and Radial Disc Brake)



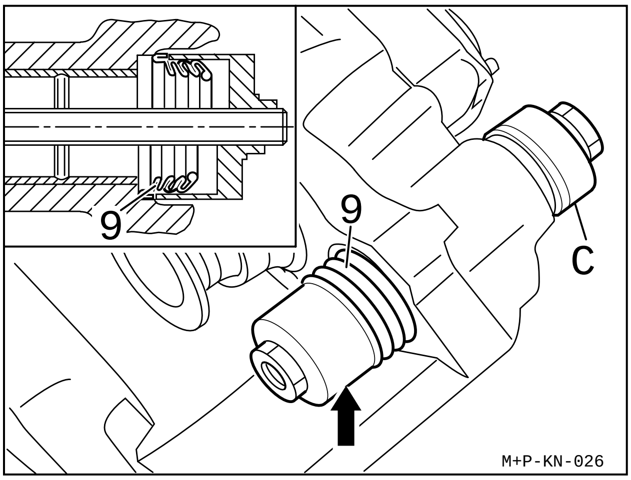
Remove Caliper (see Section 10.1)

Remove Ring (58)

Pull out Sleeve (5)

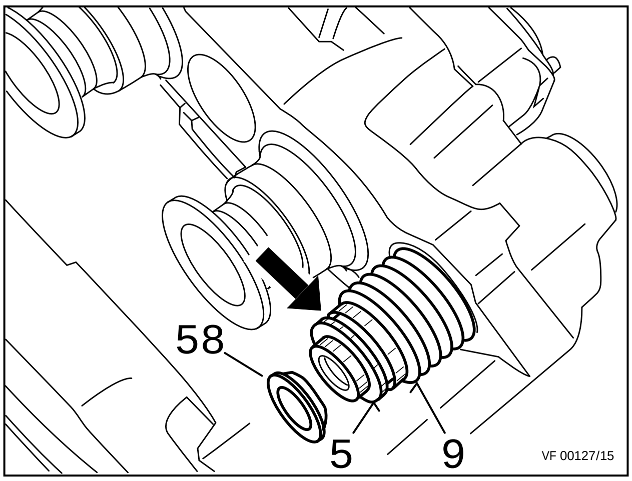
Push out Boot (9) with screw driver.

Inspect and clean contact area of Boot (9)



Put new Boot (9) into the Sleeve (arrow) of the Tool C (Order No II19253).

Position Sleeve with Boot (9) into the Caliper bore and pull in.



Fit the Sleeve (5)
The Boot end must engage in the groove of the Sleeve (5) (arrow). Lock with Ring (58) by pushing until it engages.

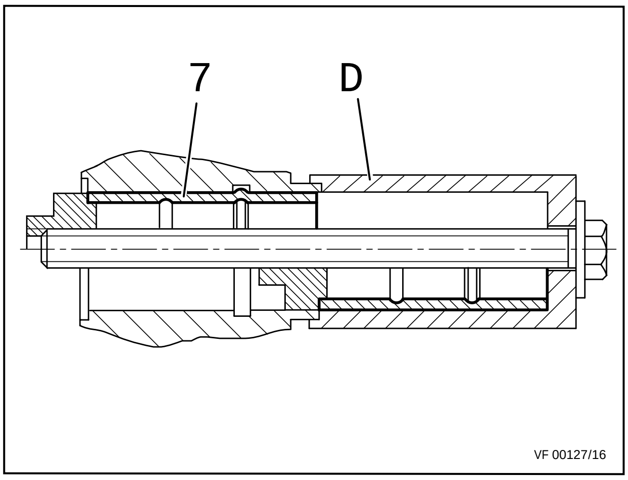
Important:
Before fitting the Caliper the unsealed Sleeve with the Rubber Bush should be checked for its ability to slide.

Fit Caliper (see Section 10.2).

9 Guide Pin Bush replacement
(for “Axial- and Radial Disc Brake”)

Remove Caliper (see Section 10.1)

Remove Sleeve (5) and inner Boot (9) (see Section 8).



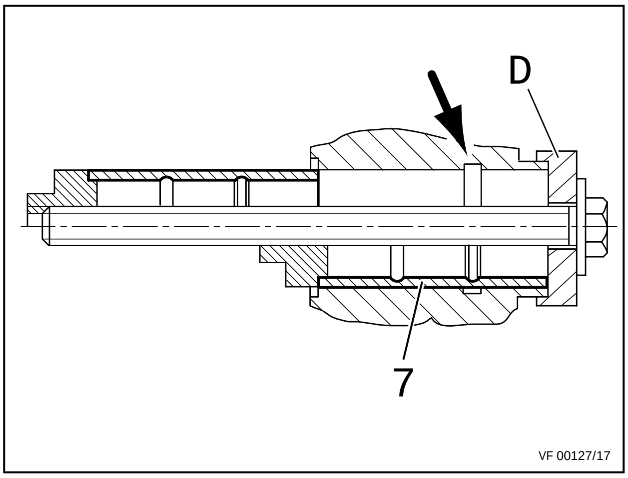
9.1 Brass Bush (7) replacement

Remove old Sleeve (5).

Pull out Bush (7) with Tool (D) (Order No. II19254).

If Caliper has no groove (see arrow)
(Note: Groove is always located on the inboard side)

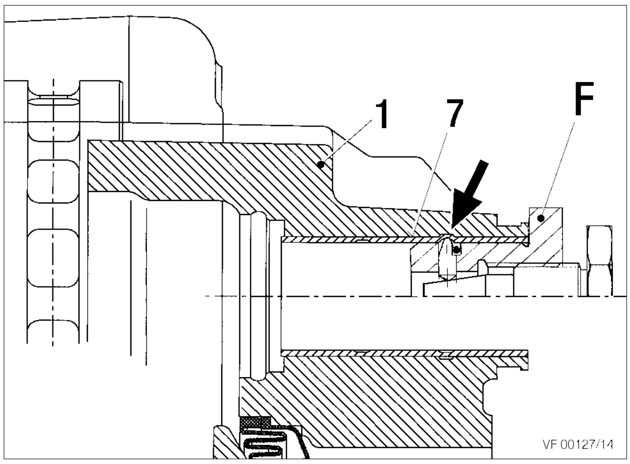
Pull in new Brass Bush (7) with Tool (D).



If Caliper has a groove:
Pull in new Brass Bush (7) with Tool (D).
To prevent longitudinal displacement use Tool (F) (Order No II36797) to create new groove.

Check contact area of Brass Bush (7) for burrs.
Remove burrs.
Grease Bush with white Grease RENOLIT HLT2 (Order No II14525).

Insert new Sleeve (5).

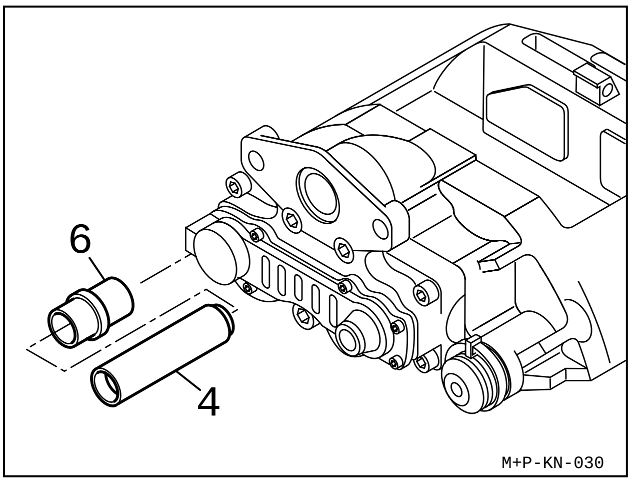


Note:
The Guide Pins Kit contains new Sleeves (4) & (5) and new Caliper Bolts (39) & (40) (see Section 1.2 and 1.4).

9.2 Rubber Bush (6) replacement

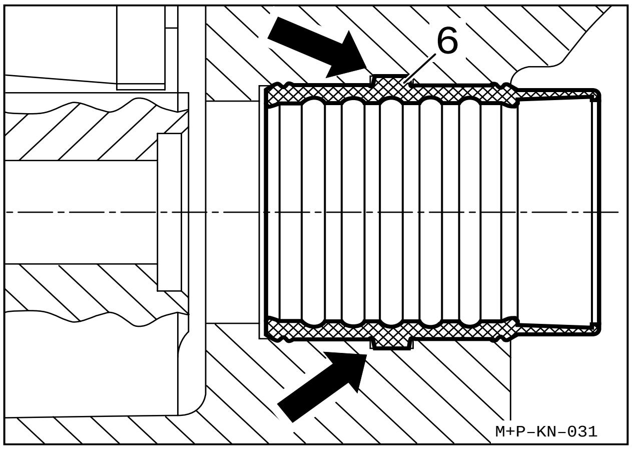
Remove old Sleeve (4)

Pull Rubber Bush (6) out of bore.
Check bore for corrosion, clean if necessary with Corrosion protection paint (e.g. Zinc spray).



Note:
Grease new Rubber Bush (6) inside and outside with green Grease SYNTHESO GL EP 1 (Order No II32793).

Deform new Rubber Bush (6) and push from the inner side of the Caliper into the bore.
Push Rubber Bush (6) so that the outer positioning ring locates in the groove (see arrows).



IMPORTANT!

Under no circumstances must the white Grease (containing mineral oil) be used for lubricating the Bush or Sleeve. Use only synthetic based green Grease (Part Number II32793).

Note:
The Guide Pins Kit contains new Sleeves (4) & (5) and new Caliper Bolts (39) & (40).

Assemble Sleeve (4)

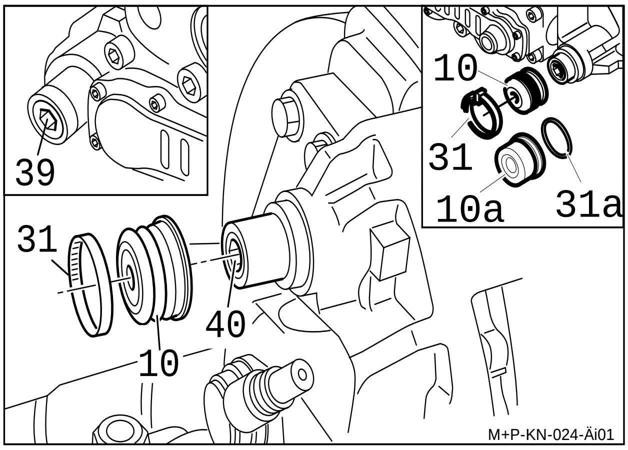
Re-fit Caliper (see Section 10.2)

Important:
Torque Caliper Bolts to 285^{+25} Nm and check that the Caliper slides easily.

10 Caliper replacement

(for Axial- and Radial Disc Brake)

10.1 Caliper removal

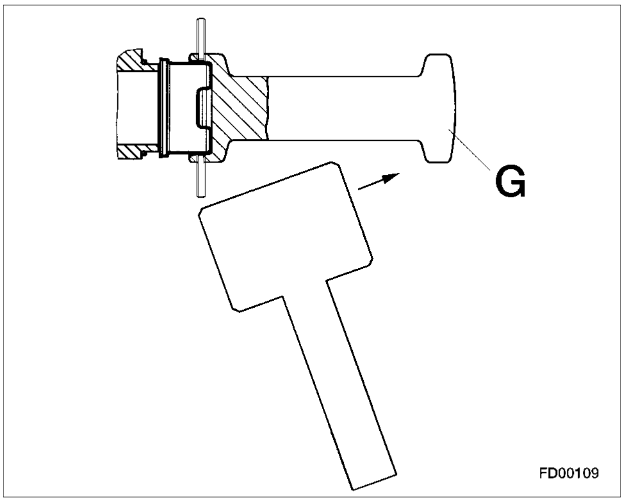


Remove Pads (see Section 6.1)

Remove Actuator (see Section 12.1 and 12.3).

Remove Outer Boot Clip (31) and take off Outer Boot (10)

Note:
As well as Calipers with Outer Boot (10) and Outer Boot Clip (31) there are versions with Steel Cap (10a) and O-Ring (31a) available.



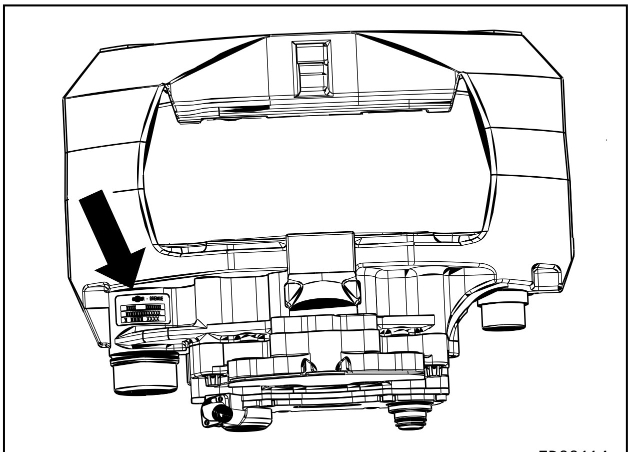
On models with Steel Caps (10a) and O-Rings (31a), place tool (G) (Part Number Z001105) onto the Steel Cap and tighten the threated pin by a hexagon socket spanner. Then use hammer as shown.

Remove Cylinder Bolts (39 and 40).

WARNING!

Hold Caliper only at its outer side. Never get your fingers between Caliper and Carrier!

Remove Caliper from Carrier.



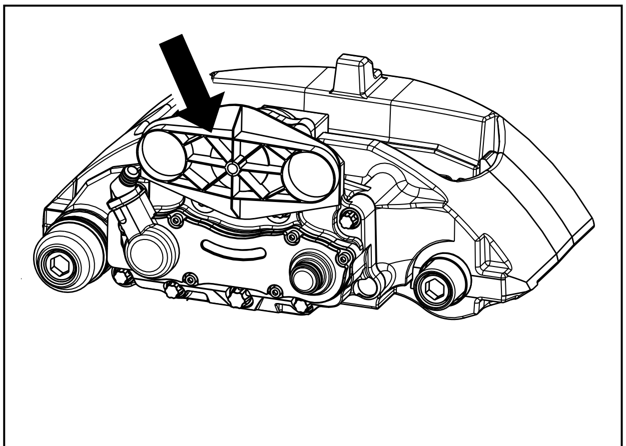
FD00114

IMPORTANT!

The opening or dismantling of the Caliper has not been authorized. Use only Genuine Knorr-Bremse Service Exchange Calipers.

10.2 Caliper fitting

The correct choice of Caliper must be ensured by checking the Part No. on the label (arrow, picture above)

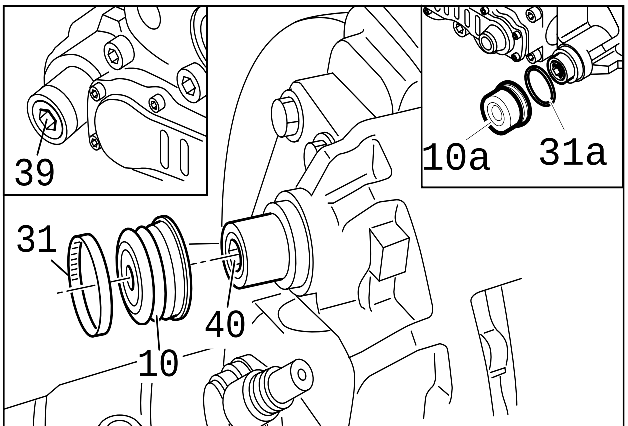


FD00116

Note:
Service Exchange Calipers have a blue label.

The Service Exchange Caliper has a plastic cap or an adhesive tape in the area of the Actuator attachment. Remove the cap tape after installing the Caliper (see arrow).

Note:
The service exchange Caliper includes sealing and guiding elements. The Pads are not included.



FD00113

WARNING!

Hold Caliper only at its outer side. Never get your fingers between Caliper and Carrier!

10.2.1 Caliper with Outer Boot (10)

Locate the Caliper to the Carrier.

Screw-in Caliper Bolts (39 and 40) and tighten to 285^{+25} Nm (use only new parts).

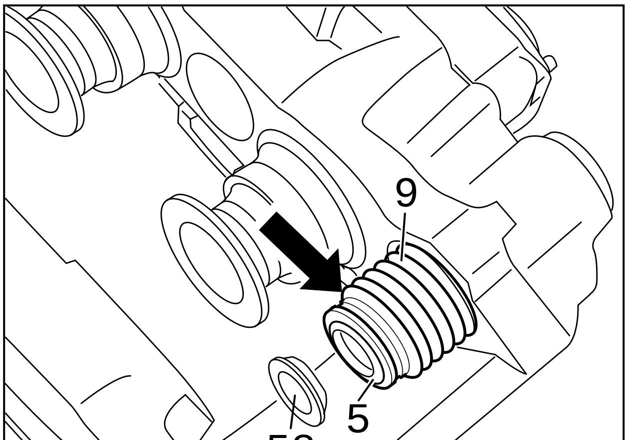
Check that the Caliper slides easily.

Check the position of the Inner Boot (9) on the Sleeve (5).

Check Adjuster function (see Section 5.2)

If necessary use new Outer Boot (10).

Check grease-free seating of the Outer Boot (10) on the Caliper (1)

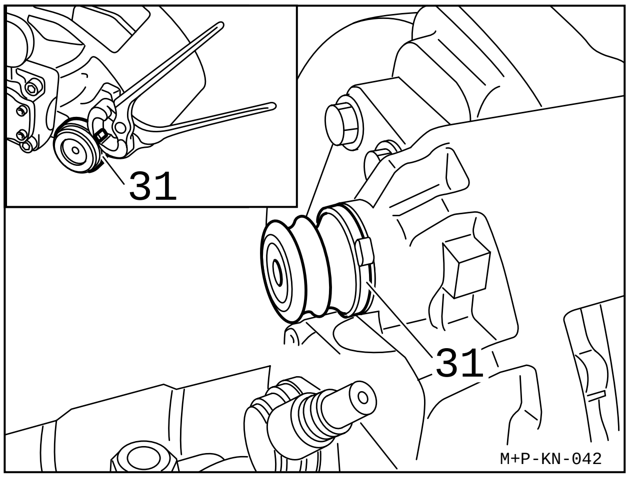


M+P-KN-027

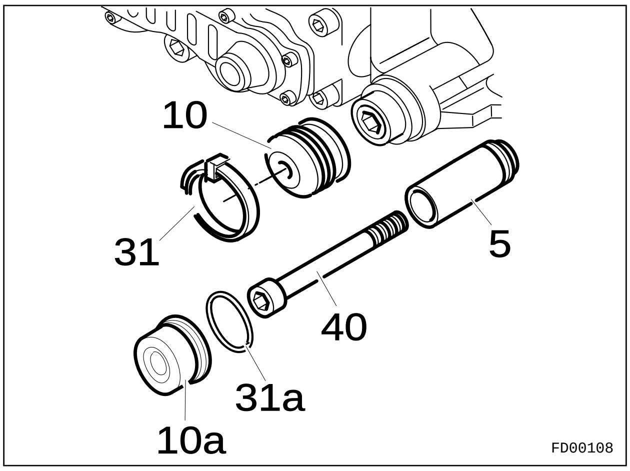
Tighten Outer Boot Clip (31)

Fit the Pads (see Section 6.2)

Attach Brake Chamber or Spring Brake (see Section 12.2 or 12.4)



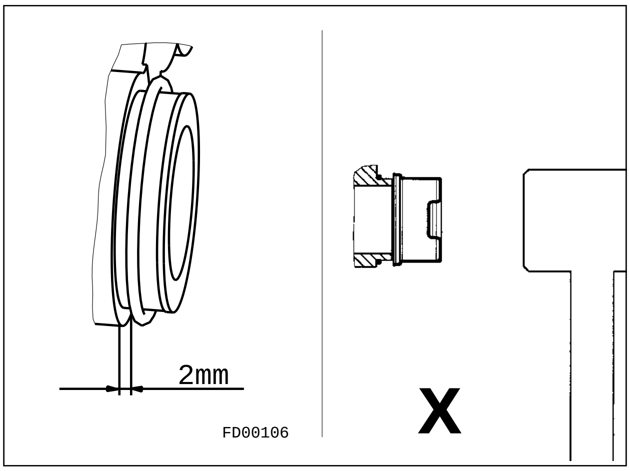
10.2.2 Caliper with Steelcap (10a)



IMPORTANT!

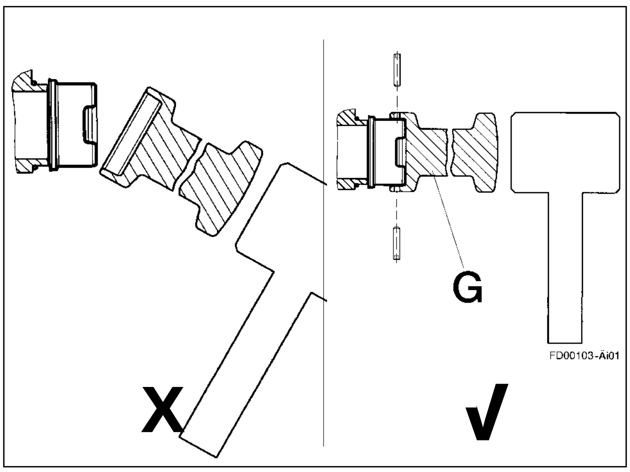
It is only allowed to replace the Outer Boot (10) by the Steel Cap (10a) when replacing the Sleeve (5), the O-Ring (31a) and the Screw (40) at the same time. Replace only after permission by Axle- or Vehicle-manufacturer. On SB 6... (19,5") only permissible after manufacturing date A0026. (see type plate).

It may be easier to remove the Caliper and the Carrier from the axle to replace the Steel Cap.



Assemply at the Vehicle :

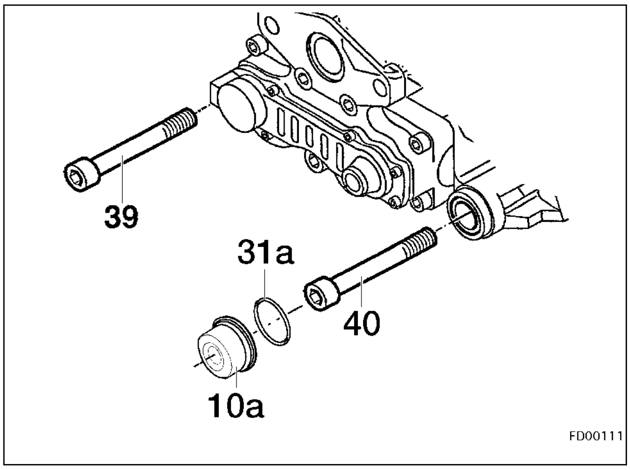
The fitting must be carried out with Pads still installed.
- Clean area.
- Using the Grease supplied (II14525), lightly lubricate the O-Ring and place it over the cast spigot (see Sketch).
- Remove Threated Pins from assembly tool (G) to avoid demage of the Steel Cap.
- Hold the new Steel Cap on the end of the Spigot. By using a suitable press or special assembly tool (Part Number Z001105) and a hammer, press the Steel Cap fully on the spigot making sure not to deform the Cap.
  After removal the Steel Cap and the O-Ring must not be refitted.



IMPORTANT!

The Steel Cap (10a) and the O-Ring must only be used once.

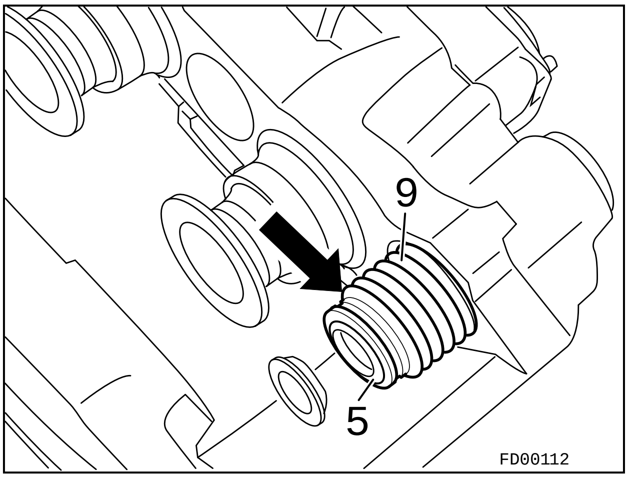
Assemply on the Caliper and Carrier removed from the axle:



IMPORTANT!

It is <u>only</u> allowed to replace the Outer Boot (10) by the Steel Cap (10a) when replacing the Sleeve (5), the O-Ring (31a) and the Screw (40) at the same time. Replace only after permission by Axle- or Vehicle-manufacturer. On SB 6... (19,5“) only permissible after manufacturing date A0026. (see type plate).

Put the Caliper on the Carrier.



IMPORTANT!

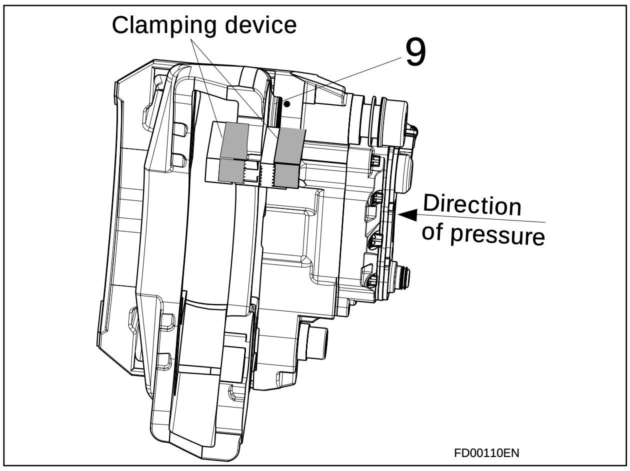
Special threated Screw (40) and Steel Cap (10a) as well as the O-Ring (31a) must be renewed whenever Screw (40) has been removed.

Screw-in Caliper Bolts (39 and 40) and tighten to 285^{+25} Nm.

Check the position of the Inner Boot (9) on the Sleeve (5).

Check that the Caliper slides easily.

In the shown clamping (e.g. vice) press the Caliper against the Carrier as far as possible. The inner Boot (9) must be in compressed condition, this to prevent air being trapped inside of the Cap.



The assembly of the Steel Cap (10a) can now be carried out as in Section “ Assembly at the Vehicle“.

Check Adjuster (Section 5.2).

11 Carrier replacement
(for Axial- and Radial Disc Brake)

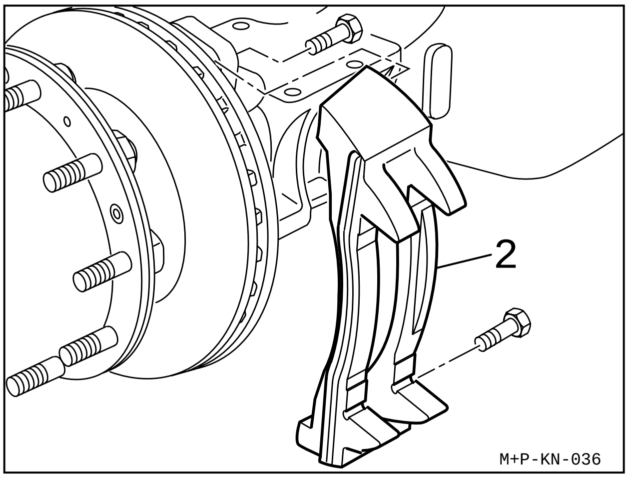
Remove Caliper (see Section 10.1).

Remove Carrier (2) from axle.

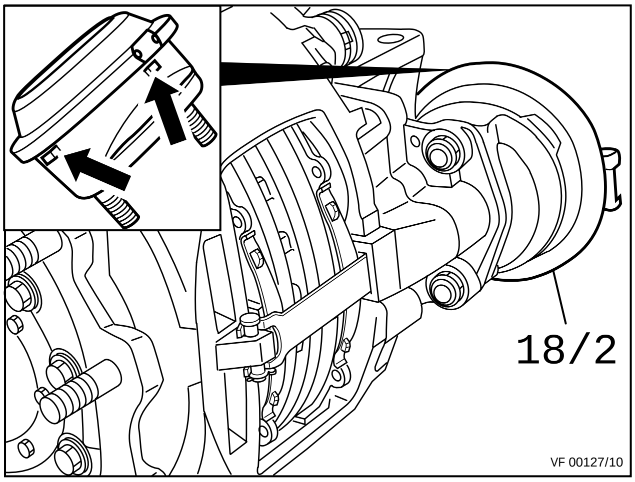
Clean axle contact area.

Attach new Carrier with new bolts from the relevant truck manufacturer. Bolts are not supplied by Knorr-Bremse.

Attach Caliper (see Section 10.2)



12 Actuation cylinder replacement
(for “Axial- and Radial Disc Brake”)



12.1 Brake Chamber removal

Disconnect air line from Brake Chamber (18/2)

Unscrew Brake Chamber Mounting Nuts (do not re-use them).

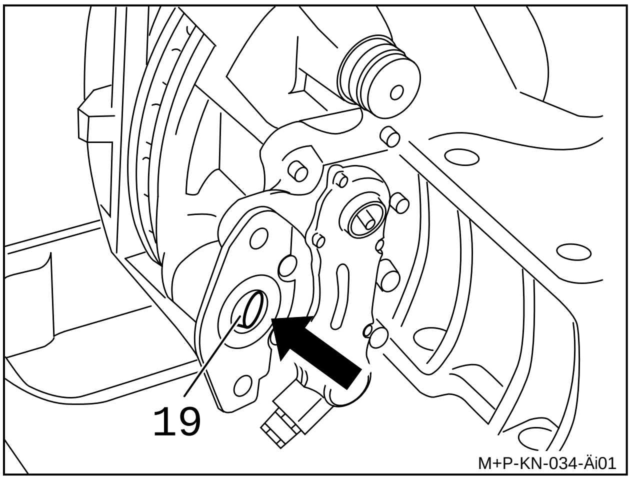
Remove Brake Chamber

12.2 Brake Chamber fitting

IMPORTANT:
New Brake Chambers (18/2) have drain plugs installed. Remove bottom plug (see arrows). All other drain holes should be plugged.

Before fitting the new Brake Actuator, the sealing surface (see arrow) must be cleaned, and the Spherical Cup (19) in the Lever must be greased with white Grease RENOLIT HLT2 (Order no II14525).

Surface area of the flange must be plain and clean.



IMPORTANT!

Do not use Grease containing molybdenum disulphate. Use only KORR-Actuators which are recommended by the Vehicle Manufacturer.

Attach Actuator with new Nuts (self-locking EN ISO 7042) and torque tighten to 180^{+30} Nm.

Connect air hose and check for leakage.

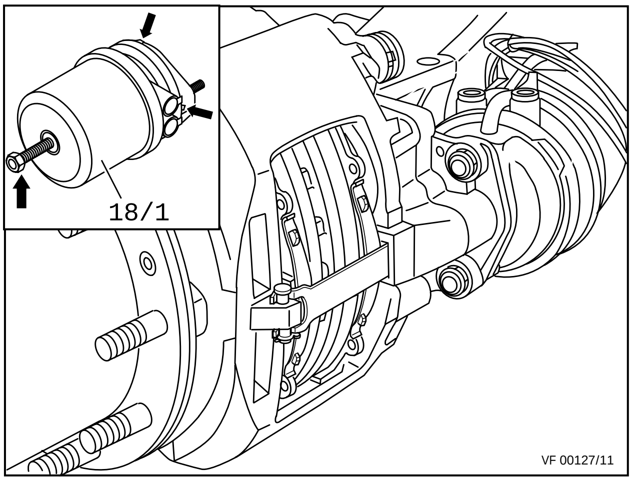
Make sure that hose is not twisted and that chafing is not possible.

IMPORTANT!

Check function and effectiveness of the brake.

12.3 Spring Brake removal

> ***CAUTION!***
>
> *Chock wheels before releasing Spring Brake*



Release parking brake, move Hand Control Valve to ‘run’ position.

Screw-out Release Bolt (arrow) with a maximum torque of 35Nm.

Release air from brake, move Hand Control Valve to ‘park’ position.

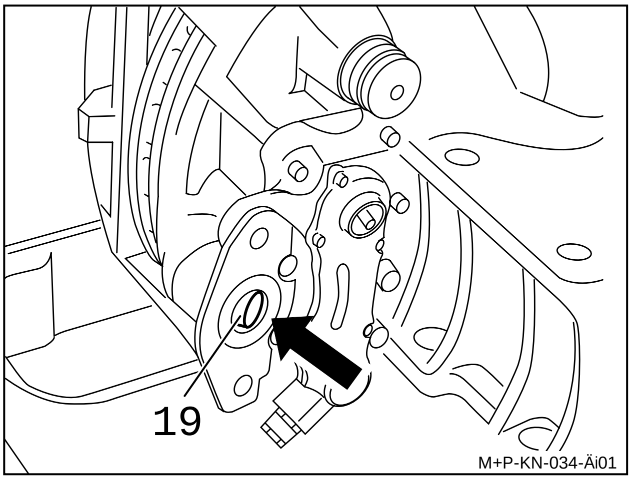
Disconnect air hoses from Spring Brake Actuator (18/1)

Unscrew Spring Brake Actuator Mounting Nuts (do not re-use).

Remove Spring Brake Actuator.

12.4 Spring Brake fitting

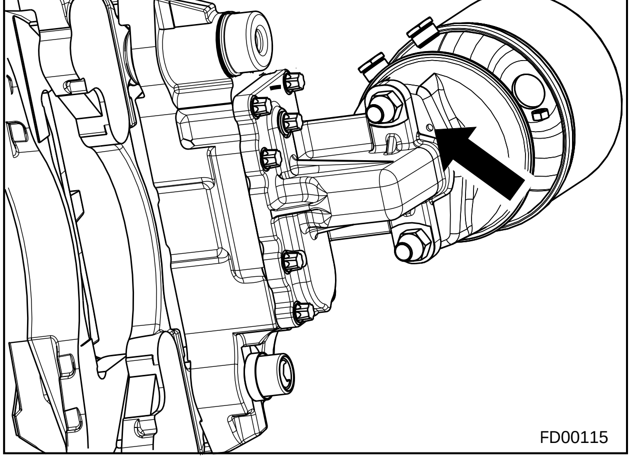
IMPORTANT!
New Spring Brake Actuators (18/1) have drain plugs installed. Remove bottom plug (see arrows).
All other drain holes should be plugged.



Before fitting the new Brake Actuator, the sealing surfaces have to be cleaned, and the Spherical Cup (19) in the Lever must be greased with white Grease RENOLIT HLT2 (Order no II14525)

Surface area of the flange must be plain and clean.

> ***IMPORTANT!***
>
> *Do not use grease containing molybdenum disulphate.*
> *Use only KNORR-BREMSE Actuators which are recommended by the Vehicle Manufacturer.*



> ***IMPORTANT!***
>
> *On Radial Disc Brake the Train Plugs in the bottom of the Cylinderflange must be open.*

Attach Actuator with new Nuts
(self-locking EN ISO 7042) and torque tighten to
180^{+30} Nm.

Connect air hose, ensuring that hoses are not mixed up.

Make sure that hoses are not twisted and that chafing is not possible.

Release parking brake, move Hand Control Valve to 'run' position, and check for leakage.

Screw in Spring Brake Release bolt to maximum 70 Nm.

IMPORTANT!

Check function and effectiveness of the brake.

13 Additional information

13.1 Service Video

A Video is available for additional information.
Order number: RA-SB0002.DE Video (German)
RA-SB0002.EN Video (English)
(in UK. order KBP2060/1)
RA-SB0002.IT Video (Italian)
RA-SB0002.SP Video (Spannish)
RA-SB0002.PO Video (Portugese)
RA-SB0002.DA Video (Danish)
RA-SB0002.HU Video (Hungarian)
RA-SB0002.FR Video (French)

13.2 Service Tool Kit ZB 9032

For service and repair work we recommend our Tool Kit ZB 9032 II 37951/004EX, which contains all necessary special tools.

13.3 Diagnostic Equipment

For vehicles fitted with continuous potentiometer type wear sensors, Knorr-Bremse Diagnostic Equipment may be used to ensure quick and simple measurement of wear at each caliper.
See sections 5.4 and 5.5.

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SECTION 13: WHEELS, HUBS & TIRES

CONTENTS

ILLUSTRATIONS

1. WHEELS

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. If equipped with hub-mounted wheels, all studs and nuts 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 for coaches 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.

NOTE
MTH vehicles come equipped with 22.50 X 10.5 wheel dimensions (571.5 X 266.7 mm) for 365/70 R 22.5 tires on front and tag axle.

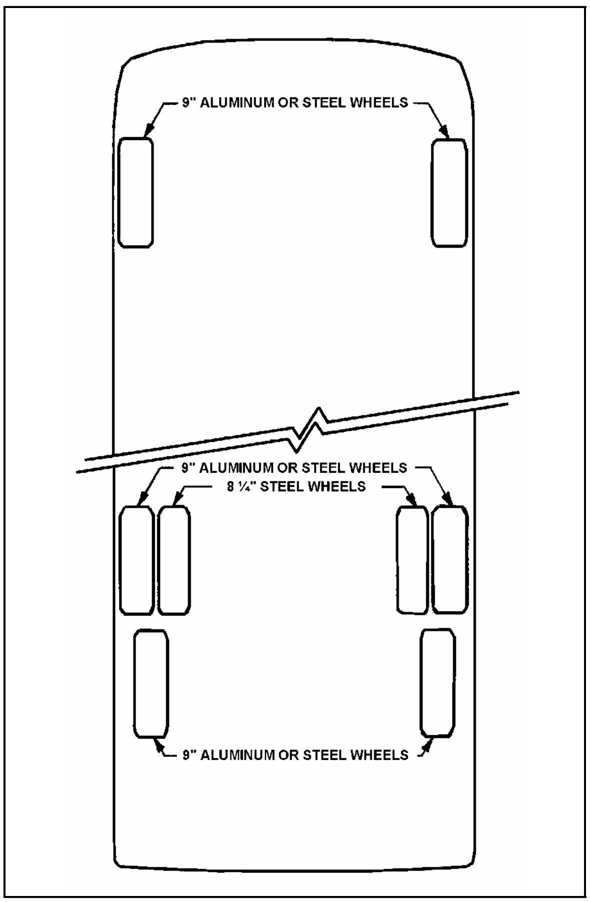

FIGURE 1: ALUM/STEEL WHEEL ARRANGEMENT 13001

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.

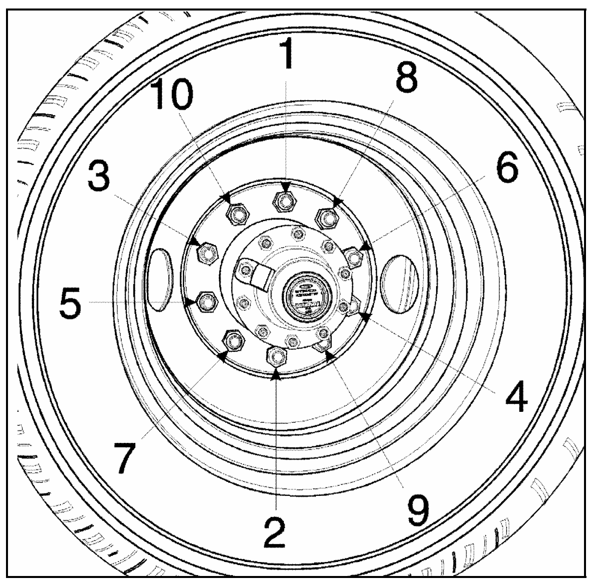

FIGURE 2: TIGHTENING SEQUENCE 13018

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.

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. 3), 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 180º 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 of 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 ¾-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 runout. 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 runout exceeds 0.0625 inch (1,6 mm), the wheel must be replaced.

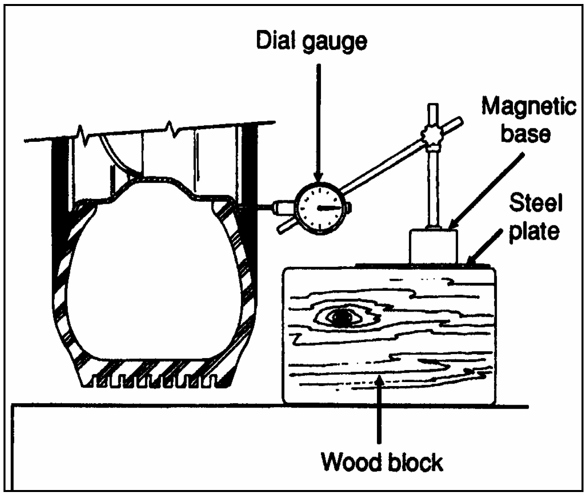

FIGURE 3: DIAL GAUGE INSTALLATION 13008

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 runout 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 ¾"-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.

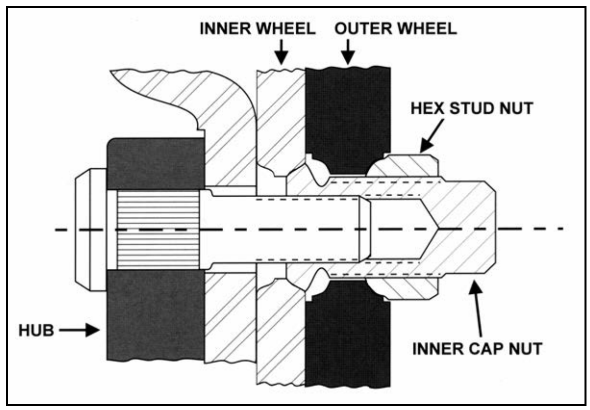

FIGURE 4: STUD-MOUNTED WHEELS 13007

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.

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.

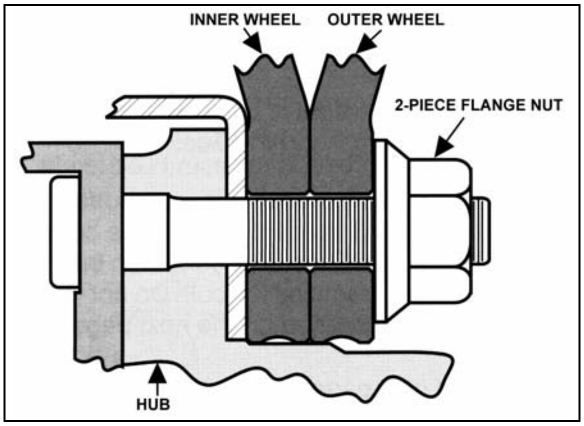

FIGURE 5: HUB-MOUNTED WHEELS 13025

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 for a new bearing.

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 10.

NOTE
For vehicles equipped with Independent Front Suspension, refer to Section 16 "Suspension".

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, ¼ to 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 (IF APPLICABLE)

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.

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.

NOTE
Converted vehicles contain no spare wheel. Access to compartment is also obtained by pulling the release handle located in the front service compartment.

⚠ 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.

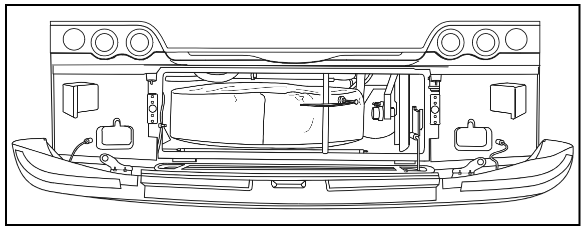

FIGURE 6: SPARE WHEEL COMPARTMENT

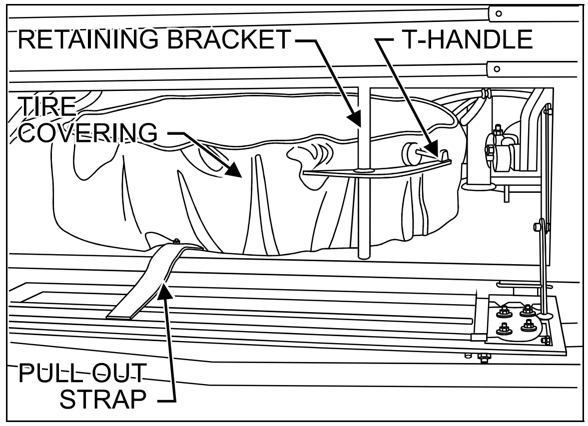

FIGURE 7: SPARE WHEEL AND TIRE 18415

NOTE
The jack and wheelnut wrench are either stored at right in forward baggage compartment or at left in rear baggage compartment.

The jack/tools kit stowed in the forward R.H. baggage compartment contains a:

1. Hydraulic jack;
2. Jack bar;
3. Wheel nut wrench and extension;
4. Triangular reflectors box.

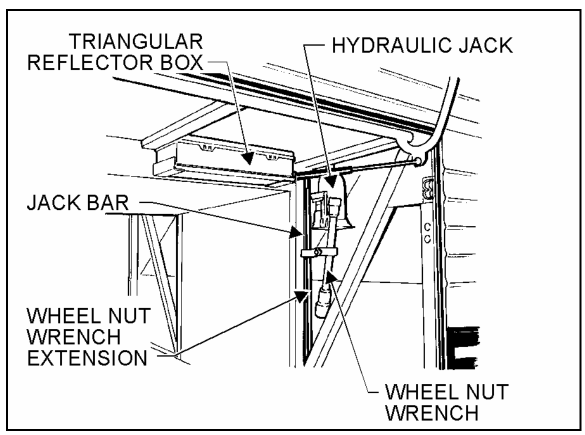

FIGURE 8: FORWARD R. H. SIDE COMPARTMENT 23012

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.

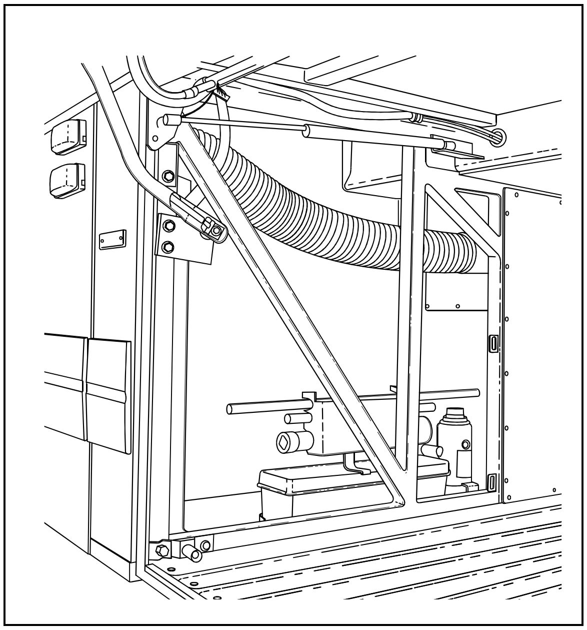

FIGURE 9: REAR BAGGAGE COMP. L.H. SIDE

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".

⚠ WARNING ⚠

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. 10). 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

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.

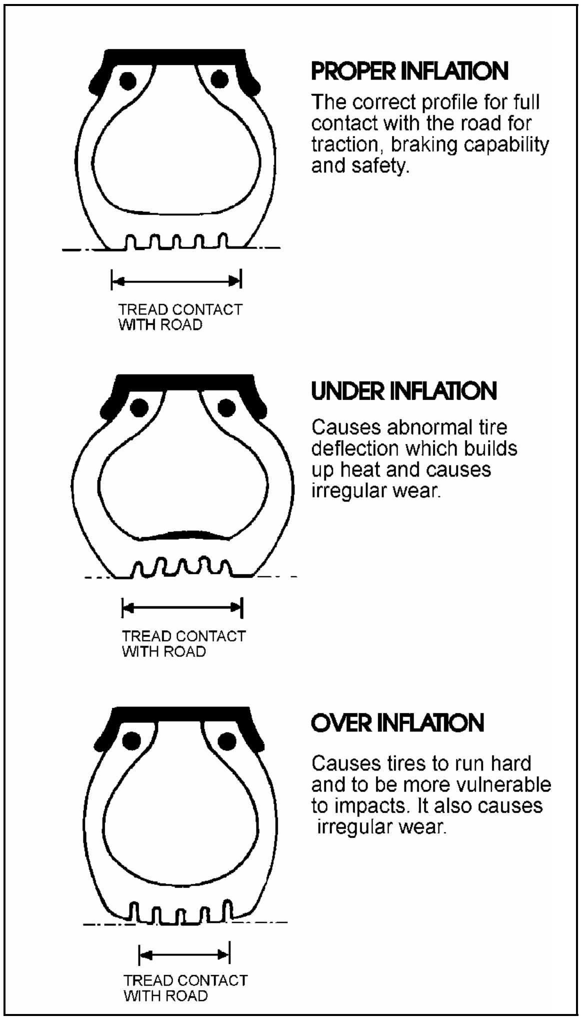

FIGURE 10: TIRE INFLATION 13009

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"

⚠ 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.

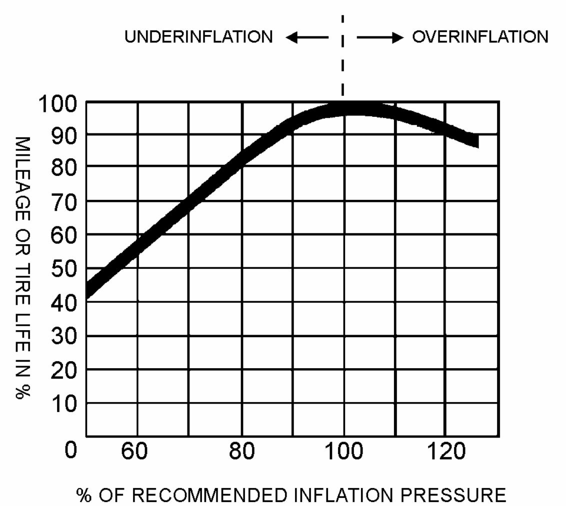

FIGURE 11: TIRE LIFE / INFLATION PRESSURE 13010

⚠ 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 on coaches)

Wheel size.. 9" X 22.5"

Wheel nut torque.. 450 - 500 lbf-ft (610 - 680 Nm)

Tire size.. 315/80 R 22.5

SPECIAL WHEELS FOR VEHICLES EQUIPPED WITH IFS (Front & Tag axle)

Wheel size.. 10.5" X 22.5"

Wheel nut torque.. 450 - 500 lbf-ft (610 - 680 Nm)

Tire size.. 365/70 R 22.5

RECOMMENDED TIRE INFLATION PRESSURE AT MAXIMUM LOAD (cold)

NOTE
Vehicle is delivered with the specific inflation pressure certification plate according to the tire selection.

⚠ WARNING ⚠
Special tire selection may lower maximum allowable speed limit, even below posted speed limit. For maximum safety, check with tire manufacturer.

⚠ CAUTION ⚠
In the case of a converted vehicle, weigh fully loaded and pressurize according to tire manufacturer's recommendations.

⚠ 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

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

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 raiting 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 sruface 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	7 to 11 foot-pounds for part numbers
TR 509	TR 542 Series
TR 510	TR 543 Series
TR 511	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).

Wheel Load Rating (Pounds) — Maximum Inflation Pressure — FMVSS 120 Designation

ALCOA® FORGED MAX LOAD 7300 MAX PSI 120 T-DOT

060602 PART NO 883620DB 22.5X8.25 15^{o} DC

Date of Manufacture (Day/Month/Year) — Wheel Description

Prior to June 1996, all Alcoa heavy duty truck wheels has the Alcoa identification symbol 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 raiting to maximum wheel load rating.

Refer to tire manufacturer’s recommedation 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.

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

ALCOA

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[3]	Inset inches	Maximum inflation PSI – cold	Valve stem	Part number[2]	DiscMate™	Stabilizer	Front outer cap nuts	Rear inner cap nuts Al/Al	Rear inner cap nuts Al/Stl	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[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 Al/Al	Rear inner cap nuts Al/Stl	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

Alcoa Inter-America, Inc.
115-A Matheson Blvd. West, Suite 207
Mississauga, Ontario L5R 3L1
800.668.1150

ALCOA

www.alcoawheels.com

SECTION 14: STEERING

CONTENTS

ILLUSTRATIONS

1. STEERING SYSTEM

1.1 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.

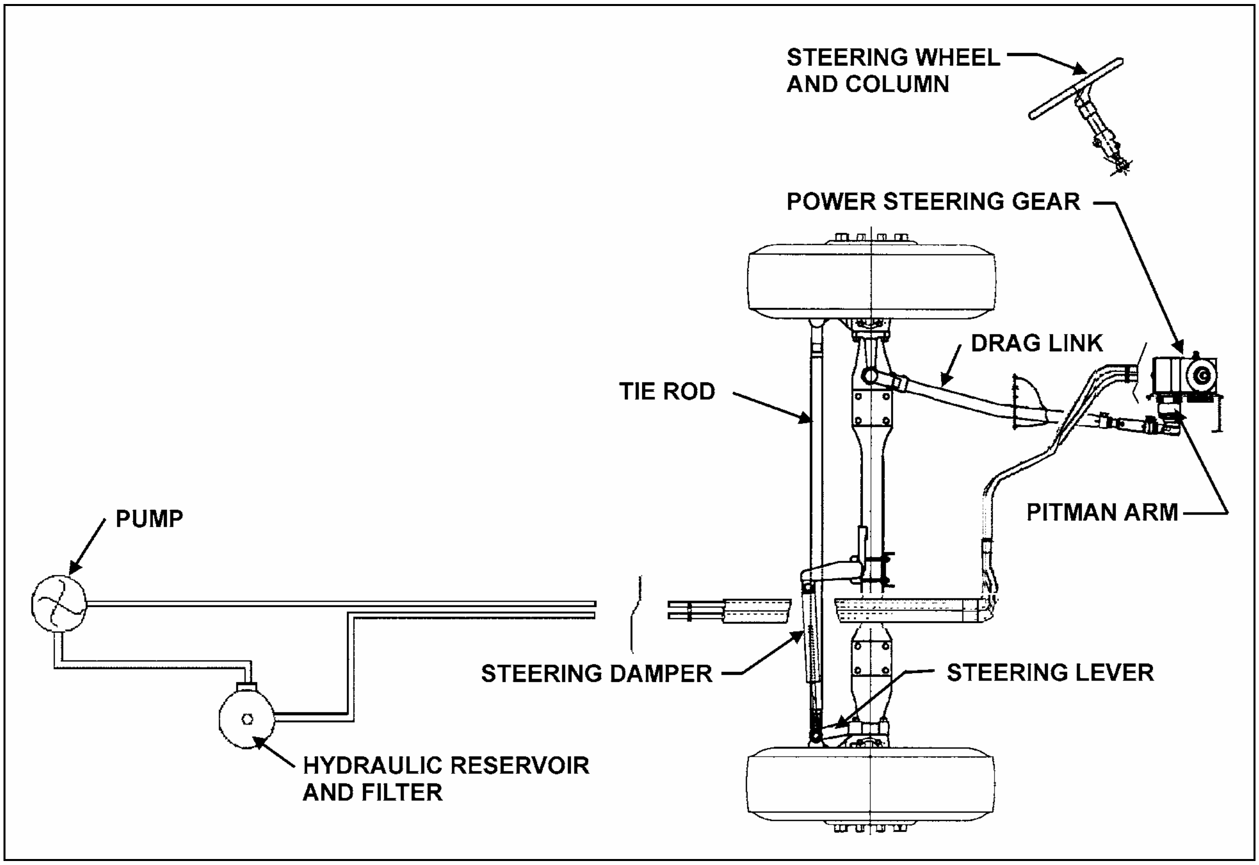

FIGURE 1: STEERING SYSTEM AXLE SETUP 14041

2. POWER STEERING GEAR

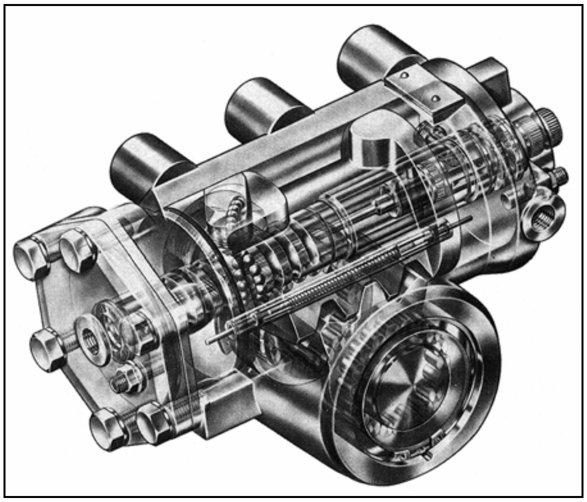

FIGURE 2: POWER STEERING GEAR 14035

2.1 DESCRIPTION

The power steering gear is located in the lower part of front service compartment (Figs. 2 & 3). 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.

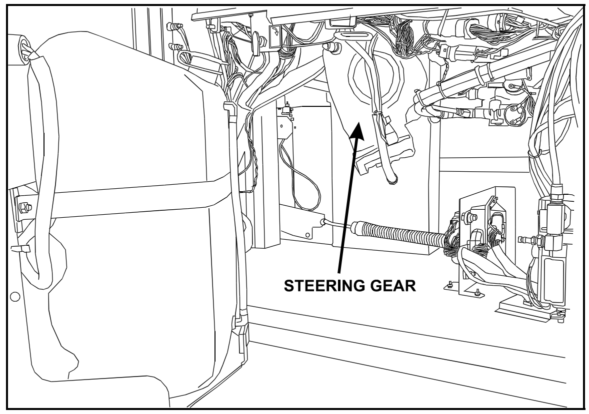

FIGURE 3: FRONT SERVICE COMPARTMENT 14039

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.

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"* and the "TRW - Chart Your Way To Easy Steering" guide annexed to this section.

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 DESCRIPTION

The 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.

6.2 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"*.

6.3 MAINTENANCE

Refer to the *"ZF-SERVOCOM Repair Manual"* and the *"TRW - Power Steering Pump Service Manual"* annexed to this section.

7. STEERING WHEEL

7.1 REMOVAL

1. Set the battery master switch located in the R.H. side rear service compartment, or the engine compartment to the *"OFF"* position.
2. Using a tool, such as a small flat head screwdriver, pry off the air horn cap.
3. Loosen the small screw in center of cap and the other retaining the black wire, then disconnect the white terminal. Remove horn cap.
4. Loosen and remove the steering wheel nut.
5. Using a suitable puller, remove the steering wheel.

7.2 INSTALLATION

To install, reverse the removal procedure. Torque steering wheel nut to 35-45 lbf-ft (47-60 Nm).

8. STEERING COLUMN

8.1 REMOVAL

To disassemble the steering column from system, refer to Figure 4. 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:

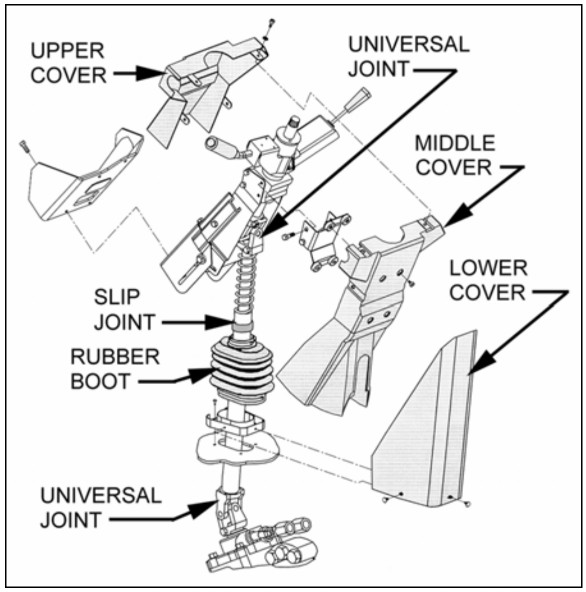

FIGURE 4: STEERING COLUMN 14040

1. From the front driver's compartment area, remove the three plastic fasteners on steering column lower cover. Remove the lower cover (Fig. 4).
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.

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 Adjusment".*

⚠ 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).

⚠ WARNING ⚠

Always wear approved eye protection when operating pullers.

⚠ CAUTION ⚠

Do not drive (hammer in) 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.

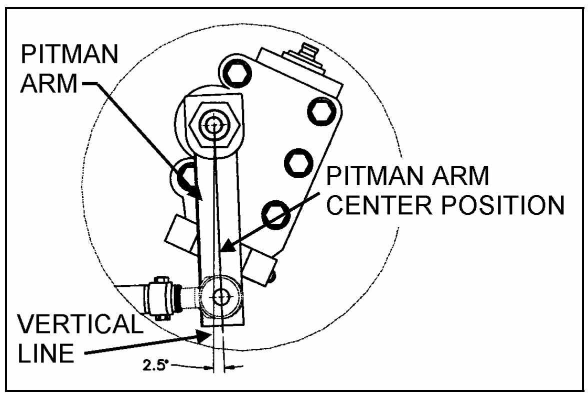

FIGURE 5: PITMAN ARM ADJUSTMENT 14037

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.
6. 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).

NOTE
Use a new nut if the previously removed nut was punched.

3. Lock nut with sector shaft using a punch mark into the groove (Refer to figure 6).

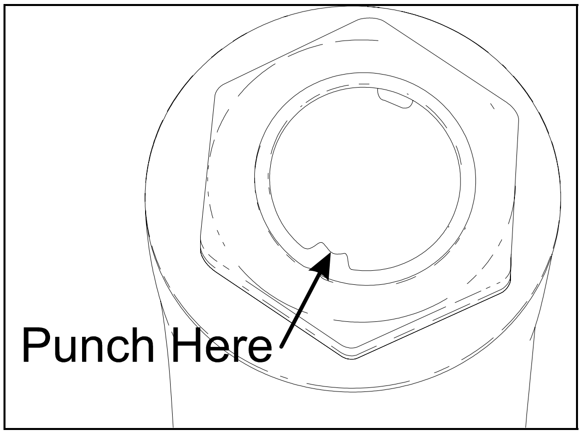

FIGURE 6: FIXING NUT PUNCH MARK

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.

⚠ CAUTION ⚠
Input shaft marks must be aligned before adjusting pitman arm.

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. 5 for details).
3. The pitman arm should be adjusted to an angle of 2.5º 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 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).

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-IIE 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".*

⚠ WARNING ⚠
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. 7).

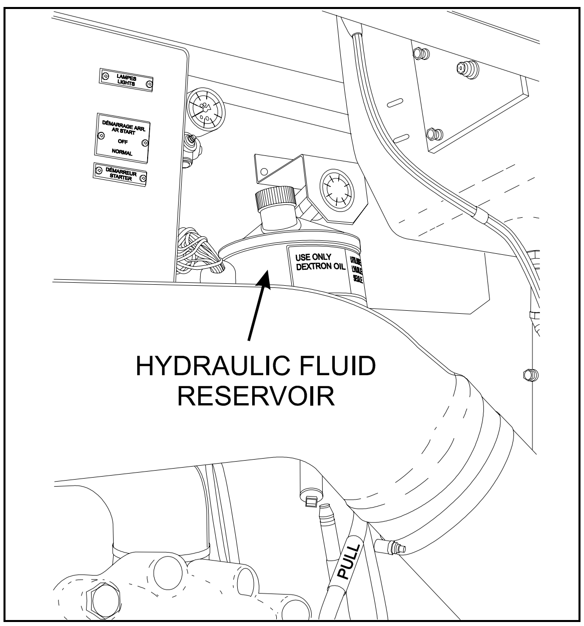

FIGURE 7: HYDRAULIC FLUID RESERVOIR LOCATION 14044

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.

12.1.1 Oil Level Check Procedure

1. Stop engine. Open engine compartment R.H. side door.

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. 8).

4. Adjust level to *"FULL"* mark using proper dipstick side depending on fluid temperature, use *"Dexron-IIE or Dexron-III"* automatic transmission oil.

5. Reinsert and tighten the dipstick.

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.

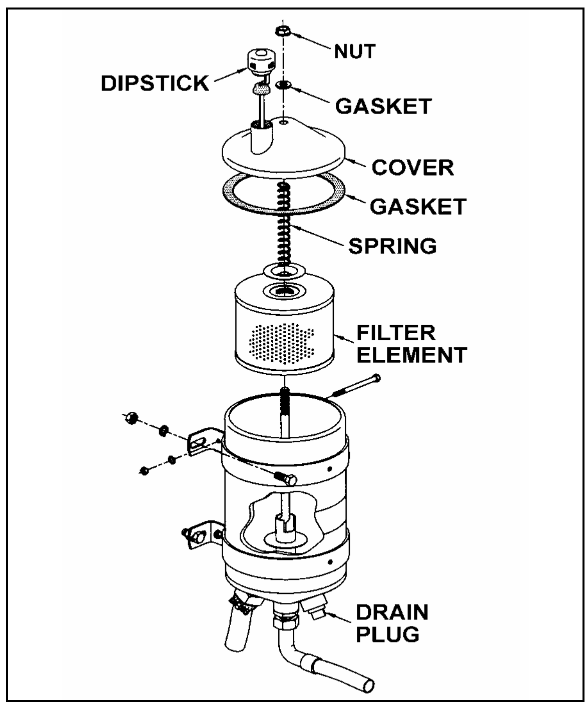

FIGURE 8: POWER STEERING FLUID RESERVOIR 14018A

12.2 STEERING STABILIZER CYLINDER (DAMPER)

The steering damper is located on R.H. side, at back of front axle (Fig.9).

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.

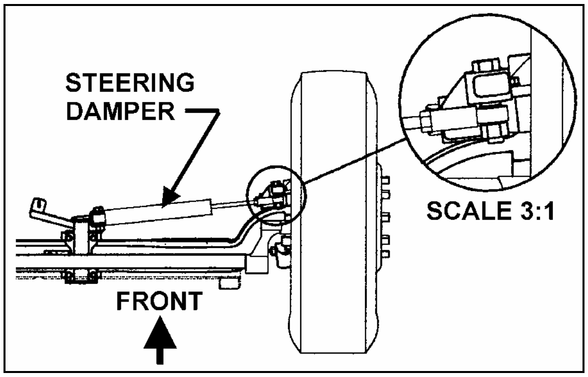

FIGURE 9: STEERING STABILIZER (DAMPER) 14042

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")*.

12.4 POWER STEERING HYDRAULIC PUMP

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

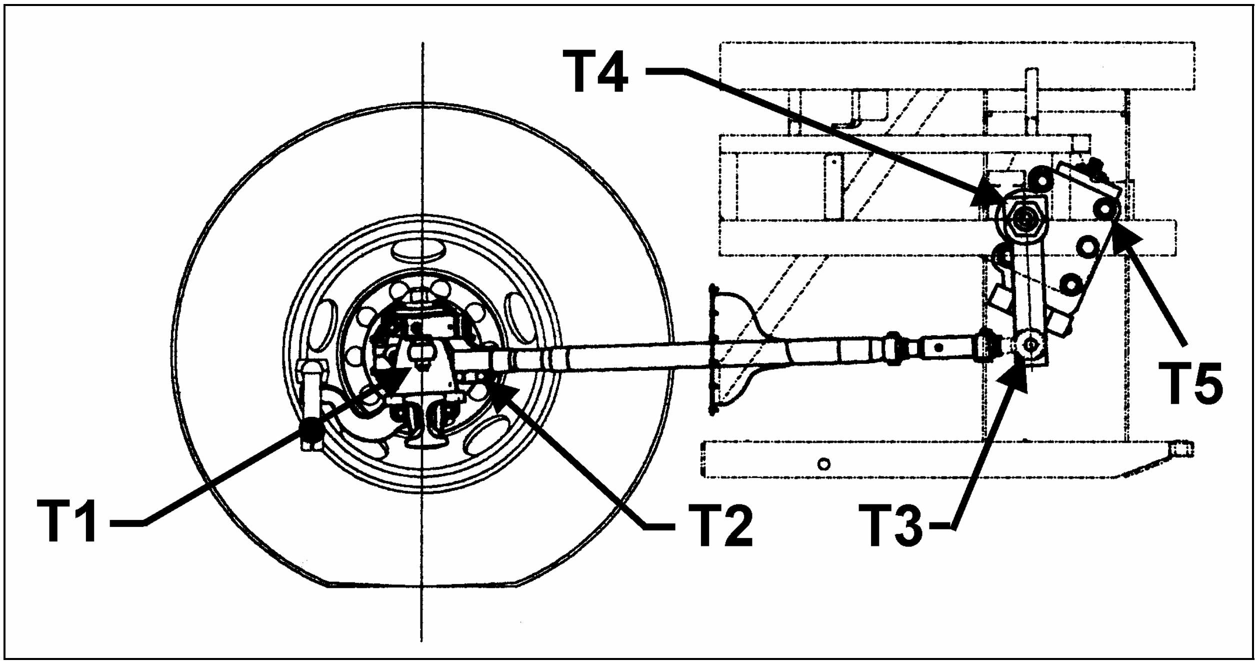

FIGURE 10: DRAG LINK COMPONENTS 14038

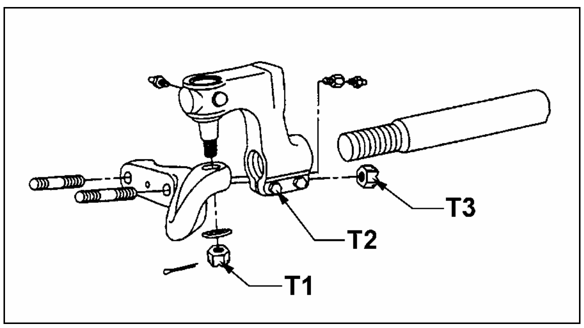

FIGURE 11: TIE ROD END 14036

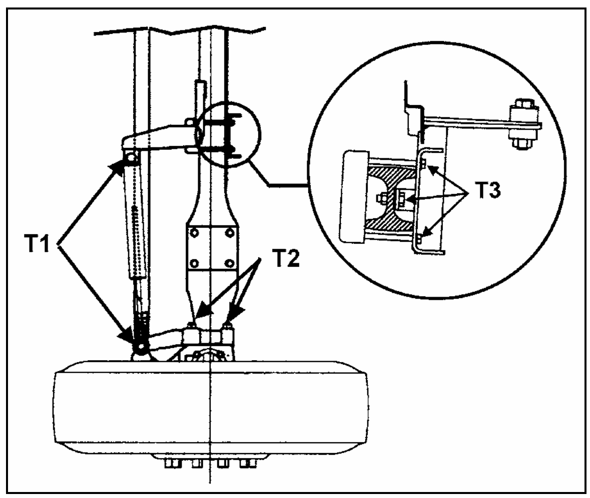

FIGURE 12: FRONT AXLE COMPONENTS 14045

DRY TORQUES			
Description	**Reference**	**Lbf-ft**	**Nm**
Drag Link End Stud Nut (on steering arm)	Fig. 10, T1	160-300	220-410
Drag Link End Pinch Bolt Nuts	Fig. 10, T2	50-65	70-90
Drag Link End Stud Nut (on pitman arm)	Fig. 10, T3	160-215	220-290
Pitman Arm Fixing Nut	Fig. 10, T4	470-570	637-773
Tie Rod End Screw Pin Nut	Fig. 11, T1	100-175	135-240
Tie Rod End Pinch bolt Nuts	Fig. 11, T2	65-75	90-100
Lower Lever Stud Nuts	Fig.11, T3	190-275	260-375
Steering Stabilizer (damper) Fixing Nuts	Fig. 12, T1	100-120	135-165
Steering Top Lever Nuts	Fig. 12, T2	150-200	205-275
Steering Damper Mounting Support Nuts	Fig. 12, T3	65-70	90-95

TORQUE (LUBRICATED WITH LOCTITE #242 BLUE)			
Description	**Reference**	**Lbf-ft**	**Nm**
Steering Gear Fixing Bolts (5)	Fig. 10, T5	265-310	360-420

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

Make .... TRW
Type .... PS Series
Relief valve setting .... 2,175 psi (14 990 kPa)
Controlled flow rate .... 4.23 gpm (16 lpm)
Inlet port .... 1 1/4 NPT
Outlet port .... 3/4-16 straight thread SAE O' ring boss conn.
Supplier number PS251615L10200
Prevost number 661009
Gasket - Supplier number 23516100
Gasket - Prevost number 510488

Power Steering Reservoir

Make .... Nelson Muffler
Oil capacity .... 4 US qts (3.7 liters)
Supplier number 91410A
Prevost number 660982
Make .... Nelson Muffler
Element filter - Supplier number .... 83804 E
Element filter - Prevost number 660987

Steering Stabilizer Cylinder (Damper)

Make .... Arvin
Extended length .... 32.73±0.12"
Collapsed length .... 20.26±0.12"
Stroke .... 12.47±0.12"
Supplier number 651535
Prevost number 660979
Dust cap - Prevost number 660980

ZF-Servocomtronic®

Supplement to the Repair Manual ZF–Servocom

ZF FRIEDRICHSHAFEN AG
GESCHÄFTSBEREICH LENKUNGSTECHNIK

D - 73522 Schwäbisch Gmünd

Telephone: (07171) 31-0 Telefax: (07171) 31-4396

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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.

Page

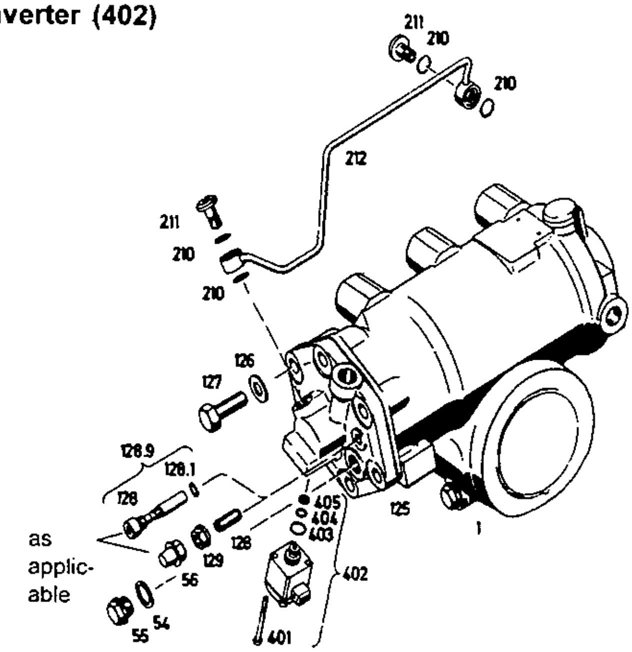
Notes:

→ 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).

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).

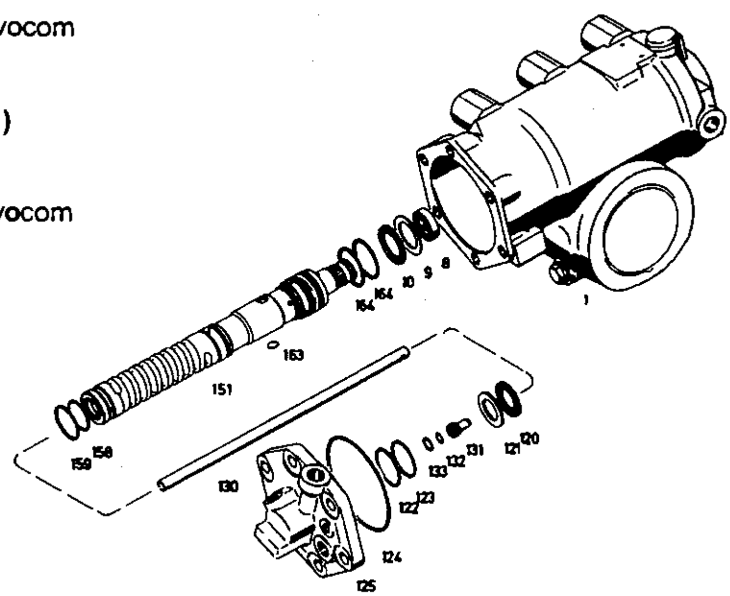
Pull pipe (130) together with reaction piston (131) out of worm (151).

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)

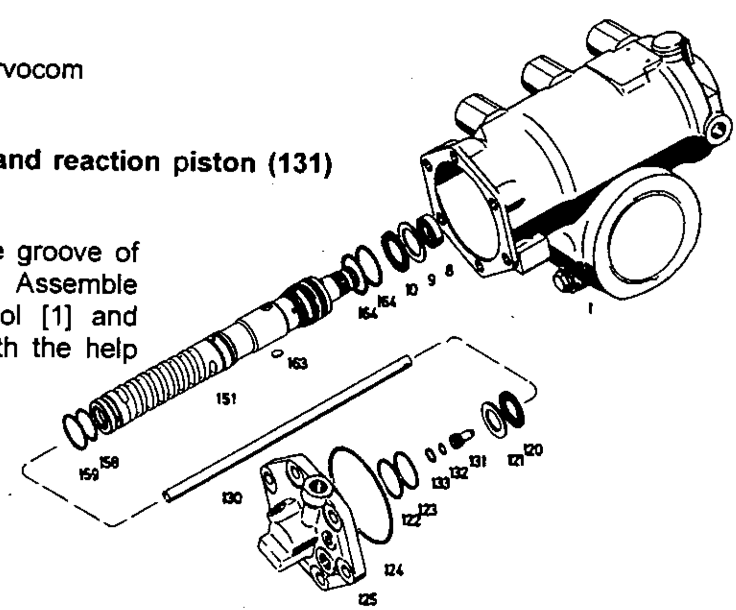
See Repair Manual ZF–Servocom

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)

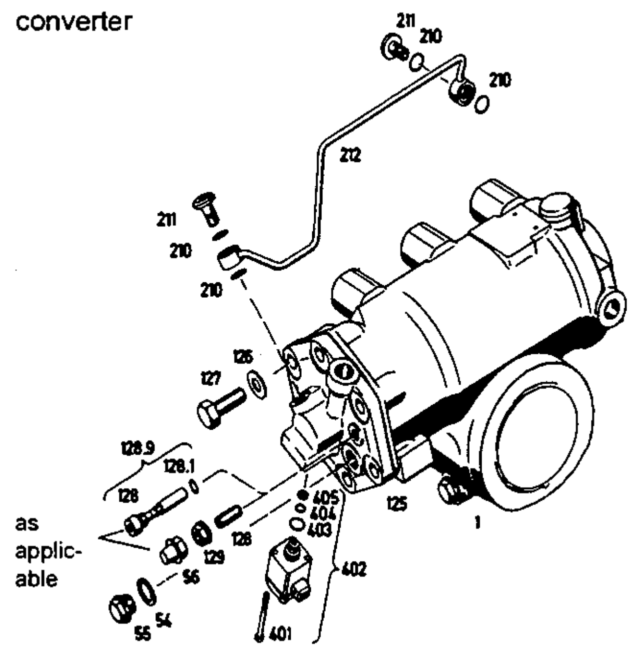
See Repair Manual ZF–Servocom

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] (Servotronictest) 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 Servotronictest unit, you should read the corresponding operating instructions.

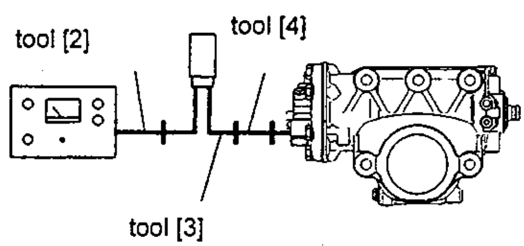
The following functional test refers to the separate checking of the converter and of the control unit. The joint checking of both units is described in the above–mentioned operating instructions.

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 Servotronictest (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 Servotronictest to position "0" .

→ Note on the Servotronictest 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 Servotronictest 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 Servotronictest 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.

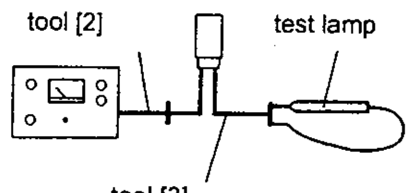
2.2 Functional test of the control unit:

→ Connect the Servotronictest 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 Servotronictest to position "0".

→ Connect tool [3] to Servotronictest (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 Servotronictest to position "Tacho/speedometer".

→ Turn control knob 5 (Tacho/speedometer).

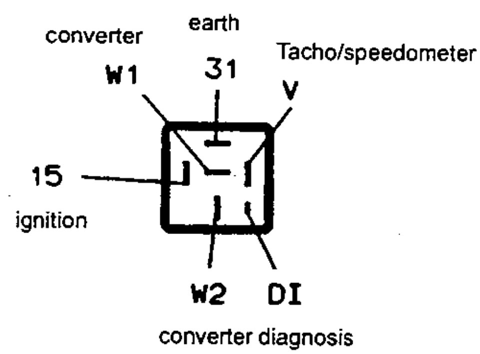
When the control knob is turned to the right end position, the test lamp must light up.

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 Servotronictest 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.

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.

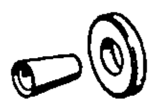
VI. Special tools

Note:
The special tools listed below refer to the standard version and the design state of the ZF–Servocomtronic on the basis of which the entire manual has been compiled.

Other tools may consequently be required for the particular ZF–Servocomtronic unit to be repaired.

Tool [1] — **Part-No.**

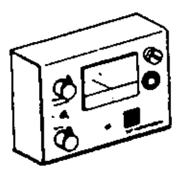
Guide bush — 8098 798 004



Mounting ring — 8098 798 655

Tool [2]

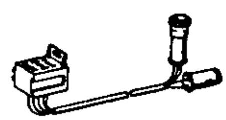
Servotronictest — 7418 798 545



Power supply unit — 7418 798 546

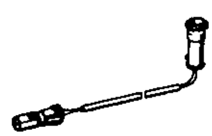
Tool [3]

Adapter — 7038 340 201



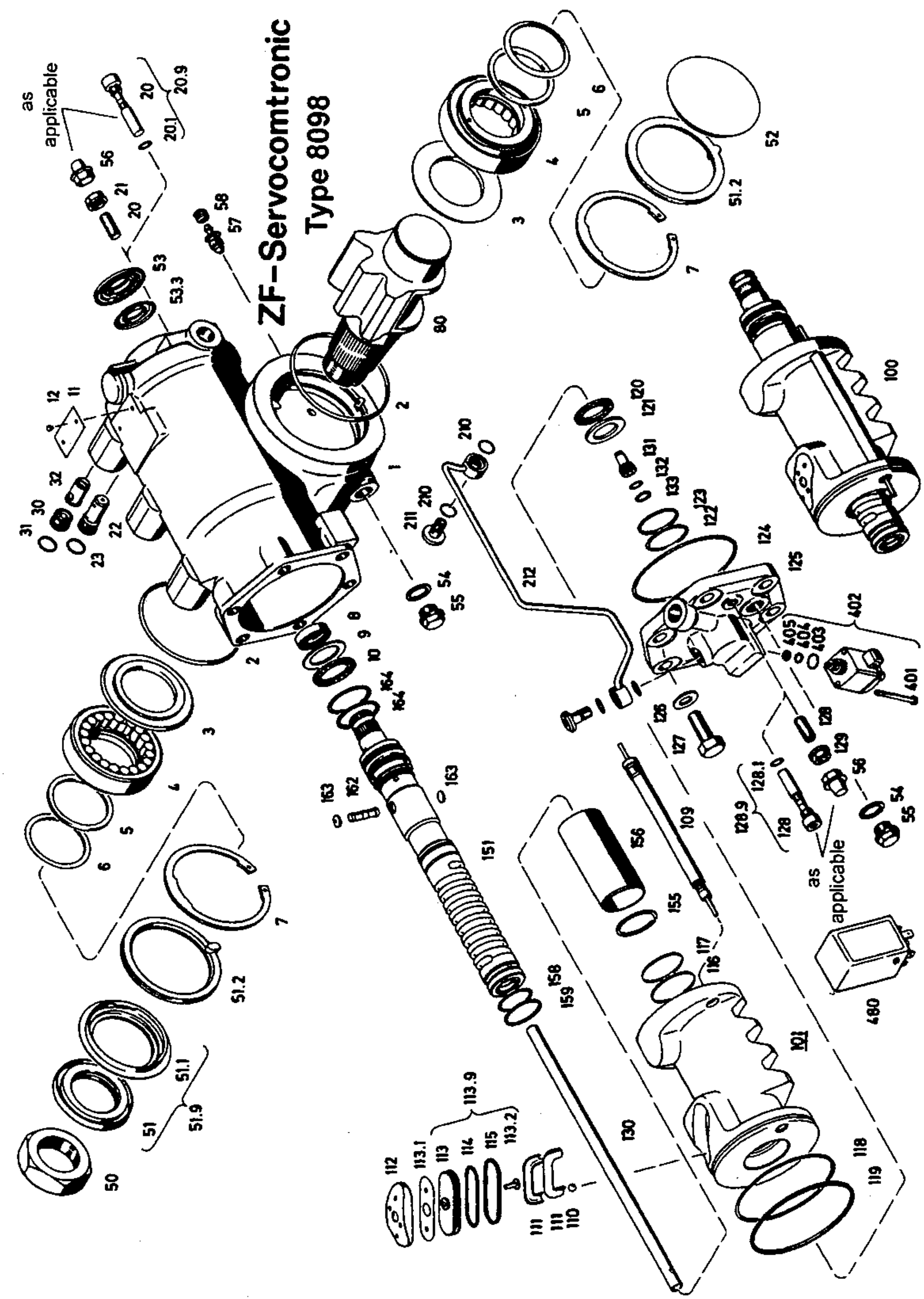
Tool [4]

Adapter cable — 7418 798 543



VII.Key to numbers in figures and exploded drawing

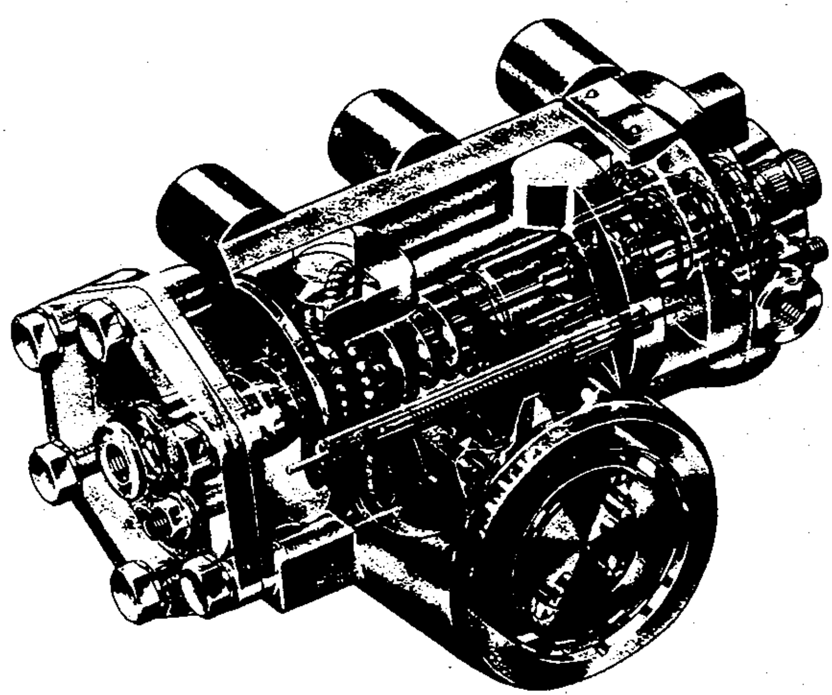
130.0	pipe
131.0	reaction piston
132.0	O–ring
133.0	sealing ring
401.0	cap screw
402.0	converter
403.0	O–ring
404.0	O–ring
405.0	oil screen


ZF-Servocomtronic
Type 8098
as applicable
as applicable

ZF-Servocom

Types 8090 - 8099
(Single and dual-circuit versions)

Repair Manual



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G 8090 R–KTI 10/96 e

→ 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.

Contents

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).

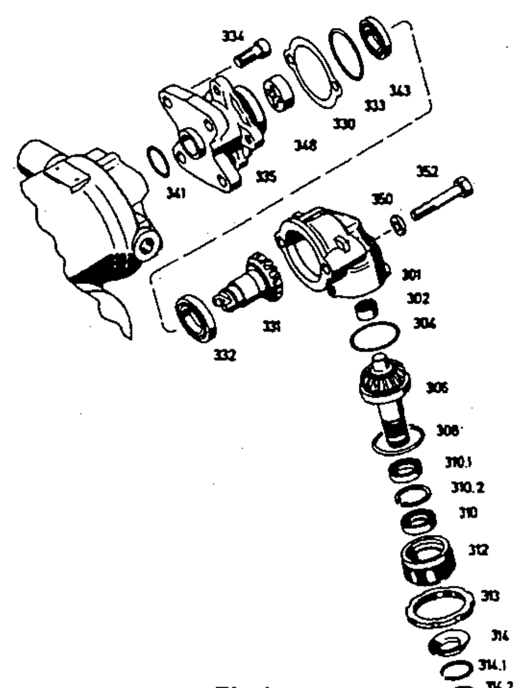


Fig.1

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).

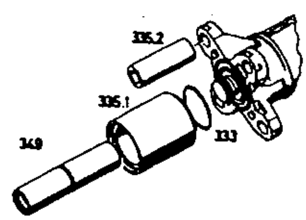


Fig.2

2.2.2 Remove pipes

Remove pipes (335.1 and 335.2). Dismantle O-ring (333) ***(Fig.2)***.

2.2.3 Disassembly of bevel box

Remove protecting cap (314) and draw off shaft seal (310) with tool [33] ***(see Fig.4)***.

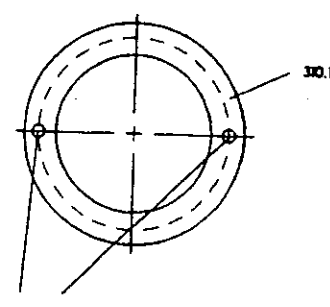


Fig.3

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).

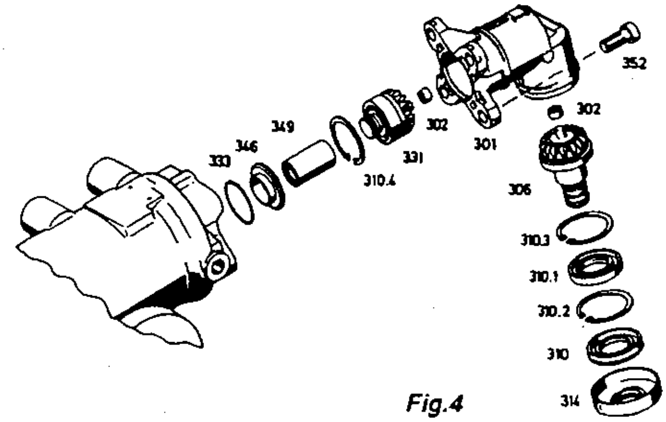


Fig.4

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).c
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).

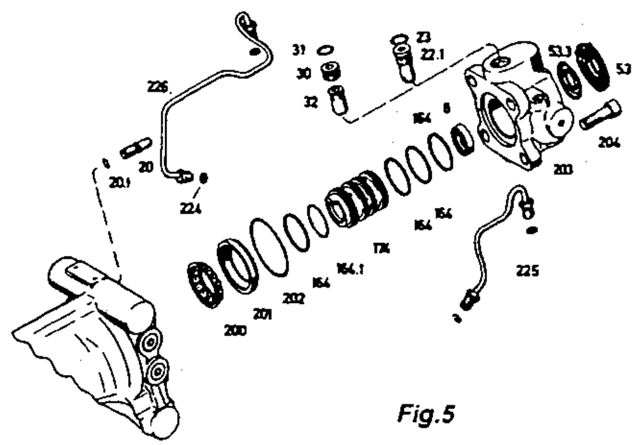


Fig.5

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)*.

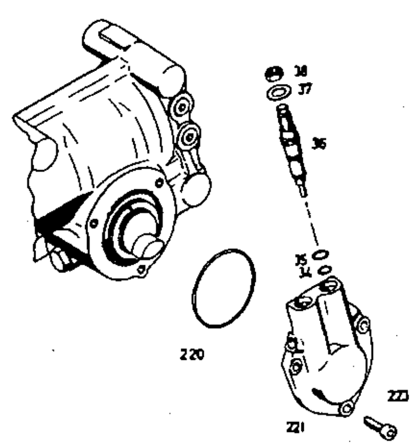


Fig.6

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).

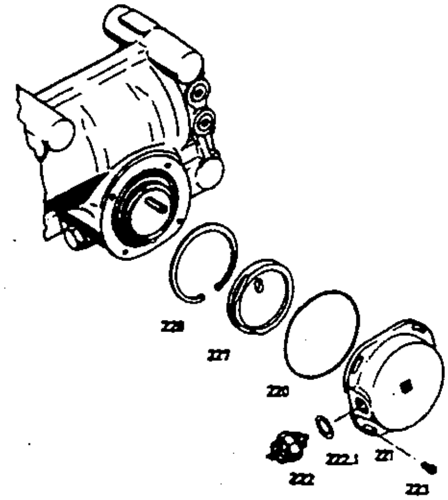


Fig.7

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).

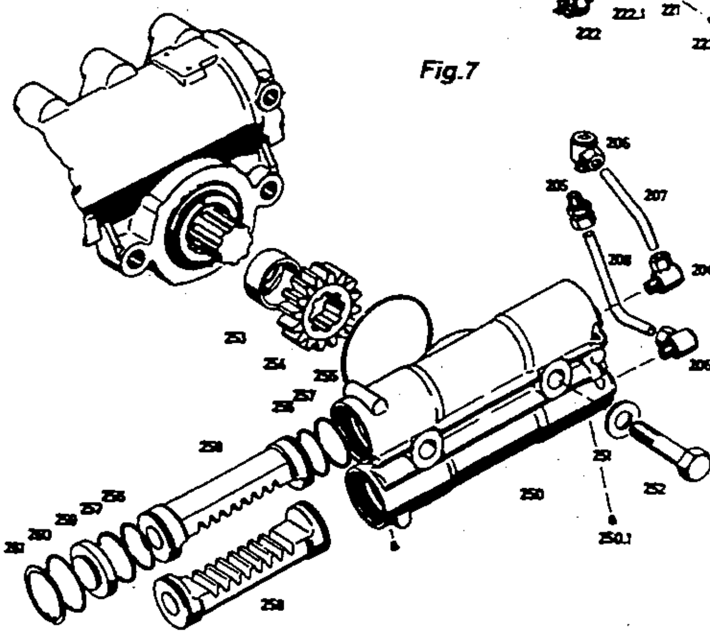


Fig.8

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).

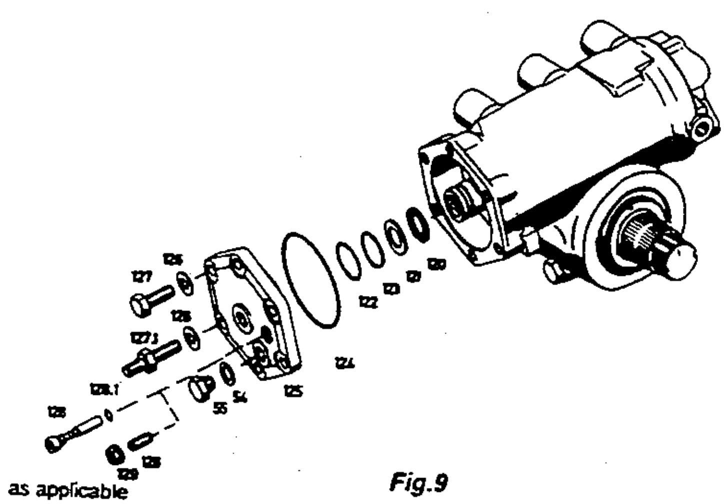


Fig.9

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.

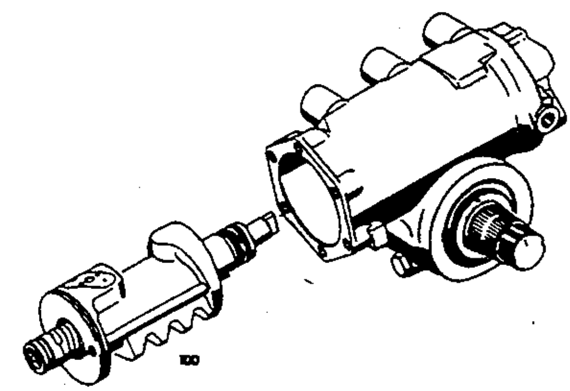


Fig.10

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).

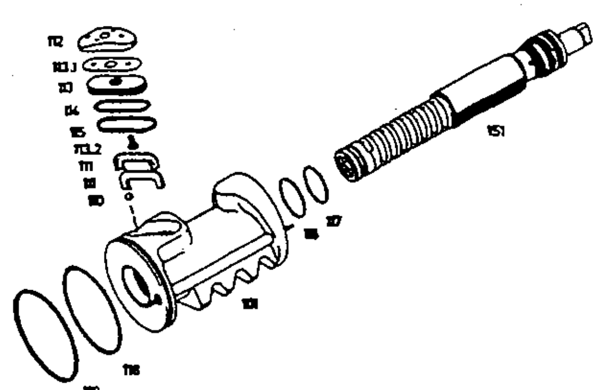


Fig.11

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)*.

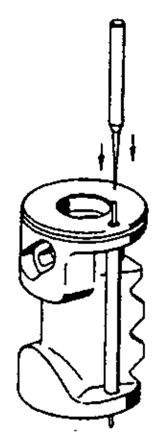


Fig.12

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

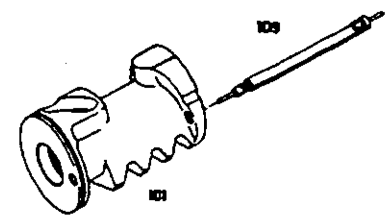


Fig.13

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.

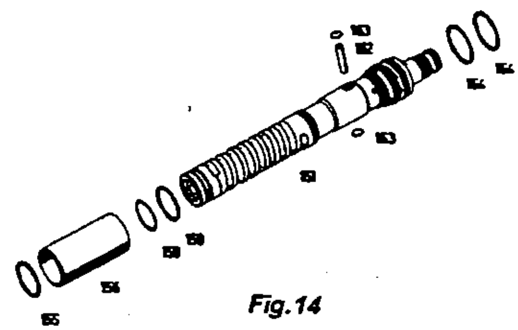


Fig.14

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).

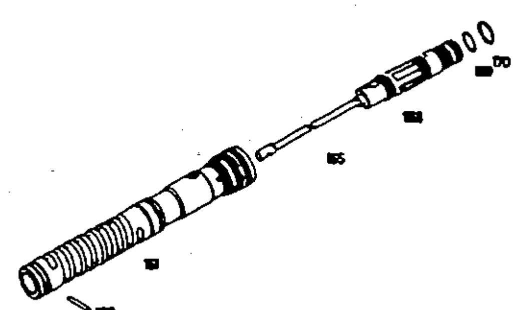


Fig.15

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).

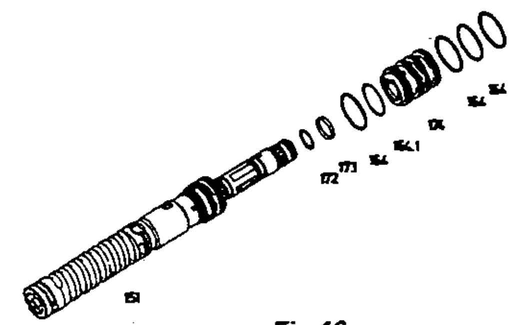


Fig.16

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)*.

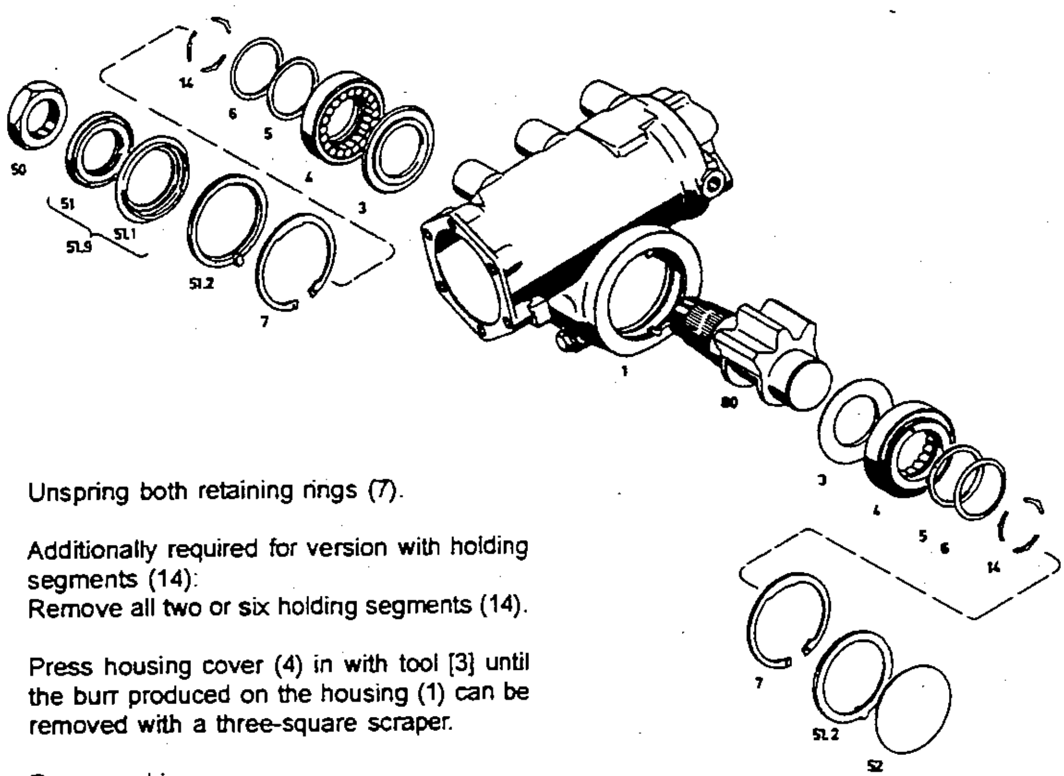


Fig.17

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.

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).

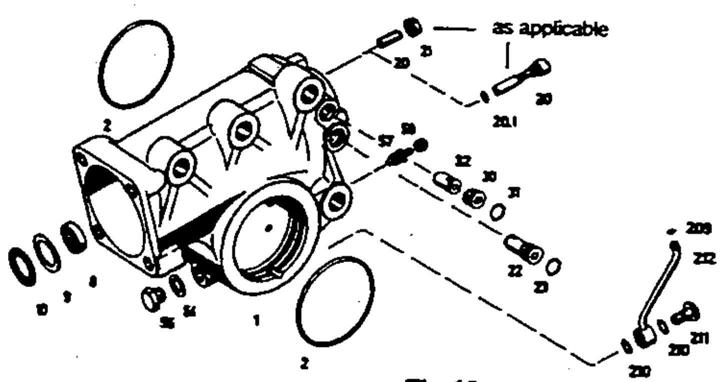


Fig.18

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).

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).

→ 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 (161) 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

→ 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

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).

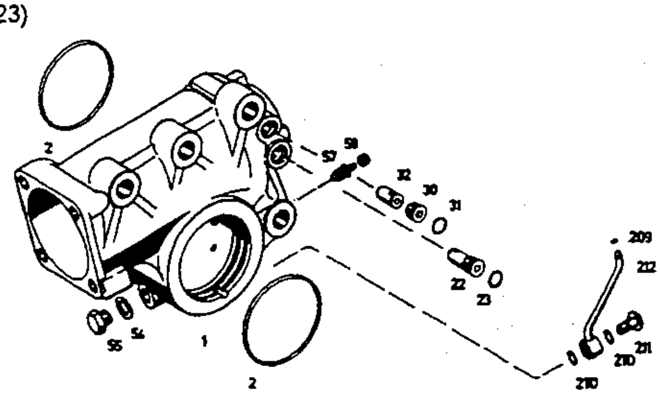


Fig.19

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.

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)*.

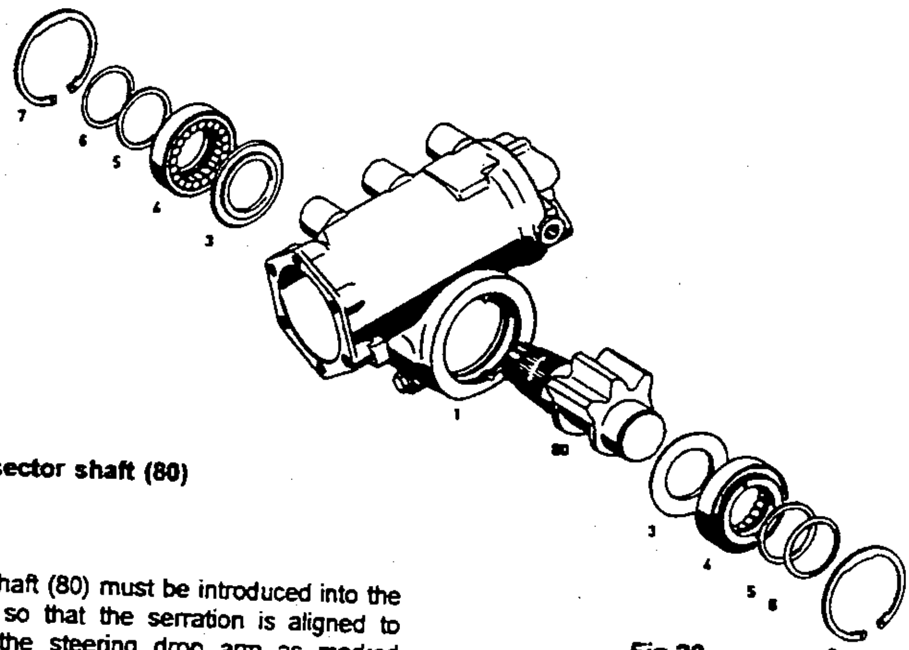


Fig.20

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)*.

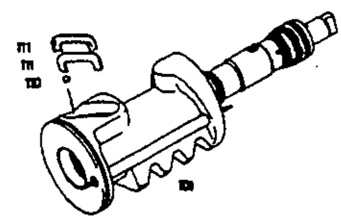


Fig.21

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.

- **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.***

Measurement of friction torque

Measurement of tilting clearance

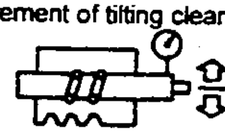


Fig.22

→ 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)***.

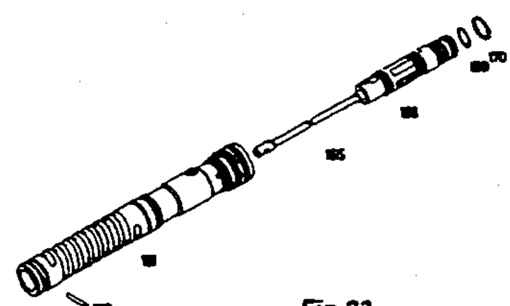


Fig.23

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].

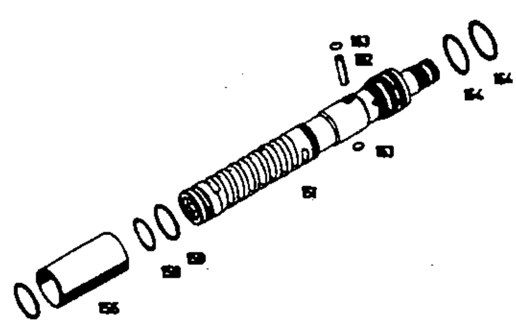


Fig.24

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).

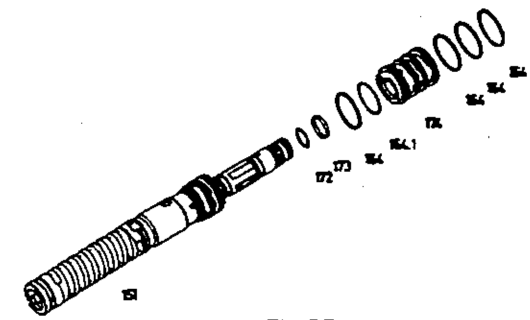


Fig.25

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].

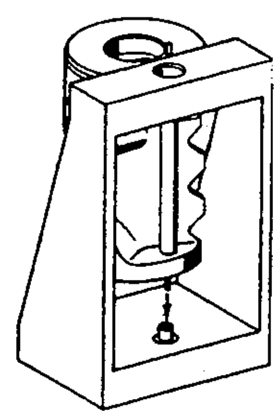


Fig.26

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.

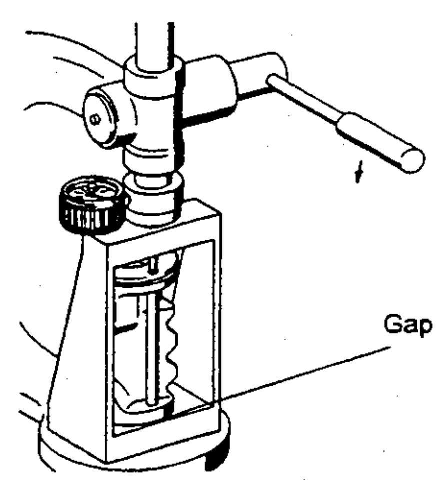


Fig.27

6.2 Versions with screwed valve insert (109) - steering limiter valve

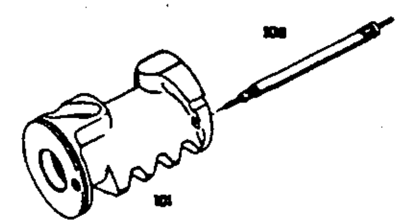


Fig.28

Screw valve insert (109) into piston as far as possible with tool [2] ***(Fig.28)*** (tightening torque: 15±1 Nm).

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).

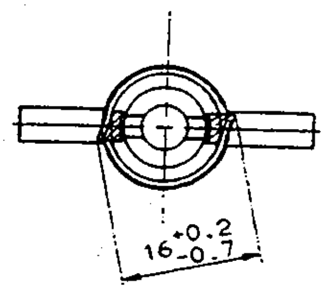


Fig.29

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).

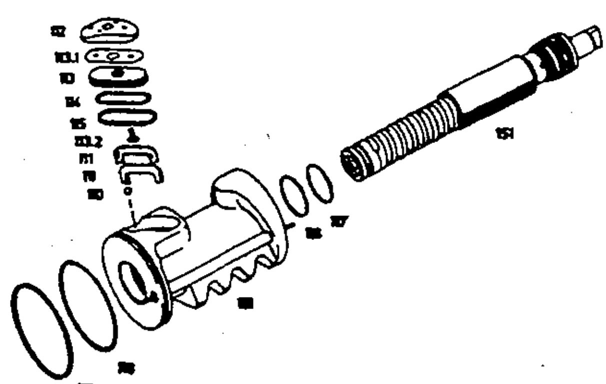


Fig.30

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

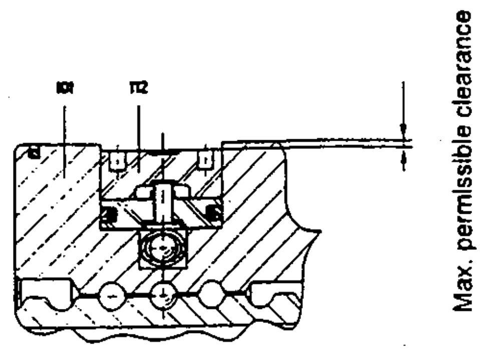


Fig.31

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).

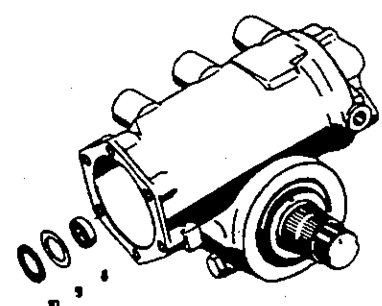


Fig.32

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.

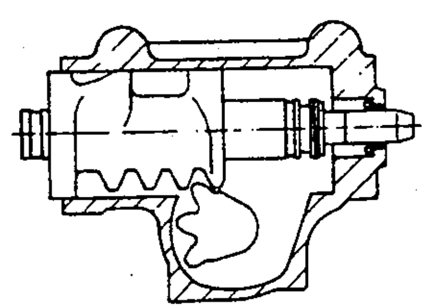


Fig.33

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)*.

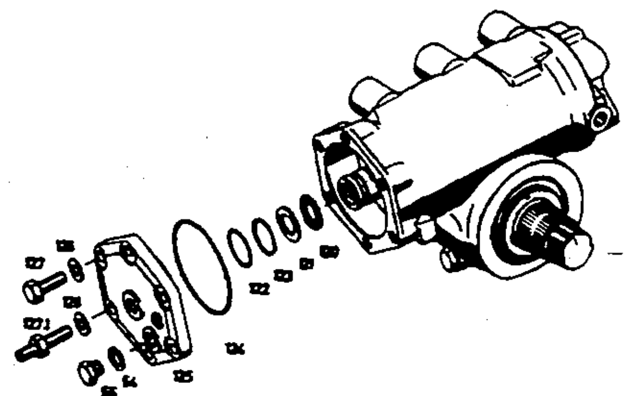


Fig.34

Note:
The following sealing elements should not be fitted until the worm bearing - section 12 - has been adjusted.

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).

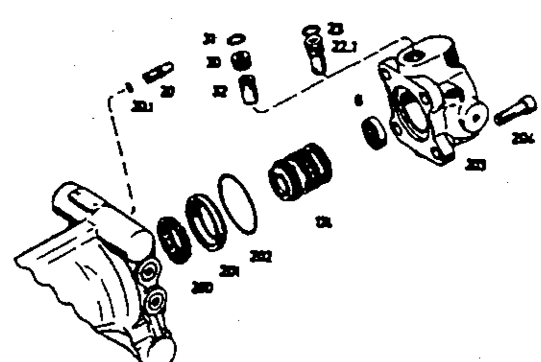


Fig.35

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)***.

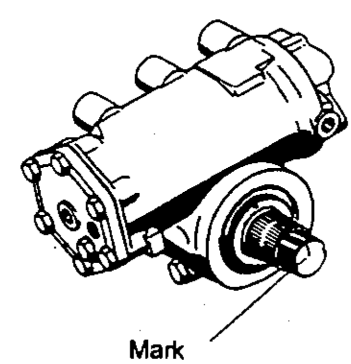


Fig.36

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].

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

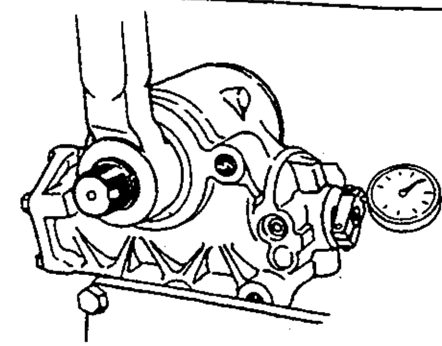


Fig.37

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 ouside 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)*.

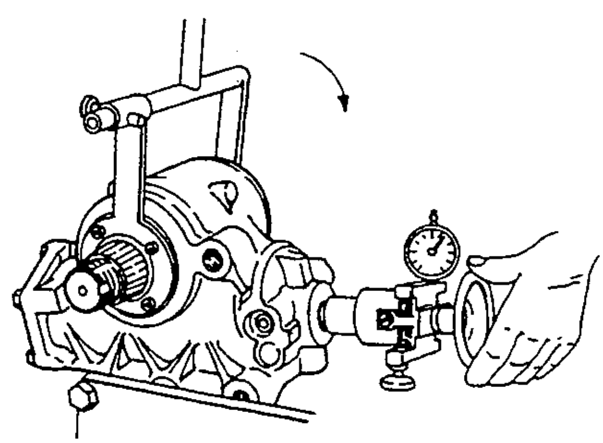


Fig.38

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.

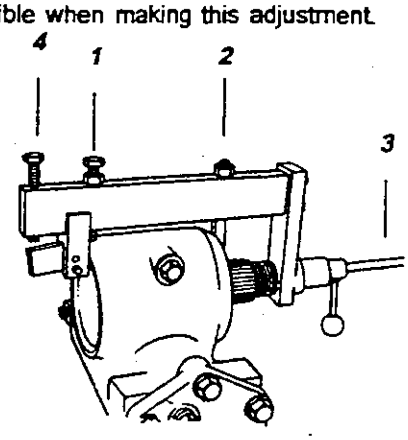


Fig.39

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)*.

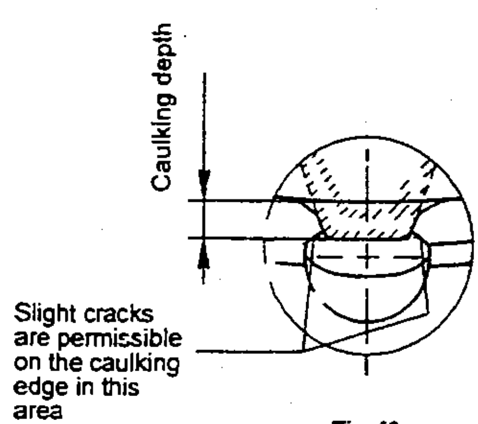


Fig.40

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.

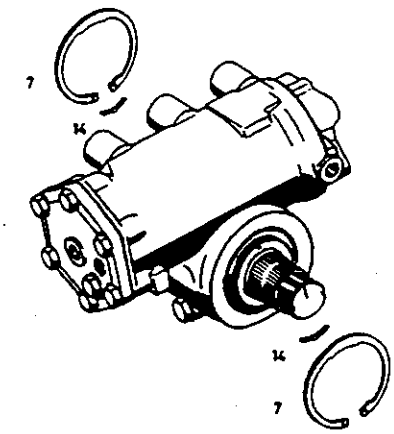


Fig.41

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.

14.2.2 Repeat the complete procedure for the other side as described in section 14.1.1.

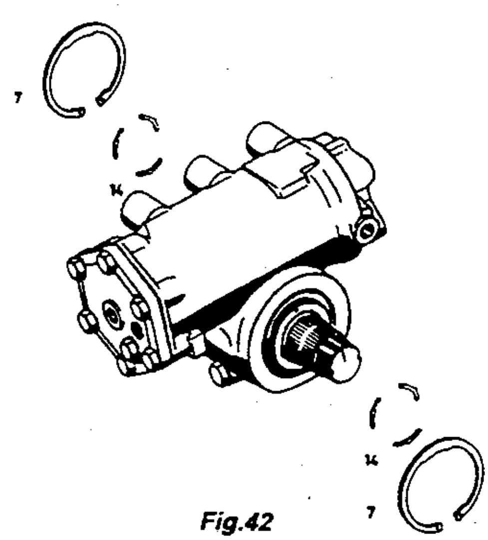


Fig.42

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).

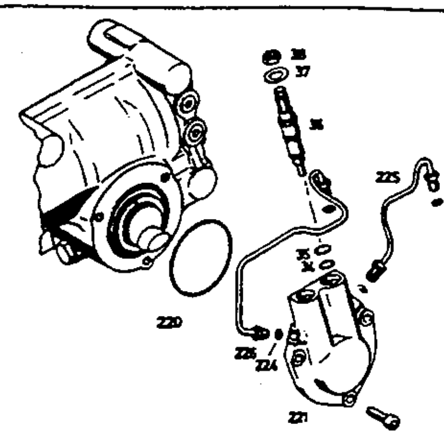


Fig.43

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).

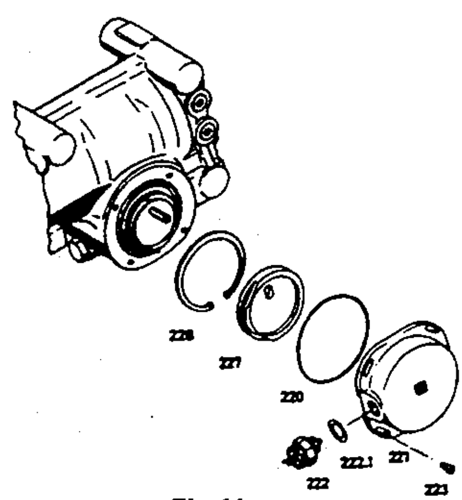


Fig.44

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 cm^3 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)*.

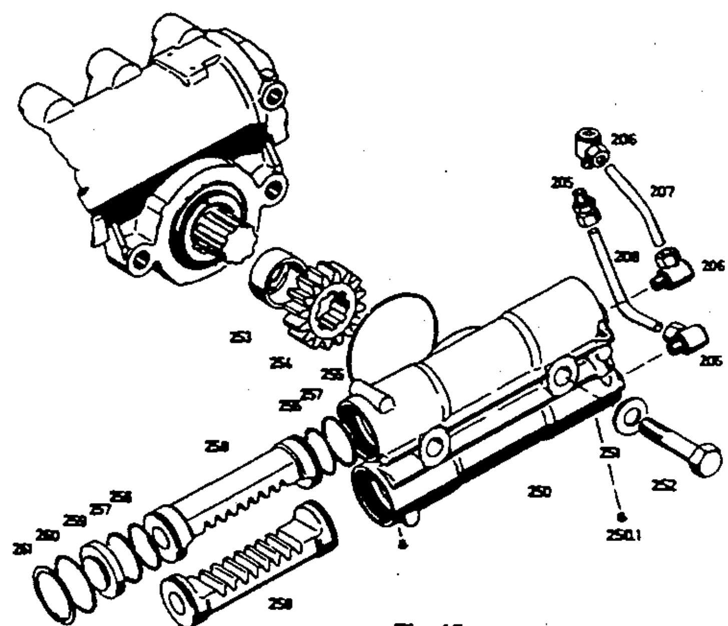


Fig.45

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).

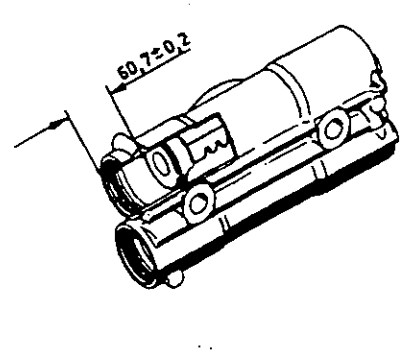


Fig.46

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).

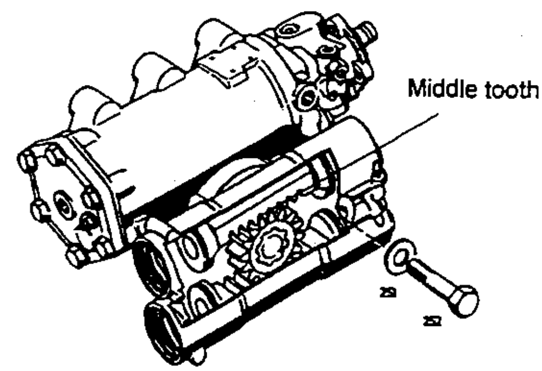


Fig.47

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).

17.1.2 Preassemble bevel box

Press needle sleeve (302) into housing (301) as far as possible with tool [29] ***(Fig.48)***.

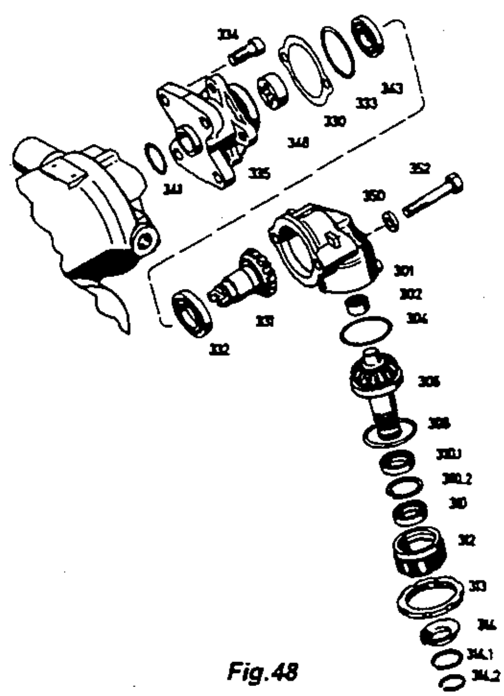


Fig.48

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.

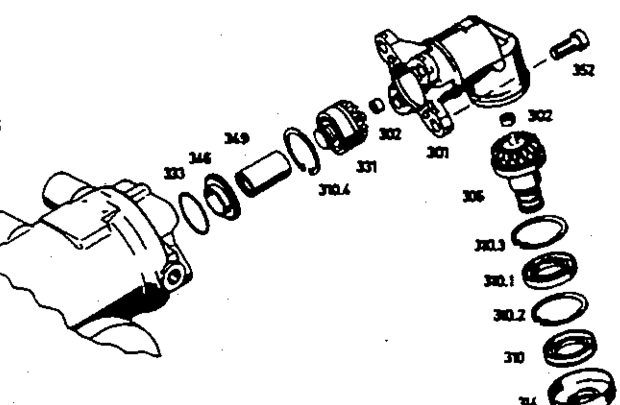


Fig.49

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).

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.

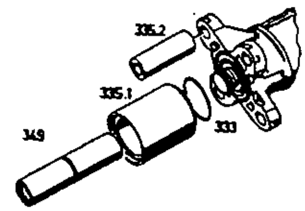


Fig.50

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.

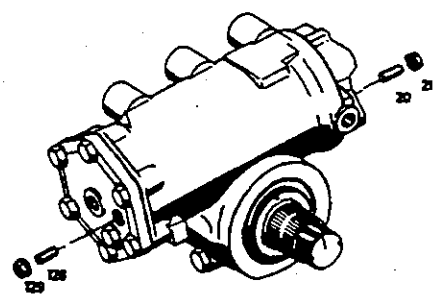


Fig.51

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).***

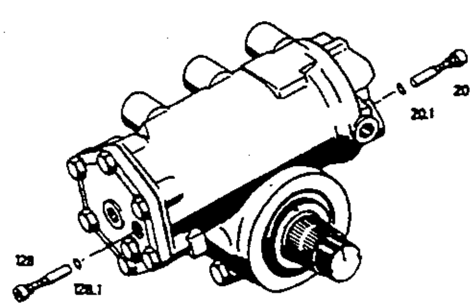


Fig.52

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.

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).

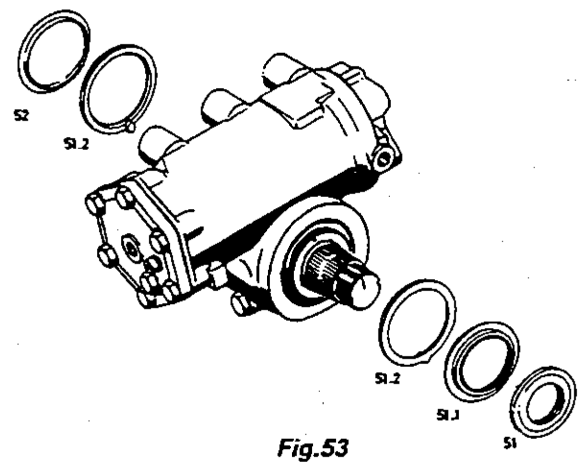


Fig.53

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)***.

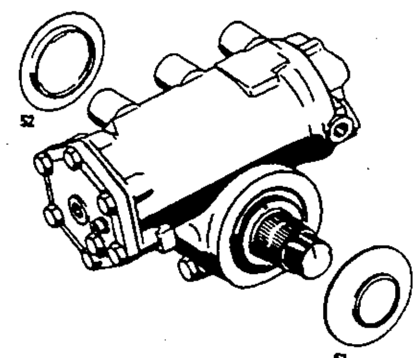


Fig.54

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).

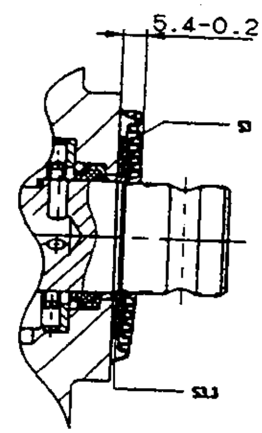


Fig.55

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)***.

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)***.

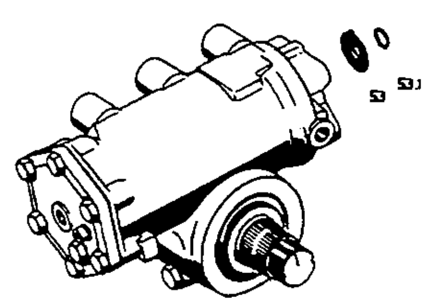


Fig.56

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.

Position of markings for straight-ahead position

View Y

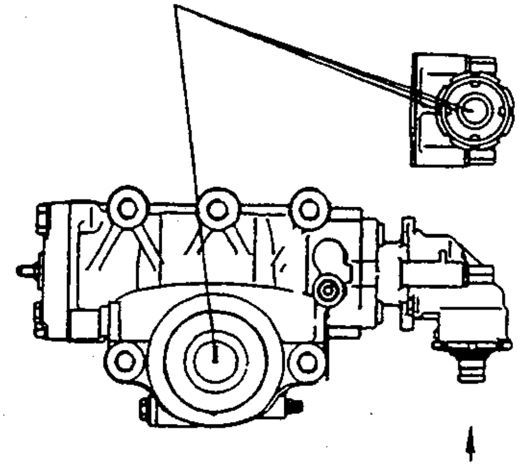


Fig.57

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)*.

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.

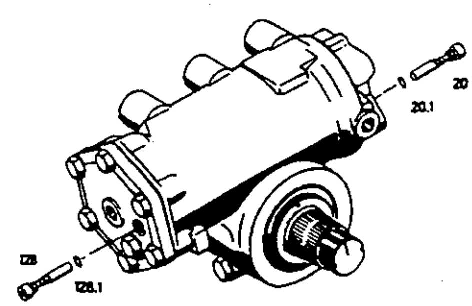


Fig.58

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.

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).

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.

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.

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.

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 dm^3/min (1 cm^3/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.

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 → Replace
	→ Valve insert (22) defective	→ Replace
For dual-circuit versions also:		
	→ Working cylinder defective	→ Repair → 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 → Replace
For dual-circuit versions also:		
	→ Valves (36) defective/ wrongly set	→ Repair → Replace → 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

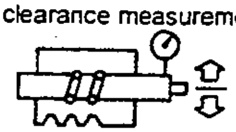
VI. Friction torques, adjustment values and tightening torques

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 ...) and variable (e.g. iv_1, iv_2 ...)	Friction torque [Ncm] without bevel box	Friction torque [Ncm] with bevel box
8090		
i_1 = 15.2 : 1 iv_1 = 16.6 : 1 / 14.0 :1	max. 160	max. 240
i_2 = 18.0 : 1 iv_2 = 19.6 : 1 / 16.6 : 1	max. 140	max. 220

8095		
i_1 = 17.0 : 1 iv_1 = 18.5 : 1 / 15.6 :1	max. 180	max. 260
i_2 = 19.6 : 1 iv_2 = 21.3 : 1 / 18.1 :1	max. 160	max. 240
i_3 = 23.1 : 1 iv_3 = 25.2 : 1 / 21.3 :1	max. 140	max. 220
8097		
i_1 = 16.6 : 1 iv_1 = 18.2 : 1 / 15.4 :1	max. 200	max. 280
i_2 = 18.9 : 1 iv_2 = 20.6 : 1 / 17.4 :1	max. 180	max. 260
i_3 = 21.8 : 1 iv_3 = 23.7 : 1 / 20.1 :1	max. 160	max. 240
i_4 = 25.7 : 1 iv_4 = 28.1 : 1 23.8 : 1	max. 140	max. 220
8098		
i_1 = 18.3 : 1 iv_1 = 20.1 : 1 / 17.0 :1	max. 220	max. 300
i_2 = 20.7 : 1 iv_2 = 22.6 : 1 19.2 : 1	max. 200	max. 280
i_3 = 23.9 : 1 iv_3 = 26.1 : 1 22.1 : 1	max. 180	max. 260

Type Transmission constant (e.g. i_1, i_2 ...) and variable (e.g. iv_1, iv_2...)	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 iv_1 = 18.5 : 1 / 15.6:1	max. 210	-	max. 290	-
i_2 = 19.6 : 1 iv_2 = 21.3 : 1 / 18.1:1	max. 190	-	max. 270	-
i_3 = 23.1 : 1 iv_3 = 25.2 : 1 21.3:1	max. 170	-	max. 250	-
8099				
i_1 = 18.3 : 1 iv_1 = 20.1 : 1 / 17.0:1	max. 250	max. 320	max. 330	max. 400
i_2 = 20.7 : 1 iv_2 = 22.6 : 1 19.2:1	max. 230	max. 300	max. 310	max. 380
i_3 = 23.9 : 1 iv_3 = 26.1 : 1 / 22.2:1	max. 210	max. 280	max. 290	max. 360

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

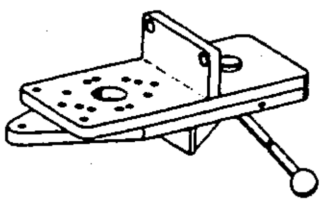
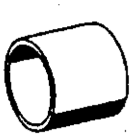
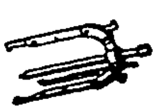
Tightening torques:

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.

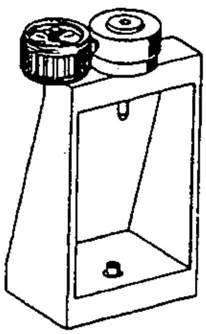
Tool	8090	8095	8096	8097	8098	8099
Tool [1] Assembly vice 	7418 798 654					
Tool [2] Insert for screw–out and screw–in the valve insert (109) 	8098 798 151					
Tool [3] Sleeve for pressing the housing covers (4) 	8090 798 006	8095 798 002		8097 798 002	8098 798 002	
Tool [4] Puller for housing cover (4) 	8090 798 201					

Tool [5]

Guide bush for housing cover (4)

Tool [6]

Peening fixture for valve insert (109)



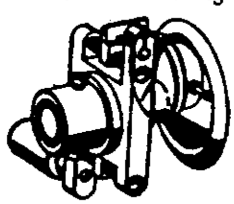
Tool [7]

Punch for screwed valve insert (109)

Tool [8]

Insert for tool [9]

	8090	8095	8096	8097	8098	8099
Tool [5]		8043 798 001				
Tool [6]	8090 798 655					
Tool [7]	8098 798 654					
Tool [8] 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	
Tool [9] Torque measuring device 	7470 798 703					
Tool [10] Dial gauge: Graduation 0.01 mm 	7470 798 706					
Tool [11] Guide bush for sealing rings (164) 	8090 798 004	8090 798 001				
for dual-circuit version			8090 798 005			8090 798 005

	8090	8095	8096	8097	8098	8099
Tool [12] Pliers for pressing on the sealing rings (164) 	8090 798 652	8090 798 651				
Tool [13] Sleeve for mounting the O–ring (172) and the sealing ring (173) 			8096 798 001			8096 798 001
Tool [14] Mandrel for shaft seal (8) 	8090 798 052	8090 798 051				
Tool [15] Guide bush for shaft seal (8) 	8090 798 002	8090 798 003				

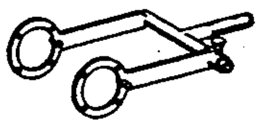
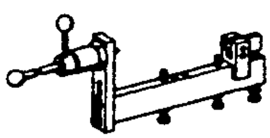
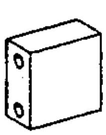
Tool [16]

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					

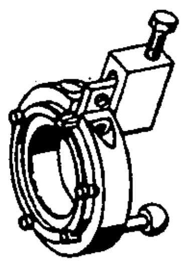
Tool [17]

Dial gauge graduation 0.001 mm for tool [16]

	8090	8095	8096	8097	8098	8099
Tool [18] Adjusting device for pressure point setting 	8090 798 151					
Tool [19] Insert for tool [18] (2 pieces are required) 	8090 798 551	8095 798 551		8097 798 551	8098 798 551	
Tool [20] Assembly tool for prying over of housing covers (4) 	8090 798 654					
Tool [21] Extension for tool [20] for steerings with C–mass >137 mm 					8090 798 656	

Tool [22]

Assembly tool for threefold prying

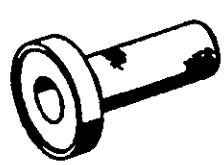


Tool [23]

Insert for torx screw (250.1)

Tool [24]

Mandrel for pressing the protecting cap (53)

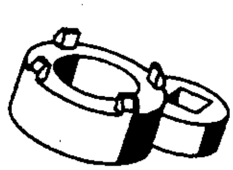


Tool	8090	8095	8096	8097	8098	8099
[22]			8096 798 651		8098 798 651	
[23]						7016 798 152
[24]	8090 798 053	8095 798 051				

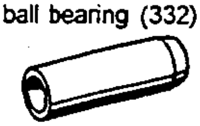
Bevel box with cross disc (348)

Tool [25]

Grooved nut wrench for adjusting screw (312)



Tool	8096	8097	8098	8099
[25]	1249 898 151			

<table>
<tr><th></th><th>8096</th><th>8097</th><th>8098</th><th>8099</th></tr>
<tr><td>Tool [26]
Puller for needle sleeve (302)
</td><td colspan="4">7421 798 201</td></tr>
<tr><td>Tool [27]
Counter for tool [26]
and [34]
</td><td colspan="4">7421 798 351</td></tr>
<tr><td>Tool [28]
Mandrel for ball bearing (343)
</td><td colspan="4">7421 798 051</td></tr>
<tr><td>Tool [29]
Mandrel for needle sleeve (302)
</td><td colspan="4">7677 798 051</td></tr>
<tr><td>Tool [30]
Press–in sleeve for
ball bearing (332)
</td><td colspan="4">7330 798 053</td></tr>
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8096	8097	8098	8099

Tool [31]

Mandrel for shaft seal
(310 and 310.1)

7418 798 051

Tool [32]

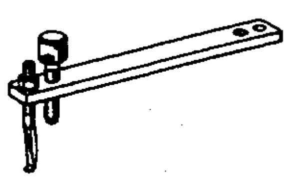
Guide bush for shaft seal
(310 und 310.1)

8090 798 003

Bevel box with coupling sleeve (349)

Tool [33]

Puller for shaft seal (310)



8052 798 201

Tool [34]

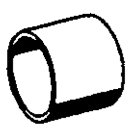
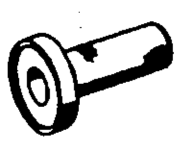
Puller for needle sleeve (302)

8098 798 201

Tool [35]

Extension for tool [34]

8098 798 202

<table>
<tr><th></th><th>8096</th><th>8097</th><th>8098</th><th>8099</th></tr>
<tr><td>Tool [36]
Mandrel for needle sleeve (302)
</td><td colspan="4">8098 798 052</td></tr>
<tr><td>Tool [37]
Sleeve for shaft seal (310.1)
</td><td colspan="4">8090 798 006</td></tr>
<tr><td>Tool [38]
Guide bush for shaft seal (310)
</td><td colspan="4">8098 798 003</td></tr>
<tr><td>Tool [39]
Mandrel for shaft seal (310)
</td><td colspan="4">8098 798 051</td></tr>
</table>

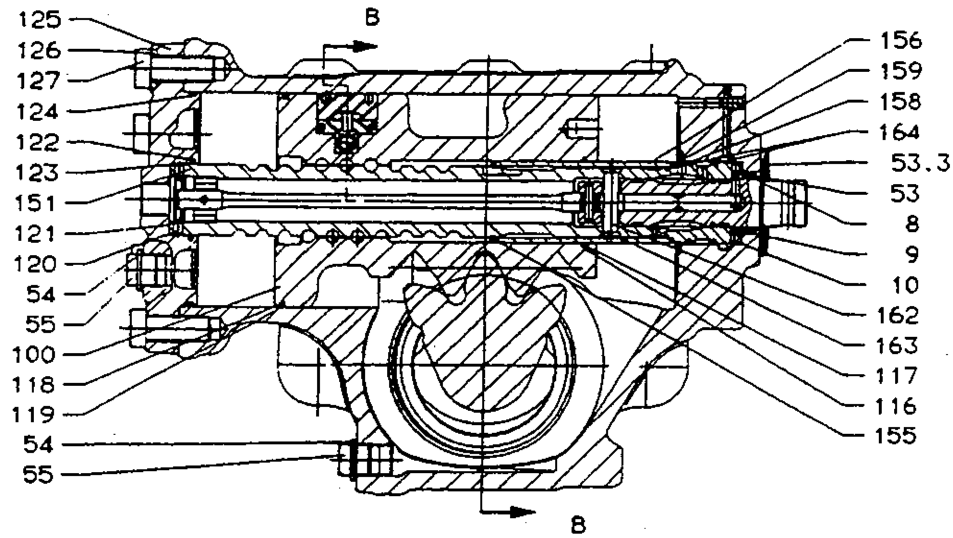
VIII. Key to numbers in figures, sectional drawings and exploded drawings

1.0	Housing
2.0	O-ring
3.0	Washer
4.0	Housing cover
5.0	Gasket
6.0	Support ring
7.0	Retaining ring
8.0	Shaft seal
9.0	Axial-, washer
10.0	Needle cage
11.0	Type plate
12.0	Grooved stud
14.0	Holding segment
20.0	Set screw / Adjusting screw / Screw
20.1	O-ring
21.0	Collar nut
22.0	Valve insert
22.1	Valve insert
23.0	O-ring
30.0	Screw
31.0	O-ring
32.0	Valve insert
34.0	O-ring
35.0	O-ring
36.0	Valve
37.0	Washer
38.0	Hex nut
50.0	Locking nut
51.0	Dust seal
51.1	Stop-ring
51.2	Gasket
51.9	Dust seal
52.0	Plug
53.0	Protecting cap
53.1	Retaining ring
53.3	Gasket
54.0	Sealing ring
55.0	Screw plug
56.0	Protecting sleeve
57.0	Breather
58.0	Protecting cap
63.0	Stick-on label
80.0	Sector shaft
100.0	Piston
101.0	Piston
109.0	Valve insert
110.0	Ball set
111.0	Recirculating half tube
112.0	Gasket/Plug
113.0	Gasket
113.1	Compensating plate
113.2	Pin
114.0	O-ring
115.0	Sealing ring
116.0	Sealing ring
117.0	Sealing ring
118.0	O-ring
119.0	Gasket
120.0	Needle cage
121.0	Washer
122.0	O-ring
123.0	Sealing ring
124.0	O-ring
125.0	Cylinder cover
126.0	Washer
127.0	Hexagon screw
127.1	Screw
128.0	Set screw / Screw
128.1	O-ring
129.0	Collar nut
150.0	Worm
151.0	Worm
155.0	Snap ring
156.0	Sliding tube
157.0	Bush
158.0	O-ring
159.0	Sealing ring
160.0	Pin
161.0	Worm
162.0	Pin

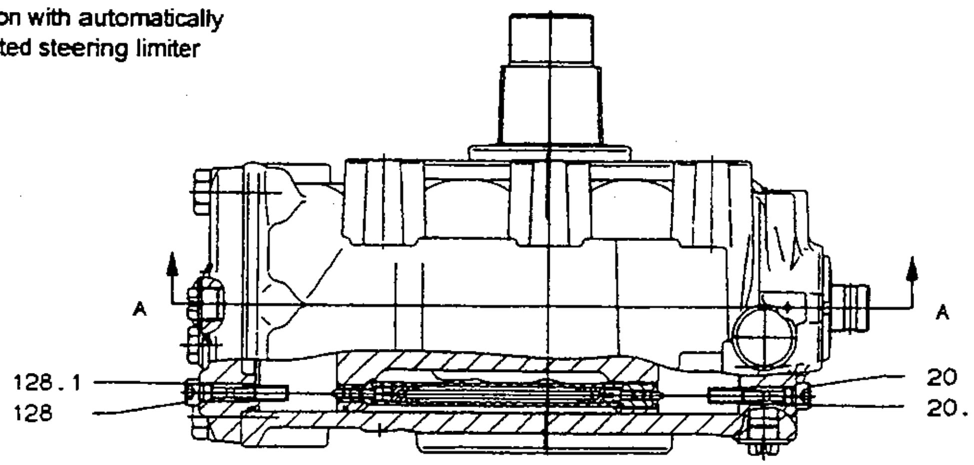
163.0	Plug
164.0	Sealing ring
164.1	O-ring
165.0	Torsion bar
166.0	Needle cage
166.1	Snap ring
167.0	Pin
168.0	Valve slide
169.0	O-ring
170.0	Sealing ring
171.0	Needle cage
172.0	O-ring
173.0	Sealing ring
174.0	Control sleeve
200.0	Ball cage
201.0	Bearing ring
202.0	O-ring
203.0	Valve housing
204.0	Cap screw
205.0	Pipe union
206.0	Pipe union
207.0	Pipe
208.0	Pipe
209.0	O-ring
210.0	O-ring
211.0	Union screw
212.0	Pipe
220.0	O-ring
221.0	Housing cover / Cover
222.0	Steering limiter kit / Switch
222.1	Washer
223.0	Cap screw
224.0	O-ring
225.0	Pipe
226.0	Pipe
227.0	Cam disc
228.0	Retaining ring
250.0	Add-on cylinder
250.1	Torx screw
251.0	Washer
252.0	Hexagon screw
253.0	Bush
254.0	Gear
255.0	O-ring
256.0	O-ring
257.0	Gasket
258.0	Piston
259.0	Cylinder cover
260.0	O-ring
261.0	Retaining ring
301.0	Housing
302.0	Needle sleeve
304.0	Washer
306.0	Bevel gear
308.0	O-ring
310.0	Shaft seal
310.1	Shaft seal
310.2	Retaining ring
310.3	Retaining ring
310.4	Retaining ring
312.0	Adjusting screw
313.0	Slotted nut
314.0	Dust seal / Protecting cap
314.1	Snap ring
314.2	Snap ring
330.0	Shim plate
331.0	Bevel gear
332.0	Ball bearing
333.0	O-ring
334.0	Cap screw
335.0	Intermediate flange
335.1	Pipe
335.2	Pipe
341.0	O-ring
343.0	Ball bearing
346.0	Centering ring
348.0	Cross disc
349.0	Coupling sleeve
350.0	Washer
352.0	Hexagon screw/Screw/ Cap screw

Types 8090 - 8099

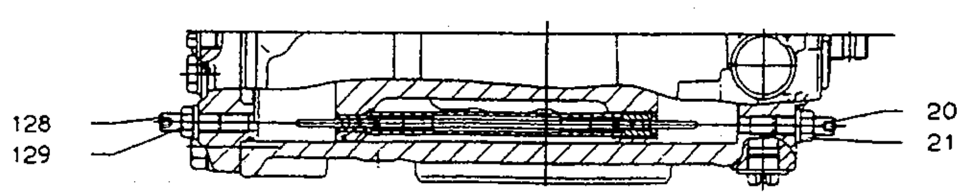
Section A-A



Version with automatically adjusted steering limiter

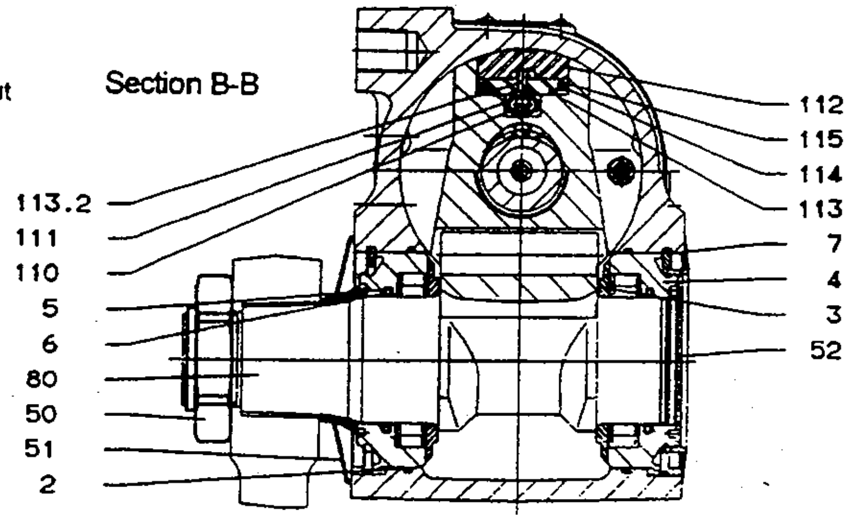


Version with manually adjusted steering limiter



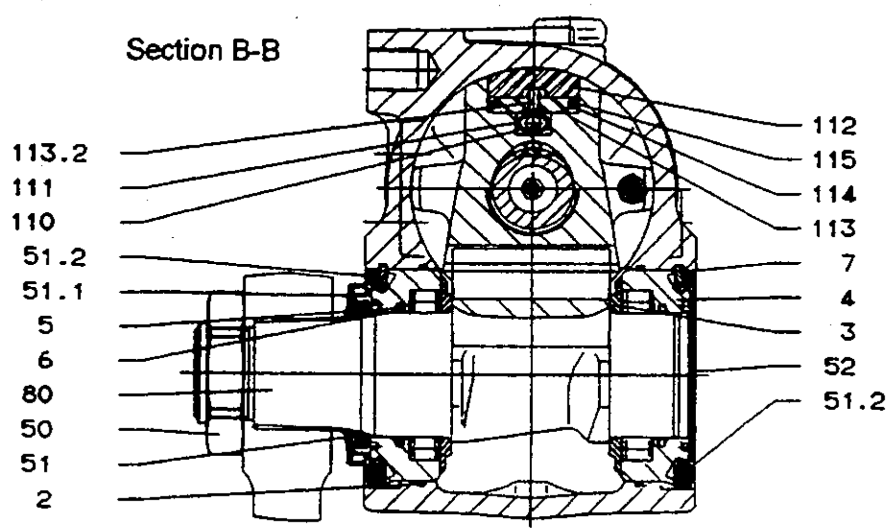
Version without gasket (51.2)

Section B-B



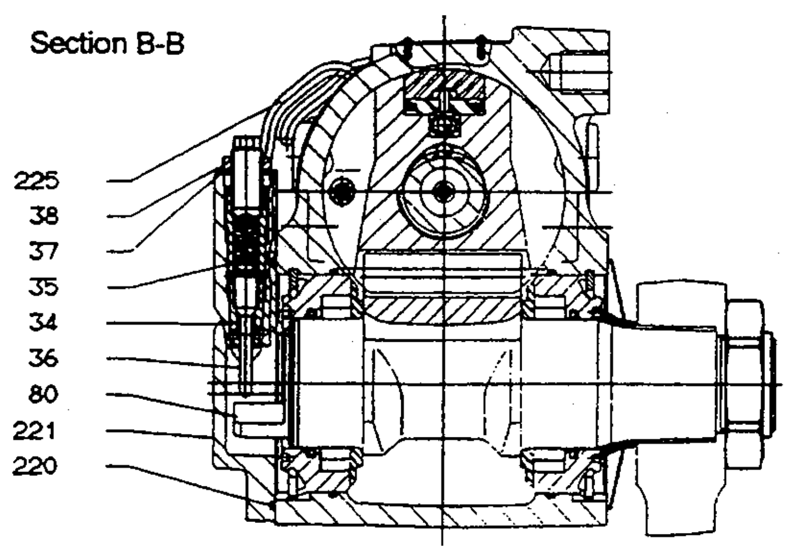
Version with gasket (51.2)

Section B-B

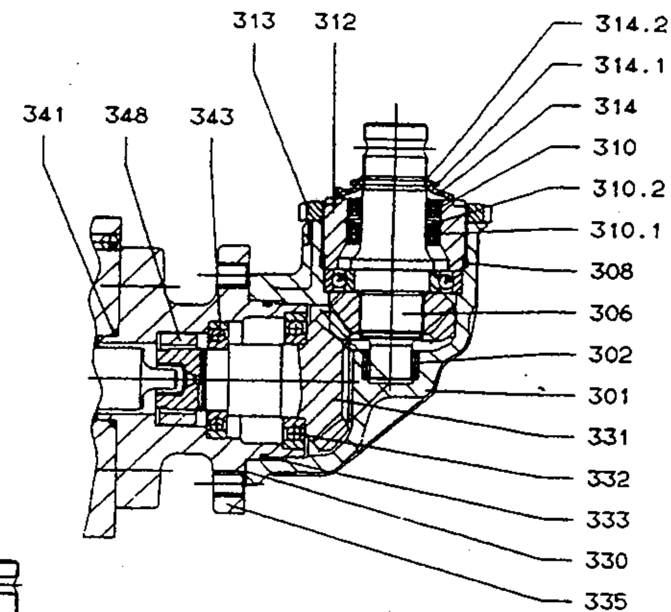


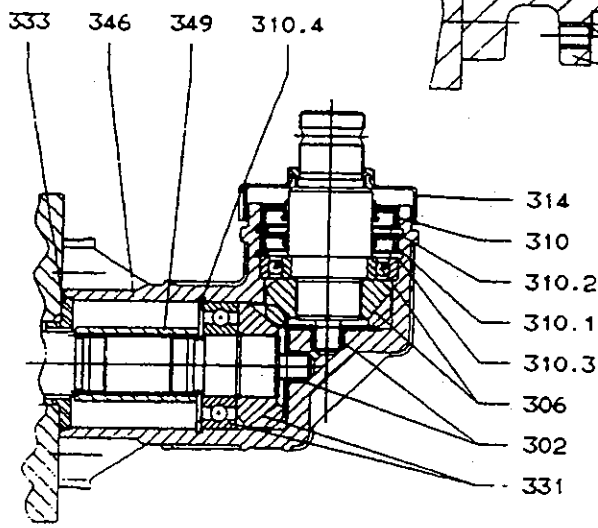
Section B-B

Dual-circuit version with steering limiter in housing cover (221)



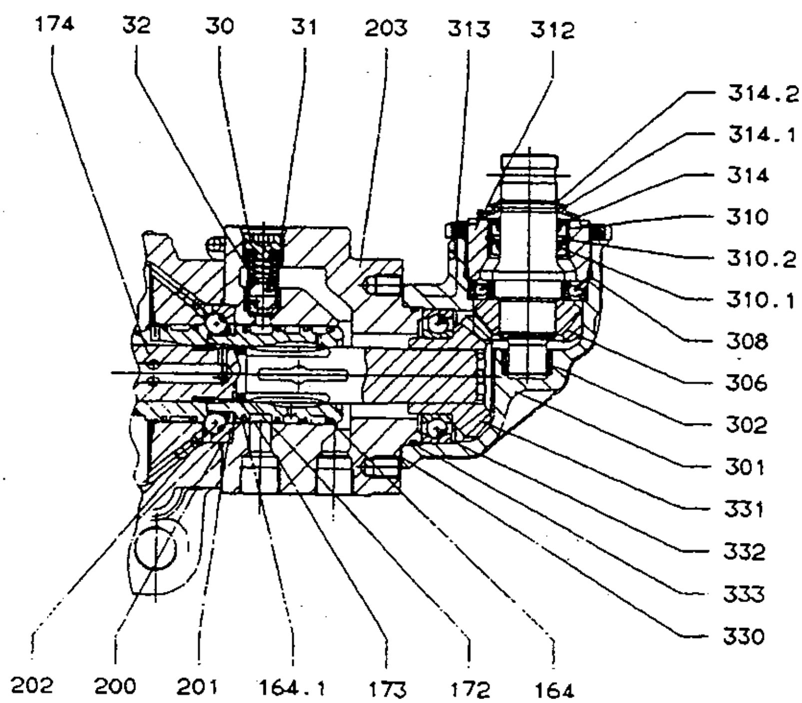
Bevel box with
cross disc (348)

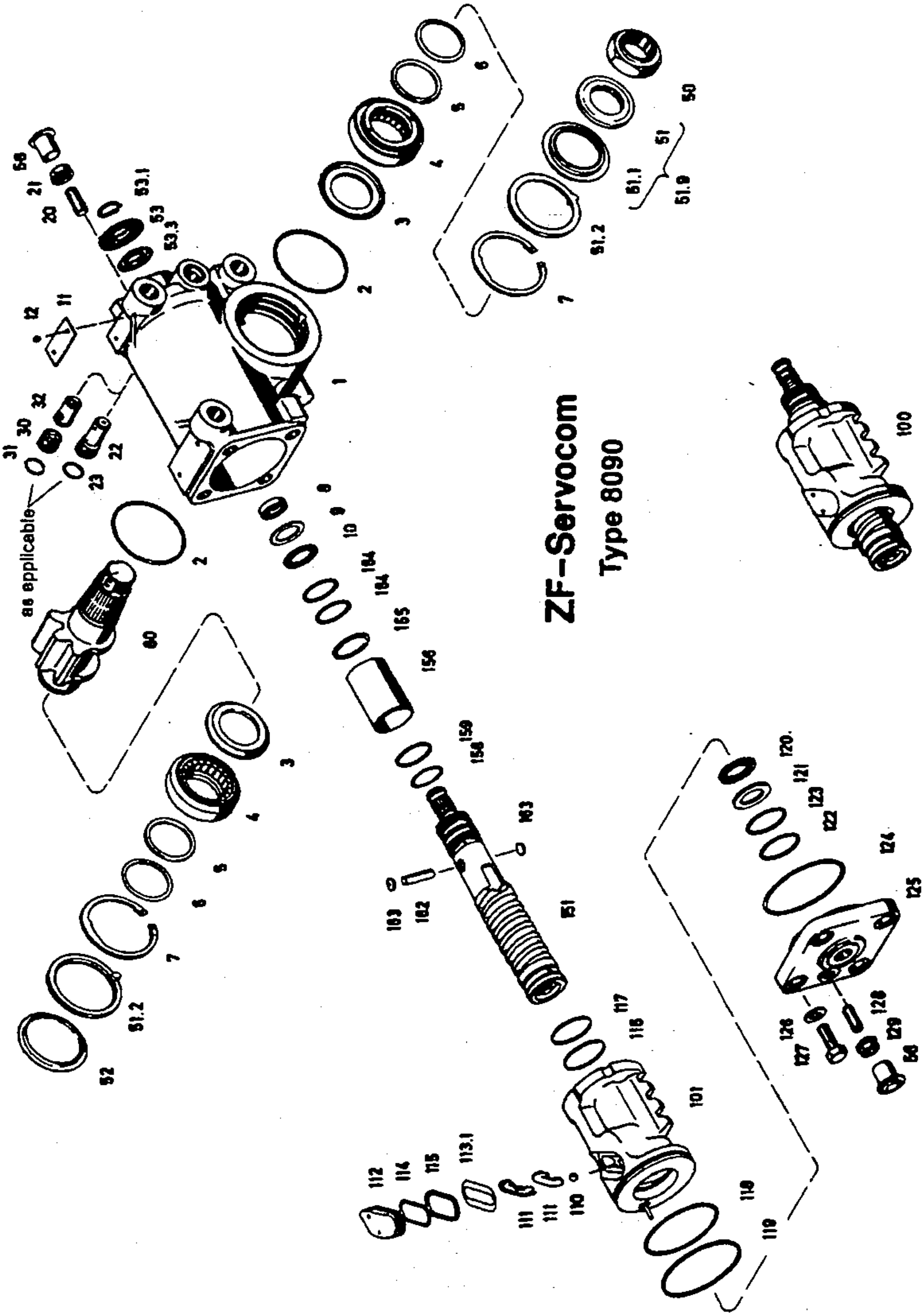


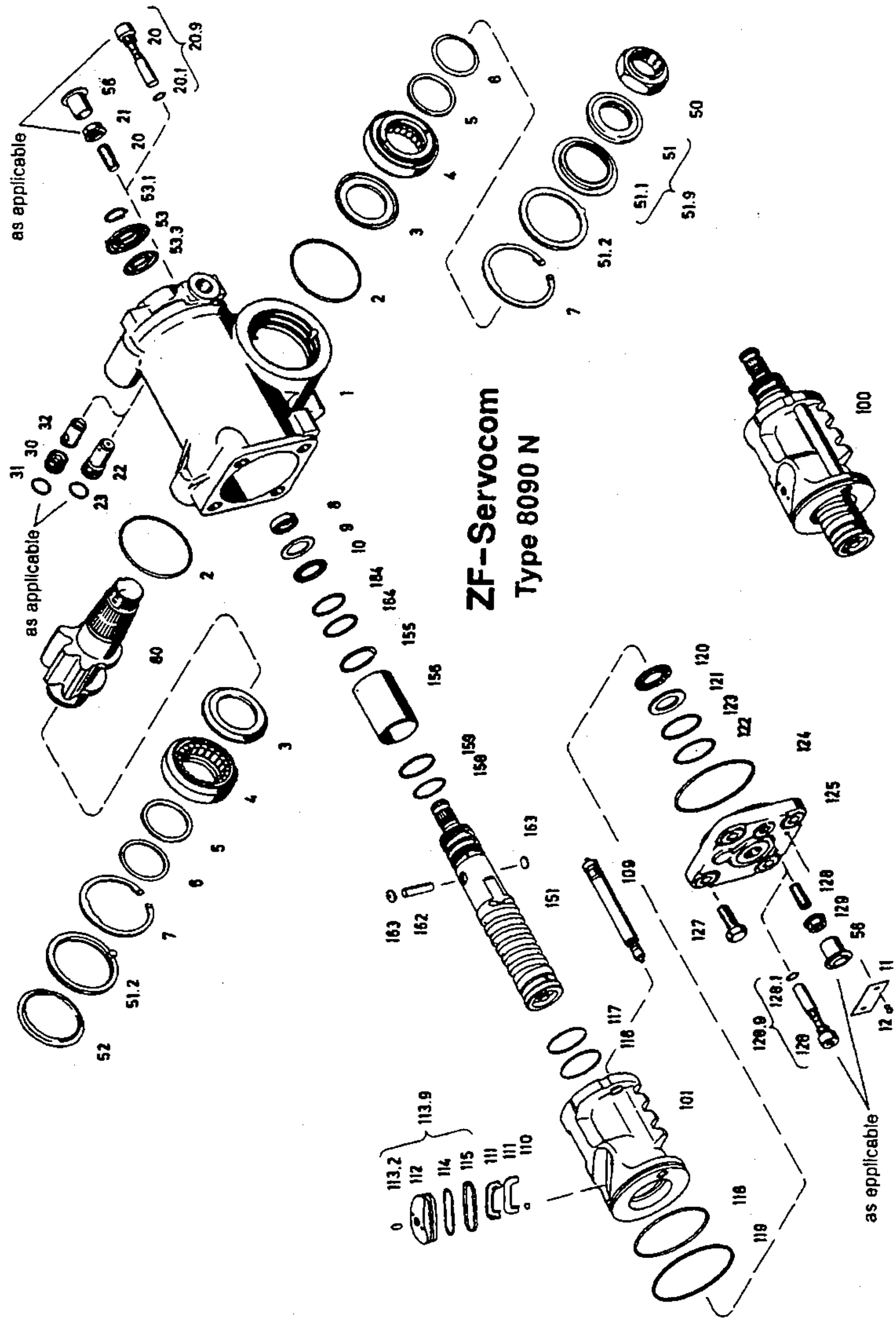


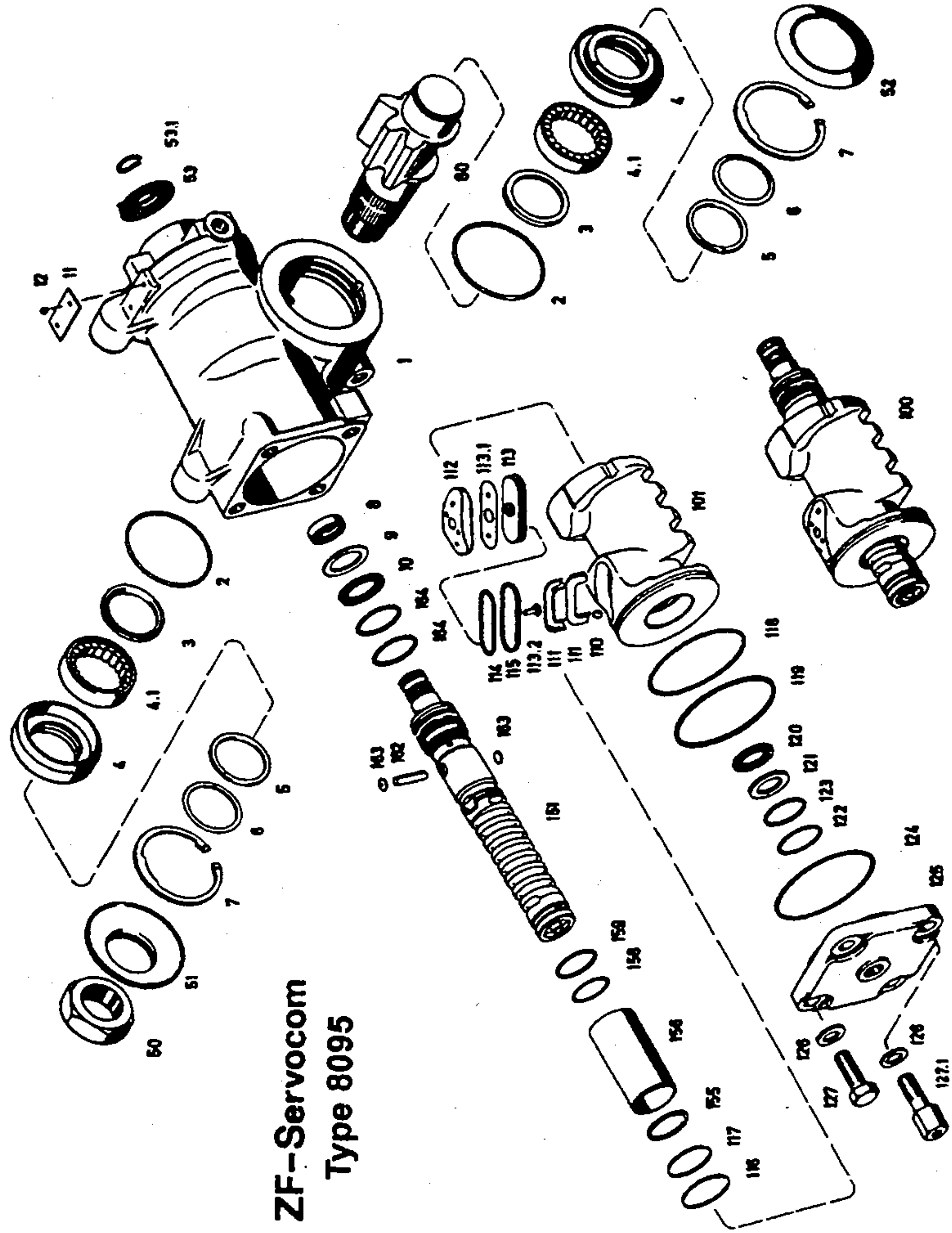
Bevel box with
coupling sleeve (349)

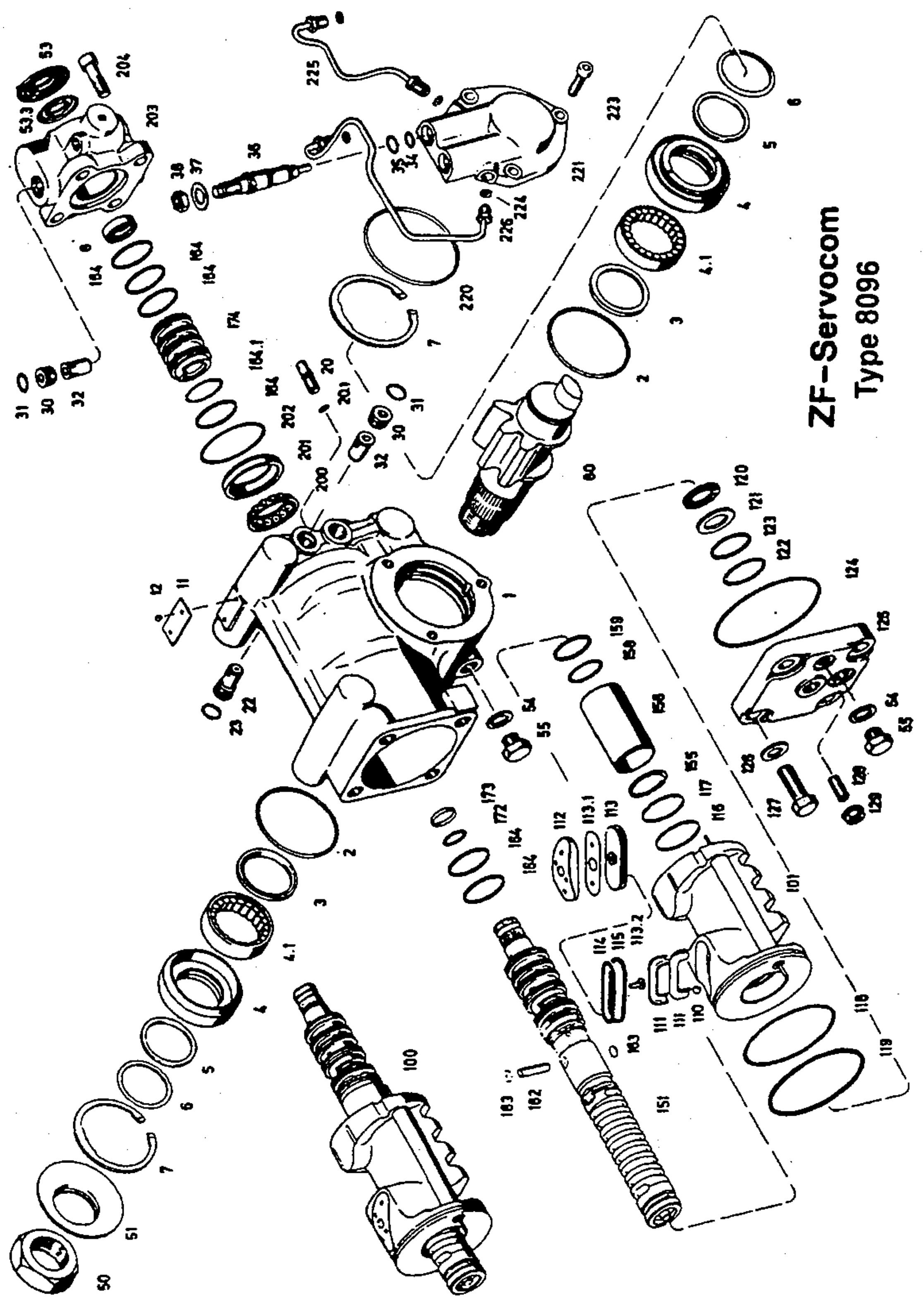
Dual-circuit version
with bevel box

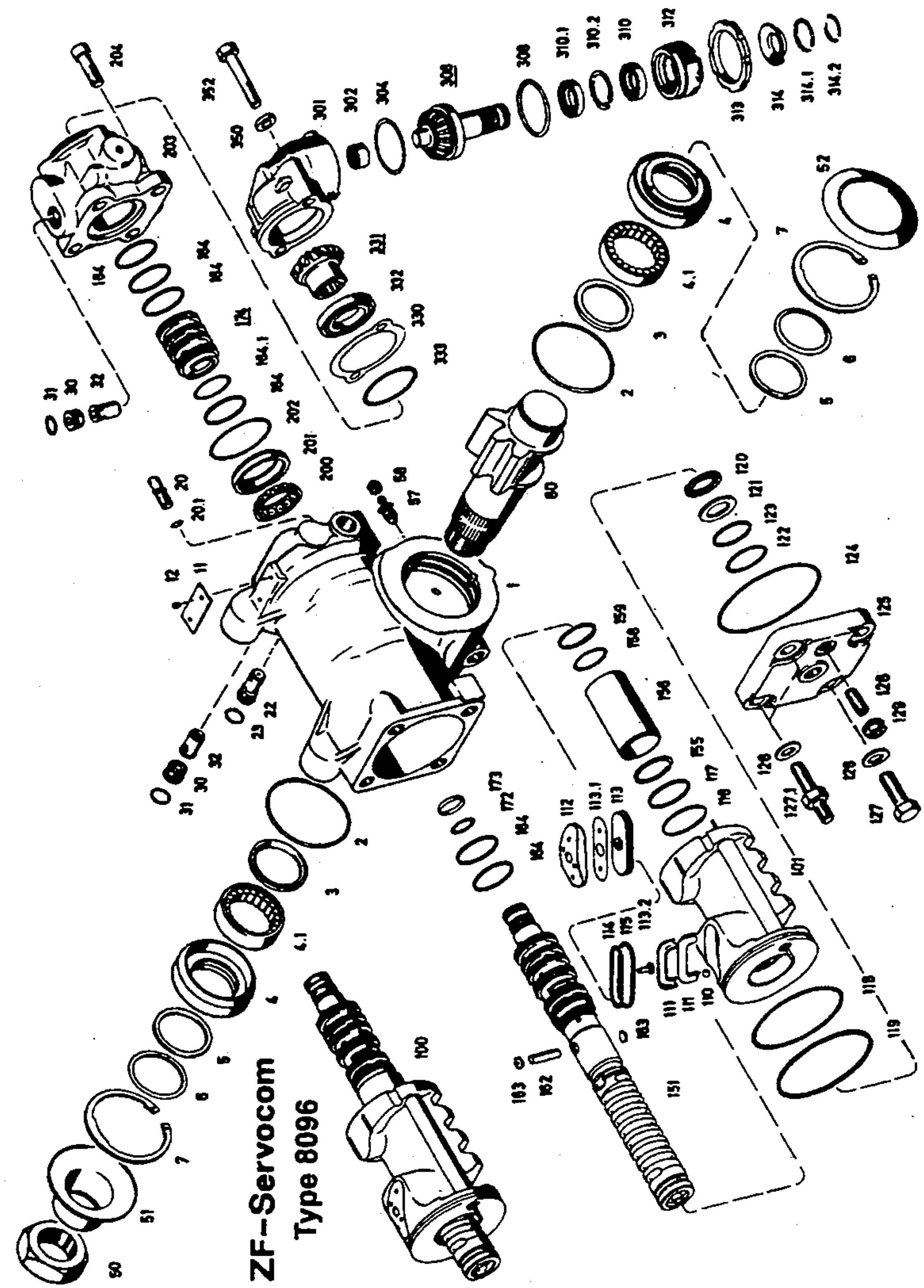


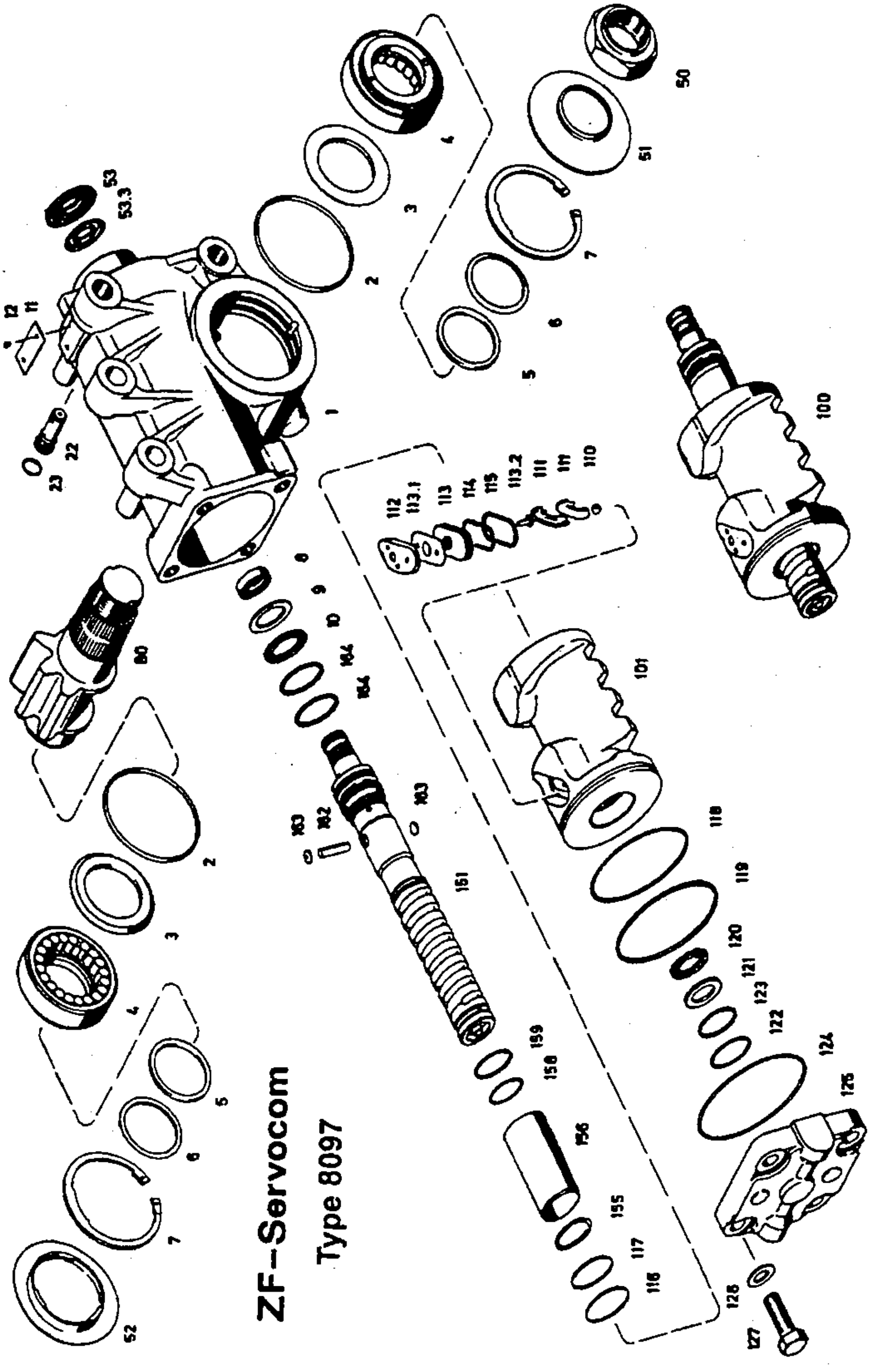

ZF-Servocom
Type 8090
as applicable


ZF-Servocom
Type 8090 N
as applicable
as applicable
as applicable
as applicable


ZF-Servocom
Type 8095


ZF-Servocom
Type 8096


ZF–Servocom
Type 8096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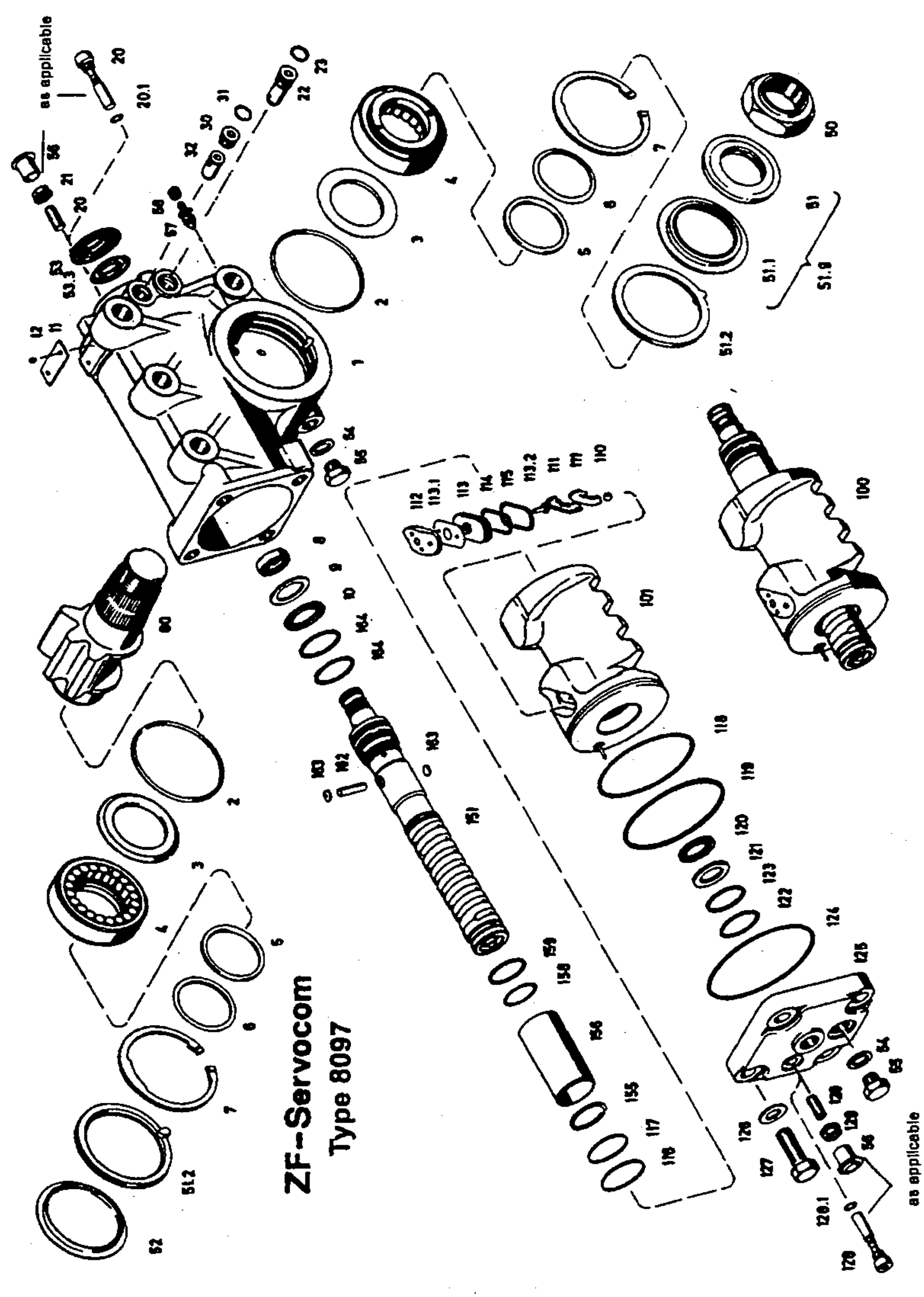
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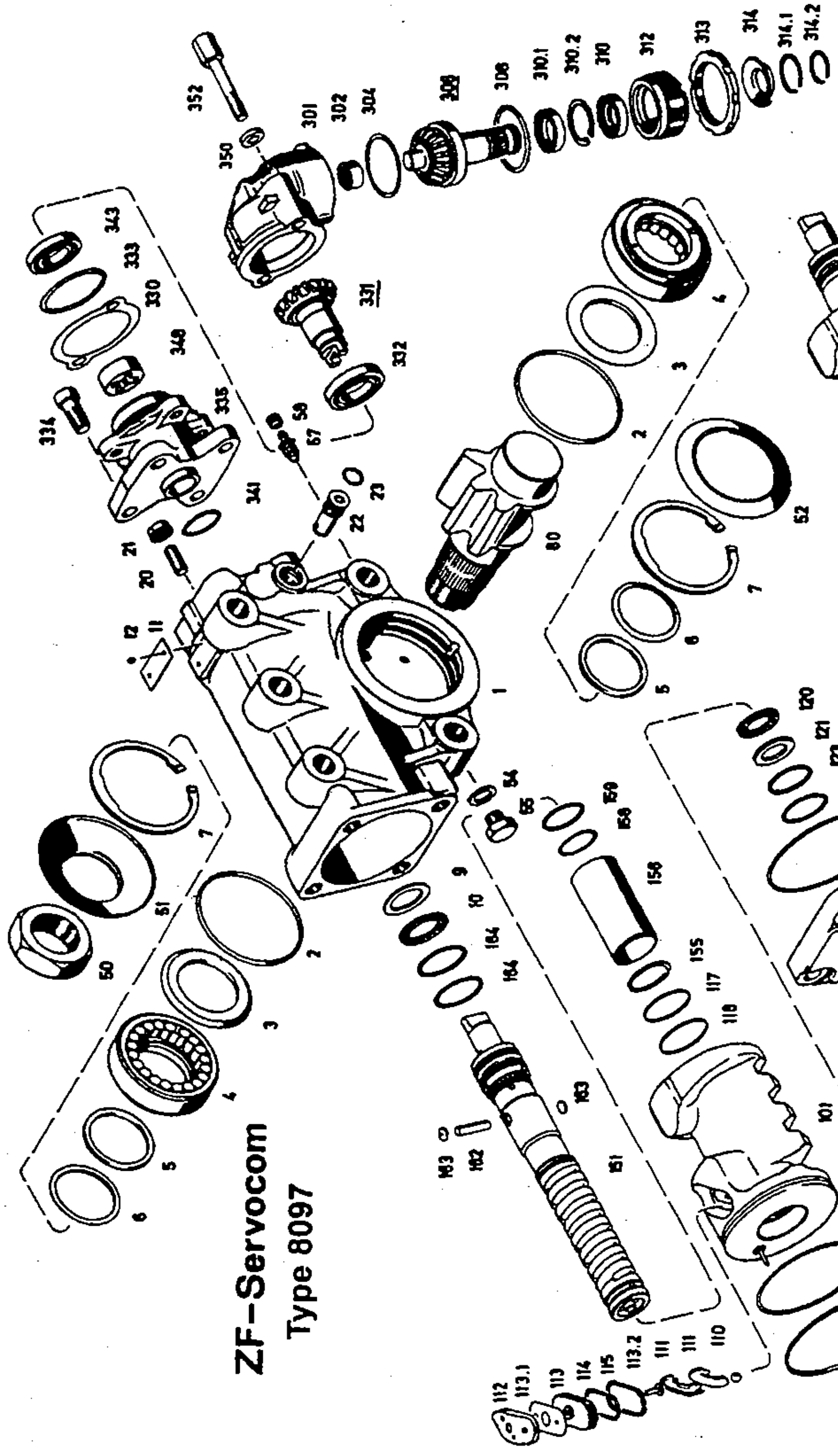
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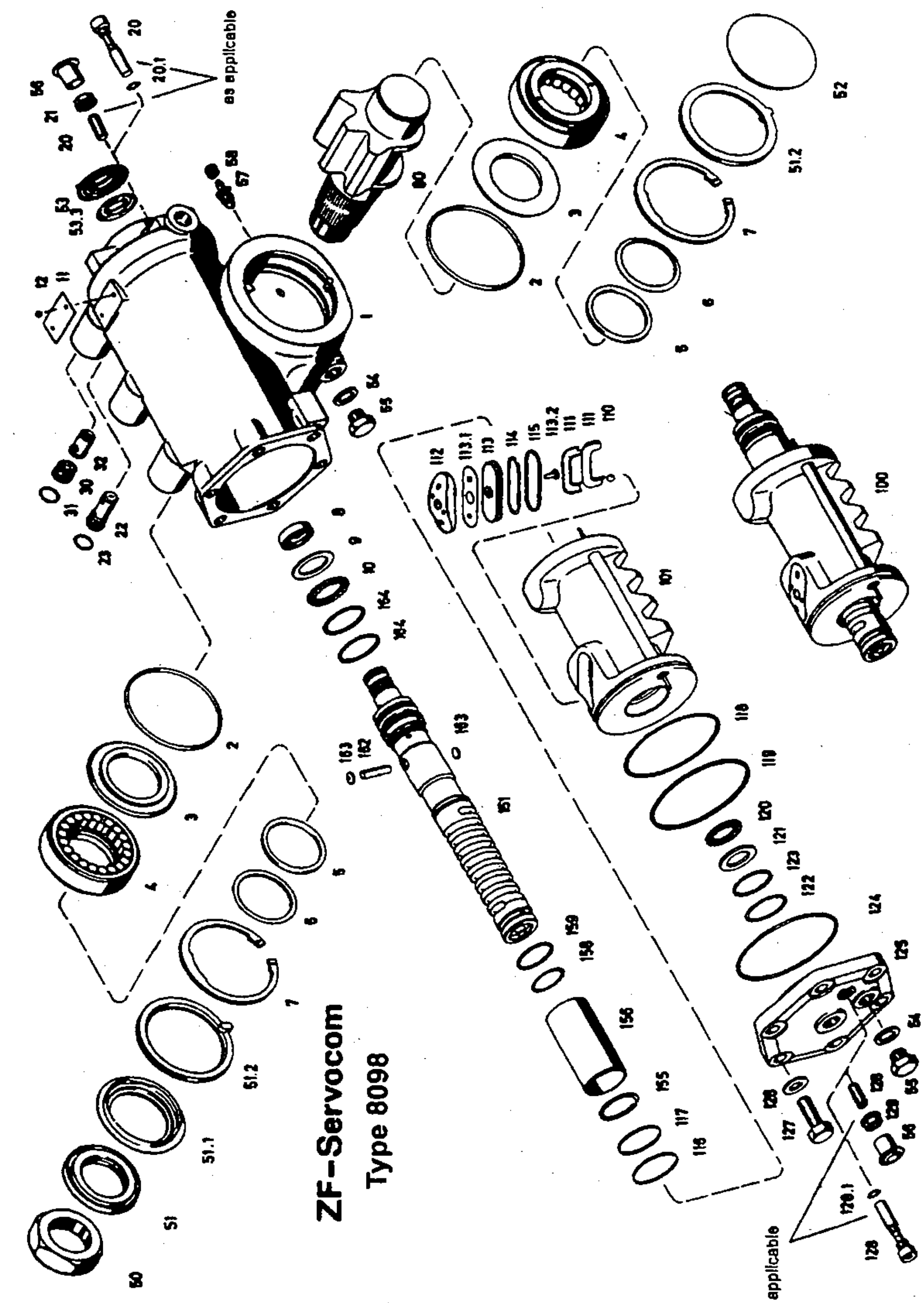
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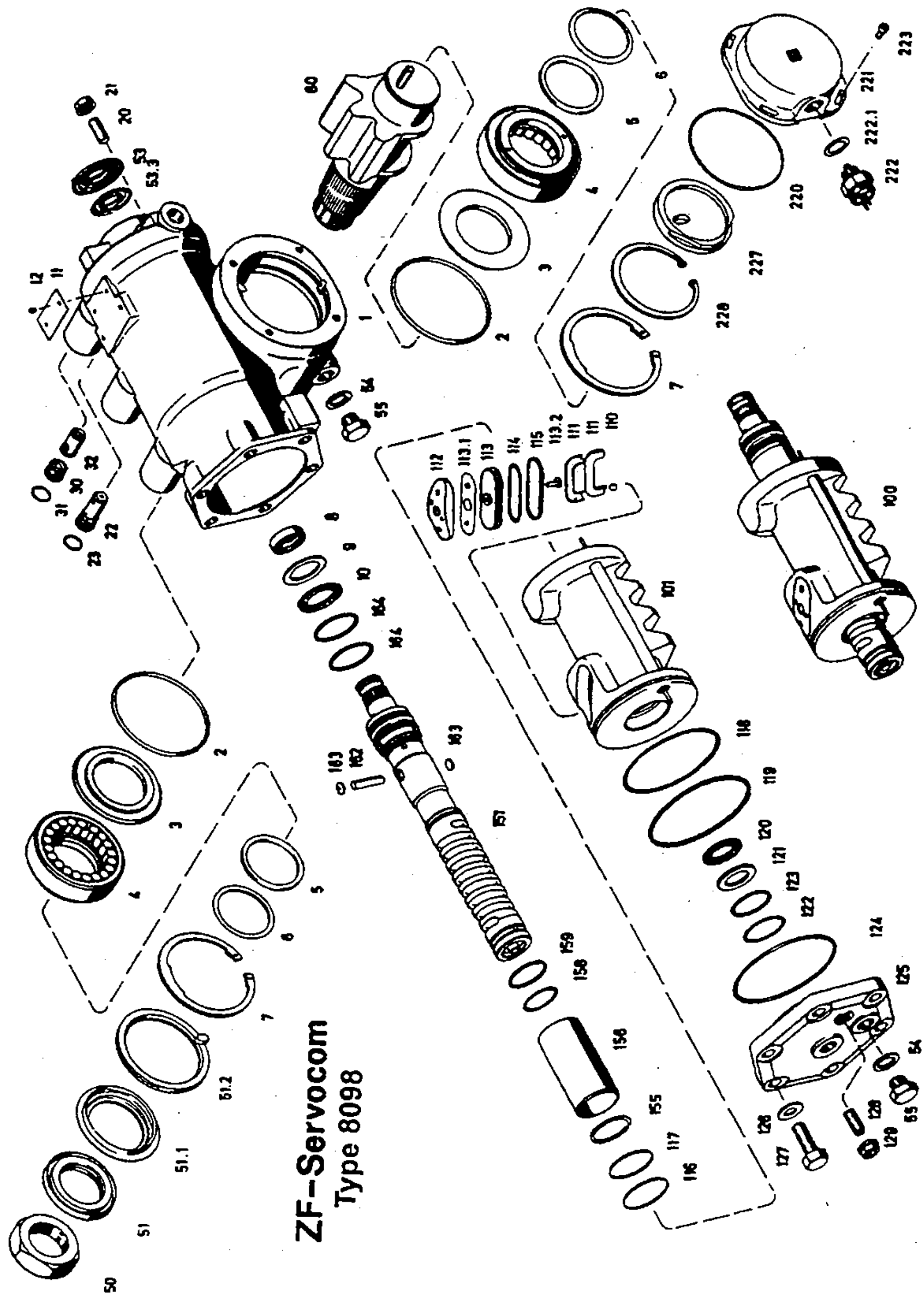
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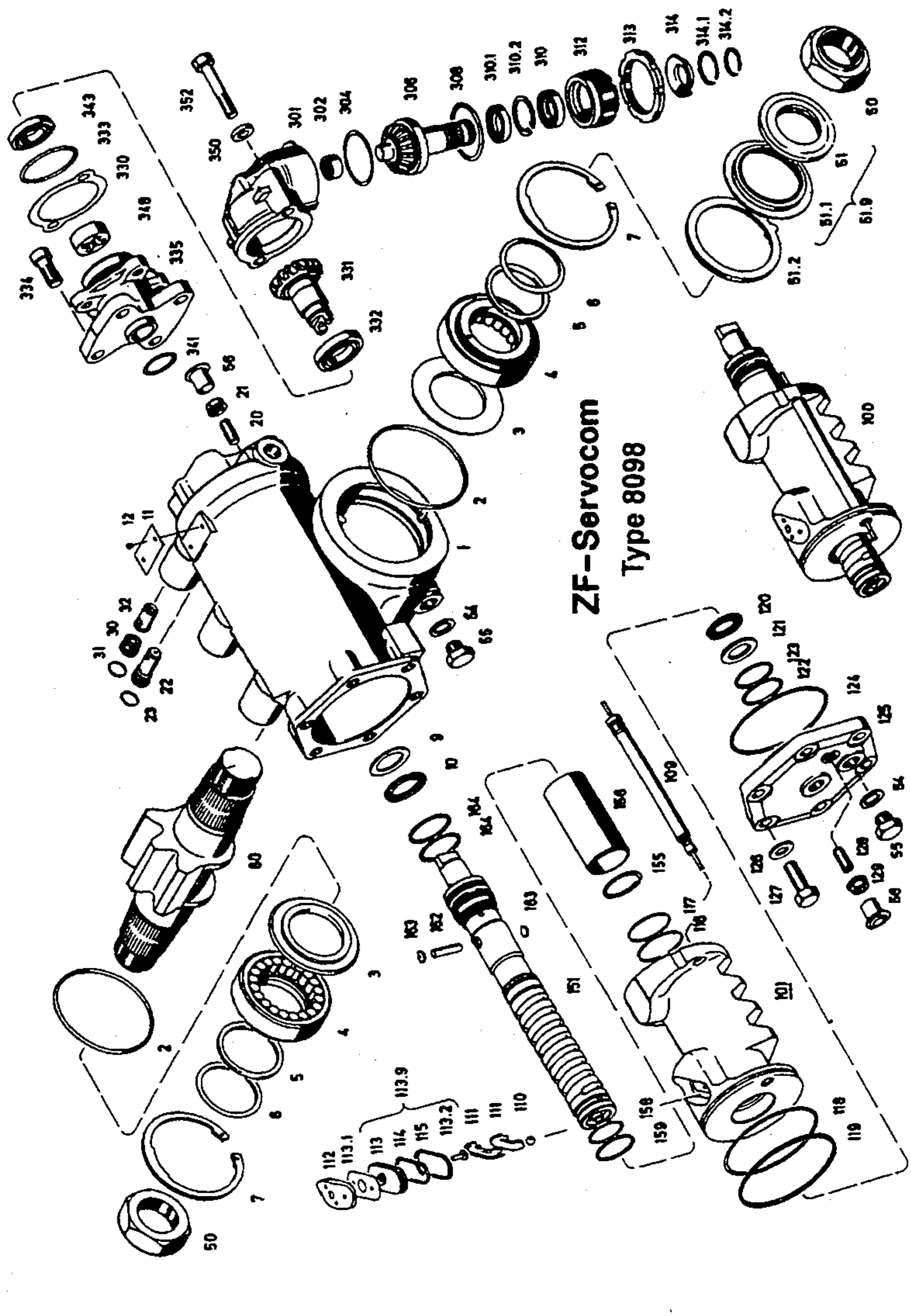
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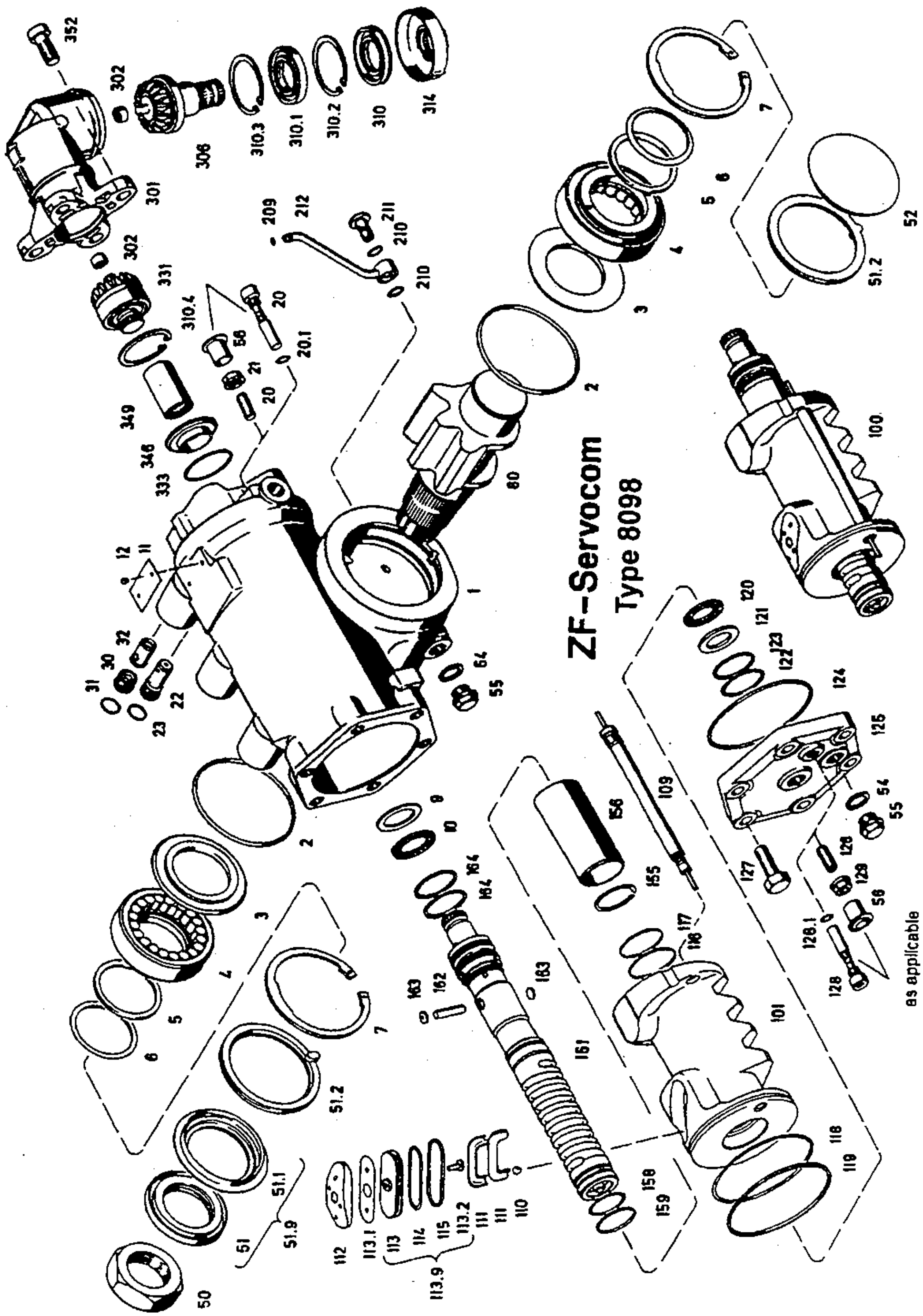
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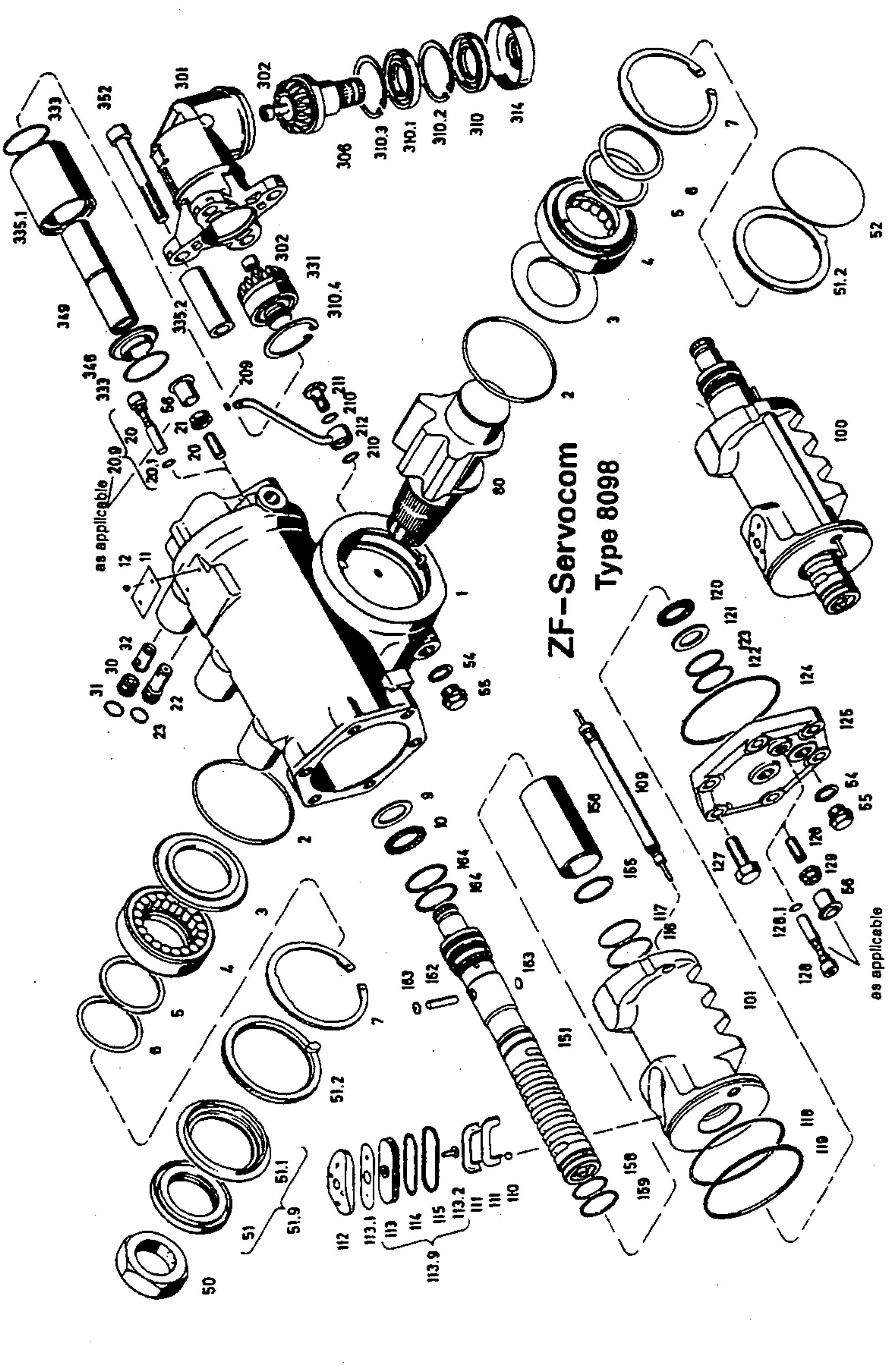
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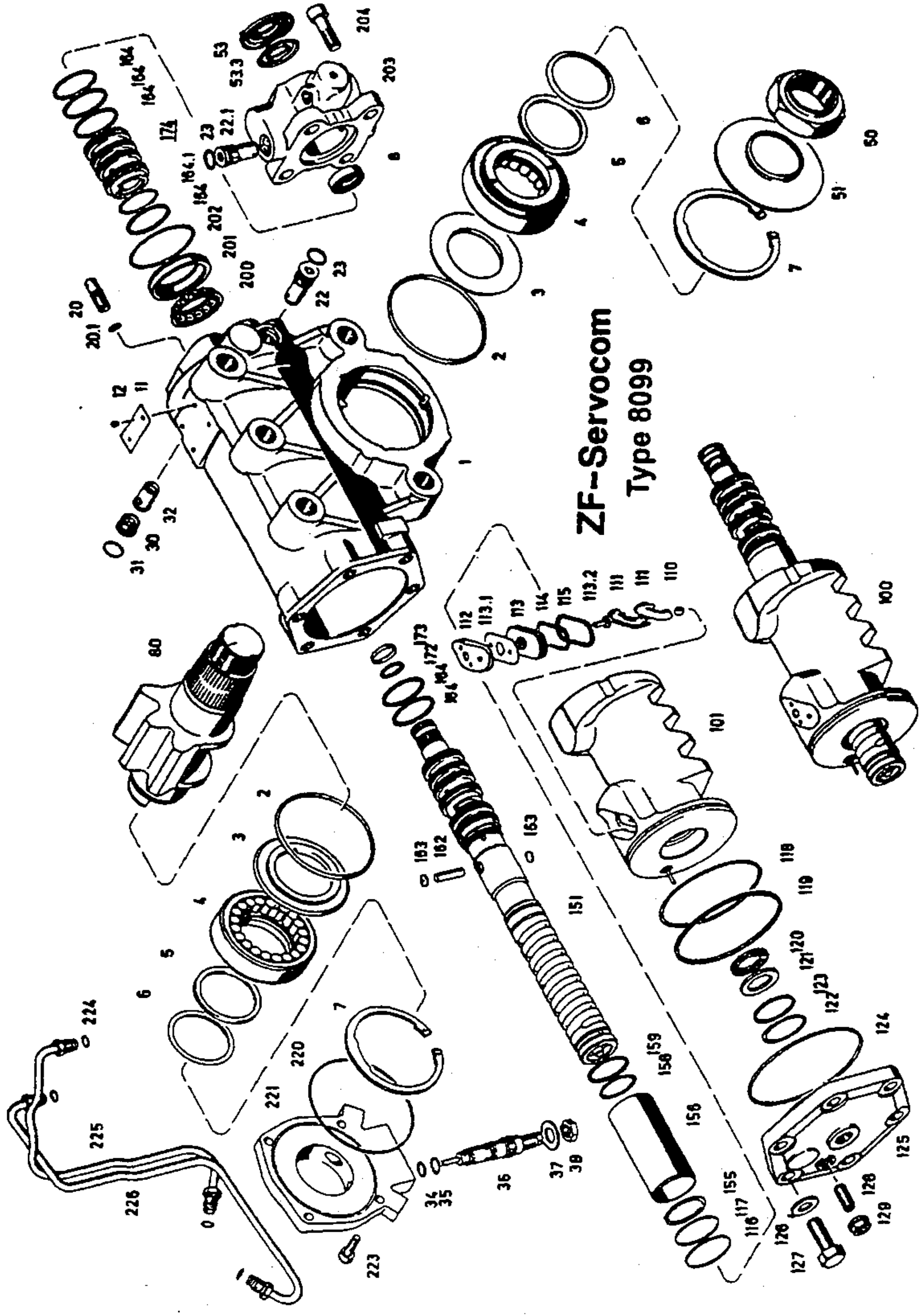
ZF-Servocom
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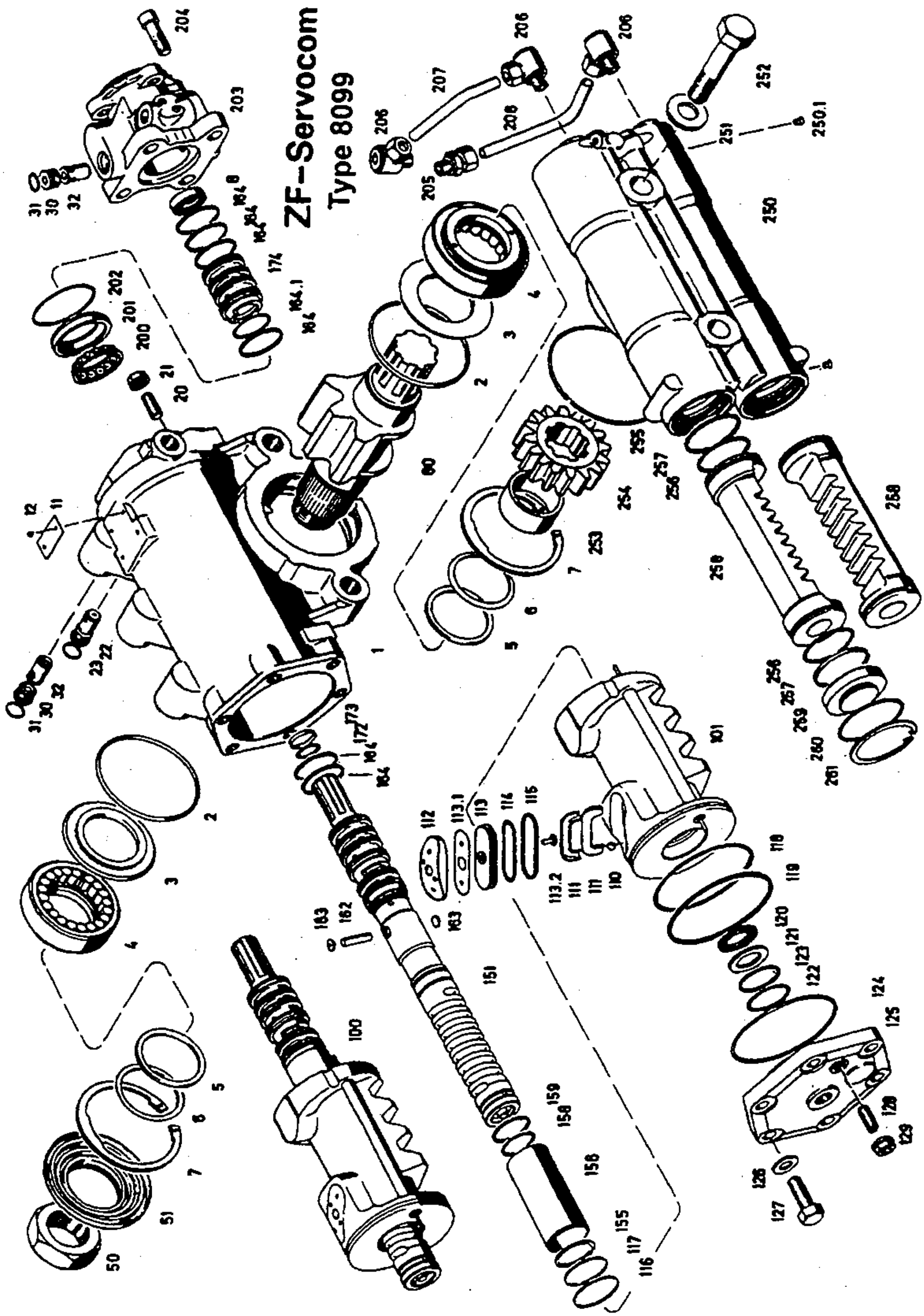
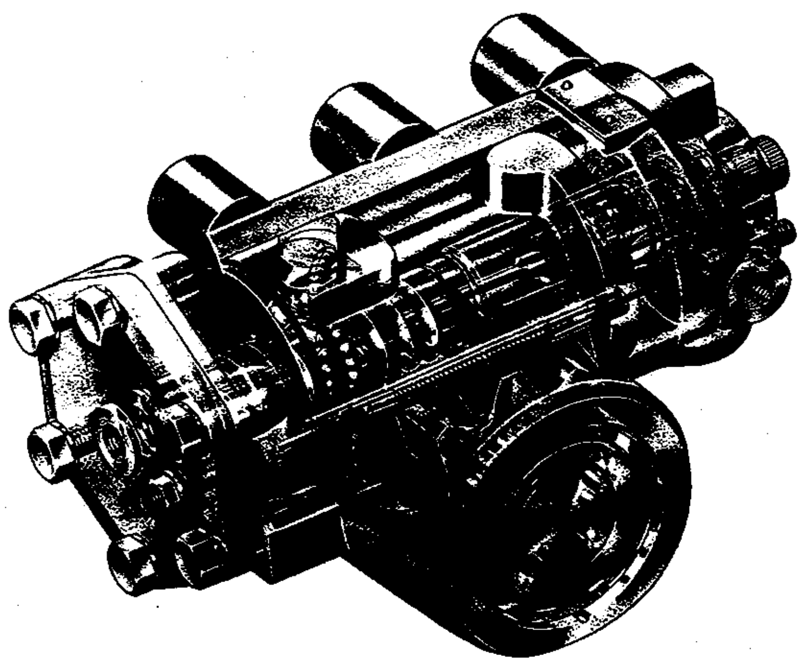

ZF-Servocom
Type 8099

ZF-Servocom®

and ZF Recirculating ball power steering (CV)

Operating, servicing/maintenance and inspection instructions



ZF-FRIEDRICHSHAFEN AG
GESCHÄFTSBEREICH LENKUNGSTECHNIK

D-73522 Schwäbisch Gmünd

Telephone: (07171)31-0   Telefax: (07171)31-4396

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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.

Table of contents:

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

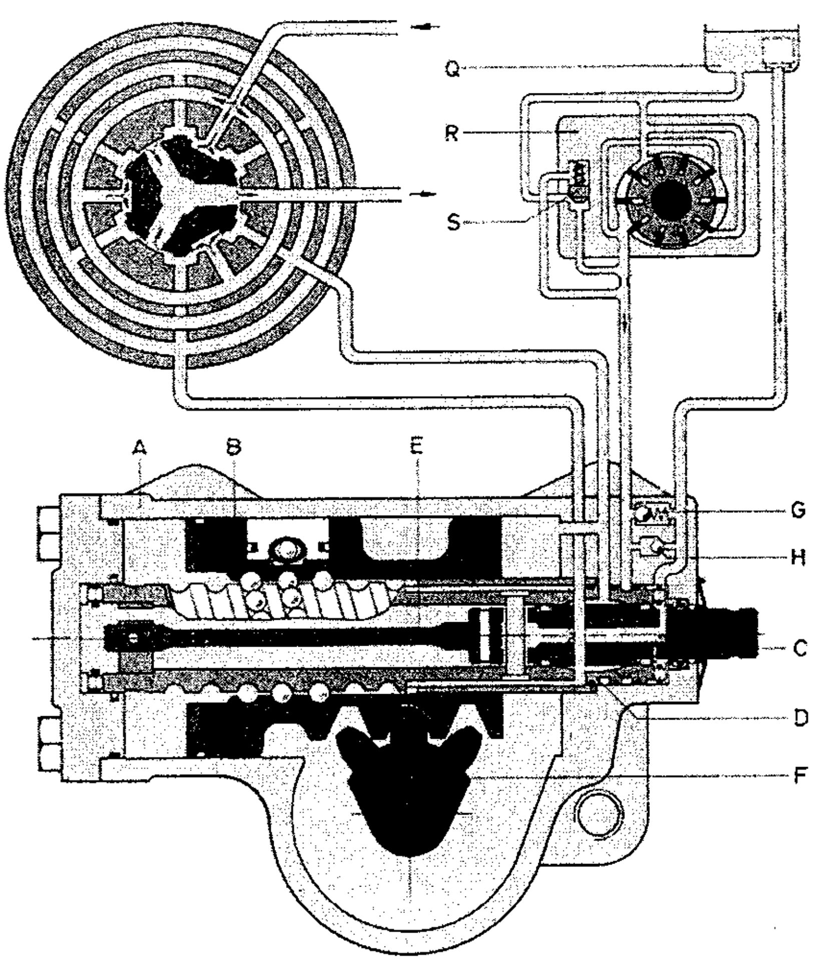
1.1 Construction

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.

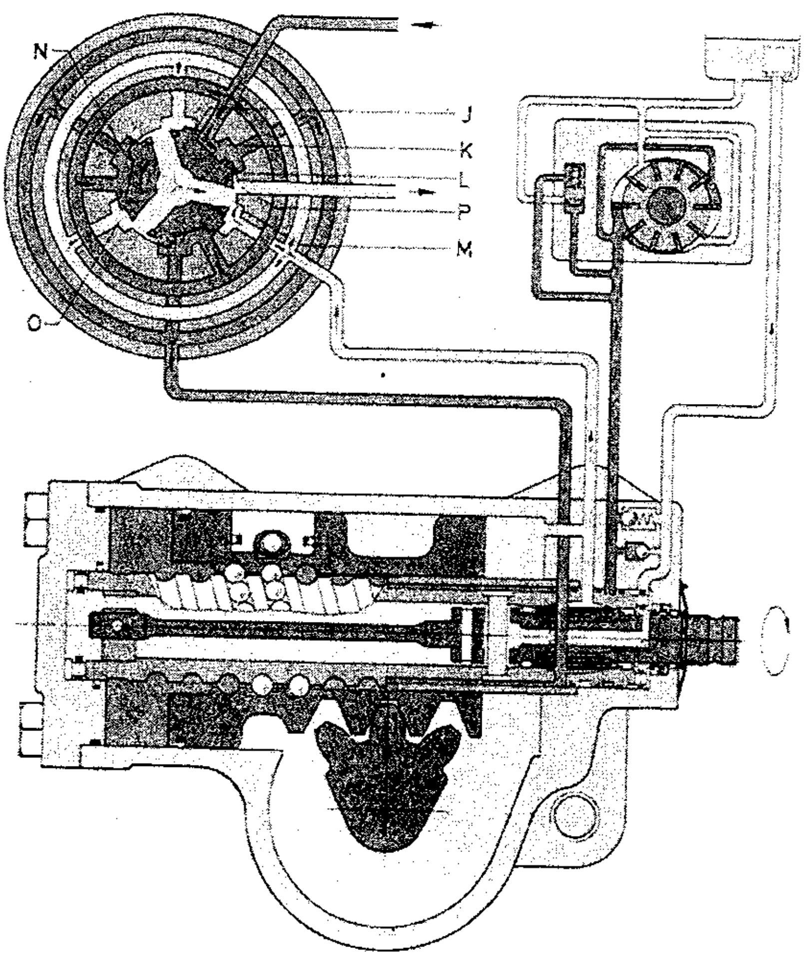
Compared with constant transmission, steering versions with variable transmission are more directly designed in the centre area than outside the centre area. The resulting smaller steering corrections benefit steering behaviour in straight–ahead driving. At the same time, the indirect transmission means 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

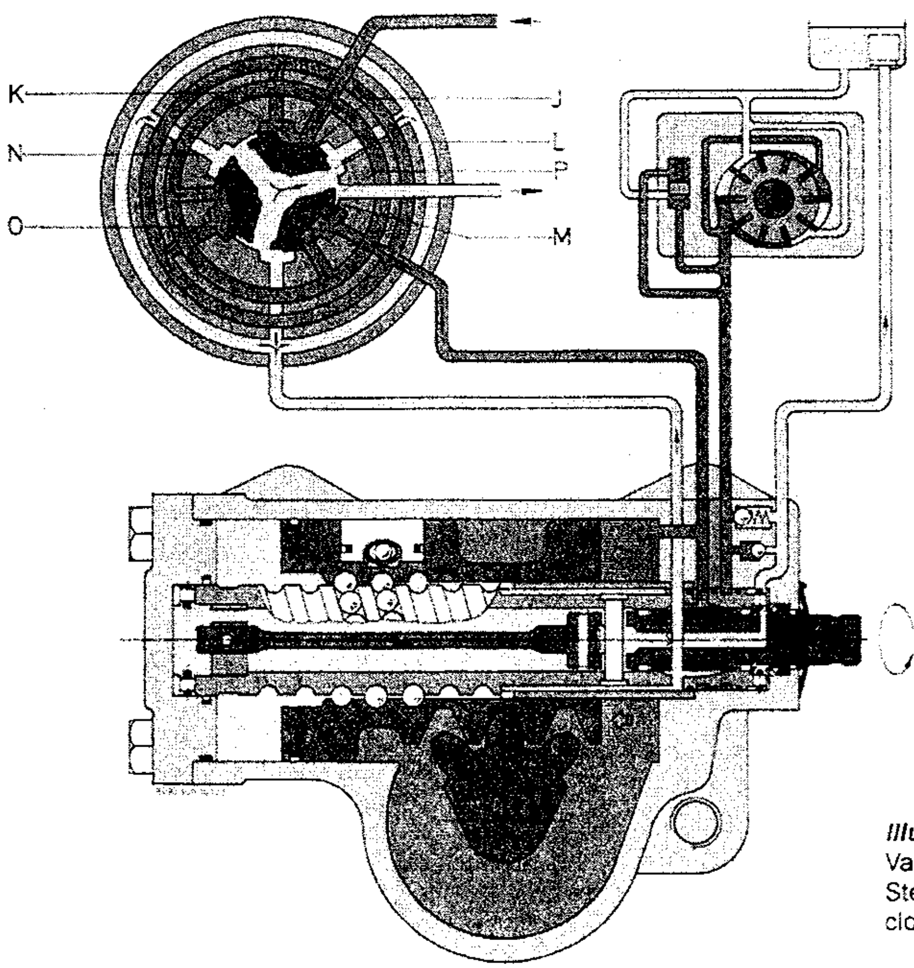
The 3 functional diagrams of ***Illus. 1*** to ***3*** show valve and oil flow in a simplified way for ease of comprehension. These diagrams also show the valve in cross–section so that the connections from the control valve to the cylinder compartments and the functioning of the valve can be shown schematically.

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.



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

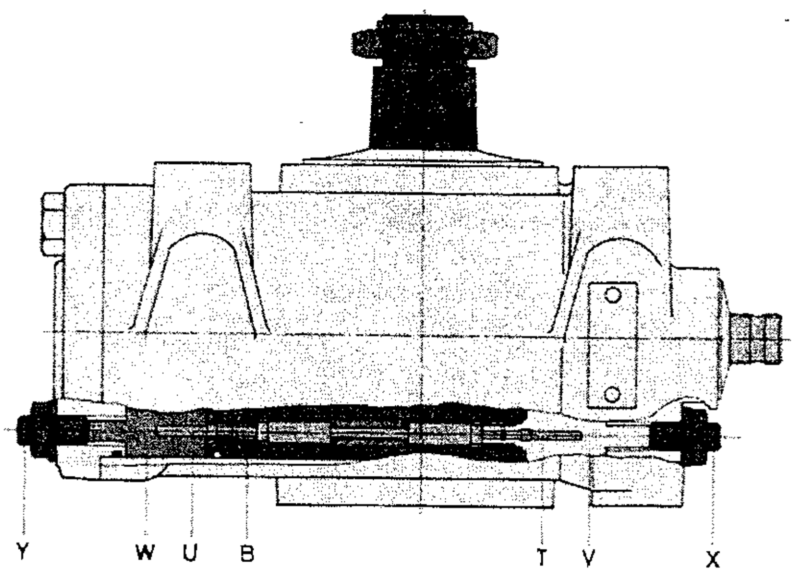
Illus. 3
Valve slide in working position. Steering wheel turn in anti-clockwise direction.

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

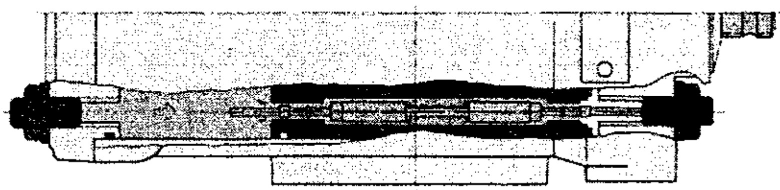
V right cylinder compartment
W left cylinder compartment

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.



reduced operating pressure return flow pressure

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.

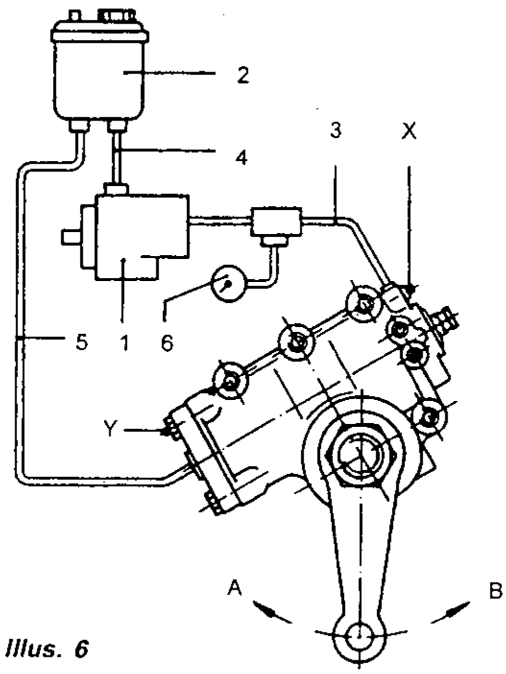
Once the wheel lock has been reached, a brief (max. 5 seconds) continued turning of the steering wheel will overcome the self–aligning force of the steering valve until a fixed steering wheel lock is achieved.

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 dm^3/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.

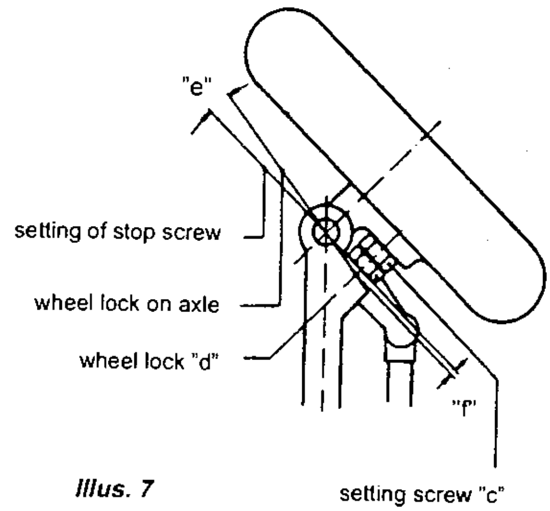
The vehicle manufacturer may prescribe a mode of setting that differs from the abovedescribed (e. g. insertion of a spacer), ***see Illus. 26.***



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 dm^3/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.

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).

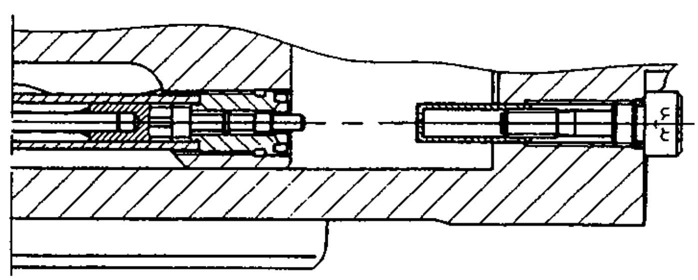
If a lower pressure is measured, the corresponding setting screw must be **screwed out** again (anticlockwise).

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

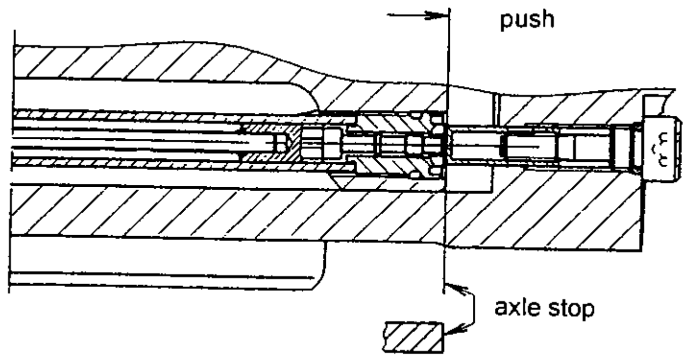
With the automatically adjustable hydraulic steering limiter, screws (X and Y) with pressed–on sliding sleeves are located in place of setting screws.
These function in the same way as with the manually adjustable hydraulic steering limiter. In the limit positions, the valve piston tappets meet the sliding 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

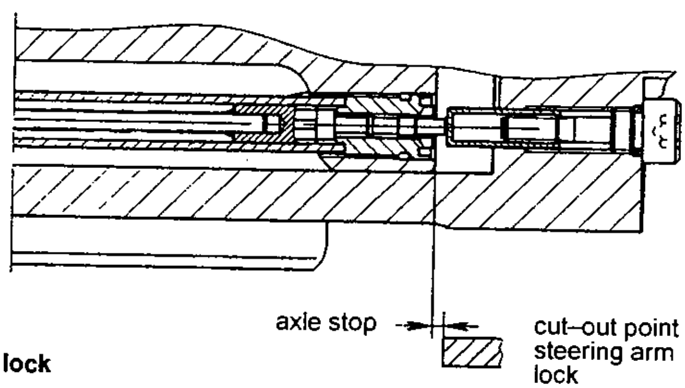


When the above conditions have been met, the steering wheel must be turned to the maximum wheel lock with or without hydraulic assistance. This causes the piston to push the sliding sleeve on the screw to the cut–out position ***(Illus. 9)***. The steering limiter valve is permanently open during this 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:

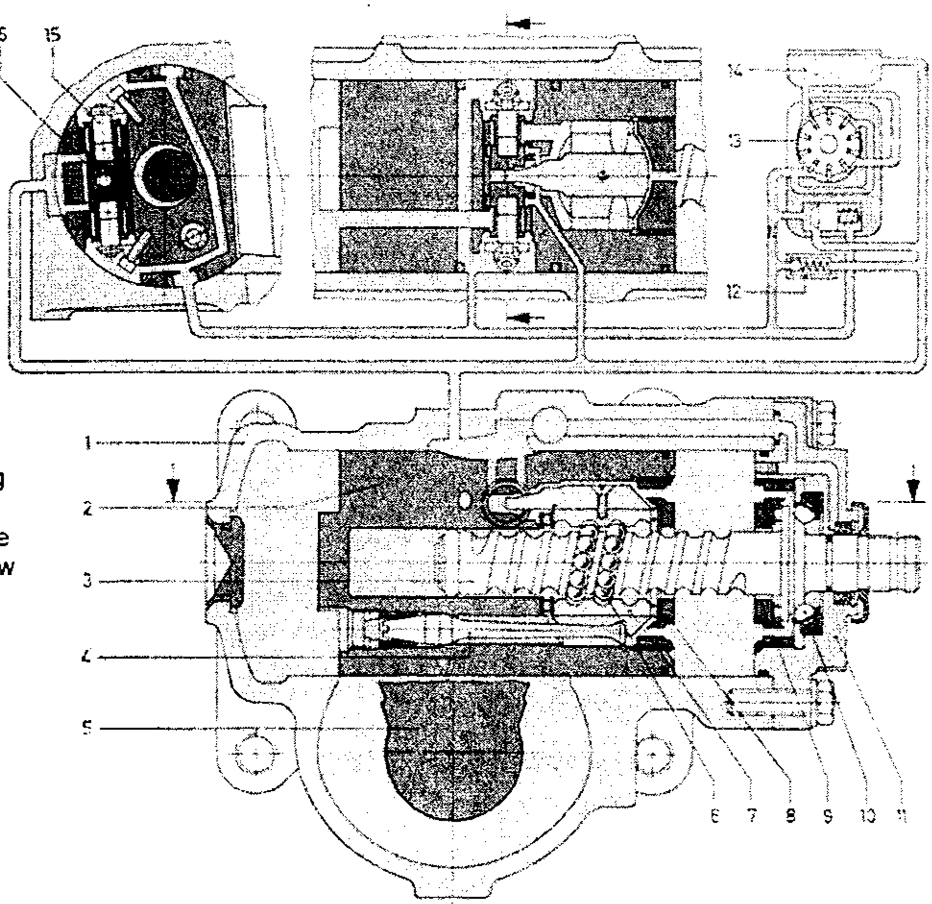
The housing contains a control valve, working cylinder and a complete mechanical steering gear. The pressure oil for the steering is delivered by a motor–driven pressure oil pump which is supplied with oil from an oil tank. The housing (1 or A) is designed as a cylinder for the piston (2 or B) which 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

1 Housing
2 Piston
3 Worm
4 Flexible rod
5 Sector shaft
6 Balls
7 Steering nut
8 Threaded ring
9 Threaded ring
10 Angular ball bearing
11 Cover
12 Pressure relief valve
13 Wing pump with flow control valve
14 Oil tank
15 Recoil piston
16 Valve piston



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.

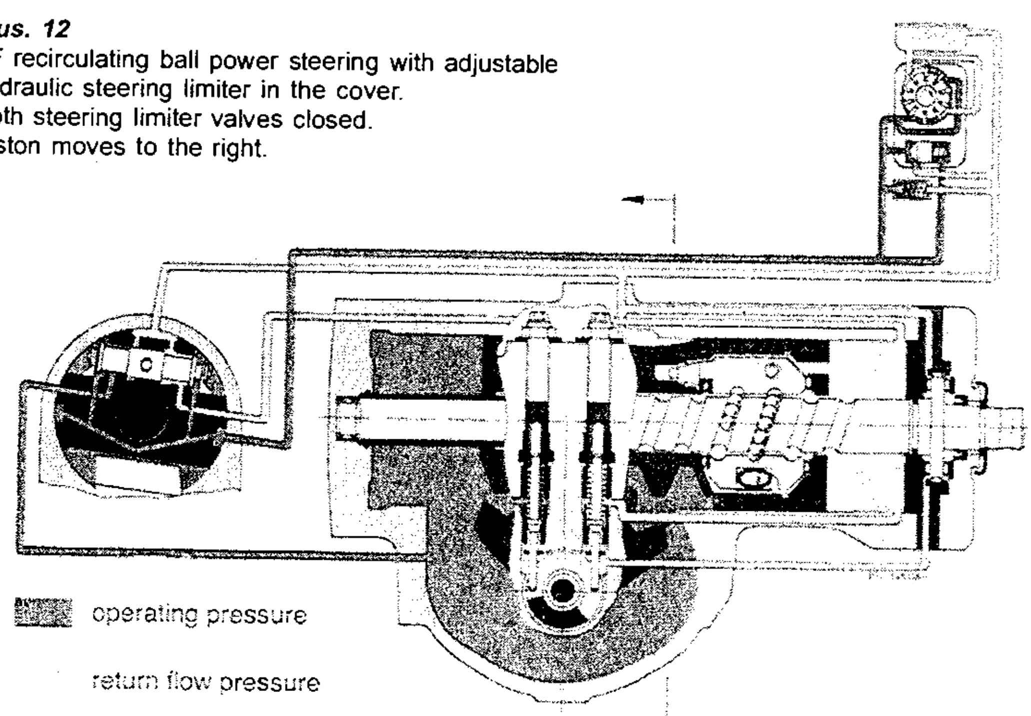
Action of the recoil pistons:
These have a floating bearing in the hole of the valve piston. But they are held axially and secured through connection with retaining plates. The outer faces of both pistons are constantly charged with pressure oil, whereas only one of the inner faces in the working position 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.

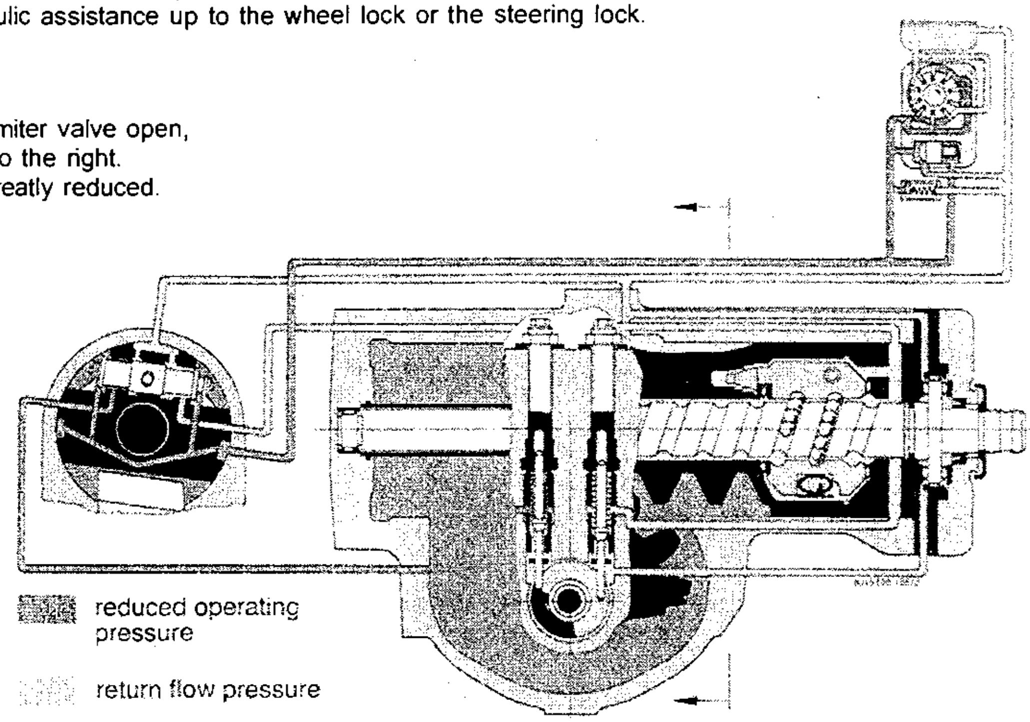


When the sector shaft is turned in a clockwise direction (see ***Illus. 13***, piston moves to the right), the left valve piston is actuated according to a defined steering arm lock, which can be altered by screwing the valve in or out. The pressure oil can then flow through the valve seat from the left cylinder to the return. The position of the steering valve is not changed. The right steering limiter valve remains closed during this process.

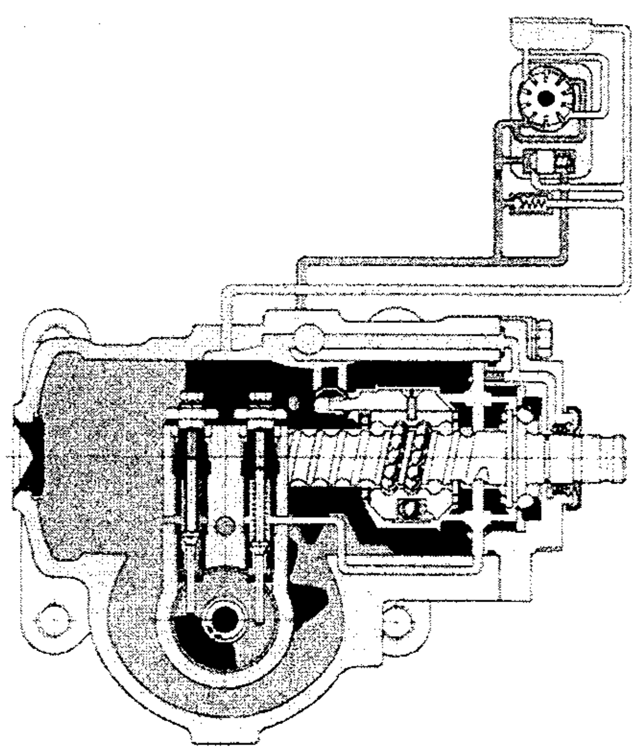
When the sector shaft is turned in an anticlockwise direction, the right valve opens according to a predetermined path, so that the pressure oil can flow from the right cylinder to the return.

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.

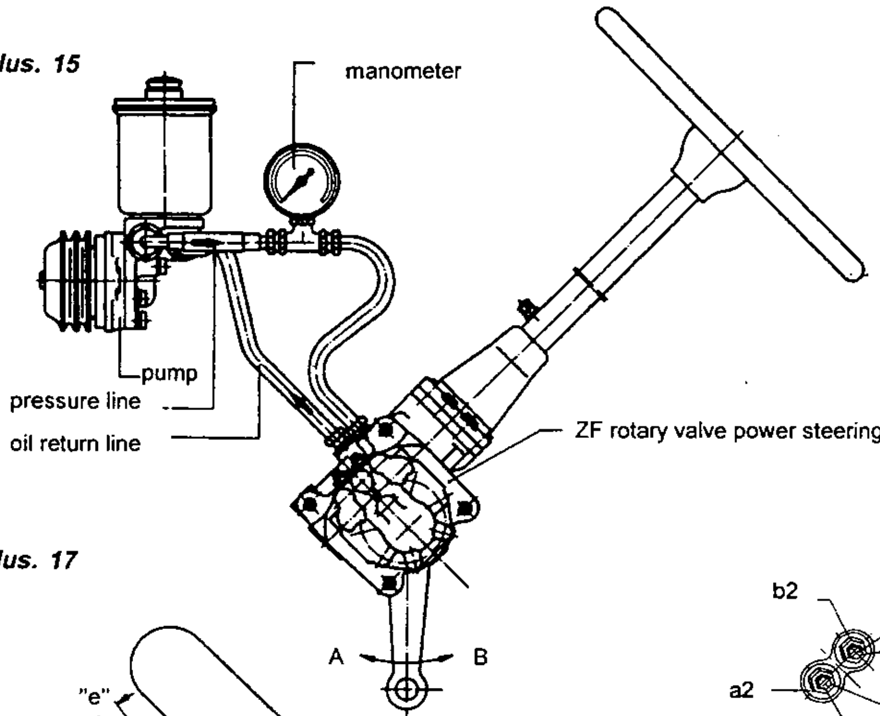
Tightening torque for lock nut: 25 to 35 Nm.

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".

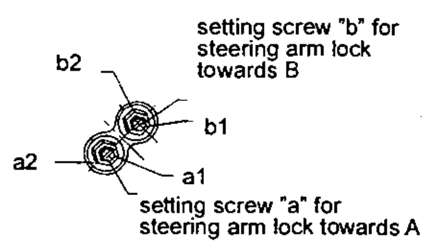
The vehicle manufacturer may prescribe a mode of setting that differs from the abovedescribed (e. g. insertion of a spacer), ***see Illus. 26***.

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.

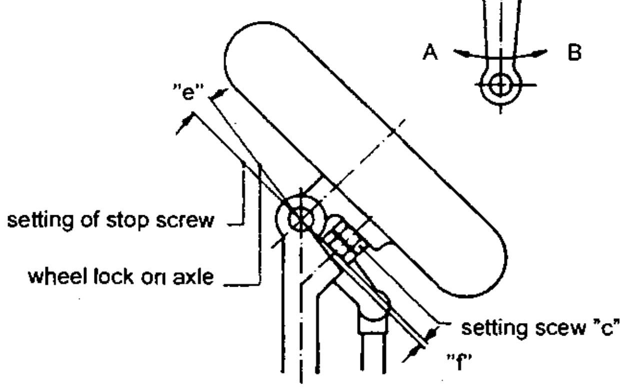
Illus. 15



Illus. 16



Illus. 17



Illus. 17 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.

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 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.

If a pressure greater than 35 bar is measured, the corresponding steering limiter valve (55) must be **screwed** further **into** the cover (clockwise).

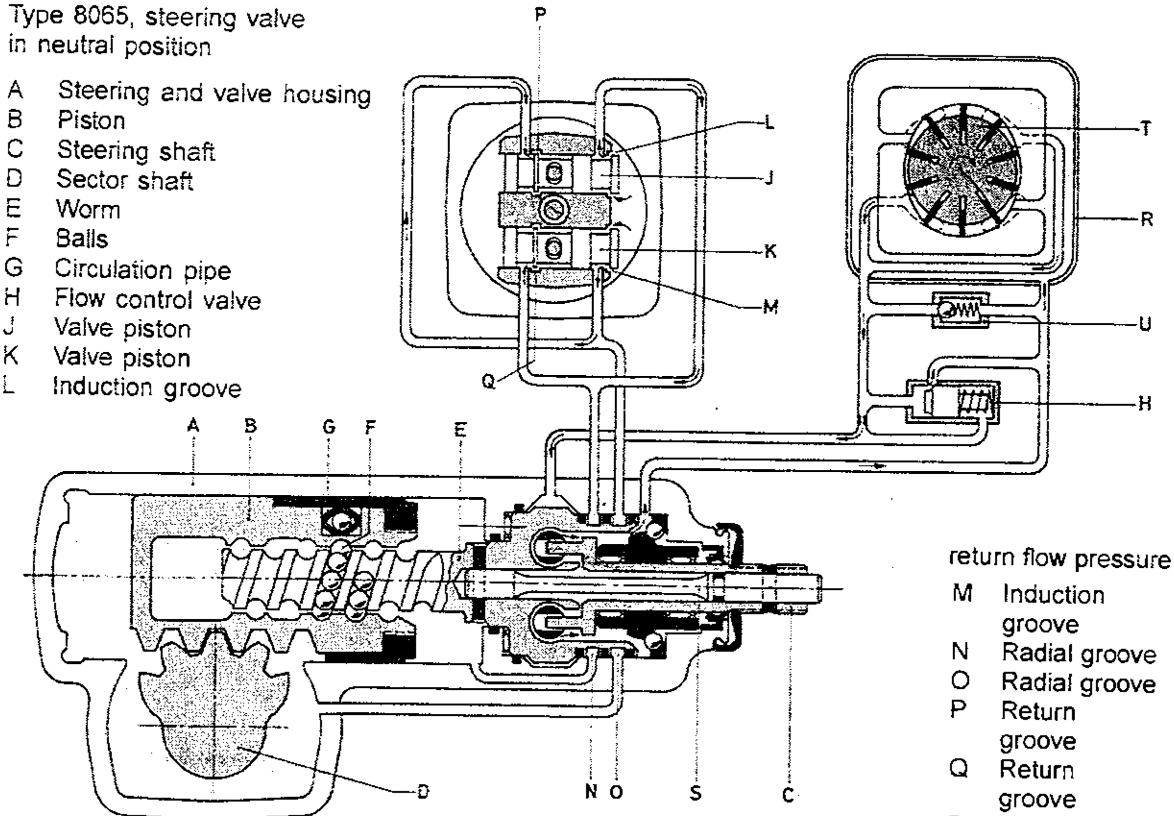
If a pressure lower than 30 bar is measured, the corresponding steering limiter valve (55) must be **screwed** further **out** (anticlockwise).

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



return flow pressure
M Induction groove
N Radial groove
O Radial groove
P Return groove
Q Return groove
R Oil tank
S Torsion bar
T Pressure oil pump
U Pressure relief valve

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.

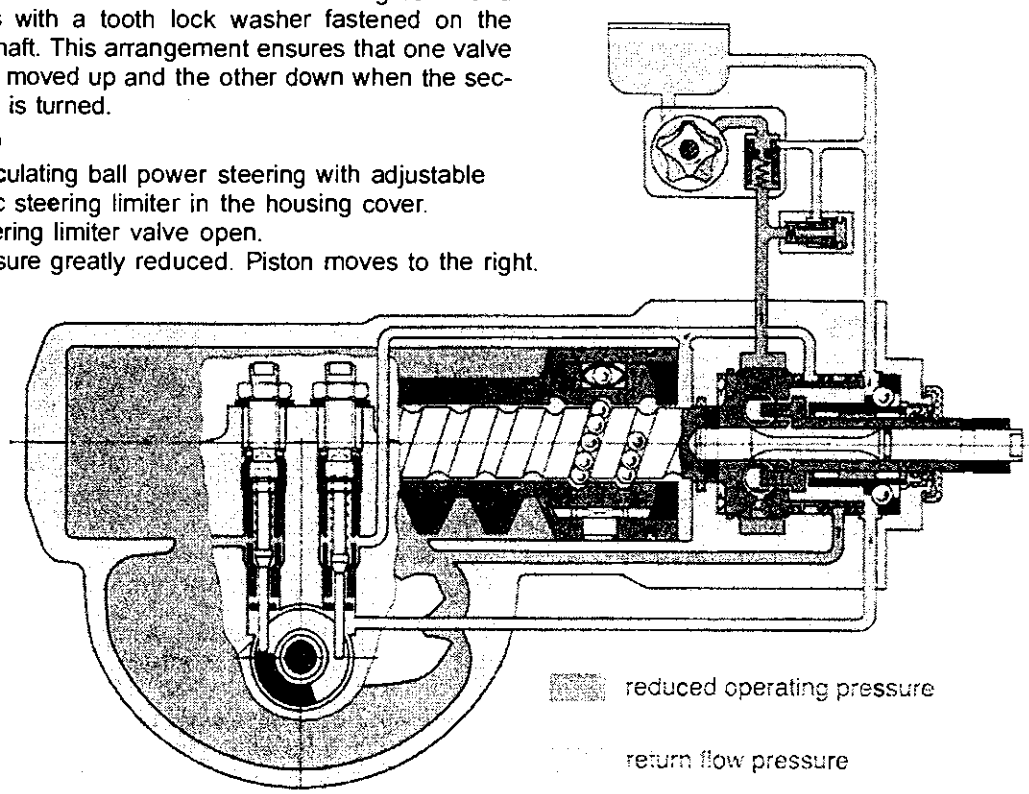
The pressure oil flows through the induction groove (L) of the upper valve piston to the left radial groove (N) and from there into the right cylinder, so that the piston movement is hydraulically assisted. However, at the same time the pressure oil reaches the return groove (Q) of the lower valve piston, 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)***.

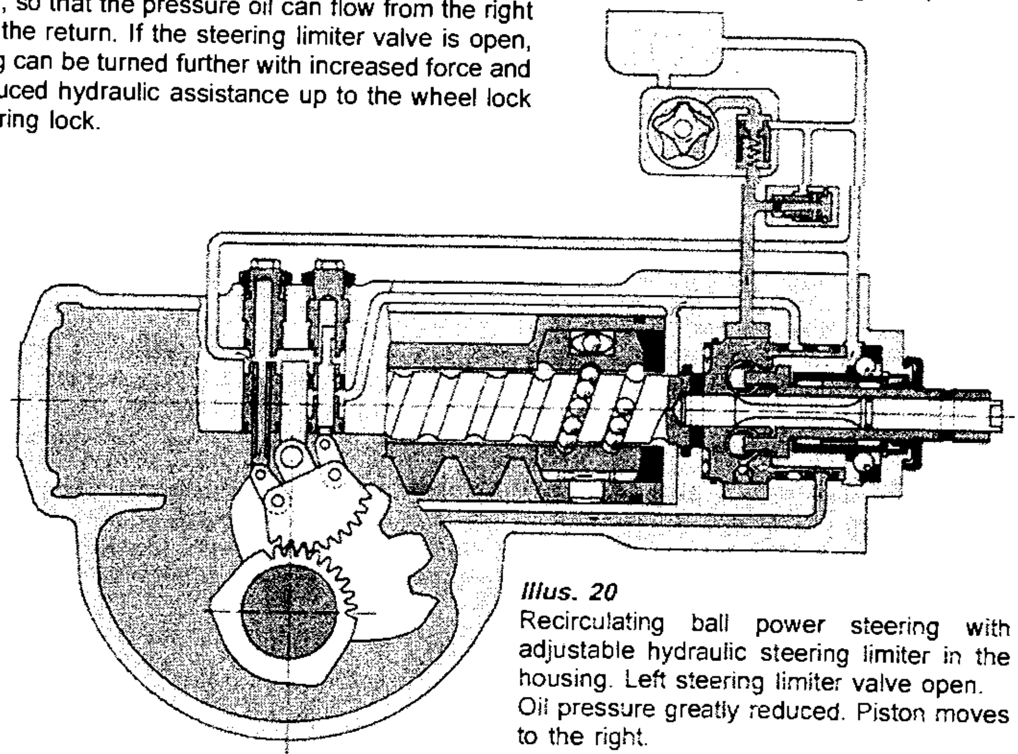
The valves are connected to the return by holes. The pressure oil of the left cylinder flows through a hole in the housing cover to the left valve, while the pressure oil of the right cylinder reaches the right valve through a hole in the housing.
If the steering limiter valves are located in the housing – ***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 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 dismounted 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)

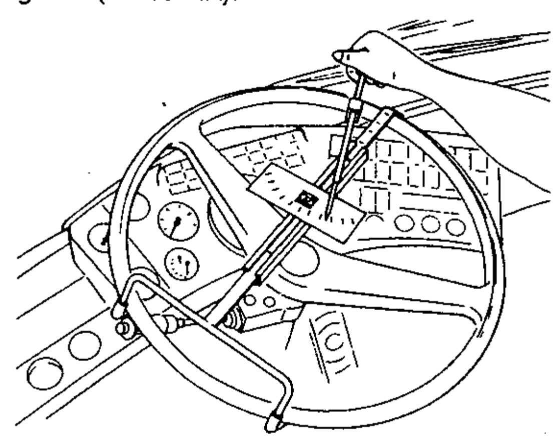
   a) Jack up steering axle.

   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).



Illus. 21

   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.

   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 valve 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.

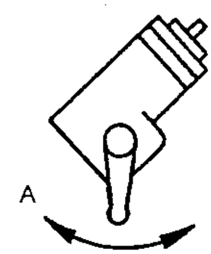
Grades of oil used: Spectron FO 20 from DEA or equivalent calcium complex grease of consistency class 2.

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).

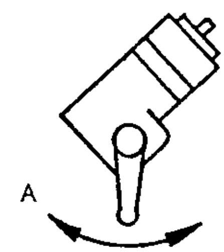
1.2 Apply grease to shaft seal (see note) and fit protecting cap (70). Protecting caps of new design on the housing must be pretensioned. Push universal joint on serration in such a way that the slot of the lower yoke aligns with the marking on the steering arm.

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

a) 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).

b) Disconnect pressure and return line from steering system.

c) Unscrew fastening screws (95 and 134). Remove valve housing. Press out shaft seal (131) from outside in.

d) 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).

e) 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

f) 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.

g) 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) Plush 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).

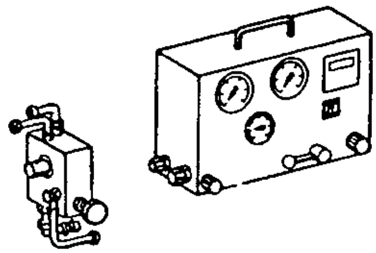
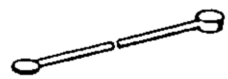
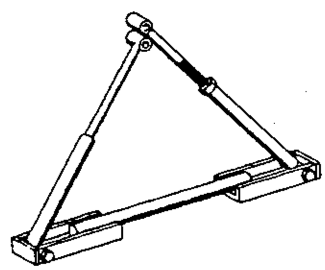
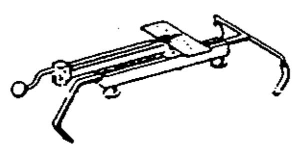
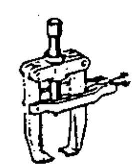
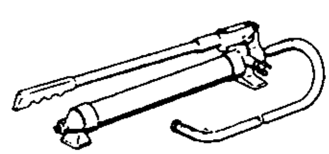
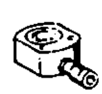
b) Insert valve core (32) into housing hole. Screw in screw (30) with fitted and greased o–ring (21).

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 number
Tool [1] a) Servotest 550 hydraulic steering tester b) Sep. flow control valve 2 dm^3/min - Servocom only		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		418 798 214
for steering shaft diameters from 55 mm, useful width 102 mm		7418 798 213
for steering shaft diameters from 55 mm, useful width 120 mm		7418 798 216

b) Tools for repair, type 8033–46

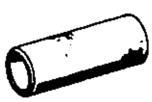
Tool [8]
Inserting sleeve or mandrel for shaft seal (129) – steering arm
a) for version with intermediate cover (122)

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

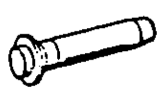
Tool [11]
Guide sleeve or inserting sleeve for shaft seal (6) in housing neck



	8033	8036	8037	8038	8042	8043 8044	8045	8046
Tool [8] a)		8052 798 056		7418 798 051			7418 798 051	
Tool [8] b)	8033 798 001		8037 798 002	7404 798 001				
Tool [9]	7832 798 001	8052 798 003	7359 798 001	7418 798 006				
Tool [10]		7409 798 001		7425 798 002	8065 798 001		7438 798 002	
Tool [11]		7419 798 003		7425 798 002	8065 798 002		7438 798 003	

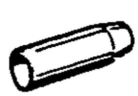
c) Tools for repair, type 8056–70

Tool [12]
Mandrel for shaft seal (131) in valve housing

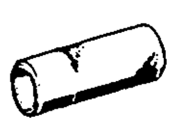


Tool [13]
Guide sleeve for protecting shaft seal (131) on lower steering arm

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
Tool [12]	8052 798 051		7418 798 051			
Tool [13]	8052 798 003		7418 798 006			
Tool [14]	8056 798 001	7409 798 001	7425 798 002	8065 798 001		7438 798 002
Tool [15]	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 dismounted (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

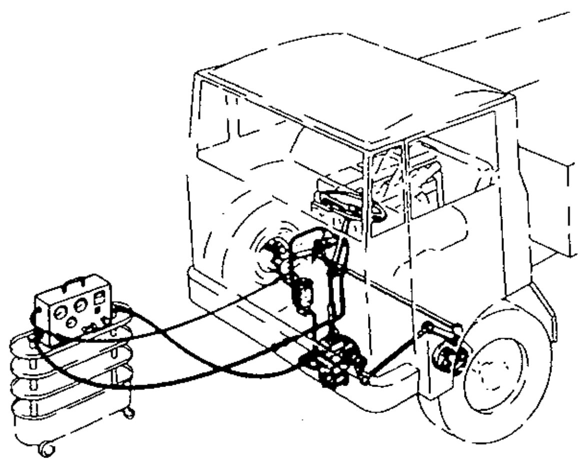
Check tension of V–belts using the usual thumb tests (adhere to instructions of vehicle manufacturer). The V–belts must not overrun even under maximum pressure. Replace defective V–belts.

4. Fitting hydraulic steering tester

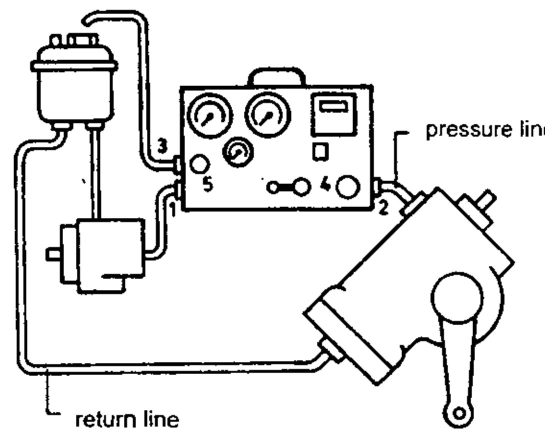
Fit Servotest 550 hydraulic steering tester in the pressure line between oil pump and ZF power steering (see ***Illus. 24*** and ***25***) in such a way that the display instruments can be easily observed from the driver's seat. Connect pressure line from pump with connection "input 1" of tester and 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 ± 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

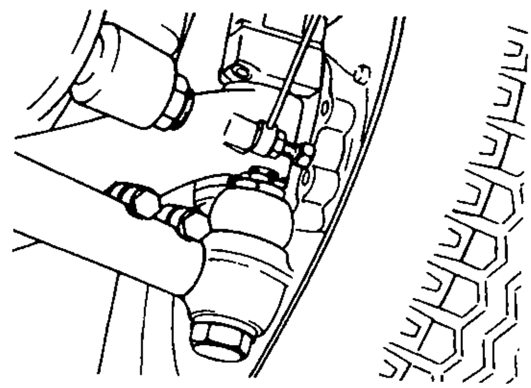
Carry out check as described under a), but with no spacers inserted. If there is no space on the wheel lock parts or the oil pressure does not fall to the value given in Section II Para. 2, fit new sliding valve assemblies (20 or 128) and reset steering limiter according to Section II Para. 1.5.

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 dm^3/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.

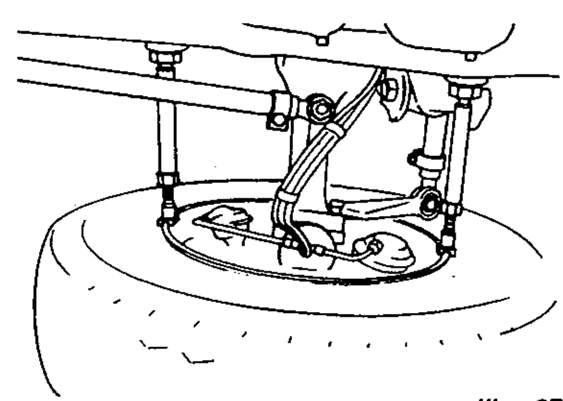
c) Seals in steering are defective – dismantle steering and have repaired by ZF service agency.

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)***.

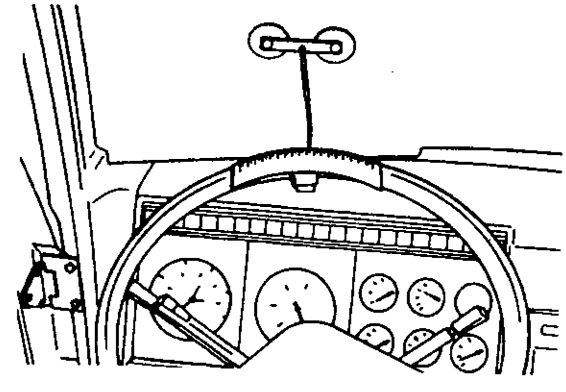


Illus.27

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



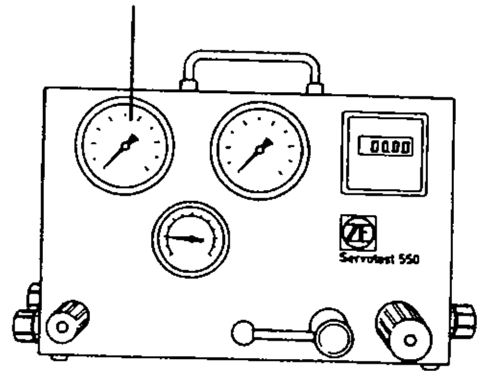
Illus.28

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.

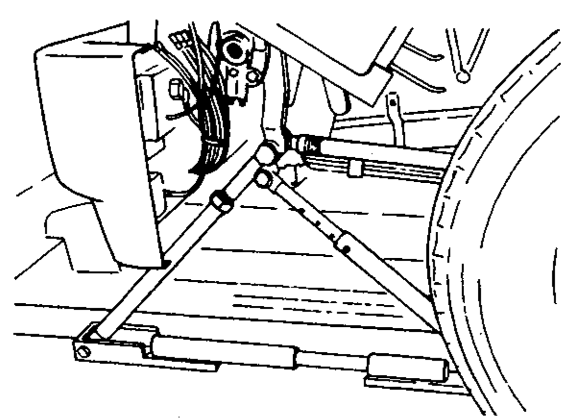
flow pressure + 1 bar



Illus.29

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.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 dismounting 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 tum 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:

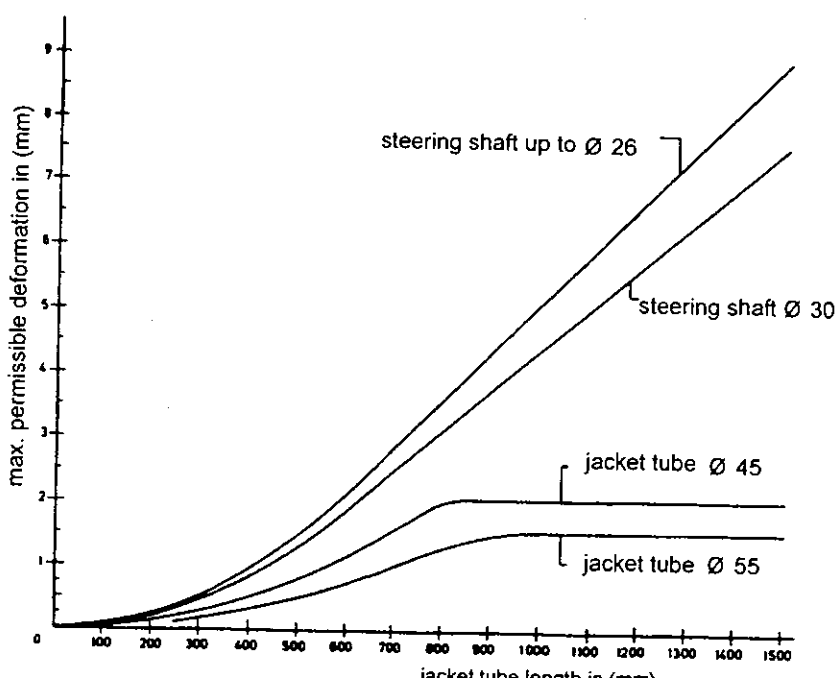
3.1 Check freedom of the steering gear or separately installed angle gear in the assembly with bearing block, steering arm and eccentric rod(s).

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***

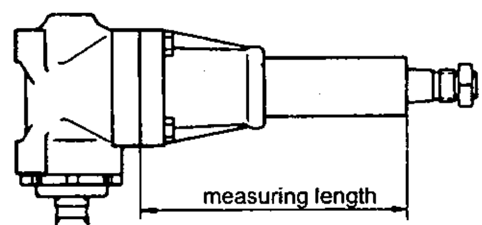
3.3 **Checking the permissible deformation of the jacket tube**

To do this, the steering shaft must be marked on one point on the periphery. Then tum 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)***.



measuring length = jacket tube length ***Illus. 32***

4. Tum 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 dismounting 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.

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 dismounted – 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.

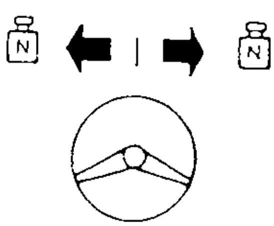
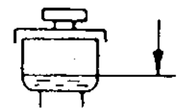
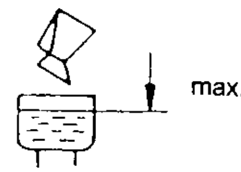
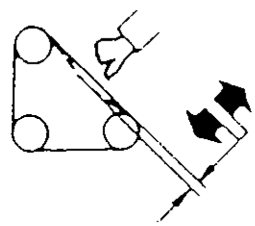
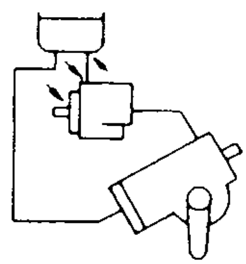
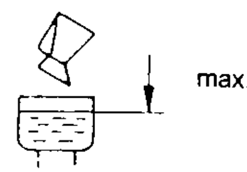
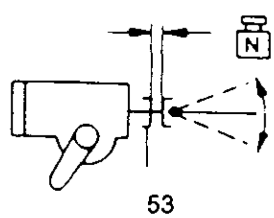
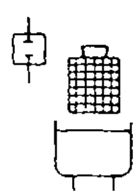
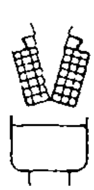
XI. Troubleshooting

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.

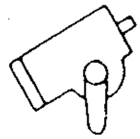
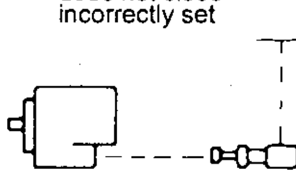
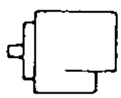
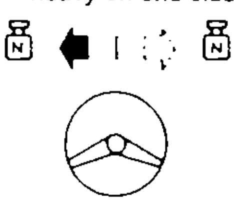
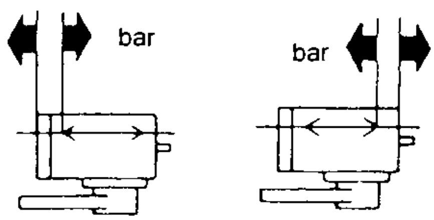
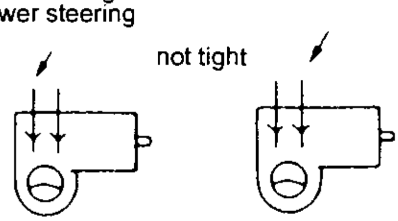
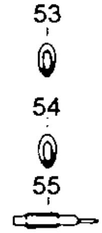
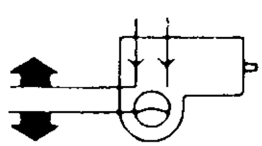
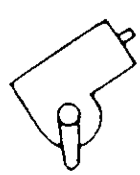
However, if this should not be the case, the following information should help locate and eliminate any problems.

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.

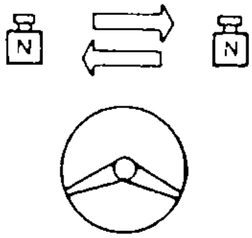
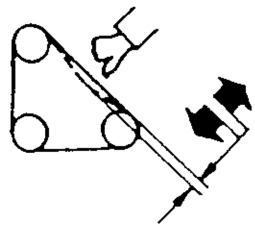
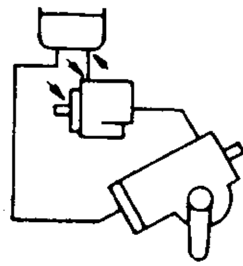
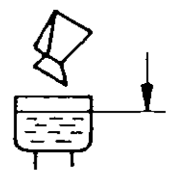
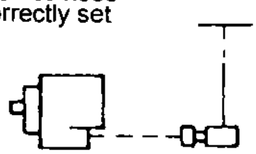
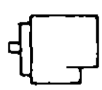
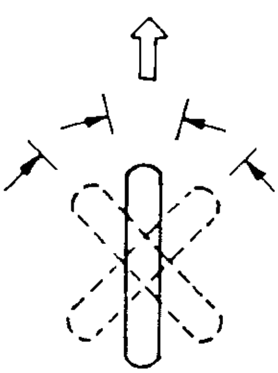
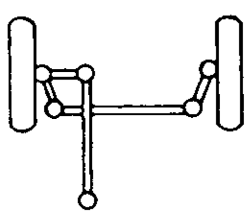
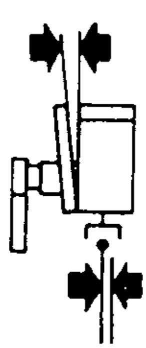
We must also point out that the use of very frothy oils can lead to faults, since such oils can only release air with difficulty, or not at all, once it has penetrated the steering system.

Fault	Cause	Remedy
heavy on both sides 		eliminate leakage 
		tension V–belt $\boxed{1}$
		replace seals $\boxed{1}$  ventilate
		grind off / replace $\boxed{1}$
	 contaminated/ broken	replace, clean control valve, suction line
		replace, clean control valve, suction line

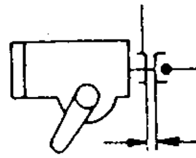
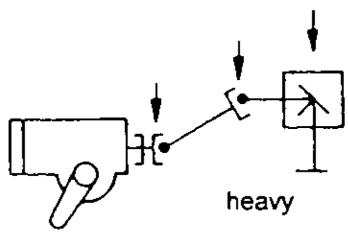
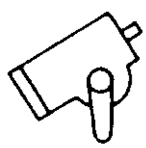
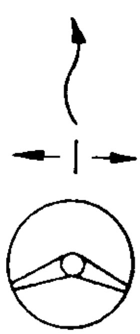
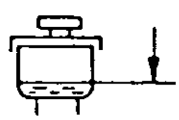
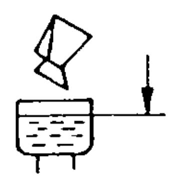
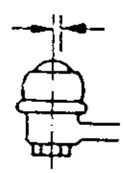
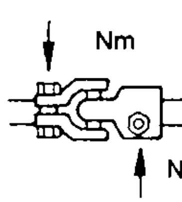
$\boxed{1}$ refer to instruction of vehicle manufacturer

Fault	Cause	Remedy
	 internal fault	exchange steering [1]
	does not close – incorrectly set 	clean replace
	 internal fault	exchange pump [1]
heavy on one side 	Servocom 	set section II
	Recirculating ball power steering  	replace
	bar 	set section II
	internal fault 	exchange steering [1]

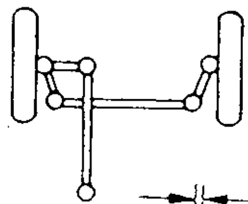
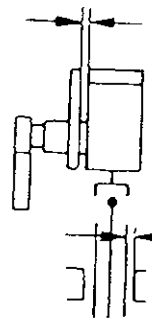
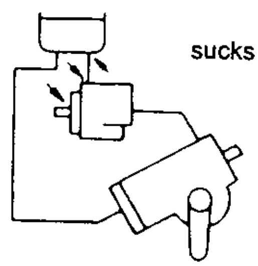
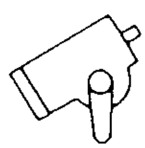
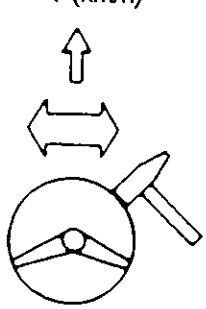
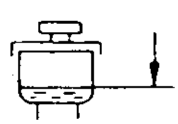
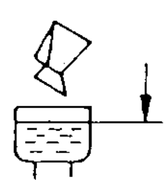
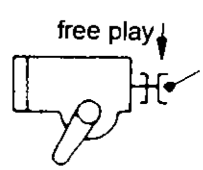
[1] refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
heavy on quick steering 		tension V–belt [1]
	sucks in air 	replace seal  ventilate
	does not close – incorrectly set  729	clean replace
	 internal fault	exchange pump [1]
inhibiting return V (km/h) 	 heavy	lubricate [1]
	distorted 	loosen bracing [1]

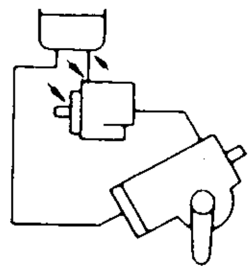
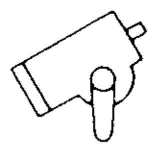
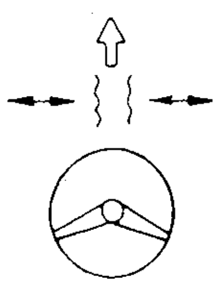
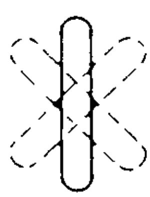
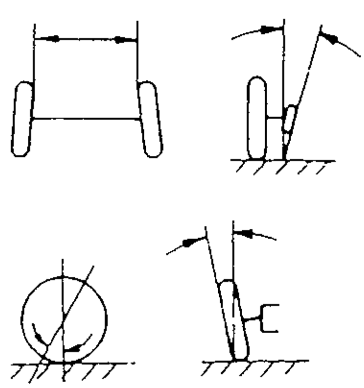
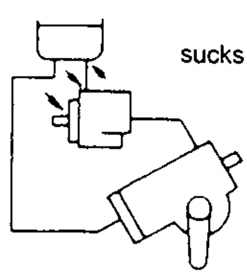
[1] refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
	53  sticks	grind off / replace $\boxed{1}$
	 heavy	lubricate / replace $\boxed{1}$
	 internal fault	exchange steering $\boxed{1}$
not exact V (km/h) 	 min.	eliminate leakage  max. ventilate
		tighten / exchange $\boxed{1}$
	 Nm	tighten / exchange $\boxed{1}$
	Nm  Nm	tighten / exchange $\boxed{1}$

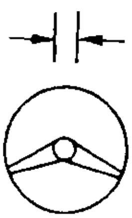
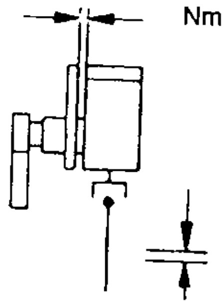
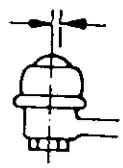
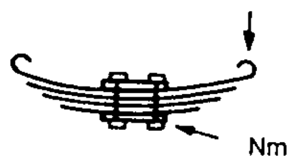
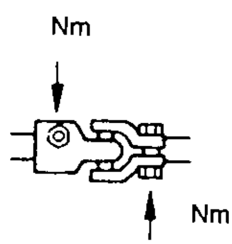
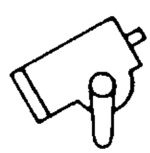
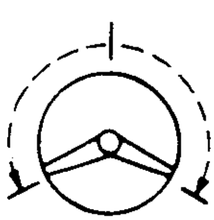
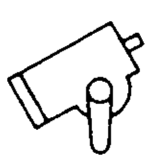
$\boxed{1}$ refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
	 heavy	lubricate $\boxed{1}$
		tighten $\boxed{1}$
	 sucks in air	replace seals ventilate
	 internal fault	exchange steering $\boxed{1}$
steering wheel locks V (km/h) 	 min	eliminate leakage 
	 free play	replace $\boxed{1}$

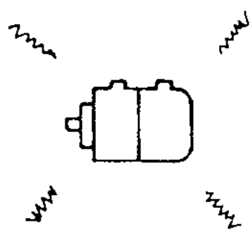
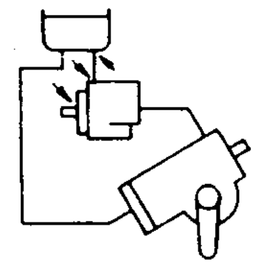
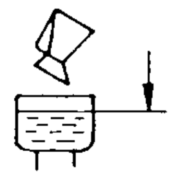
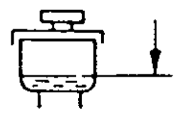
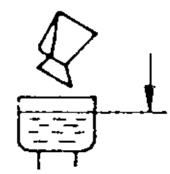
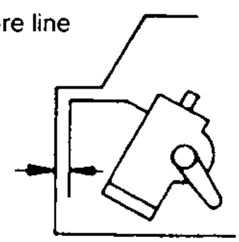
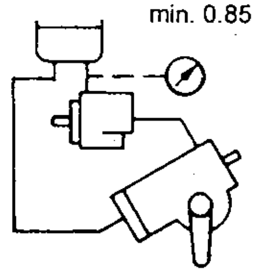
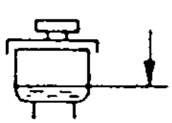
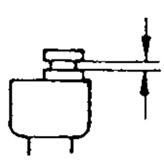
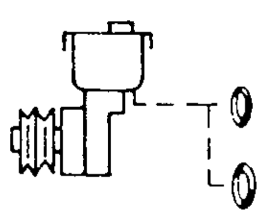
$\boxed{1}$ refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
	 sucks in air	replace seals ventilate
	 internal fault	exchange steering [1]
torsional vibrations V (km/h) 	 imbalance	balance [1]
		set [1]
	 sucks in air	replace seals ventilate

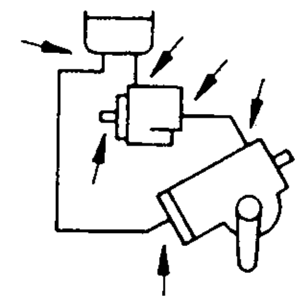
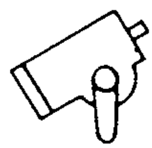
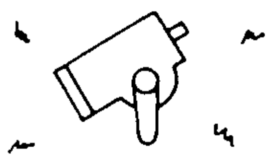
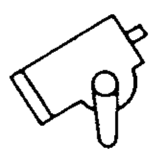
[1] refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
play in steering wheel 	   	tighten / replace $\boxed{1}$
	 internal fault	exchange steering $\boxed{1}$
runs out 	 internal fault	exchange steering $\boxed{1}$

$\boxed{1}$ refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
noises 	sucks in air 	replace seals  max. ventilate
	 min.	eliminate leakage  max.
	pressure line 	rubber retainer [1]
	min. 0.85 bar 	ZF service agency
loss of oil  min.		close
	 616 617	replace

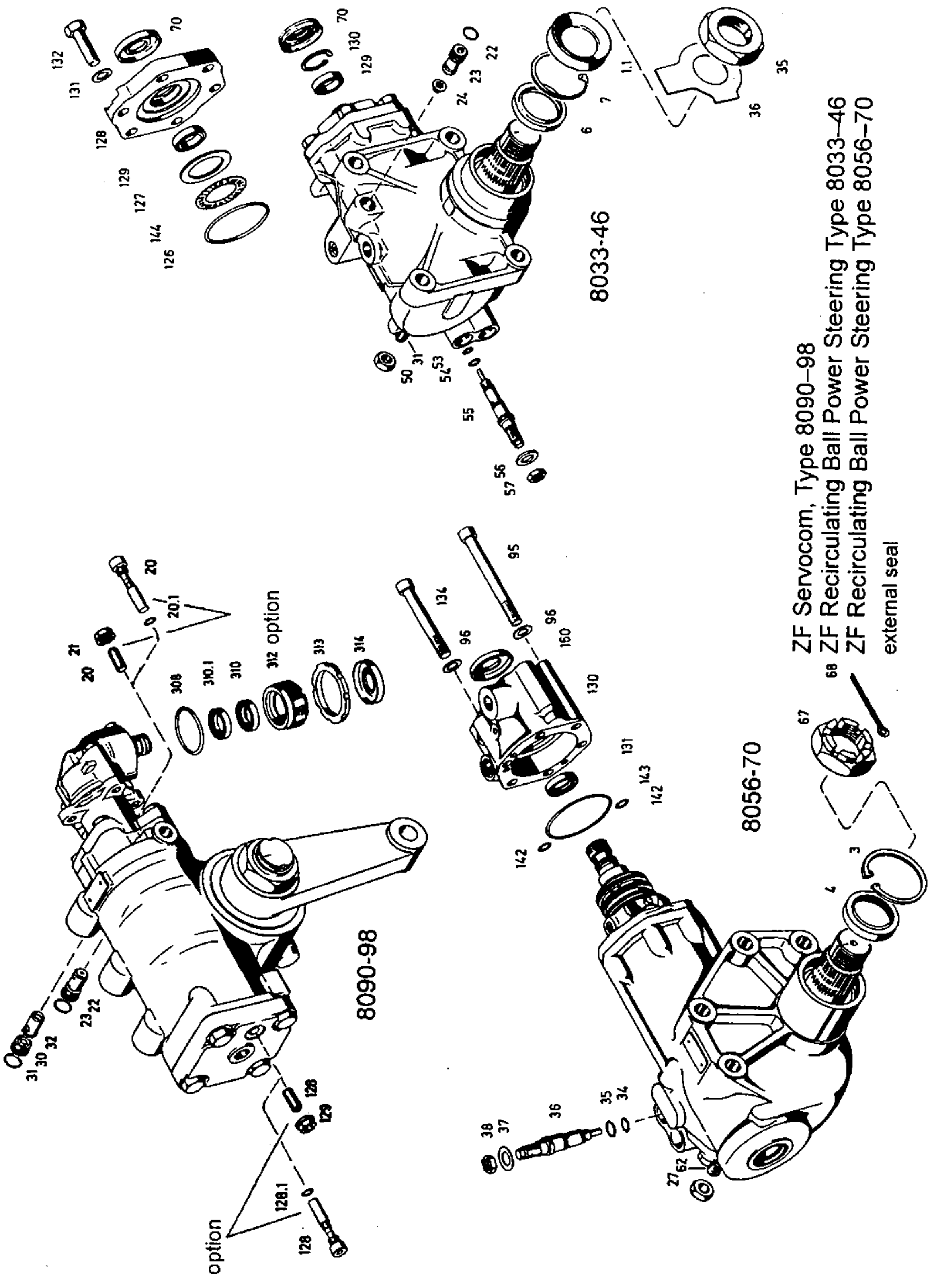
[1] refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
		replace seals tighten lines
	 internal fault	exchange steering [1]
noises 	 internal fault	exchange steering [1]

[1] refer to instructions of vehicle manufacturer

XII. Key to numbers in illustrations and exploded views

1.	Housing
1.1	Dust seal
3	Circlip / Locking ring
4	Shaft seal
6	Shaft seal
7	Circlip / Locking ring
20	Stud / screw
20.1	O–ring
21	Flanged nut / Collar nut
22	Pressure control valve
23	O–ring
24	Screen filter
27	Hexagon nut
30	Screw
31	O–ring / Adjusting screw
32	Feeder valve / Suction valve
34	O–ring
35	O–ring
36	Valve accessories
37	Washer / Disk
38	Hexagon nut
50	Grommet nut
51	Dust seal
53	O–ring
54	O–ring
55	Valve
56	Washer / Disk
57	Hexagon nut
62	Adjusting screw
70	Protective cap
95	Cheese head screw
96	Washer / Disk
122	Intermediate cover
126	O–ring
127	Bearing plate
128	Stud / Cover / Screw
128.1	O–ring
129	Flanged nut / Collar nut
130	Valve housing / Circlip / Locking ring
131	Washer / Shaft seal
132	Hexagon screw
134	Cheese head screw
142	O–ring
143	O–ring
144	Thrust needle cage / Axial needle cage
151	Valve body
152	Valve spring
153	O–ring
154	Setting plate / Adjusting plate
155	Valve guide
156	O–ring
157	Circlip / Locking ring
158	Plug screw
160	Protective cap
306	Bevel gear wheel
308	O–ring
310	External shaft seal
310.1	Internal shaft seal
312	Adjusting screw
313	Slotted nut / Grooved nut
314	Protective cap



ZF Servocom, Type 8090–98
ZF Recirculating Ball Power Steering Type 8033–46
ZF Recirculating Ball Power Steering Type 8056–70

CONTENTS

ILLUSTRATIONS

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, 3, 4 and 5). 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;

For a description of all these systems, refer to the appropriate heading in this section.

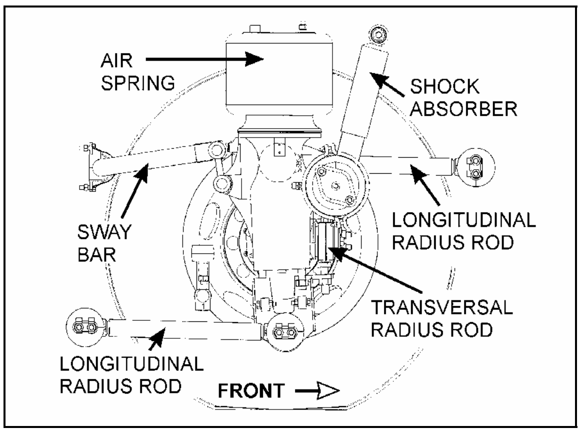


FIGURE 1: FRONT SUSPENSION COMPONENTS 16096

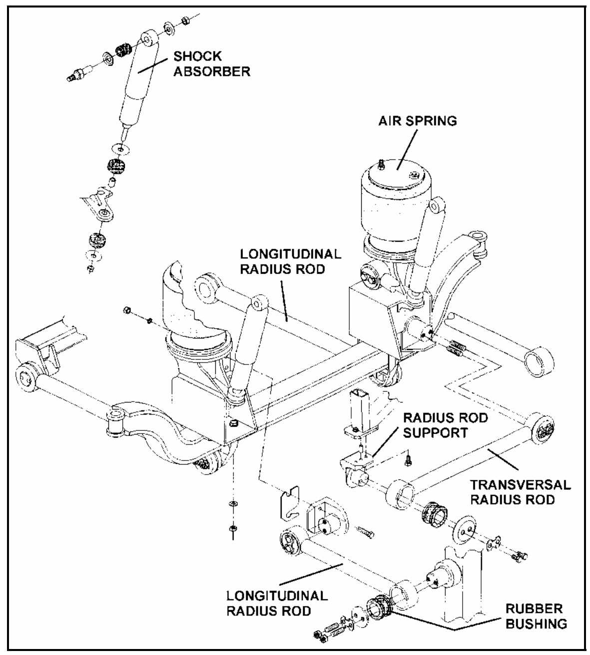


FIGURE 2: DETAILS OF FRONT SUSPENSION 16110

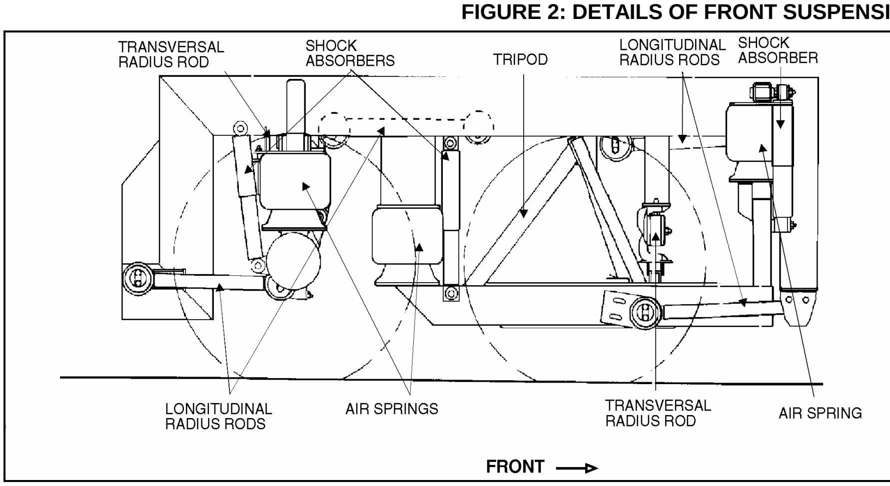


FIGURE 3: REAR SUSPENSION COMPONENTS 16027

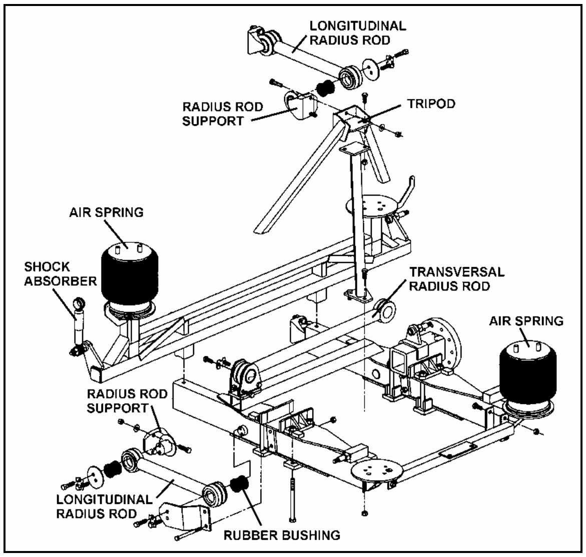


FIGURE 4: DETAILS OF REAR SUSPENSION 16106

2. 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 three axles is provided with air springs that are attached to the subframe and to the axles (Fig. 6).

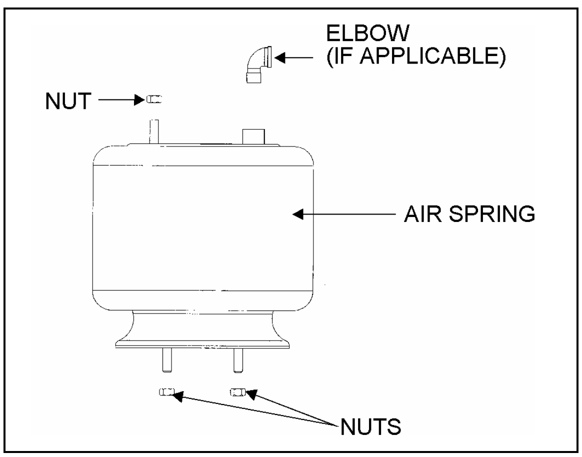


FIGURE 6: AIR SPRING 16052

2.1 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.

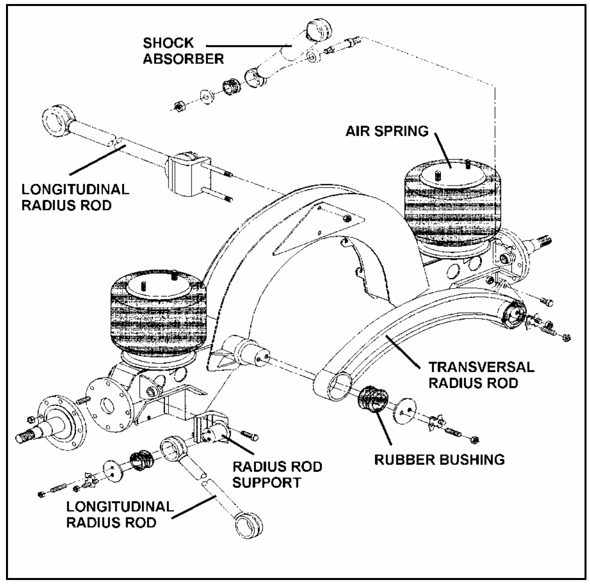


FIGURE 5: TAG AXLE SUSPENSION 16107

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.

2.2 REMOVAL

NOTE
Suspension air springs (front, 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.

2.3 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.

3. 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 and tag axles are each provided with two shock absorbers while the drive axle is provided with four of them (Fig. 1, 2, 3, 4 and 5).

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.

3.1 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.

3.2 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 7 for details.
2. Remove the shock absorber assembly from pins.
3. Remove the two inner bushings from the shock absorber and discard them.

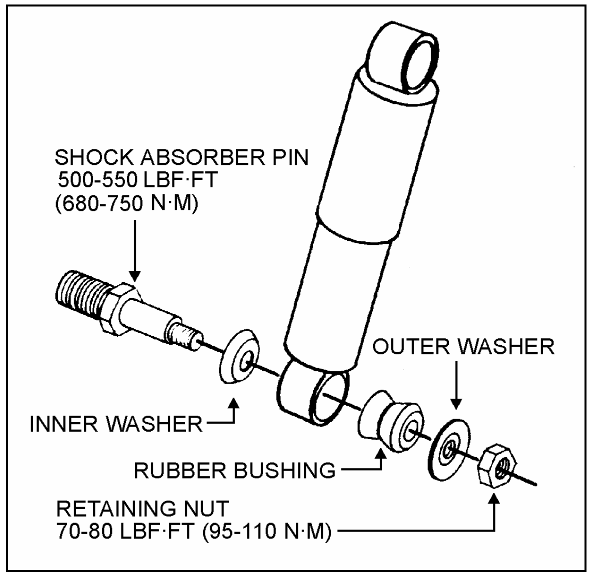


FIGURE 7: SHOCK ABSORBER 16008

3.3 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. 8).
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).

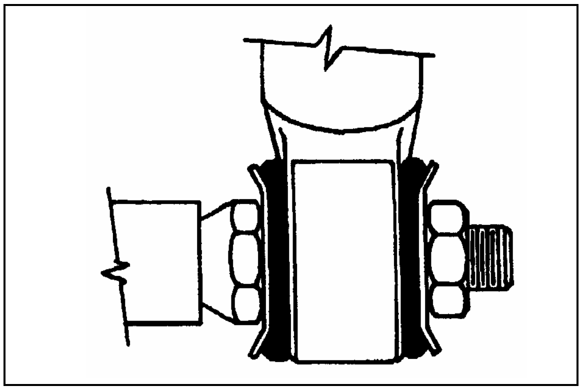


FIGURE 8: TYPICAL SHOCK ABSORBER SETUP 16009

5. Place the lower and upper mounting pin stud nuts and torque to 70 - 80 lbf-ft (95 – 110 Nm).

4. 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), four 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 1, 2, 3, 4 and 5 for details. These rods transmit both braking and driving forces from the axles to the vehicle body.

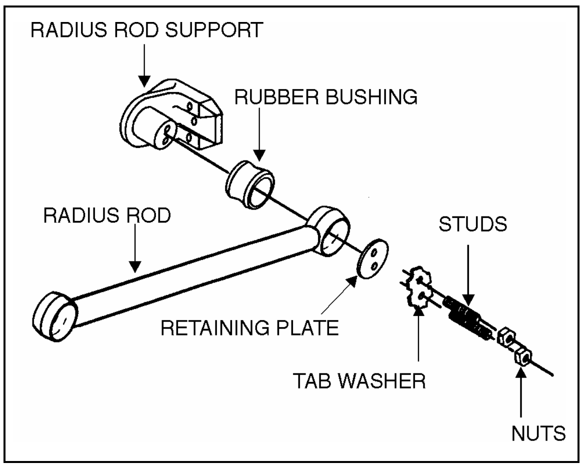


FIGURE 9: TYPICAL RADIUS ROD SETUP 16010

4.1 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.

4.2 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. 9).
2. Remove the tab washer and the retaining plates and radius rod ends from anchor pins, and then remove the radius rod.

4.3 BUSHING REMOVAL

1. Safely support the radius rod as shown in figure 10.

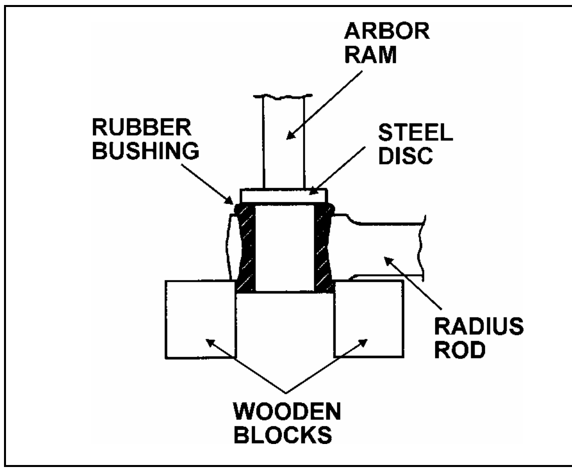


FIGURE 10: RADIUS ROD BUSHING REMOVAL 16011

2. Place a flat steel disc, slightly smaller than the outside diameter of the bushing (Fig. 10).
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.

4.4 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. 11).
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.

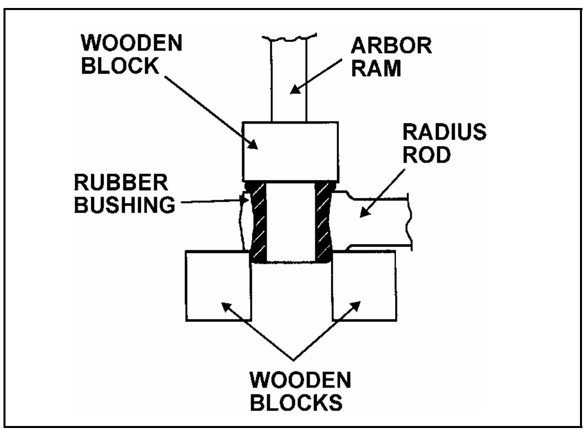


FIGURE 11: RADIUS ROD BUSHING INSTALLATION 16012

4.5 INSTALLATION

1. Lightly spray the radius rod support with water. Place the radius rod end over the radius rod support (Fig. 12).
2. Position the retaining plate. Install the tab washer and nuts (or bolts).

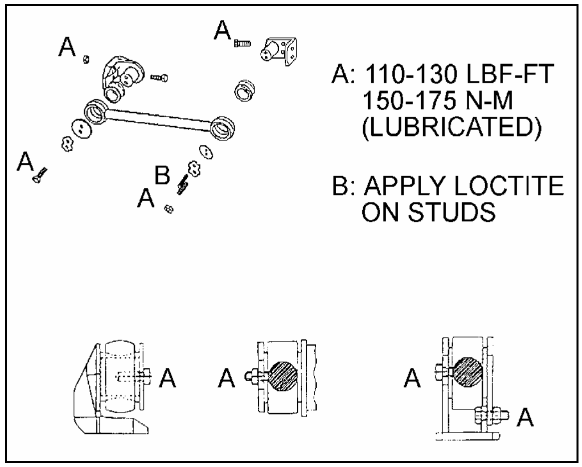


FIGURE 12: RADIUS ROD INSTALLATION 16028

⚠ 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. 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. 13). Vehicles equipped with an independent front suspension (IFS) are provided with two sway bars. Refer to supplement information on independent front suspension for more details.

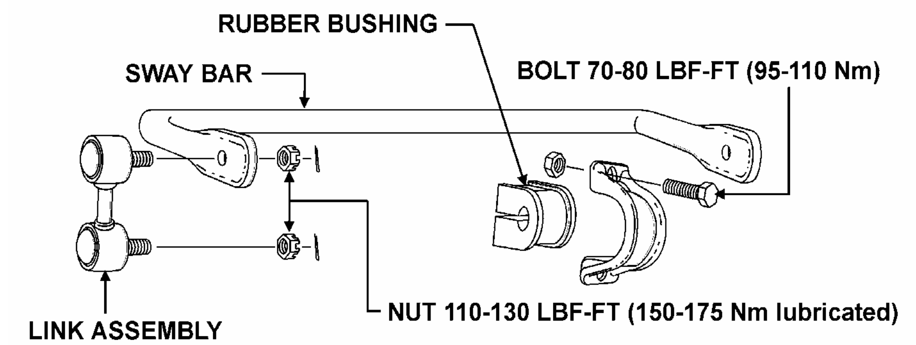


FIGURE 13: I-BEAM FRONT AXLE SWAY BAR 16099

5.1 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.

5.2 INSTALLATION

1. Loosely install the sway bar.
2. Tighten the eight bushing collar nuts to 70 - 80 lbf-ft (95 - 110 Nm) (Fig. 13).
3. Install two sway bar link upper and lower nuts and tighten to 100 - 130 lbf-ft (150 - 175 Nm) (Fig. 13).
4. Install a cotter pin on each nut and bend.

6. SUSPENSION AIR SYSTEM

The suspension air system has its own air reservoir (accessory tank) which is located behind the front axle. Pressurized air from the main tank (wet tank) flows through a pressure protection valve (PR-2), installed on the accessory air tank then flows to the accessory air tank.

The pressure protection valve (PR-2) controls the pressure at which compressed air is delivered to the accessory air tank. The valve remains closed until a preset pressure is reached (approximately 70 psi (485 kPa)). It then opens and passes air out the delivery port.

The main use for this valve is to protect the main air system by ensuring at all times a sufficient air pressure in the main system (i.e. air delivered to the accessories will be shut off in case of a decrease in pressure). Maintenance and repair information on the pressure protection valve is supplied in the applicable booklet, annexed to Section 12, *“Brakes and Air System”* under reference number SD-03-2010.

⚠ WARNING ⚠
Depressurize parts prior to removal.

6.1 INSPECTION

The following inspection should be performed at established service inspection periods. Performing these procedures will allow substandard performance to be discovered before the condition becomes bad enough to cause operator complaints and failure on a run.

1. Visually inspect the suspension air lines for evidence of chafing on metal parts or other damage.
2. Visually inspect the air springs for cracks, abrasion or other damage.

3. Replace any parts found to be damaged.

6.2 AIR LINE TEST

With the main air system at normal operating pressure [95 – 125 psi (655 – 860 kPa)], coat all suspension air line connections and air spring mountings with a solution of soap and water. Air leakage will produce soap bubbles. Any leak found must be corrected as no air leakage is permissible.

6.3 AIR TANK MAINTENANCE

Refer to Section 12, “Brakes and Air System” under “Maintenance” for complete instructions on air tank maintenance.

7. SUSPENSION HEIGHT ADJUSTMENT

The flow of pressurized air from the accessory air tank to the air springs is controlled by three height control valves. These valves are mounted to the subframe and connected to the axles through an arm and link connection. This connection allows 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 axle, and regulates air to front axle 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. Refer to figure 15.

The appropriate vehicle body height is obtained by measuring the clearance of all the air springs installed on the front and drive axles. The clearance should be 11 11/16” (297 mm) for the air springs installed on the front axle and 11 ½” ± ¼” (292 ± 6 mm) for those installed on the drive axle. Refer to figure 14 to identify the correct location where the measure has to be taken. 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 the height of vehicle and down to lower it. Check that main air pressure is at normal operating pressure and raise the vehicle to the specified height.

⚠ CAUTION ⚠
Because of the ‘’deadband’’, 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 through fill cycle.

To adjust suspension height, proceed as follows:

1. With the vehicle at normal operating air pressure, check the air spring clearance as illustrated in figure 14. This clearance should be 11 11/16” (297 mm) for the front axle air springs and 11 ½” ± ¼” (292 ± 6 mm) for those on the drive axle.

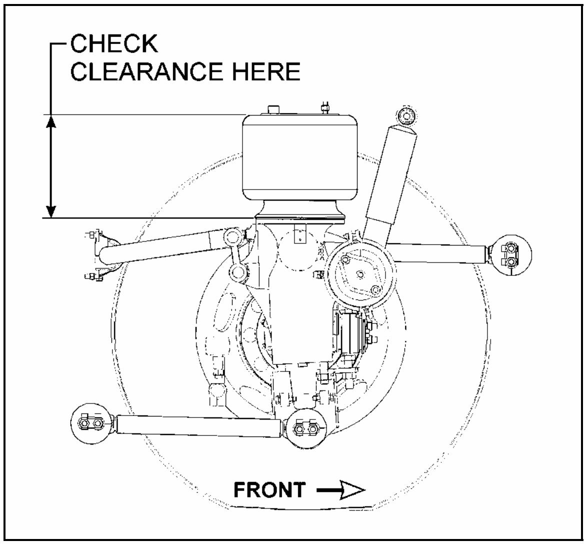


FIGURE 14: TYPICAL AIR SPRING CLEARANCE 16097

NOTE
The measure should be taken from under the upper air spring support on subframe to top of the lower air spring support on axle (refer to fig. 14 for more details). If adjustment is required, begin with the drive axle.

2. Loosen the adjusting nuts on the connecting rod of height control valve to raise or lower the overtravel lever until the desired clearance is reached.
3. If there is not enough play on adjusting nuts, it is possible to make further adjustments by loosening the clamp on the rubber coupling and bringing it up or down.

NOTE
Allow suspension to stabilize before taking reading.

4. When the desired height is obtained, tighten adjusting nuts and clamp.

8. HEIGHT CONTROL VALVES

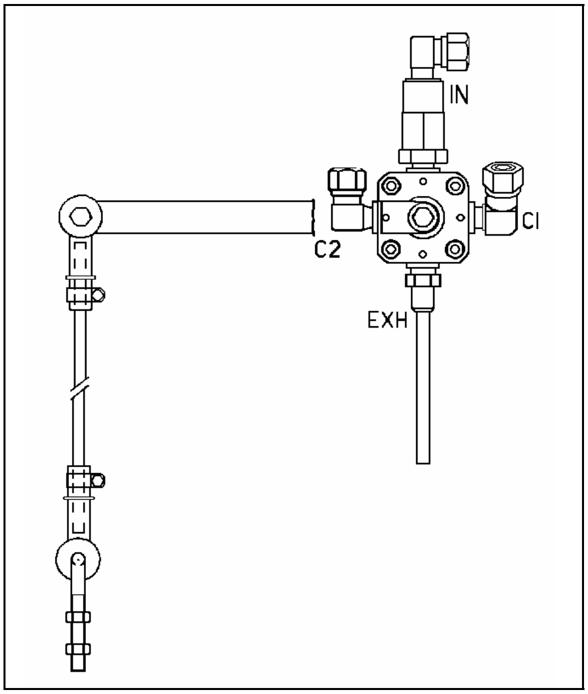


FIGURE 15: HEIGHT CONTROL VALVE 16093

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.

8.1 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 point.

8.1.1 Removal and installation

Before disconnecting any height control valve air lines, securely support the vehicle by its jacking points on the body, and place safety support underneath body. Refer to *"Vehicle Jacking Points"* in Section 18, *"Body"*.

1. Exhaust air from air system by opening the drain cock on accessory air reservoir.
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 ends of the lines with tape.
4. Remove the two 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.

8.1.2 Air leakage test

NOTE
The following procedure applies when valve assembly has been removed from vehicle.

1. Clean the exterior of valve assembly.
2. Connect air pressure line to air inlet port, then allow air pressure build-up (70- 100 psi (480 - 690 kPa)).
3. Dip the valve assembly in a container of water, and watch for air bubbles when the overtravel lever is in the center position. No air should escape from any point of the valve assembly.

4. If bubbles appear from the air spring port, this is an indication that the air inlet valve assembly is defective and must be replaced.
5. Remove air pressure line from air inlet fitting and connect it to the air spring port. If bubbles appear at the air inlet check valve port, this is an indication that the check valve unit is defective and must be replaced.
6. If bubbles appear at the exhaust port, this is an indication that the exhaust valve assembly is defective and must be replaced.
7. If bubbles appear around edge of valve cover plate, the cover plate gasket must be replaced.
8. If no leaks are found, remove valve assembly from water, then with air pressure still connected to the air spring port, actuate overtravel lever to remove any excess water which may have entered exhaust valve chamber. Remove air line, connect it to the air inlet port, and repeat operation to remove water from the air inlet valve chamber.

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).

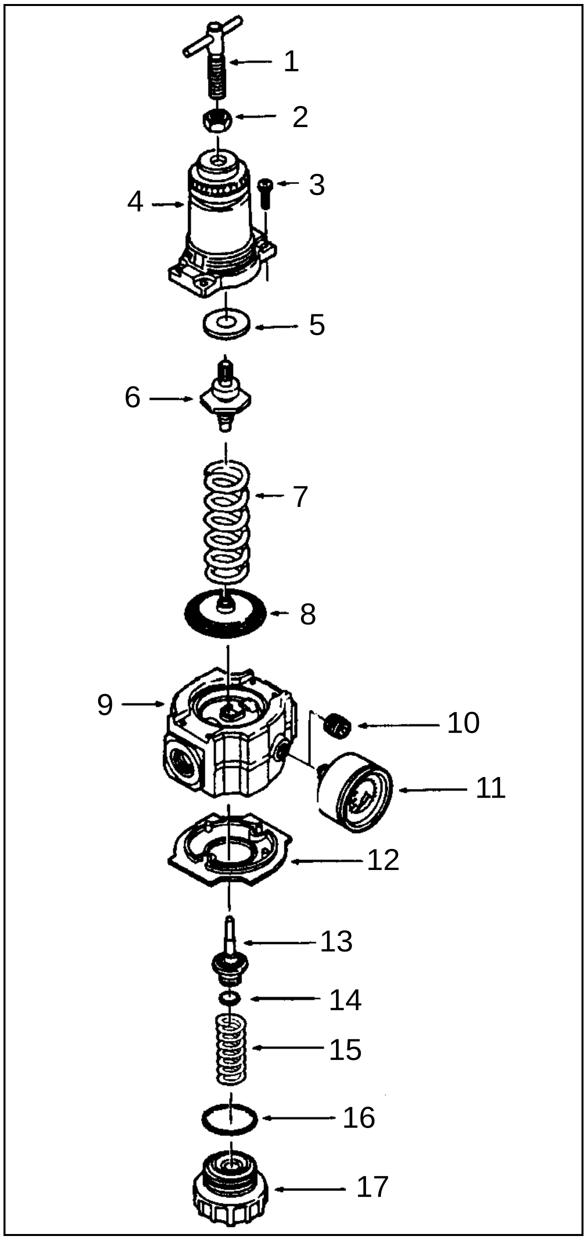


FIGURE 16: REGULATING VALVE 16035

10.3.1 Adjustment

1. Before turning on system air pressure, release jam nut (2, Fig. 16) 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. 16) 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. 16) 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.

10.3.4 Reassembly

1. Lubricate O-ring (14 and 16, Fig. 16), valve stem (13, Fig. 16), tip of adjusting screw (1, Fig. 16), and the outer circumference and both sides of the thrust washer (9, Fig. 16) with a light coat of good quality O-ring grease.
2. 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 XL2 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.

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.

12. TROUBLESHOOTING

Condition	Cause	Correction
Bellows deflate over time	1. Defective check valve assembly. 2. Defective exhaust valve assembly. 3. Leak in air line and/or bellows. 4. Defective valve cover, rubber O-rings or gasket.	1. Replace check valve assembly. 2. Replace exhaust valve assembly. 3. Replace air line or bellows. 4. Replace valve cover, O-rings or gasket.
Bellows raise to full height and fail to exhaust air pressure	1. A clogged exhaust screen in height control valve assembly. 2. A combination clogged exhaust screen and defective air inlet valve assembly.	1. Remove and clean screen. 2. Clean exhaust screen and replace air inlet valve assembly.
Erratic valve action	1. Dirt or foreign matter in the air valve lever chamber. 2. Defectives valves.	1. Remove valve cover and blow out dirt. Install cover using new gasket. 2. Overhaul height control valve assembly
Vehicle body fails to level to satisfactory ride height	1. Improper height control valve overtravel lever adjustment	1. Adjust lever as directed.

13. PARTS SPECIFICATIONS

Front 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

Front axle shock absorbers

Make ....Sachs

Color ....Black

Type N45X225HA

Ext. Diam. ....75 mm

Collapsed length .... 15.51” (394 mm)

Extended length....................... 24.37” (619 mm)

Supplier number 481700000207

Prévost number 630252

Drive and tag axle shock absorbers

Make ....Sachs

Color ....Black

Type N45X225HA

Ext. Diam. ....75 mm

Collapsed length .... 15.51” (394 mm)

Extended length....................... 24.37” (619 mm)

Supplier number 481700000209

Prévost number 630253

Height control valve (MTH, front only)

Make.. Barksdale

Quantity used 1

Supplier number...................52321POAQ3-Q62

Prévost number......................................630157

Height control valve (coach, all axles & MTH, 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 number....................................D0043B

Prévost number......................................641130

Coil

Voltage ....24 V DC

Current draw .... 29 amperes

Supplier number.................................. 54932-27

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 Axle)

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.

SECTION 16: MTH EQUIPPED WITH INDEPENDENT FRONT SUSPENSION (IFS)

CONTENTS

ILLUSTRATIONS

1. INTRODUCTION

This supplement contains service procedures and specifications that apply to the PREVOST converted coach shell vehicles equipped with an independent front suspension.

This text contains information unique to the independent suspension system. In the case you cannot find information on a subject in this supplement section, the information given in the regular sections of the Maintenance Manual will apply.

2. 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. The hydraulic power cylinder provides an added source of assistance and being connected to the R.H. wheel, makes it such that the total steering forces are produced with minimal stress on mechanical linkages (Fig. 1).

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 of supplement.

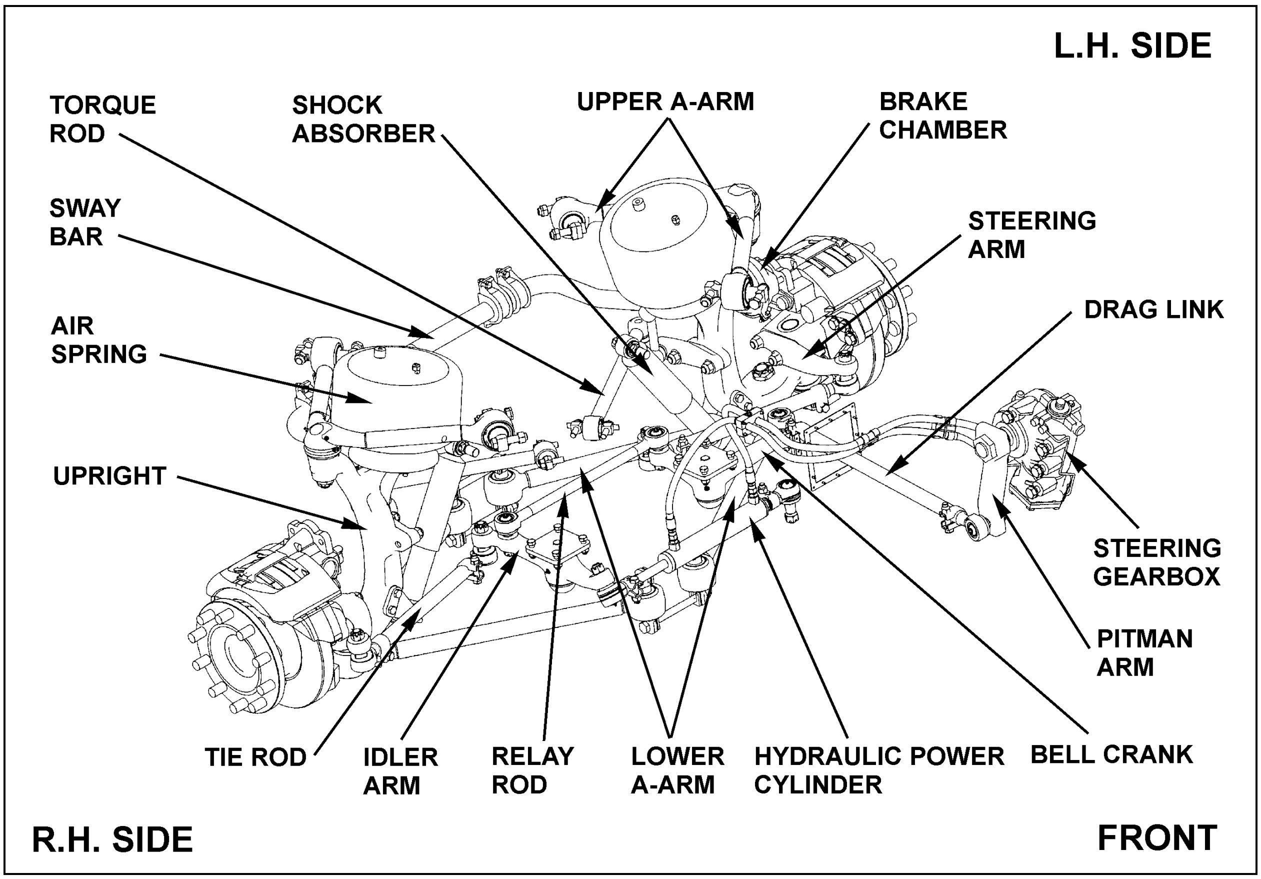


FIGURE 1: SUSPENSION AND STEERING LINKAGE 16124

Turning Angle

The maximum turning angle is set mechanically through the two steering stop screws installed on the swivel assembly. The turning angle (56° + 0° - 1°) 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 "4. 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 2 to 7 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 XL2 Maintenance Manual, Section 14, "Steering", under heading: "Setting and Functional Test".

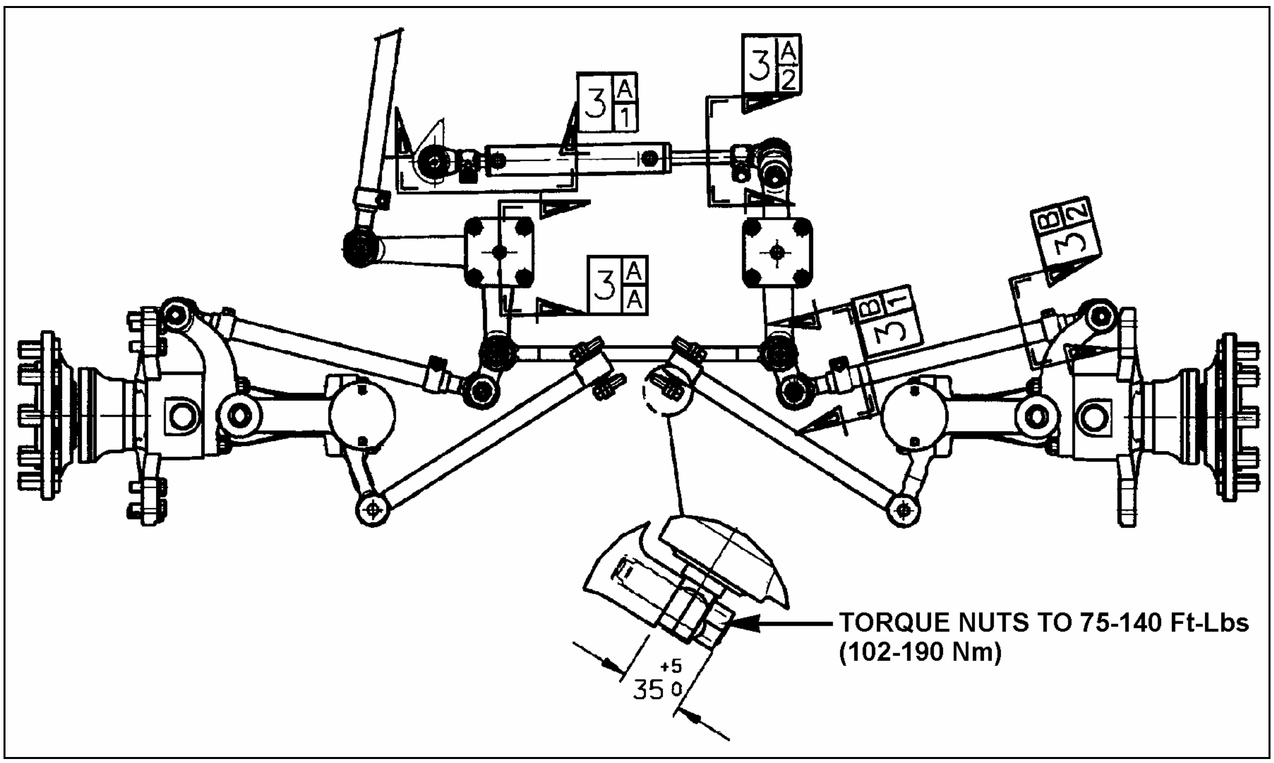


FIGURE 2: LOCATION OF CLAMPS 16126

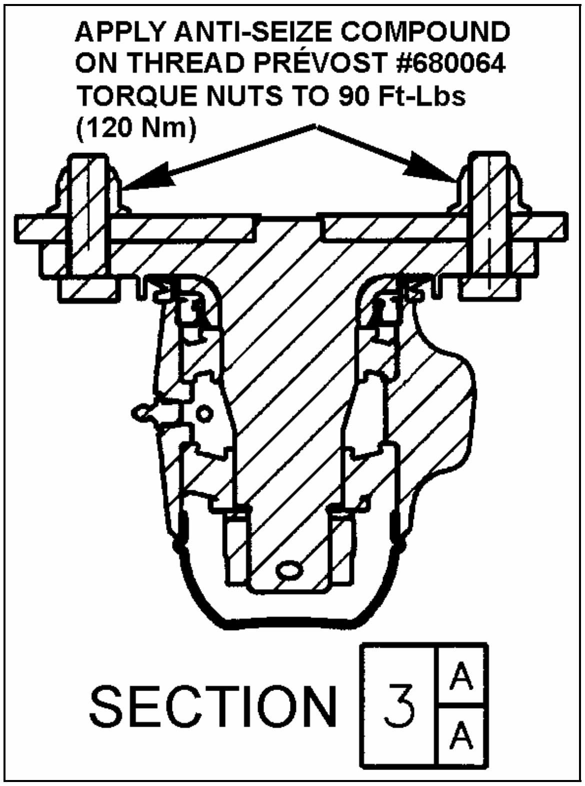


FIGURE 3: CLAMP POSITIONING 16128

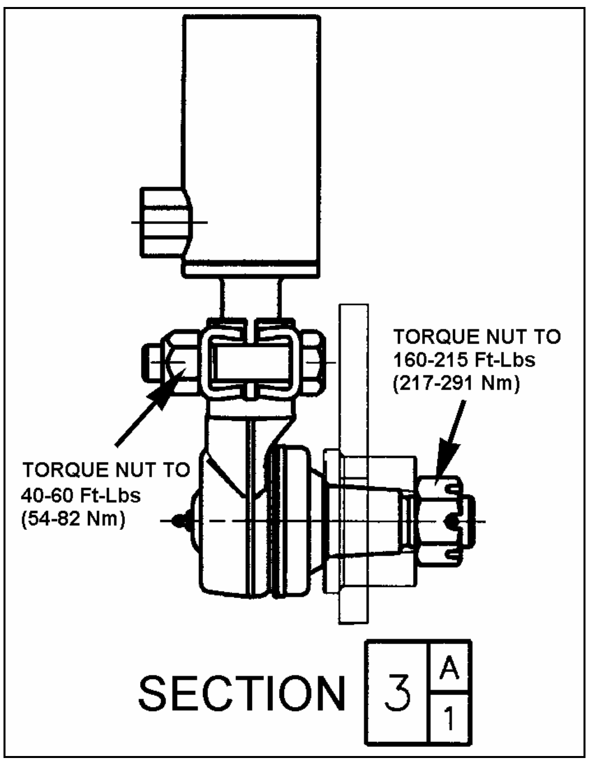


FIGURE 4: CLAMP POSITIONING 16121

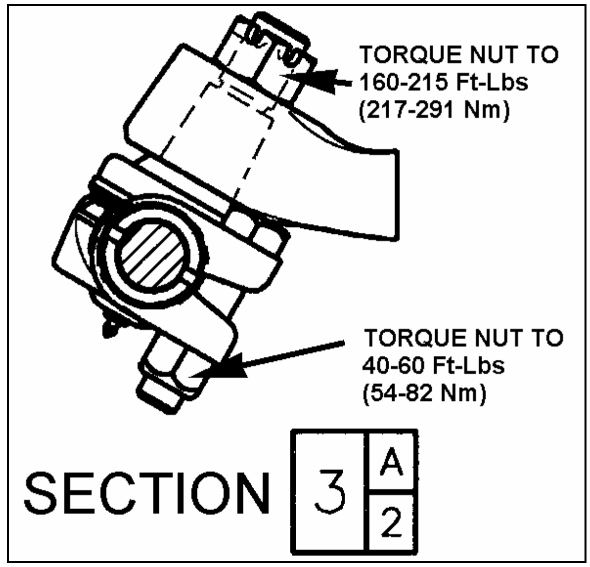


FIGURE 5: CLAMP POSITIONING 16122

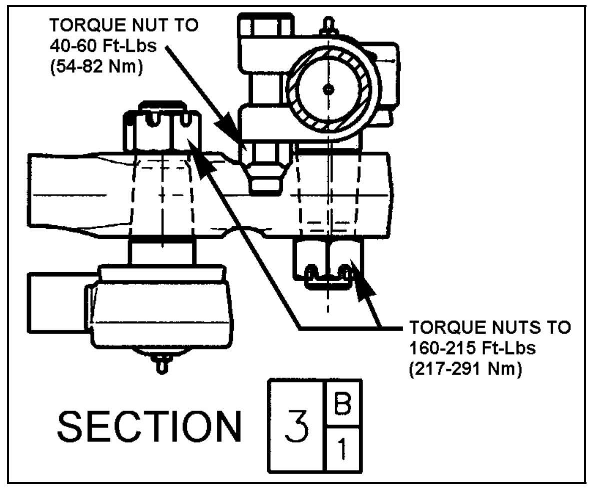


FIGURE 6: CLAMP POSITIONING 16120

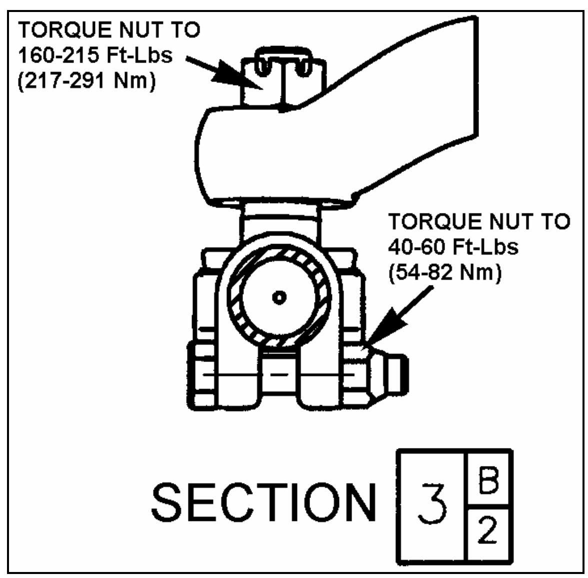


FIGURE 7: CLAMP POSITIONING 16123

2.1 POWER STEERING HYDRAULIC PUMP

Refer to the "TRW Power Steering Pump Service Manual" annexed at the end of Section 14

2.2 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 Supplement. Check to insure that all stud nuts and mounting bolts and nuts have been tightened to proper torques listed under "16. Torque Table" at the end of this supplement.

1. First, align the input shafts marks.
2. Afterwards, the pitman arm should be adjusted with reference marks aligned or to an angle of 90° in relation with the horizontal axis (Fig. 8).
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.
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 Supplement.

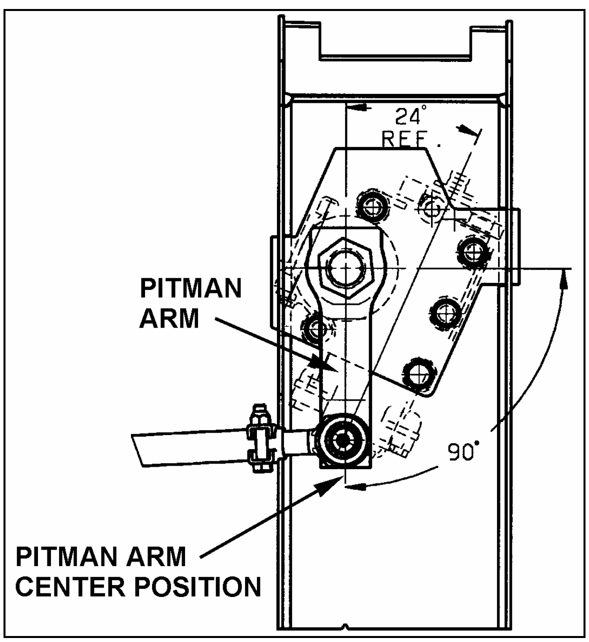


FIGURE 8: PITMAN ARM ALIGNMENT 14037

2.3 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.
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.

2.4 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 (545-612 Nm).

NOTE
Use a new nut if the previously removed nut was punched.

⚠ CAUTION ⚠
Lock nut with sector shaft using a punch mark into the groove (Refer to figure 9).

3. Connect drag link to pitman arm. Install washers. Tighten nut to 160-215 lbf-ft (218-292 Nm). Advance nut to next alignment cotter pin slot and install a new cotter pin.

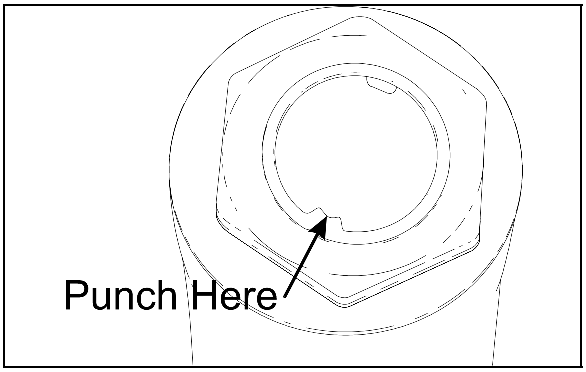


FIGURE 9: FIXING NUT PUNCH MARK 16098

2.5 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 supplement.

2.5.1 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 "2.1 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 (54-82 Nm), then test the adjustment. Front wheels should turn from right to left extremities without noticeable binding at drag link ends.

2.6 BELL CRANK AND IDLER ARM

Bell crank and idler arm are equipped with one lubrication fitting and should be lubricated as directed in paragraph "2.9 Lubrication Fittings" at the end of this Supplement.

2.6.1 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.

2.6.2 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. 10).
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. 10).

2.6.3 Bell Crank or Idler Arm Ball Joint Reassembly

NOTE
For bearing installation use tool Prévost # 110684.

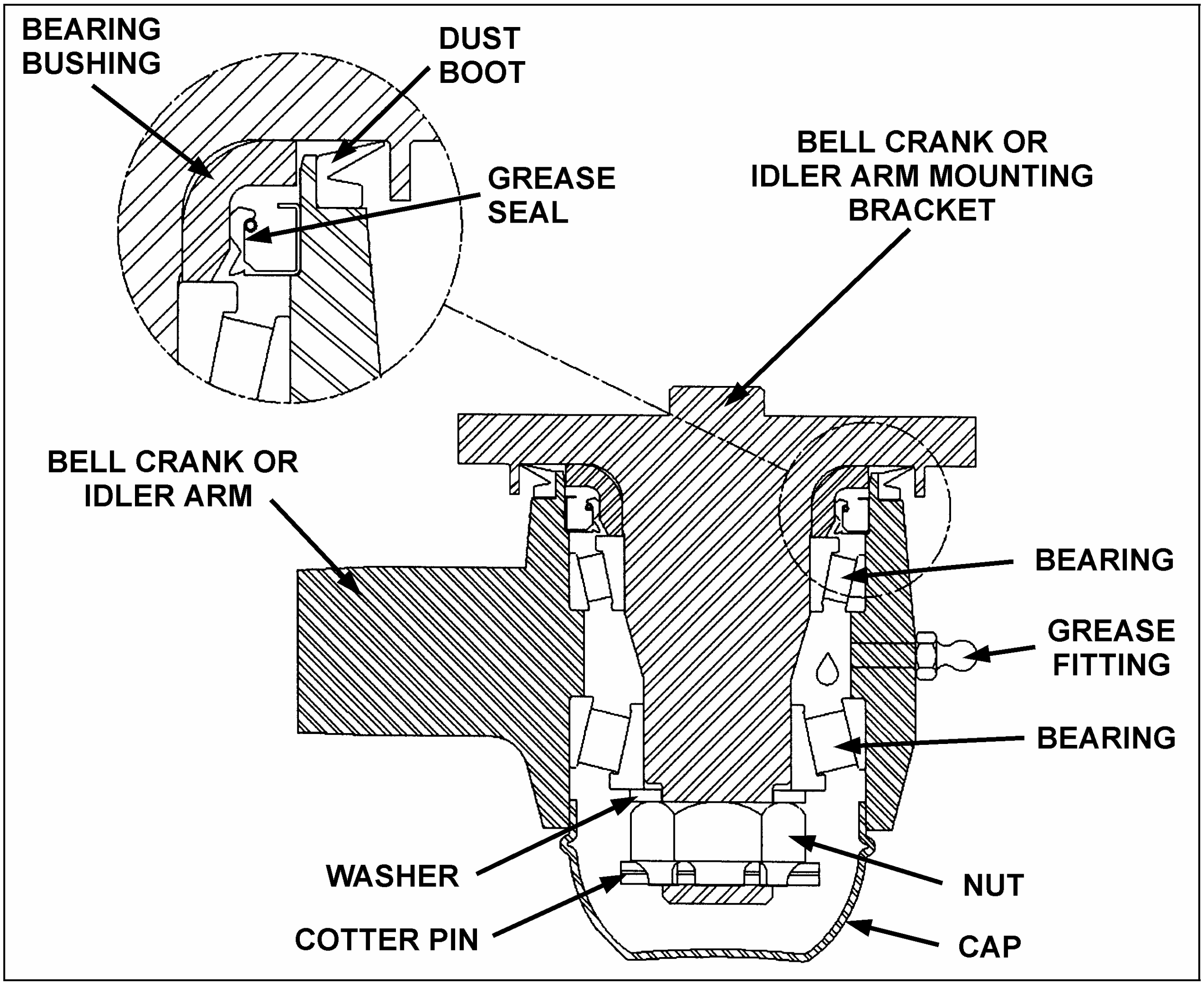


FIGURE 10: BELL CRANK AND IDLER ARM 16109

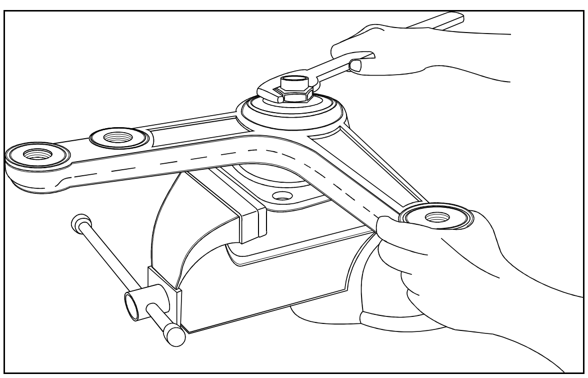


FIGURE 11: BELL CRANK 16044

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. 10).

NOTE
Install grease seal according to figure 8. 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. 10).
4. Install bearing and nut.

NOTE
Apply grease on bearing before installation.

5. Firmly tighten nut (Fig. 11).
6. Unscrew nut until bell crank or idler arm starts to turn by the application of 1 to 3 pounds load (Fig. 12).

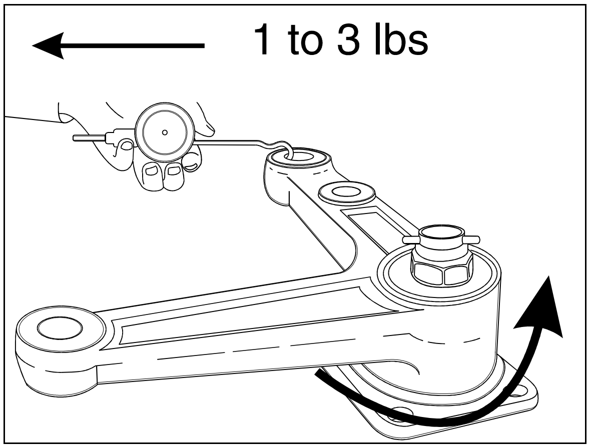


FIGURE 12: BELL CRANK 16045

7. Check for loose bearings by applying an up and down load on bell crank or idler lever (Fig. 12). The lever is not supposed to move in the vertical axis direction.
8. Align nut with cotter pin slot (tighten) and install a new cotter pin.

NOTE
Bend cotter pin around the nut (Fig. 10). 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 "6. Front End Alignment" of this supplement.

2.7 RELAY ROD

Relay rod ends are equipped with lubrication fittings and should be lubricated as directed in paragraph "2.9 Lubrication Fittings" in this supplement.

NOTE
The relay rod is crimped in place and it is not possible to remove the ball joints.

2.7.1 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.

2.8 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 "2.9 Lubrication Fittings" at the end of this section.

2.8.1 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.

2.8.2 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 "6.4.2 Toe-In Adjustment" of this supplement.

5. Make sure tie rod ends are properly aligned with ball studs, then torque tie rod end clamp bolts to 40-60 lbf-ft (54-82 Nm).

NOTE
If tie rod is not properly aligned with stud, binding will result.

2.9 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.

2.9.1 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.

2.9.2 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 160-215 lbf-ft (217-291 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 "3.2 Installation" of the maintenance manual.

2.10 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. 13) shows approximate location of steering lubrication fittings.

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 V-Link Outer 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).

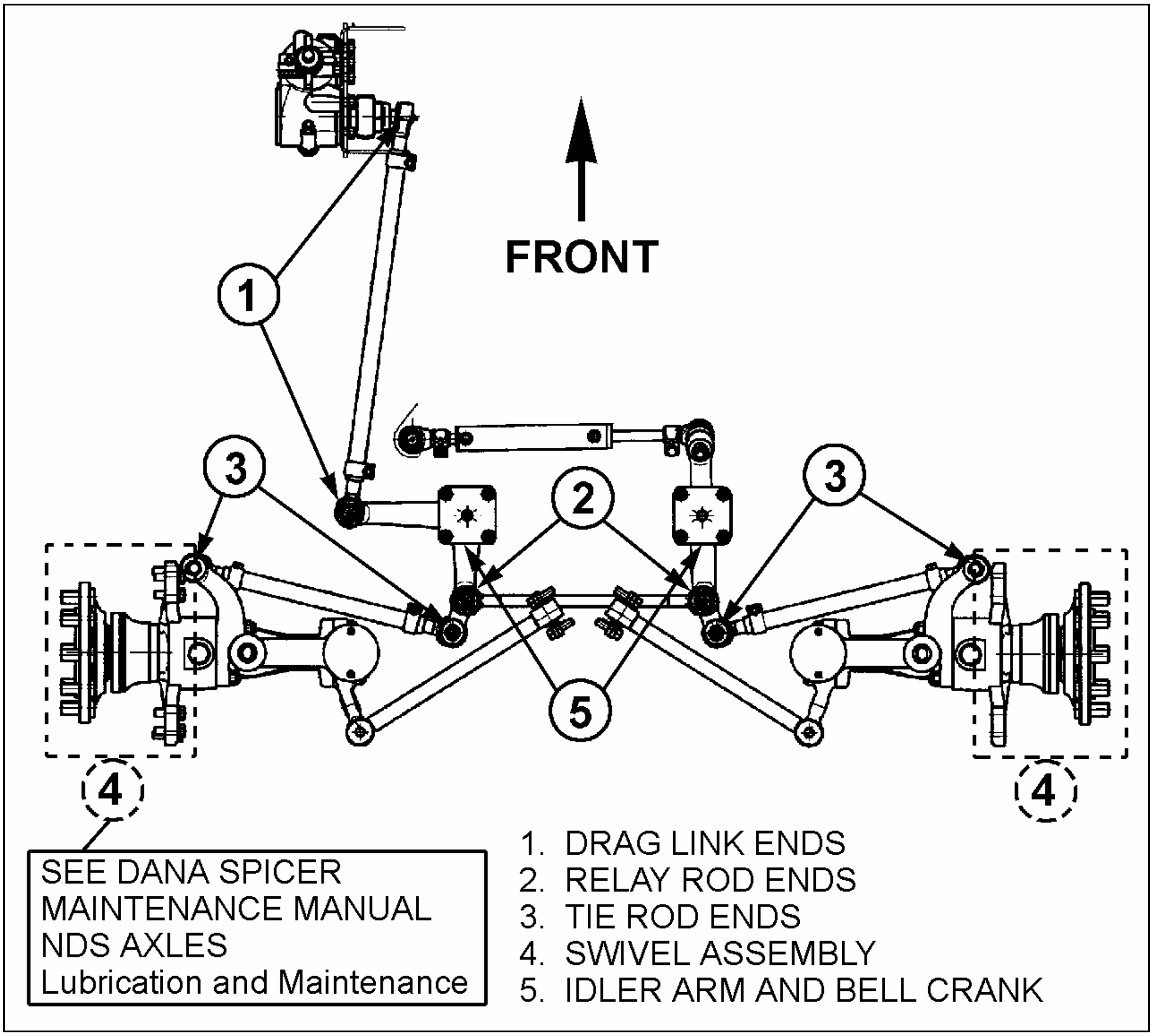


FIGURE 13: LUBRICATION FITTINGS' LOCATION DIAGRAM 16118

3. BALL JOINTS

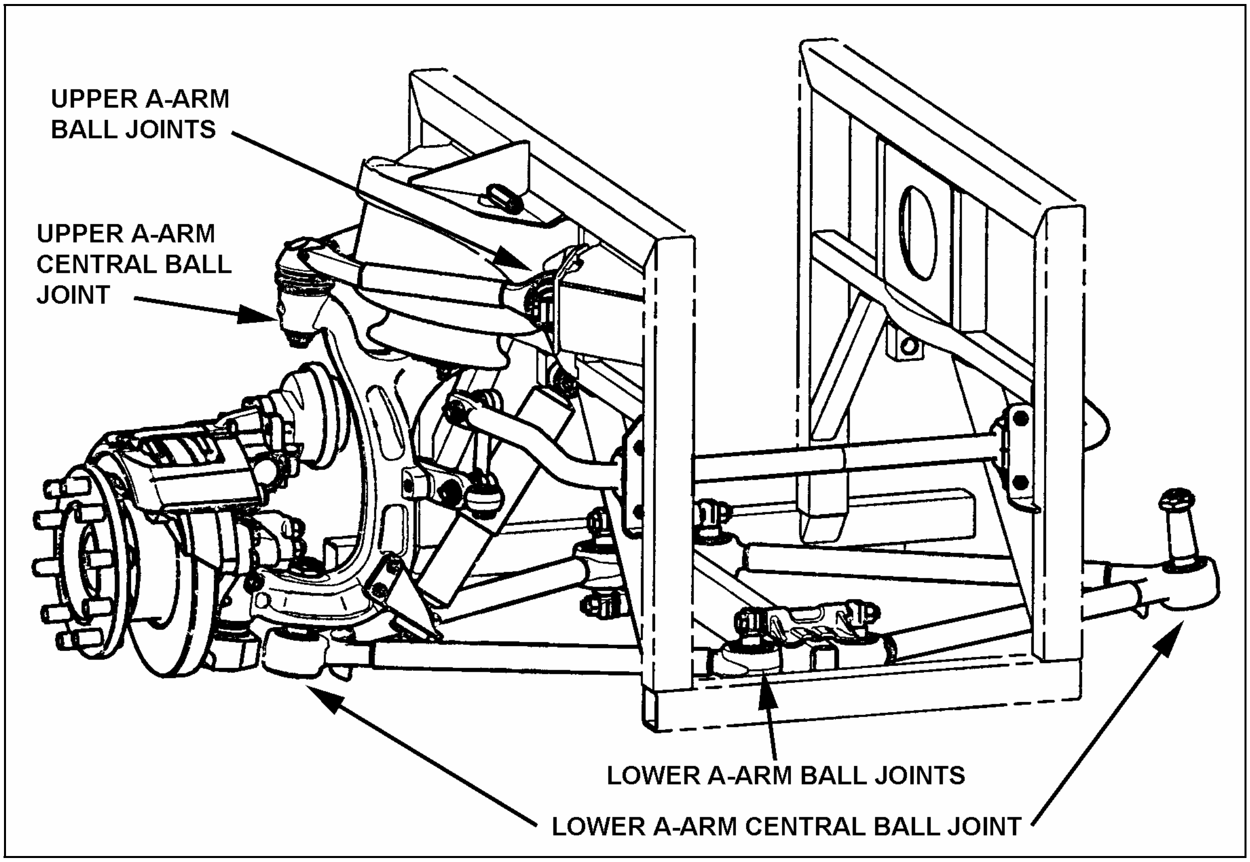


FIGURE 14: BALL JOINTS LOCATION 16137

4. 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.

4.1 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.

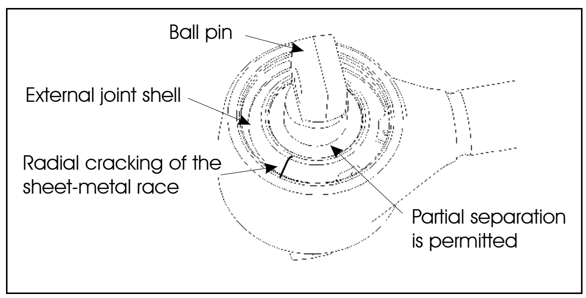


Figure 15: A-ARM BALL JOINTS

4.2 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.

4.3 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.

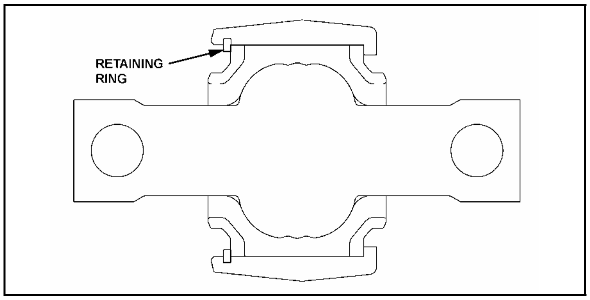


FIGURE 16: UPPER A-ARM BALL JOINT

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.

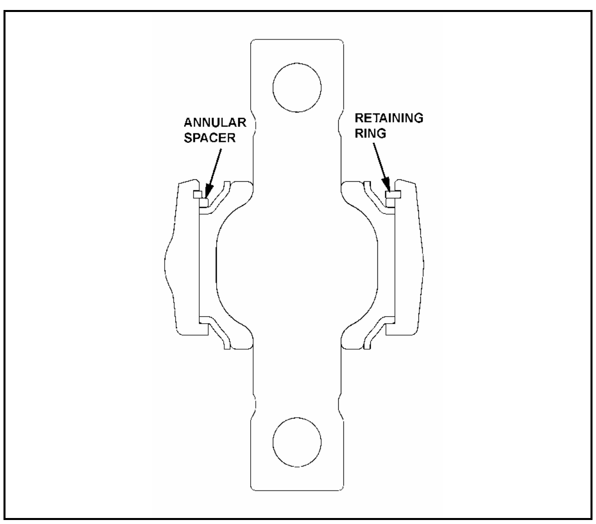


FIGURE 17: LOWER A-ARM BALL JOINTS 16047

5. LOWER A- ARM CENTRAL BALL JOINT

5.1 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.

5.2 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

5.3 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.

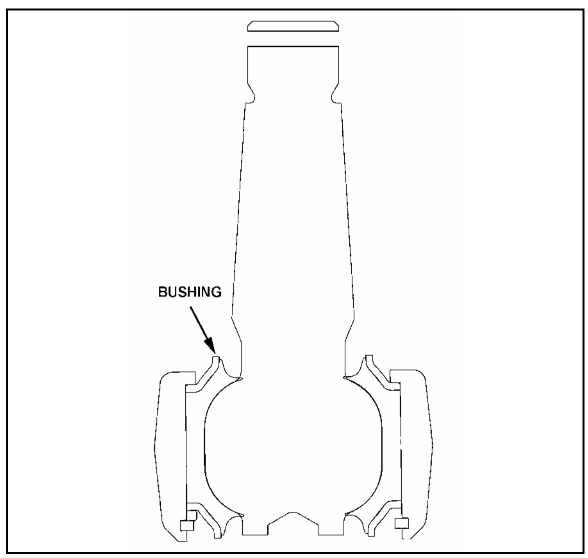


FIGURE 18: LOWER A-ARM CENTRAL BALL JOINT

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.

3. 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.

6. UPPER A-ARM CENTRAL BALL JOINT

6.1 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.

6.2 PLAY MEASUREMENT

1. Raise the vehicle and support through axle jacking points.

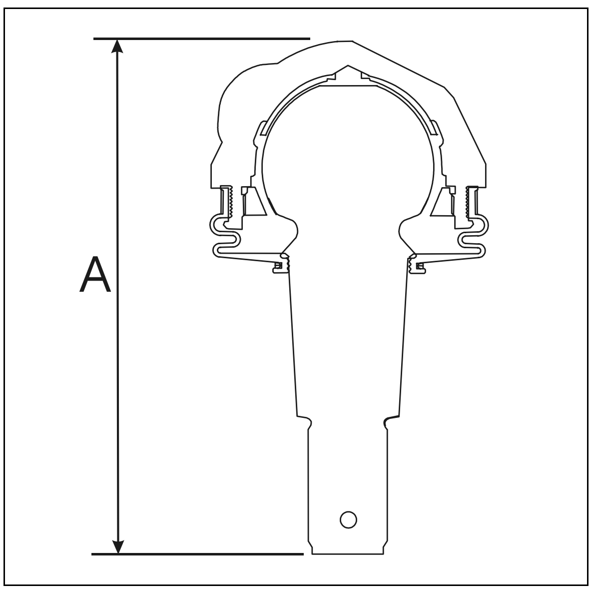


FIGURE 19: UPPER A-ARM CENTRAL BALL JOINT 16116

2. Using a caliper, measure dimension A on figure 19.
3. 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 the dimension A. If the difference between the two dimensions is greater than 0.060" (1.5mm), then the ball joint should be replaced.

7. 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 23.**
- **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.**

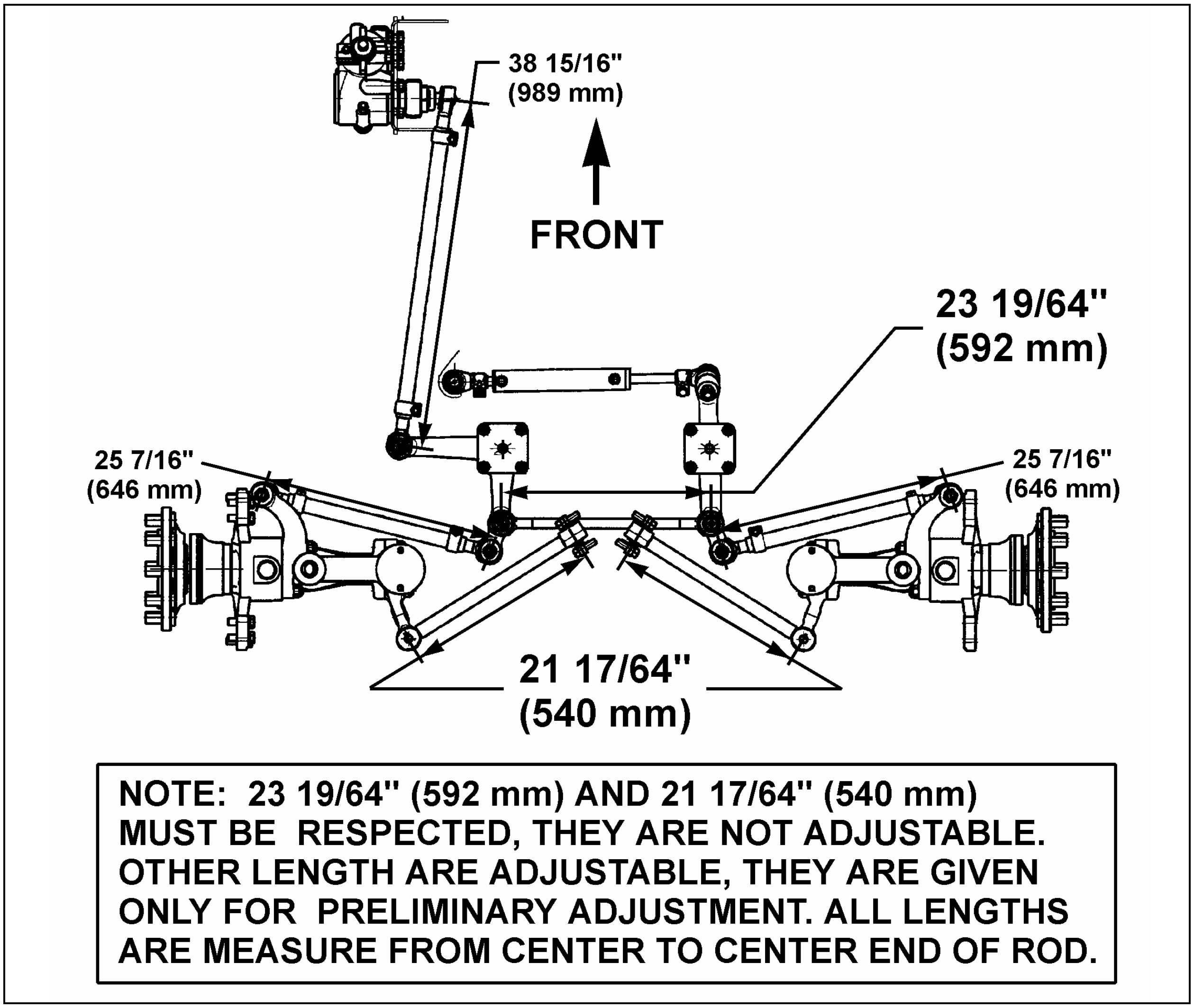


FIGURE 20: STEERING LINKAGE MEASURE 16132

7.1 ALIGNMENT TERMINOLOGY

Wheel Camber

The amount the wheels are inclined from the vertical plane (A, Fig. 21).

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. 21).

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. 21).

Front Axle Caster

The inclination of the king pin from vertical in the fore and aft direction (C, Fig. 21).

7.2 FRONT END INSPECTION

Before checking front end alignment, make the following inspection:

1. Check that the vehicle is at normal ride height (see paragraph "11. 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. 20). Check if the length of the relay rod is 23 19/64" (592 mm).

7.3 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 looking 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.

7.4 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.

7.4.1 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 ±1/32 of an inch less than the rear measurement.

7.4.2 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 "6.4.1 Toe-in Check" of this Supplement.
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 8.

NOTE
Use only tie rods to adjust toe-in.

7.5 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.

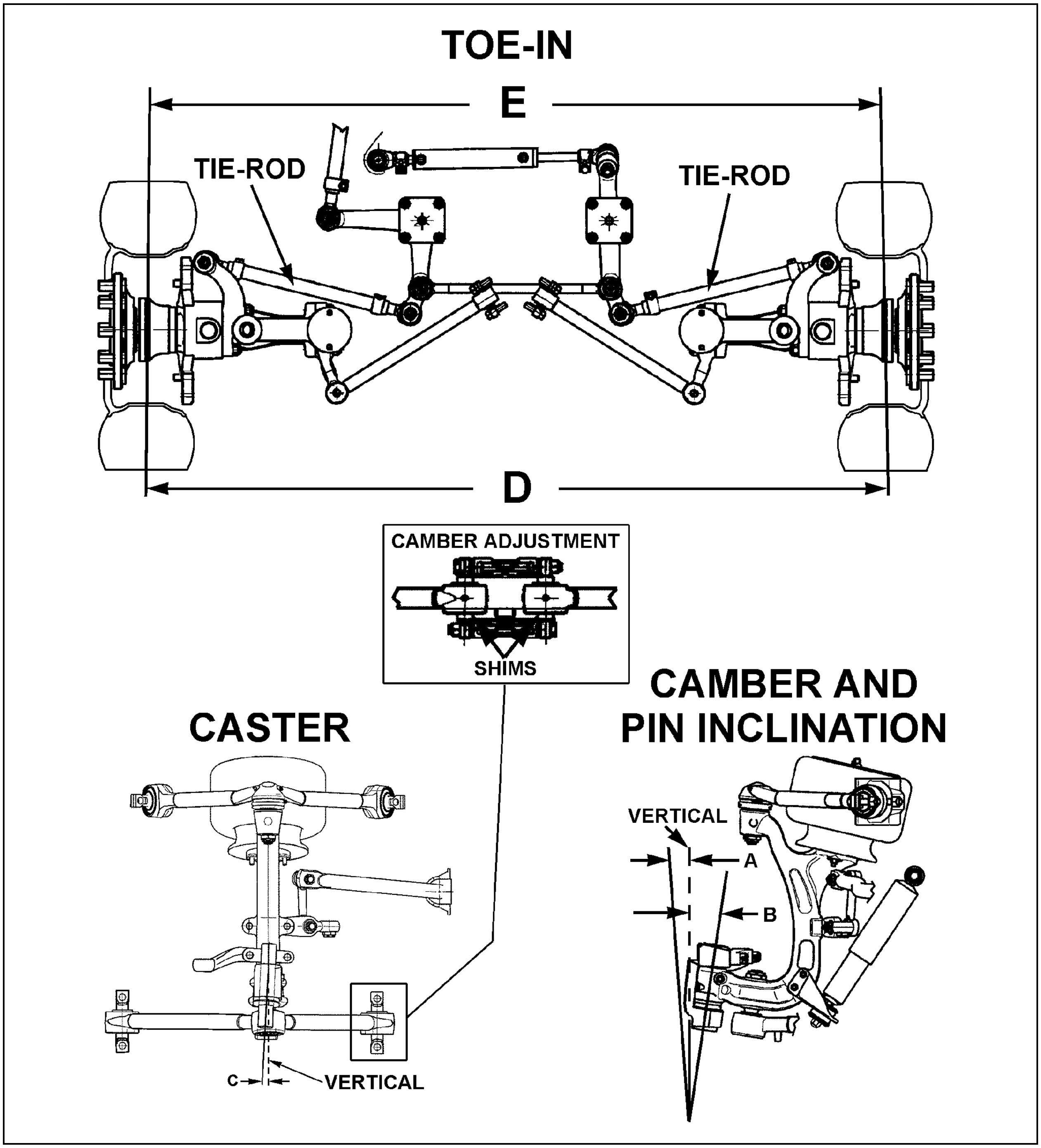


FIGURE 21: FRONT END ALIGNMENT DIAGRAM 16133

ALIGNMENT SPECS (See Figure 21)							
		Minimal		Nominal		Maximal	
Load		Non-converted	Converted	Non-converted	Converted	Non-converted	Converted
A	WHEEL CAMBER	0.2	-0.150	0.35	0.0	0.55	0.200
B	KING PIN INCLINATION	8° (not adjustable)					
C	CASTER	2.55		2.8		3.05	
D-E	TOE-IN	0.08		0.13		0.17	

Variations from the specified caster will affect steering stability, cause wandering, wheel shimmy, and reduce returnability when pulling out of curves.

7.6 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 "7. Front End Alignment".

8. 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.

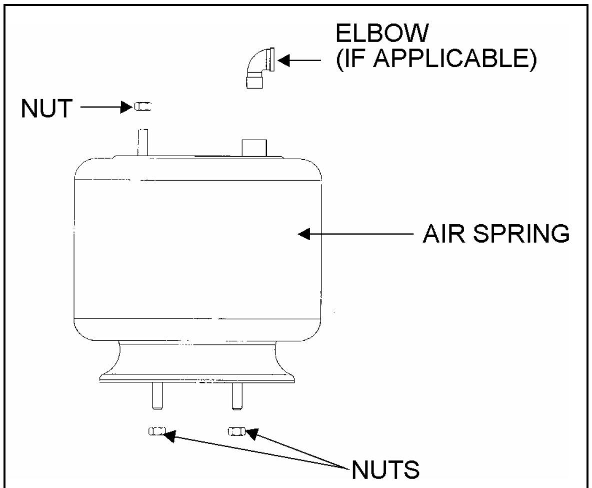


FIGURE 22: AIR SPRINGS 16052

8.1 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.

8.2 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.

8.3 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.

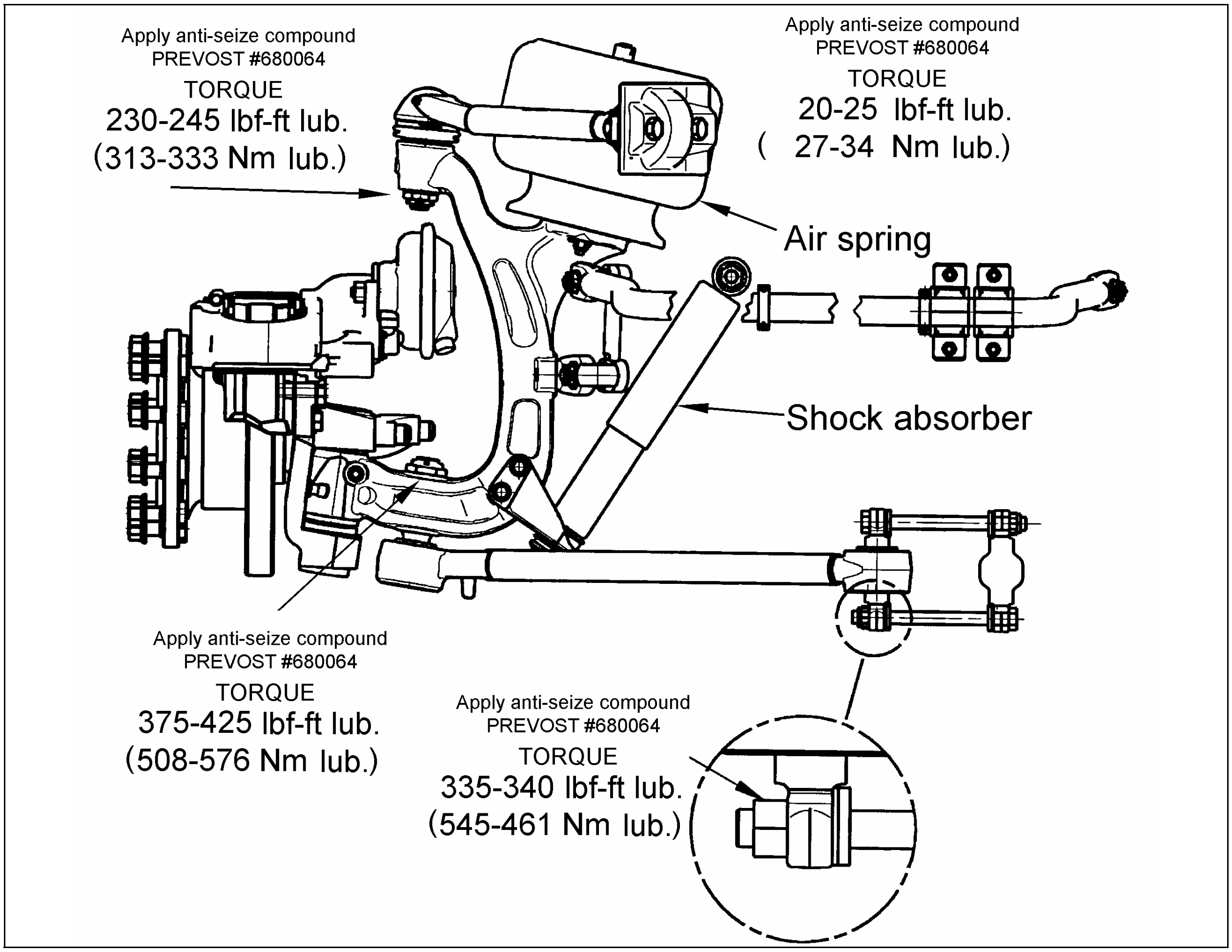


FIGURE 23: AIR SPRING AND SHOCK ABSORBER 16145

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.

9. 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.

9.1 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 24 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.

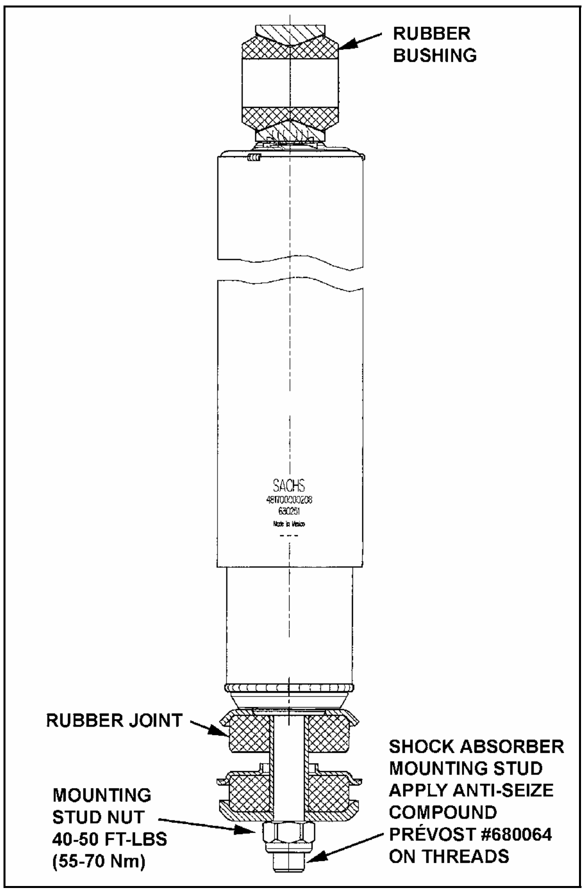


FIGURE 24: SHOCK ABSORBER 16112

9.2 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. 24).
4. Install washer and rubber joint on shock absorber mounting stud (lower side).
5. Install the shock absorber as shown in figure 18 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 (54–68 Nm).
7. Place the upper mounting pin stud nut and torque to 70-85 lbf-ft (95–116 Nm).

10. SWAY BAR

A sway bar is provided on the front and drive axles to increase vehicle stability. It controls lateral motion (swaying movement) of vehicle.

10.1 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.

10.2 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.

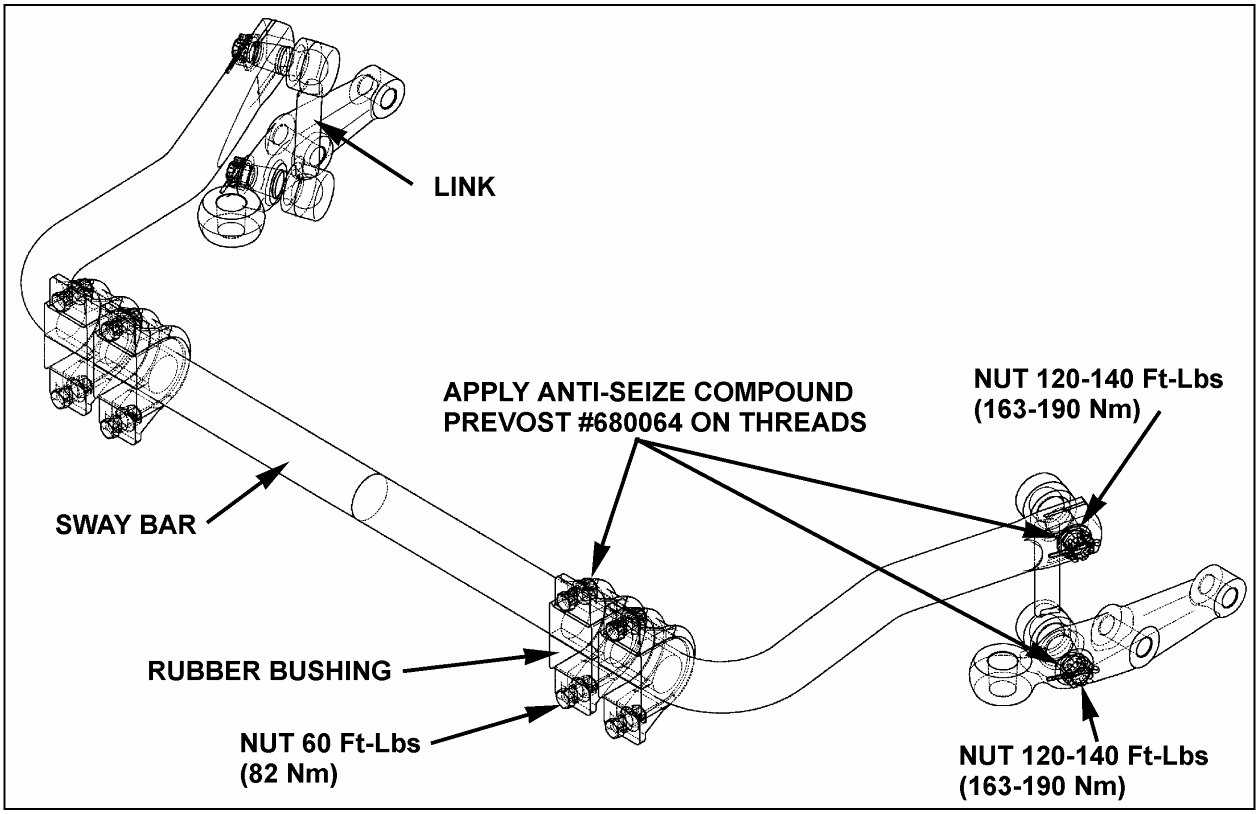


FIGURE 25: SWAY BAR (FRONT SUSPENSION) 16055

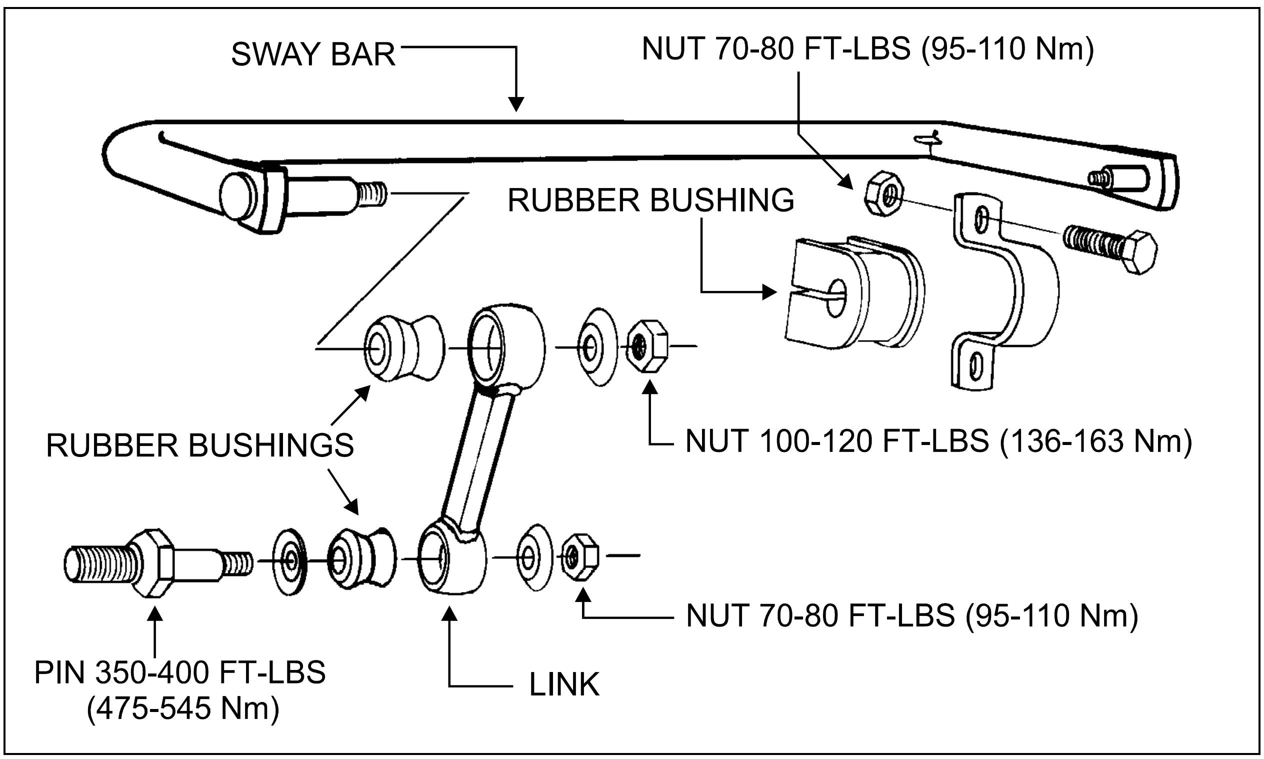


FIGURE 26: SWAY BAR (REAR SUSPENSION) 16014

11. INDEPENDENT FRONT SUSPENSION ADJUSTMENT

Converted coach shells are equipped with "LEVEL-LOW" leveling system. The purpose of the "LEVEL-LOW" is to adjust suspension in three separate points (front, rear right and rear left air springs) in order to level vehicle body. Three height control valves, automatically control air pressure in the three separate points (air springs) and maintains a constant vehicle height regardless of load, or load distribution. The control solenoid valve supplies air to the five way three-position air control valve, which bypasses the height control valve, and opens a passage to allow the air control and exhaust valve to release/supply air from airs springs. To improve road comfort, an expansion air tank is installed in series with each air springs.

In addition to the above suspension components the system also includes: sway bar, upper and lower suspensions, bars and shock absorbers (Fig. 1).

NOTE
Only for preliminary adjustment, refer to figure 20. Torque rod length must be fixed to 21 17/64" (540 mm) and relay rod to 23 19/64" (592 mm).

⚠ CAUTION ⚠
Parts must be replaced by ones with the same part numbers or with equivalent parts, if replacement becomes necessary. Do not use parts of lesser quality or substitute design. Torque values must be used as specified during reassembly to assure proper retention of these parts.

12. 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 (Fig. 27). 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.

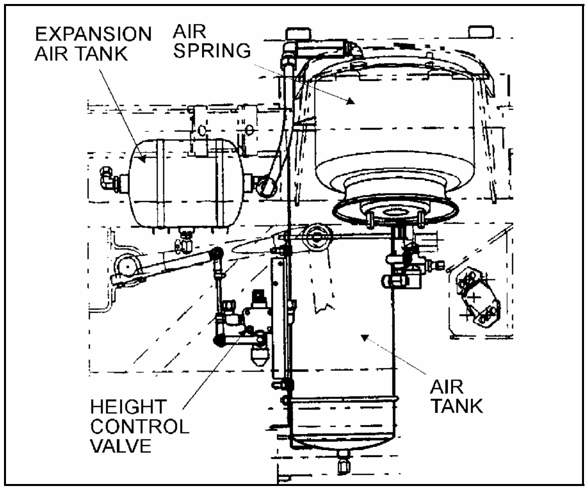


FIGURE 27: HEIGHT CONTROL VALVE LOCATION 16057

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 ± ¼" (279 ± 6 mm). Refer to figure 28 to identify the correct area to take measurement. The rear air springs clearance should be 11 ½ ± ¼" (292 ± 6 mm) (refer to Maintenance Manual, Section 16, under "Suspension Height Adjustment" for rear height control valves' adjustment). 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.

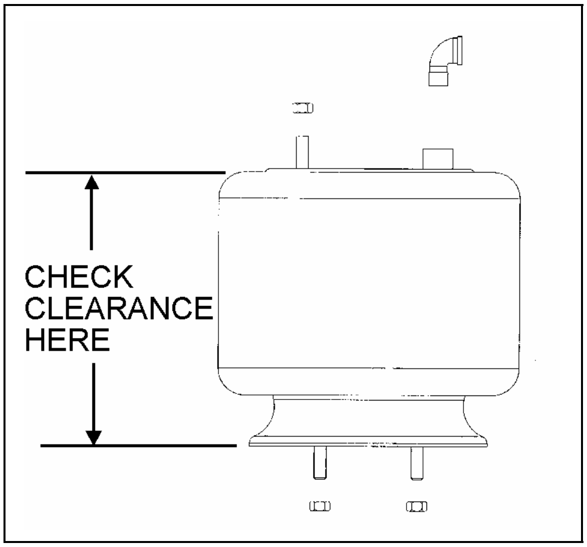


FIGURE 28: TYPICAL AIR SPRING CLEARANCE 16058

⚠ 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.

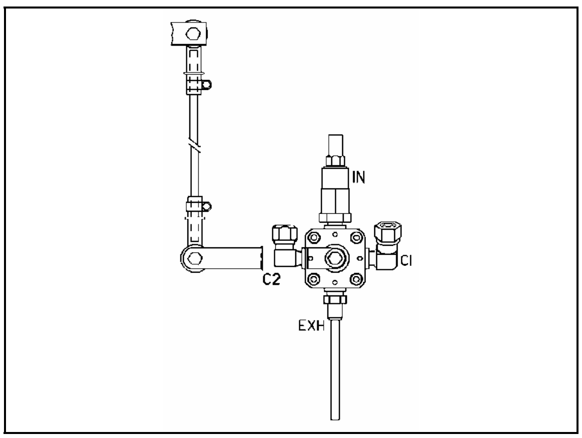


FIGURE 29: FRONT HEIGHT CONTROL VALVE 16100

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 ± ¼" (279 ± 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 28 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. 29).

NOTE

Allow suspension to stabilize before taking reading.

When the desired height is obtained, tighten clamp.

Rear air springs clearance

Refer to XL2 Maintenance Manual, Section 16, under "Suspension Height Adjustment".

13. 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:

13.1 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.

13.2 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.

13.3 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.

13.4 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.

13.5 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.

14. "LEVEL-LOW" LEVELING SYSTEM

The purpose of the *"level-low"* leveling system is to adjust suspension in three separate points (front, rear right and rear left) in order to level vehicle body. This system can be put into service when the ignition key is turned to the *"ON"* position, and must be used only when the parking brake is applied. The *"level-low"* warning light on the dashboard indicates that the selector switch is not in the *"OFF"* position. Level low system controls are located on L.H. side control panel.

14.1 PRINCIPLES OF OPERATION

DOWN:

The (front/rear right/rear left) control solenoid valve supplies air to the (front/rear right/rear left) five-way three-position air control valve, which bypasses the (front/rear right/rear left) height control valve, and opens a passage to allow the air control and exhaust valve to release air from (front/rear right/rear left) air springs.

UP:

The (front/rear right/rear left) control solenoid valve supplies air to the (front/rear right/rear left) five-way three-position air control valve, which bypasses the (front/rear right/rear left) height control valve, and opens a passage to allow the air control and exhaust valve to supply air to (front/rear right/rear left) air springs.

DRIVE:

When the ignition key is turned to the *"ON"* position with selector knob in the *"DRIVE"* position, the drive control solenoid valve supplies air to all five-way three-position air control valves, each one opening a passage to allow height control valves to accomplish their function.

When the ignition key is turned to the *"OFF"* position and selector knob to the *"DRIVE"* position, the air is entrapped between air springs and five-way three-position air control valves to ensure the adjusted level will be kept.

⚠ WARNING ⚠
Never move vehicle with selector knob in any other position than the "DRIVE" position.

14.2 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"*.

15. 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 supplement 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. 30).

In addition, an expansion air tank is installed in series with each air spring.

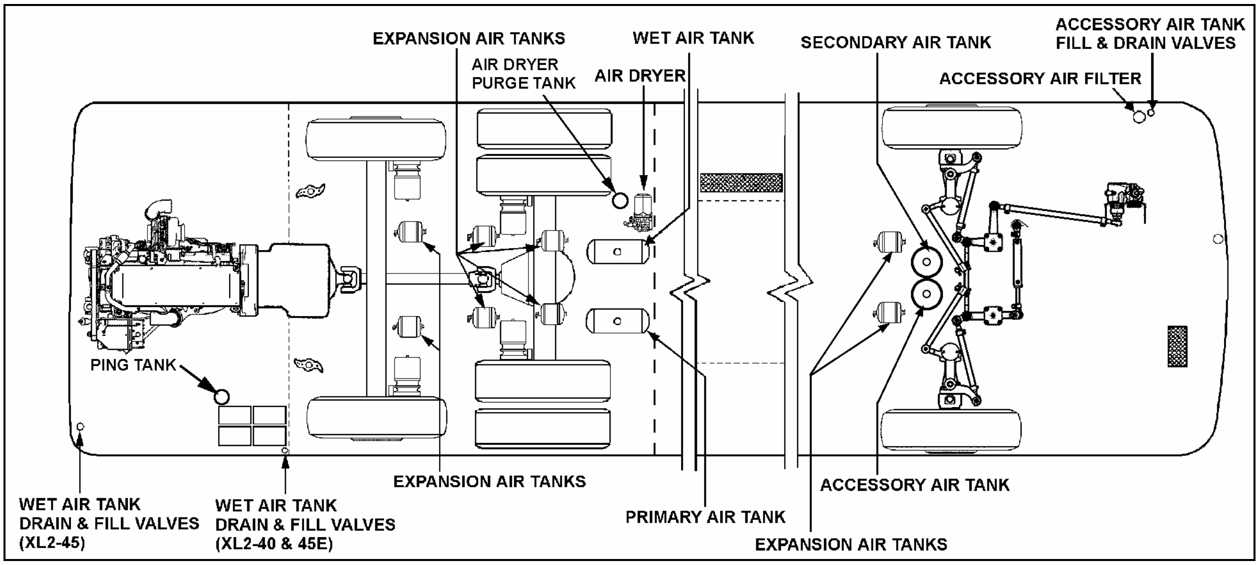


FIGURE 30: LOCATION OF AIR TANKS 24007

15.1 AIR TANK MAINTENANCE

Ensure that the accessory 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. 30).

Moreover, purge all tanks by their bottom drain valves at specified intervals.

15.1.1 Wet Air Tank

This tank is installed above L.H. wheel of drive axle, 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. 31).

15.1.2 Primary Air Tank

The primary air tank is located above R.H. wheel of drive axle.

This tank is provided with a bottom drain valve (Fig. 30). 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.

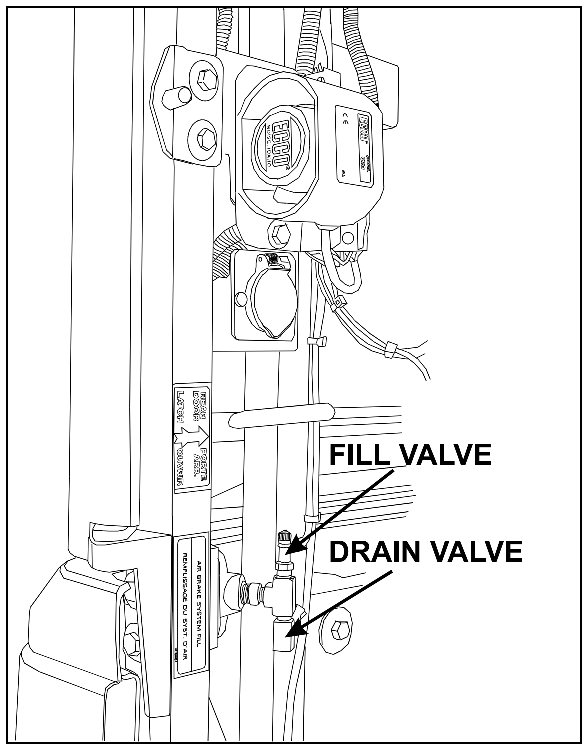


FIGURE 31: REAR VALVE LOCATION 12202

15.1.3 Secondary Air Tank

This tank is located in front wheelhousing, between air springs. The tank is installed vertically and is provided with a bottom drain valve (Fig. 30).

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.

15.1.4 Accessory Air Tank

The accessory air tank is installed next to the secondary air tank. The tank is installed vertically and is provided with a bottom drain valve (Fig. 30).

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. 32) underneath the accessory air filter. Refer to Section 12, paragraph "4. Accessory Air Filter" of the maintenance manual for daily purge procedure.

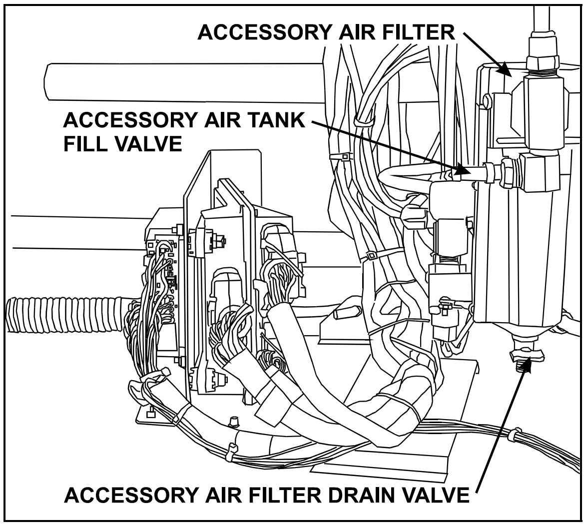


FIGURE 32: FRONT VALVE LOCATION 12201

15.1.5 Expansion Air Tank

Two expansion tanks are located in front wheelhousing. These air tanks are located behind secondary and accessory air tank. Also, six expansion tanks are located near rear air springs (Fig. 30). 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.

15.2 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. 31).

⚠ 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. 32).

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.

16. 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 *"Front Axle".*

17. TORQUE TABLE

DESCRIPTION	QTY	REFERENCE	TORQUE (DRY) Lbf-ft / Nm	
Pitman Arm to Steering Gear Fixing Nut	1	8	400-450	545-610
Drag Link to Pitman Arm Stud Nut*	1	---	160-215	220-290
Drag Link to Bell crank Stud Nut*	1	---	160-215	220-290
Drag Link Socket End Clamp Bolt Nut	2	---	40-60	55-80
Relay Rod to Bell crank Stud Nut*	1	---	160-215	220-290
Relay Rod to Idler Arm Stud Nut*	1	5	160-215	220-290
Tie Rod to Bell crank Stud Nut*	1	---	160-215	220-290
Tie Rod to Idler Arm Stud Nut*	1	5	160-215	220-290
Tie Rod to Steering Arm Stud Nut*	2	3	160-215	220-290
Tie Rod End Clamp Bolt Nut	4	3	40-60	55-80
Steering Arm to Swivel Nut*	4	---	190	260
Torque Rod Stud Nut	2	4	160-215	220-290
Idler Arm and Bell Crank Cap Screws	8	9	8	11
Torque Rod Mounting Bracket Nut	4	6	75-140	100-190
Torque Rod Clamp Nut	4	4	53-59	72-80
Jacking Point Bracket Nut	8	19	70-80	95-110
Bushing Collar Nut	8	20	72-88	98-120
Sway Bar Link Upper Nuts (Rear Suspension)	2	20	100-120	135-160
Sway Bar Link Lower Nuts (Rear Suspension)	2	20	70-80	95-110

DESCRIPTION	QTY	REFERENCE	TORQUE (Lubricated) (Anti-Seize #680064) Lbf-ft / Nm	
Idler Arm and Bell Crank Mounting Bracket Nut	8	5	90-120	120-160
Shock Absorber Mounting Stud Nut	2	19	40-50	55-70
Shock Absorber Pin Nut	2	19	70-85	95-115
Air Spring Nut	3	18	20-25	27-34
Sway Bar Link Upper and Lower Nuts (Front Suspension)	2	20	120-140	160-190
Upper A-Arm Stud Nut*	2	18	230-245	315-335
Lower A-Arm Bracket Nut	8	18	375-425	510-580

DESCRIPTION	QTY	REFERENCE	TORQUE (Lubricated) (Loctite #242 Blue) Lbf-ft / Nm	
Shock Absorber Pin	2	19	350-400	475-545
Steering Gear to Mounting Bracket Bolt	5	8	355	485

- **Tighten nut to specified torque, then advance to next aligning cotter pin slot and install a new cotter pin.**

18. SPECIFICATIONS

Front Axle Air Springs

Make .... Goodyear Tire and Rubber
Diameter .... 14.5 inches
Air Inlet........ 1/2''- 14 NPTF
Supplier number 1R14-167
Prévost number 630239

Shock Absorbers

Collapsed length........ 350 mm
Extended Length .... 560 mm
Supplier number 481700000208
Prévost number 630251

Height Control Valve

Make........ Barksdale
Supplier number .... 52321POAQ3-Q26 and 52321POAQ3-Q62
Prévost number .... 630156 and 630157

Steering Gear Box

Make........ ZF-Servocom
Supplier number 8098-988-570
Prévost number 661045

Steering Gear Box (Optional)

Make........ ZF-Servocomtronic
Supplier number 8098-988-571
Prévost number 661044

Power Steering Hydraulic Pump

Make........ TRW
Supplier number PS251616L10200
Prévost number 661070

Power Steering Hydraulic Cylinder

Make........ Hyco
Supplier number 007-0300-0
Prévost number 661076

Shim (Camber Adjustment)

Thickness .... 3.175 mm
Prévost number 160993
Thickness .... 6.35 mm
Prévost number 160992

Sway bar bushing (Drive Axle)

Make........ Prévost
Prévost number 130953

SECTION 16: COACHES EQUIPPED WITH INDEPENDENT FRONT SUSPENSION (IFS)

CONTENTS

ILLUSTRATIONS

1. INTRODUCTION

This supplement contains service procedures and specifications that apply to the PREVOST coaches equipped with an independent front suspension.

This text contains information unique to the independent suspension system. In the case you cannot find information on a subject in this supplement section, the information given in the regular sections of the Maintenance Manual will apply.

2. 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. 1).

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 of supplement.

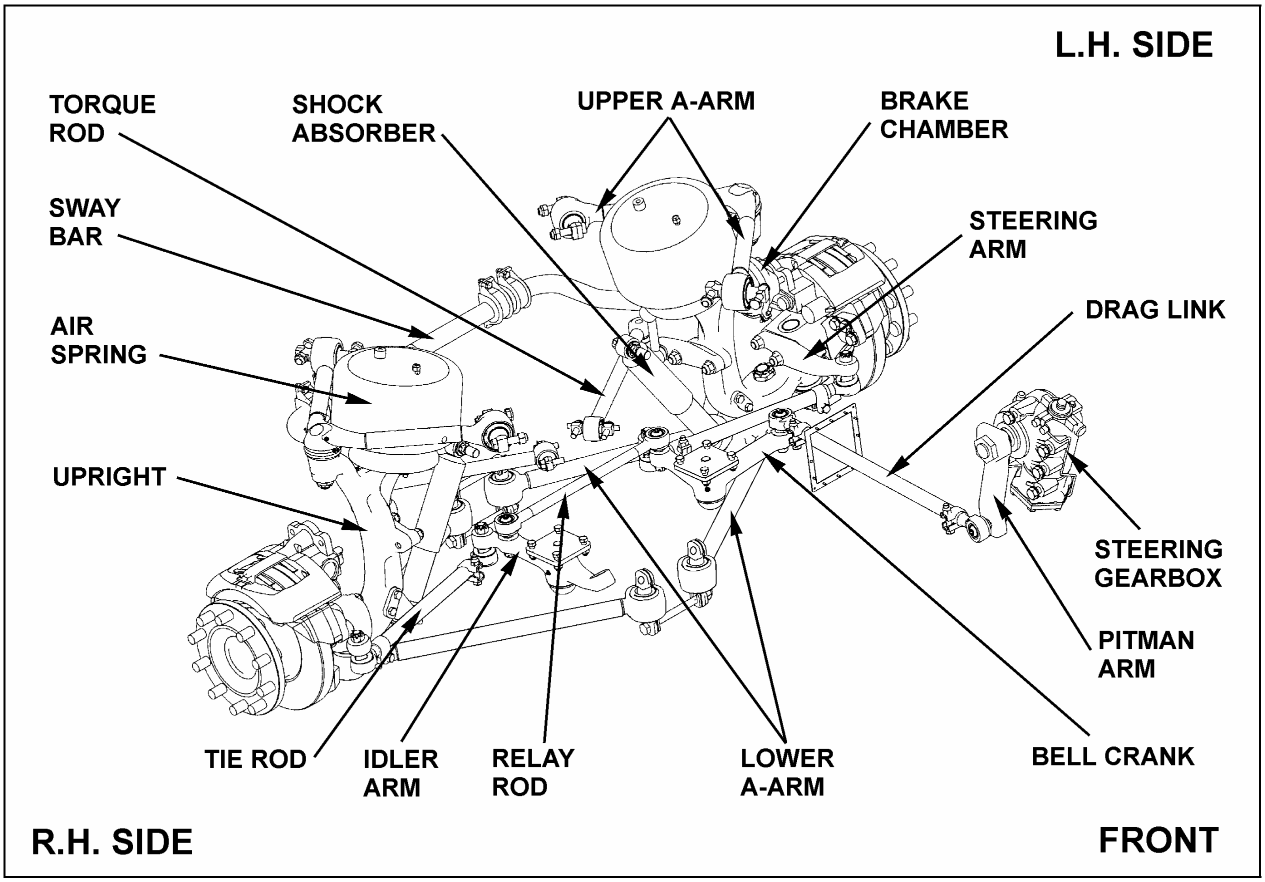


FIGURE 1: SUSPENSION AND STEERING LINKAGE 16125

Turning Angle

The maximum turning angle is set mechanically through the two steering stop screws installed on the swivel assembly. The turning angle (56° + 0° - 1°) 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 "4. 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 2 to 5 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 XL2 Maintenance Manual, Section 14, "Steering", under heading: "Setting and Functional Test".

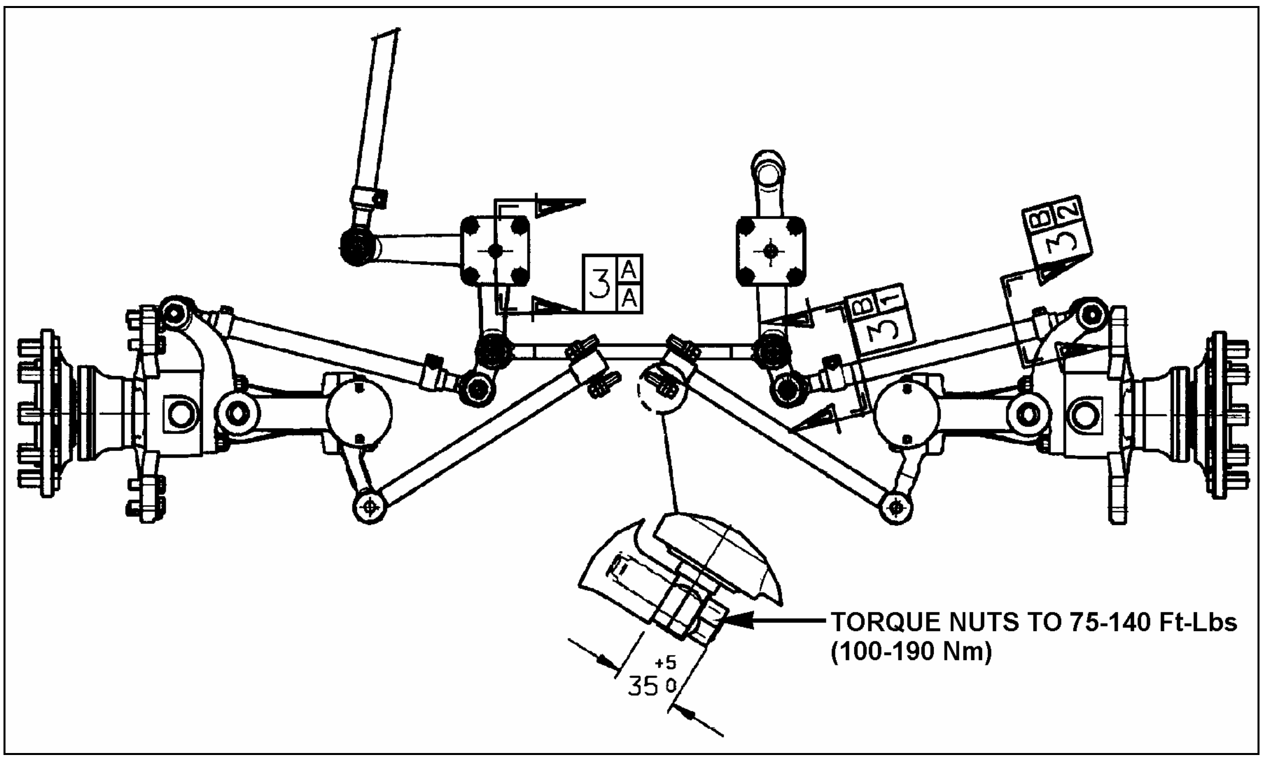


FIGURE 2: LOCATION OF CLAMPS 16127

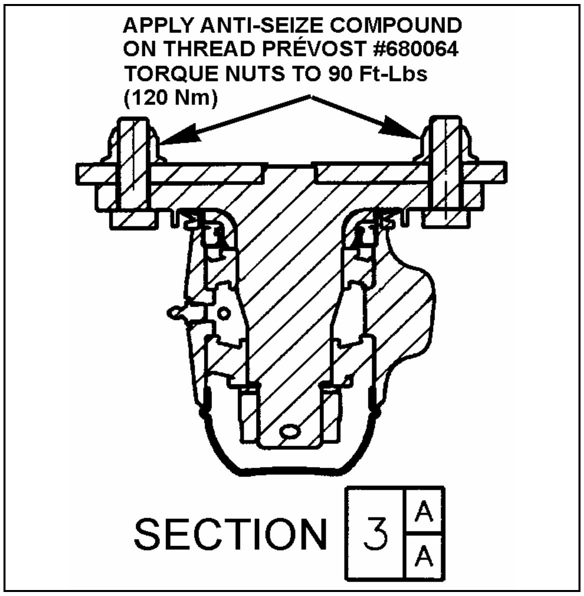


FIGURE 3: CLAMP POSITIONING 16128

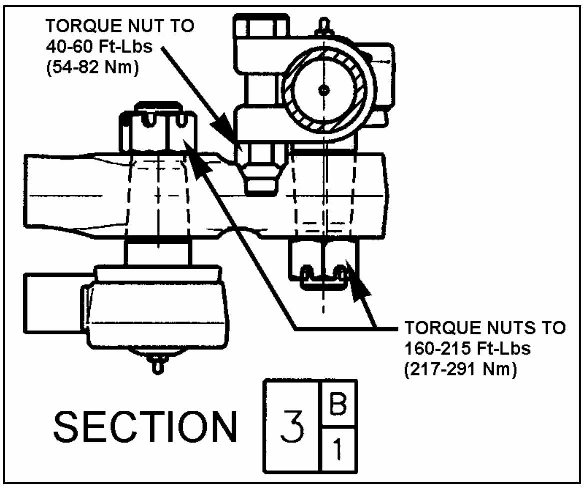


FIGURE 4: CLAMP POSITIONING 16120

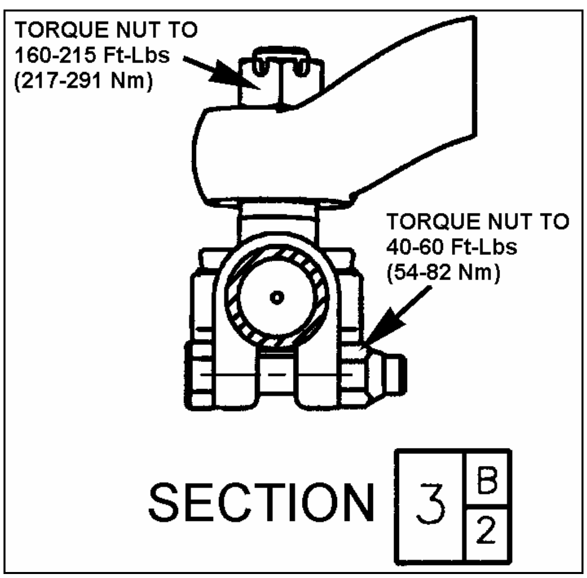


FIGURE 5: CLAMP POSITIONING 16123

2.1 POWER STEERING HYDRAULIC PUMP

Refer to the "TRW Power Steering Pump Service Manual" annexed at the end of Section 14.

2.2 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 Supplement. Check to insure that all stud nuts and mounting bolts and nuts have been tightened to proper torques listed under "16. Torque Table" at the end of this supplement.

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. 6).
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.
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 Supplement.

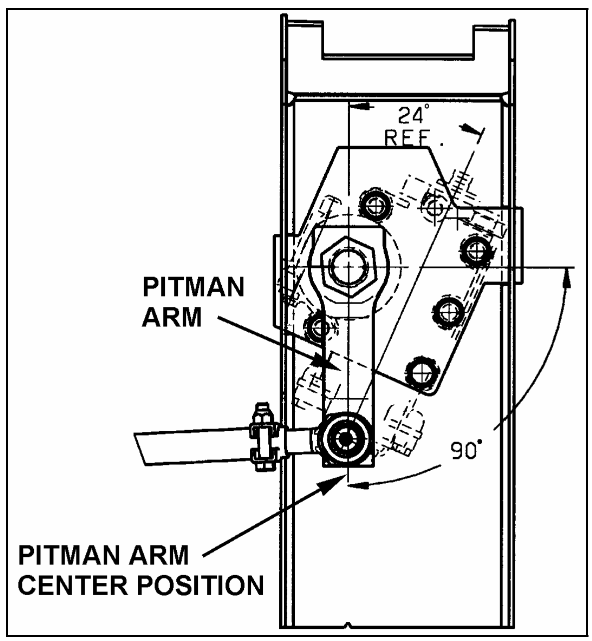


FIGURE 6: PITMAN ARM ALIGNMENT 14037

2.3 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.
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.

2.4 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).

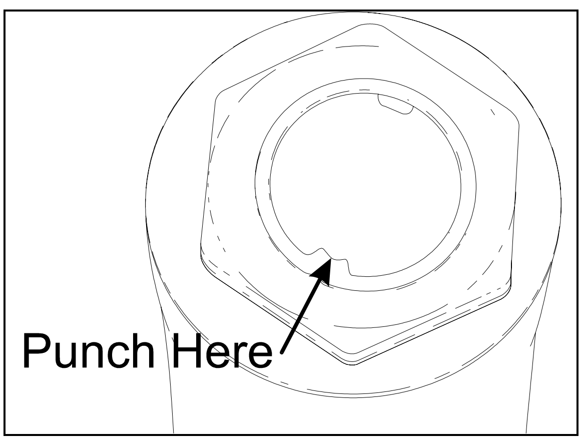


FIGURE 7: FIXING NUT PUNCH MARK 16098

NOTE
Use a new nut if the previously removed nut was punched.

⚠ CAUTION ⚠
Lock nut with sector shaft using a punch mark into the groove (Refer to figure 7).

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.

2.5 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 supplement.

2.5.1 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 "2.1 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.

2.6 BELL CRANK AND IDLER ARM

Bell crank and idler arm are equipped with one lubrication fitting and should be lubricated as directed in paragraph "2.9 Lubrication Fittings" at the end of this Supplement.

2.6.1 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.

2.6.2 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.10).
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. 10).

2.6.3 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. 10).

NOTE
Install grease seal according to figure 9. 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. 10).
4. Install bearing and nut.

NOTE
Apply grease on bearing before installation.

5. Firmly tighten nut (Fig. 8).

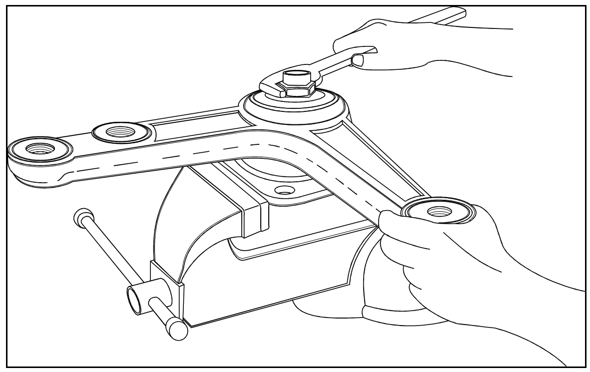


FIGURE 8: BELL CRANK 16044

6. Unscrew nut until bell crank or idler arm starts to turn by the application of 1 to 3 pounds load (Fig. 9).

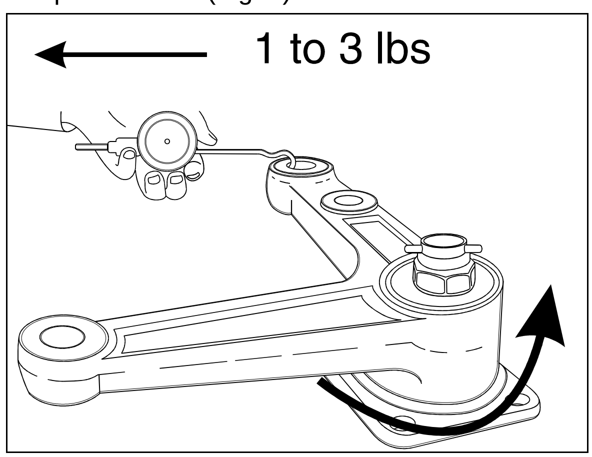


FIGURE 9: BELL CRANK 16045

7. Check for loose bearings by applying an up and down load on bell crank or idler lever (Fig. 10). The lever is not supposed to move in the vertical axis direction.

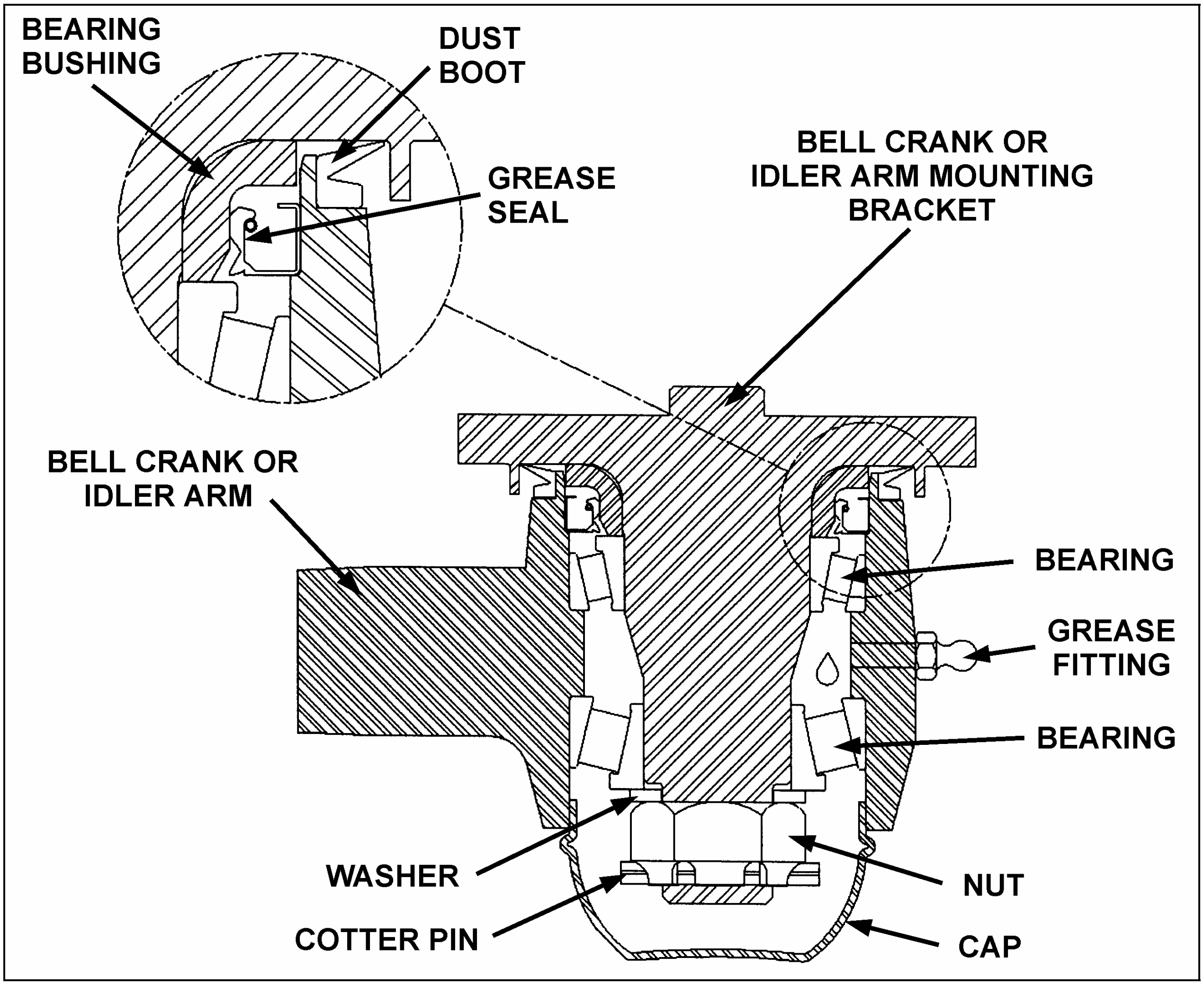


FIGURE 10: BELL CRANK AND IDLER ARM BALL JOINT 16109

8. Align nut with cotter pin slot (tighten) and install a new cotter pin.

NOTE
Bend cotter pin around the nut (Fig. 10). 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 "6. Front End Alignment" of this supplement.

2.7 RELAY ROD

Relay rod ends are equipped with lubrication fittings and should be lubricated as directed in paragraph "2.9 Lubrication Fittings" in this supplement.

NOTE
The relay rod is crimped in place and it is not possible to remove the ball joints.

2.7.1 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.

2.8 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 "2.9 Lubrication Fittings" at the end of this section.

2.8.1 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

2.8.2 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 "6.4.2 Toe-In Adjustment" of this supplement.

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.

2.9 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.

2.9.1 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.

2.9.2 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 "3.2 Installation" of the maintenance manual.

2.10 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. 11) shows approximate location of steering lubrication fittings.

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 V-Link Outer 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).

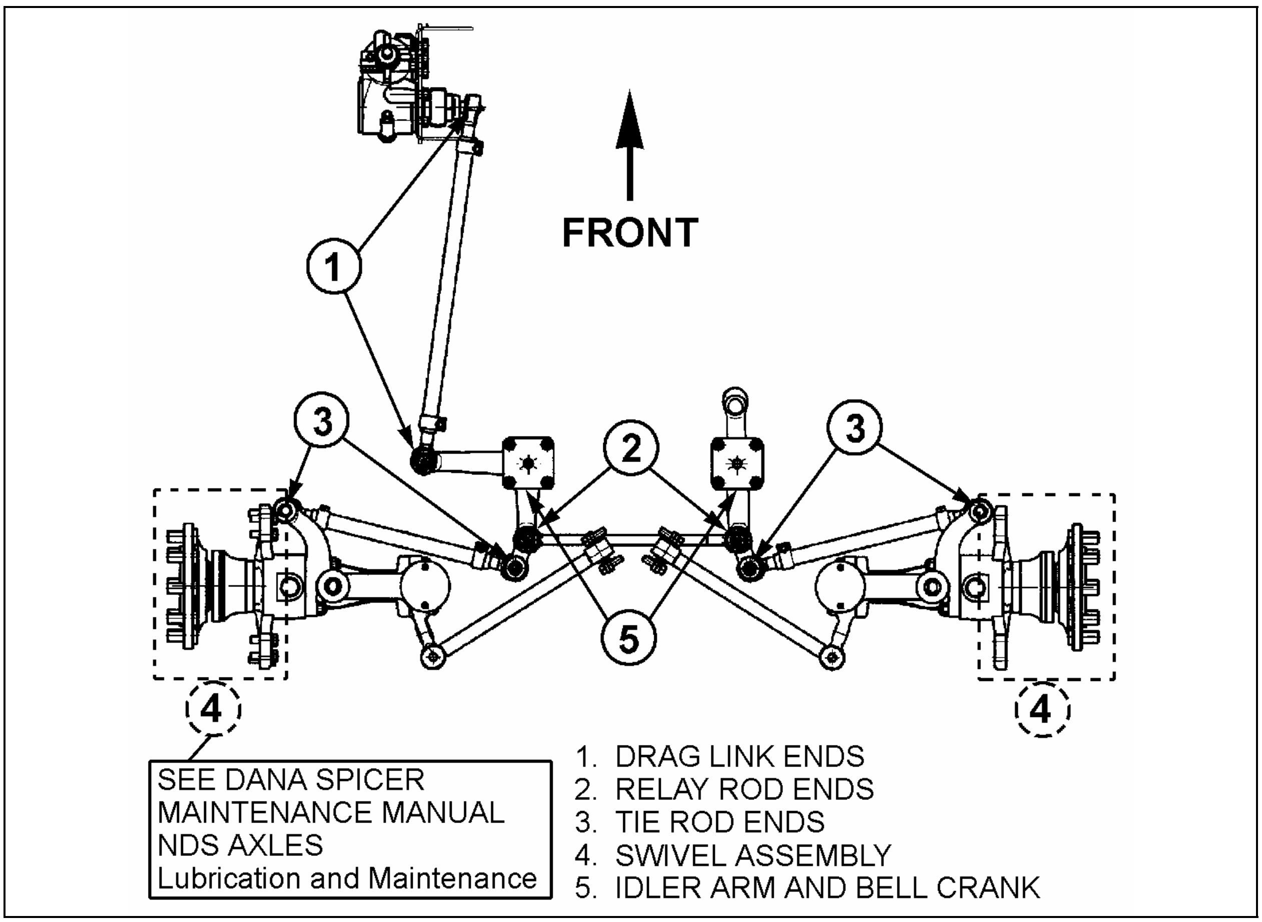


FIGURE 11: LUBRICATION FITTINGS' LOCATION DIAGRAM 16119

3. BALL JOINTS

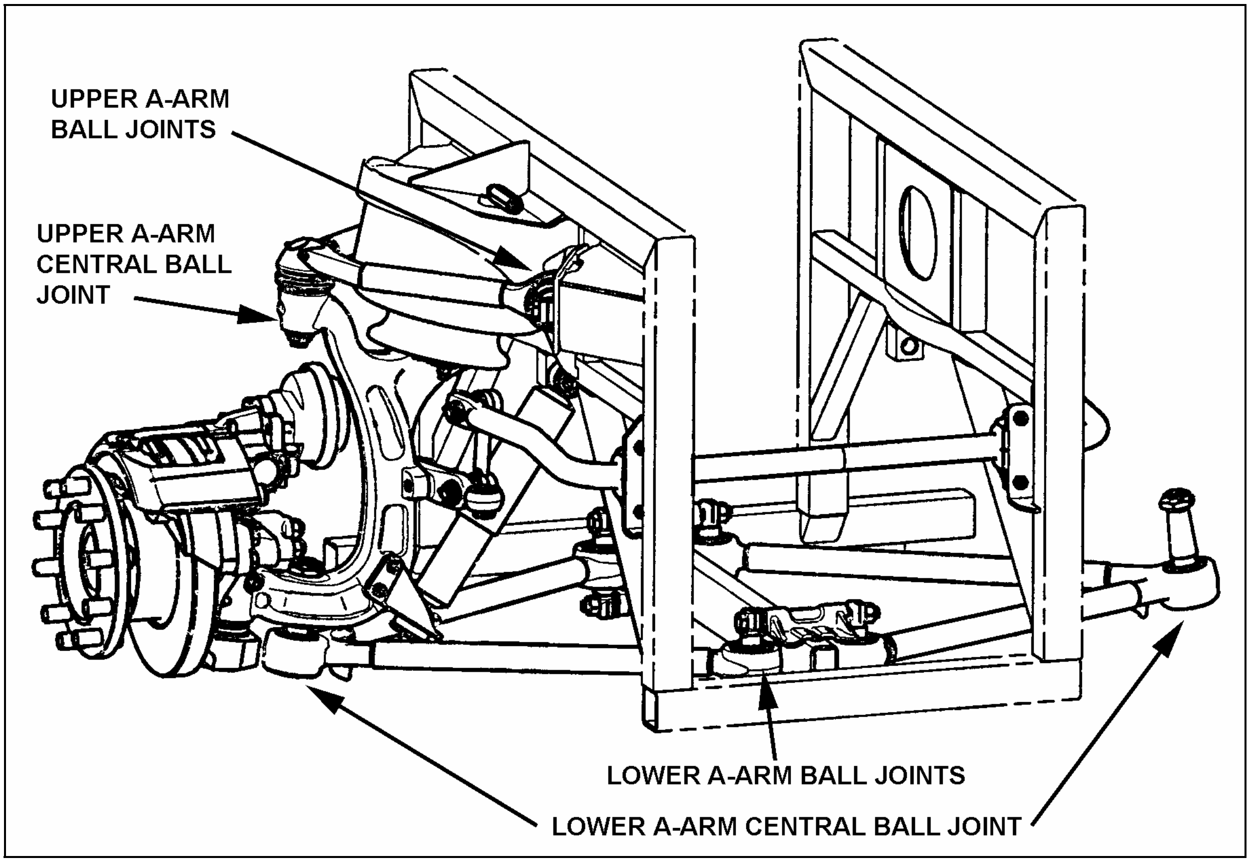


FIGURE 12: BALL JOINTS LOCATION 16137

4. 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.

4.1 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. <u>Free play is not acceptable</u>.

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.

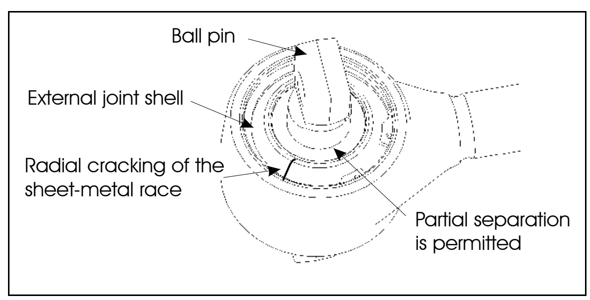


FIGURE 13: A-ARM BALL JOINTS

4.2 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.

4.3 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.

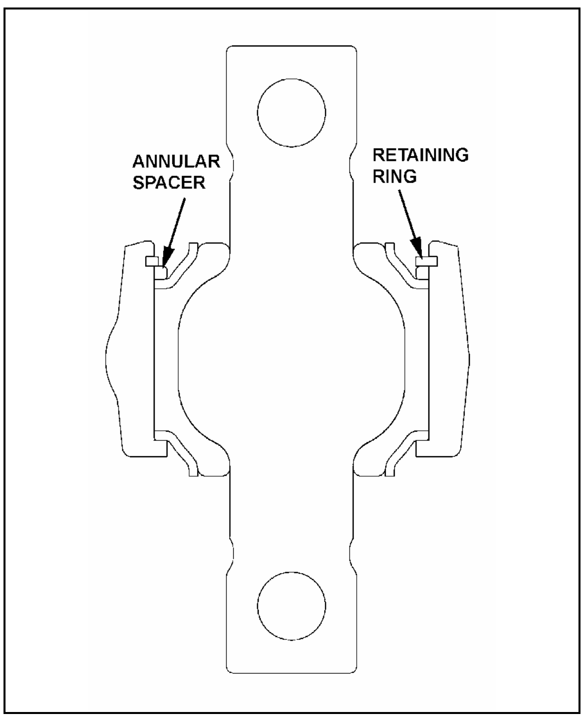


FIGURE 14: LOWER A-ARM BALL JOINTS 16114

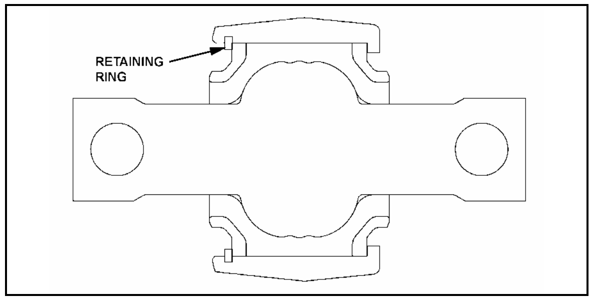


FIGURE 15: UPPER A-ARM BALL JOINTS 16115

5. LOWER A- ARM CENTRAL BALL JOINT

5.1 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.

5.2 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.

5.3 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.

3. 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.

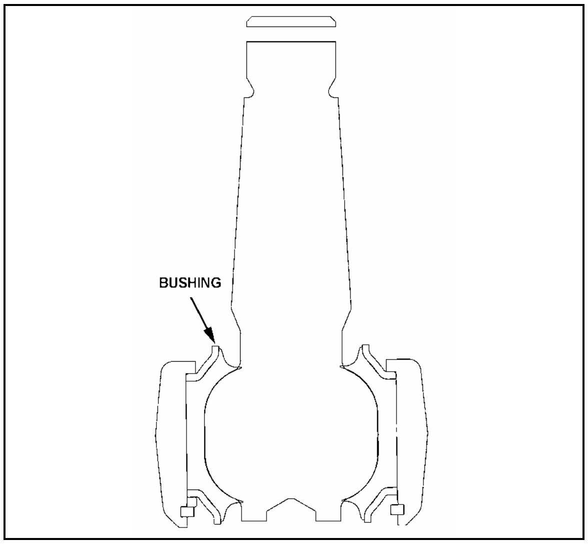


FIGURE 16: LOWER A-ARM CENTRAL BALL JOINT 16113

6. UPPER A-ARM CENTRAL BALL JOINT

6.1 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.

6.2 PLAY MEASUREMENT

1. Raise the vehicle and support through axle jacking points.
2. Using a caliper, measure dimension A on figure 17.
3. 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 the dimension A. If the difference between the two dimensions is greater than 0.060" (1.5mm), then the ball joint should be replaced.

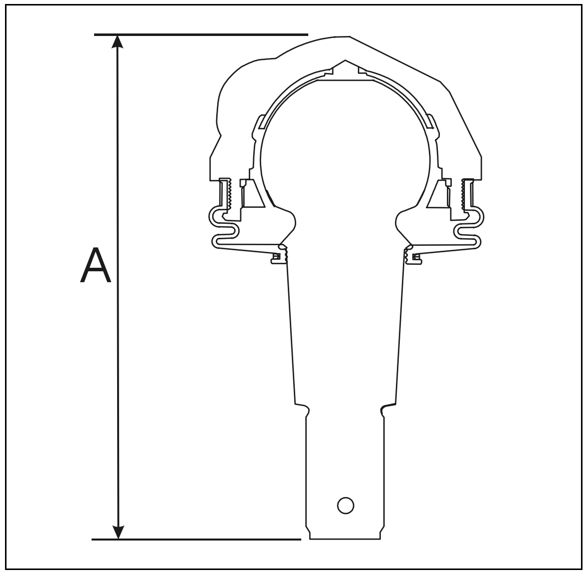


FIGURE 17: UPPER A-ARM CENTRAL BALL JOINT 16116

7. 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 21.**
- **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.**

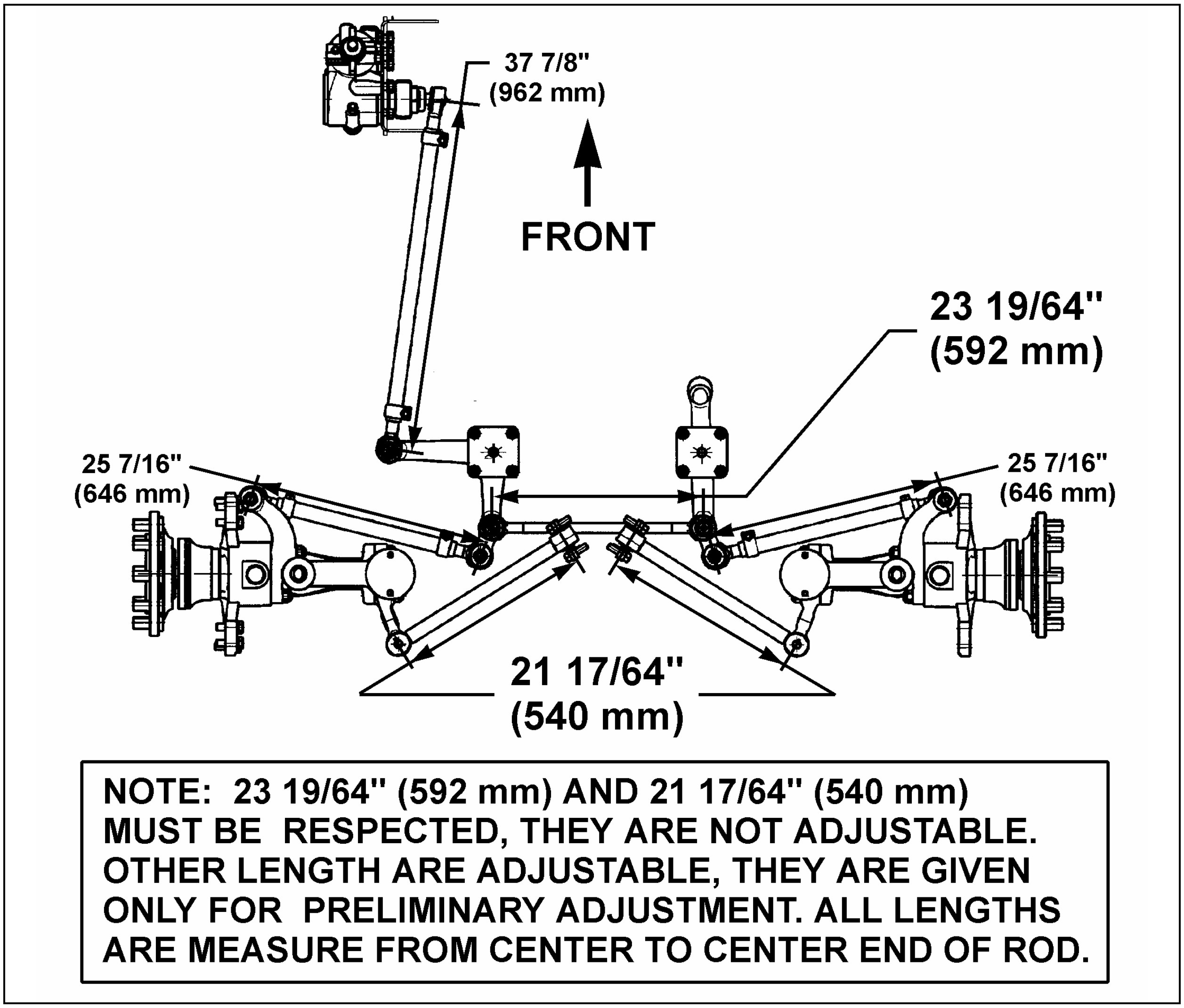


FIGURE 18: STEERING LINKAGE MEASURE 16130

7.1 ALIGNMENT TERMINOLOGY

Wheel Camber

The amount the wheels are inclined from the vertical plane (A, Fig. 18).

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. 18).

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. 18).

Front Axle Caster

The inclination of the king pin from vertical in the fore and aft direction (C, Fig. 18).

7.2 FRONT END INSPECTION

Before checking front end alignment, make the following inspection:

1. Check that the vehicle is at normal ride height (see paragraph "11. 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. 18). Check if the length of the relay rod is 23 19/64" (592 mm).

7.3 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 looking 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.

7.4 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.

7.4.1 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 ±1/32 of an inch less than the rear measurement.

7.4.2 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 "6.4.1 Toe-in Check" of this Supplement.
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 6.

NOTE
Use only tie rods to adjust toe-in.

7.5 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.

7.6 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 "7: Front End Alignment".

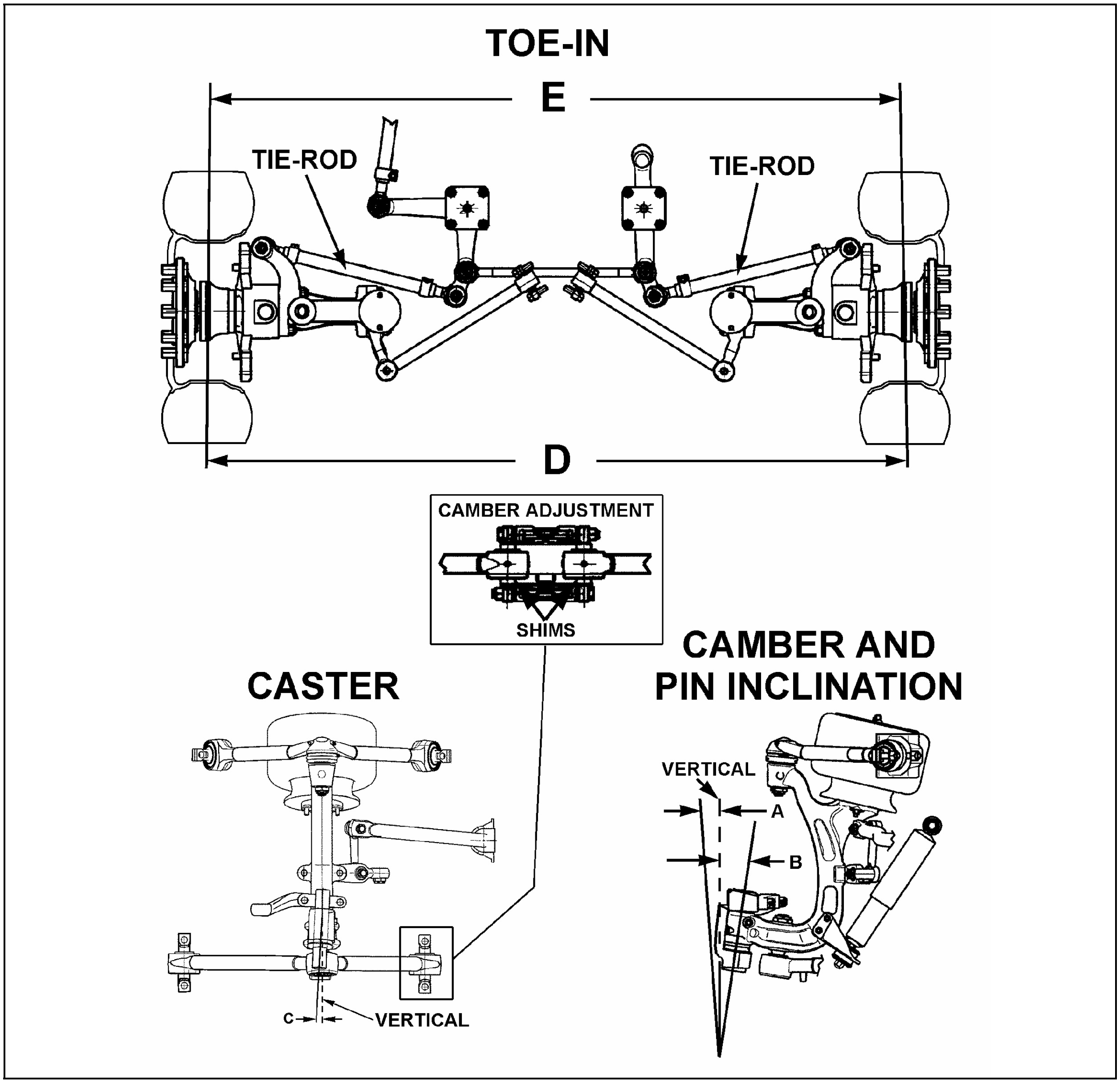


FIGURE 19: FRONT END ALIGNMENT DIAGRAM

16134

ALIGNMENT SPECS (See Figure 19)				
		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	TOE-IN	0.08	0.13	0.17

8. 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.

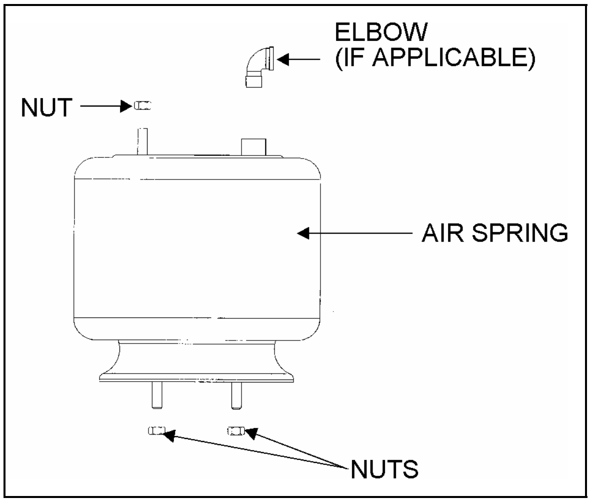


FIGURE 20: AIR SPRINGS 16052

8.1 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.

8.2 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.

8.3 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.

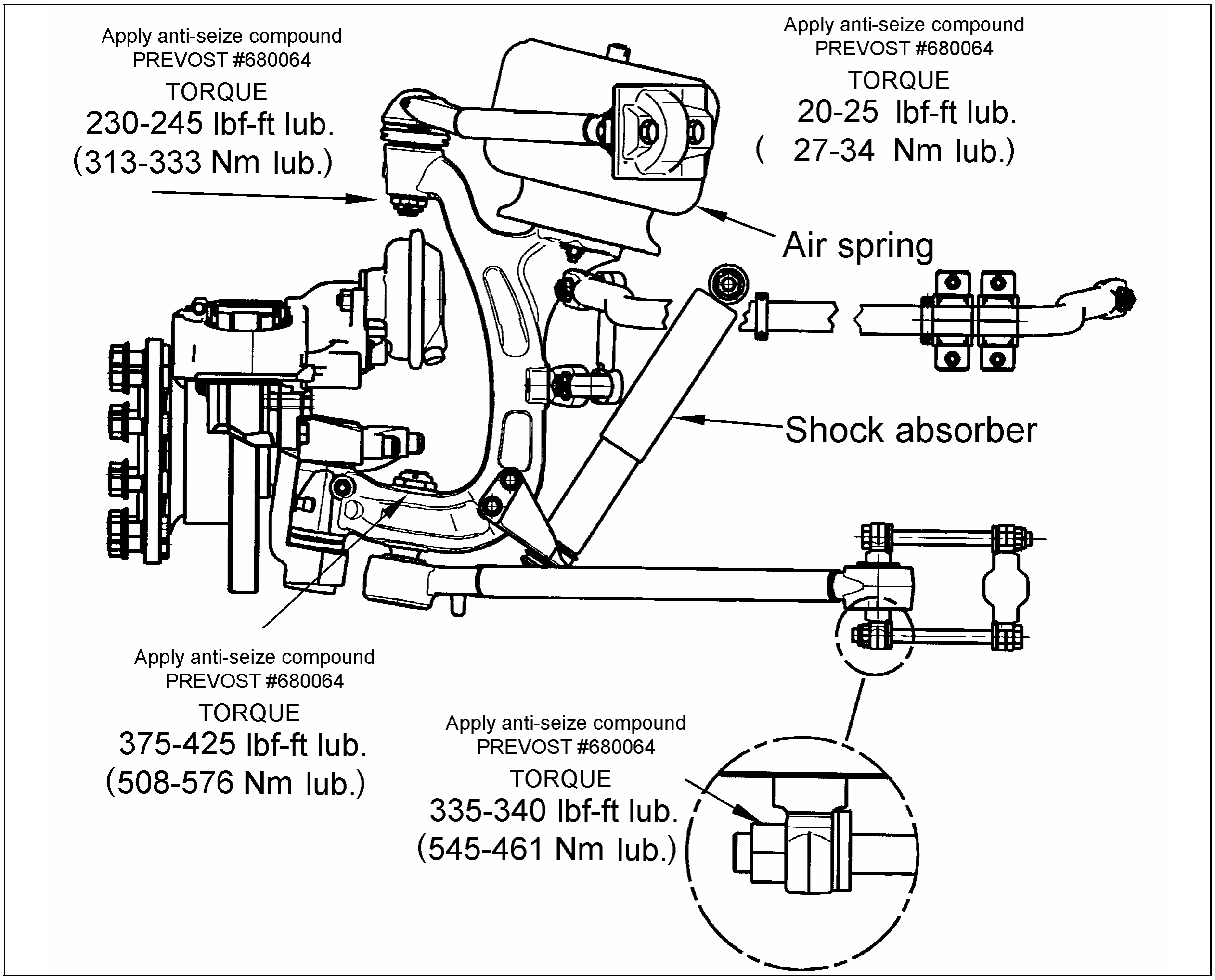


FIGURE 21: AIR SPRING AND SHOCK ABSORBER 16145

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.

9. 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.

9.1 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 22 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.

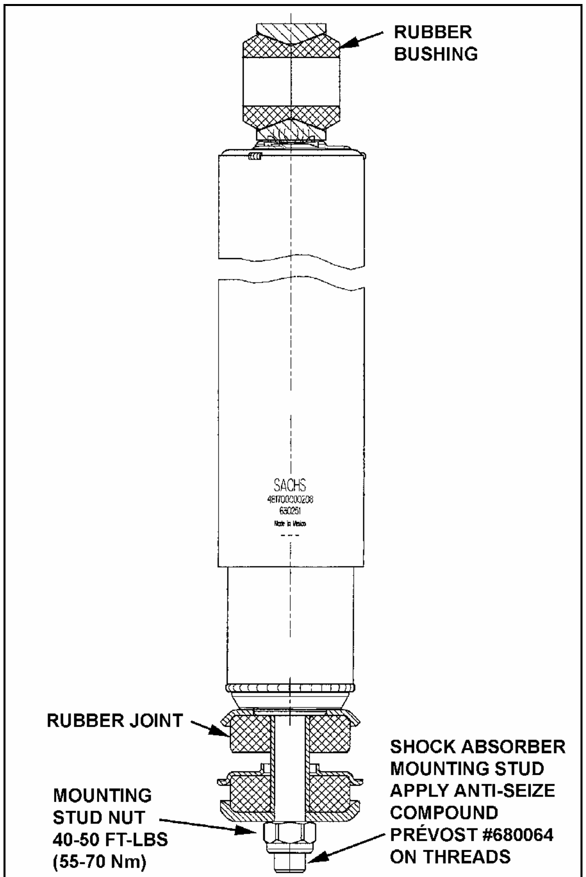


FIGURE 22: SHOCK ABSORBER 16112

9.2 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. 22).
4. Install washer and rubber joint on shock absorber mounting stud (lower side).
5. Install the shock absorber as shown in figure 18 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).

10. SWAY BAR

A sway bar is provided on the front and drive axles to increase vehicle stability. It controls lateral motion (swaying movement) of vehicle.

10.1 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.

10.2 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.

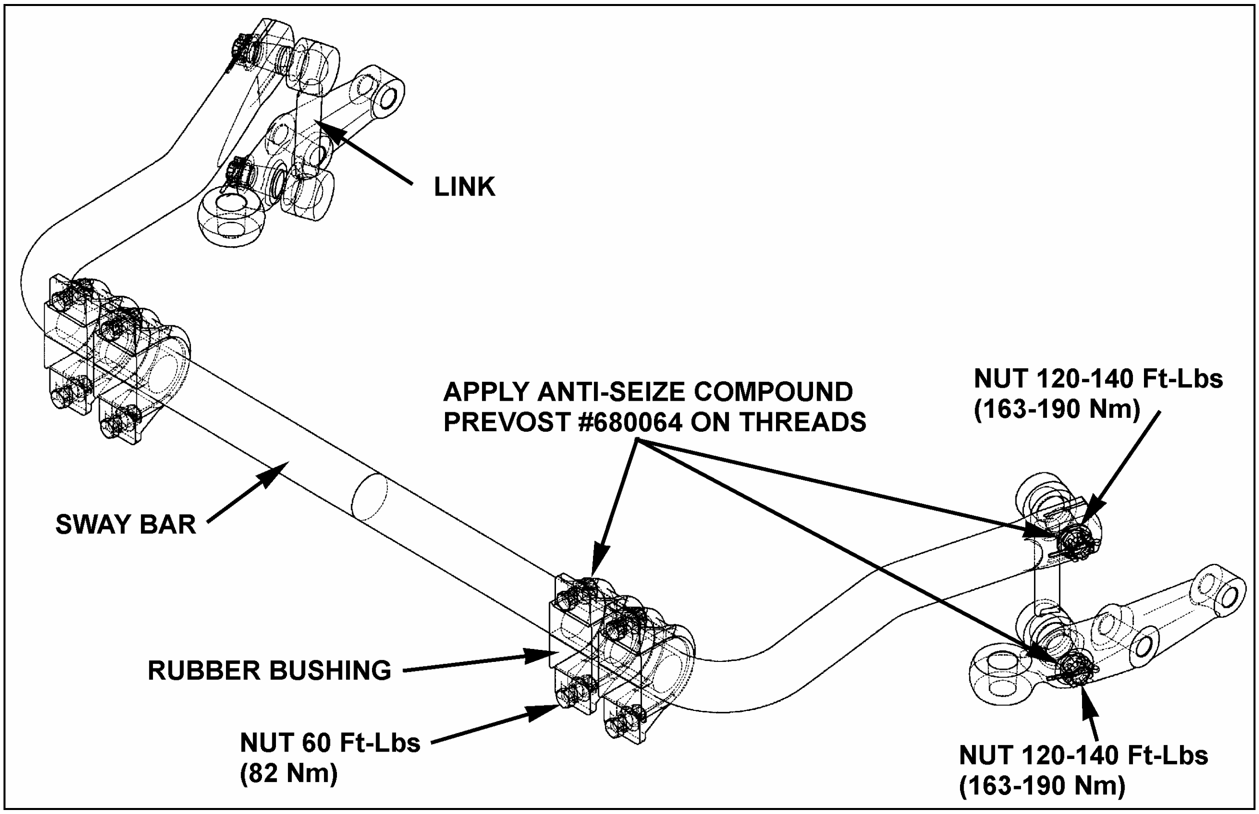


FIGURE 23: SWAY BAR (FRONT SUSPENSION) 16055

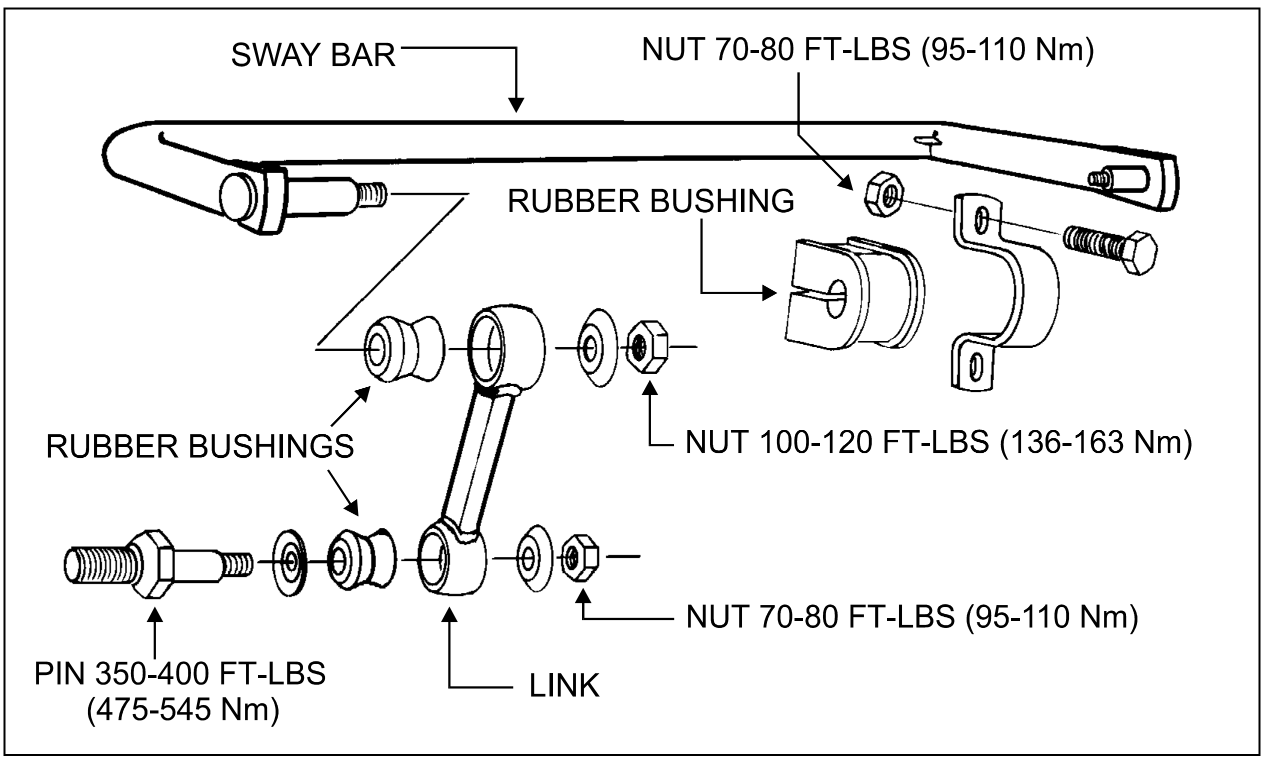


FIGURE 24: SWAY BAR (REAR SUSPENSION) 16014

11. 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 ± ¼" (279 ± 6 mm). Refer to figure 25 to identify the correct area to take measurement. The rear air springs clearance should be 11 ½ ± ¼" (292 ± 6 mm) (refer to Maintenance Manual, Section 16, under "Suspension Height Adjustment" for rear height control valves' adjustment).

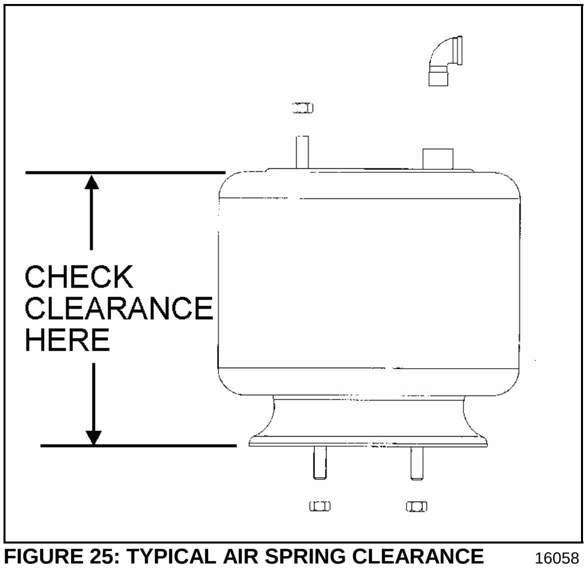


FIGURE 25: TYPICAL AIR SPRING CLEARANCE 16058

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.

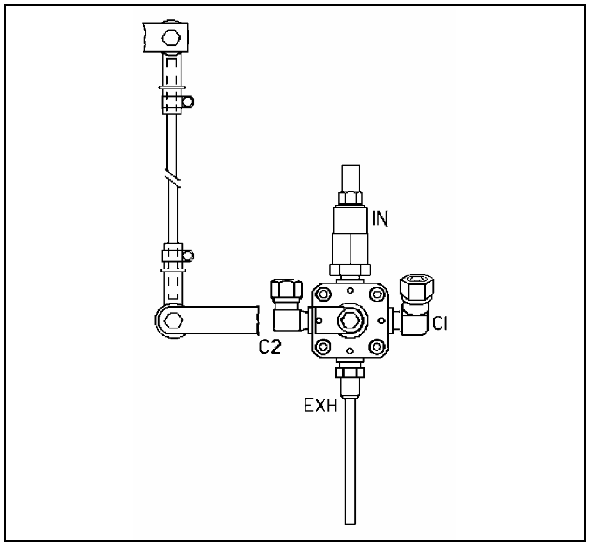


FIGURE 26: FRONT HEIGHT CONTROL VALVE 16100

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 ± ¼" (279 ± 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 25 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. 26).

NOTE
Allow suspension to stabilize before taking reading.

When the desired height is obtained, tighten clamp.

Rear air springs clearance

Refer to XL2 Maintenance Manual, Section 16, under "Suspension Height Adjustment".

12. 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:

12.1 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.

12.2 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.

12.3 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.

12.4 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.

12.5 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.

13. 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 supplement 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. 27).

In addition, an expansion air tank is installed in series with each air spring.

13.1 AIR TANK MAINTENANCE

Ensure that the accessory 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. 29).

Moreover, purge all tanks by their bottom drain valves at specified intervals.

13.1.1 Wet Air Tank

This tank is installed above L.H. wheel of drive axle, 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. 28).

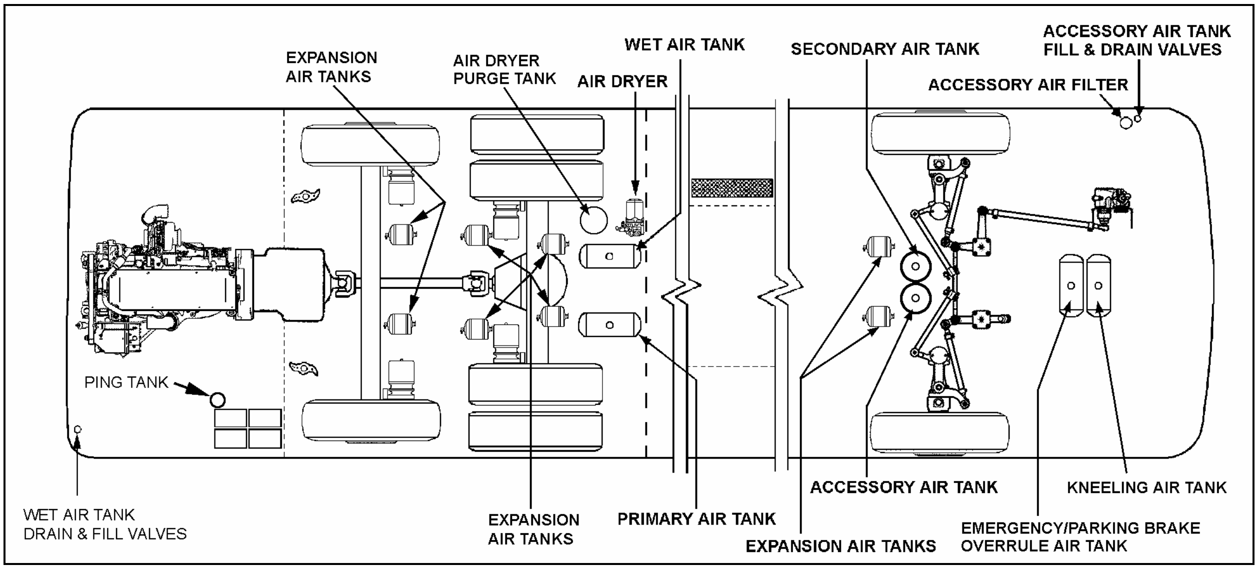


FIGURE 27: LOCATION OF AIR TANKS 24007C

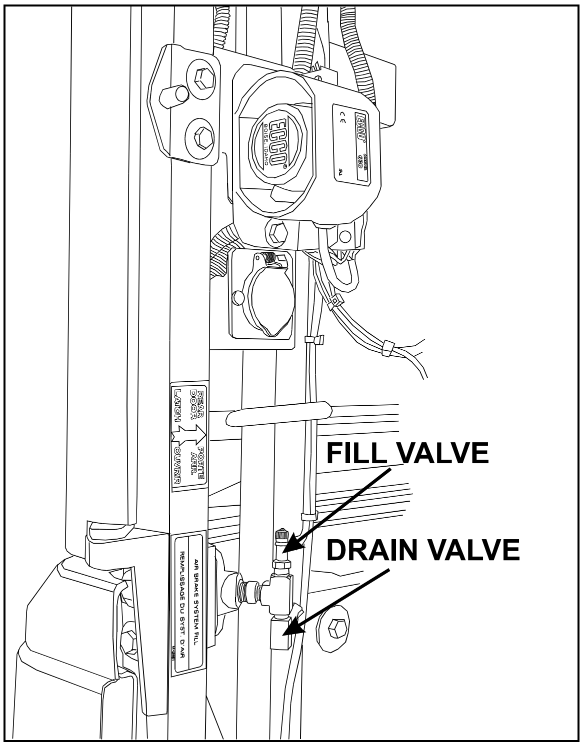


FIGURE 28: REAR VALVE LOCATION 12202

13.1.2 Primary Air Tank

The primary air tank is located above R.H. wheel of drive axle.

This tank is provided with a bottom drain valve (Fig. 27). 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.

13.1.3 Secondary Air Tank

This tank is located in front wheelhousing, between air springs. The tank is installed vertically and is provided with a bottom drain valve (Fig. 27).

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.

13.1.4 Accessory Air Tank

The accessory air tank is installed next to the secondary air tank. The tank is installed vertically and is provided with a bottom drain valve (Fig. 27).

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. 28) underneath the accessory air filter. Refer to Section 12, paragraph "4. Accessory Air Filter" of the maintenance manual for daily purge procedure.

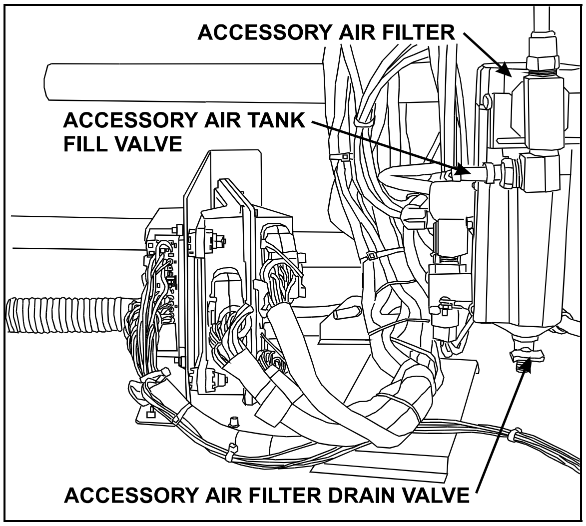


FIGURE 29: FRONT VALVE LOCATION 12201

13.1.5 Expansion Air Tank

Two expansion tanks are located in front wheelhousing. These air tanks are located behind secondary and accessory air tank. Also, six expansion tanks are located near rear air springs (Fig. 27). 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.

13.2 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. 28).

⚠ 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. 29).

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.

14. 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 *"Front Axle".*

15. TORQUE TABLE

DESCRIPTION	***QTY***	***REFERENCE***	***TORQUE (DRY) Lbf-ft / Nm***	
Pitman Arm to Steering Gear Fixing Nut	*1*	*8*	*400-450*	*545-610*
Drag Link to Pitman Arm Stud Nut *****	*1*	*---*	*160-215*	*220-290*
Drag Link to Bell crank Stud Nut *****	*1*	*---*	*160-215*	*220-290*
Drag Link Socket End Clamp Bolt Nut	*2*	*---*	*40-60*	*55-80*
Relay Rod to Bell crank Stud Nut *****	*1*	*---*	*160-215*	*220-290*
Relay Rod to Idler Arm Stud Nut *****	*1*	*5*	*160-215*	*220-290*
Tie Rod to Bell crank Stud Nut *****	*1*	*---*	*160-215*	*220-290*
Tie Rod to Idler Arm Stud Nut *****	*1*	*5*	*160-215*	*220-290*
Tie Rod to Steering Arm Stud Nut *****	*2*	*3*	*160-215*	*220-290*
Tie Rod End Clamp Bolt Nut	*4*	*3*	*40-60*	*55-80*
Steering Arm to Swivel Nut *****	*4*	*---*	*190*	*260*
Torque Rod Stud Nut	*2*	*4*	*160-215*	*220-290*
Idler Arm and Bell Crank Cap Screws	*8*	*9*	*8*	*11*
Torque Rod Mounting Bracket Nut	*4*	*6*	*75-140*	*100-190*
Torque Rod Clamp Nut	*4*	*4*	*53-59*	*72-80*
Jacking Point Bracket Nut	*8*	*19*	*70-80*	*95-110*
Bushing Collar Nut	*8*	*20*	*72-88*	*98-120*
Sway Bar Link Upper Nuts (Rear Suspension)	*2*	*20*	*100-120*	*135-160*
Sway Bar Link Lower Nuts (Rear Suspension)	*2*	*20*	*70-80*	*95-110*

DESCRIPTION	***QTY***	***REFERENCE***	***TORQUE (Lubricated) (Anti-Seize #680064) Lbf-ft / Nm***	
Idler Arm and Bell Crank Mounting Bracket Nut	*8*	*5*	*90-120*	*120-160*
Shock Absorber Mounting Stud Nut	*2*	*19*	*40-50*	*55-70*
Shock Absorber Pin Nut	*2*	*19*	*70-85*	*95-115*
Air Spring Nut	*3*	*18*	*20-25*	*27-34*
Sway Bar Link Upper and Lower Nuts (Front Suspension)	*2*	*20*	*120-140*	*160-190*
Upper A-Arm Stud Nut *****	*2*	*18*	*230-245*	*315-335*
Lower A-Arm Bracket Nut	*8*	*18*	*375-425*	*510-580*

DESCRIPTION	***QTY***	***REFERENCE***	***TORQUE (Lubricated) (Loctite #242 Blue) Lbf-ft / Nm***	
Shock Absorber Pin	*2*	*19*	*350-400*	*475-545*
Steering Gear to Mounting Bracket Bolt	*5*	*8*	*355*	*485*

- **Tighten nut to specified torque, then advance to next aligning cotter pin slot and install a new cotter pin.**

16. SPECIFICATIONS

Front Axle Air Springs

Make .... Goodyear Tire and Rubber
Diameter .... 14.5 inches
Air Inlet .... 1/2''- 14 NPTF
Supplier number 1R14-167
Prévost number 630239

Shock Absorbers

Collapsed length .... 350 mm
Extended Length .... 560 mm
Supplier number 481700000208
Prévost number 630251

Height Control Valve

Make .... Barksdale
Supplier number .... 52321POAQ3-Q26 and 52321POAQ3-Q62
Prévost number .... 630156 and 630157

Steering Gear Box

Make .... ZF-Servocom
Supplier number 8098-988-570
Prévost number 661045

Steering Gear Box (Optional)

Make .... ZF-Servocomtronic
Supplier number 8098-988-571
Prévost number 661044

Power Steering Hydraulic Pump

Make .... TRW
Supplier number PS251616L10200
Prévost number 661070

Shim (Camber Adjustment)

Thickness .... 3.175 mm
Prévost number 160993
Thickness .... 6.35 mm
Prévost number 160992

Sway bar bushing (Drive Axle)

Make .... Prévost
Prévost number 130953

SACHS

Guideline to Evaluate Warranty Claims

Heavy-duty Shock Absorbers

Index:

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

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

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

SACHS

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

CONTENTS

ILLUSTRATIONS

1. VEHICLE EXTERIOR

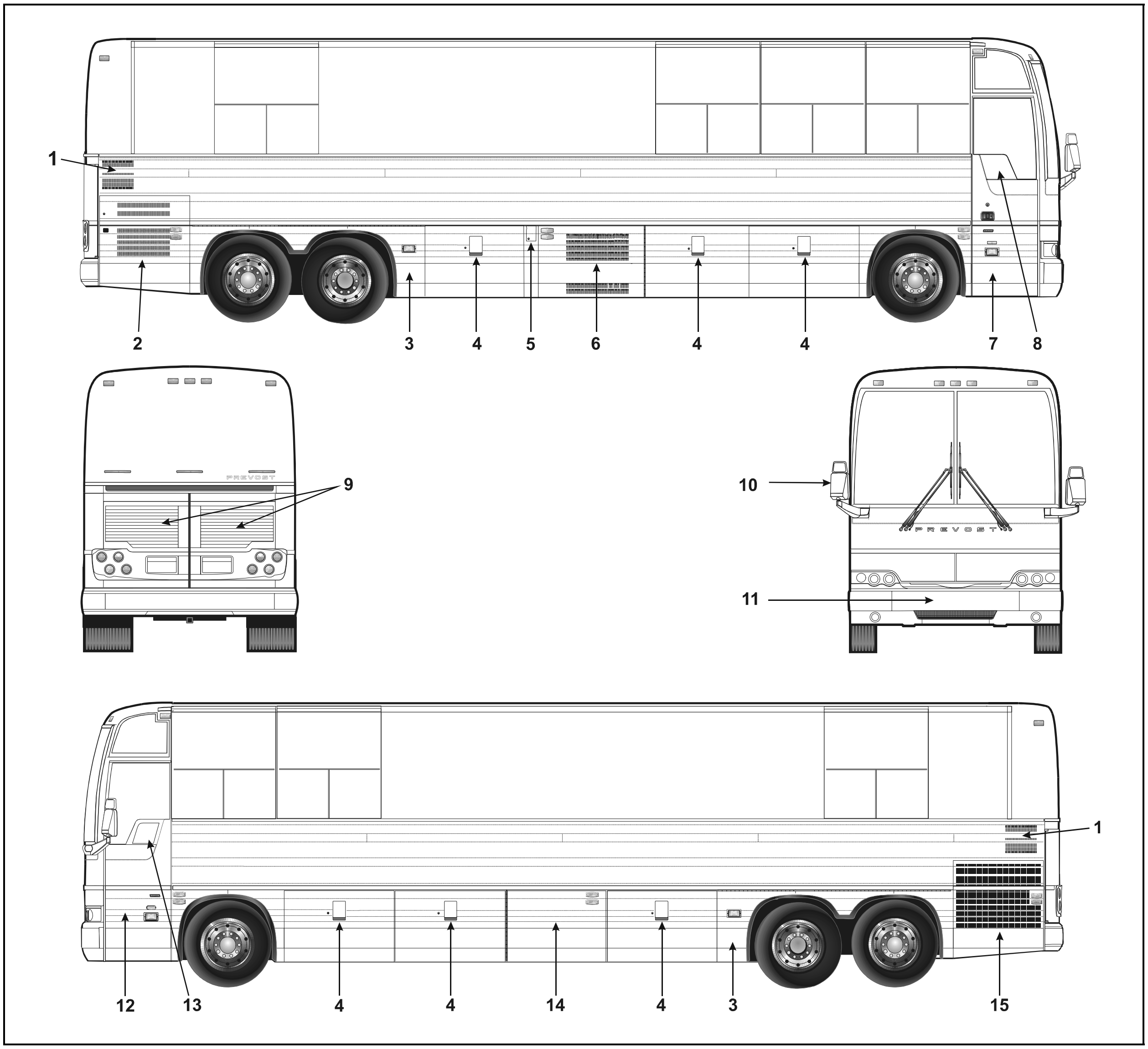


FIGURE 1: XL2-40 CONVERTED VEHICLE EXTERIOR VIEW (TYPICAL)

1. Engine air intake duct
2. Engine compartment R.H. side door
3. Hinged rear fender
4. Baggage compartment
5. Fuel filler door
6. Condenser compartment or Baggage compartment
7. Entrance door
8. Entrance door power window
9. Engine compartment rear doors
10. Rear-view mirror
11. Reclining bumper
12. Front service compartment
13. Driver's power window
14. Evaporator compartment or Baggage compartment
15. Radiator door

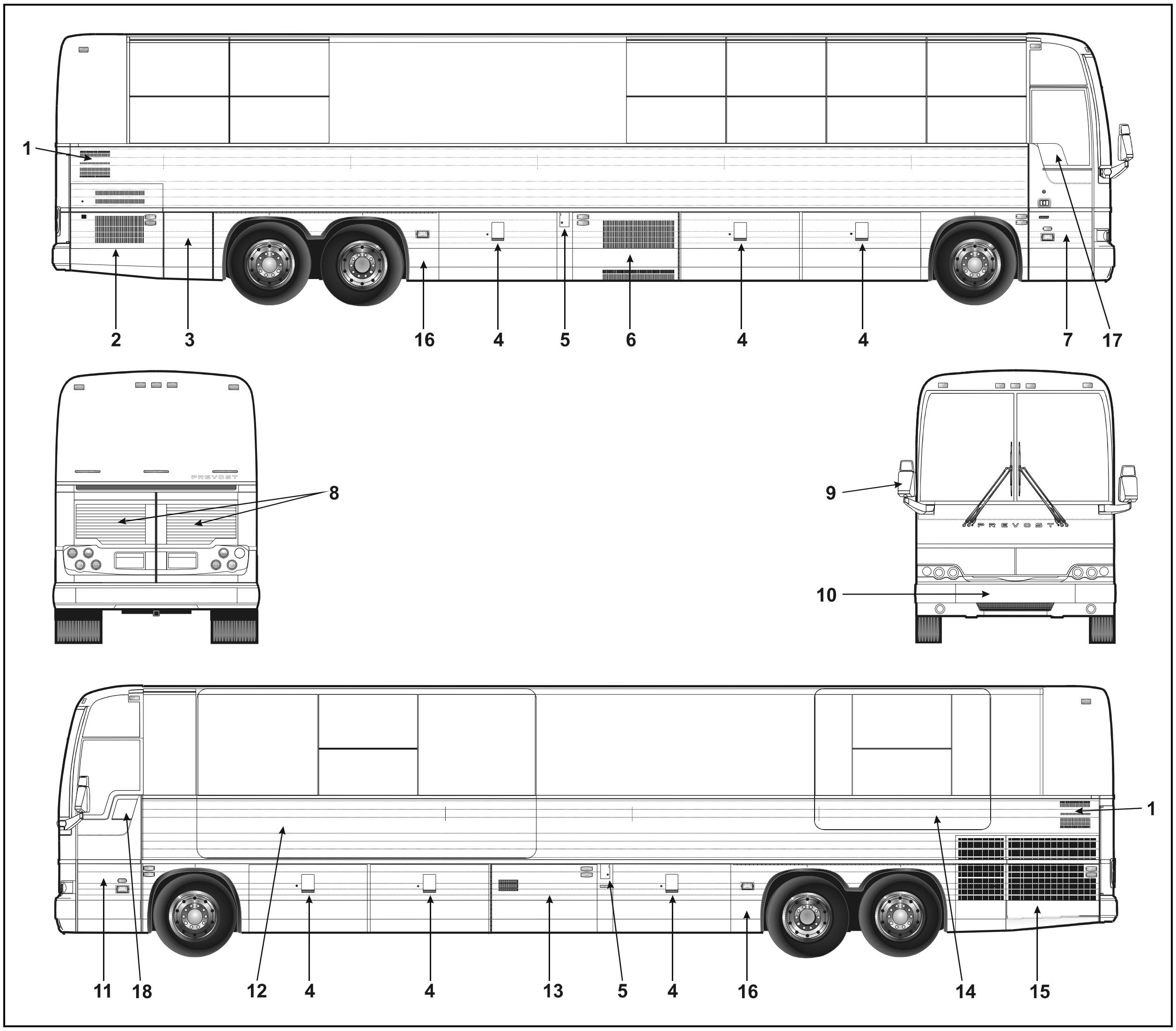


FIGURE 2: XL2-45 CONVERTED VEHICLE EXTERIOR VIEW (TYPICAL) 18362

1. Engine air intake duct
2. Engine compartment R.H. side door
3. R.H. side rear service compartment
4. Baggage compartment
5. Fuel filler door
6. Condenser compartment or Baggage compartment
7. Entrance door
8. Engine compartment rear doors
9. Rear-view mirror
10. Reclining bumper
11. Front service compartment
12. Front Slide-Out (Optional)
13. Evaporator compartment or Baggage compartment and access to Slide-out electrical panel
14. Rear Slide-Out (Optional)
15. Radiator door
16. Hinged rear fender
17. Entrance door power window
18. Driver’s power window

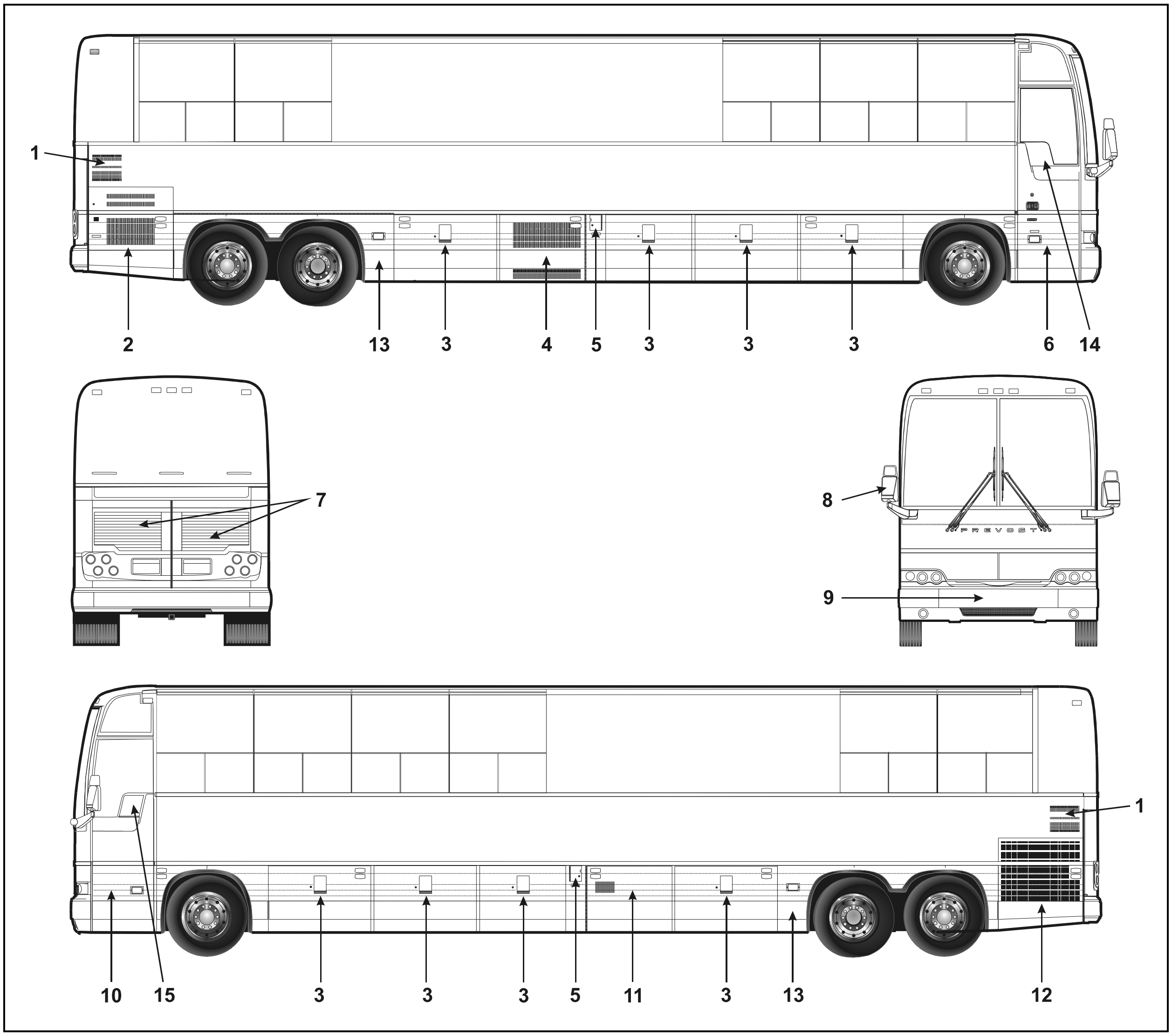


FIGURE 3: XL2-45E CONVERTED VEHICLE EXTERIOR VIEW (TYPICAL) 18369

1. Engine compartment R.H. side door
2. Engine air intake duct
3. Baggage compartment
4. Fuel filler door
5. Condenser compartment or Baggage compartment
6. Entrance door
7. Engine compartment rear doors
8. Rear-view mirror
9. Reclining bumper
10. Front service compartment
11. Evaporator compartment or Baggage compartment
12. Radiator door
13. Hinged rear fender
14. Entrance door power window
15. Driver's power window

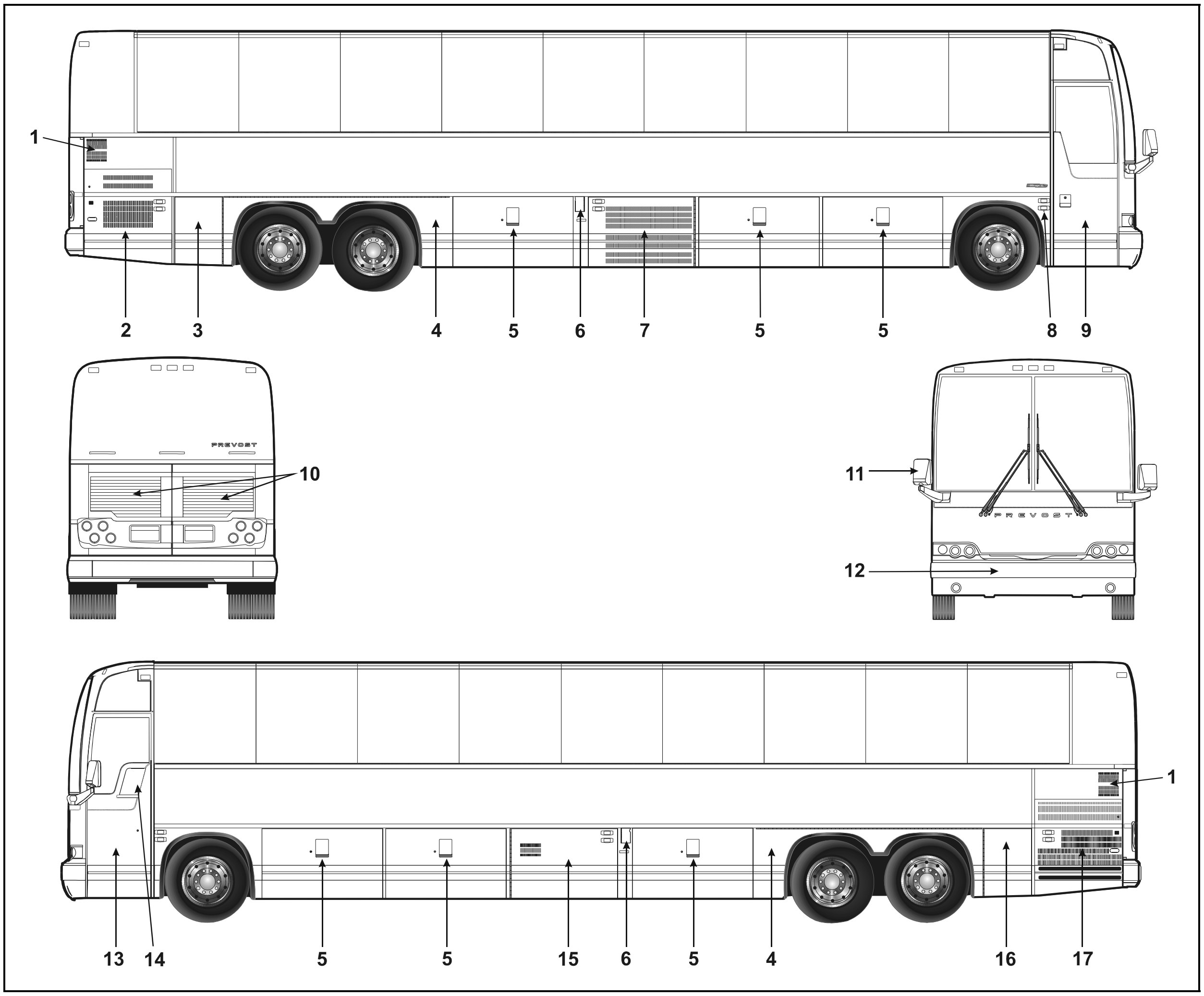


FIGURE 4: XL2-45 COACH EXTERIOR VIEW (TYPICAL) 18367

1. Engine air intake duct
2. Engine compartment R.H. side door
3. Main Power compartment
4. Hinged rear fender
5. Baggage compartment
6. Fuel filler door
7. Condenser compartment
8. Entrance door control switch
9. Entrance door
10. Engine compartment rear doors
11. Rear-view mirror
12. Reclining bumper
13. Front service compartment
14. Driver's power window
15. Evaporator compartment
16. L.H. Rear service compartment
17. Radiator door

2. STRUCTURE

The body of the XL2 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. 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 UNDER-STRUCTURE AND VISUALLY INSPECT FOR CALCIUM DEPOSIT, CORROSION OR ANY DIRT ACCUMULATED ONTO EXPOSED SURFACES. VISUALLY INSPECT SEALING BEADS CONDITION. VISUALLY INSPECT IF UNDERFLOOR IS PEALING. 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		

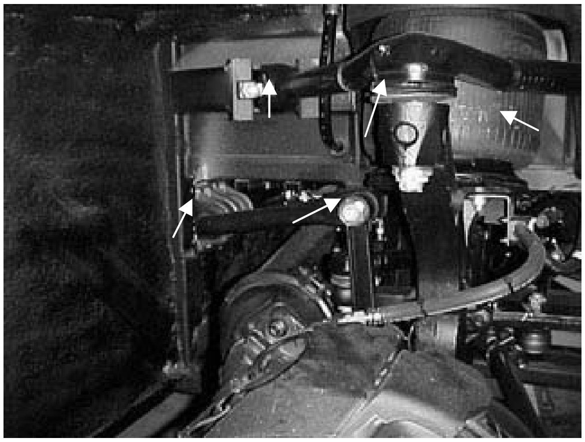
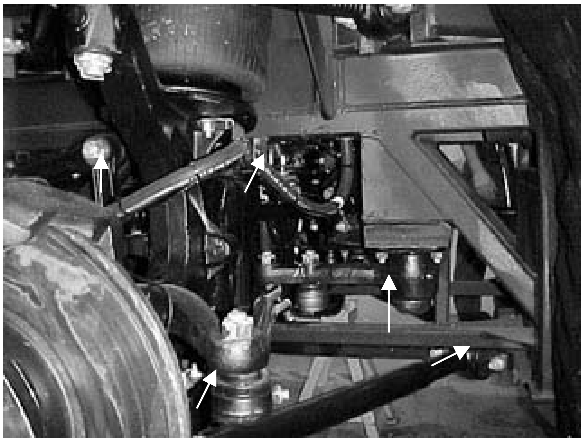
⚠ WARNING ⚠
Failure to follow this preventive maintenance schedule will result in warranty void.

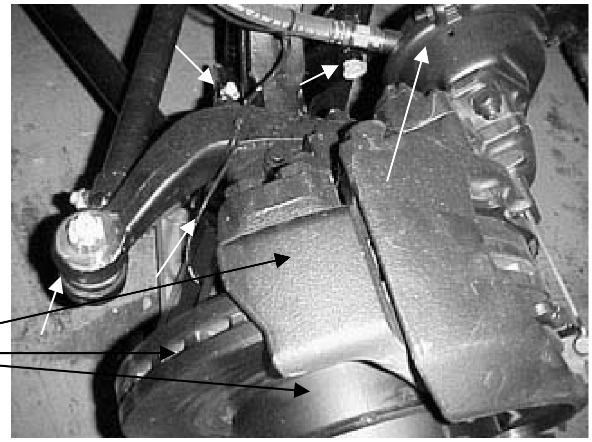
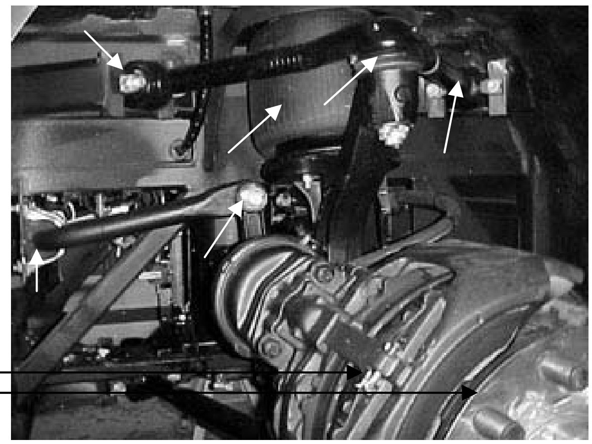
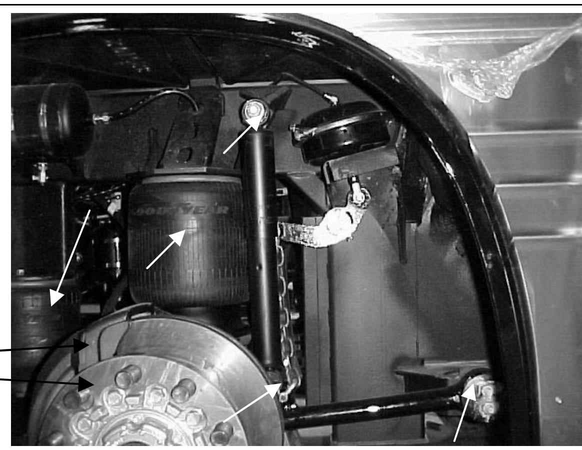
3.3 RUST INHIBITOR APPLICATION

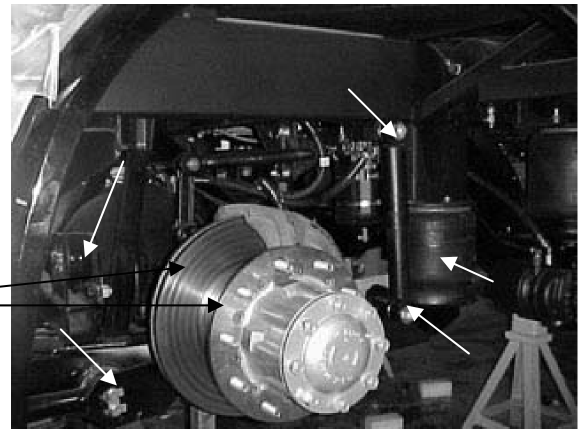
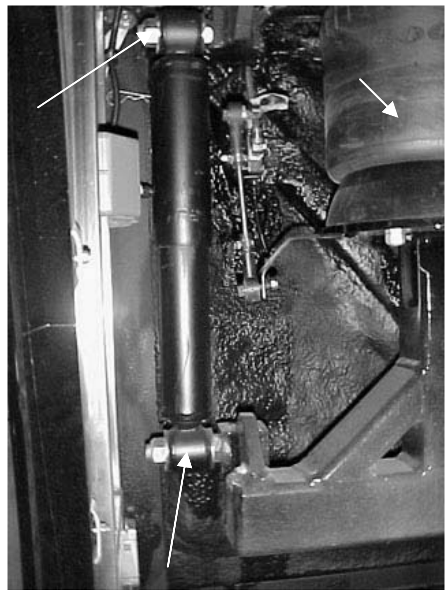
Material: Tectyl 185 GW
R1KG21

Safety Rules: Use safety glasses
Supplied air hood

Solvent-resistant rubber gloves

1.0 Wash both wheelhousing mechanical parts before masking.	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.
2.0 Dry all water sprayed parts. Surface temperature and dew point must be respected before applying rust inhibitor.	Air pressure system may be used, refer to annex 1 for surface temperature and dew point.
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.	
3.1 **Front wheelhousing** Front view	
3.2 **Front wheelhousing**	

3.3 **Front wheelhousing** (Entire braking system)	
4.0 **Rear wheelhousing** a) Mask all rubber joints. Braking system must also be protected (refer to arrows). Commercial aluminum foil may be used for masking (Entire braking system)	
4.1 **Rear wheelhousing** (Entire braking system)	

4.2 **Rear wheelhousing** (Entire braking system)	
4.3 **Rear wheelhousing**	
5.0 Close off wheelhousing using masking paper.	Prevent rust inhibitor from coming in contact with paint. To close off wheelhousing, a polythene sheet may be used.
6.0 Apply TECTYL 185 GW black rust inhibitor onto wheelhousing mechanical parts.	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**.
7.0 Remove all masking material 30 minutes after application.	

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. FIBERGLASS REPAIR

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 ^{o}F (21-24 ^{o}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
Roughening the surface improves adhesion of resin.

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 ^{o}F (60 ^{o}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. 5).

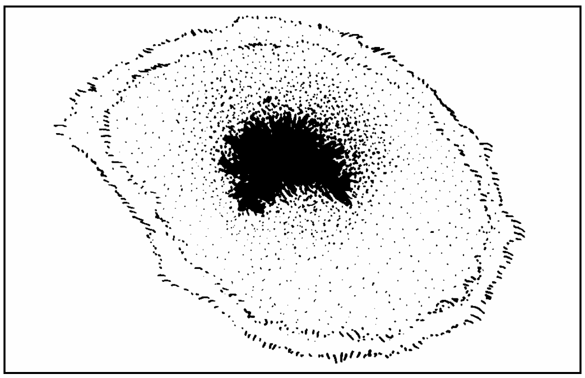


FIGURE 5: FIBERGLASS REPAIR 18089

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. 6).

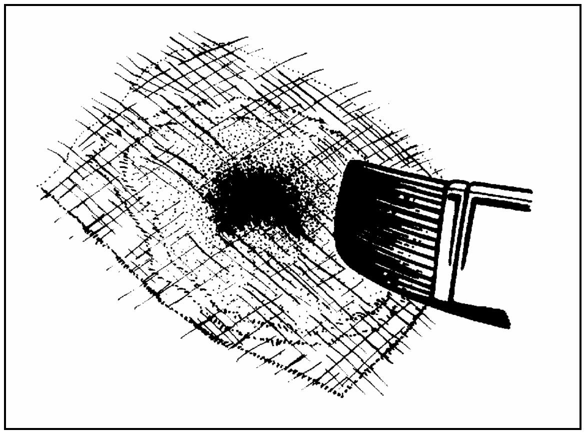


FIGURE 6: FIBERGLASS REPAIR 18090

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. 7).

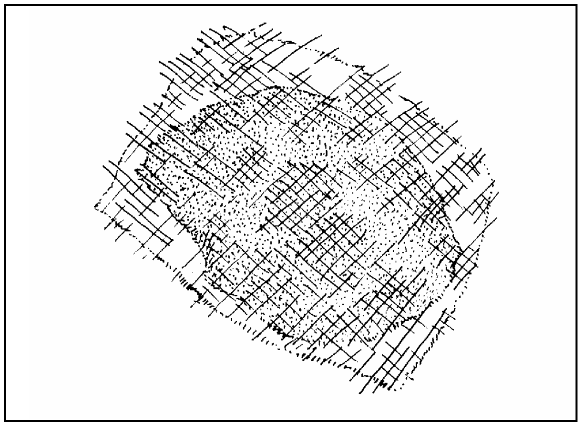


FIGURE 7: FIBERGLASS REPAIR 18091

Allow area to harden and contour the area with coarse sandpaper #100 (Fig. 8).

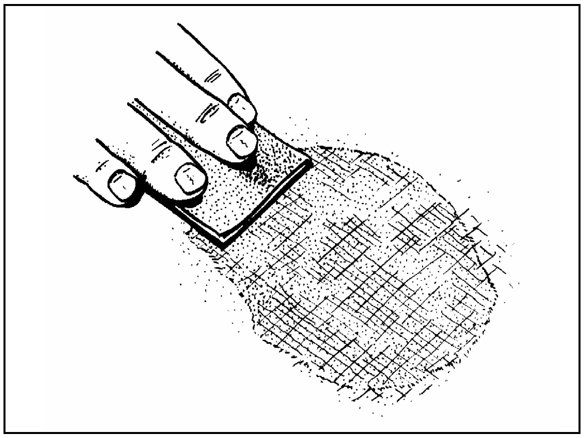


FIGURE 8: FIBERGLASS REPAIR 18092

Cover the area with a layer of resin putty and allow drying for approximately 15 to 20 minutes (Fig. 9).

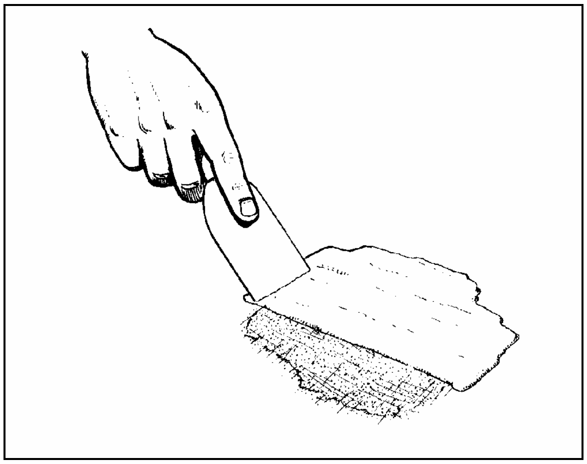


FIGURE 9: FIBERGLASS REPAIR 18093

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. PAINTING

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 Standox "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 Füllprimer ST-11000 (68-2973)	STANDOX Non-Stop Füllprimer 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

6. BODY REPAIR

NOTE
The purpose of this procedure is to explain the steps to be followed in order to get a good adherence. These steps are of the uppermost importance to obtain 100 % adherence. For a complete description of the procedure, refer to the applicable video.

6.1 FRONT FACE

6.1.1 Front Face Body Panel And Molding

For removal of front face body panel and molding, you will need:

Drill with drill bits,
Lever or similar tool,
Olfa knife,
"C"-clamp,
Razor sharp window scraper.

Front Face Molding Removal

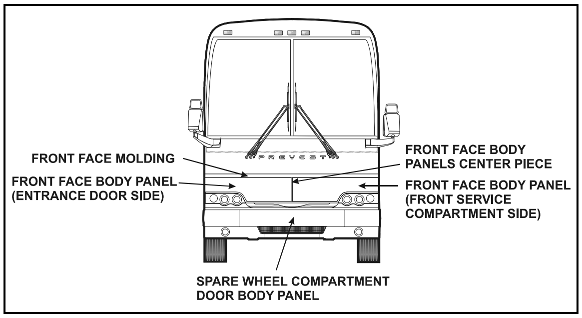
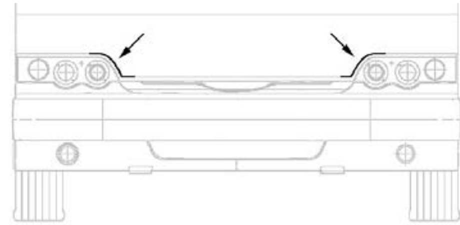
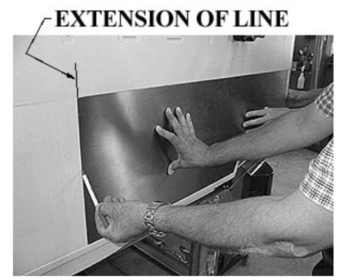
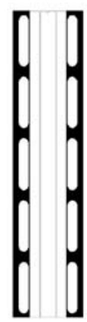
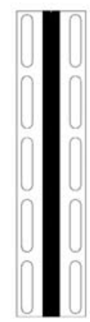
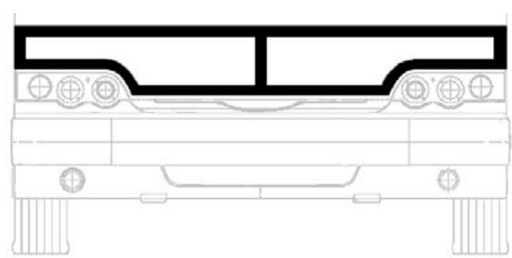


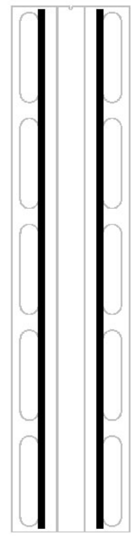
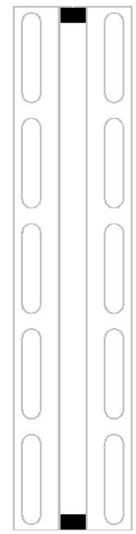
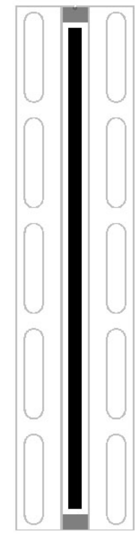
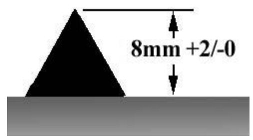
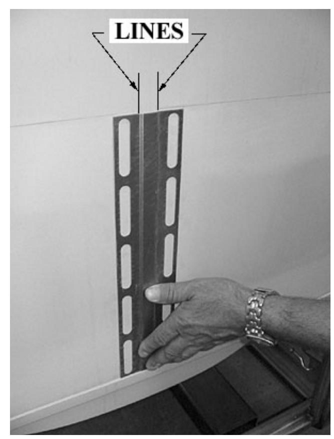
FIGURE 10: VIEW OF FRONT FACE

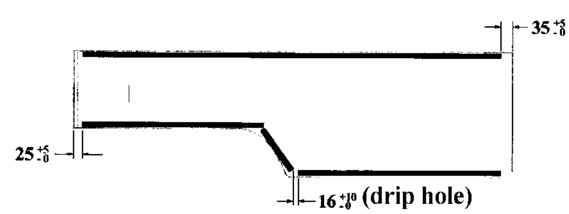
- First of all, pry loose the front face molding using the lever. Save molding if only the body panel needs to be changed.
- Using the Olfa knife, cut the Sika bead and the double-face self adhesive tape. Remove the Sika bead and self adhesive tape residue with the scraper.

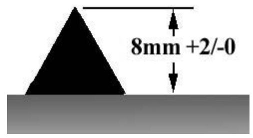
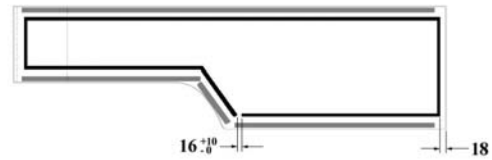
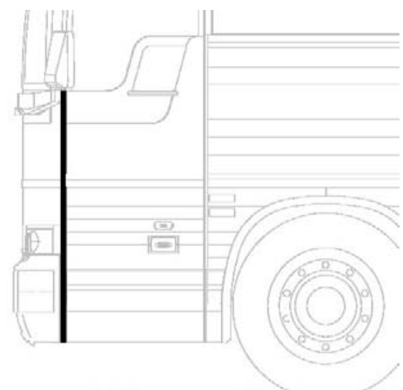
Front Face Body Panel Removal

- Using a drill and a 1/8" drill bit remove the rivets fixing the vertical molding. The stainless steel molding is located on the entrance door or service door frame side depending on body panel to be removed.
- Using the Olfa knife, cut the Sika bead and the double-face self adhesive tape. Remove the Sika bead and self adhesive tape residue with the scraper.
- Pry loose the front face body panel using the lever.
- While somebody cuts the Sika bead and double-face self adhesive tape, another person pulls the body panel using the "C"-clamp to exert tension.
- Using the window scraper, remove any Sika bead or self adhesive tape residue left on fiber glass surface.

Step		Description	Illustration
1.00		Check condition of panels.	
1.05		**Panel Positioning**	
	A)	Position the panel so that its outline follows the contour of the headlamp.	
	B)	Draw a line on the side of the panel for reference. Extend the line above the panel.	
1.10 *		**S/S Panel Preparation**	**Top**  **Bottom** 
	A)	Clean using anti-silicone. *(See PR000001, Section A)*	
	B)	Sand using Scotchbrite. *(See PR000001, Section G)*	
	C)	Clean using anti-silicone. *(See PR000001, Section A)*	
	D)	Apply Sika 205. *(See PR000001, Section B)*	
1.15		**Fiberglass Preparation**	
	A)	Sand using Scotchbrite. *(See PR000001, Section G)*	
	B)	Clean using tack cloth.	
	C)	Clean using anti-silicone. *(See PR000001, Section A)*	

	D)	Apply Sika 205. *(See PR000001, Section B)*	
1.20	**Center Piece Installation**		A)  B)  C) 
	A)	Apply double-face tape **1/32 X ¼** on top of center piece.	
	B)	Apply double-face tape **1/8 X ¼** underneath center piece.	
	C)	Apply some Sika 252. *Triangular shape bead* 	
	D)	Center and position center piece with reference to the lines performed at step 1.05 B. *Note: Position center piece before compressing* double-face tape.	

1.25	**L.H. & R.H. Panel Installation**		
	A)	Apply double-face tape **1/16 X 1/4** about 1mm from panel edge.	

	B)	Apply Sika 252. *Triangular shape bead* 	
	C)	Position and glue side panels with reference to the lines draw at step 1.05 B). Compress side panel using a blackboard eraser. *Note: Position side panel before compressing double-face tape.*	
	D)	If applicable, remove excess of Sika using a spatula and clean surfaces using Sika 208.	
1.30	A)	Position entrance door or service door frame vertical molding.	
	B)	Drill using a **#30** drill bit & rivet.	

6.1.2 Spare Wheel Compartment Door Body Panel

For the removal of spare wheel compartment door body panel,

You will need:

A hammer,
Screwdriver,
Locking pliers,
Putty knife,
Heat gun,

- And isopropyl alcohol.
- Lower and remove front bumper.
- Remove spare wheel compartment door.
- First of all, using a lever or rigid screwdriver, pry loose body panel edge.
- Using a pair of locking pliers, gradually separate stainless steel body panel from door frame.
- Use the screwdriver to detach completely the stainless steel body panel from door frame.

Door Frame Preparation

- Start cleaning the door frame by removing double-face self adhesive tape.
- Use a heat gun and putty knife to remove the dried off Ciba 8535 epoxy glue residue.

⚠ WARNING ⚠

Make sure that heat gun nozzle does not get any closer than 4 inches from the surface.

⚠ WARNING ⚠

Because of its great toxicity, care should be taken not to use a buffer or other sanding method for glue removal.

- Then, using a scratch pad “Scotch Brite”, scratch the perimeter of door frame where the adhesive will be applied.
- Wear latex gloves and use a “Chix” cloth with isopropyl alcohol in order to remove any residue from scratching left onto the stainless steel surface.

NOTE

Apply evenly around the perimeter of the panel. Use two clothes, first one applies product while second one immediately dries surface off before product evaporation.

Body Panel Preparation

- Using a scratch pad “Scotch Brite”, scratch a 2 inch wide surface around the perimeter of the panel where the adhesive will be applied.
- Use a Chix cloth and anti-silicone to remove any dust or residue.
- Clean the perimeter of the panel using isopropyl alcohol. Use two clothes, first one applies product while second one immediately dries surface off before product evaporation.

Sikaflex 252 Adhesive Sealant Application

- Check Sikaflex 252 adhesive sealant for expiration date.
- Cut ¼ of V shape nozzle length for proper flow of glue. Perforate cartridge tip.
- Apply Sika bead along the perimeter of body panel ½” from double-face self adhesive tape.
- Peel the back from the self adhesive tape.

⚠ CAUTION ⚠

You only have 10 minutes to install the body panel before the adhesive starts to dry.

Stainless Steel Body Panel Installation

- Stainless steel body panel must be installed within 45 minutes.
- Align body panel with door frame and lightly press perimeter of body panel.
- Allow to dry for 6 hours before handling.

NOTE

If for any reason you must remove the body panel from the door frame and the 6 hours have elapsed, you must wait ***7 days*** *so that glue has time to cure.*

6.1.3 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.

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. 12).
- 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.

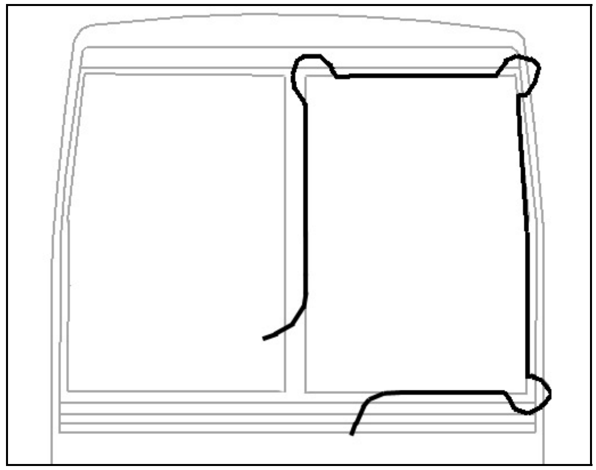


FIGURE 11: WINDSHIELD INSTALLATION USING ROPE

- Spray soapy water on a regular basis to ease this operation.
- Using the same type of plastic spatula, repeat the same operation from inside of vehicle, gradually inserting the windshield into the groove.

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. 13).
- 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.

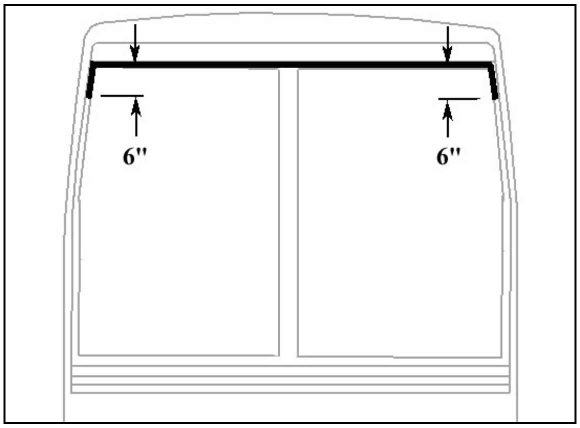


FIGURE 12: APPLICATION 0F SIKA 221 BLACK

- When filler insertion is almost complete, cut filler leaving ¼" of excess length to thwart filler contraction over time then insert filler into groove.
- Reinstall center post and interior finishing panels.
- Clean windshield surface of butyl residue.

6.2 ENTRANCE DOOR OR FRONT SERVICE DOOR BODY PANEL

For the removal of entrance door or front service door body panel, you will need:

Pneumatic "Zip gun" type tool;
Razor sharp window scraper;

- Before removing body panel, you can to ease repair uninstall entrance door or front service door from vehicle. If applicable, remove reflector, keyless system keyboard and cornering light.
- You must also remove horizontal finishing molding located underneath the window. This molding is glued and will have to be replaced because it will be damaged at removal.
- Remove interior finishing panel to access rub rail fixing bolts, then remove rub rail.
- Using the "**Zip Gun**", cut Sika bead located ¼ inch (7-8 mm) from each body panel edge and around cornering light.
- Separate body panel from door.
- Remove from door surface Sika bead and double-face self adhesive tape residue using a razor sharp window scraper.
- Use a Chix cloth and anti-silicone to remove any dust or residue.

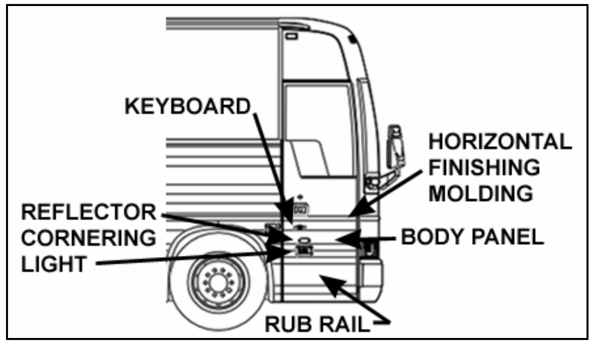


FIGURE 13: ENTRANCE DOOR BODY PANEL

Door Surface Preparation

- First of all, check Sika 205 cleaner expiration date.
- Before applying Sika cleaner, fold "Chix" cloth twice for proper width.
- Apply an even coat onto the door frame perimeter and allow to dry for 2 minutes (maximum 2 hours).
- Discard waste according to applicable environmental regulations, use dangerous waste containers.

Stainless Steel Body Panel Preparation

- Check that new body panel is the required one and is free of defects or scratches.
- Wear latex gloves and use a "Chix" cloth with isopropyl alcohol in order to remove any dirt or oily film left onto the stainless steel surface.

NOTE
Apply evenly around the perimeter of the panel. Use two clothes, first one applies product while second one immediately dries surface off before product evaporation.

- Using a scratch pad "Scotch Brite", scratch a 2 inch wide surface around the perimeter of the panel where the adhesive will be applied. The purpose being to create scratches onto the surface to increase adherence.
- Use again a chix cloth and anti-silicone to remove any dust or residue.

- Before applying Sika cleaner, fold “Chix” cloth twice for proper width.
- Apply an even coat onto the treated surface.
- Allow 2 minutes for drying in the case of stainless steel (maximum 2 hours).
- Apply a double-face self adhesive tape 1/8 by ½ inch on each side and at the top of body panel and around cornering light. Apply tape 1/8 inch from body panel edges and flush with cornering light perimeter.
- Peel back from double-face self adhesive tape.

Sikaflex 252 Adhesive Sealant Application

- Check Sikaflex 252 adhesive sealant for expiration date.
- Using a “V” shape nozzle, apply Sika bead ¼ inch (6-7 mm) from double-face self adhesive tape on all three sides of body panel and around cornering light.
- Once the body panel is compressed, the Sika bead will spread until it touches the tape.

NOTE
Sika adhesive bead height must be greater than double-face self adhesive tape.

NOTE
You only have 15 minutes to install body panel once the adhesive is applied.

- Peel the back from the self adhesive tape.
- Carefully center and align body panel edges with the door fiber glass surface.
- Ideally two persons should perform this installation.
- Lightly compress the body panel along the double-face self adhesive tape, then compress using a dry erasable marker board brush so as not to scratch or damage the stainless steel surface.
- Apply masking tape on both body panel sides.
- Using a caulking nozzle and “SIKAFLEX 221” adhesive, fill the cavity to seal both body panel sides and around cornering light.
- Wearing surgical gloves, smooth down the joint with your finger.
- Remove masking tape and protective plastic lamination.

6.2.1 Entrance Door Or Front Service Door Lower Body Panel

For the removal of entrance door or front service door lower body panel, you will need:

Pneumatic “Zip gun” type tool;
Razor sharp window scraper;

- Remove interior finishing panel to access rub rail fixing bolts, then remove rub rail.
- Remove two lower body panel fixing rivets.
- Using the “**Zip Gun**”, cut Sika bead located on each lower body panel side.
- Remove lower body panel.
- Remove Sika bead residue using a razor sharp window scraper.
- Use a Chix cloth and anti-silicone to remove any dust or residue.

Door Surface Preparation

- First of all, check Sika 205 cleaner expiration date.
- Before applying Sika cleaner, fold “Chix” cloth twice for proper width.
- Apply an even coat onto the door frame perimeter and allow drying for 2 minutes.
- Discard waste according to applicable environmental regulations, use dangerous waste containers.

Stainless Steel Body Panel Preparation

- Check that new body panel is the required one and is free of defects or scratches.
- Wear latex gloves and use a “Chix” cloth with isopropyl alcohol in order to remove any dirt or oily film left onto the stainless steel surface.

NOTE
Apply evenly around the perimeter of the panel. Use two clothes, first one applies product while second one immediately dries surface off before product evaporation.

- Using a scratch pad “Scotch Brite”, scratch a 2 inch wide surface on each side of the panel where the adhesive will be applied.

The purpose being to create scratches onto the surface to increase adherence.

- Use again a Chix cloth and anti-silicone to remove any dust or residue.
- Before applying Sika cleaner, fold “Chix” cloth twice for proper width.
- Apply an even coat onto the treated surface.
- Allow 2 minutes for drying in the case of stainless steel.

Sikaflex 252 Adhesive Sealant Application

- Check Sikaflex 252 adhesive sealant for expiration date.
- Using a “V” shape nozzle, apply Sika bead 1 inch (25 mm) from both lower body panel side edges.

NOTE
You only have 15 minutes to install body panel once the adhesive is applied.

- Insert lower body panel bottom edge under the door and underneath the upper panel and carefully center and align lower body panel side edges with the door fiber glass surface.
- Ideally two persons should perform this installation.
- Lightly compress the body panel along the Sika bead, then compress using a dry erasable marker board brush so as not to scratch or damage the stainless steel surface.
- Fix lower body panel using two rivets.
- Apply masking tape on both lower body panel sides.
- Using a caulking nozzle and “SIKAFLEX 221” adhesive, fill the cavity to seal both body panel sides.
- Wearing surgical gloves, smooth down the joint with your finger.
- Remove masking tape and protective plastic lamination.

6.3 BAGGAGE COMPARTMENT OR REAR SERVICE COMPARTMENT DOOR BODY PANEL

For the removal and installation of baggage compartment or rear service 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.

Door Lower Panel

Door lower panel is riveted only, not glued. If panel needs to be changed, remove fixing rivets using a drill and drill bits. Line up new panel and secure using 6 stainless steel rivets.

Body Panel Removal

- In the following procedure, only the door upper part needs to be changed.
- Using a drill with drill bits, remove the door upper part fixing rivets.
- 9 rivets are located in the door handle opening and 2 at the door upper edge.
- Using the “Zip Gun”, cut Sika bead located ½ 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.
- Use a second person equipped with a pair of locking pliers to bend the body panel as you cut the Sika bead. Bend body panel enough to reach around the handle and continue to detach completely the stainless steel body panel from door frame
- Using the window scraper, remove any Sika bead or self adhesive tape residue left on the fiber glass.

Body Panel Preparation

- Using a scratch pad “Scotch Brite”, scratch a 2 inch wide surface on the panel two sides and bottom part where the adhesive will be applied. The purpose being to create scratches onto the surface to increase adherence.

- Use a Chix cloth and anti-silicone to remove any dust or residue.
- Before applying Sika 205 cleaner, fold “Chix” cloth twice for proper width.
- Apply an even coat onto the treated surface.
- Allow 5 minutes for drying in the case of stainless steel.

Door Frame Preparation

- Using the window scraper, remove any Sika bead residue left on the door frame surface.
- First of all, check Sika 205 cleaner expiration date.
- Before applying Sika cleaner, fold “Chix” cloth twice for proper width. Apply an even coat onto the treated surface.
- Discard waste according to applicable environmental regulations, use dangerous waste containers.
- Allow 2 minutes for drying in the case of stainless steel.

NOTE
In the case of baggage compartment door, apply wax paste around handle opening frame and at door frame upper part.

Gluing Jig Installation

- For best results, it is important that gluing jig installation for baggage and rear service door be performed properly according to part number and dimensions.
- **For more information, refer to gluing jig setup diagram (Fig. 14).**

Rear Service Door

- Lay down stainless steel body panel into the gluing jig as per setup diagram. Ensure it is lined up and set square with the reference marks.
- Heat Sikaflex 255 adhesive for at least 15 minutes, apply adhesive as per previously removed panel.
- Carefully lay down door metallic frame onto the stainless steel body panel inserting the upper part into the panel curved lip.
- Install compression bars to compress and hold body panel during curing process.
- Once cured, apply masking tape on both body panel sides.
- Using a caulking nozzle and “SIKAFLEX 221” adhesive, fill the cavity to seal both body panel sides.
- Wearing surgical gloves, smooth down the joint with your finger.
- Remove masking tape and protective plastic lamination.

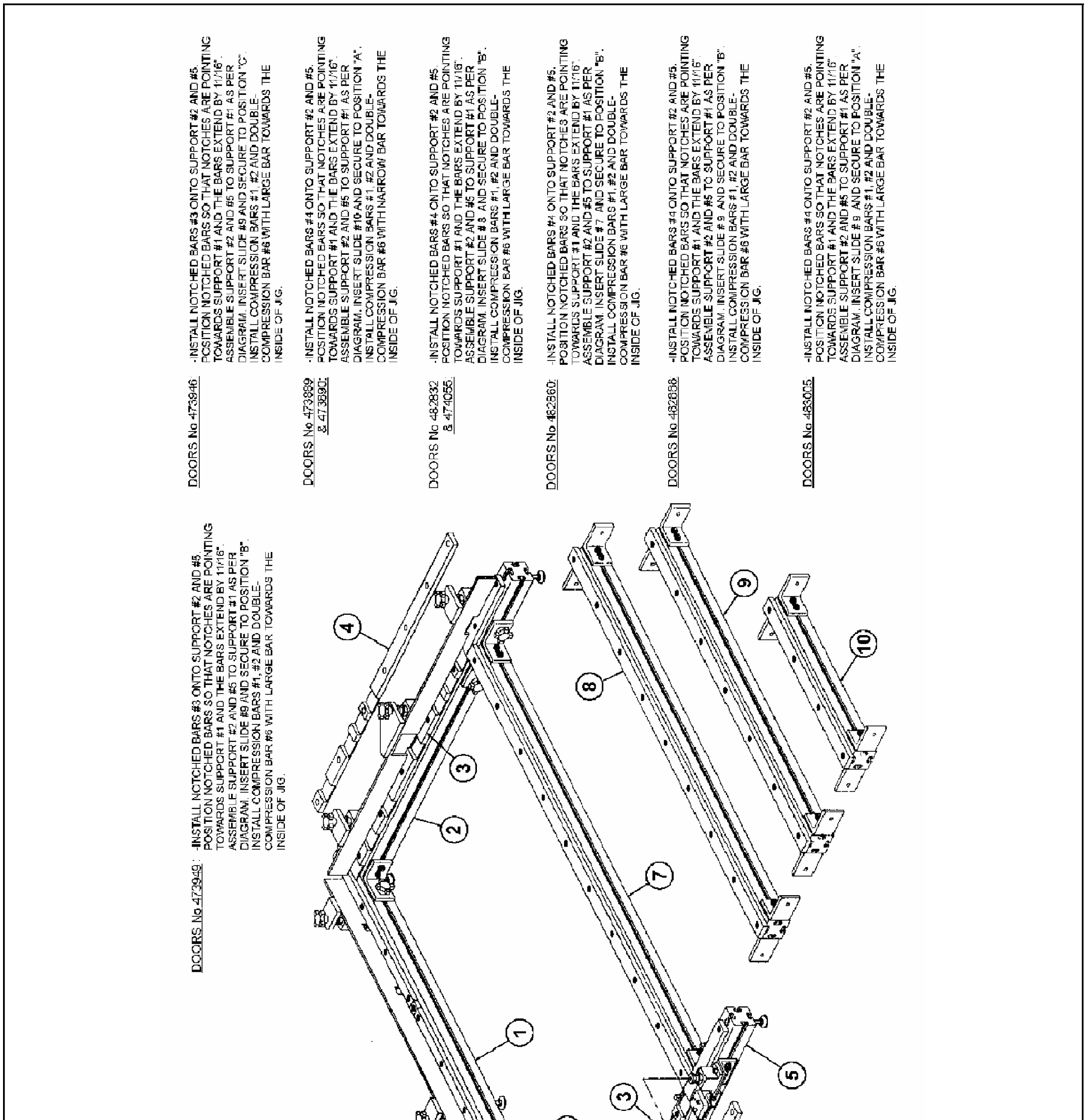


FIGURE 14: GLUING JIG SETUP DIAGRAM

Baggage Compartment Door

- Install gluing jig for a baggage compartment door. Refer to the included setup diagram according to part number and door dimensions.
- Lay down stainless steel body panel into the gluing jig as per setup diagram. Ensure it is lined up and set square with the reference marks.
- Heat Sikaflex 255 adhesive for at least 15 minutes, apply adhesive as per previously removed panel.
- Apply Sika 221 around handle opening frame.
- Carefully lay down door metallic frame onto the stainless steel body panel inserting the upper part into the panel curved lip.
- Carefully flip door frame and body panel over and install 9 rivets in the door handle opening and 2 at door upper part.
- Flip door frame and body panel over again and install compression bars to compress and hold body panel during curing process.
- Once cured, apply masking tape on both body panel sides.
- Using a caulking nozzle and "SIKAFLEX 221" adhesive, fill the cavity to seal both body panel sides.
- Wearing surgical gloves, smooth down the joint with your finger.
- Remove masking tape and protective plastic lamination.

6.4 MTH SIDE PANEL REPLACEMENT PROCEDURE

Material :

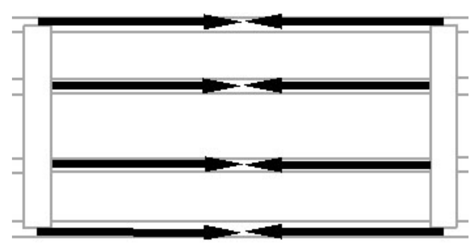
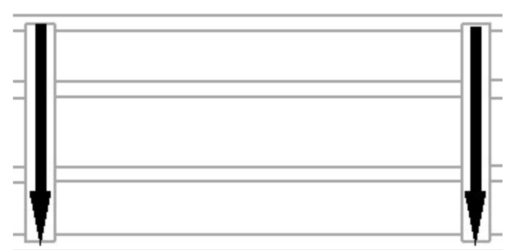
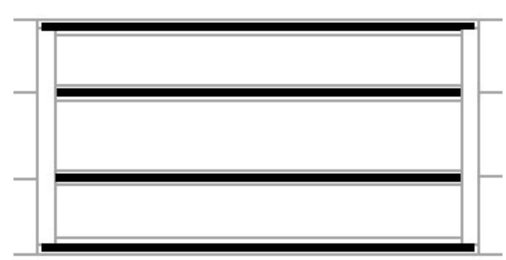
Anti-silicone (682989)	√	**Scotchbrite gray (680226)**	√	**Sika 206 G+P 1 liter (683446)**	√
	√	**Sika Aktivator (683661)**	√	**Sika 221 gray**	√
CHIX cloth (682384)	√			**Sika 252 black**	√
Blue cloth (682383)	√			**Sika 221 + Booster**	√

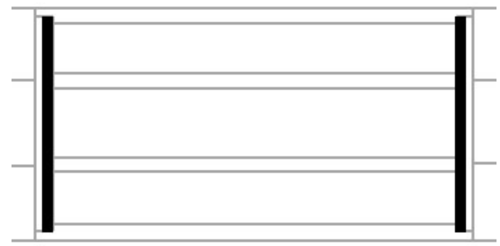
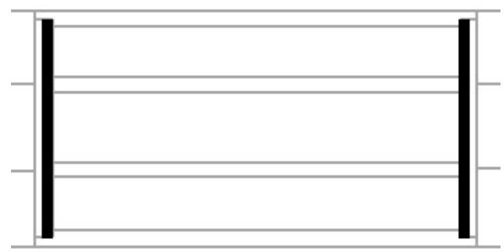
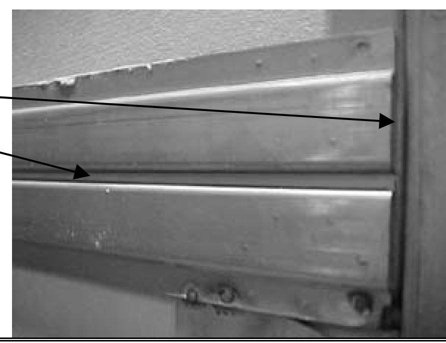
Equipment :

Glue Gun	√	

SECTION 1 SIDE PANEL GLUED WITH CIBA (Ciba on the horizontal tubing, Sika on the vertical tubing)			
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 finishing molding supports. Use a #11 titanium drill bit to remove rivet heads.	
	C)	Use the pair of locking pliers to remove top and bottom finishing molding supports.	
	D)	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 backers at each end.	Be careful not to damage the adjacent surfaces.
	E)	Use the c-clamp to peel the side panel from the back structural panel and at the same time gradually cut Sika bead with a sharp knife.	

	F)	Use a heat gun and putty knife to remove the dried off Ciba epoxy glue residue.	- Make sure that heat gun nozzle tip is at least 4” from surface. - Because of its great toxicity, care should be taken not to use a buffer or other sanding method for glue removal.
	G)	Remove Sika bead using putty knife or pneumatic knife.	- Never heat Sikaflex glue in order to remove it - It is not necessary to remove 100% of SikaFlex.
	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.
1.05	**Side Panel Positioning**		
	A)	Install side panel onto the vehicle, align and center panel with adjacent panels and temporary fix using two 1/8 ‘’ rivets at top (2 for side panels and 3 for engine air intake panels).	**Make sure that side panel is centered or that gap is between 3 and 4.5 mm with adjacent panels.**
	B)	Install conforming jig vertical supports onto the panel and drill holes into the temporary fixed vertical supports.	
	C)	Remove vertical supports and side panel.	

1.10	**Vehicle Surface Preparation**		
	A)	Clean horizontal supports using anti-silicone See PR000001 section A.	
	B)	Clean vertical “backers” using anti-silicone even if some Sika 252 residue is present. See PR000001 section A.	
	C)	Use the belt sander to sand horizontal supports (grit coarse) **For an aluminum surface, you have 3 hrs maximum between sanding and the application of glue.**	

	D)	**NOT APPLICABLE IF VERTICAL BACKERS ARE GRIT BLAST** Use the orbital sander (Scotchbrite grit 7446B) or a 2" disc grinder (grit coarse) to sand vertical backers. **For an aluminum surface, you have 3 hrs maximum between sanding and the application of glue.**	**CAUTION: Sand a 1 7/8″ to 2 ¼″ width surface.** 
	E)	Clean all sanded surfaces using anti-silicone See PR000001 section A.	
	F)	Apply Sika Aktivator onto the vertical backers See PR000001 section C.	
	G)	Install a neoprene foam tape at the center of panel horizontal supports and at each end if needed.	

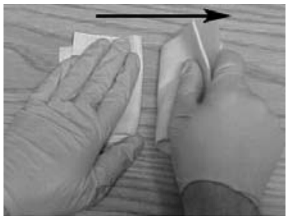
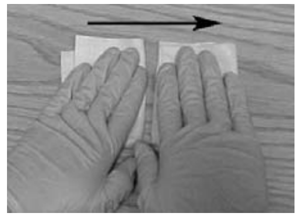
PR000001 Section A Alcohol or Anti-silicone

	*1.* **Apply** **CHIX cloth**		*2.* **Dry immediately** **Blue cloth**

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.

PR000001 Section C   Sika Aktivator

Glass		Other application	
	Plastic scraper CHIX cloth CHIX cloth		CHIX cloth CHIX cloth

1. **Apply and dry immedi-ately**

2. **Allow to dry**

Mandatory	**Minimum time :5 minutes**
	After 2 hours: Remove dust using dry Chix cloth and start cleaning operation again
Optional: **Before applying any other product**	If surface seems dusty, remove dust using dry Chix cloth and start cleaning operation again.
	If surface seems greasy or with finger marks, start cleaning operation again.

PR000001 Section D   Sika Primer 206 G+P

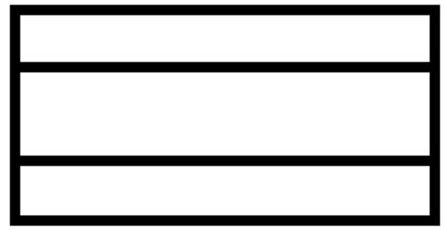
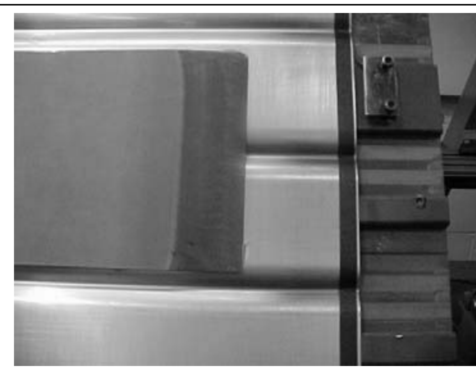
1. **Shake bottle to mix product**

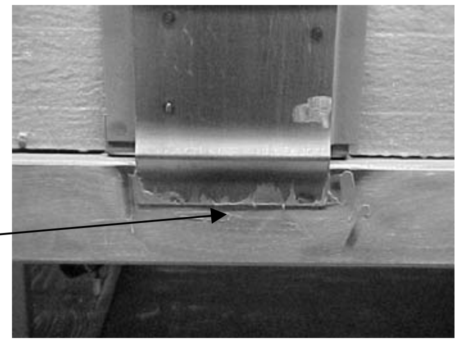
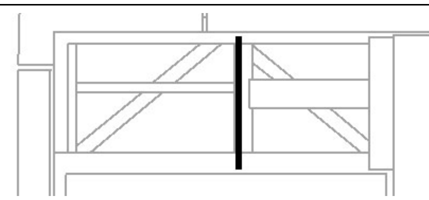
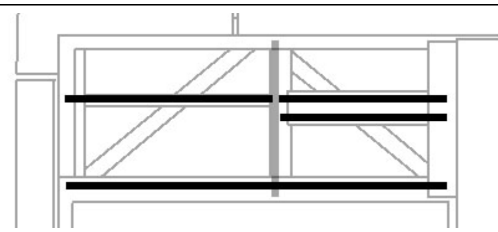
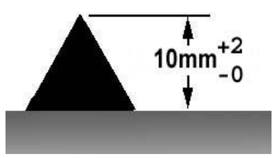
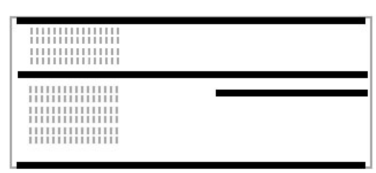
2. **Apply a thin layer**

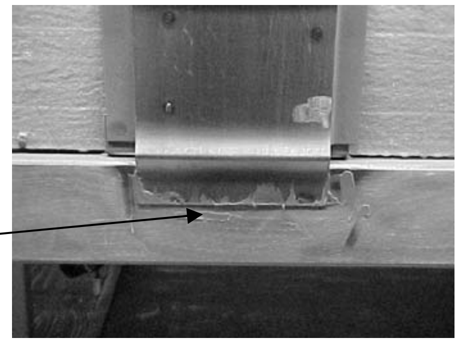
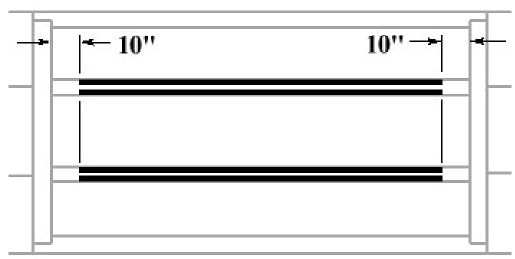
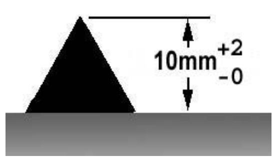
Chiffon CHIX

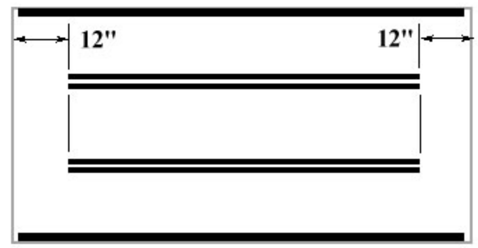
3. **Allow to dry**

Mandatory	**206 G+P**	**Minimum time: 10 minutes**
		After 2 hours: Remove dust using damp cloth (pure water)
		After 8 days : Reactivate with Aktivator as per section "C"
Optional: **Before applying any other product**		If surface seems dusty, remove dust using Chix damp cloth (pure water).
		If surface seems greasy or with finger marks, reactivate with Aktivator.

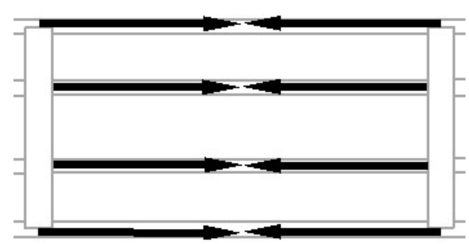
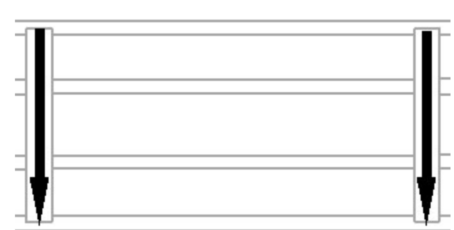
1.15 *		**Side Panel Preparation**	
	A)	Use a Chix cloth and anti-silicone to remove any dust or residue from the whole side panel surface	**For all Service Centers or if side panel is dusty**
	B)	Clean using anti-silicone See PR000001 section A.	
	C)	Sand using Scotchbrite	
	D)	Clean using anti-silicone See PR000001 section A.	
	E)	Apply Sika Aktivator onto a 2″ +/- ½″ width surface. See PR000001 section C.	
	F)	Install a 1/16″ x 1/4″ neoprene foam tape at each side panel end, 1 mm from panel edge. Make sure foam tape reaches bottom of creases.	
1.20		**Preparation of Ciba Epoxy Glue Cartridges**	You need about 7 cartridges for a large side panel. Use a constant and controlled source of heat. Maximum temperature is 120 °F.
	A)	Before applying glue, heat Ciba glue cartridges to reduce viscosity and speed up process. Make sure glue temperature is correct and you have sufficient cartridges.	
	B)	Perforate cartridge tip and install mixing nozzle. Cut mixing nozzle at 3rd notch.	
	C)	Insert cartridge into the gun.	
	D)	Before applying glue, heed this procedure: If a new mixing nozzle is used, install mixing nozzle onto the cartridge and insert into the gun. Take a sample of glue before applying. When changing cartridge without changing the mixing nozzle, take a sample of glue then install mixing nozzle onto the cartridge.	

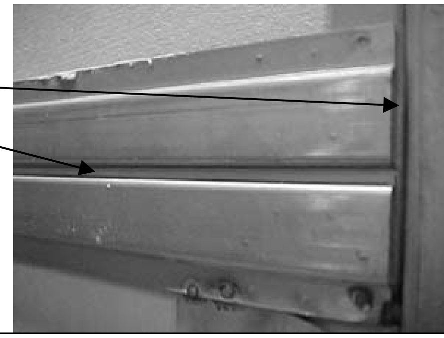
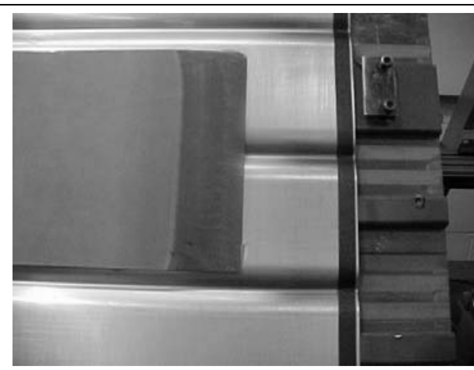
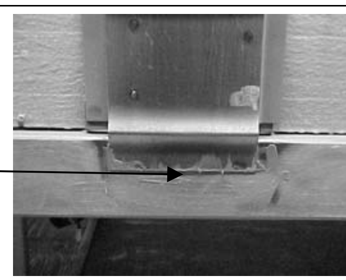
1.25 *	**Engine Air Intake Panel Installation**		
	To know the time allotted between glue application and final installation; refer to annex 4		
	Always check color of glue before applying (charcoal gray). If the color turns black or white during application, remove this portion using a putty knife and clean with thinner		
	A)	If more than one hour has elapsed between the first cleaning and the application of glue or if in doubt, clean panel and vehicle surface again using anti-silicone See PR000001 section A.	
	B)	Seal each vertical "backer" end. Seal top and bottom part of vertical backer using Sika 221 gray or Ciba 8535.	
	C)	Apply bead (¼″ minimum dia.) Sika 252 onto structure.	
	D)	Apply bead (¼″ minimum dia.) Ciba onto structure.	
	E)	Apply Sika 252 onto air intake panel 1″ +¼″ / -0 from panel edge 	
	F)	Apply Ciba onto air intake panel **Make sure that Ciba and Sika beads adjoin.** (¼″ minimum dia.)	
	G)	Install air intake panel using rivets and conforming jigs.	

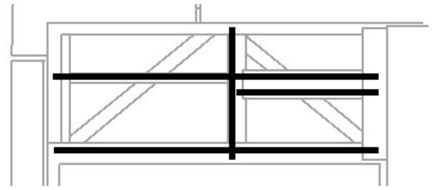
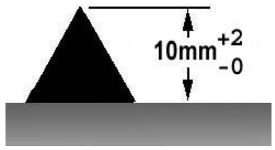
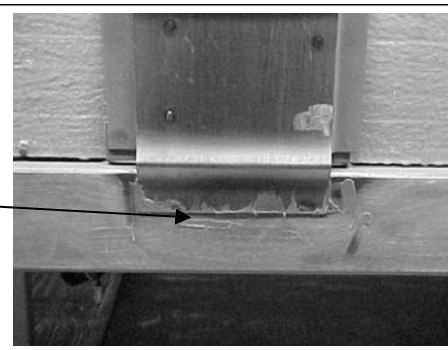
1.30	Side Panel Installation	
	To know the time allotted between glue application and final installation; refer to annex 4	
	Always check color of glue before applying (charcoal gray). If the color turns black or white during application, remove this portion using a putty knife and clean with thinner	
A)	If more than one hour has elapsed between the first cleaning and the application of glue or if in doubt, clean panel and vehicle surface again using anti-silicone See PR000001 section A.	
B)	Seal each vertical "backer" end. Seal top and bottom part of vertical backer using Sika 221 gray or Ciba 8535.	
C)	**MTH W5 only.** Apply Sika 252 or 255 onto the awnings reinforcement plates Height of bead 3/8″ +1/8″ / -0.	
D)	Apply Ciba onto horizontal supports (¼″ minimum dia.)	
E)	Apply Sika 252 onto side panel 1″ +¼″ / -0 from panel edge 	

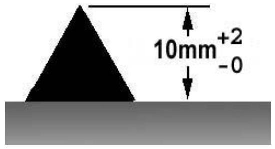
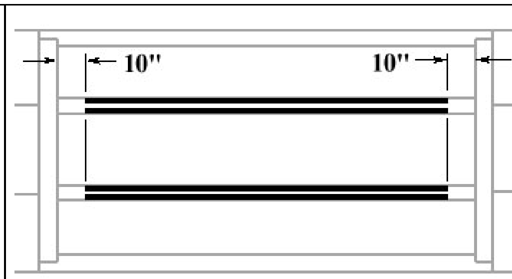
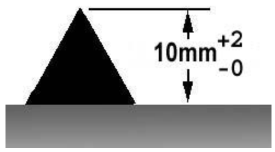
F)	Apply Ciba onto side panel **Make sure that Ciba and Sika beads adjoin.** (¼″ minimum dia.)	
G)	Carefully install panel onto the vehicle and hold it in place using the pre-drilled holes and rivets. Check positioning using backers.	Make sure that side panel is centered or that gap is between 3 and 4.5 mm with adjacent panels.
H)	Fix conforming jig vertical supports onto the panel using the pre-drilled holes and screws. Apply pressure.	40 psi ±2 air pressure and check gap between panels.
I)	Install horizontal pressure bars onto the vertical supports.	
J)	Wait allotted curing period	See Annex 4
K)	Remove conforming jigs and seal 1/8″ rivet heads using Sika 221.	
L)	**Side Panel Upper Joint** 1) Clean surface using anti-silicone See PR000001 section A. 2) Apply Sika Aktivator See PR000001 section C. 3) Apply Sika 252 to seal structural tubing and side panel upper edge	
M)	If necessary, clean excess of CIBA glue in the joints.	
N)	If the first or last side panel was replaced, the vertical joint must be redone. 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 back plate. Clean using Sika 205. Allow 5 minutes minimum for drying. Wear surgical gloves and smooth down the joint with your finger.	

SECTION 2 SIDE PANEL GLUED WITH SIKA

2.00	**Removal**		
	A)	Remove top and bottom finishing moldings. 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 You need to remove the finishing molding support and rivets in the case of engine air intake panel.
	B)	Insert a flat screwdriver between the side panel and the vehicle chassis, in the top left and right corners.	
	C)	Use the c-clamp to peel the side panel from the back structural panel as far as the middle and at the same time gradually cut Sika bead with a sharp knife. Do the same for the other corner.	Ideally, the hoist or chain block must be fastened to the floor while pulling from a 45^{o} angle so as not to damage the vehicle structure
	D)	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.
	E)	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.
2.05	**Side Panel Positioning**		
	A)	Install side panel onto the vehicle, align and center panel with adjacent panels and temporary fix using two 1/8 '' rivets at top (2 for side panels and 3 for engine air intake panels).	**Make sure that side panel is centered or that gap is between 3 and 4.5 mm with adjacent panels.**
	B)	Install conforming jig vertical supports onto the panel and drill holes into the temporary fixed vertical supports.	
	C)	Remove vertical supports and side panel.	
2.10	**Vehicle Surface Preparation**		
	A)	Clean horizontal supports using anti-silicone See PR000001 section A.	
	B)	Clean vertical "backers" using anti-silicone. See PR000001 section A.	
	C)	If necessary, touch up with primer See PR000001 section D.	
	D)	Reactivate all surfaces using Sika Aktivator See PR000001 section C.	

	E)	Install a neoprene foam tape at the center of panel horizontal supports and at each end if needed.	
2.15 *	**Side Panel Preparation**		
	If you receive a side panel with 206G+P primer already applied, reactivate surface as per PR000001 section D. You don't have to perform step a) to e) hereafter. Refer to the date written onto the panel.		
	A)	Use a Chix cloth to remove any dust or residue from the whole side panel surface	**For all Service Centers or if side panel is dusty**
	B)	Clean using anti-silicone See PR000001 section A.	
	C)	Sand using Scotchbrite	
	D)	Clean using anti-silicone See PR000001 section A.	
	E)	Apply Sika 206 G+P Primer See PR000001 section D.	
	F)	Install a 1/16″ x 1/4″ neoprene foam tape at each side panel end, 1 mm from panel edge. Make sure foam tape reaches bottom of creases.	
2.20	**Engine Air Intake Panel Installation**		
	A)	If more than one hour has elapsed between the first cleaning and the application of glue or if in doubt, see PR000001 section D.	
	B)	Seal each vertical "backer" end. Seal top and bottom part of vertical backer using Sika 221 gray	

	C)	Apply a bead of Sika 221+booster onto structure (¼″ minimum dia.) **Time allotted between glue application and final installation: 30 minutes maximum**	
	D)	Apply a bead of Sika 221+booster onto air intake panel 1″ +¼″ / -0 from panel edge. **Time allotted between glue application and final installation: 30 minutes maximum** 	
	E)	Install air intake panel using rivets and conforming jigs.	**Conforming Jig Installation Time: 4 hours** **Time before moving vehicle: 8 hours**
2.25	**Side Panel Installation**		
	A)	If more than one hour has elapsed between the first cleaning and the application of glue or if in doubt, see PR000001 section D.	
	B)	Seal each vertical “backer” end. Seal top and bottom part of vertical backer using Sika 221 gray	
	C)	**MTH W5 only.** Apply Sika 252 or 255 onto the awnings reinforcement plates Height of bead 3/8″ +1/8″ / -0.	

D)	Apply Sika 221+booster onto horizontal supports **Time allotted between glue application and final installation: 30 minutes maximum** 	
E)	Apply Sika 221+booster onto side panel 1″ +¼″ / -0 from panel edge **Time allotted between glue application and final installation: 30 minutes maximum** 	
F)	Carefully install panel onto the vehicle and hold it in place using the pre-drilled holes and rivets. Check positioning using backers.	Make sure that side panel is centered or that gap is between 3 and 4.5 mm with adjacent panels.
G)	Fix conforming jig vertical supports onto the panel using the pre-drilled holes and screws. Apply pressure.	40 psi ±2 air pressure and check gap between panels.
H)	Install horizontal pressure bars onto the vertical supports..	
I)	Wait allotted curing period	**Conforming Jig Installation Time: 4 hours** **Time before moving vehicle: 8 hours**
J)	Remove conforming jigs and seal 1/8″ rivet heads using Sika 221.	
K)	**Side Panel Upper Joint** 1) Clean surface using anti-silicone See PR000001 section A. 2) Apply Sika Aktivator See PR000001 section C. 3) Apply Sika 252 to seal structural tubing and side panel upper edge	
L)	If necessary, clean excess of Sika glue in the joints.	

	M)	If the first or last side panel was replaced, the vertical joint must be redone. 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 back plate. Clean using Sika 205. Allow 5 minutes minimum for drying. Wear surgical gloves and smooth down the joint with your finger.	

SIDE PANEL REPAIR OR REPLACEMENT

MTH – XL2

NOTE
All defects and solutions proposed hereafter can be used with any side panel.

DEFECT	***SOLUTION***	***NOTE***
1. Improper positioning of vertical bead (especially engine air intake panel).	Replace side panel	Refer to procedure
2. Impossible to seal side panel.	Replace side panel	Refer to procedure
3. Ungluing of vertical or horizontal bead.	Replace side panel	Refer to procedure
4. Improper conforming of side panel at horizontal supports level.	From inside of vehicle, reapply adhesive between horizontal supports and side panel, see annex # 1	Check horizontal supports for straightness using a straight edge by measuring side panel.
5. Small water infiltration through a vertical joint without ungluing.	Seal from inside of vehicle, see annex #2	Use Sikaflex 221
6. Major water infiltration through engine air intake panel without ungluing.	Depending on the case, replace or repair side panel, see annex # 3	

ANNEX # 1 (Side panel glued with Ciba only)

For this operation, you must remove interior insulation, insert a small tube connected to Ciba cartridge mixing nozzle and inject the glue between horizontal supports and side panel. Ensure to fill in under horizontal supports so as to trap the adhesive between support and side panel.

ANNEX # 2

When performing water test, a small water infiltration through vertical joint is possible. Ensure that no ungluing is occurring at joint level then seal vertical joint from inside of vehicle. Ensure to completely dry the area before sealing. Seal using Sikaflex 221 gray.

ANNEX # 3

If there is water infiltration through engine air intake panel and first rear side panel joint, it is likely that water infiltrates through air intake panel itself or through joint between two panels. Before repairing, ensure that vertical joint lower portion is filled with Sikaflex 221 adhesive up to Ciba adhesive and ensure that engine air intake panel adhesion is proper. If there is still evidence of water infiltration, you must replace engine air intake panel. If water infiltration is through vertical joint, you must replace first rear side panel.

	ANNEX 4 TABLE OF ALLOTTED CURING PERIODS (CIBA adhesive) (NO-HEAT CONFORMING JIGS)				
Room Temperature	Conforming Jig Installation Time	Complete stop of vehicle (without moving)	Time before moving vehicle ±10°F with room temperature	Polishing after the application of adhesive or before vehicle back in operation	Time allotted between glue application and final installation
87°F	4 HRS	8HRS	8HRS	16HRS	25m
77°F	6HRS	12HRS	12HRS	24HRS	45m
72°F	7HRS	14HRS	14HRS	28HRS	50m
67°F	8HRS	16HRS	16HRS	32HRS	1HR
<67°F	*NO APPLICATION OF ADHESIVE IS ALLOWED*				

6.5 LATERAL FIXED WINDOW

Depending on the method chosen for fixed side window removal or installation, you may need:

* Drill equipped with a sharp pointed rod into which a small hole was drilled;
* Razor sharp window scraper;
* Braided windshield wire and a pair of handles;
* Gloves, goggles or face shield.

Fixed Window Removal

1st Method

NOTE
This method is used only in the case of a regular fixed side window. For the fixed upper portion of awning or sliding windows, you must use method number 2.

- Apply a sticky plastic film onto all of window outside surface for safety reason.
- Using a drill equipped with the special sharp pointed rod, drill through the window seal into one of the bottom corners, from a 30º 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.

2nd Method

- Apply a sticky plastic film onto all of window outside surface.
- To limit as much damage as possible, remove any interior molding in the way. Install a plastic film on the window interior surface and secure using masking tape onto all of window perimeter.

NOTE
Do not stretch plastic film and leave enough play to be able to push window out without tearing the plastic film.

- Using a ball peen hammer, hit one of the window bottom corners from the **outside**.
- Carefully push window out and lift it up sufficiently to separate it from the aluminum molding.
- Attach the windshield wire to a fish wire and thread it underneath the aluminum molding behind the rivets.
- Detach wire from fish wire and continue cutting using the handle.
- Make a notch at each window top corner to make sure you pass underneath the remaining pieces of glass.
- Remove the aluminum molding and clean up the frame using the window scraper.
- Before starting window frame treatment, make sure window frame is truly clean and free of pieces of glass.
- First of all, check Sika 205 cleaner expiration date.
- Before applying Sika cleaner, fold “Chix” cloth twice for proper width.
- Apply an even coat onto the window frame and allow to dry for 10 minutes.
- Discard waste according to applicable environmental regulations, use dangerous waste containers.
- Apply masking tape before applying Sika glue to protect paint and adjacent window during surface treatment.

Window Surface Treatment

- Use “Spray Away” or “ESSEX GC-800” window cleaner (Prévost #683926) around window perimeter and edges to remove any oily film while inspecting for damages.

- Wipe clean using a dry cloth.
- Repeat previous step using a second dry cloth to ensure window is truly clean and allow to dry for 1 minute.
- Install two stops into the aluminum extrusion one inch from each window edge.

Preparation Of Window When Using Sikatack Ultrafast 2 Adhesive

- Check “SIKA 205” product expiration date.
- Before applying Sika cleaner, fold “Chix” cloth twice for proper width.
- Apply an even coat onto the window casement and allow to dry for 2 minutes.
- Apply Sika 206 G+P primer onto the window casement and allow to dry for 10 minutes.

Fixed Side Window Installation Using Sikatack Ultrafast 2

- Use “Sikatack Ultrafast 2” adhesive.
- Check product expiration date.
- Always heat adhesive first for 15 minutes in an oven.

NOTE
You only have 10 minutes to install window once the SIKA ULTRAFAST 2 product is applied.

- Using a triangular nozzle, apply a Sikatack Ultrafast 2 bead on all of window frame perimeter. Apply a second bead on frame top.
- Two persons may then install window by inserting the top part into the aluminum extrusion and then carefully rest the window casement against the frame aligning the bottom part.
- Install two stops into the aluminum extrusion one inch from each window edge.

Window Temporary Fixing Using Sikatack Ultrafast 2 Adhesive

1st Method

- From the outside, lean a straight edge against each window side to guide the person in charge of the suction jig installation. The window must be on the same level than the adjacent one(s).
- From the inside, remove finishing molding, install the cups onto the glass surface, 6 inches from bottom of window and screw down the jig ends onto the frame metallic structure to adjust depth.

NOTE
The person outside the vehicle must guide throughout this procedure.

- Finally, maximum watertightness is achieved when you notice the bead running over towards the inside.
- Allow drying for at least 6 hours.

2nd Method

- From the outside, use a ram or a jack equipped with a padded surface at one end and secured to the other end.
- This equipment must be easily adjustable and compress the window against the frame.
- Lean the padded surface 6 inches from the bottom of window, use a straight edge and adjust the equipment so that the window is level with the adjacent one(s).
- Finally, maximum watertightness is achieved when you notice the bead running over towards the inside.
- Allow drying for at least 6 hours.

6.6 DRIVER’S WINDOW AND UPPER LATERAL WINDOW

For the removal of driver’s window or upper lateral window, you will need:

Pneumatic «Zip gun» type tool;
Razor sharp window scraper;
“Olfa” knife;
Face shield.

- In the case of driver’s window only, open front service compartment door.
- Mark the position of the driver’s window for future reference.
- 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.
- First of all, check Sika 205 cleaner expiration date.
- Before applying Sika cleaner, fold “Chix” cloth twice for proper width.
- Apply an even coat onto the inside of window frame and allow to dry for 2 minutes (maximum 2 hours).
- Discard waste according to applicable environmental regulations, use dangerous waste containers.
- Apply masking tape before applying Sika glue to protect paint and adjacent window during surface treatment.

Window surface treatment

- Use Spray Away or “ESSEX GC-800” window cleaner (Prévost #683926) around window perimeter and edges to remove any oily film while inspecting for damages.
- Wipe clean using a dry cloth.
- Repeat previous step using a second dry cloth to ensure window is truly clean and allow drying for 1 minute.
- Check “SIKA 205” product expiration date.
- Before applying Sika cleaner, fold “Chix” cloth twice for proper width.
- Apply an even coat onto the inside of window frame and allow drying for 2 minutes.

Driver’s Window Installation

- Use “Sikatack Ultrafast 2” adhesive.
- Check product expiration date.
- Always heat adhesive first for 15 minutes in an oven.

NOTE
You only have 10 minutes to install window once the SIKA ULTRAFAST 2 product is applied.

- Apply a double-face self adhesive tape 1/8 by ¼ inch inside window frame to prevent glue from reaching the inside of the vehicle and to mechanically hold the window until the adhesive is cured. Peel the back from the tape.
- To support the window, position two “Quick Grip” type pliers at the base of the frame.
- Using the caulking nozzle, seal the top edge with SIKA ULTRAFAST 2.
- Change for a triangular nozzle with a 15 mm opening, apply a Sika bead on all 4 window edges beside the double-face self adhesive tape.
- Center and align the window base using the two pliers while pressing firmly the window perimeter against the frame.
- If this has not been done already, apply masking tape near the window edge adjacent to front face before doing finishing joint. Using a caulking nozzle and Sika Utrafast 2 adhesive, complete a finishing joint and scrape the excess with a plastic scraper.

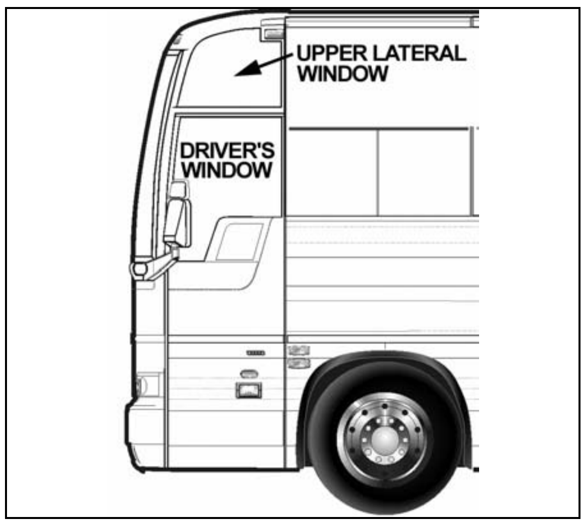


FIGURE 15: DRIVER'S OR UPPER LATERAL WINDOW

- Complete a second finishing joint at the window top making sure there are no cavities.
- Carefully remove masking tape.

- Wet “Ultrafast 2” adhesive every 15-20 minutes using water to accelerate the curing process.
- Do not move the vehicle for 2 hours.

Upper Lateral Window Installation

- Use “Sikatack Ultrafast 2” adhesive.
- Check product expiration date.
- Always heat adhesive first for 15 minutes in an oven.

NOTE
You only have 10 minutes to install window once the SIKA ULTRAFAST 2 product is applied.

- Apply a double-face self adhesive tape 1/8 by ¼ inch inside window frame to prevent glue from reaching the inside of the vehicle and to mechanically hold the window until the adhesive is cured. Peel the back from the tape.
- Remove the lens from the clearance light.
- Change for a triangular nozzle with a 15 mm opening, apply a Sika bead on all 4 window edges beside the double-face self adhesive tape.
- Center the window while pressing firmly the window perimeter against the frame.
- If this has not been done already, apply masking tape before doing finishing joint. Using a caulking nozzle and Sika Utrafast 2 adhesive, complete a finishing joint and scrape the excess with a plastic scraper.
- Carefully remove masking tape.
- Wet “Ultrafast 2” adhesive every 15-20 minutes using water to accelerate the curing process.
- Do not move the vehicle for 2 hours.

6.7 ENGINE COMPARTMENT DOOR BODY PANEL

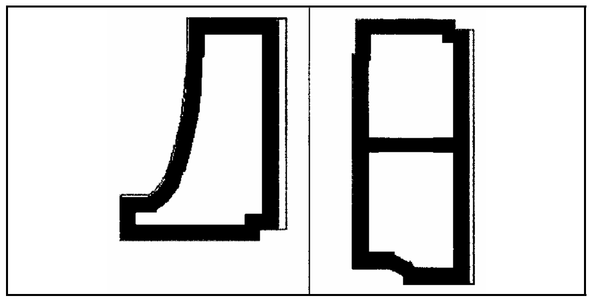
For the removal of engine compartment door body panel, you will need :

A pneumatic “Zip gun” type tool,
Razor sharp window scraper to remove Sika adhesive residue,
A pair of locking pliers,
And isopropyl alcohol.

- Remove damaged engine compartment door from vehicle (refer to Maintenance Manual, in this section).
- Install the damaged door onto an appropriate support.
- Wearing gloves, goggles and ear plugs, pry loose body panel using a “Zip gun” or lever starting from the edge opposite the curved side.

⚠ CAUTION ⚠
Do not damage painted surface.

- Use the “Zip gun” to detach completely the stainless steel body panel from door frame.
- Use a second person equipped with a pair of locking pliers to pull the body panel as you cut the Sika bead.



⚠ WARNING ⚠
Be very careful when pulling the body panel, somebody could get hurt if the body panel suddenly detach from the door surface without notice.

Door Frame Preparation

- Using the window scraper, remove any Sika bead or self adhesive tape residue left on the fiber glass surface.
- First of all, check Sika 205 cleaner expiration date.
- Before applying Sika cleaner, fold “Chix” cloth twice for proper width. Apply an even coat onto the treated surface.

NOTE
Make sure not to get any Sika cleaner onto the surrounding painted surfaces.

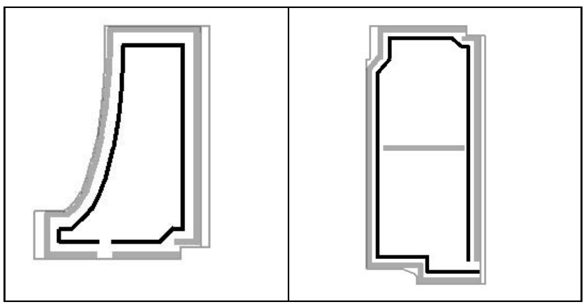
- Discard waste according to applicable environmental regulations, use dangerous waste containers.

- Allow 2 minutes for drying in the case of fiber glass (maximum 2 hours).

Body Panel Preparation

- Check that new body panel is the required one and is free of defects or scratches.
- Clean using anti-silicone in order to remove any dirt or oily film left onto the stainless steel surface.

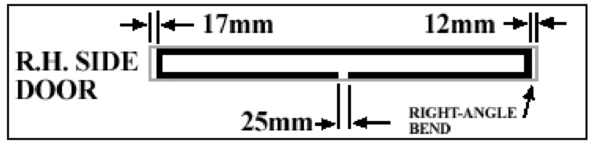
NOTE
Apply evenly around the perimeter of the panel. Use two clothes, first one applies product while second one immediately dries surface off before product evaporation.

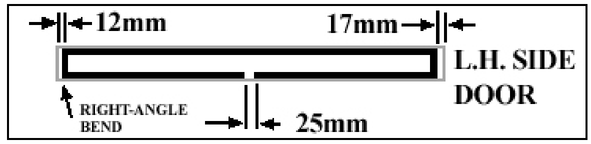


- Then, using a scratch pad “Scotch Brite”, scratch the perimeter of door where the adhesive will be applied.

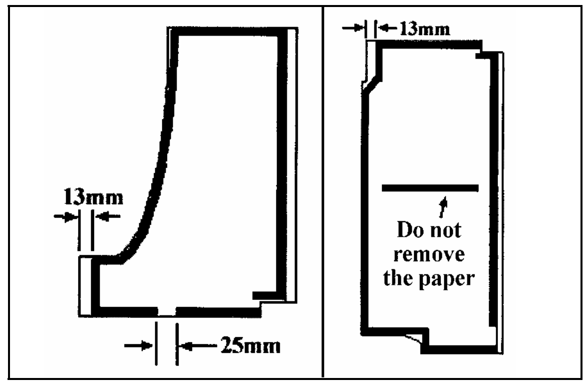
NOTE
It is important to support underneath the curved surface so as not to change the angle of the body panel and therefore prevent deformation.

- Use a Chix cloth and anti-silicone to remove any dust or residue.
- Apply an even coat of Sika cleaner onto the treated surface and allow 2 minutes (max. 2 hours) for drying in the case of stainless steel.
- Apply a double-face self adhesive tape.



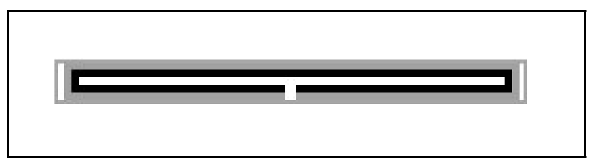


- Always leave a length of self adhesive tape on each side of the body panel, sufficient enough to be able to peel the back from the tape when installing the body panel.



Sikaflex 252 Adhesive Application

- Use a “V” shape nozzle, cut the tip and apply Sika bead ¾ inch (15 mm) from double-face self adhesive tape.



- Ideally two persons should perform this installation.
- Carefully center and align body panel while the second person keeps the self adhesive tape extremities outside the body panel.

NOTE
Make sure drip hole is at the bottom of panels.

- Peel the back from the self adhesive tape located underneath the body panel.
- Finally, compress using a dry erasable marker board brush so as not to scratch or damage the stainless steel surface.

7. ENTRANCE DOOR

7.1 COACH 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 (Fig. 16). Door activation is controlled by a relay panel, located near the defroster and wiper motors. The accessory air reservoir supplies air to this system.

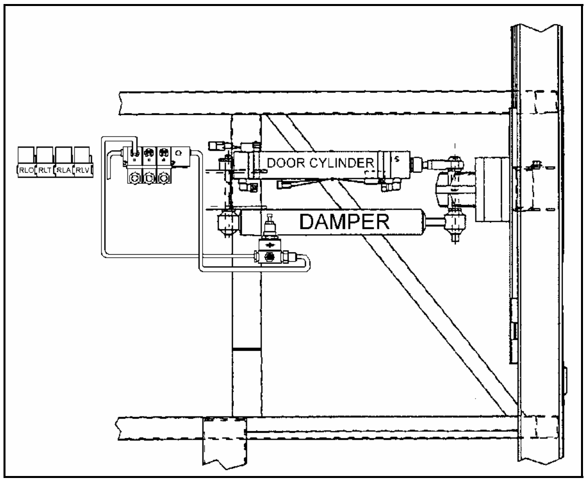


FIGURE 16: DOOR CYLINDER AND DAMPER

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.

7.1.1 Operation

The air-operated door is controlled from inside the coach by two push-button switches located on the R.H. dashboard.

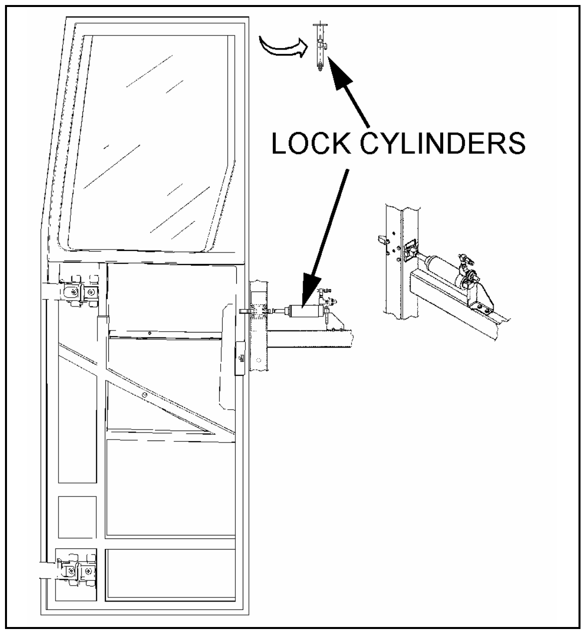


FIGURE 17: COACH ENTRANCE DOOR

Opening and closing of the door from outside the coach is accomplished by a momentary toggle switch located near the coach model nameplate (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.

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.

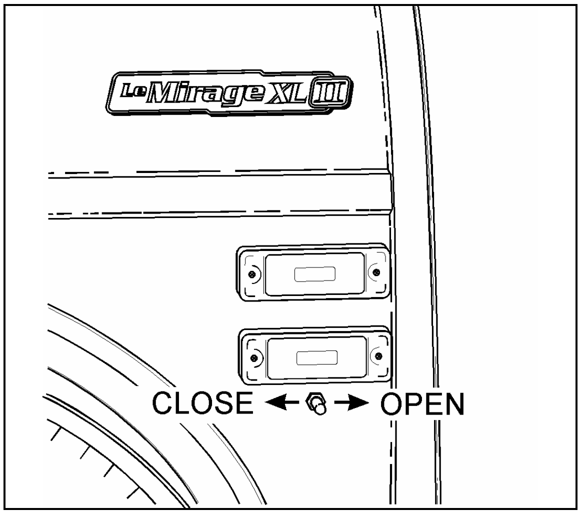


FIGURE 18: ENTRANCE DOOR CONTROL SWITCH

If the door has been locked with the key, a lever on the door can be moved to unlock.

7.1.2 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.

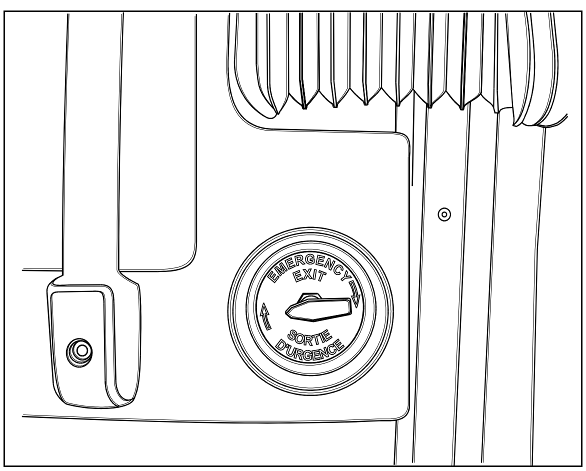


FIGURE 19: EMERGENCY EXIT VALVE 18321

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.

7.1.3 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. 20):

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. 20).

NOTE

In figure 20, 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.

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. 20).

5. The damper can now be refitted in the vehicle.
6. Reinstall panels and entrance door hinge cover.

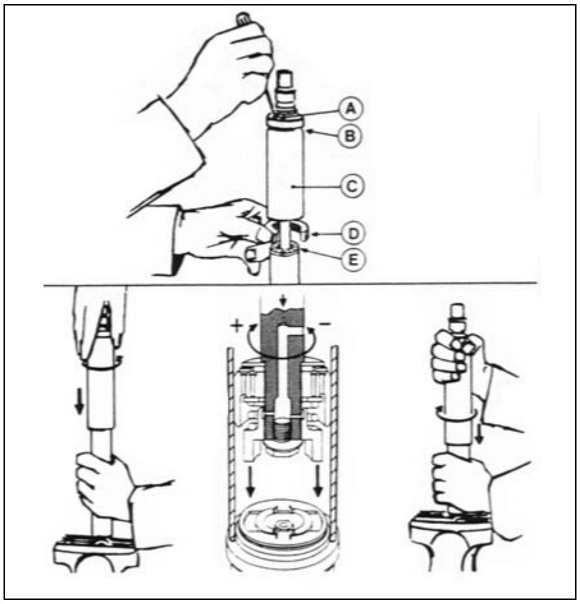


FIGURE 20: DAMPER

7.1.4 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 21.
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.

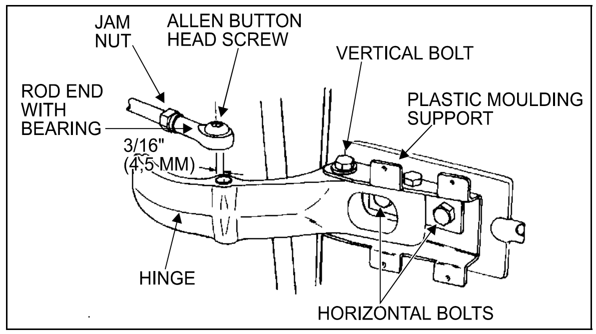


FIGURE 21: UPPER DOOR HINGE 18058

7.1.5 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 22).

NOTE
The front measurements are the most important. If required, ask an assistant to help you to perform the following adjustments.

3. If required loosen the bolts retaining the door to the hinges. Adjust the bolts to obtain the proper seal compression.

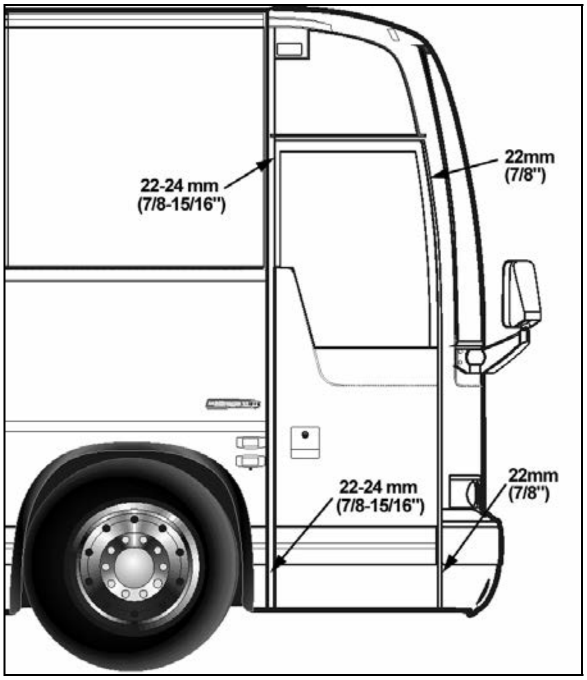


FIGURE 22: SEAL COMPRESSION ADJUSTMENT

7.1.6 Door Seal Replacement

1. Inspect the seal; if cracked or torn, it must be replaced:
2. Remove the old seal and with a sharp edge knife, scrape tape left on the fiberglass door surface.
3. Sand the surface of the door where a new seal will be applied with 240 grit sandpaper.
4. Clean the surface with alcohol.

⚠ CAUTION ⚠
Wear rubber gloves and do not smoke when cleaning.

5. Peel of protective paper from the seal. Position the seal flush with the top, sides and lower edges of the door.
6. Progress slowly all around the door.
7. Cut the seal and glue both ends with LOCTITE 414 glue.
8. To assure bonding, press a small roller on top of the new seal.

7.1.7 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.
	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 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.

7.1.8 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

7.2 ENTRANCE DOOR (MTH)

There are three ways of unlocking the entrance door from the inside of vehicle. The two first consist in actuating the rocker switch on the dashboard, but this last operation will also unlock the baggage compartments. Finally, you can unlock the door by sliding its lock lever to the left. If the orange tab on the door lock lever is visible, the door is unlocked.

You may lock/unlock the entrance door from the outside with the lock key provided with the vehicle. Turn key CCW to lock and CW to unlock the entrance door.

7.2.1 Keyless Entry System

With this system, you can lock or unlock the entrance door as well as the baggage and service compartment doors. The keyboard is located below the entrance door handle. The module is pre-programmed by the manufacturer and this code can not be deleted. Moreover, you can program your own entry code. Refer to the "Owner's Manual" for instructions on how to program your own entry code.

When you use the keyless entry system, the keyboard and stepwell lights illuminate. Do not push the buttons with a key, pencil or any other hard object as it could damage the buttons.

Although each button is provided with two digits separated by a vertical line, there is only one contact per button. Always press the center of the button (between the two digits, on the vertical line).

If you let more than five seconds pass between each button press, the system shuts down, and you have to enter your code again. If the keyless entry system does not work properly, use the key to lock or unlock entrance or compartment doors. To know more about the keyless system, refer to the "Owner's Manual".

NOTE
You must unlock the entrance door before you unlock with the appropriate key any baggage or service compartment doors.

7.2.2 Door Adjustment

Check around the perimeter of the door for binding. If any binding is found, adjust as follows:

7.2.3 Horizontal And Vertical Adjustments

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.

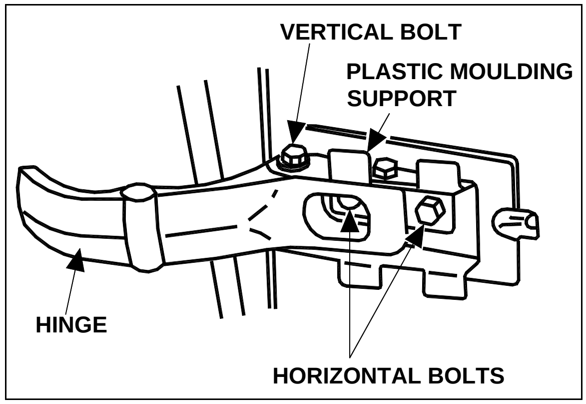


FIGURE 23: ENTRANCE DOOR (MTH) 18058

2. Support the door with a wooden block and a hydraulic jack.
3. 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.
4. Check door fit.
5. Using the screws, fasten the plastic trim to cover the hinges.

7.2.4 Seal Compression Adjustment

1. Close the door, 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 22).

NOTE
The front measurements are the most important. If required, ask an assistant to help you to perform the following adjustments.

2. If required loosen the bolts retaining the door to the hinges. Adjust the bolts to obtain the proper seal compression.

7.2.5 Door Seal Replacement

1. Inspect the seal; if cracked or torn, it must be replaced:
2. Remove the old seal and with a sharp edge knife, scrape tape left on the fiberglass door surface.
3. Sand the surface of the door where a new seal will be applied with 240 grit sandpaper.
4. Clean the surface with alcohol.

⚠ CAUTION ⚠
Wear rubber gloves and do not smoke when cleaning.

5. Peel of protective paper from the seal. Position the seal flush with the top, sides and lower edges of the door.
6. Progress slowly all around the door.
7. Cut the seal and glue both ends with LOCTITE 414 glue.
8. To assure bonding, press a small roller on top of the new seal.

7.2.6 Door Lubrication

Part	Lubricant	Frequency
Latches Upper door catch	Low temperature grease	Every six months
Door locking mechanism	White grease	Every six months
Key hole Hinges	Low viscosity oil	Every six months

7.2.7 Door Latch Mechanism

Generally, when the latch mechanism malfunctions, a number of causes may be responsible for this situation. No single procedure will correct this situation. It is best to remove the protective cover and to look for binding, used or bent parts. Operate the latch mechanism and try to find where any binding occurs. Replacing a part or slightly bending a rod should be enough. Remember, having a global understanding of the mechanical activity will generally lead you to the cause of the problem, and ultimately to an easy repair.

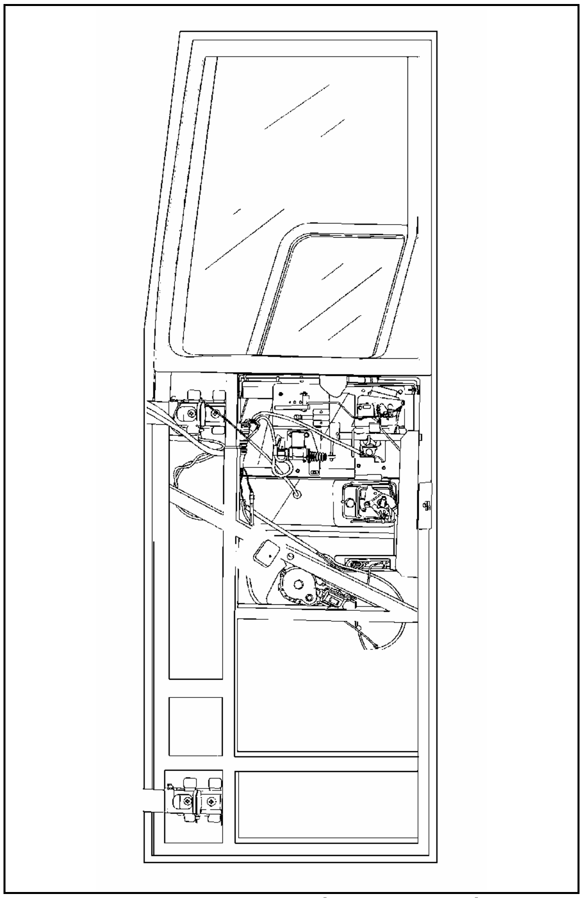


FIGURE 24: ENTRANCE DOOR (MTH, TYPICAL)

8. BUMPER REMOVAL AND INSTALLATION

8.1 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 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.

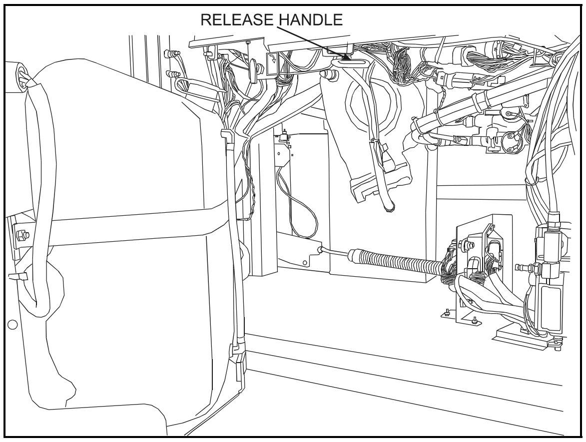


FIGURE 25: FRONT BUMPER RELEASE HANDLE

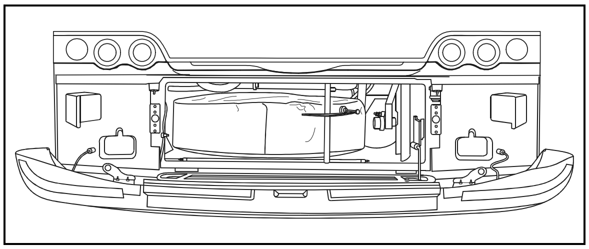


FIGURE 26: FRONT BUMPER

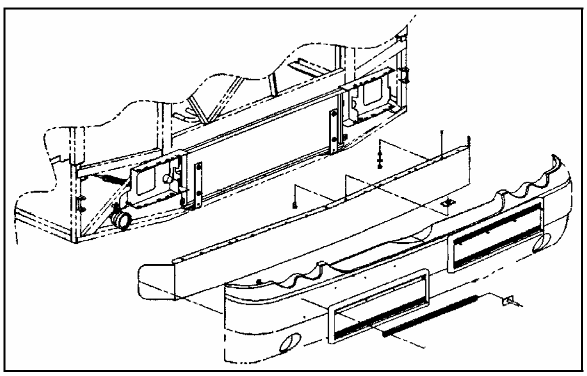


FIGURE 27: FRONT BUMPER REMOVAL 18565

8.2 REAR BUMPER REMOVAL

MTH and coach model rear bumpers are very similar, so is their removal and installation.

1. Remove three bolts on each side holding bumper to vehicle and remove bumper.
2. To install bumper, reverse the procedure.

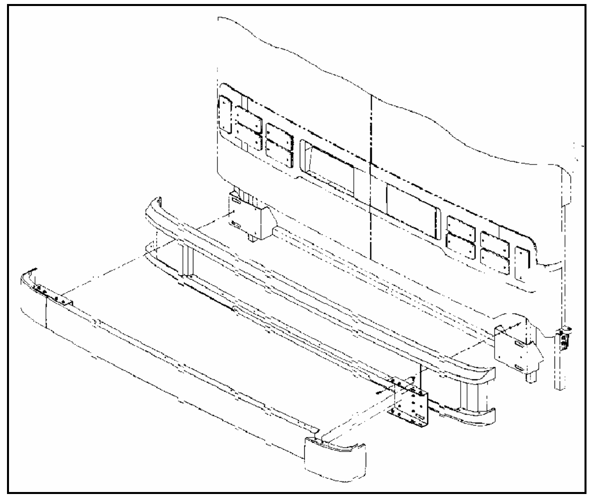


FIGURE 28: REAR BUMPER

9. DRIVER'S OR ENTRANCE DOOR POWER WINDOW

Driver's and entrance door power windows are similar, only the door opening mechanism is different. If the window or regulator is defective, it must be replaced. The following instructions refer to figure 29 or 30:

9.1 DRIVER'S POWER WINDOW

9.1.1 Window Removal And Installation

1. Open the door and remove the door finishing panel.
2. Remove the screws holding the window to the lifting mechanism. Move aside the holding plate.
3. Lower the window completely to detach from the opening.
4. Reverse the procedure to install.

9.1.2 Regulator Removal And Installation

1. Open the door and remove the door finishing panel.
2. Remove the screws holding the window to the lifting mechanism. Move aside the holding plate.
3. Unfasten the two bolts fixing the regulator assembly. Disconnect connector from regulator.
4. Reverse the procedure to reinstall.

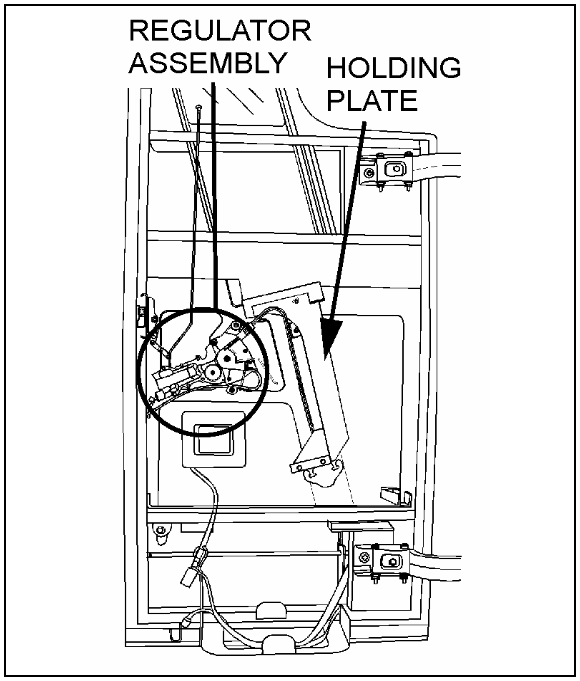


FIGURE 29: DRIVER'S POWER WINDOW

9.2 ENTRANCE DOOR POWER WINDOW

9.2.1 Window Removal And Installation

1. Open the door and remove the door finishing panel.
2. Remove the four bolts fixing the entrance door locking mechanism support to the door.
3. Remove the screws holding the window to the lifting mechanism. Move aside the holding plate.
4. Remove the assembly by slipping it under the vehicle structural members.
5. Lower the window completely to detach from the opening.
6. Reverse the procedure to reinstall.

9.2.2 Regulator Removal And Installation

1. Open the door and remove the door finishing panel.
2. Remove the screws holding the window to the lifting mechanism. Move aside the holding plate.
3. Unfasten the two bolts fixing the regulator assembly. Disconnect connector from regulator.
4. Remove the regulator assembly by slipping it under the vehicle structural members.
5. Reverse the procedure to reinstall.

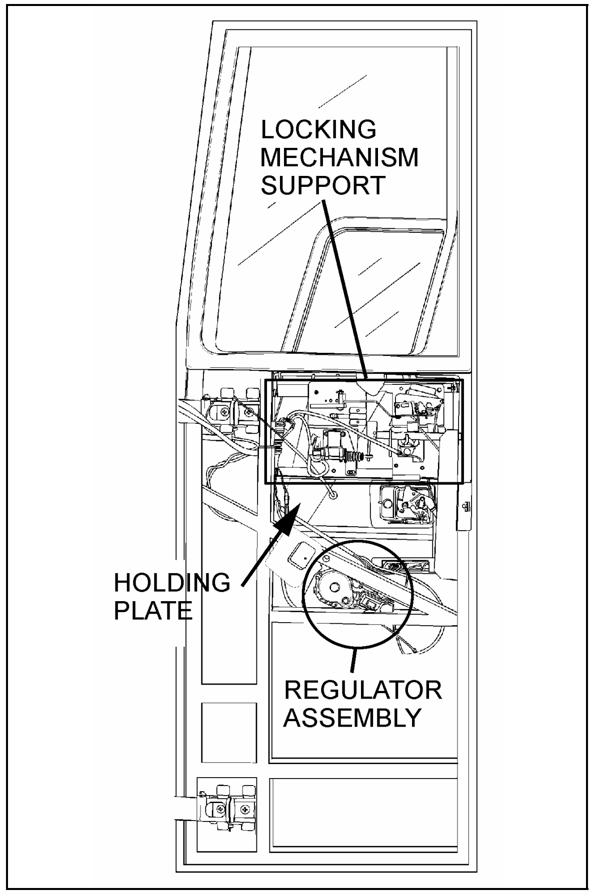


FIGURE 30: ENTRANCE DOOR POWER WINDOW

10. 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 section for procedures on how to seal this area.

⚠ 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.

10.1 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 32.

⚠ 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.

10.2 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.

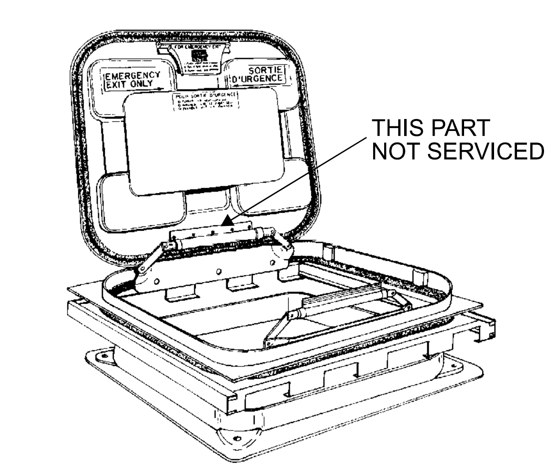


FIGURE 31: ESCAPE HATCH 18104

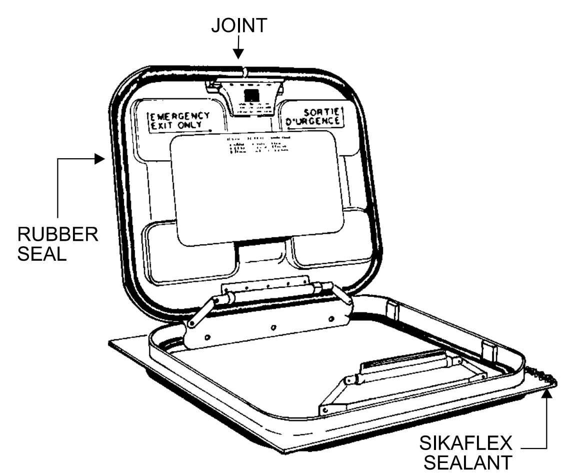


FIGURE 32: ESCAPE HATCH 18105

10.3 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.

10.4 ESCAPE HATCH FRAME

When necessary, the escape hatch frame can be removed and replaced in the following way:

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.

11. PASSENGER SEATS

XLII-45 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 cusion 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.

11.1 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.

11.2 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 35.
5. Remove 2 nuts and washers holding seat frame to pedestal rods. See figure 36.

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.

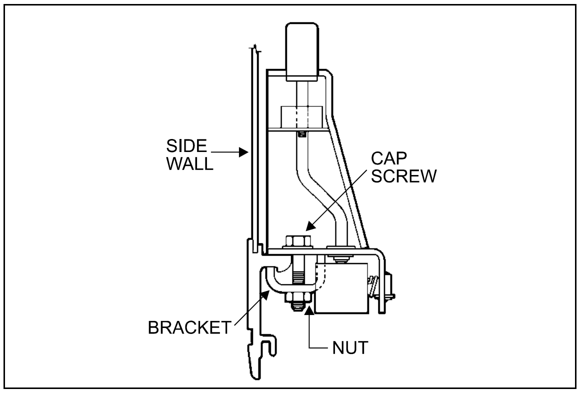


FIGURE 33: ARMREST 18106

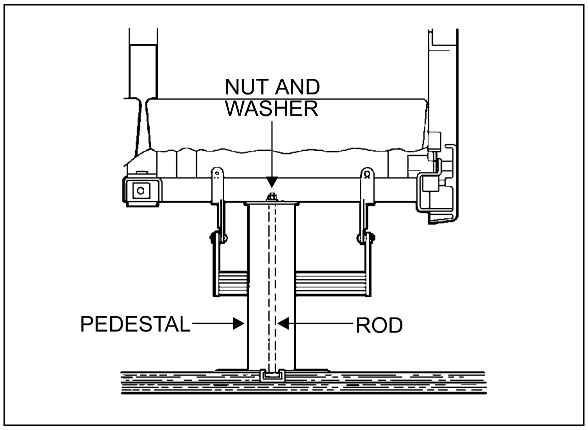


FIGURE 34: SEAT PEDESTAL ASSEMBLY 18107

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.

11.3 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.

11.3.1 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.

11.3.2 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.

11.3.3 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.

12. TARABUS FLOOR COVERING REPAIR OR REPLACEMENT

On XL2 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 35).

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 figure36).

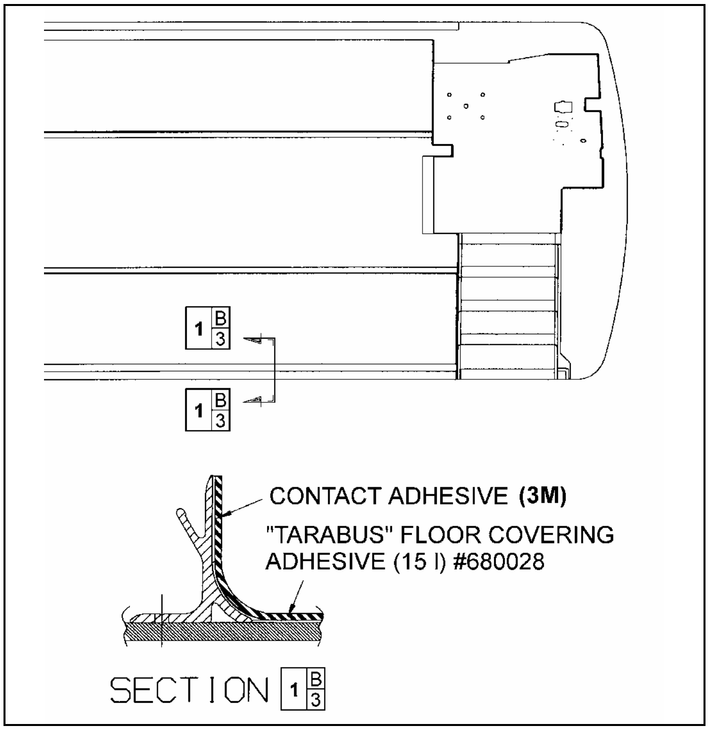


FIGURE 35: TARABUS FLOOR COVERING ADHESIVE APPLICATION

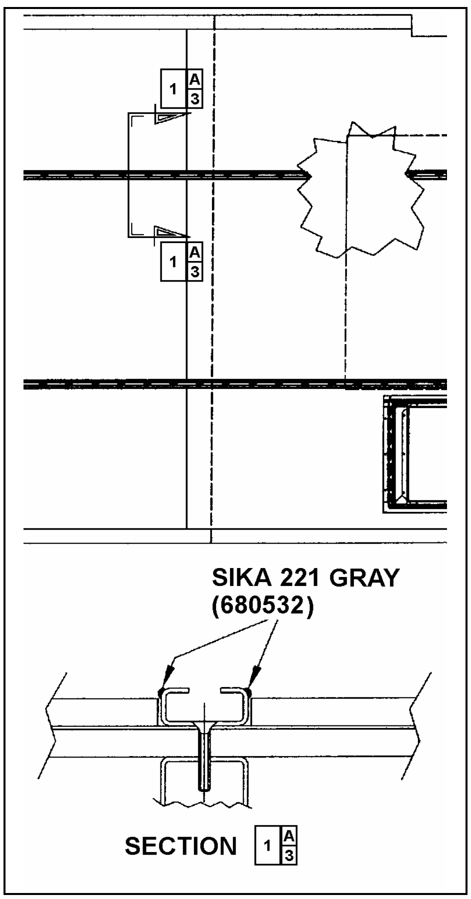


FIGURE 36: APPLICATION OF SIKA 221 GRAY

12.1 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.

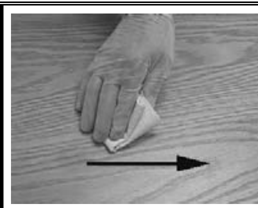
PREPARATION OF “TARABUS” FLOOR COVERING

1. Sand under step using “Scotchbrite”.
2. Clean using anti-silicone (refer to Section A).

Section A Alcohol or Anti-silicone

***1.* Apply**

CHIX cloth



***2.* Dry immediately**

Blue cloth

***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

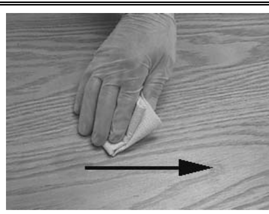
3. **Allow drying**

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**

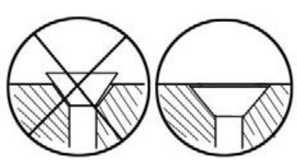
CHIX cloth

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.		

XL2 VEHICLE FRONT STEPS GLUING

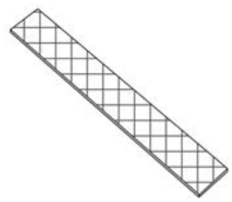
1. Use step nosing to measure and cut necessary length of white safety strip.
2. Use a screw to check depth of countersinking in step nosing. Screw top must not stick out beyond the aluminum surface. Countersink if needed.



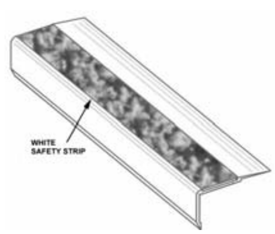
3. Apply some Sika 252 onto the step; make sure to cover the whole surface of the step. Use a serrated spreader with 1/8-inch serration to spread Sika.
4. Apply a bead of Sika 221 onto the perimeter of the step.
5. Install step and press with hands. If Sika overflows, clean with Sika 208. Repeat previous 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).

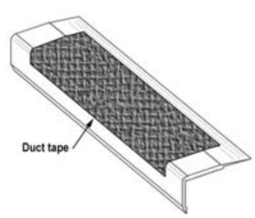
8. Apply some Sika 221 onto white safety strip, spread with a spatula to cover the whole surface.



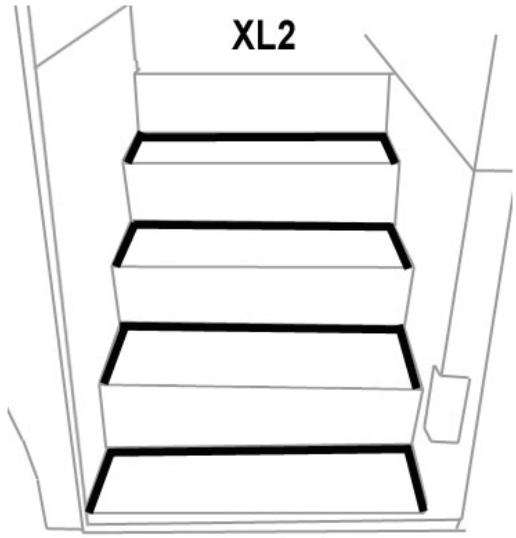
9. Position white safety strip then press using hands. If Sika overflows, clean with Sika 208.



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.



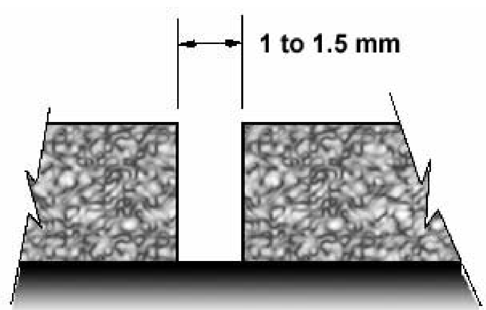
12.2 WELDING OF JOINT BETWEEN WHITE SAFETY STRIP AND "TARABUS" FLOOR COVERING

1. Pre-heat welding torch;

   Set welding torch to position #4.5 (temperature of 500 °C),

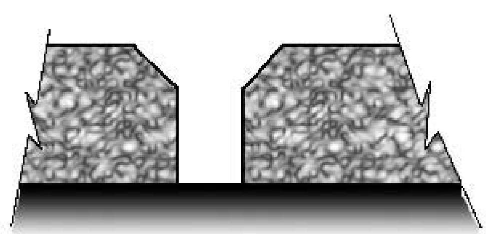
   Heating time: 5 minutes.

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.



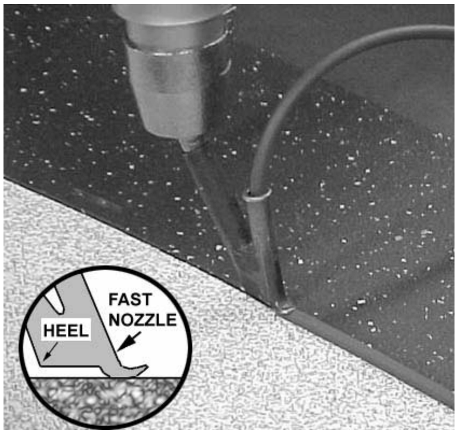
NOTE
The chamfer width must always be less than the filler bead diameter (between 2.5 and 3 mm).

4. Use chamfer knife. **Be careful not to overcut or to cut to the side to prevent damaging "Tarabus" covering.**

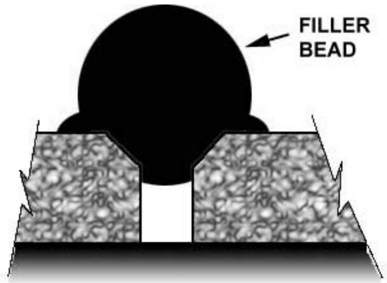
5. Add (about 6 inches) some length to the required length of filler bead to make the joint then cut.
6. Take position with welding torch. The proper position is with a slight slope to the rear.

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).

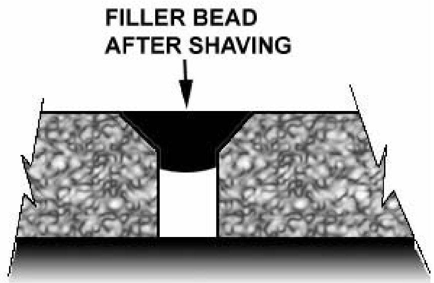


9. Allow cooling down of filler bead (about 5 minutes).



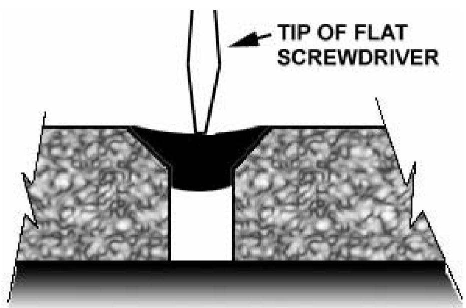
10. Shave filler bead to make it level to the floor. Use supplied knife designed for that purpose.

NOTE
To facilitate the cut, you can spray some soapy water onto the joint.

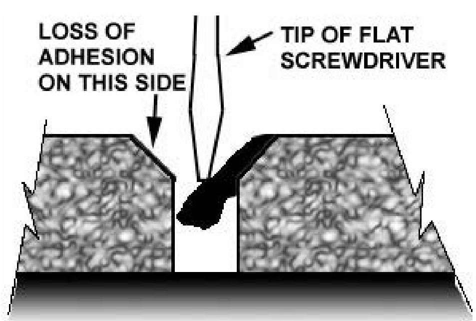


⚠ **CAUTION** ⚠
The procedure for turning the torch off must absolutely be followed. If this step is not taken, the element may burn.

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.



12.3 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.

13. COACH SIDE WINDOWS

Nine passenger side windows are provided on each side on XL2-45. 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.

13.1 EMERGENCY EXIT WINDOWS

Three of the windows on curb side of the XLII-45 serve as emergency exits, while there are four on driver’s side. See figure 37. 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.

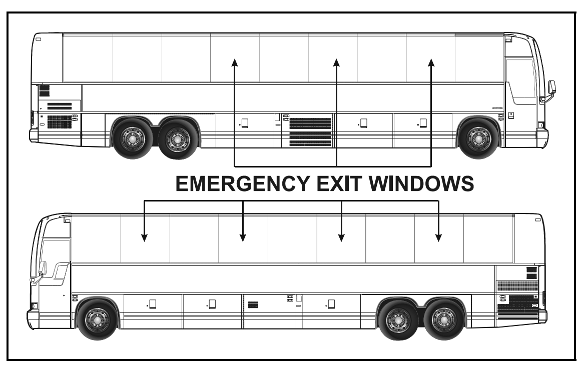


FIGURE 37: XL2-45 COACH

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. 38).

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.

13.1.1 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.

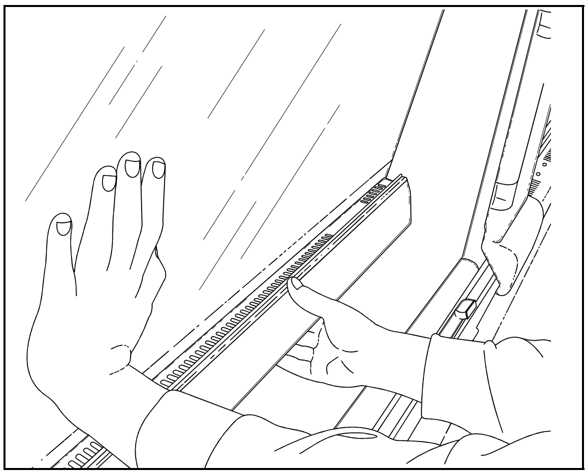


FIGURE 38: EMERGENCY EXIT WINDOW

13.1.2 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.

13.1.3 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.
5. Reverse the procedure to install a new emergency exit window.

14. ELECTRIC AWNING WINDOW

The electric awning windows are connected directly on the batteries 24 V DC terminal block. As a result, they can be operated regardless of the state open or close of the master switch. However, the circuit is protected with fuse F41 (10A) located in the front service compartment.

14.1 OPERATION

Opening sequence: switch SW1B or SW2B is closed. Window latch solenoid SOL1-A and SOL1-B are turned on along with M1 window motor. Once the latch is open, proximity switch PROX1 is de-activated, turning sol1-A and SOL1-B off.

Closing sequence: switch SW1A or SW2A is closed, turning on relay R1which turns on M1 in reverse polarity, closing the window. Once the window is closed, PROX1 is activated, turning on sol1-A and SOL1-B in reverse polarity latching the window closed.

14.2 WINDOW REMOVAL

Replacement awning window does not include a new motor. If in working order, transfer the motor of the replaced window to the replacement window. If not, the motor can be bought separately. When replacing the window, keep the components in working order as spare parts.

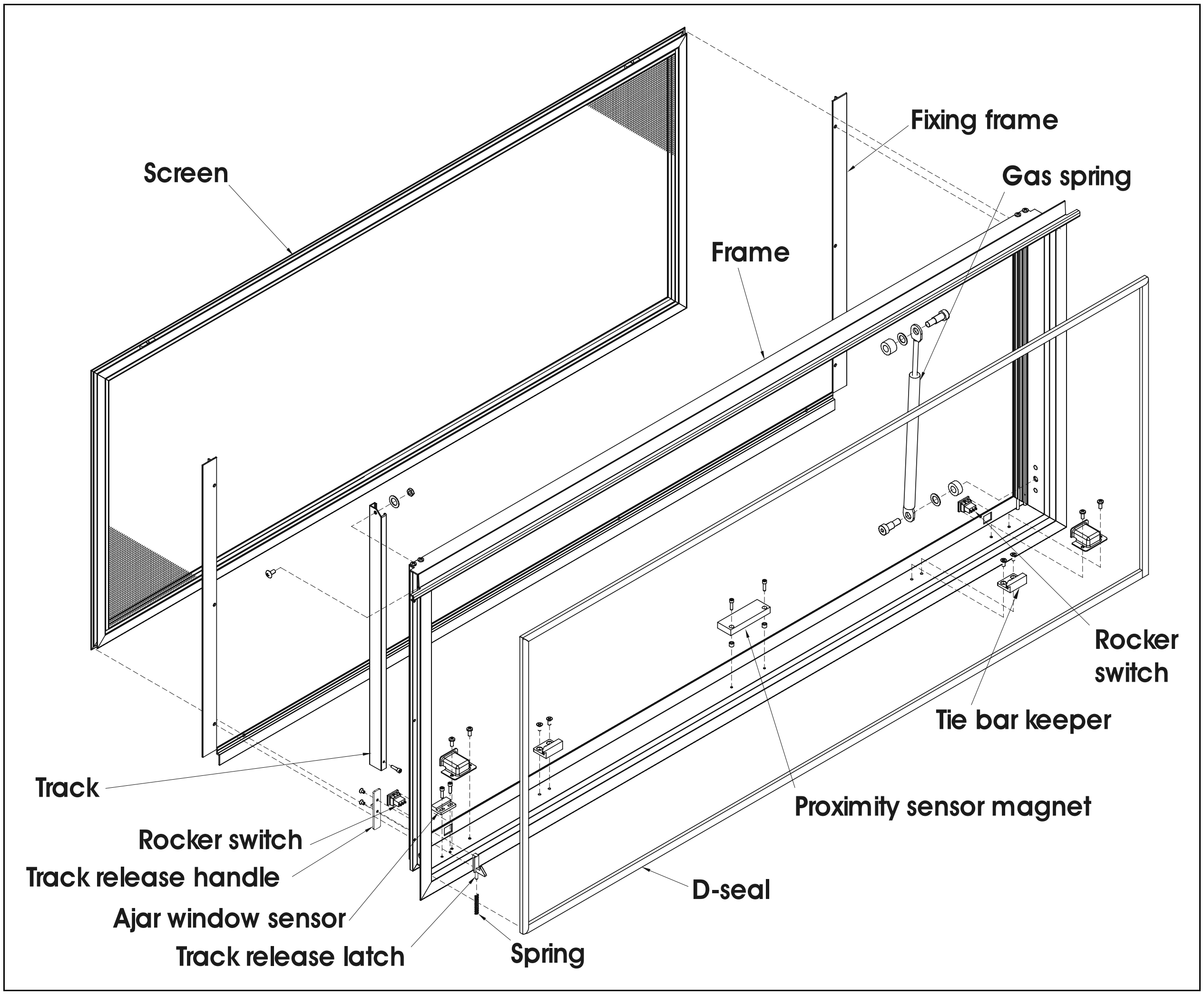


FIGURE 39: ELECTRIC AWNING WINDOW EXPLODED VIEW (FRAME) 18586

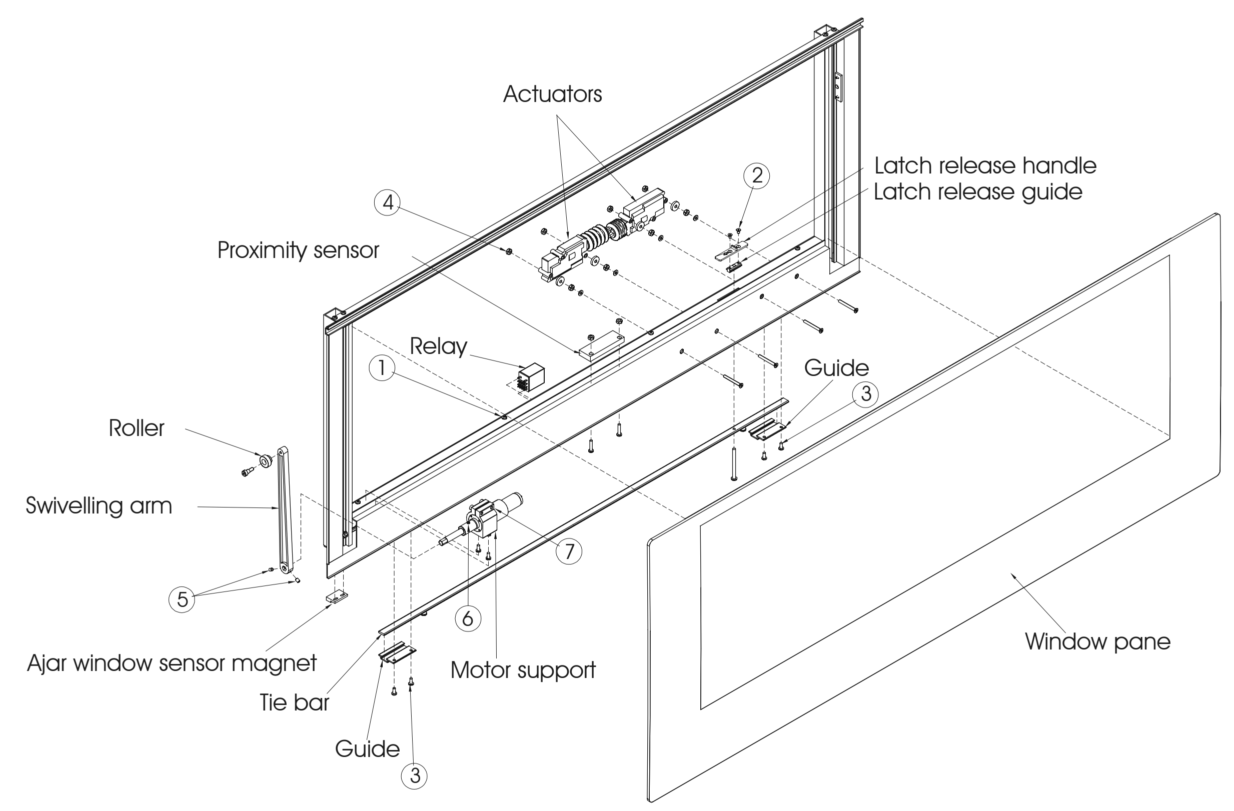


FIGURE 40: ELECTRIC AWNING WINDOW EXPLODED VIEW (SASH) 18583

1. Open the window and push downwards on the track release handle to release the track from the window frame.
2. Take out the screw at the lower end of the track to let free the swiveling arm roller.
3. Unplug connector C1 in the upper right corner. Dismount the gas spring from the window.
4. Loosen the set screws #5 (figure 39)(rotate the arm to get to the second set screw) and disengage the swiveling arm from the motor shaft extension.
5. Push the glass window out ninety degrees (90°).

⚠ CAUTION ⚠
The window may fall out.

6. The window is free and can be unhooked.
7. Reverse procedure to install a new one.

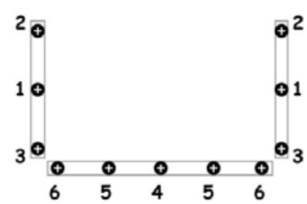
14.3 ACTUATOR REPLACEMENT

1. Unlatch the window using the manual latch release handle and open the window by pushing downwards on the track release handle.
2. Remove actuator access cover by taking out screws #1 (8x).
3. Take out screws #2 (2x) and remove latch release handle and guide.
4. Take out the guide screws #3 (4x) and remove tie bar.
5. Unplug connector C3 or C4 from problem actuator, unscrew nuts #4 (2x) and remove the actuator.
6. Reverse operations for reinstallation.

14.4 MOTOR REPLACEMENT

1. Open the window and push downwards on the track release handle to release the track from the window frame.
2. Take out the screw at the lower end of the track to let free the swiveling arm roller.
3. Remove actuator access cover by taking out screws #1 (8x).
4. Loosen the set screws #5 (rotate the arm to get to the second set screw) and disengage the swiveling arm from the motor shaft extension.
5. Unplug motor connector C2 and dismount motor and support assembly.

6. The shaft extension is glued to the motor shaft. It has to be heated to break the binding to permit removal. Loosen set screw #6 and remove the shaft extension. Also loosen screw #7 and remove motor from the support.
7. Reverse operations for reinstallation.

ELECTRIC AWNING WINDOW – CONVERTER CHECKLIST	
Check the electrical circuit & proximity sensor	A: The latching system will not operate without power. Is there electrical power to the latching circuit? The manual latch release handle, on the sill sash will be seen to move if there is power on this circuit, or it can be checked with an electrical tester. If there is no power to this circuit when the window is closed and either rocker switch are switched "ON", there is a problem with the electrical system. B: The Proximity Sensor on the sash may not be switching power to the latching circuit if the magnet is not getting close enough to the switch OR the Proximity Sensor may be broken (or stuck in one position). Is the proximity sensor switching when the window is closed?
Check the release force required to operate the manual latch release handle	A: If the pull force required to move the latch release is more than 20lbs the window will not latch properly. Average pull force during testing by manufacturer is 12lbs -15lbs. What is the force required to release the handle? Check using a force gauge (same test done by manufacturer).
Check Installation	A: If the window is too tightly installed OR if the sequence for tightening the clamping frame screws Is incorrect the window may not close properly. Was the window installed correctly? Was the correct sequence (see below) used when tightening the clamping frame screws?  B: Removing the shipping blocks before the window is installed can create major problems. Were the shipping blocks in place during installation? C: Failure to remove the shipping blocks after installation can create interference between sash and frame. Have the shipping blocks been removed after installation? D: The window is misaligned or not installed squarely. Is there interference with any coach parts? Is there proper clearance between the bottom of the outer glass and the belt-line trim / seal?
Check for missing parts or misaligned parts	A: The frame and sash are misaligned. Is there any interference between the sash and frame? Is there clearance between the sash and the rocker switch covers? B: Tie-bar guides are missing. Check that the tie-bar guides are installed. There should be 4 installed on H windows, and 3 installed on XL2 windows.

15. BODY PANELS AND DOORS

Each of the doors should be checked for proper operation. This includes latching. Also, inspect each of the doors for damage, missing, or loose parts. Repair or replace those parts as needed. Unless otherwise noted, body panels and doors should be aligned and centered with surrounding panels. In general, a gap of ¼ inch (6 mm) is desirable between panels.

16. BAGGAGE COMPARTMENT DOORS

The baggage compartment doors on the vehicle are of identical design. The doors are pantograph, vertical-lift type and are fully sealed. Each door has a flush-mounted latch handle. To open, lift latch handle, then pull door outward and up. The door is held open by 2 gas-charged cylinders. To close, leave latch handle in the open position, pull downward on door and push down on latch to secure door. The door lower arm is spring loaded to secure effort required to close the door (Fig. 41).

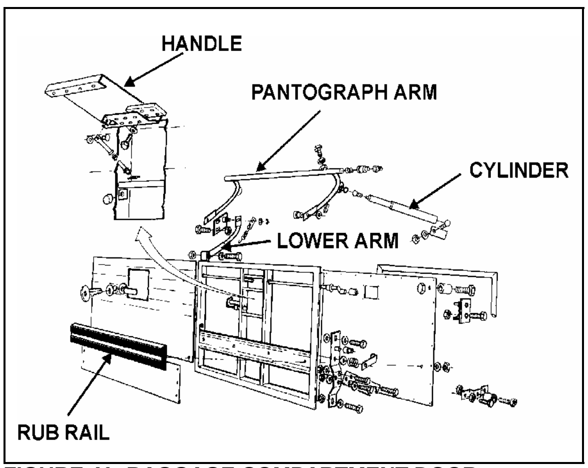


FIGURE 41: BAGGAGE COMPARTMENT DOOR 18145

If a door does not remain in the fully open position, one or both cylinders on that door is (are) defective. To test the cylinders, first support the door in the open position with proper equipment. Disconnect the rod end of one cylinder and retract the rod. If strong resistance is felt, the cylinder is in good condition and can be reinstalled. If the rod retracts with little effort, the cylinder is defective and should be replaced at once. Use the same procedure to test the other cylinder on that door.

16.1 DOOR REMOVAL

⚠ CAUTION ⚠
Two people are required to remove the baggage compartment doors.

1. Maintain the door halfway open by placing a wooden block between one of the pantograph arms and the upper frame.
2. Remove cap screw, lock washer and flat washer retaining lower arm to door
3. Remove spring pins and lock washers fastening the pantograph arms to the door.

⚠ WARNING ⚠
Support the door properly to prevent it from falling.

4. Spread the pantograph arms away from the door and remove door.
5. Inspect all pivot points and bushings for wear and damage. Check tension of gas-charged cylinders and replace if necessary.

16.2 PANTOGRAPH ARMS REMOVAL AND INSTALLATION

1. Disconnect rod end of gas-charged cylinders from the pantograph arms.
2. Loosen jam nut and cap screw locking the horizontal member of the pantograph to the pivot pin.
3. Slide pantograph assembly to the right and remove assembly from the vehicle.
4. To install, perform the removal instructions in reverse.

16.3 DOOR INSTALLATION

1. Use a wooden block to support the pantograph arms horizontally.
2. Support the door and insert each pantograph arm into the pivot pins on the side of the door.
3. Install washer and spring pin to fasten each arm to its pivot pin.
4. Fasten lower arm to the door with flat washer, lock washer and cap screw.
5. Remove wooden block and close baggage compartment door.

Door should be adjusted to leave a gap of 3/16" (5 cm) above the top edge of the door. To adjust, loosen the bolts retaining lock plate support and position the door correctly. Tighten the bolts after the adjustment.

If the baggage door locks too tightly or too loosely, the position of the catch striker is misadjusted. To adjust, loosen the catch striker retaining bolts, position the striker correctly and tighten the retaining bolts.
If the lower part of the baggage door does not close evenly with the side of the vehicle, adjust the lock plates by loosening their retaining bolts and positioning the locking plates correctly (Fig. 42).

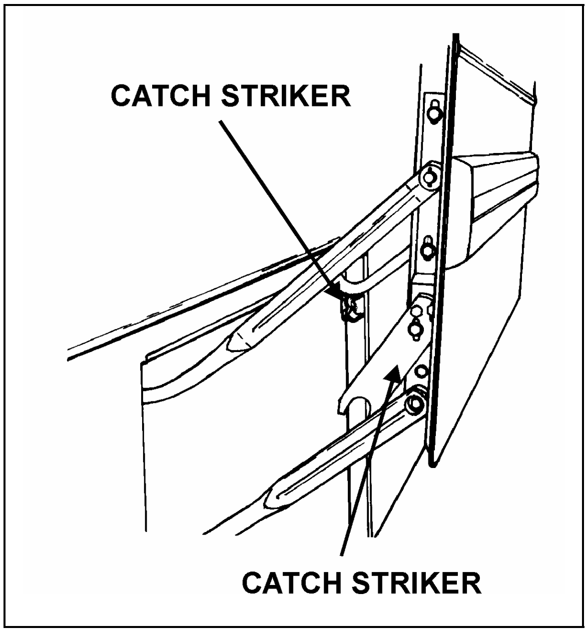


FIGURE 42: BAGGAGE DOOR CATCH STRIKER 18146

17. ENGINE COMPARTMENT DOORS

Engine compartment doors may be adjusted for proper fit by untightening hinge bolts:

1. Loosen the bolts, (1, 2 Fig. 43) holding the hinge to the vehicle structure to shift the door "UP or DOWN".
2. Loosening the bolts (3, Fig. 43) 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.

To adjust the latch mechanism (4, Fig. 43) 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.

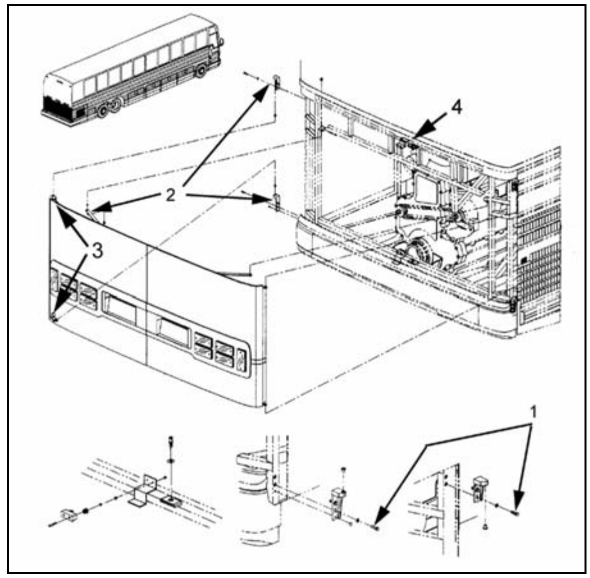


FIGURE 43: ENGINE COMPARTMENT DOORS

18. RADIATOR DOOR ADJUSTMENT

Radiator door may be adjusted for proper fit by untightening hinge bolts:

1. Loosen the bolts, (1, Fig. 44) holding the hinge to the vehicle structure to shift the door "IN or OUT" and "UP or DOWN".
2. Loosening the bolts (2, Fig. 44) allows the door to be shifted "LEFT or RIGHT" and "UP or DOWN".
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. 44) 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.

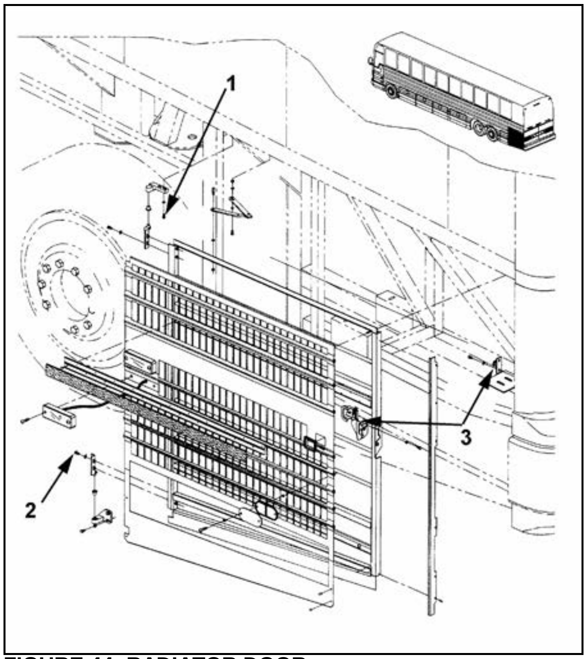


FIGURE 44: RADIATOR DOOR

19. 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. 45) holding the hinge to the vehicle structure to shift the door "IN or OUT" and "UP or DOWN".
2. Loosening the bolts (2, Fig. 45) allows the door to be shifted "LEFT or RIGHT" and "UP or DOWN".
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. 45) 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.

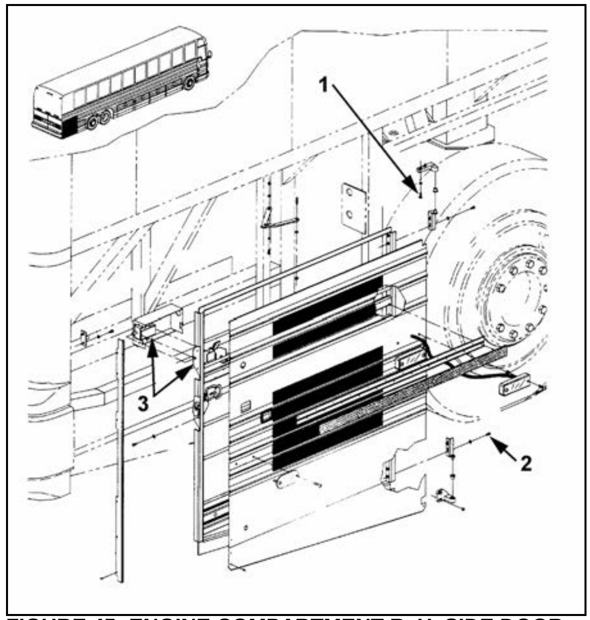


FIGURE 45: ENGINE COMPARTMENT R. H. SIDE DOOR

20. CONDENSER DOOR ADJUSTMENT

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.

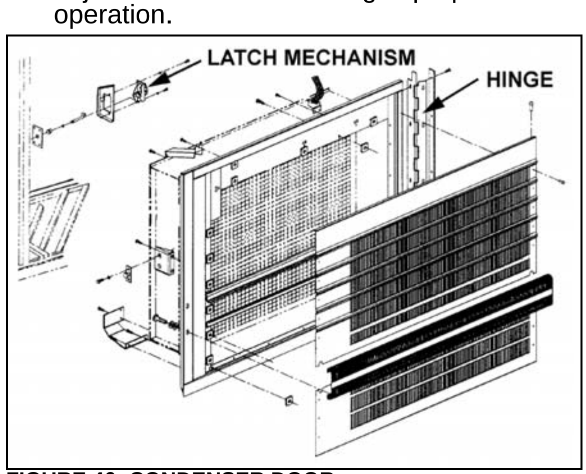


FIGURE 46: CONDENSER DOOR

21. EVAPORATOR DOOR ADJUSTMENT

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.
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.

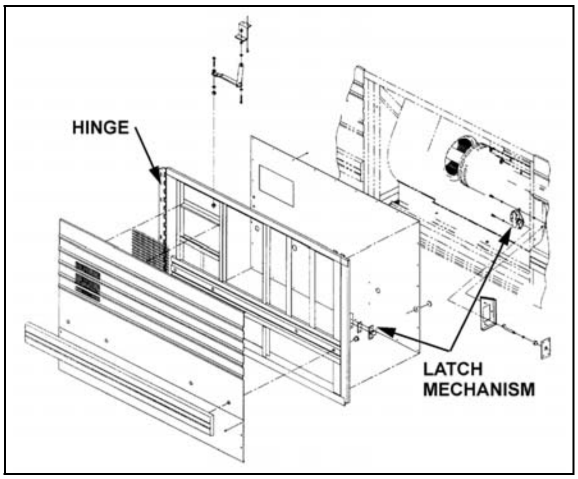


FIGURE 47: EVAPORATOR DOOR

22. 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 parts.
4. Tighten the nuts.
5. Check that the door swings freely and closes properly.

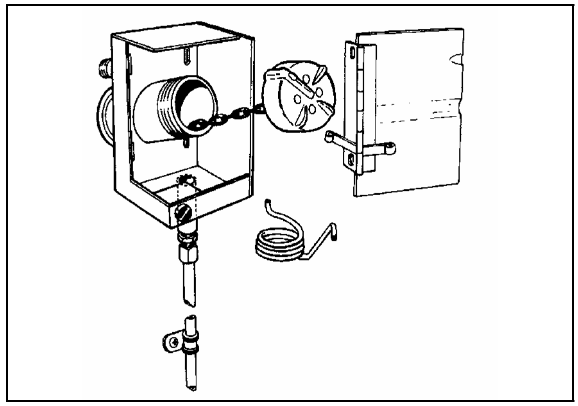


FIGURE 48: FUEL FILLER DOOR

23. FRONT SERVICE COMPARTMENT DOOR

For adjustment of the front service compartment door, refer to paragraph 7 in this section.

24. L.H. SIDE REAR SERVICE COMPARTMENT DOOR

1. Open the L. H. side rear service compartment door.
2. Loosen the screws fixing the hinge to hinge attachment or hinge to door assembly. Loosening the screws allows the L. H. side rear service compartment door assembly to be shifted "LEFT or RIGHT" and "UP or DOWN" or “IN and OUT”.
3. Adjust L. H. side rear service compartment 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.

To adjust the latch mechanism and the striker pin:

1. Open the door to access the striker pin.
2. Loosen slightly the striker pin.
3. Using a hammer, adjust the striker pin to center it in the door latch mechanism.
4. Tighten the striker pin.

Check door fit and operation.

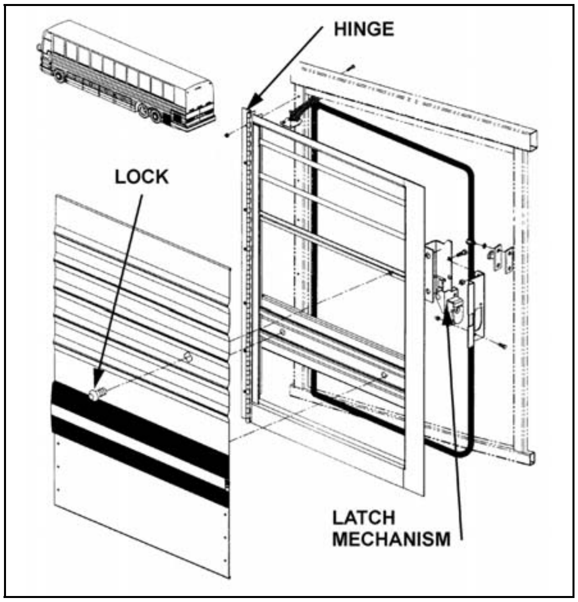


FIGURE 49: L.H. SIDE REAR SERVICE COMPARTMENT DOOR

25. R.H. SIDE REAR SERVICE COMPARTMENT OR MAIN POWER COMPARTMENT DOOR

To adjust the R. H. side rear service compartment (MTH) or main power compartment (Coaches) door:

1. Open the compartment door.
2. Loosen the screws fixing the hinge to hinge attachment or hinge to door assembly. Loosening the screws allows the compartment door assembly to be shifted "LEFT or RIGHT" and "UP or DOWN" or “IN and OUT”.
3. Adjust compartment 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.

To adjust the latch mechanism and the striker pin:

1. Open the door to access the striker pin.
2. Loosen slightly the striker pin.
3. Using a hammer, adjust the striker pin to center it in the door latch mechanism.
4. Tighten the striker pin.

Check door fit and operation.

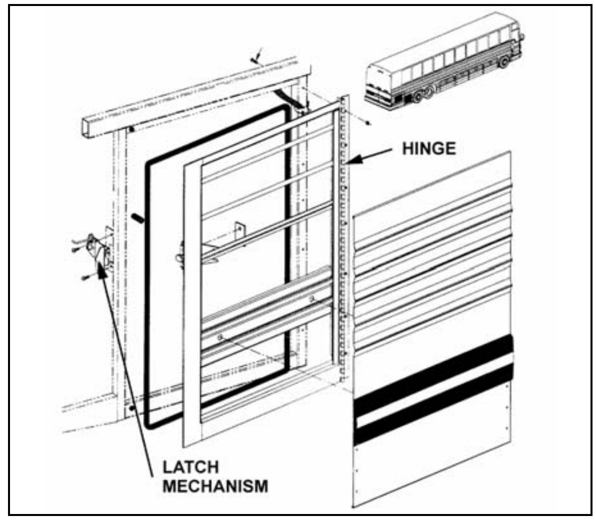


FIGURE 50: R.H. SIDE REAR SERVICE COMPARTMENT OR MAIN POWER COMPARTMENT DOOR

26. FENDERS

On the "XL2" 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.
Front rubber 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.

27. 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 section 4 "Fiberglass Repair" and section 5 "Painting".

28. 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".

29. XL2 SMOOTH SIDE PANEL REPLACEMENT PROCEDURE

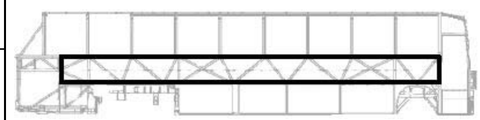
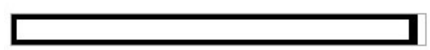
Material:

Anti-silicone (682989)	√	Scotchbrite gray (680226)	√	Sika 221 gray	√
CHIX cloth (682384)	√	Sika 205 1liter (683097)	√	Sika 252 black	√
Blue cloth (682383)	√				

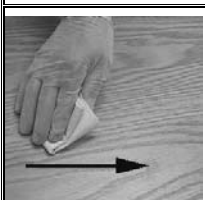
Equipment:

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^o 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.

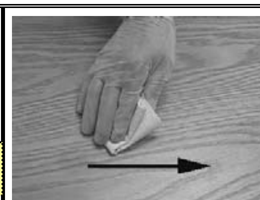
SECTION 2 PREPARATION OF SURFACES			
2.00		**VEHICLE SURFACE PREPARATION**	
	A)	Clean using "anti-silicone" until all clothes come clean. See PR000001 section A.	
	B)	Use the belt sander (grit coarse) Use a new paper on each vehicle side.	
	C)	Clean using " anti-silicone " until all clothes come clean. 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



***1.* Apply**

CHIX cloth



***2.* Dry immediately**

Blue cloth

***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.

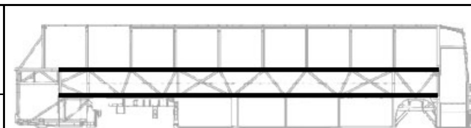
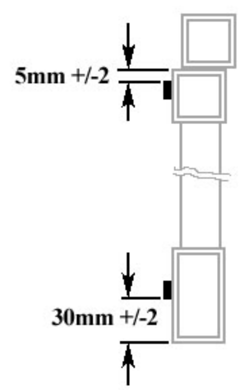
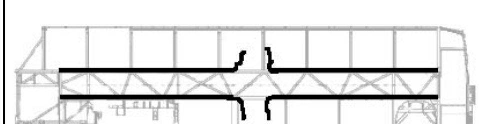
Section B Sika 205

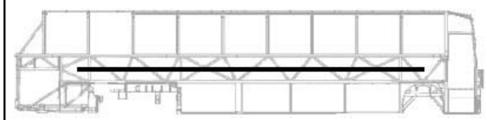
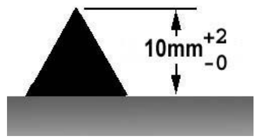
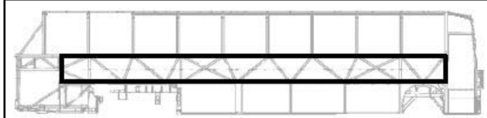
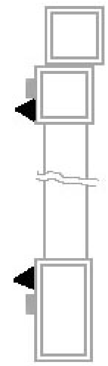
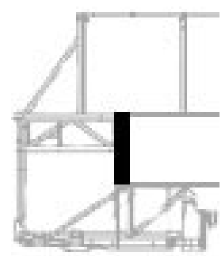
1. Apply

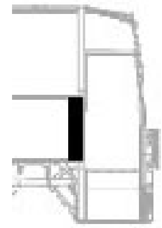
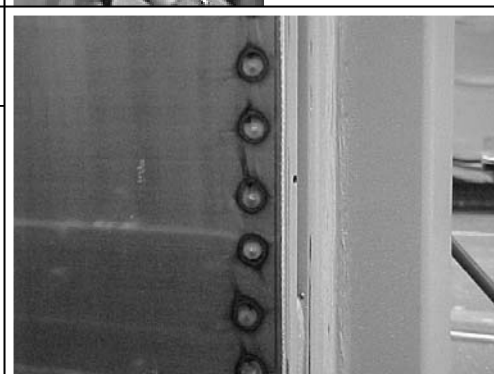
CHIX cloth

2. Allow to dry

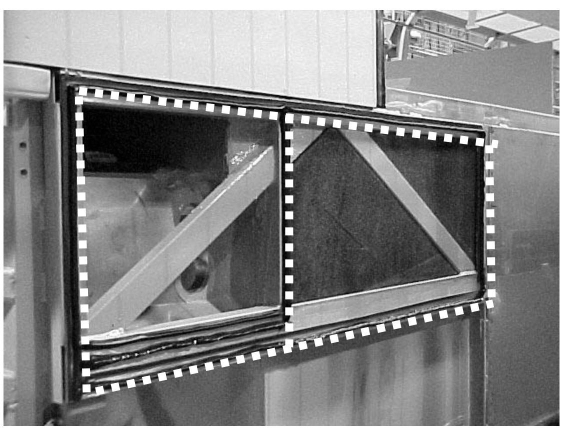
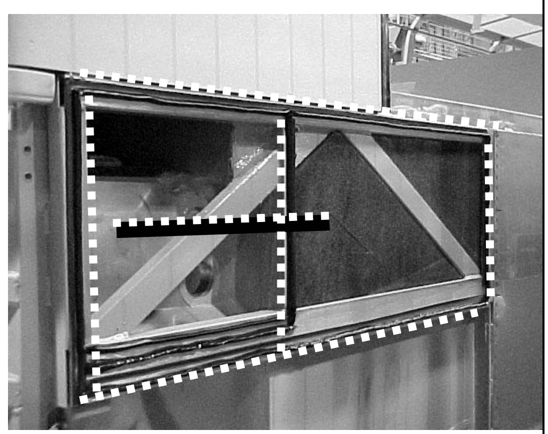
Manda-tory	**Minimum time**	**- For a smooth surface (aluminum, stainless, steel, fiber glass (gelcoat side), etc.):**	**2 minutes**
		- Pour a porous surface (fiber glass (non gelcoat side), etc.)	**10 minutes**
	After 2 hours : Reactivate surface with Sika 205		
Before applying any other product	If surface seems dusty, greasy or with finger marks, start operation again.		

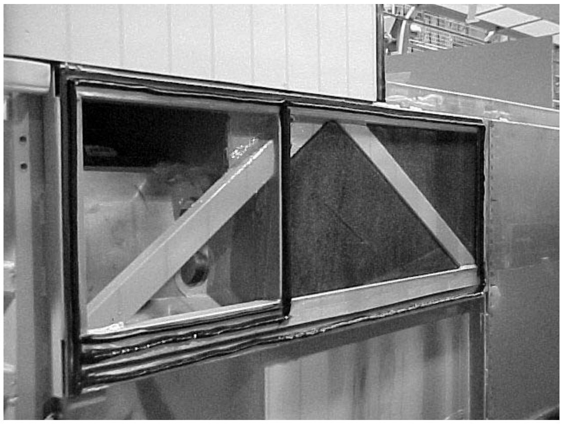
SECTION 3 SIDE PANEL INSTALLATION			
3.00	A)	Using a pencil, mark the double-face self adhesive tape position onto vehicle side.	
	B)	Apply double-face tape as per marking.	
	C)	Compress tape	
	D)	Remove protective film from double-face self adhesive tape center section.	

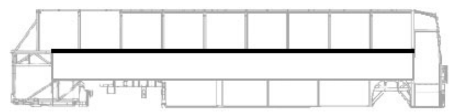
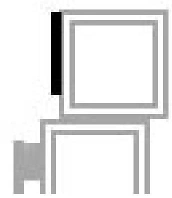
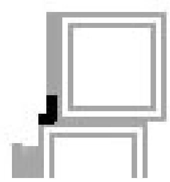
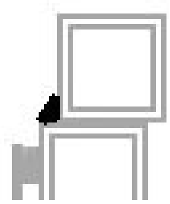
3.05	Install foam tape onto middle reinforcement then compress.		
3.10	Apply Sika 252  – Onto vehicle surface – Cut nozzle as per template – Use the guide for the application Bead must be continuous for the whole perimeter.		 
3.15	A)	Install side panel onto support jig.	
	B)	Position side panel in front of vehicle structure	
	C)	Perform final adjustment to make sure that side panel is true and square	– 30 mm. ± 2 with reference to bottom tubing – Side panel lined up with longitudinal "flat bar"
	D)	Sand rear of side panel 2" wide	
	E)	Perform tig spot welding	Quantity of "tig spot": 29 minimum.
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": 29 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 ¼" onto structure, as shown in picture Coach 	 MTH 
4.20	Install foam tape 1/16" X ¼ onto air intake panel top and bottom pleat	
4.25	Apply a bead of 252 onto structure as per picture Important: Make sure bead is continuous Triangular bead: 10mm x 8mm	

	Coach 	MTH 
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	

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	

30. 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.

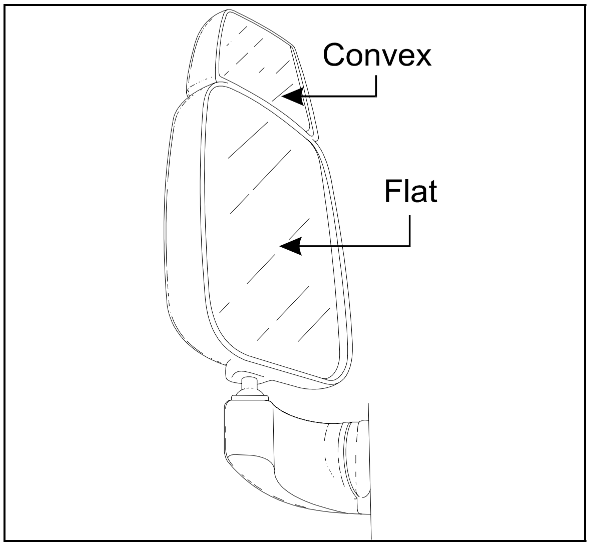


FIGURE 51: REAR VIEW MIRROR (RAMCO) 18398A

30.1 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.

30.2 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.

30.3 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.

30.4 REPLACEMENT OF MIRROR GLASS

Remove the broken glass.
Position new glass in mirror head and press to lock the Velcro in place.

30.5 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.

30.5.1 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.

30.5.2 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.

30.5.3 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.

30.5.4 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.

31. VEHICLE JACKING POINTS

The vehicle can be lifted by applying pressure under body jacking points or front 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).

⚠ CAUTION ⚠
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 52 to 58.

⚠ WARNING ⚠
Extra lift capacity may be required if luggage or any other type of load (e.g. conversion equipment) are onboard the vehicle.

⚠ CAUTION ⚠
The suspension of the vehicle must be in the normal ride position before jacking. The "Level Low" system on a motorcoach must be in the "DRIVE" position prior to turning the ignition key "OFF".

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.

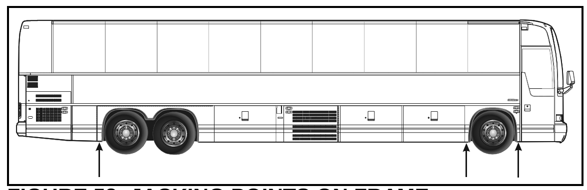


FIGURE 52: JACKING POINTS ON FRAME

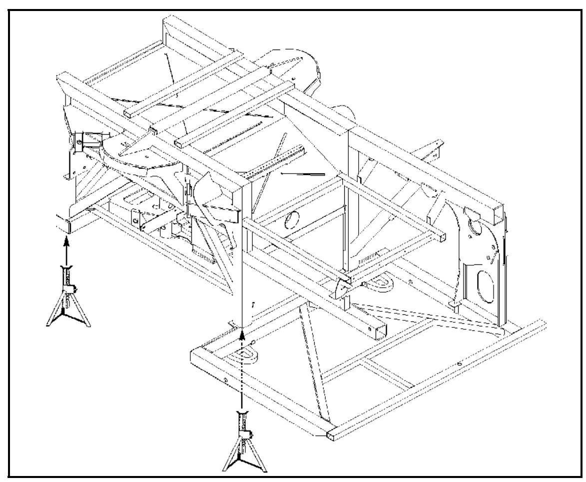


FIGURE 53: FRONT SUBFRAME JACKING POINTS 18592

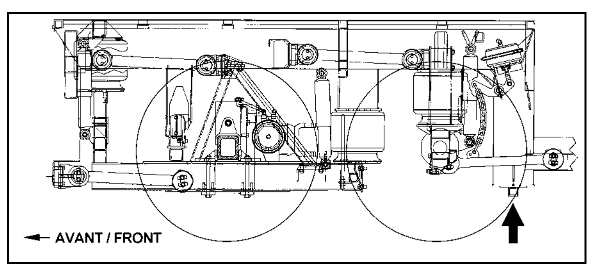


FIGURE 54: REAR SUBFRAME JACKING POINTS

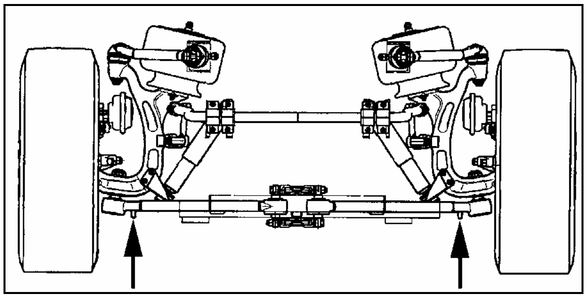


FIGURE 55: JACKING POINTS ON IND. SUSPENSION 16095

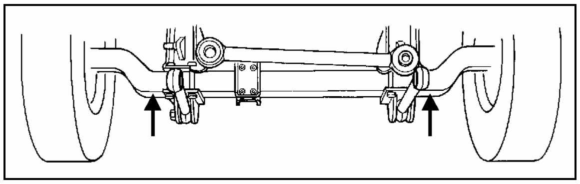


FIGURE 56: JACKING POINTS ON FRONT AXLE 18084

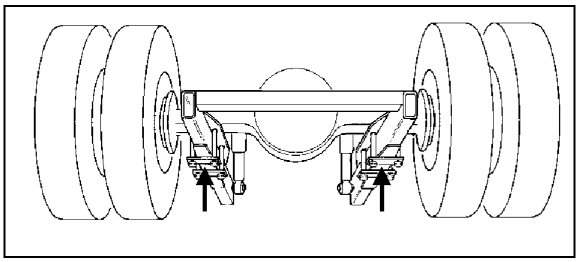


FIGURE 57: JACKING POINTS ON DRIVE AXLE OEH3B762

WARNING

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.

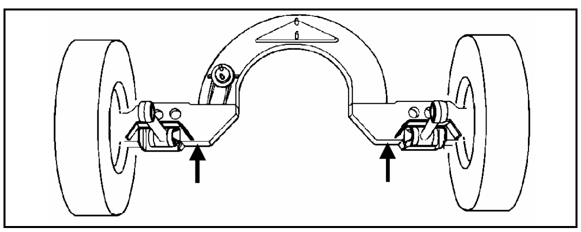


FIGURE 58: JACKING POINTS ON TAG AXLE OEH3B764

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 axle: 20,000 lb. (9 100 kg);

Drive axle: 40,000 lb. (18 200 kg).

31.1 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.

WARNING

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.

WARNING

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.

32. 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.

⚠ 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.

NOTE
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

32.1 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 Rockwell's *"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.

2. 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.
3. The emergency fill valve in the front service compartment does not supply air pressure to the brake system. The air pressure must be a minimum of 75 psi (520 kPa), and the line should be attached to the air line with a clip-on chuck.

⚠ CAUTION ⚠
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.

4. Lift the vehicle from under the front axle, and adequately secure the underside to the tow vehicle lifting attachment with chains.
5. Observe safety precautions when towing.

32.2 TOWING WITHOUT LIFTING

⚠ CAUTION ⚠
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.

1. Remove both drive axle shafts to prevent damage to the transmission. Plug axle tube to prevent oil loss. Refer to Rockwell's *"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.

2. 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 a minimum of 75 psi (520 kPa), and the line should be attached to the air line with a clip-on chuck.

⚠ CAUTION ⚠

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.

3. Position the tow truck so that the tow bar contacts the front bumper of the vehicle.
4. Attach the tow truck chains only in the tow eyes of the vehicle under the bumper and take up all the slack.
5. Attach safety chains as applicable.
6. Observe safety precautions when towing.

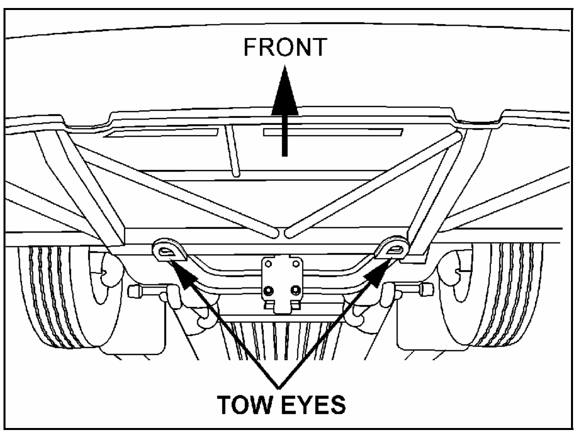


FIGURE 59: TOW EYES

33. 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

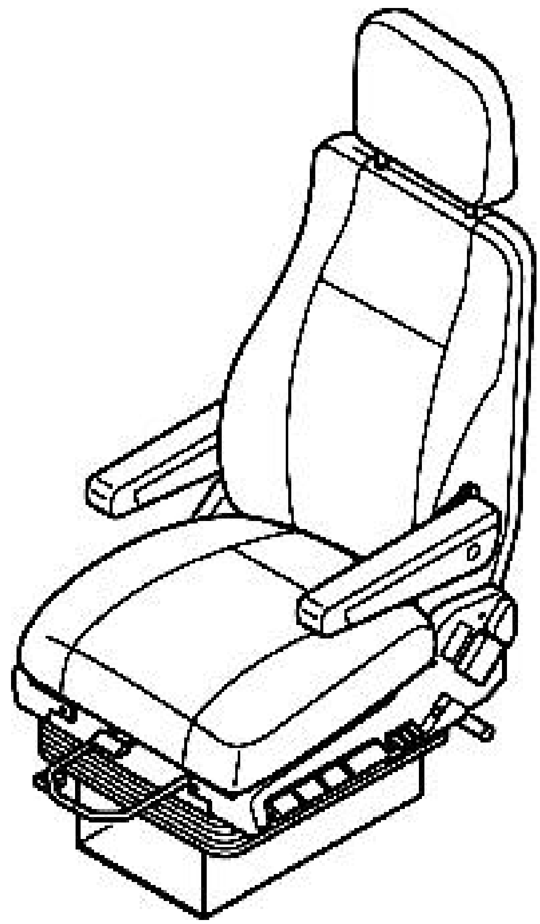
Pressure switch assembly
Prévost number 452831

Isringhausen

Seat Model 6800/338 Bus

Seat Model 6800/338 Premium LX

Service Manual



Read and understand this manual before servicing this seat.

ISRINGHAUSEN

ISRI

Manual No. 7018081-02, Rel. Jun. 1999

INTRODUCTION

SERVICE AND REPAIR

Proper service and repair are important to the safe, reliable operation of this seat. Service and repair should be preformed 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.

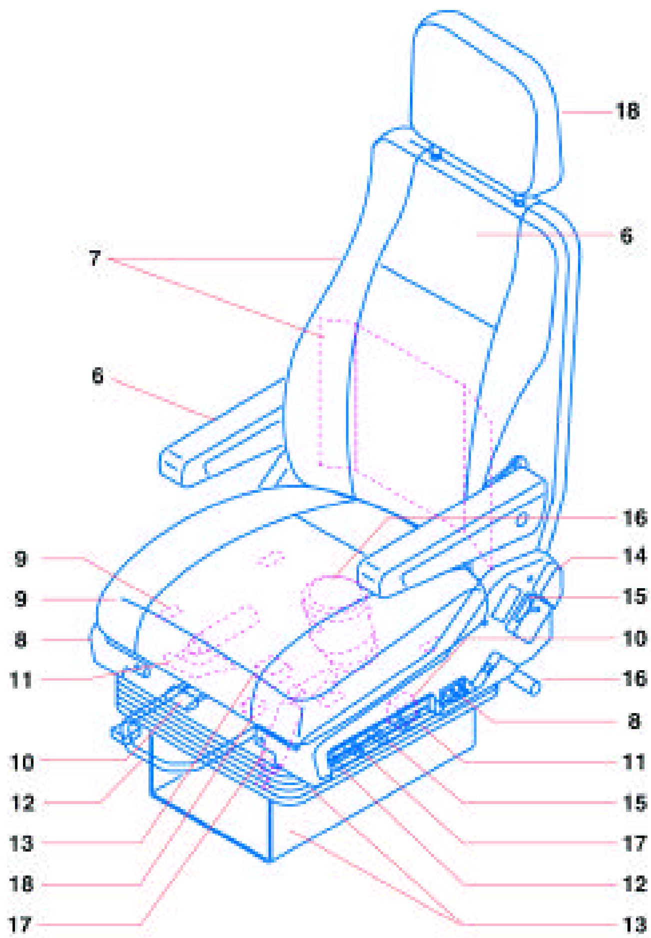
WARRANTY

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

TABLE of CONTENTS

REMOVAL AND INSTALLATION PAGE NUMBERS



GENERAL SAFETY

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 an potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION: Indicates an 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.

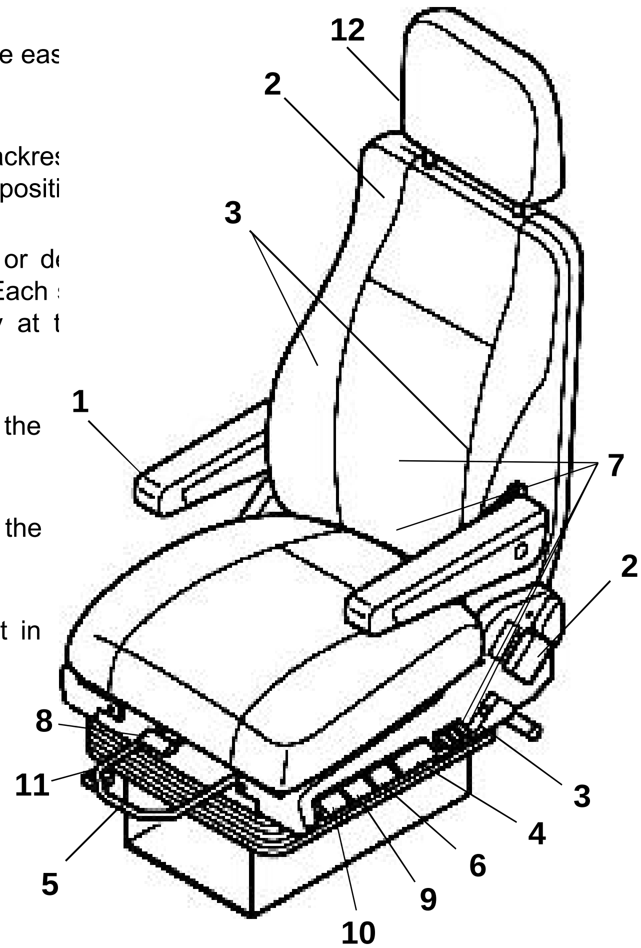
TROUBLESHOOTING

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

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 eas the armrest must stay in the adjusted position.

2. Backrest adjustment
The control should be easy to release then the backres move freely. The backrest must stay in the adjusted positi

3. Backrest side bolster
The control should be easy to move to the inflate or d position and must return to neutral when released. Each support should inflate and deflate evenly and stay at t 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 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.

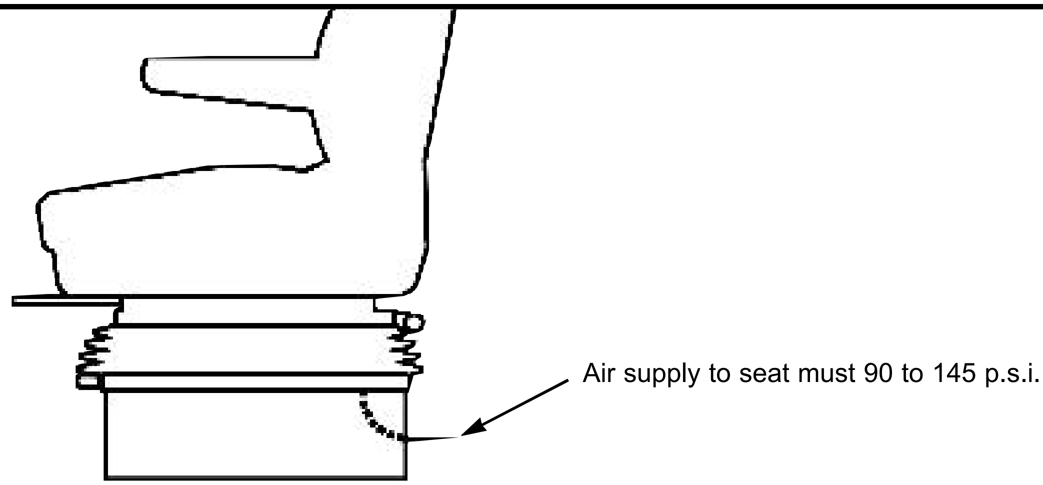
10. Quick air release
Control should be easy to move and hold seat in the adjusted position when released.

11. Horizontal isolator
Control should be easy to move and stay in position when released.

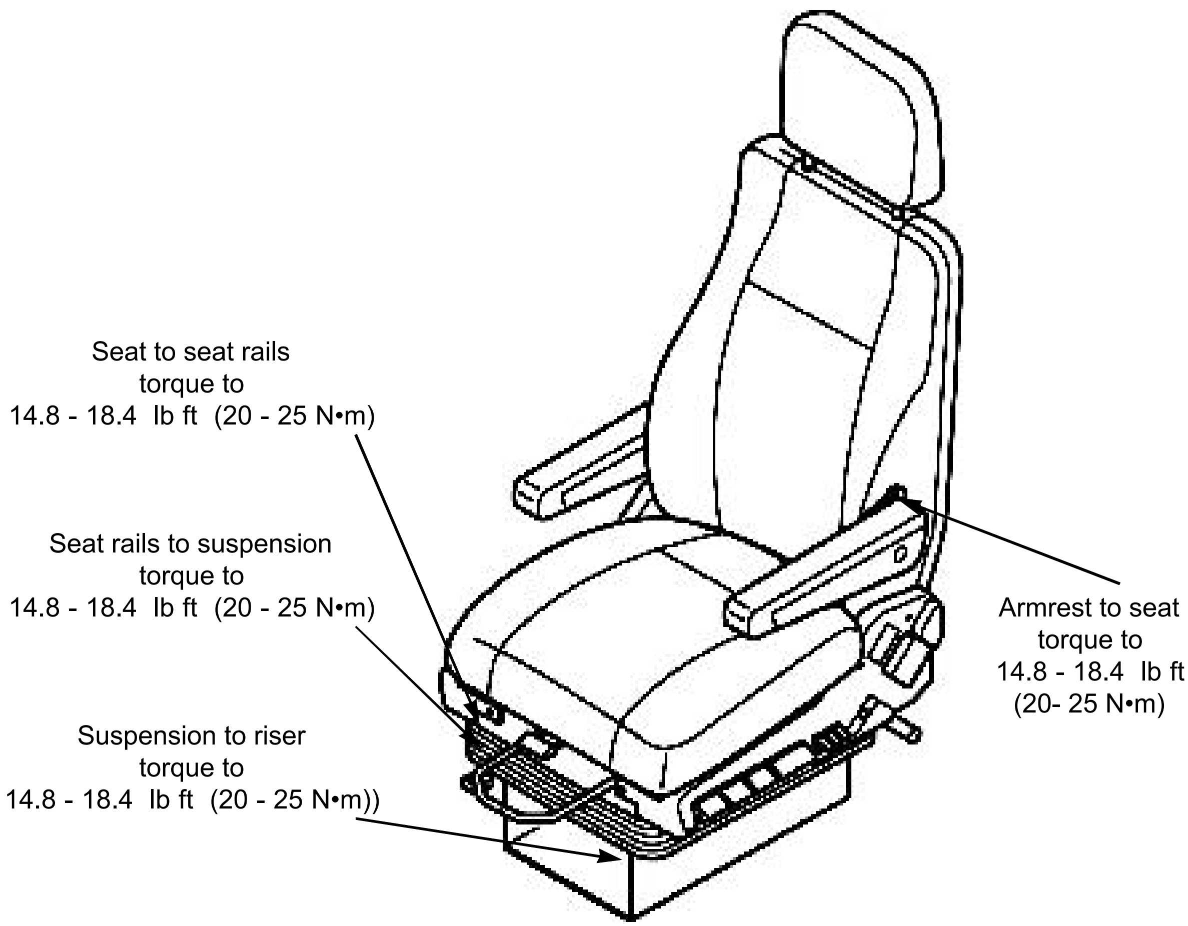
12. Headrest
Should be easy to move up and down and stay in position. Headrest should tilt forward and backward freely.

If the seat is not functioning properly take it out of service until it can be repaired.

Air supply



Critical fastener torque



⚠ CAUTION

Avoid the risk of injury. Vehicle must be in a safe parked position before working on the seat.

NOTICE

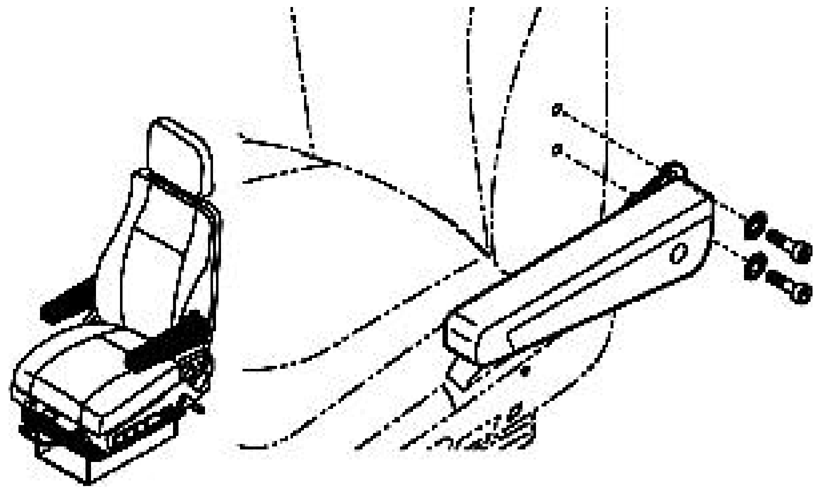
To remove seat from vehicle follow vehicle manufacturer's instructions.

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)

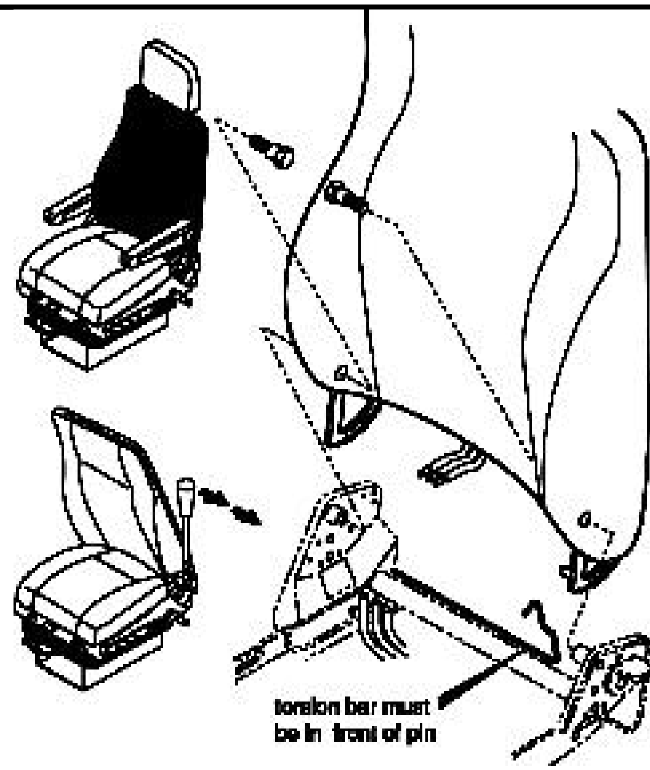


Backrest

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

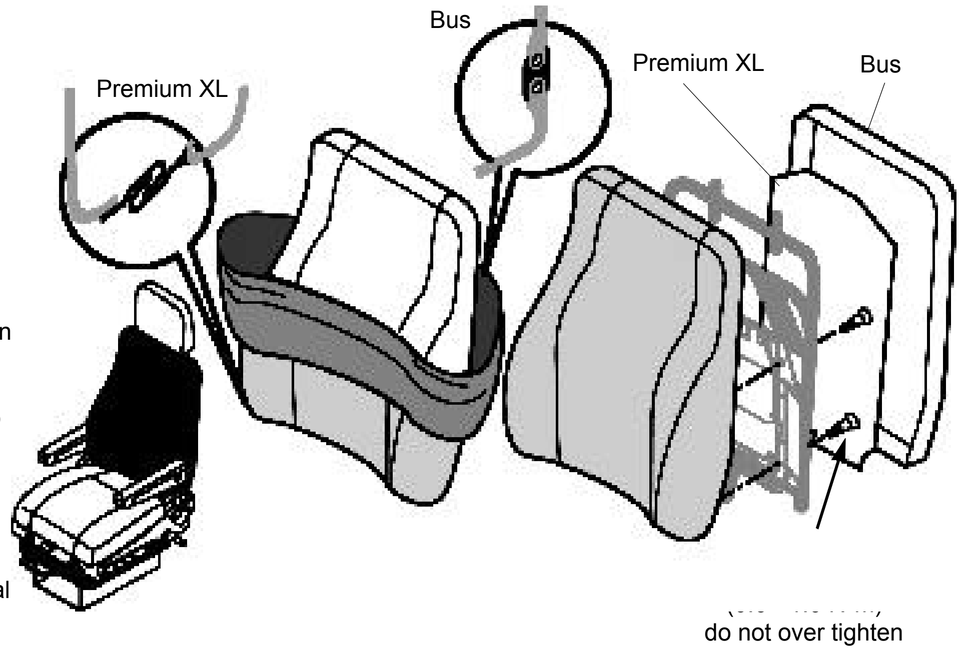


Backrest assembly

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

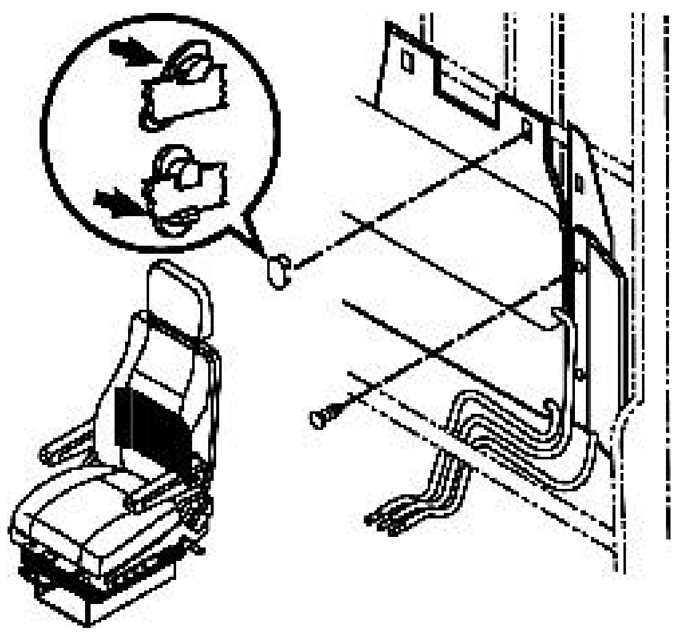


Lumbar and bolster air bags

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

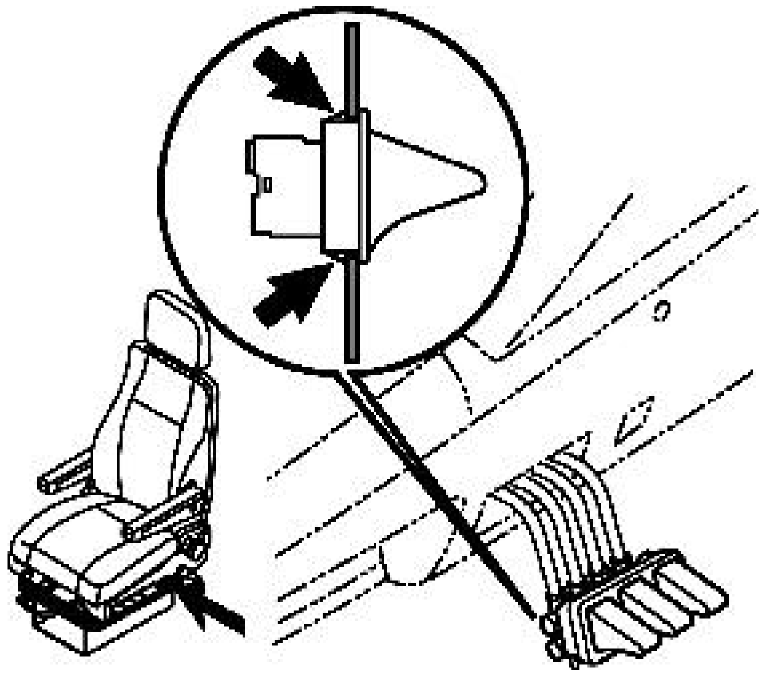


Lumbar and bolster valve

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

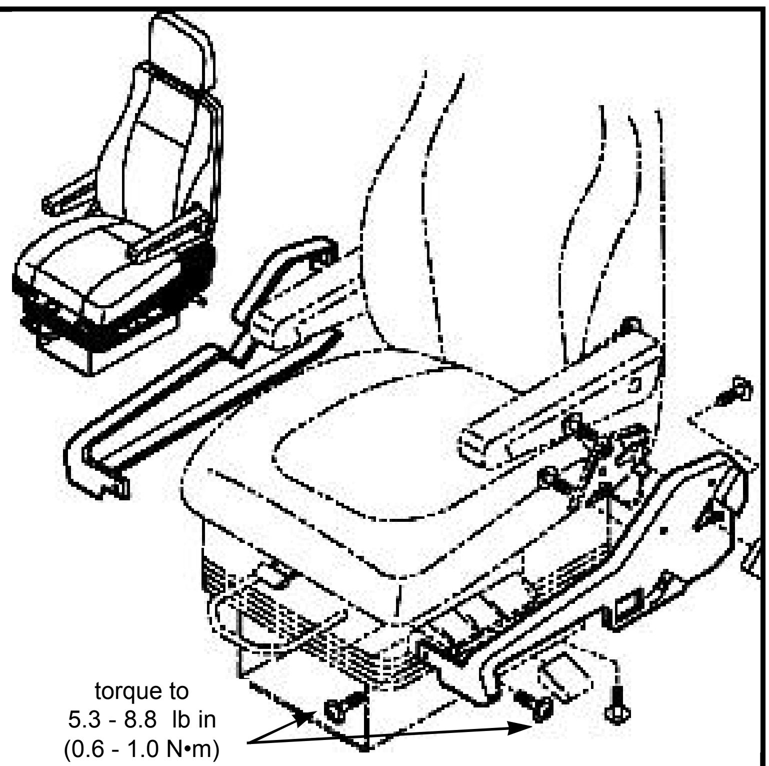
Set up
- Vehicle must be in a safe parked position or seat removed from vehicle.

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

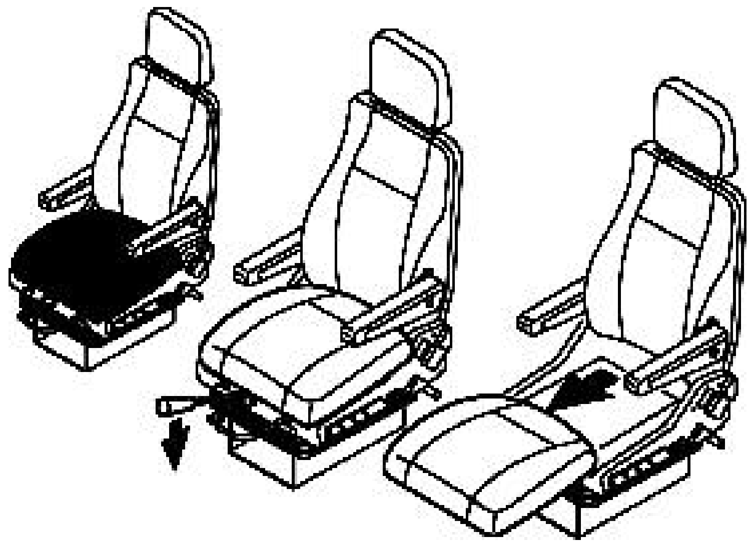


Seat pan assembly

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

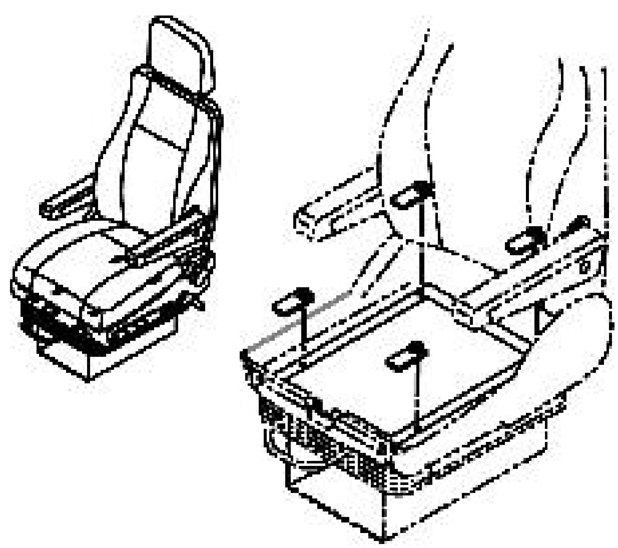


Glides - seat pan

Set up
- Seat cushion must be removed from seat (**see Cushion seat pan**)

Removal
- Remove cushion glides

Installation
- Install cushion glides to seat frame

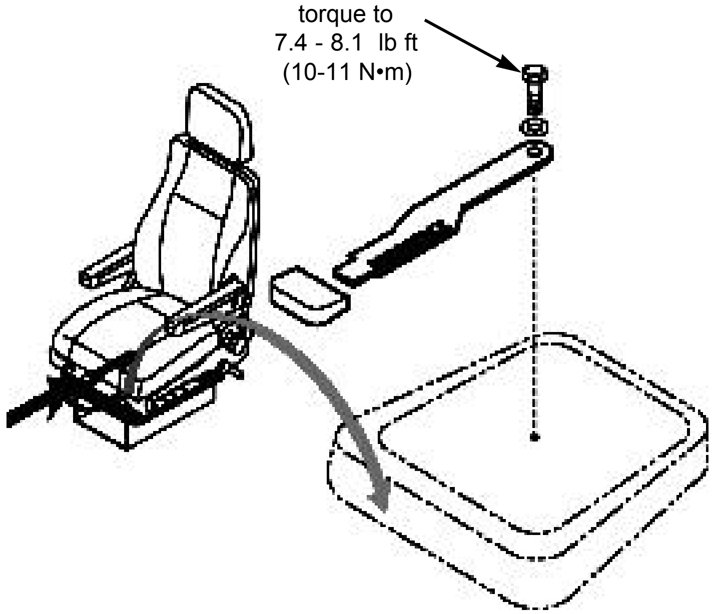


Seat pan assembly, lever and handle

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

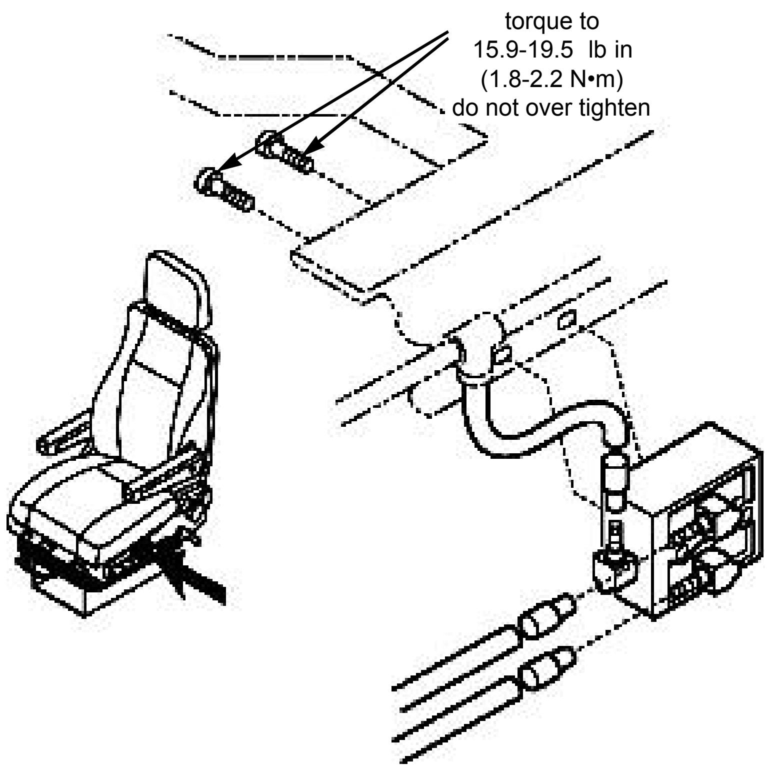


Height adjustment valve

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



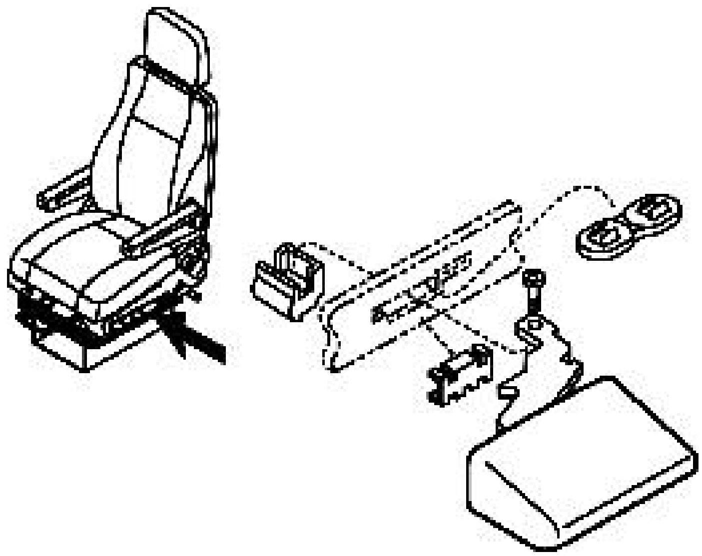
Manual No. 7018081-02, Rel. Jun. 1999

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

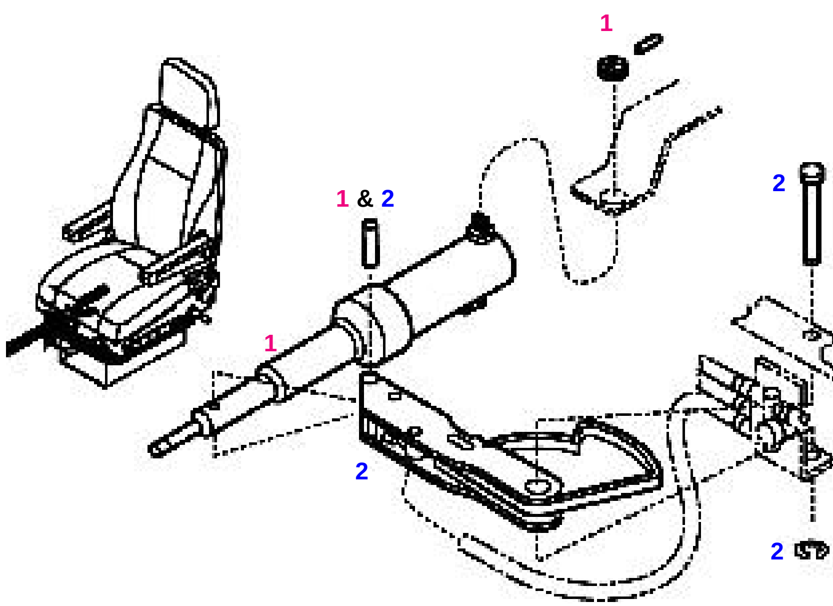
Set up
- Vehicle must be in a safe parked position or seat removed from vehicle
- Seat cushion must be removed from seat (**see Cushion seat pan**)

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



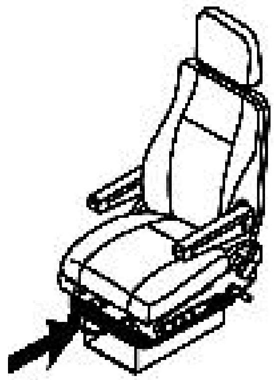
1 = Cylinder kit
2 = Cam kit

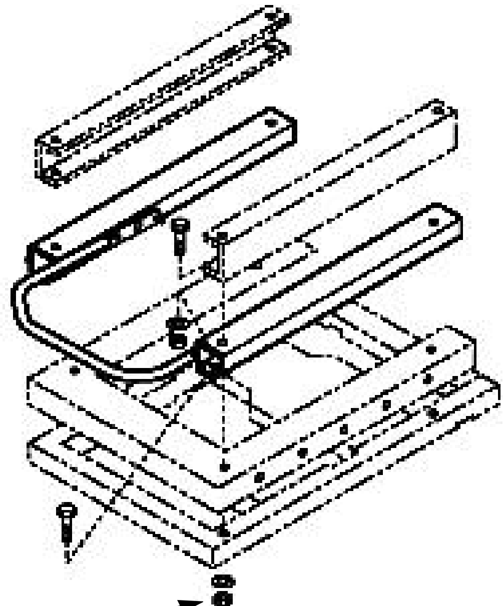
Horizontal adjustment slide set

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



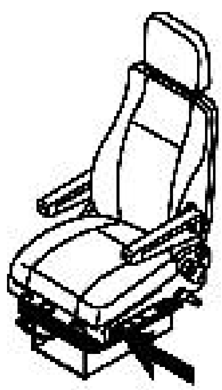


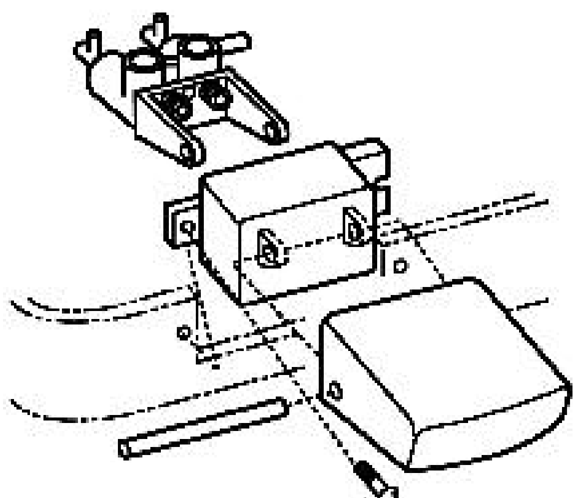
Quick air release - valve and handle LH and RH

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



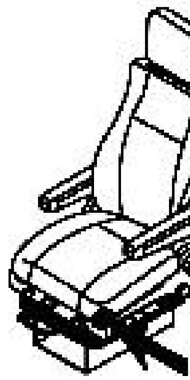


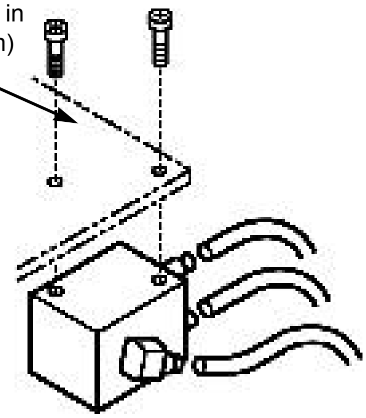
Quick air release valve - suspension

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





Riser and Suspension

Set up - riser and suspension
- Vehicle must be in a safe parked position or seat removed from vehicle.

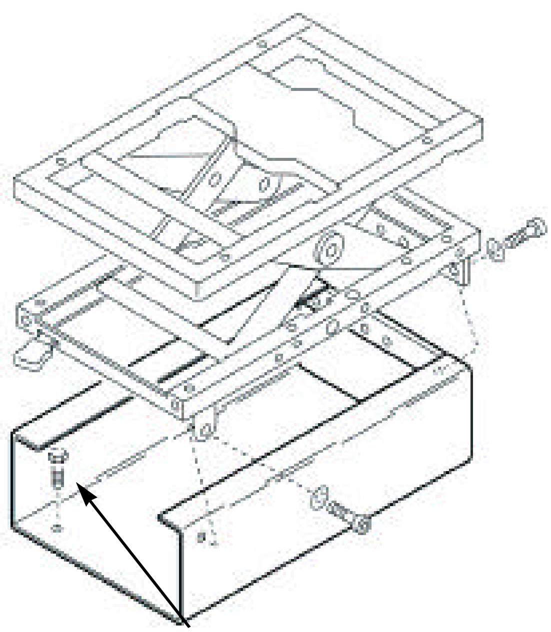
Set up - suspension
- Boot, Boot adapter plate, ICP bar, and tethers must be removed (see **Boot, Boot adapter plate, ICP bar, and tethers**)

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



Seat frame

Set up

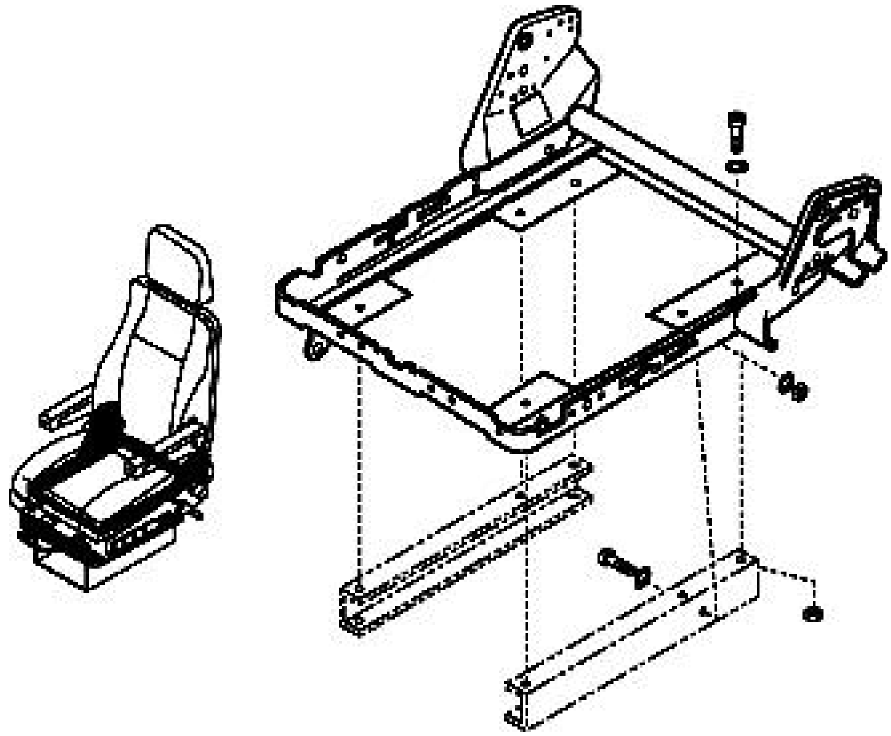
- Seat cushion and backrest must be removed from seat (**see Cushion seat pan and Backrest**)
- Shock absorber handle and cable must be removed. (**see Adjustable shock absorber handle and cable - handle end**)

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

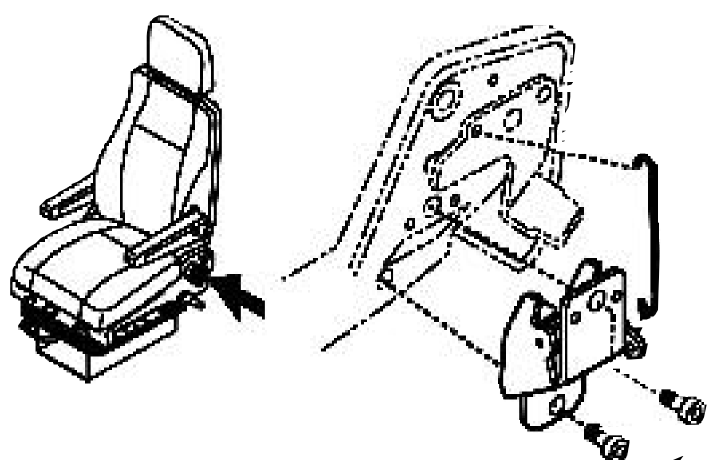
- Backrest and covers must be removed from seat (**see Backrest and Covers front, LH and RH**)

Removal

- Remove seat latch fasteners
- Remove seat latch
- Remove connecting link

Installation

- Install connecting link
- Fasten seat latch to seat frame with screws

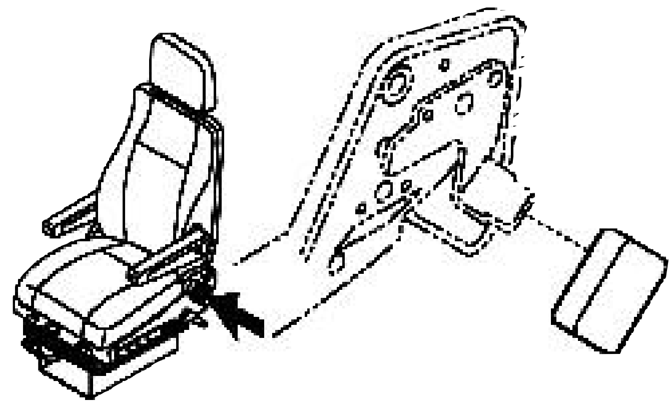


Backrest adjustment handle

Set up
- Vehicle must be in a safe parked position or seat removed from vehicle.

Removal
- Pull handle off

Installation
- Push handle on

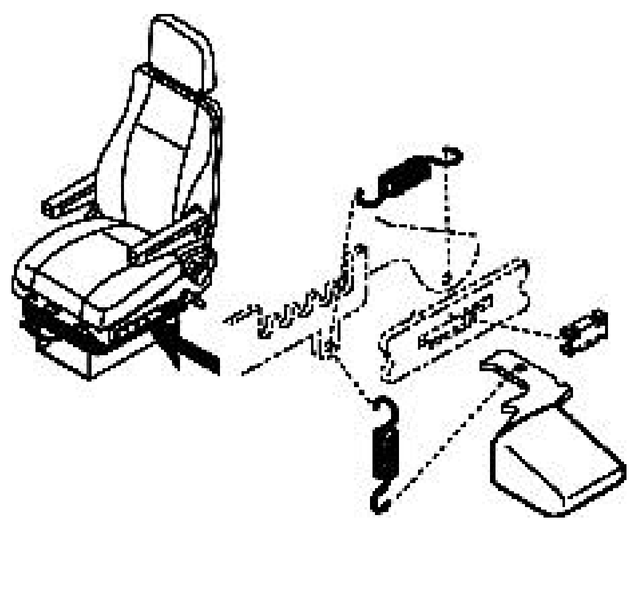


Tilt handle

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

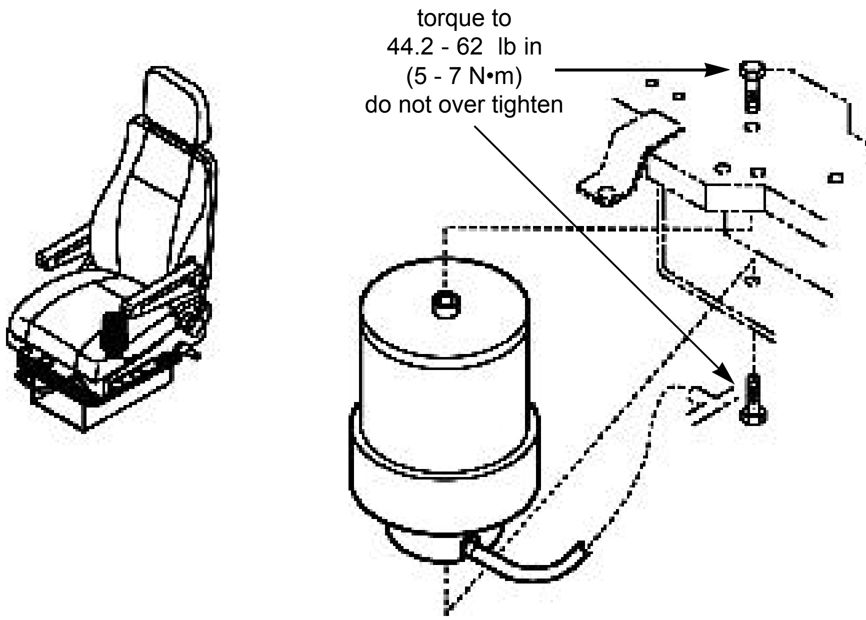


Air spring

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

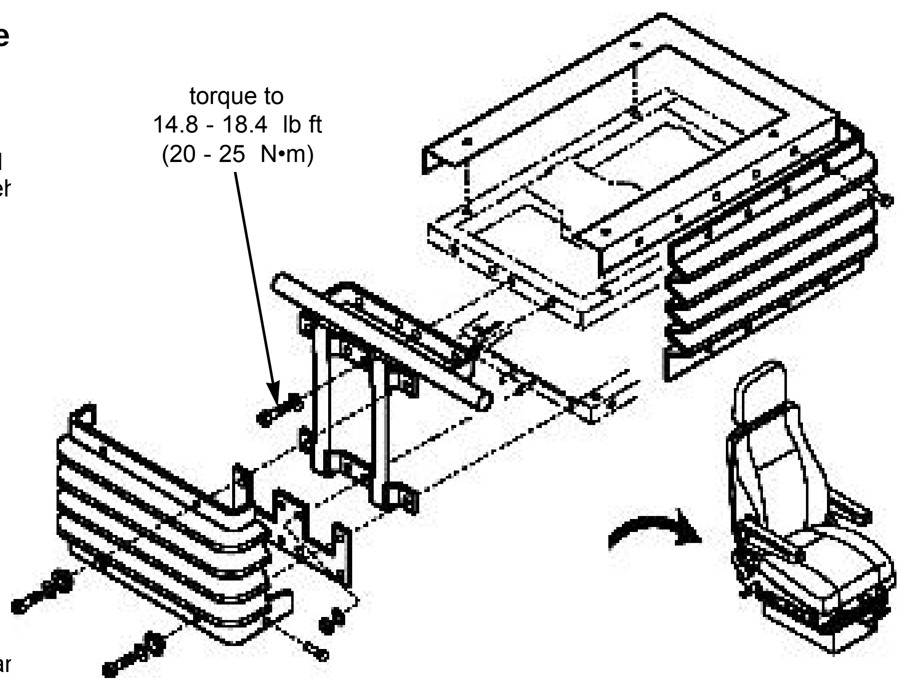


Boot, Boot adapter plate ICP bar, and tethers

Set up
- Vehicle must be in a safe parked position or seat removed from veh
- 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, ar fasteners
- Install belts to ICP bar

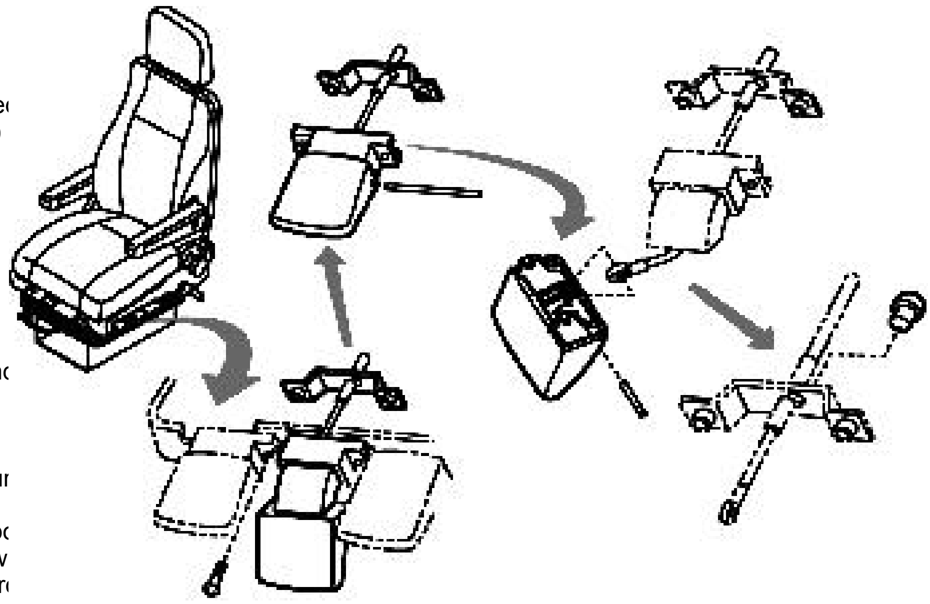


Adjustable shock absorber handle and cable (handle end)

Set up
- Seat cushion must be remove
  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 an
  remove cable

Installation
- Put cable in bracket and secu
  plug
- Route cable through control b
  and fasten to control handle w
- Fasten control handle to contr
  with pin
- Fasten control and bracket to frame with screws



Adjustable shock absorber and cable (shock absorber end)

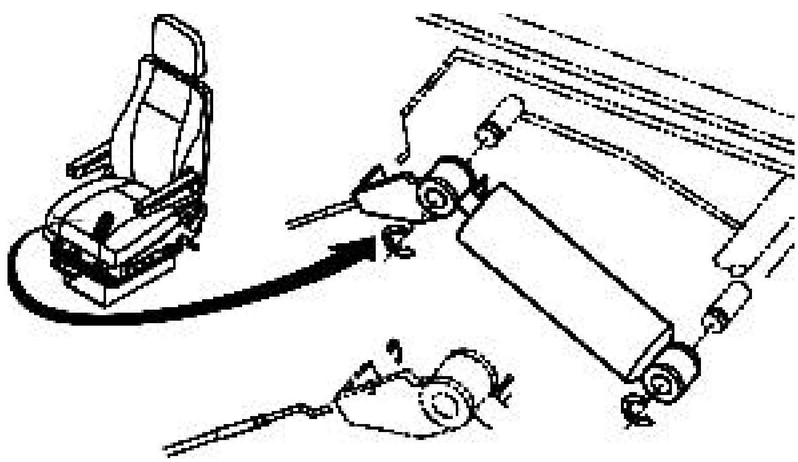
Set up
- Vehicle must be in a safe parked position or seat removed from vehicle
- Seat cushion must be removed from seat (**see Cushion seat pan**)

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

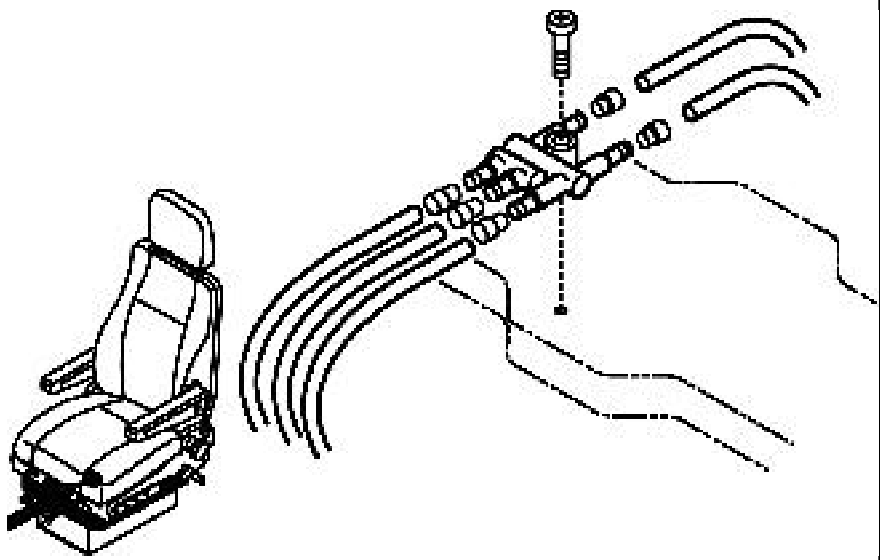


Distribution valve

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

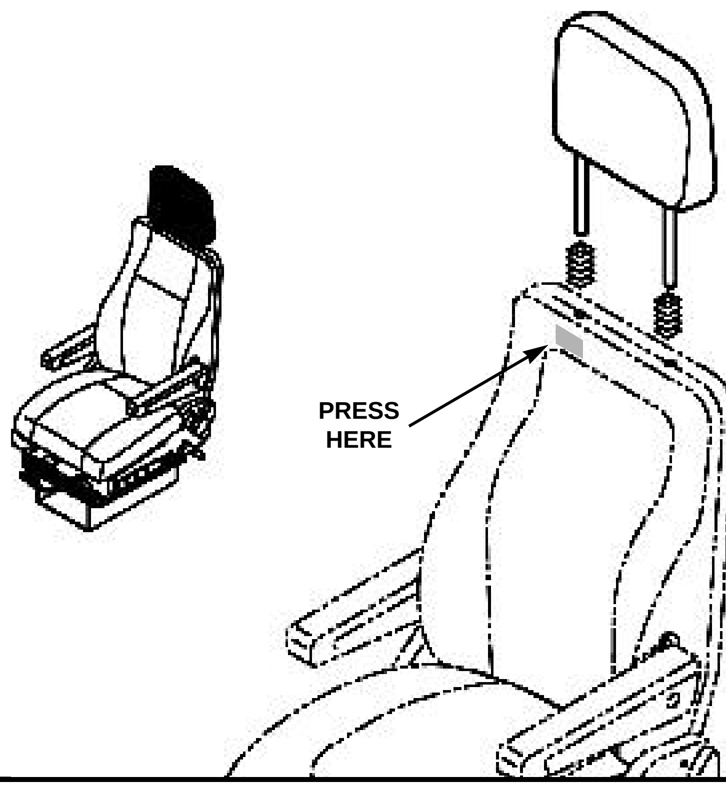


Headrest

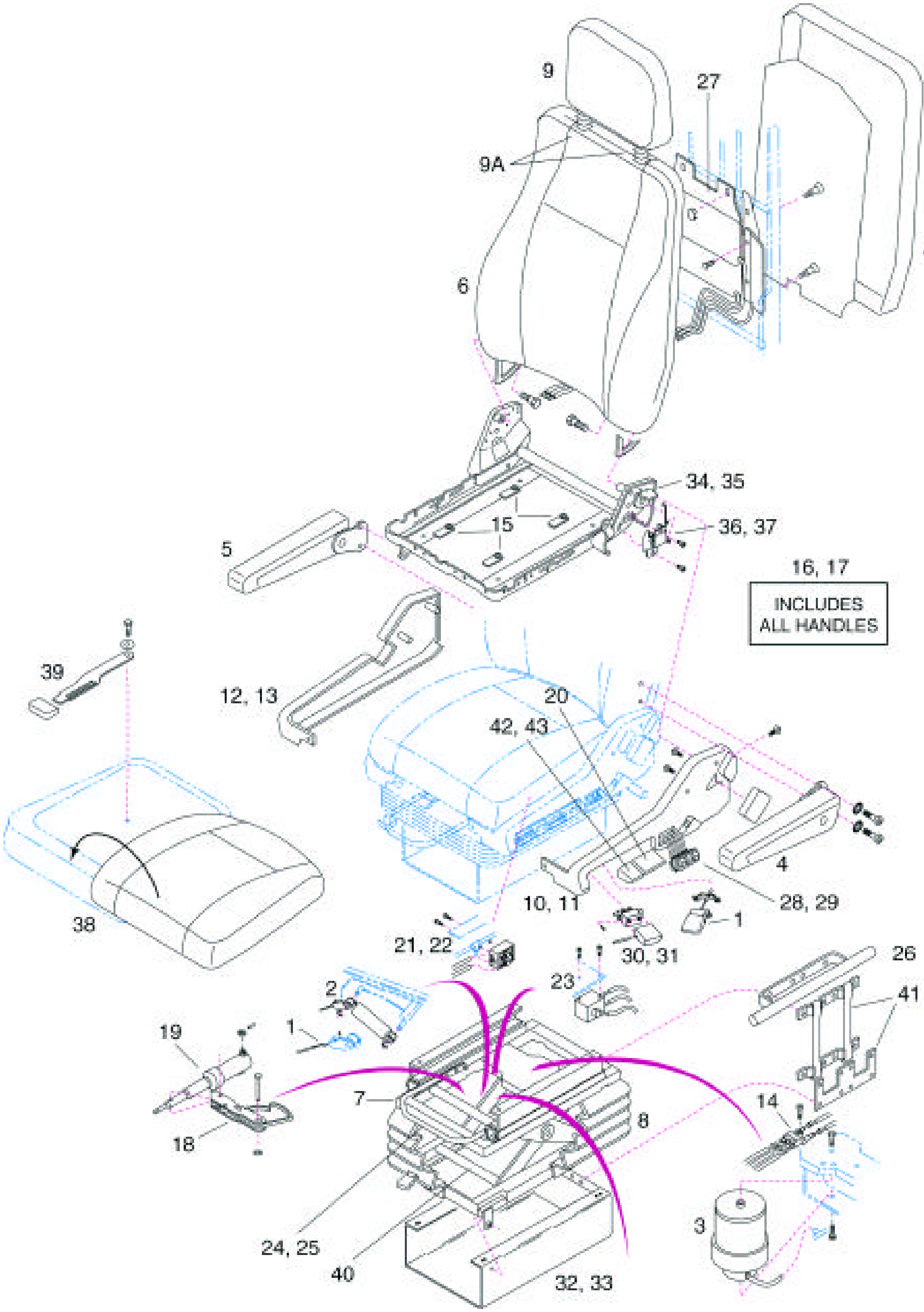
Set up
- Vehicle must be in a safe parked position or seat removed from vehicle

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



PARTS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INCLUDES
ALL HANDLES
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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)

ISRINGHAUSEN ISRI®

SERVICE PARTS LIST

Customer Name: Prevost Car   ISRI Model: 6801/525
ISRI P/N: 86506-00   Customer P/N: 860912

Seat Specification: LH controls, 16 degree restriction, Air lumbar/Manual valve (IPS5), Adjustable shock, Armrest-padded, Long air supply hose

Property / User / Application: Prevost Car motor coach

ILLUS NO.	DESCRIPTION	ISRI P/N	CUSTOMER P/N
A	Headrest Kit	------------	
B	Armrest Kit	------------	
C-024	Backrest Asm	17518-00	860739
D-008	Seat Pan Asm	14663-04	860742
E-059	Seat Frame Asm	02371-02	861099
F-016	Static Spacer	18191P	861083
G	Swivel Asm	------------	
H	Isolator Asm	------------	
J-006	Slide Set	17491	860758
K-019	Suspension Asm	17259-01	
L-004	ICP Bar	23914P	
M-001	Boot Kit	92625-01	860523
N	Riser	------------	
P	Seat Belt Kit	------------	
	Assembly Hardware		
	Bolt-Hex Hd (Backrest)	60199	
	Screw (Seat Pan)	60560	
	Nut-Hex-Nylon Lock-M8	60016	
	Bolt-Soc Hd-M8 x 16	60185	
	Bolt-Soc Hd-M8 x 20	60172	
	Spacer	40432B	
	Washer-Lock-A8.2	60400	
	Bolt-Hex Hd-M8 x 25	60055	
	Nut-Hex-Crimp Lock-M8	60008	
L-004	Cover Plate – ICP Bar	34824D	

ISRINGHAUSEN ISRI®

SERVICE PARTS LIST

ISRI P/N: 17518-00 Description: Backrest–517-LH-AL

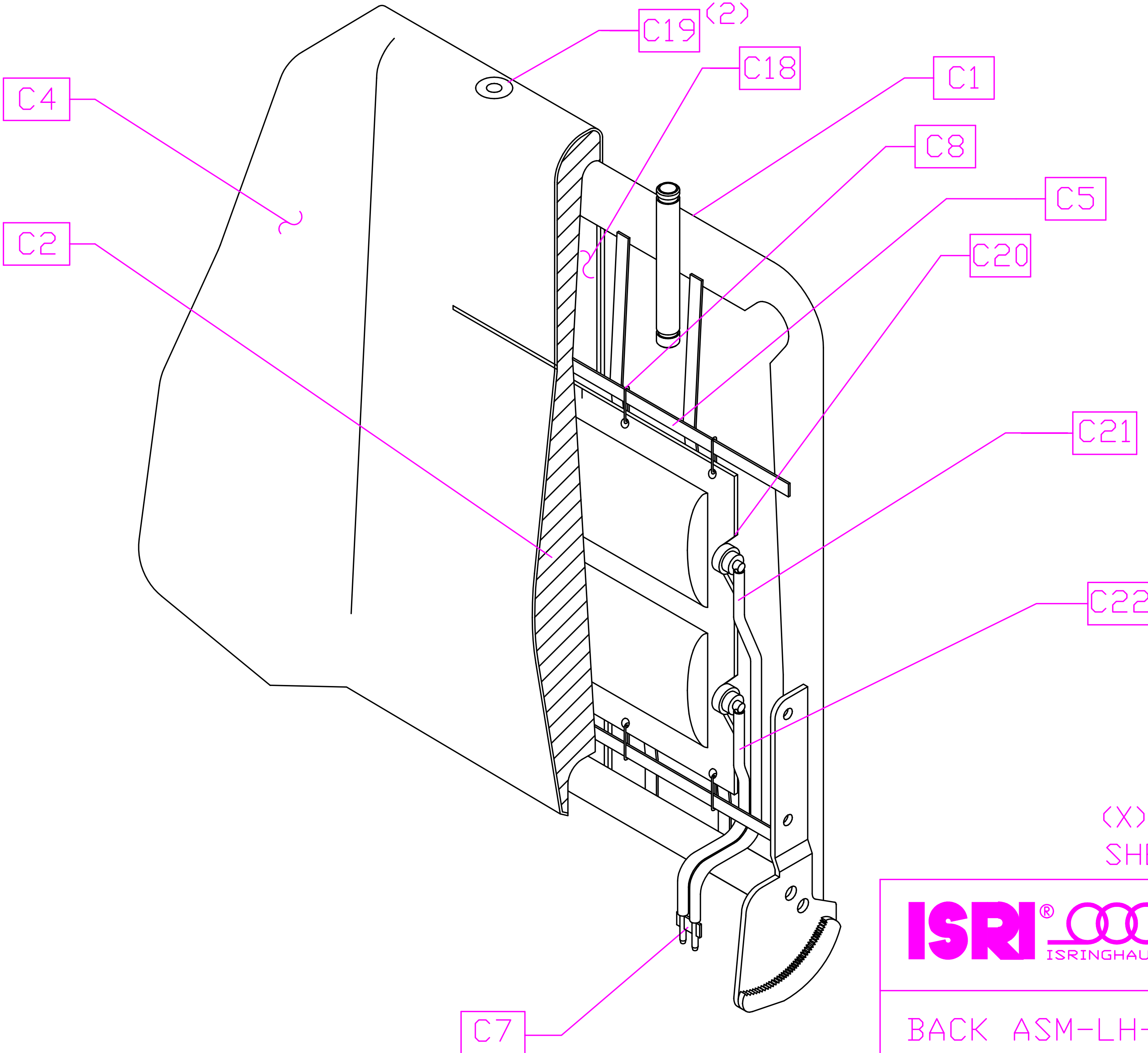
ISRI Illus. No.: C-024

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

ISRI® ISRINGHAUSEN

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

ISRI ISRINGHAUSEN

05/92
(REV 5/22/01)

KIT DESCRIPTION

C-024

ISRINGHAUSEN ISRI®

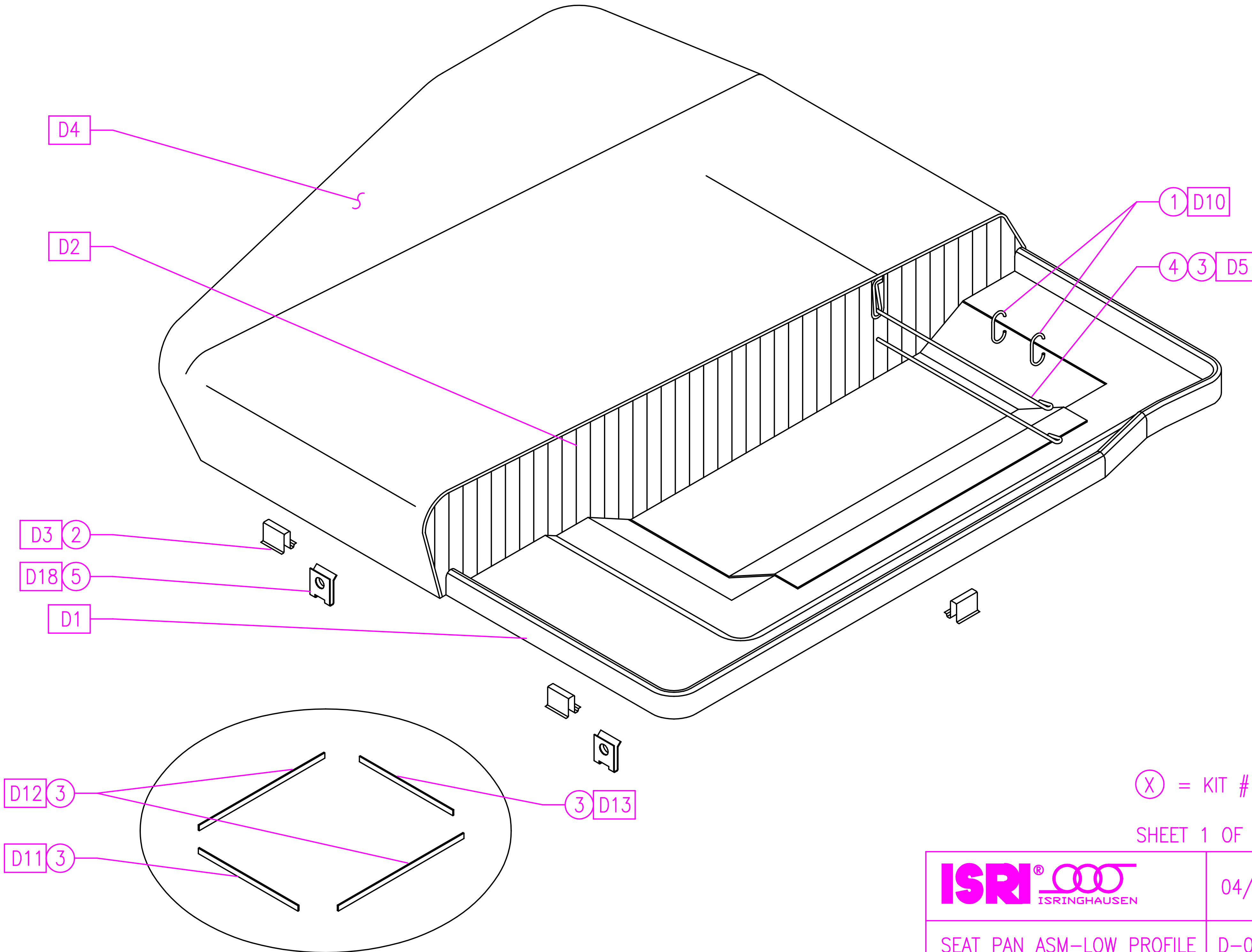
SERVICE PARTS LIST

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

ISRI® ISRINGHAUSEN	04/91
KIT DESCRIPTION	D-008

ISRINGHAUSEN ISRI

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**

ISRINGHAUSEN ISRI®

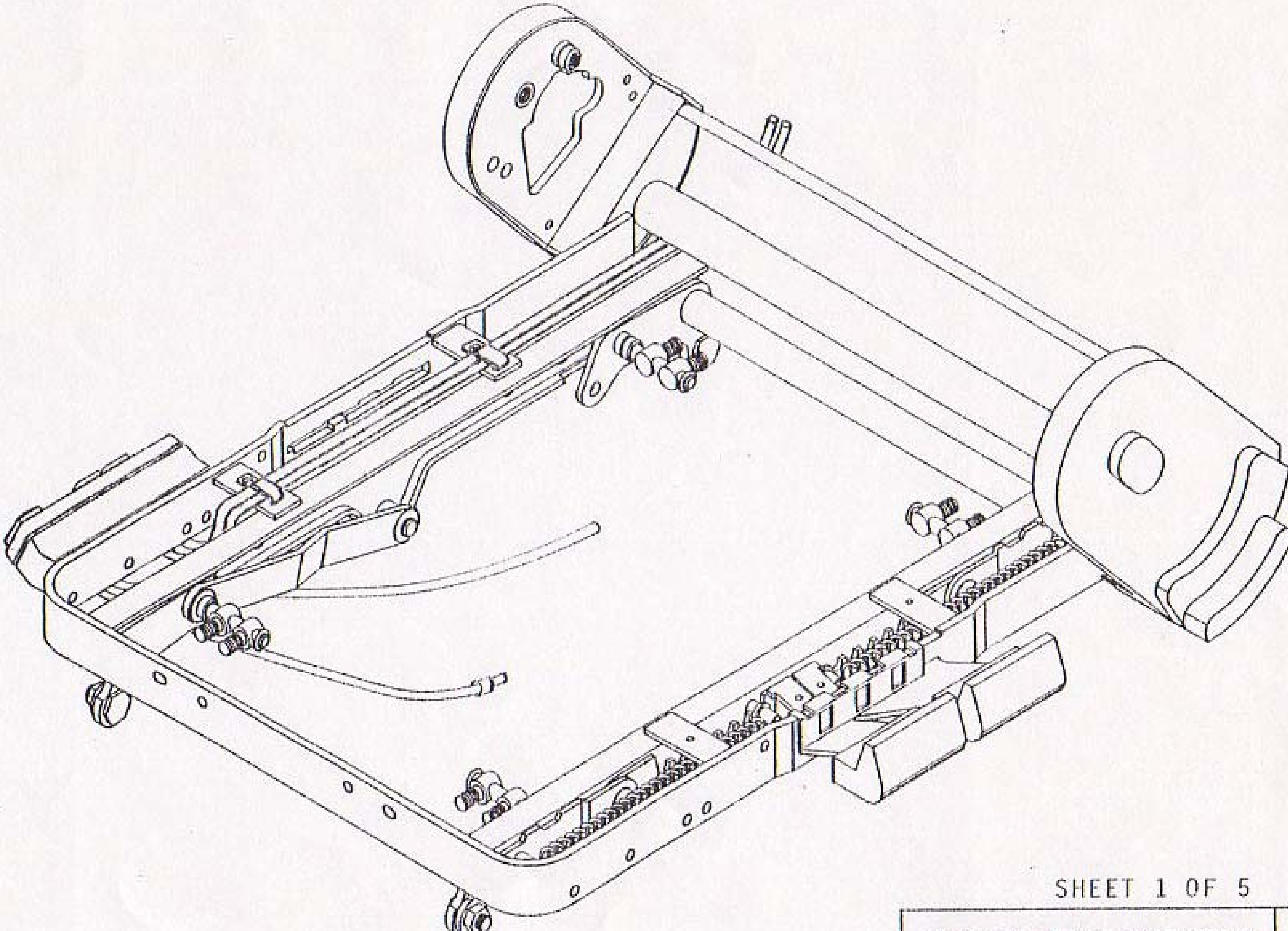
SERVICE PARTS LIST

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)

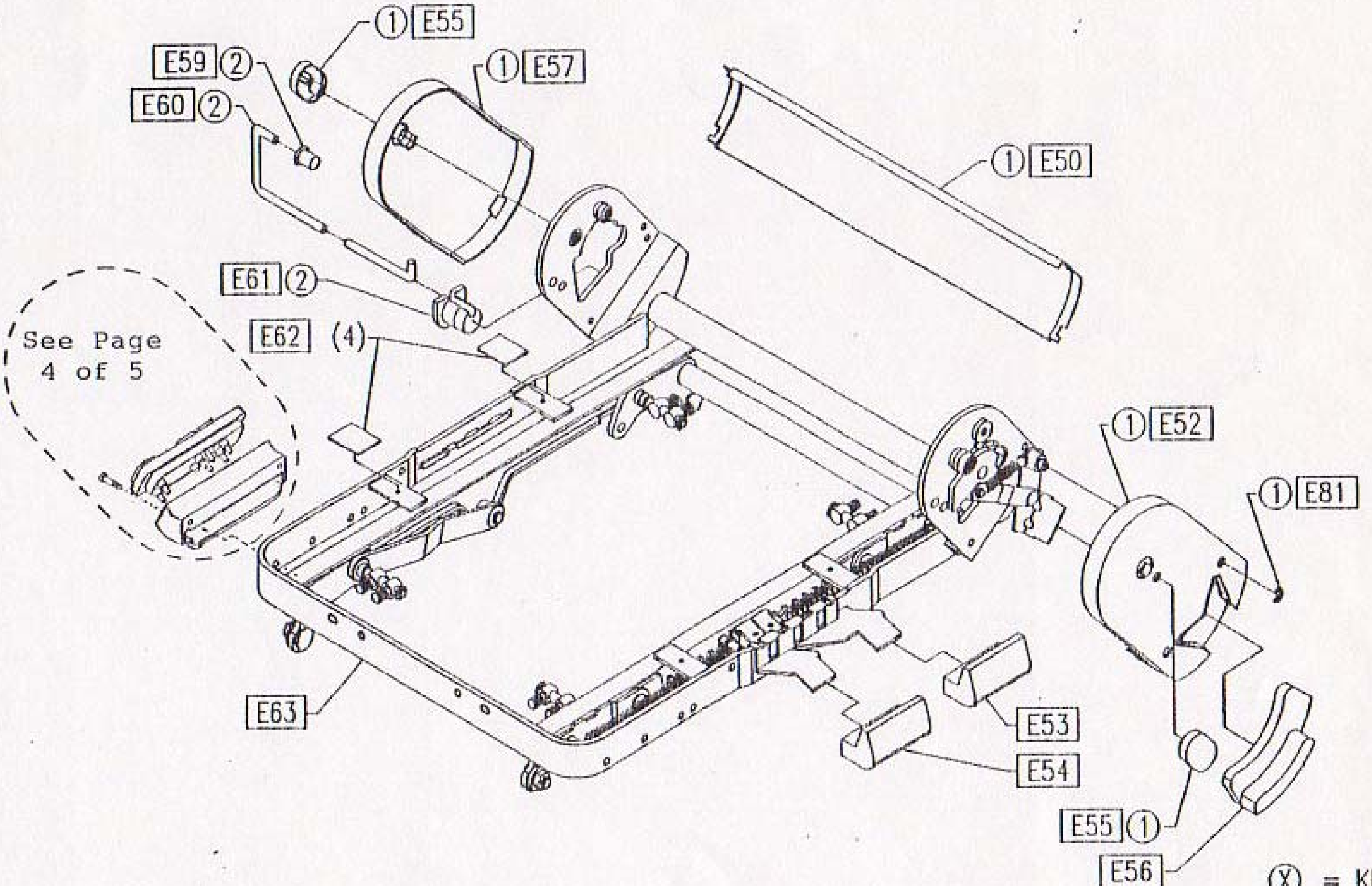
ILLUS NO.	DESCRIPTION	ISRI P/N	CUSTOMER P/N
E142	Washer – Flat – A8.4	See E3	
E143	Sleeve – Push On – PU4	* 46097-02	
E144	Sleeve – Push On – PU3	* 44713-02	
E145	Ring – Retaining	60045	
E147	Hose-PU3 (AL Supply)	See E3	
E149	Valve – AL/MV (IPS5)	See E4	
E150	Cover – Rocker – AL – Upper	* 45480-23	861093
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

ISRI® ISRINGHAUSEN	12/95
SEAT FRAME-515-LH	E-059



Ⓧ = KIT #

(X) = QUANTITY

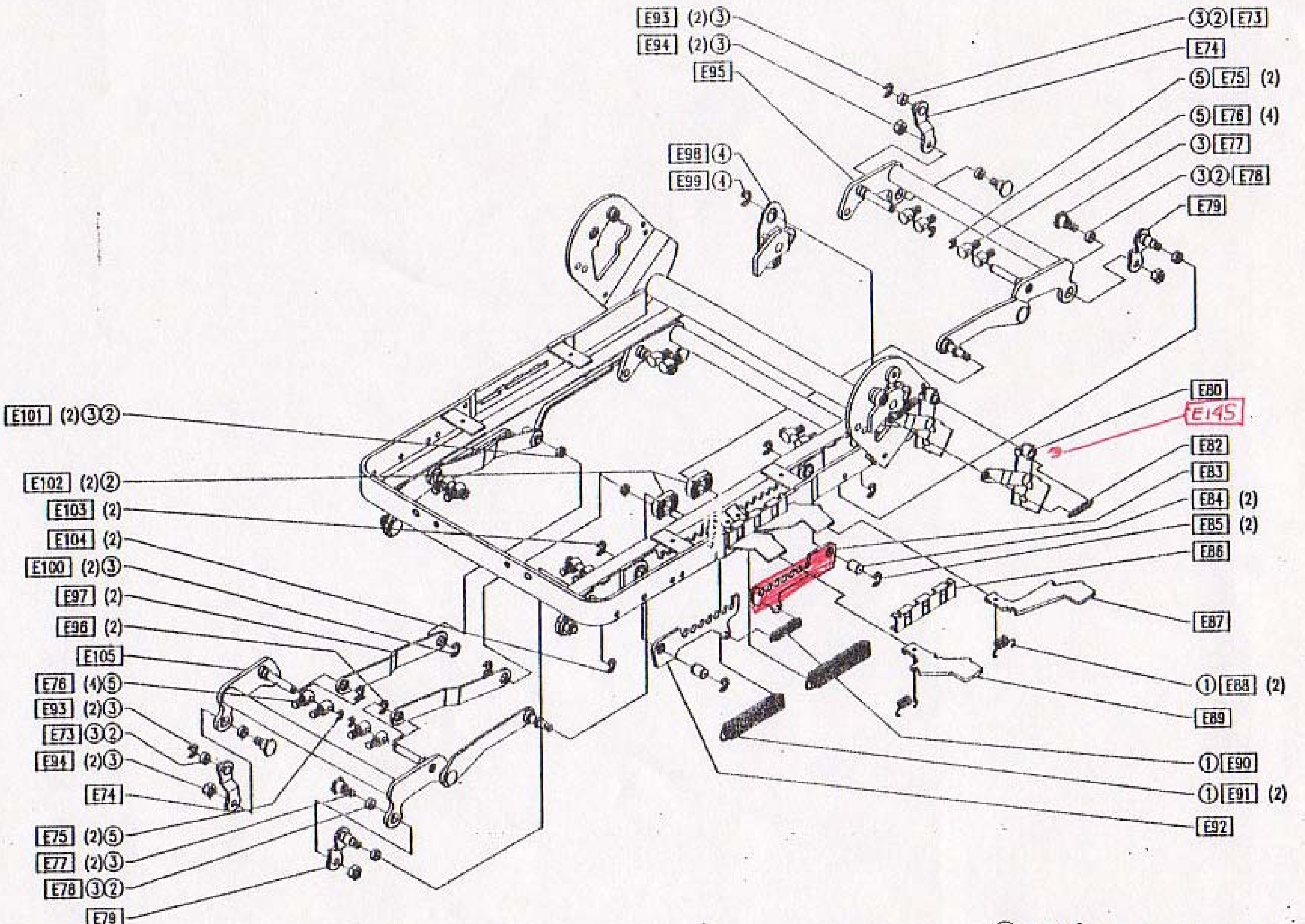
ISRI ISRINGHAUSEN

12/95

SEAT FRAME-515-LH

E-059

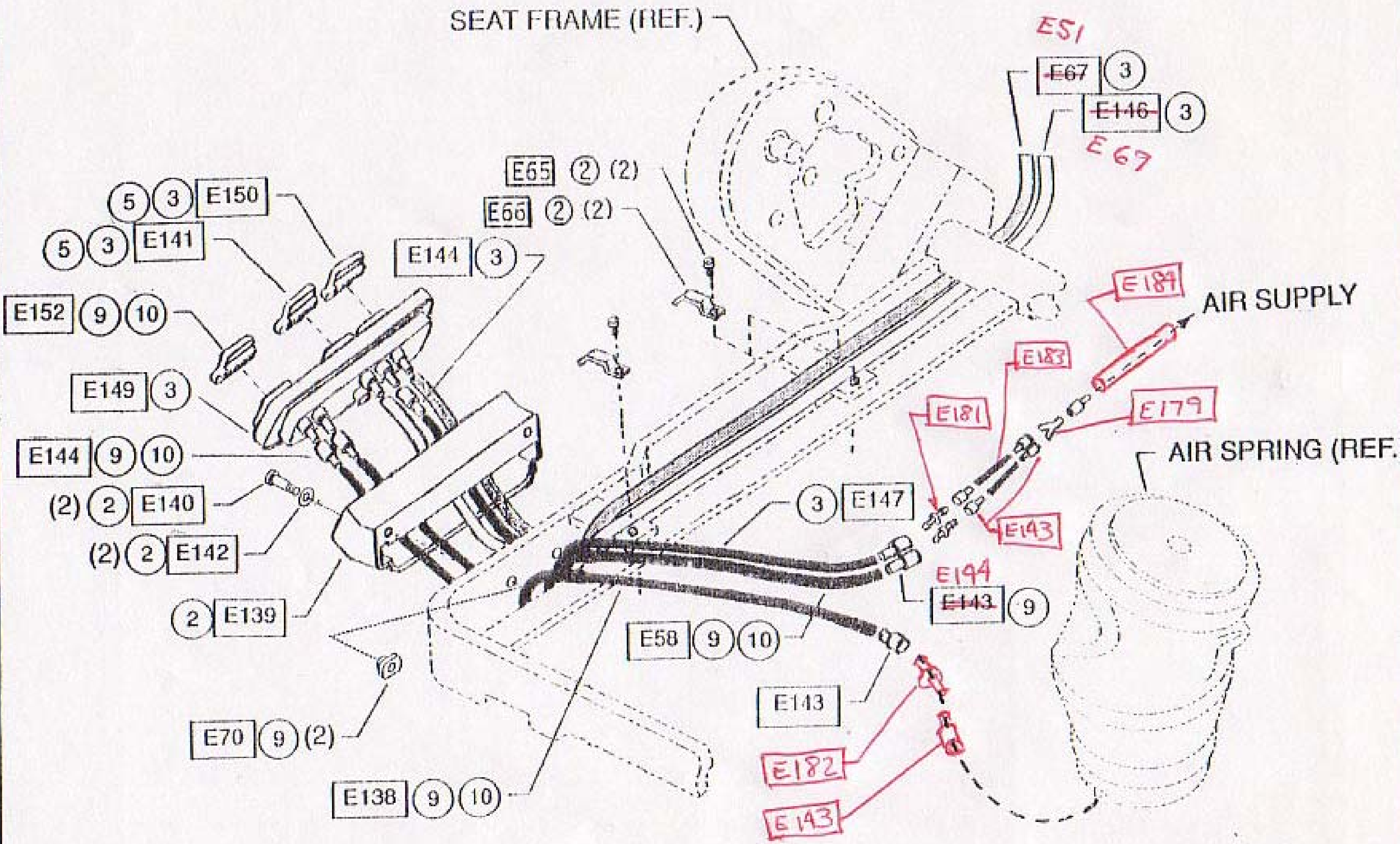
KIT #	P/N	ITEM NO. IN KIT	ITEM
1	E1	E50, E52, E55, E57, E81	SIDE PLATE KIT
2	E5	E59, E60, E61	TORSION BAR KIT



Ⓧ = KIT #
(X) = QUANTITY

SHEET 3 OF 5

ISRI	12/95
SEAT FRAME-515-LH	E-059



SHEET 4 OF 5

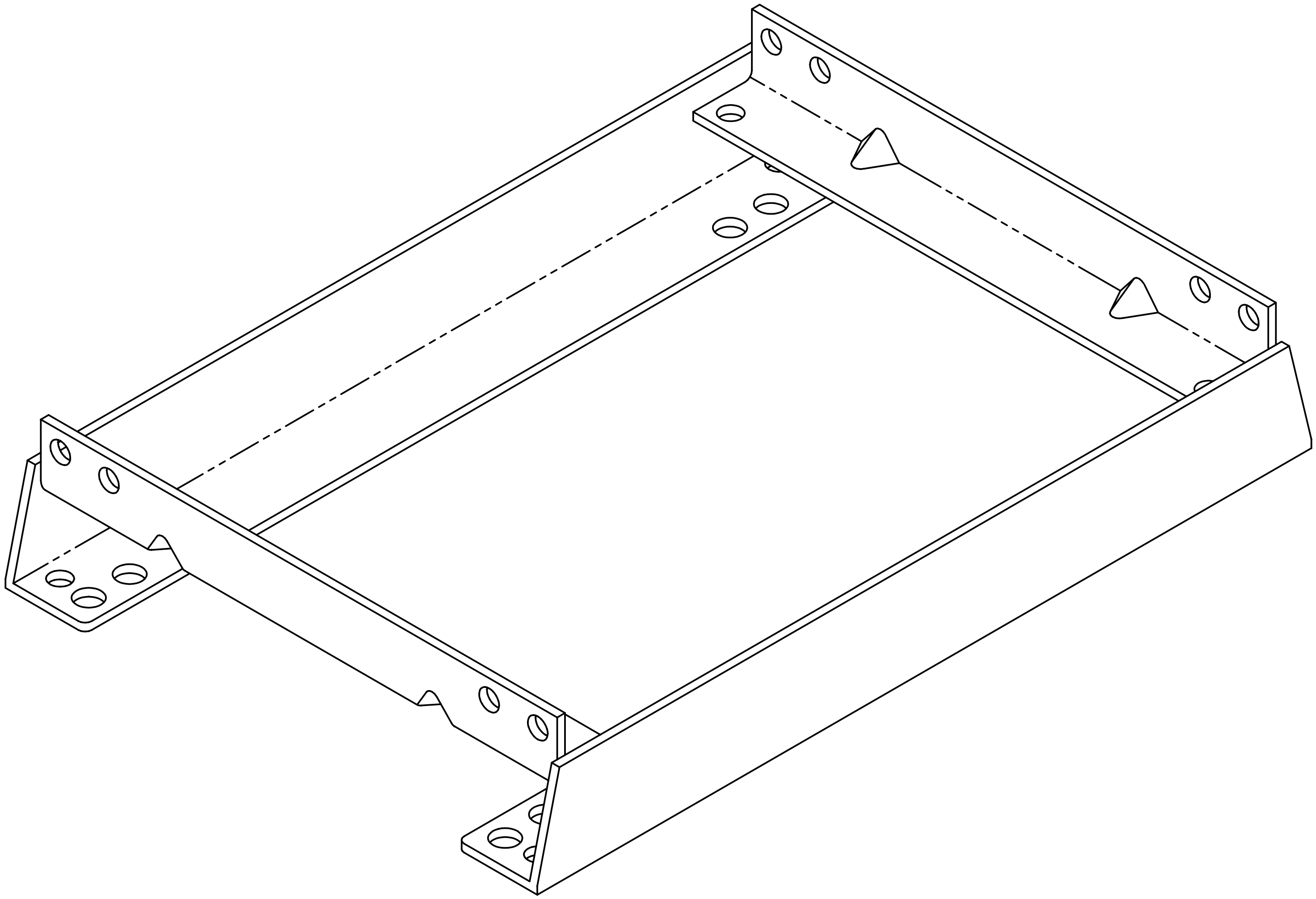
ISRI® ISRINGHAUSEN	12/95	
SEAT FRAME-515-LH	E-059	

◯ = 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

ISRI® ISRINGHAUSEN	12/95
KIT LIST	E-059



ISRI® ISRINGHAUSEN

06/99

STATIC SPACER

F-016

ISRINGHAUSEN ISRI®

SERVICE PARTS LIST

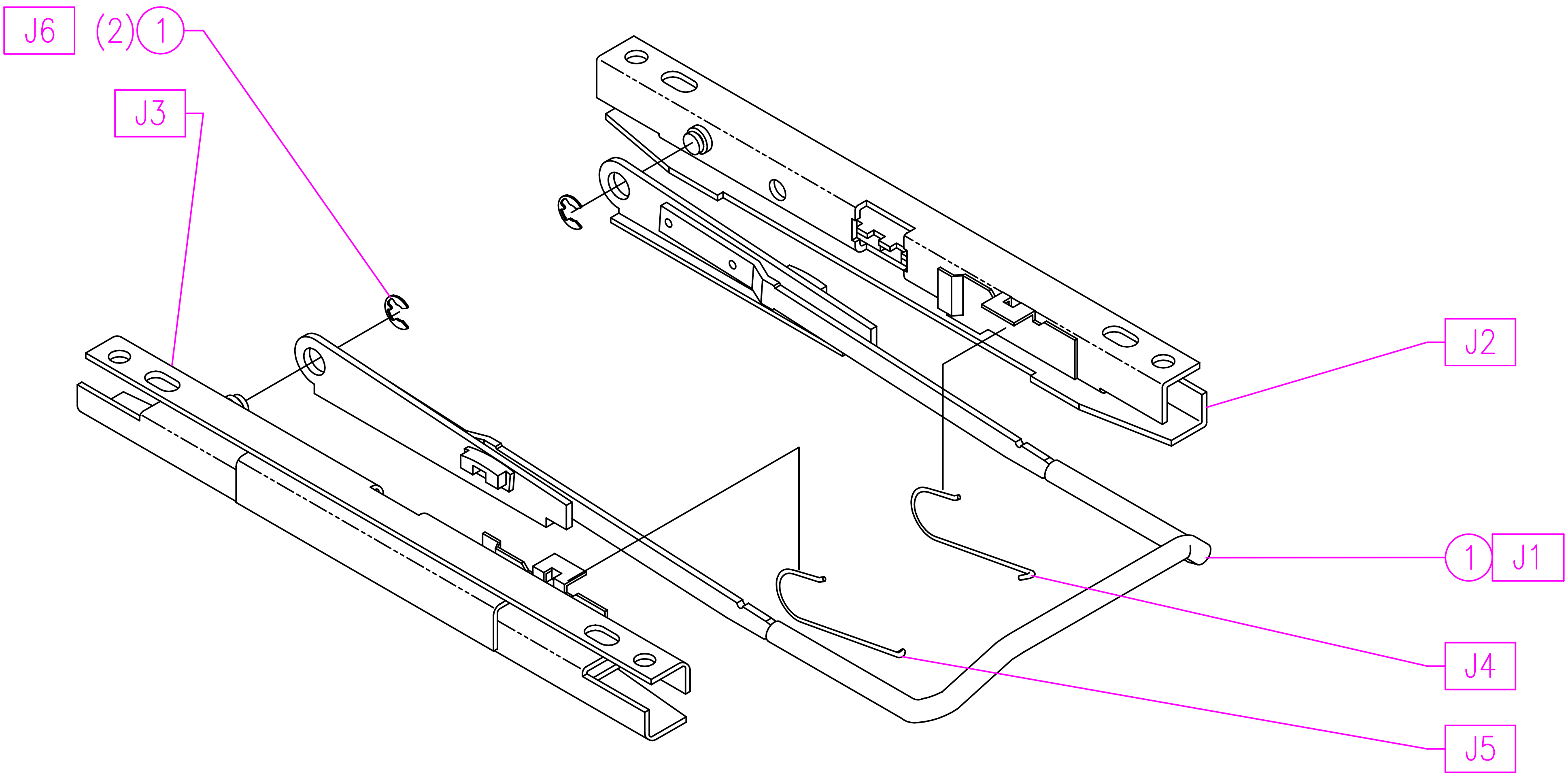
ISRI P/N: 17491 Description: Slide Set – “B” Style

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	



KIT #	P/N	ITEM NO. IN KIT	ITEM
1	J8	J1, J6	HANDLE KIT

ISRI® ISRINGHAUSEN

04/91

SLIDE SET

J-006

ISRINGHAUSEN ISRI®

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**

ISRINGHAUSEN ISRI®

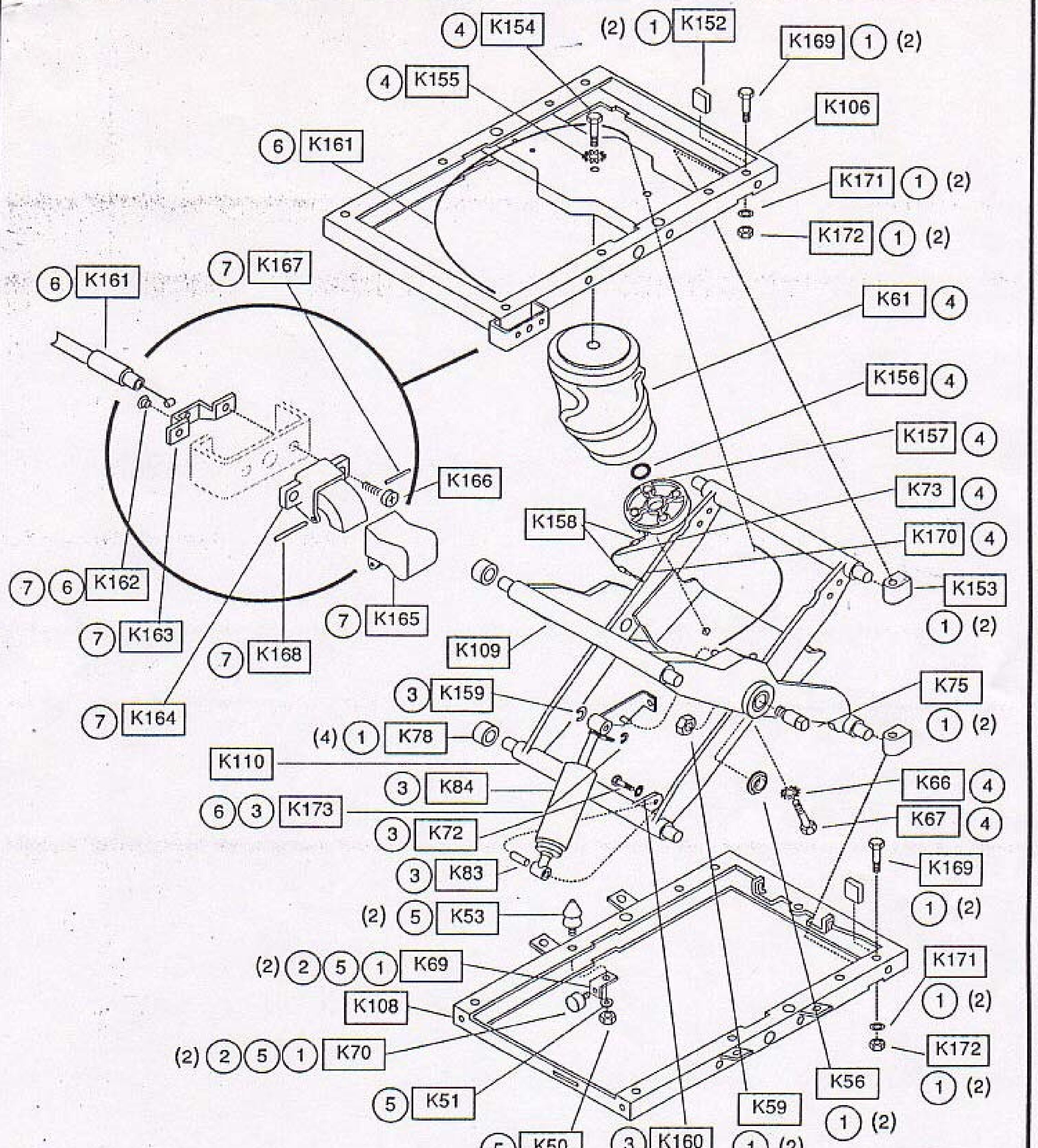
SERVICE PARTS LIST

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

◯ = KIT #

( ) = QUANTITY

Susp Asm - Air

K-019

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

ISRI® ISRINGHAUSEN | 7/92

Susp Asm - Air | K-019

SERVICE PARTS LIST

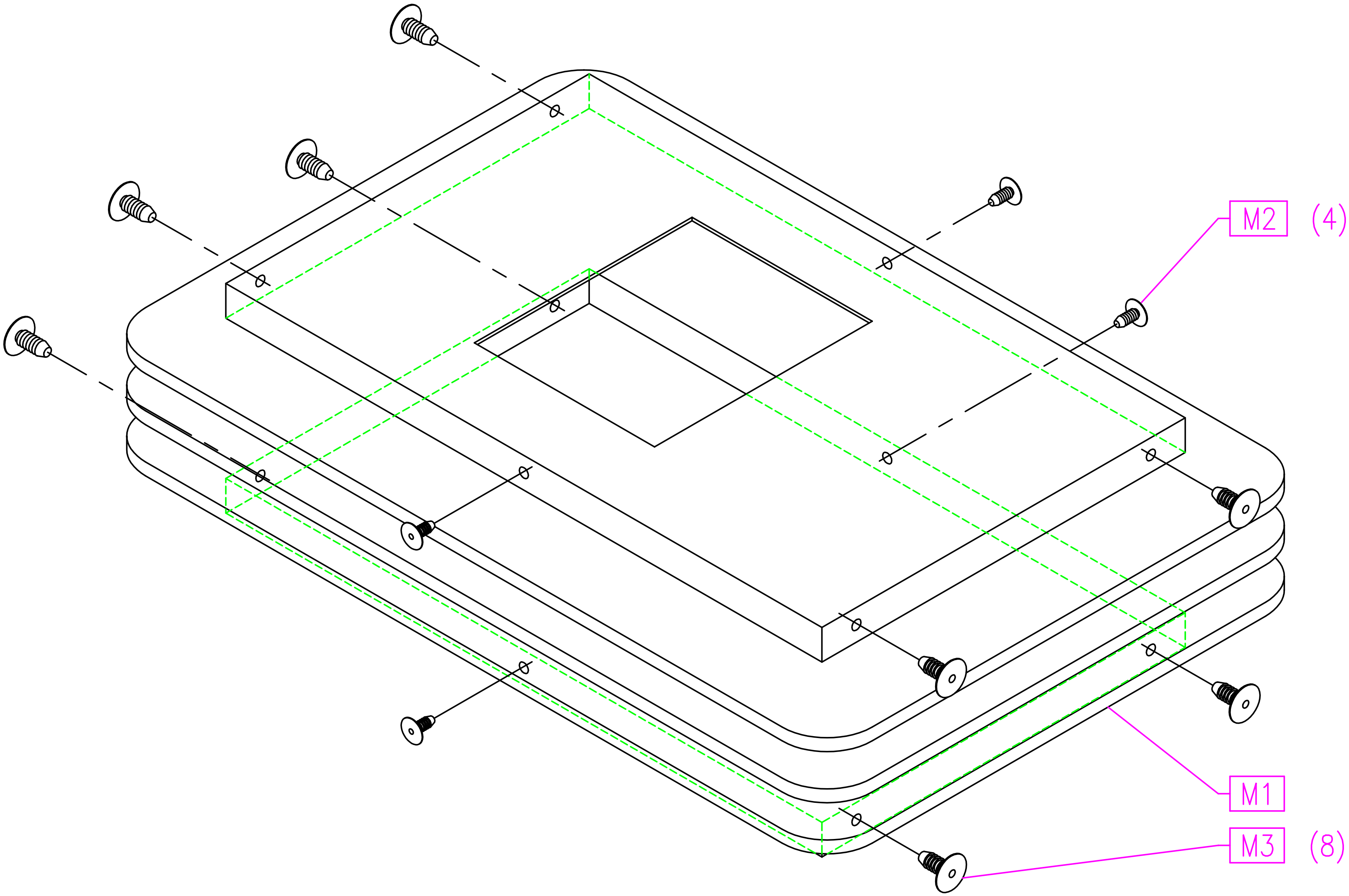
ISRI P/N: 92625-01 Description: Boot Kit-Susp–Air-AL

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

ISRI® ISRINGHAUSEN	10/90
AIR SUSP BOOT KIT	M-001

SECTION 22: HEATING AND AIR CONDITIONING

CONTENTS

ILLUSTRATIONS

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 sections: driver's and Central (passenger) sections. Vehicles equipped with a Central System are provided with a special air duct which allows a variable percentage of outside fresh air to be drawn into the vehicle and then mixed with recirculated air.

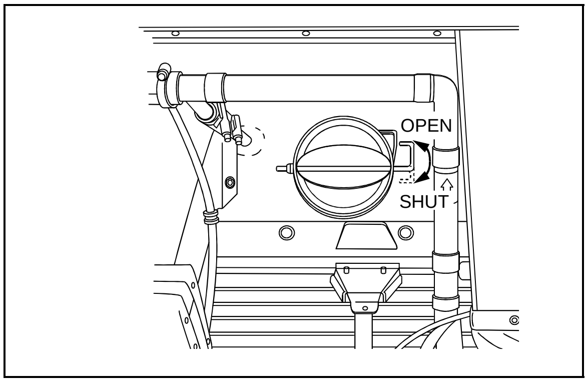


FIGURE 1: ADJUSTABLE AIR DUCT 22175

The adjustable air intake damper is located in the evaporator compartment (see *"18. BODY"* for compartment location). The damper should normally be left open. However, under extreme temperature conditions, it can be closed to block the addition of ambient air and heat or cool the air inside vehicle as desired. As soon as extreme heating or cooling is no longer required, the damper should be reopened. The interior of vehicle should always be slightly pressurized to prevent dust and moisture from entering vehicle. The HVAC systems have been designed to allow circulation of some outside fresh air, so windows should be kept closed at all times. In the event of ventilation failure, emergency escape hatch(es) (see *"18. BODY"*) can be used to provide air circulation, by simply pushing hatch upwards.

NOTE

Auxiliary A/C system (if so equipped) operates independently from main system, it has its own condenser, evaporator and compressor.

NOTE

Driver's HVAC system operates independently from main system, even though it uses the same compressor.

NOTE

Vehicles equipped with a TM-16HD Seltec compressor (driver's or auxiliary A/C) have a time delay relay installed on the electrical circuit with a reaction time of 48 seconds before magnetic clutch is engaged.

2. AIR CIRCULATION

2.1 DRIVER'S AREA

Fresh air is taken from a plenum behind the front bumper and enters the mixing box through an adjustable damper. Returning air is taken through a front dash panel into the mixing box. The "Driver A/C-Heating Recirc.-Fresh Air" control is located on the R.H. dashboard control panel. 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, with the "Main Windshield Defroster" control divert some air flow to the console, from which he can direct air to his knees and/or upper body with adjustable HVAC vents and to his feet with the appropriate button (see operator's manual).

Two additional air outlets are installed on vehicles equipped with the Central HVAC ducting system. One is located in the stepwell for snow melting. The other air outlet is located behind the driver, on his L.H. side. This air outlet can be rotated to direct Air flow.

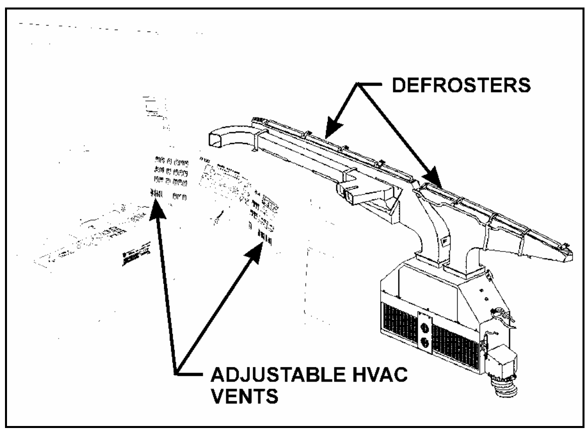


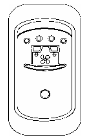
FIGURE 2: DRIVER'S AIR CIRCULATION 22171

2.2 CENTRAL AREA

(Passenger/Cabin)

Fresh air enters the vehicle on the L.H. side, through the manually adjustable damper (Fig. 1) located in evaporator compartment. The damper can be fully opened for normal operation or closed for extreme weather or highly polluted areas (Refer to the XL2 Operator's Manual for more details). Return air is drawn from inside the vehicle through the register duct (Fig. 3).

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.

XL2 coaches are also equipped with a parcel rack ventilation system, a three-position rocker switch  (0FF - 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 parcel rack fan; discharge air is fed to the rotating registers through the ventilation duct.

The parcel rack 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.

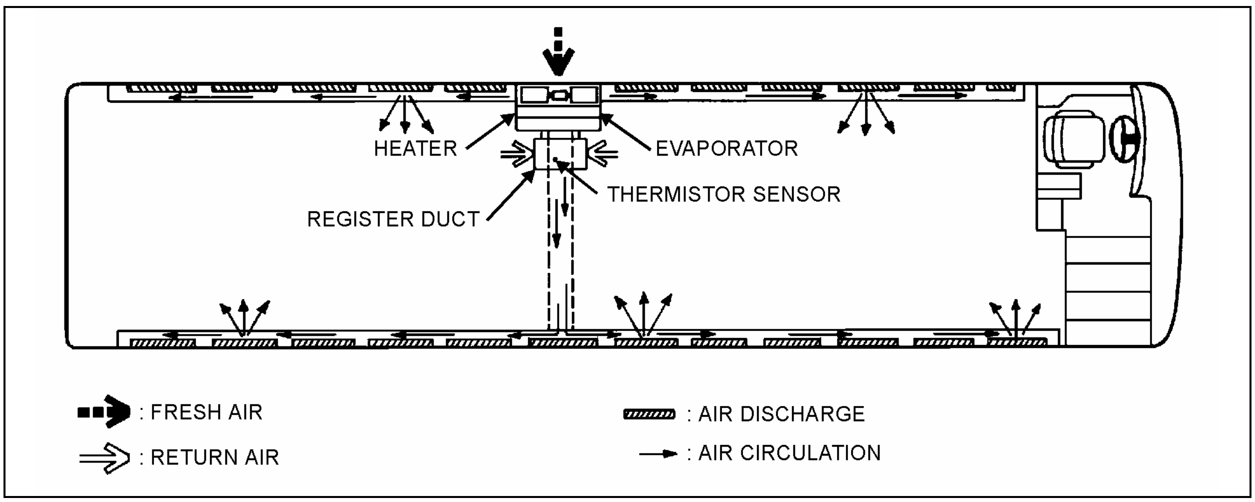


FIGURE 3: CENTRAL HVAC SYSTEM AIR CIRCULATION 22063

3. DRIVER'S HVAC SYSTEM OPERATION

The temperature control in the driver's area is provided directly by the HVAC control unit mounted on the dashboard R.H. panel (Fig. 4 and 5).

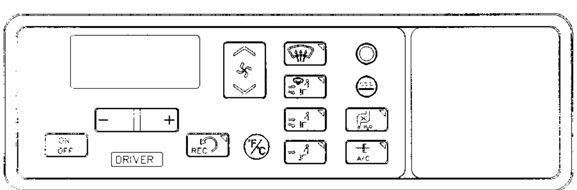


FIGURE 4: DRIVER'S HVAC SYSTEM CONTROL UNIT 22184

NOTE
The driver's area air temperature sensor is located behind the grill of the R.H. side console or inside the footwell, at the ceiling at the right of the steering column (Refer to fig.12).

3.1 VEHICLES EQUIPPED WITH A TM-16HD SELTEC COMPRESSOR

This system is completely independent, it has its own condenser, evaporator and compressor.

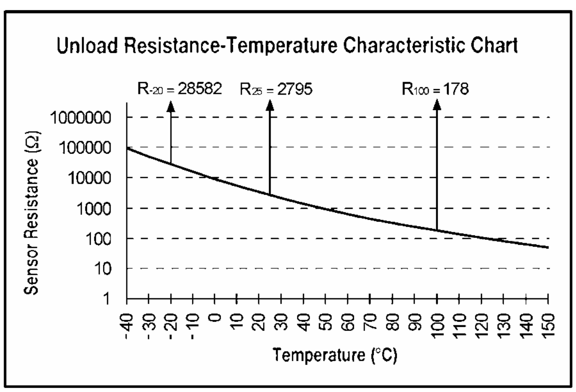
3.2 VEHICLES EQUIPPED WITH A CENTRAL SYSTEM

The driver's HVAC unit piping is paralleled with the main HVAC unit piping. Both units use the same refrigerant and coolant, and are linked to the same condenser and compressor, even if they are individually controlled. It requires the main HVAC unit to engage the A/C compressor magnetic clutch. Consequently, the driver's unit cannot be operated in the A/C mode alone.

3.3 DRIVER'S AREA AIR TEMPERATURE SENSOR RESISTANCE CHART

The following table and 2% error chart can be used to troubleshoot the driver's area air temperature sensor.

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



4. CENTRAL HVAC SYSTEM OPERATION

The HVAC control unit located on the dashboard R.H. panel, enables the selection of the temperature in the passenger area (or the living space for a converted vehicle) (refer to the Operator's Manual for details).

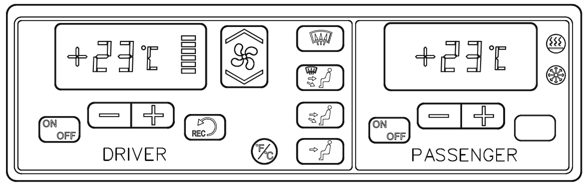


FIGURE 5: CENTRAL HVAC SYSTEM CONTROL UNIT 22274

Temperature control is provided in conjunction with a thermistor sensor inside register duct, located amidships on L.H. side of vehicle (Figs. 3 & 6).

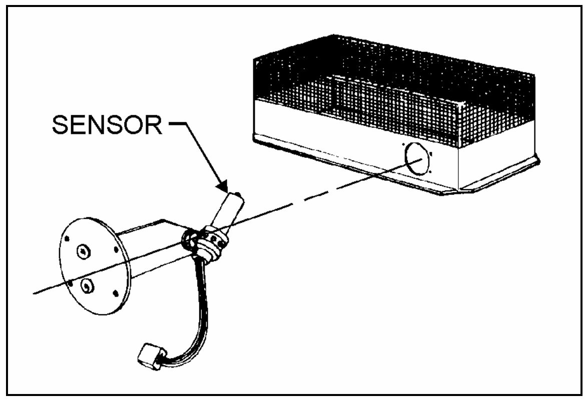


FIGURE 6: THERMISTOR SENSOR 22064

The flow of water to the vehicle's main heater core is controlled by an electric water valve which is open or closed 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 evaporator compartment, is protected by a 120 amps, manually resettable circuit breaker. The condenser fans, located in the condenser compartment, also have circuit protection via 40 amps manually resettable circuit breakers. The breakers are located in the A/C junction box in the evaporator compartment.

NOTE
The outside temperature sensor is located behind the front bumper on the L.H. side.

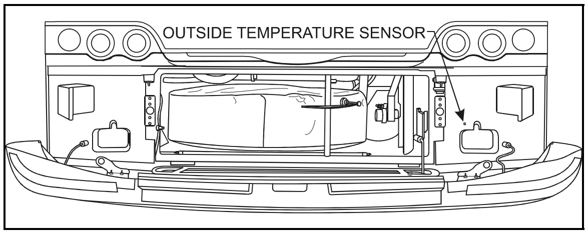


FIGURE 7: LOCATION OF OUTSIDE TEMPERATURE SENSOR

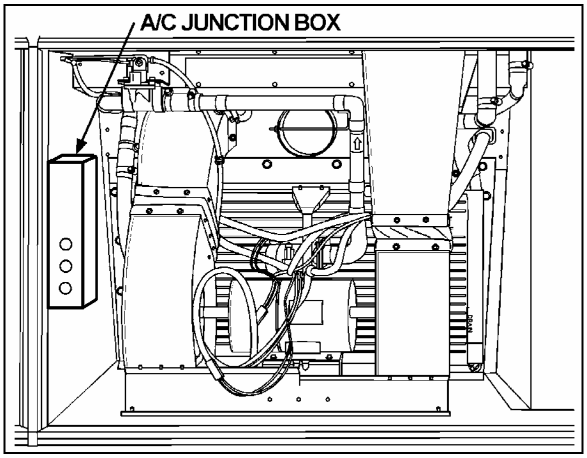


FIGURE 8: LOCATION OF A/C JUNCTION BOX IN EVAPORATOR COMPARTMENT 22178F

In order to operate the A/C system when vehicle is stationary, run the engine at fast idle. During operation of A/C system, windows should be kept closed and door(s) not left open longer than necessary. In order to prevent battery discharge, A/C & heating system will not operate when charging system is malfunctioning.

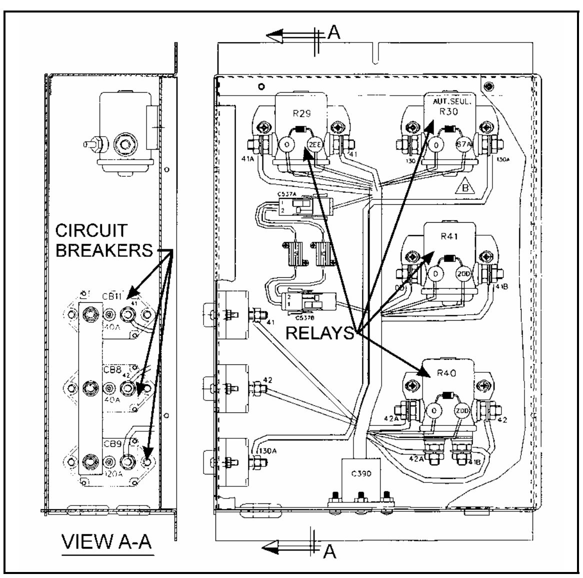


FIGURE 9: A/C JUNCTION BOX 06317

4.1 PARCEL RACK A/C (XL2 COACHES)

Optional small A/C evaporator coils may be added to both parcel racks existing air system. These auxiliary A/C system components are separate and completely independent of driver's and central systems 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.

5. HVAC UNIT MAINTENANCE

No special maintenance is required on the central, 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.

5.1 COIL CLEANING

NOTE
Squeeze rubber hose located underneath the appropriate compartment to eliminate the accumulated water and dirt when you make routine maintenance.

Check the external surface of the coil at regular intervals for dirt or any foreign matter.

For the driver's HVAC unit, flush the coil from inside. For the evaporator, back flush the coil (Fig. 10) every 12,500 miles (20 000 km) or once a year, whichever comes first.

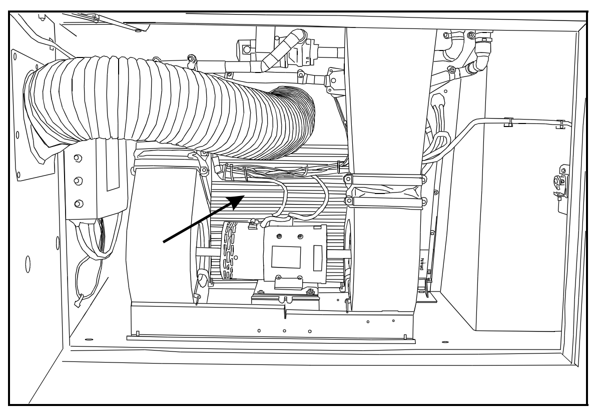


FIGURE 10: EVAPORATOR COIL CLEANING 22244

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.

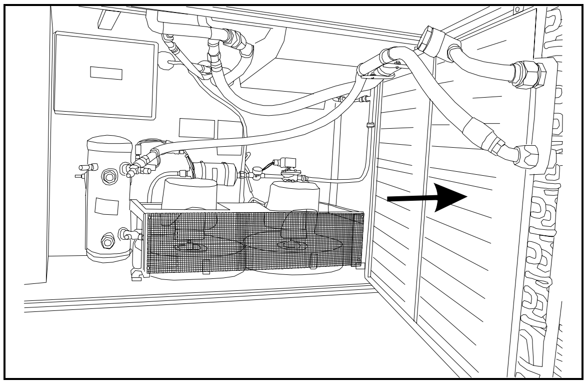


FIGURE 11: CONDENSER COIL CLEANING 22243A

⚠ 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.

5.2 DRIVER'S HVAC UNIT AIR FILTER

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 R/A and F/A filters. To clean filters back flush with water, then dry with air, every 12,000 miles (20 000 km) or once a year, which-ever comes first (Fig. 12).

NOTE

If the windshield is continuously fogged, check that the driver's air filter is not clogged.

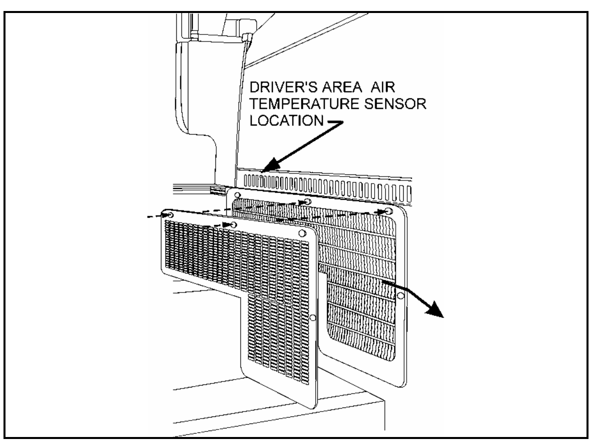


FIGURE 12: DRIVER'S AREA AIR FILTERS 22193

5.3 MAIN HVAC UNIT AIR FILTER

The main or cabin air filter is located in the evaporator compartment. To access the filter on XL2 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. 13). On MTH, to gain access, open evaporator compartment door. Remove filter panel by unscrewing the six fixing screws. Slide out the filter for cleaning (Fig. 14). To clean filter, back flush with water or soapy water, then dry with air every 12,000 miles (20 000 km) or once a year, whichever comes first.

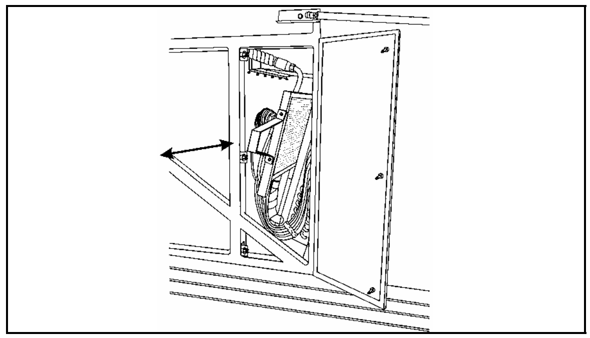


FIGURE 13: MAIN HVAC UNIT AIR FILTER 22179

⚠ CAUTION ⚠

Do not use high pressure water jet to avoid damaging filter.

⚠ CAUTION ⚠

Be sure not to reverse filter upon installation.

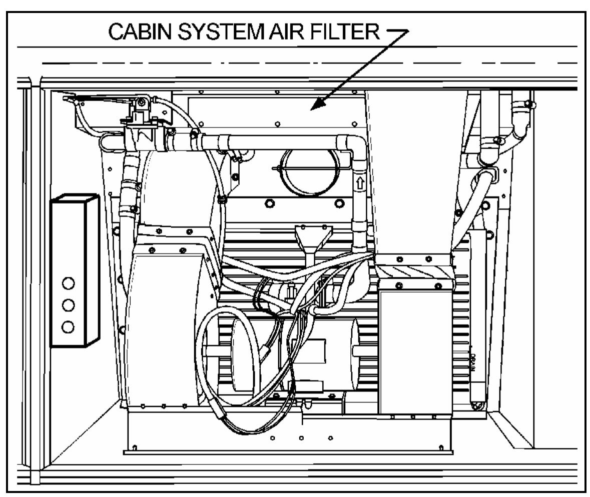


FIGURE 14: CABIN SYSTEM AIR FILTER REMOVAL 22178E

5.4 PARCEL RACK FAN AIR FILTER

A/C evaporator coils may be installed in both parcel rack air systems. Only the air filters are serviceable. The air filters are accessible from inside the parcel racks. Slide out the filters, then back flush with water, dry with air and replace. This procedure should be done every 12,000 miles (20,000 km) or once a year, whichever come first.

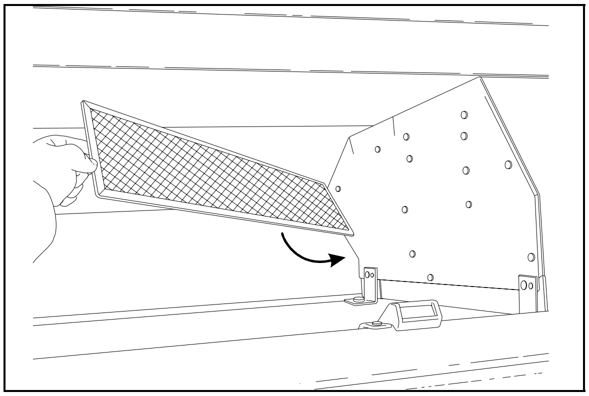


FIGURE 15: PARCEL RACK FAN AIR FILTER 22201

For A/C unit, ball valves are added on supply and return lines in the condenser compartment. They have service port to evacuate the A/C parcel rack 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.

6. EVAPORATOR MOTOR

(Central HVAC system only)

The evaporator motor is installed in the evaporator compartment (L.H. side of vehicle) (Fig. 16). It is a 27.5 volt, 2 HP (1.5 kW) motor which activates a double blower fan unit.

6.1 REMOVAL

1. Set the battery master switch to the *"OFF"* position.
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. Identify the L.H. side discharge duct inside compartment and remove the Phillips head screws retaining the flexible member to duct.
4. Repeat step 3 for the R.H. side air duct.

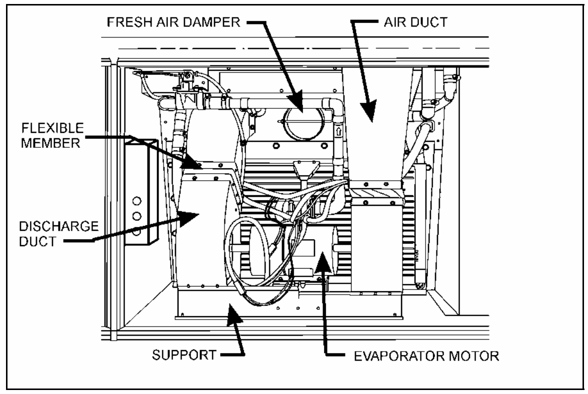


FIGURE 16: HVAC COMPARTMENT 22178

5. Disconnect the discharge air sensor connector. Remove the cable tie securing wire.
6. From under the vehicle, remove the eight bolts retaining the evaporator fan motor support. Remove the complete unit from the evaporator compartment (Fig. 17).

⚠ CAUTION ⚠
Never support evaporator motor by its output shafts while moving it.

7. 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.

6.2 INSTALLATION

To reinstall the evaporator motor, reverse "Evaporator Motor Removal" procedure.

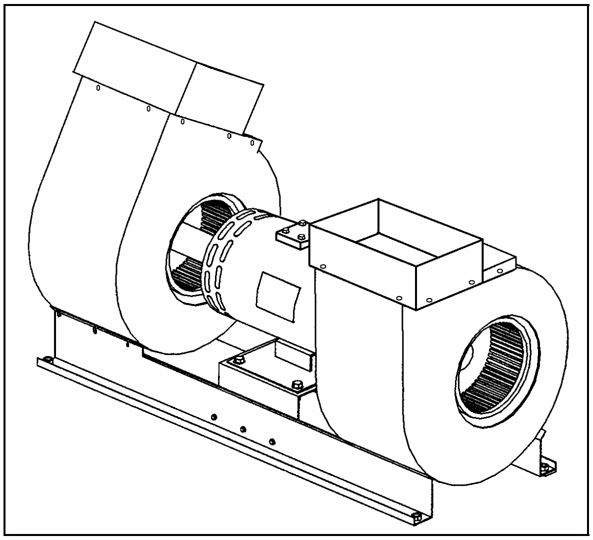


FIGURE 17: EVAPORATOR MOTOR ASSEMBLY 22208

6.3 CHECKING OPERATION OF BRUSH IN HOLDER

Lift brush slightly 1/8 inch (3 mm) and release it. Brush must produce a dry noise.

6.4 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 ¾ inch (19 mm). New brush length is 1-¼ inch. Clean brushes with a clean cloth impregnated with gasoline or alcohol.

⚠ WARNING ⚠
Cleaning products are flammable and may explode under certain conditions. Always handle in a well ventilated area.

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 standard procedure.
4. Reverse installation procedure.

6.5 BRUSH HOLDER ADJUSTMENT

NOTE
The brush holders are mounted on a support that can rotate. Rotating that support 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 holder support.
2. Loosen (do not remove) the bolts just enough to release the mechanism.
3. Move gently the exposed brush holder in order to have a maximum distance of 10 mm (3/8 inch) between the brush holder face and a reference line passing through the center of the 2 bolts on the motor housing.

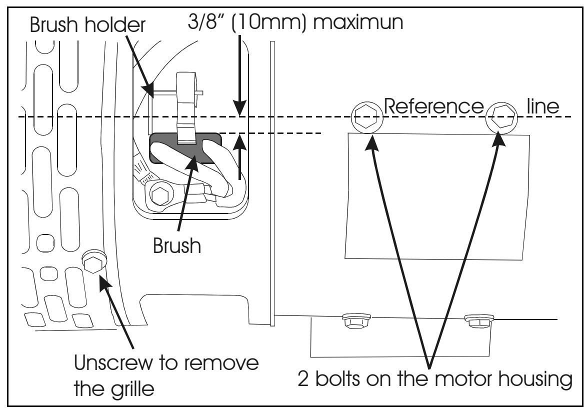


FIGURE 18: EVAPORATOR MOTOR

6.6 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. CENTRAL AIR CONDITIONING SYSTEM

The schematic of Figure 19 shows the central and auxiliary A/C system and their components. The central system is equipped with a 6 cylinder, 05G-134A Carrier compressor with an air conditioning capacity of 7½ tons. The receiver tank and filter dryer are mounted inside the condenser compartment.

XL2 Coaches may be supplied with central and auxiliary A/C system (Fig. 19). XL2 Converted vehicles (Shells) may be supplied with central or driver's A/C system only (Fig. 19 and 20). Auxiliary and driver's A/C systems come with a 6 cylinder, TM-16HD Seltec compressor with an air conditioning capacity of 2 tons.

7.1 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 Figures 19 and 20.

The air conditioning system used on XL2 series vehicle 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 back to the condenser sub-cooler. It leaves the condenser and 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 main 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 in^2 (5162 mm^2) could easily neutralize the total capacity of the system.
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.

7.2 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.

⚠ WARNING ⚠
Refrigerant in itself is nonflammable, but if it comes in contact with an open flame, it will decompose.

7.2.1 Procurement

Refrigerant is shipped and stored in metal cylinders. It is serviced in 30 and 100 pound (13,6 and 45 kg) cylinders. Approximately 24 pounds (10,9 kg) are used in the system. If vehicle is equipped with only a driver's A/C system, then 7.0 lbs (3,2 kg) (W0) or 7.5 lbs (3,4 kg) (W5 and WE) are used and approximately 5.5 lbs (2,5 kg) are used in an auxiliary A/C system.

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.

7.2.2 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.

7.2.3 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.

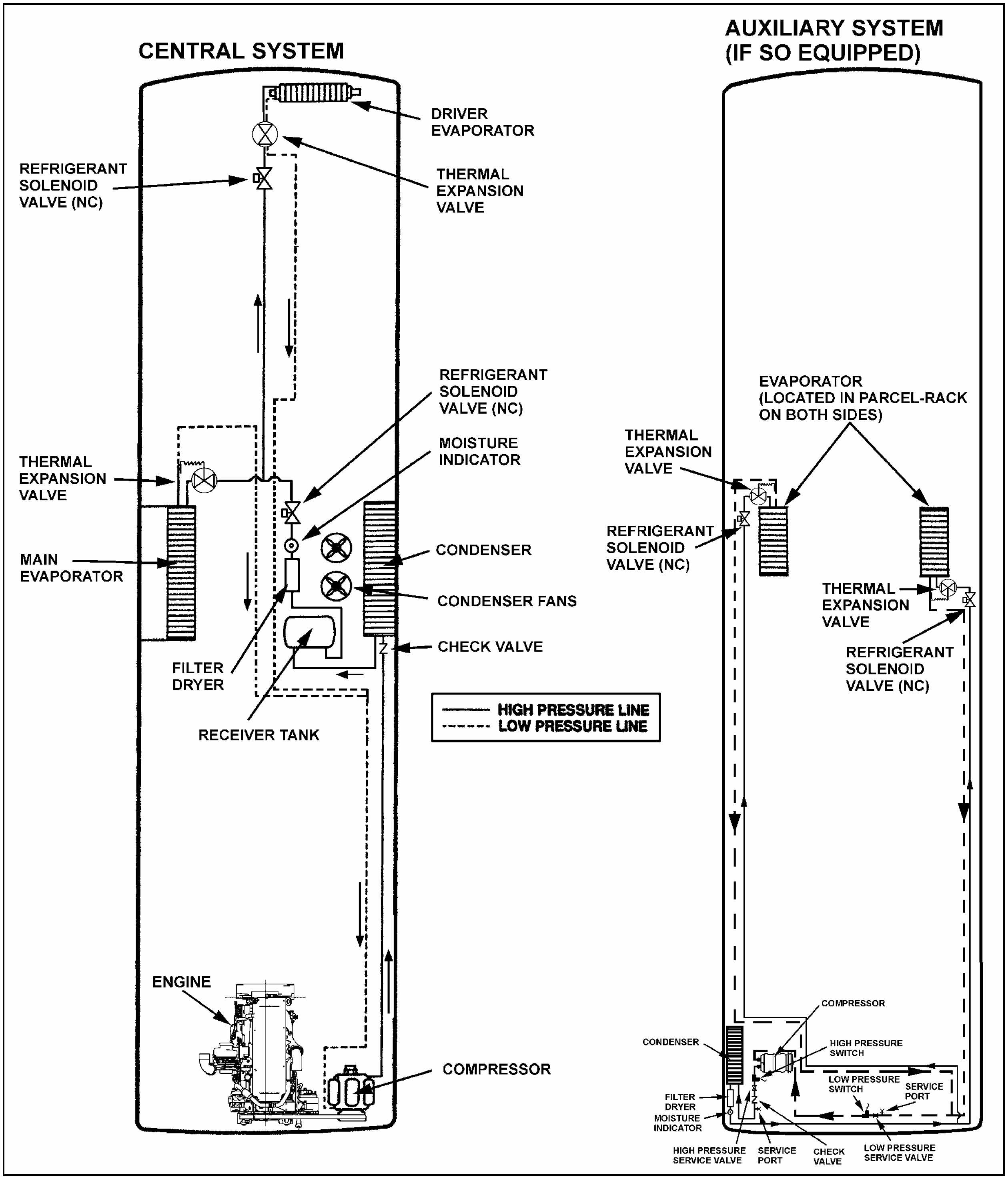


FIGURE 19: REFRIGERANT CIRCUIT (CENTRAL AND AUXILIARY SYSTEMS) 22247

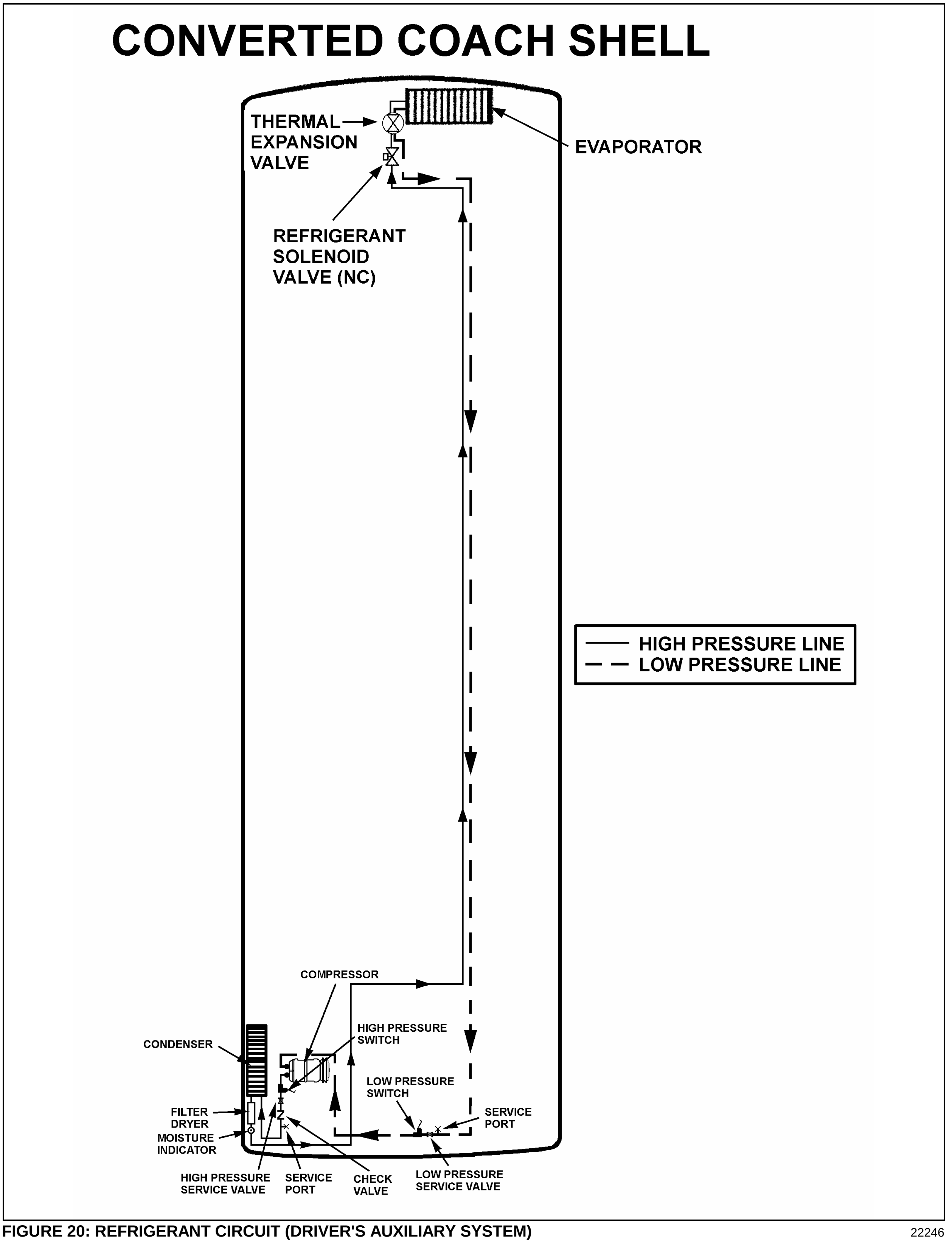


FIGURE 20: REFRIGERANT CIRCUIT (DRIVER'S AUXILIARY SYSTEM) 22246

7.2.4 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 reduced 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.

7.2.5 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.

7.3 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 or driver's A/C system only, refer to "Auxiliary Air Conditioning system and components": paragraph 9.9 "OIL RETURN OPERATION" and 9.3.4 "Refrigerant Recovery", further in this section.

⚠ 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 passenger side 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 the A/C switch, adjust *"A/C 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.

7.4 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.

7.5 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.

7.5.1 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.

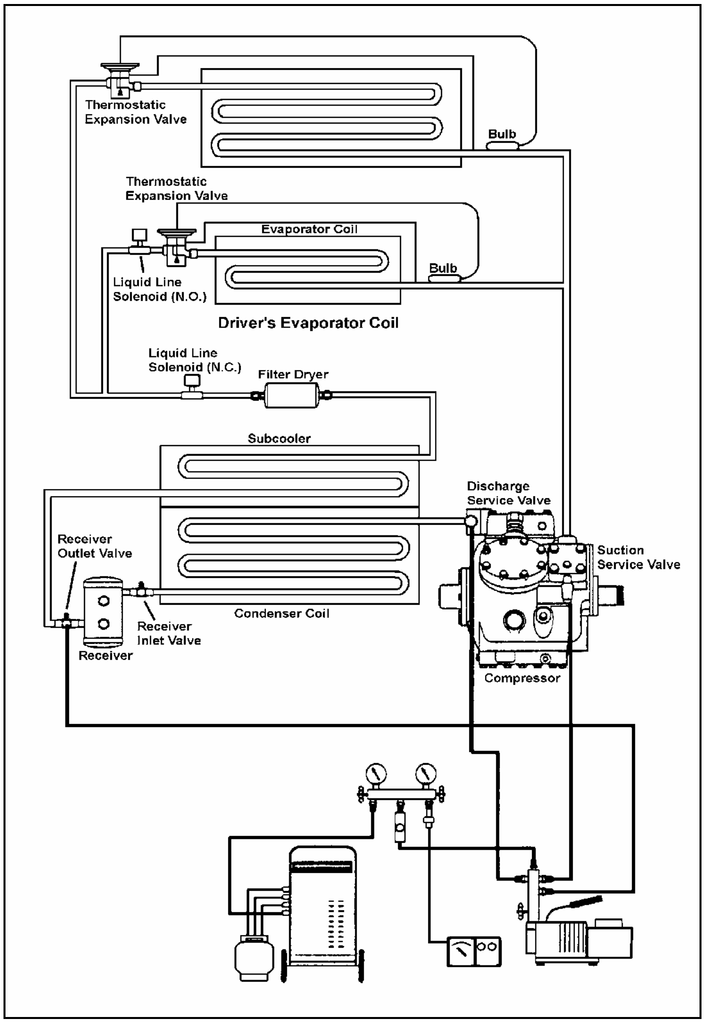


FIGURE 21: DOUBLE SWEEP EVACUATION SET-UP

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.

7.6 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), if the vehicle is equipped with a driver's system only, the system requires 7.0 lbs (3,2 kg) (W0) or 7.5 lbs (3,4 kg) (W5 and WE).

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.

7.7 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.

7.7.1 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.

7.7.2 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.

7.7.3 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.

8. CENTRAL A/C SYSTEM COMPONENTS

8.1 COMPRESSOR (CENTRAL SYSTEM)

8.1.1 Belt Replacement

⚠ WARNING ⚠

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. 22), 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. Slip the old belts off and the new ones on.
3. Reset belt tensioner pressure releasing valve (Fig. 22) to 50 psi (345 kPa) for coaches and to 45 psi (310 kPa) for MTH 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.

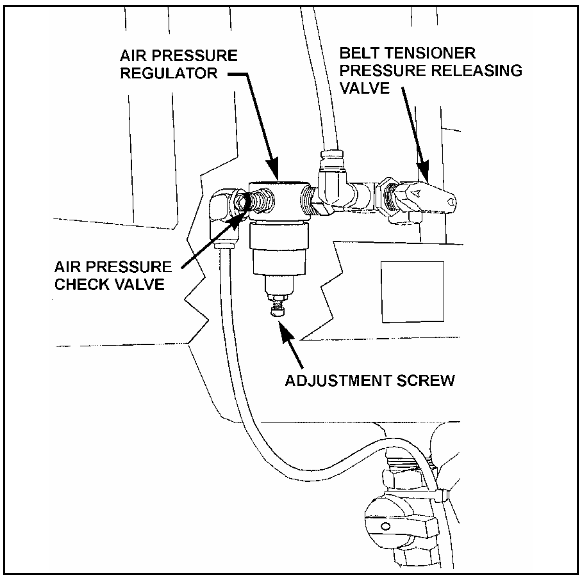


FIGURE 22: AIR PRESSURE REGULATOR 12200

NOTE
*For proper operation of the air bellows, adjust the **upper** tensioning bracket to provide a ¼ inch (7 mm) gap between stopper and bracket with the pneumatic system under normal pressure and the air pressure regulator set as per paragraph #3 (Fig. 23).*

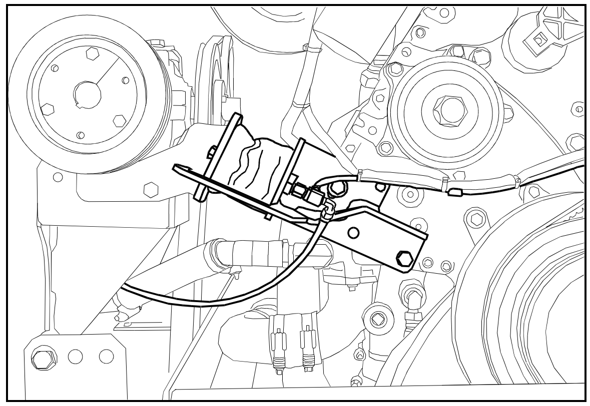


FIGURE 23: BELT TENSIONER 01059

8.1.2 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 tensioners by means of the air pressure releasing valve. After completing these procedures reset belt tensioner air pressure regulator to 50 psi (345 kPa) or 45 psi (310 kPa).

8.1.3 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. 24 & 26).
2. Check the distance between each extremity of straight edge (1. Fig. 26) 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.

8.1.4 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. 26) 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.

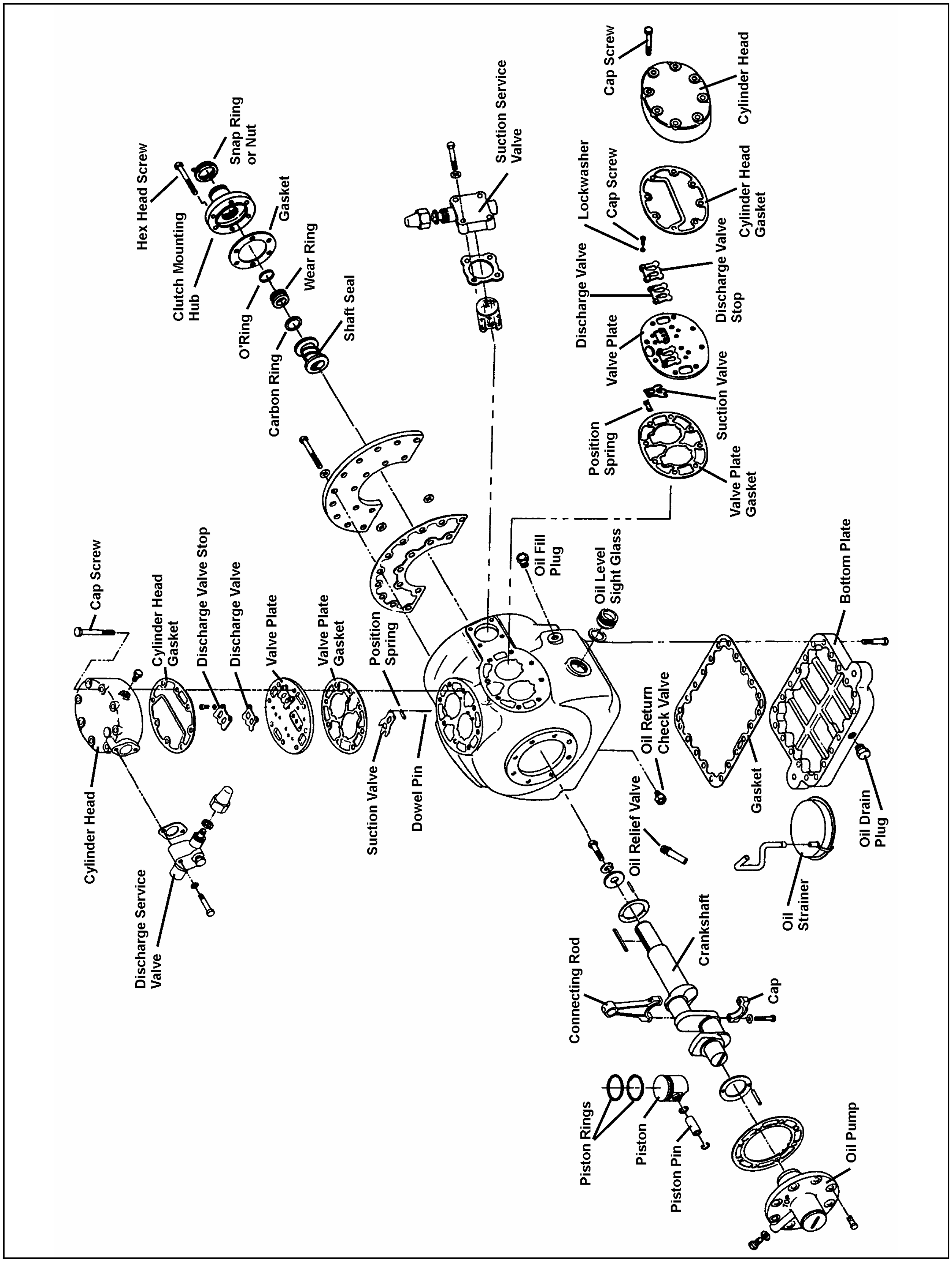


FIGURE 24: EXPLODED VIEW OF 05G COMPRESSOR

22214

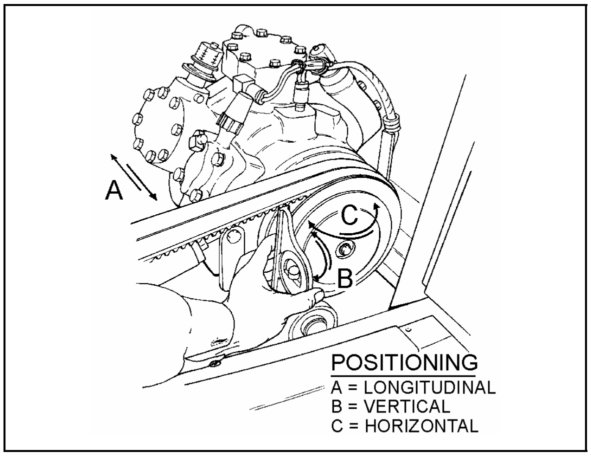


FIGURE 25: COMPRESSOR ALIGNMENT 22072

8.1.5 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^o and check if the compressor pulley is at same angle (Figs. 24 & 26). If it is not the same, shim under the appropriate pillow block in order to obtain the correct angle.

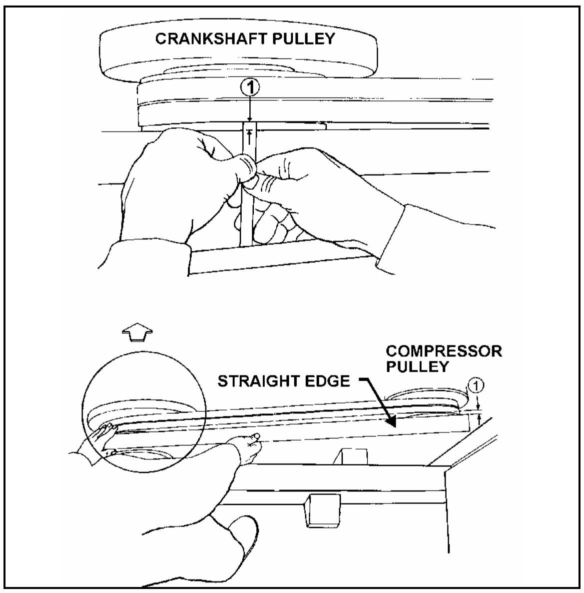


FIGURE 26: COMPRESSOR ALIGNMENT 22040

8.1.6 Compressor Maintenance

For the maintenance of the A/C compressor, see the *"Carrier Compressor Operation and Service Manual"* included at the end of this section.

⚠ CAUTION ⚠
Use only Castrol SW 68 (POE) oils with refrigerant 134a.

8.1.7 Troubleshooting Guide

A preliminary check may be made by simply feeling the cylinder heads with the unit in operation at ambient temperatures of 35^{o}F (2^{o}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.

8.2 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.

8.3 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. 28). The condenser coil, for vehicles equipped with an auxiliary or a driver's A/C system only, 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.

8.3.1 Condenser Fan Motors

Two fan motors (Fig. 27), 28.5 V - (0.6 HP - 0.42 kW) and cages 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 floor. 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.

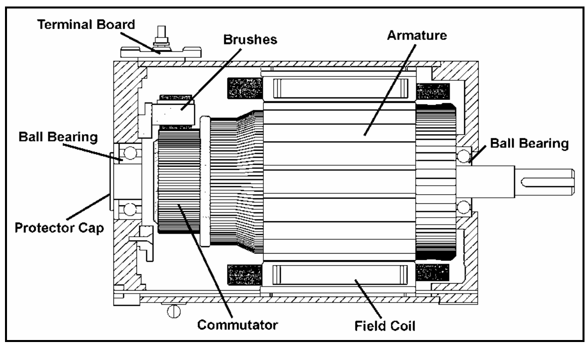


FIGURE 27: CONDENSER FAN MOTOR 22234

8.3.2 Condenser Fan Motor Removal

1. Set the battery master switch to the *“Off”* position.
2. Remove the two *“Phillips”* head screws retaining the fan motor protective cover to the square tubing. Remove the protective grill from mounting support.
3. Disconnect wiring from terminals on motor. Tag each wire to aid in identification at time of reconnection.

4. Support motor, and remove bolts which attach motor to mounting bracket. Remove the motor.

8.3.3 Preliminary Disassembly

1. Remove the brushes.
2. Unscrew the flange retaining screws on the shaft end side (opposite to the commutator end frame), and separate flange from frame (Fig. 27).
3. Remove flange and armature assembly by pushing bearing shaft toward the commutator end frame.
4. Separate flange from armature.

8.3.4 Disassembly

1. Perform preliminary disassembly.
2. Carefully note the position of the brush holder ring and the connections on the flange support.
3. Unscrew and remove the flange on the commutator end frame.
4. Remove the brush holder ring.
5. Finally, separate the following parts: brush holders, brush boxes, terminal board, bearings, etc.

8.4 RECEIVER TANK

The receiver tank is located in the condenser compartment (Fig. 28). 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.

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.

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.

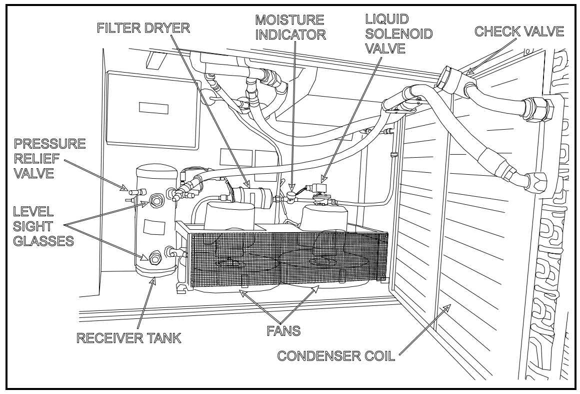


FIGURE 28: A/C CONDENSER COMPARTMENT 22243B

8.5 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 engine compartment L.H. side rear door, is installed on vehicles equipped with an auxiliary A/C system or a driver's system only. Its function is similar to that of filter used on main systems. Replace only when system is opened or a problem occurs.

8.5.1 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 ⚠
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.

⚠ WARNING ⚠
Cleaning products are flammable and may explode under certain conditions. Always handle in a well ventilated area.

8.5.2 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.

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)			

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.

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.

8.6 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.

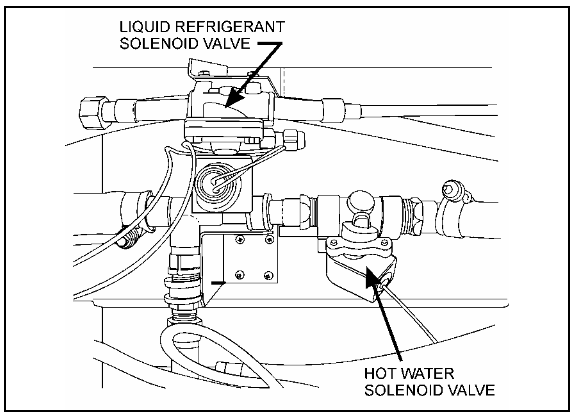


FIGURE 29: DRIVER'S EVAPORATOR LIQUID SOLENOID VALVE 22181

NOTE
An identical refrigerant solenoid valve is used on the auxiliary A/C system and is located near the auxiliary A/C unit.

8.6.1 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 ½ turn counterclockwise. To manually close valve, turn stem clockwise until tight against seat. Manual stem must be in closed position for automatic electric operation.

8.6.2 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.

8.6.3 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. 30).
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.

8.6.4 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.
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.

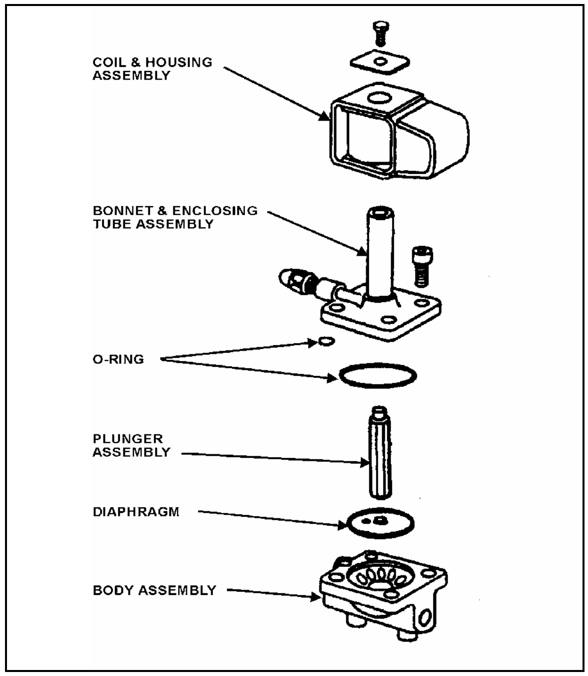


FIGURE 30: REFRIGERANT SOLENOID VALVE 22044

8.7 EXPANSION VALVE

8.7.1 Central System

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. 13 & 31). 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.

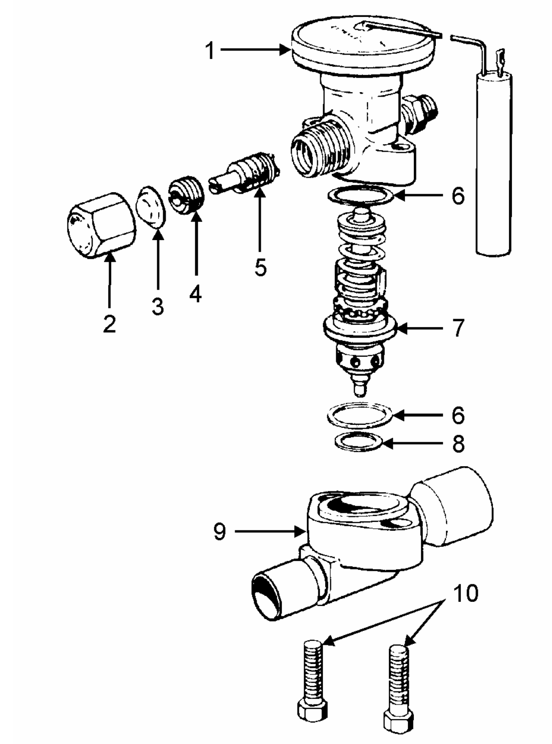
The remote bulb and power assembly is a closed system. The pressure within the remote bulb and power assembly corresponds to the saturation pressure of the refrigerant temperature leaving the evaporator and moves the valve pin in the opening direction. Opposed to this force, on the under side of the 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.

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^{o} F (-11.1 to -8.8 ^{o} 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.



1. POWER ELEMENT
2. CAP - SEAL NUT
3. BONNET - SEAL (FLARE)
4. PACKING NUT
5. ADJUSTING STEM & PACKING ASSY
6. GASKET
7. CAGE ASSY
8. GASKET
9. BODY FLANGE
1O. CAPSCREW

FIGURE 31: EXPANSION VALVE 22045

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. 32). 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^{o}F (27,7^{o}C), Then set temperature to minimum to keep the compressor on 6 cylinders.

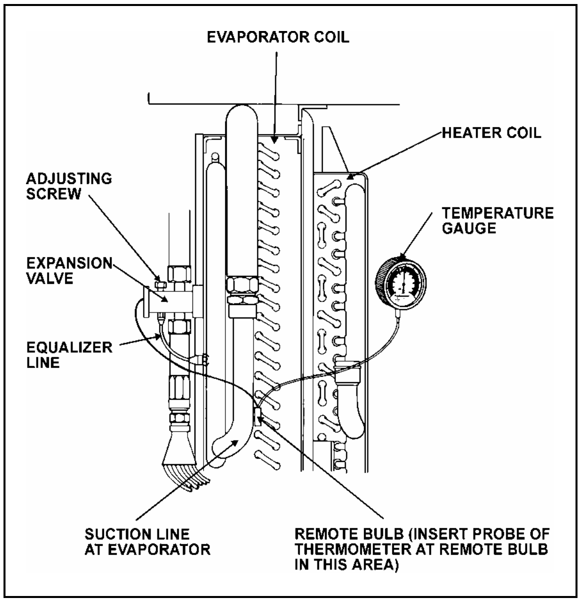


FIGURE 32: SUPERHEAT ADJUSTMENT INSTALLATION 22046

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.
3. Install a remote reading thermometer to the evaporator outlet line near the existing remote bulb (Fig. 32).
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.
6. Check approximately 5 readings of pressure at 2-minute intervals and convert to temperature using the temperatures & pressures table (page 31). 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. 33).

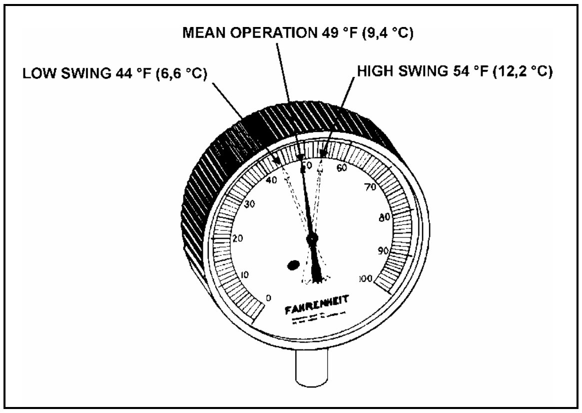


FIGURE 33: HIGH & LOW SWING TEMPERATURE AT REMOTE BULB 22047

Example of readings taken at fig. 33:

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.

6. 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

1. Pump down the system as previously indicated in this section.
2. 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.
3. Remove the two cap screws holding the power assembly to the valve body flange. Lift off the power assembly and remove the cage assembly.
4. 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.
5. Check for leaks.

Safety Instructions

1. Make sure the valve is installed with the flow arrow on the valve body corresponding to the flow direction through the piping system.
2. 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.

8.7.2 Driver’s System

The function and operation of the expansion valve for the driver'' system are similar to the main system, but no superheat adjustment is required (see figures 19 and 20).

8.8 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.

⚠ **WARNING** ⚠

Before welding any part of refrigeration system, make sure the area is well ventilated.

8.9 TROUBLESHOOTING

8.9.1 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.

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.

8.9.2 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.

<table>
<tr><th>TROUBLE</th><th>CAUSE</th></tr>
<tr><td>Frequent starting and stopping on low pressure control switch.</td><td>Lack of refrigerant. Check for leaks. Recharge.</td></tr>
<tr><td>Compressor intermittently starts and stops.</td><td>Intermittent contact in electrical control circuit. Compressor valves not in operating position.</td></tr>
<tr><td>Non-condensable in the refrigeration system.</td><td>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.

(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.)

An evaporator just does a proper cooling job without sufficient air. Shortage of air can be caused by the following:

* Dirty filters; or
* Dirty coils.</td></tr>
<tr><td colspan="2">Testing condenser pressure.

Note: R-134A pressure is function of the temperature variation.

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:

Reduced air quantity. This may be due to:
* 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.</td></tr>
</table>

8.10 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

VAPOR-PRESSURE			
TEMPERATURE		PRESSURE	
°F	°C	psi	kPa
180	82.2	385.9	2660.8
190	87.8	433.6	2989.7
200	93.3	485.0	3344.1
210	98.9	540.3	3725.4

8.11 LEAK TESTING

Some methods such as nitrogen pressure and 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:

⚠ WARNING ⚠
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.

9. AUXILIARY AIR CONDITIONING SYSTEM AND COMPONENTS

9.1 COMPRESSOR

MODEL	TM-16HD
TYPE	Swash-plate type
Number of cylinders	6
Bore	36 mm (1.42”)
Stroke	26.7 mm (1.05”)
Displacement	163 cm^3 (10cu.in)
Permissible speed	700-6000 rpm
Refrigerant	HFC-134a
Lubricant	ZXL100PG 180 cm^3
Mass	4.9 kg (10.9 lbs)

9.2 MAGNETIC CLUTCH

TYPE	Electromagnetic single-plate dry clutch
Rated Voltage	24 volts DC
Current consumption	3.75 amperes (max)
Stalling torque	49 Nm (36.1 Lbf-ft) min.
Rotation	CW/CCW
Mass	2.2 kg (4.9 lbs)

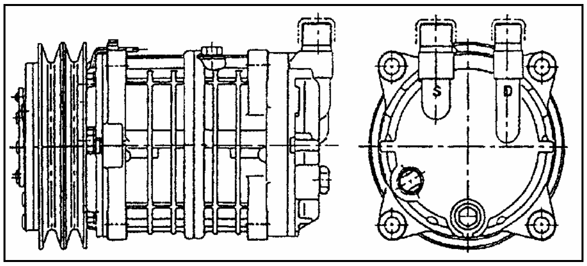


FIGURE 34: SELTEC TM-16HD COMPRESSOR

9.3 MAINTENANCE PRECAUTIONS

9.3.1 Work Area

Because the components of air conditioning systems are especially sensitive to moisture, dirt and dust, always observe the following procedures:

* Work indoors whenever possible.
* Select a level work area.
* Keep work area clean.
* Select a work area with adequate ventilation.

⚠ WARNING ⚠
Refrigerant itself is not harmful, but excessive accumulation in a closed area can cause oxygen deficiency.

* Keep open flame and flammables away from the vehicle in which the air conditioning system is being serviced. **Open flame is especially dangerous during Freon leak testing.**

⚠ WARNING ⚠
Contact with flame and high temperatures can generate toxic gases.

9.3.2 Refrigerant Handling

Never directly heat refrigerant cylinder or put in hot water heated above 40°C (104°F) since it may cause release of the safety plug or the cylinder may burst. When it is necessary to heat refrigerant cylinder for charging in cold weather, use warm water at a temperature below 40°C (104°F).

⚠ WARNING ⚠
Do not put the charge valve in the warm water.

* Never store refrigerant cylinder in direct sunlight, near flame, or where the temperature exceeds 40°C (104°F). Always store refrigerant cylinder in a cool dry place.
* Never throw or strike refrigerant cylinder and never handle roughly.

9.3.3 PAG Oil Handling

Whenever a part replacement has to be done on the system, additional task about PAG oil will have to be performed.

The compressor has little reserve and is lubricated by the oil refrigerant mixture. To perform correctly, the compressor needs the mixture to be from 3% to 6% of Poly Alkaline Glycol (PAG) oil.

When a compressor has to be top off due to a severe lost, the amount of oil to be added should be evaluated with the refrigerant charge or a compressor oil change should be performed to rise up the compressor oil charge to 180 ml or the written charge on the nameplate.

* The oil should be free from moisture, dust, metal shavings, etc.
* Do not mix with other oils.
* The moisture content of the oil increases when exposed to the air for prolonged period. Therefore, after use, seal the container immediately.

DO NOT MIX PAG AND POE OR MINERAL OILS!

9.3.4 Refrigerant Recovery

Some air conditioning system refrigerant compounds are chlorofluorocarbons, and therefore may be damaging the earth's ozone layer. Consequently, the release of refrigerant into the atmosphere must be avoided. Whenever refrigerant is to be released from the air conditioning system, a refrigerant recovery unit must be used to recover the refrigerant. This refrigerant can then be recycled and reused, which is both environmentally safe and economical.

For complete system recovery, any of the High and Low service ports can be used (Refer to fig. 19 & 20). Energize liquid solenoid valve and measure the quantity of oil recovered. For the compressor only, use the service valve port and close the valves. The service valves open permits full flow of refrigerant to service port. Service valve closed permits flow of refrigerant from compressor to service port.

9.3.5 Compressor Handling

Do not strike, drop or turn the compressor upside down. If the compressor is knocked over or turned upside down, rotate the compressor's magnetic clutch 5 to 6 times by hand to circulate the oil which has settled in the cylinder. Sudden rotation with oil in the cylinder can cause valve damage and adversely affect durability.

9.4 COMPRESSOR REMOVAL

9.4.1 When the compressor is operational

* Perform the "OIL RETURN OPERATION" (Refer to paragraph 10.9).

9.4.2 When the compressor is inoperable

* Perform the "Refrigerant Recovery" operation (Refer to paragraph 10.3.4).
* Slacken bolts A (Refer to figure 35).
* Remove bolts B & C (Refer to figure 35).
* Remove the compressor.

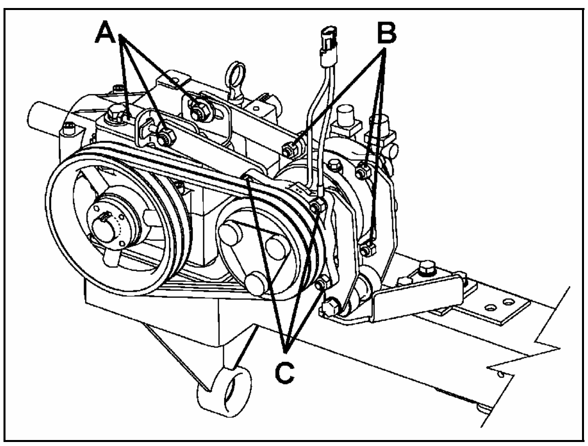


FIGURE 35: COMPRESSOR REMOVAL OR INSTALLATION 22285

9.5 INSTALLATION PRECAUTIONS

The new compressor is filled with the specified quantity of compressor oil and nitrogen gas (N^2). When mounting the compressor on the vehicle, take the following steps:

* Loosen the discharge side connector's cap and gently release N^2 from compressor (Refer to figure 36).

NOTE
Take care not to let the oil escape.

* Slowly rotate the compressor's magnetic clutch several times by hand to distribute the oil which has settled in the cylinders (Refer to figure 37).

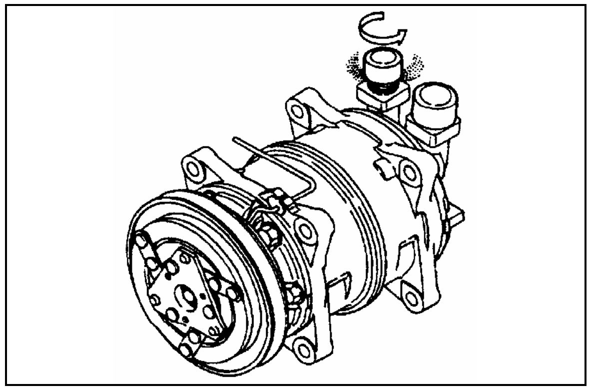


FIGURE 36: LOOSENING THE DISCHARGE SIDE CONNECTOR'S CAP

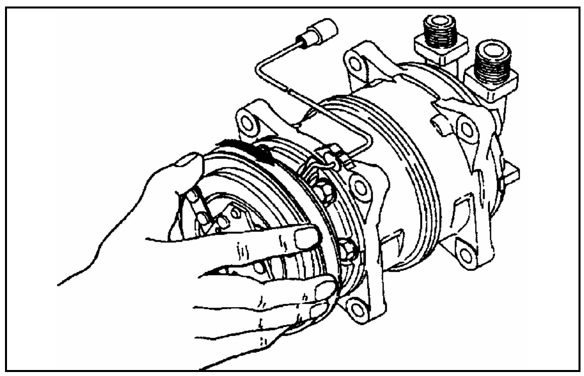


FIGURE 37: ROTATING MAGNETIC CLUTCH

* When using the old compressor in the system, the compressor should be installed after changing the oil.

9.6 COMPRESSOR OIL CHANGE

Each compressor is delivered filled with the specified quantity of compressor oil, depending on the type of air conditioning system. A label describing the amount/type of compressor oil is attached to the compressor.

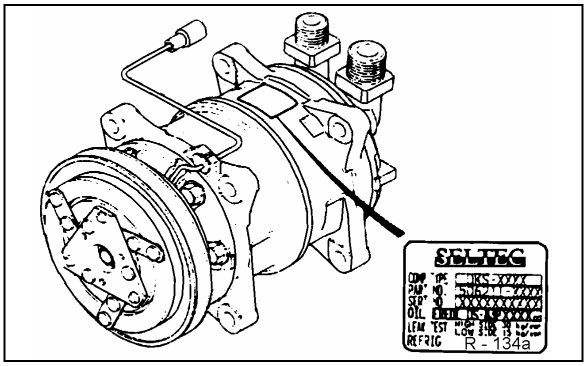


FIGURE 38: COMPRESSOR OIL LABEL

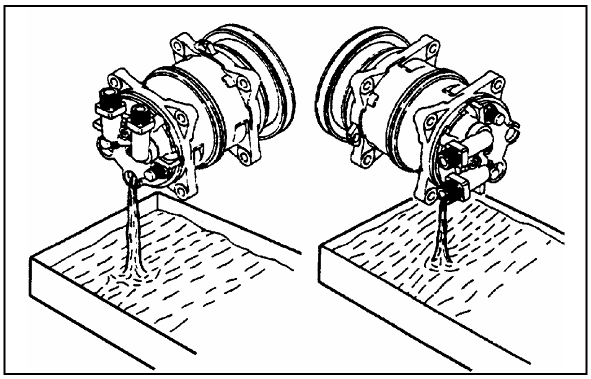


FIGURE 39: DRAINING THE OIL

* Check oil for contamination. Refer to PARAGRAPH 10.8: "COMPRESSOR OIL CONTAMINATION".
* Tighten the oil drain plug with a new o-ring lightly coated with clean compressor oil to specified torque.

Torque: 13-15 Nm (9.4-10.8 Lbf-ft)

* Add new compressor oil through the suction-side connector with the amount specified on the label (180 ml).

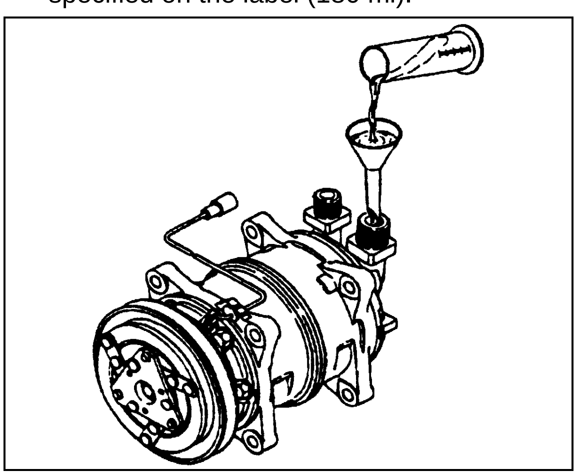


FIGURE 40: ADDING NEW COMPRESSOR OIL

9.6.1 Evacuating System Before Adding Refrigerant (Driver's or Auxiliary System)

When a system has been opened for repairs, change the filter dryer and evacuate the system. XL2-45 coaches equipped with an auxiliary system or XL2 MTH equipped with a driver's system must use high-pressure service port located on the other side of check valve and low-pressure port located alongside rear truss. (Figs. 19 and 20). 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.

9.7 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 cm³ (1.7 ozs)
Condenser	30 cm³ (1.0 ozs)
Filter-Dryer	10 cm³ (0.3 ozs)

The amount of oil recovered with the refrigerant recovery should be added at the same time.

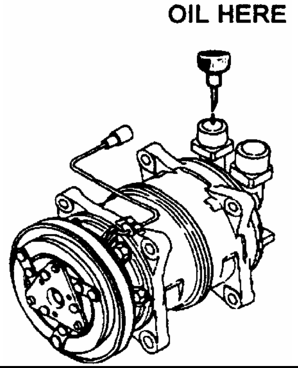


FIGURE 41: ADDING OIL AFTER REPLACING A COMPONENT

9.8 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 paragraph 10.6: “COMPRESSOR OIL CHANGE”.

9.9 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.

9.10 OIL CHECK INTERVAL

Unlike engine oil, it is not necessary to frequently check or change the compressor oil. However, it is necessary to check and replenish or replace the compressor oil in the following cases:

* Whenever the compressor, evaporator, condenser or filter-dryer is replaced.
* Whenever refrigerant has leaked from the system, evaluate the amount of oily spot.
* Whenever refrigerant is suddenly released from the cooling cycle, replenish the compressor (180 ml) plus 150 ml.
* Whenever any oil-related problems occur in the cooling cycle.

9.11 LEAK TEST PROCEDURE WITH COMPRESSOR REMOVED

When a compressor is repaired, it must be checked prior to installation.

* Install the discharge and suction caps to the connector.

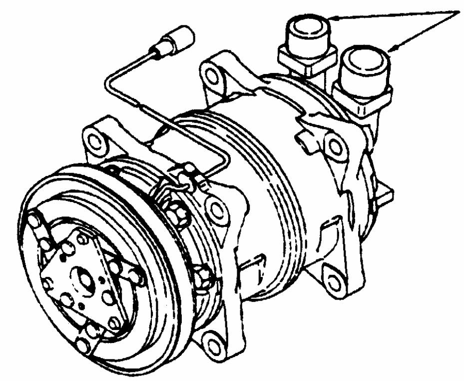


FIGURE 42: DISCHARGE AND SUCTION CAPS

* Fill the compressor with refrigerant through connector’s suction port raising the pressure to at least 0.5 Mpa (70 psi).
* Check the compressor for leaks using a leak detector.

NOTE
Never leave the compressor upside down for longer than 30 seconds. This is because the oil inside the compressor will enter the cylinders, causing liquid compression which will damage the compressor’s suction and delivery valves.

9.12 TIGHTENING TORQUES

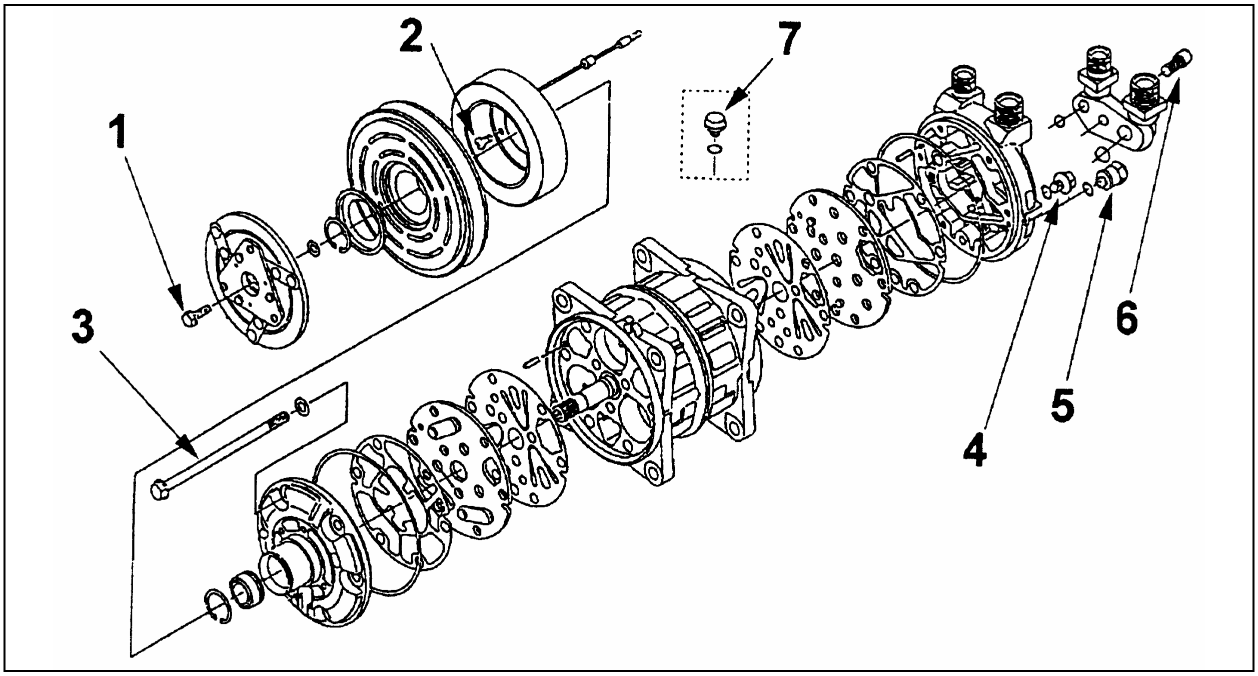


FIGURE 43: TIGHTENING TORQUES

PART	THREAD SIZE	TIGHTENING TORQUE
1. Bolt Armature	M6 x 1.0	12 - 14 Nm (8.7 - 10.1 Lbf-Ft)
2. Field Coil Screw	M5 x 0.8	4 - 6 Nm (2.9 - 4.3 Lbf-Ft)
3. Body Bolt	M8 x 1.25	20 – 24 Nm (14.5 – 17.3 Lbf-Ft)
4. Oil Drain Plug	M8 x 1.25	13 – 15 Nm (9.4 – 10.8 Lbf-Ft)
5. Pressure Relief Valve	3/8 – 24UNF	13 – 15 Nm (9.4 – 10.8 Lbf-Ft)
6. Connector Bolt	M8 x 1.25	20 – 24 Nm (14.5 – 17.3 Lbf-Ft)
7. Oil Filler Plug	M8 x 1.25	13 – 15 Nm (9.4 – 10.8 Lbf-Ft)

10. HEATING SYSTEM

The schematics of Figures 44 and 45 show respectively, the central heating system and the driver's heating system with their components.

In addition to the normal heating provided by the engine, a preheating system (104,000 Btu/hr) (optional on coaches only) may have been installed in the vehicle.

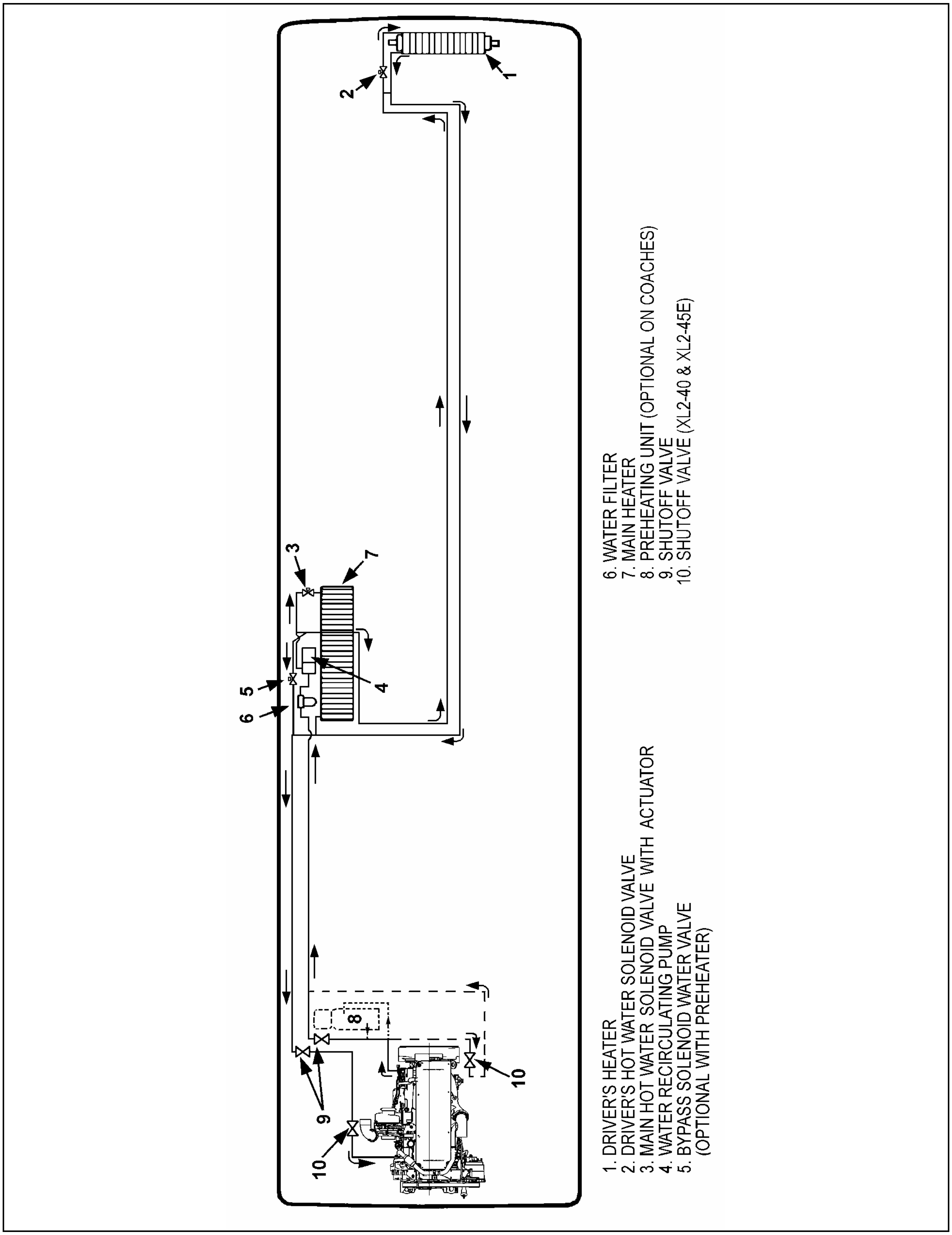


FIGURE 44: CENTRAL HEATING SYSTEM COMPONENTS 22237

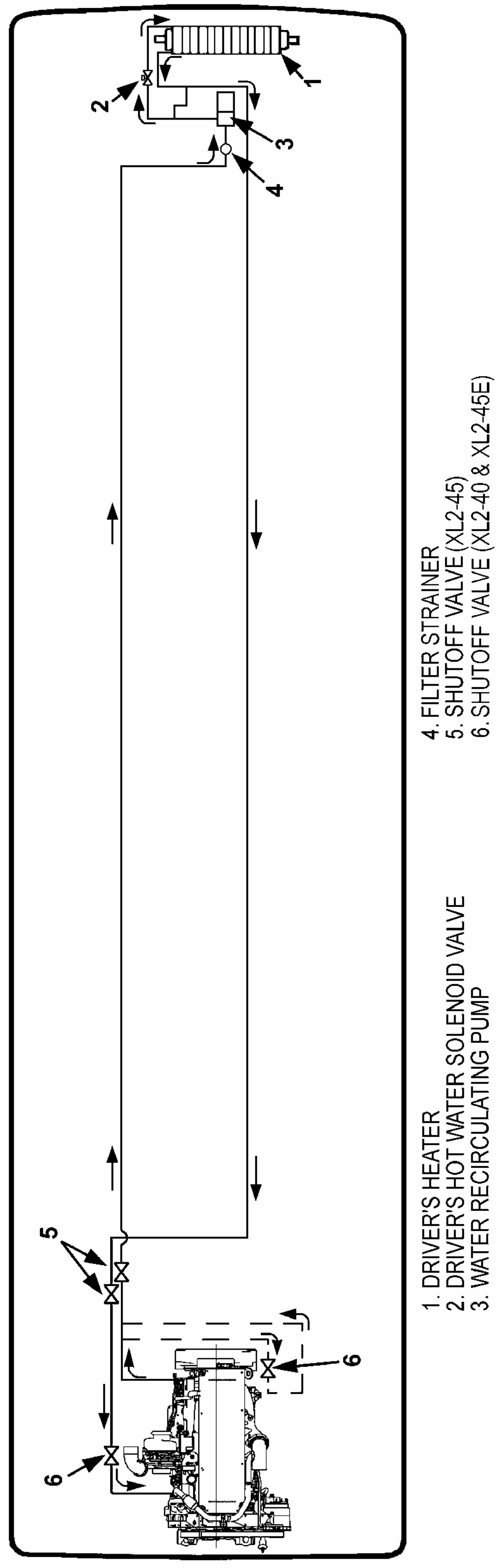


FIGURE 45: DRIVER'S HEATING SYSTEM COMPONENTS (VEHICLES EQUIPPED WITH DRIVER'S SYSTEM ONLY) 22238

10.1 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.

10.1.1 Draining Driver's Heater Core

1. Stop engine and allow engine coolant to cool.
2. Locate the normally open water solenoid valve on the ceiling of the spare wheel compartment (Fig. 46), disconnect its wiring connector, then connect a 24-volt external power source, using jumper cables, to close 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. 47) to ensure an efficient draining.

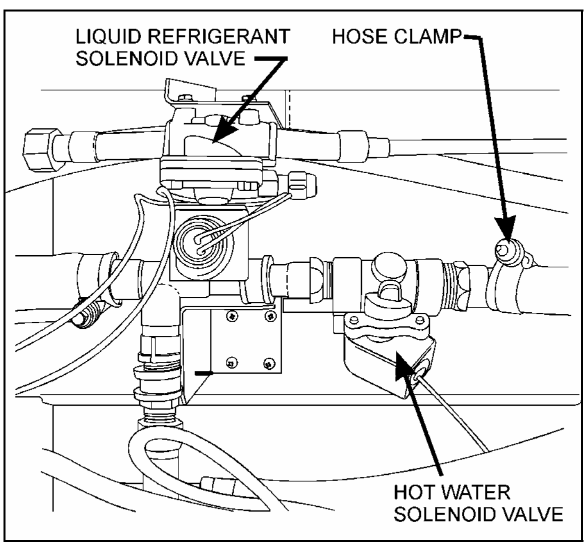


FIGURE 46: CEILING OF THE SPARE WHEEL COMPARTMENT 22181

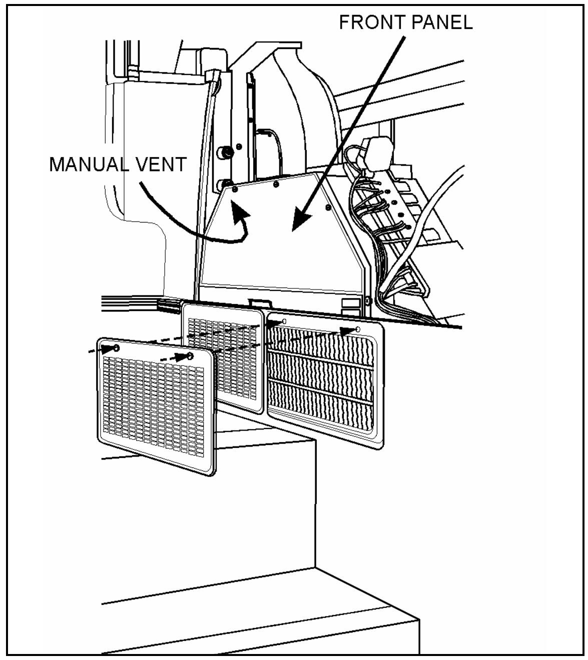


FIGURE 47: DRIVER'S HVAC UNIT 22172

10.1.2 Draining Main Heater Core

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

On XL2-40 & 45E vehicles, the valves are located in engine compartment. One is on the R.H. side of compartment and is accessible through engine compartment R.H. side door (Fig. 48).

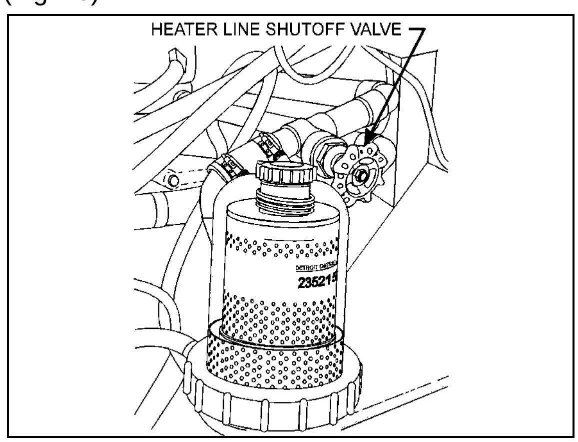


FIGURE 48: HEATER LINE SHUTOFF VALVE 05070

Another valve is located in the engine compartment under the radiator fan gearbox (Fig. 49).

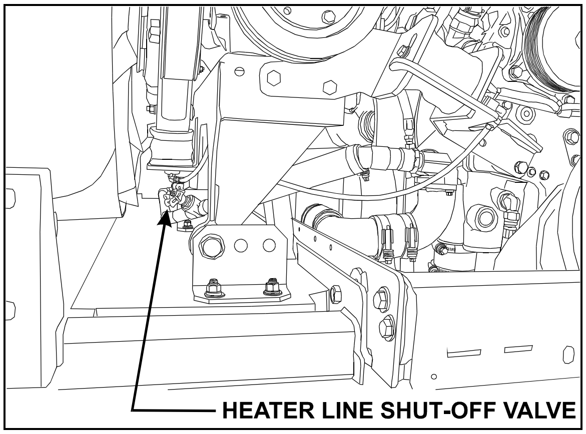


FIGURE 49: ENGINE COMPARTMENT 05078

On XL2-45 vehicles, one valve is located in the engine compartment, under the radiator fan gearbox (Fig. 49), another valve is located in the engine compartment behind splash guard panel at rear of vehicle (behind L.H. side tag axle wheel) (Fig. 50).

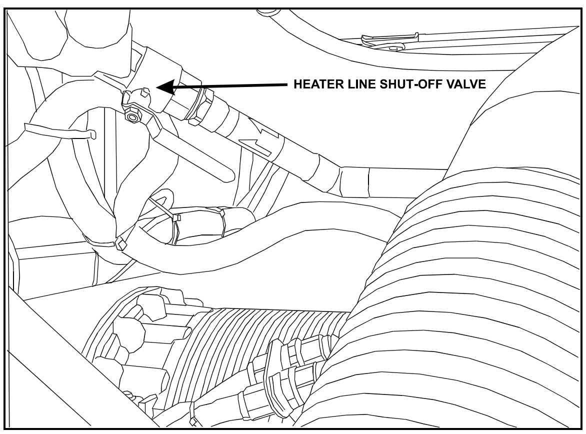


FIGURE 50: HEATER LINE SHUT-OFF VALVES 05067

3. Open the last L.H. side baggage compartment door, and then pull the black release button located on the L.H. side in order to unlock and open the evaporator compartment door.

⚠ WARNING ⚠

Before proceeding with the following step, check that coolant has cooled down.

4. Open drain cock in bottom of heater core, then open manual vent located on top of heater core (Fig. 51) in order to allow air to enter while draining.

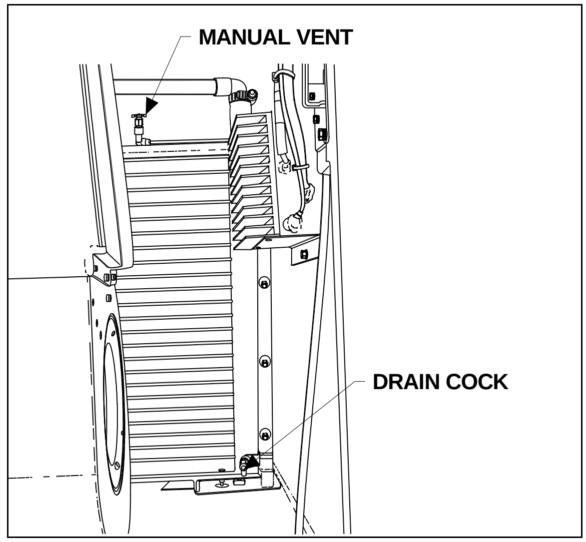


FIGURE 51: EVAPORATOR COMPARTMENT 22128

10.2 FILLING HEATING SYSTEM

1. Ensure that the drain hose is reconnected and the manual vents 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 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.

10.3 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 vents illustrated in Figures 47 and 51, and open them momentarily until no air escapes from the lines.

10.4 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.

10.5 DRIVER’S WATER SOLENOID VALVE

A two-way normally open, internal pilot-operated solenoid valve designed for smooth closing is used to control the coolant flow through the driver’s heating unit. It is mounted on the coolant inlet line of the driver’s heating unit, and is accessible through the spare wheel compartment (see fig. 46). The valve cannot be manually bypassed.

10.5.1 Improper Operation

1. Faulty control circuit: Check the electric system by energizing the solenoid. A metallic clicking noise indicates that the solenoid is operating. Absence of clicking indicates a loss of power or a defective solenoid. Check for open breaker, open-circuited or grounded coil, broken lead wires.
2. Burned-out coil: Check for open-circuited coil. Replace coil if necessary.
3. Low voltage: Check voltage across the coil leads. Voltage must be at least 85% of nameplate rating.
4. Excessive leakage: Disassemble valve and clean all parts. Replace worn or damaged parts with a complete spare part kit for best results.

10.5.2 Coil Replacement

Turn off electrical power supply and disconnect lead wires. Proceed in the following manner:

1. Remove retaining cap or clip, spacer, name plate and housing.
2. Slip spring washer, insulating washer, coil and insulating washer off the solenoid base sub-assembly. Insulating washers are omitted when a molded coil is used.
3. Coil is now accessible for replacement. Reassemble by reversing sequence of disassembly. Refer to exploded view (Fig. 52) for identification and location of parts.

NOTE
Solenoid must be completely reassembled, as the housing and internal parts complete the magnetic circuit.

⚠ CAUTION ⚠
When metal retaining clip disengages, it springs upwards.

10.5.3 Valve Disassembly

1. Drain driver's heating unit as previously explained in this section under paragraph *“Draining Heating System”.*
2. Disconnect connector from coil connector.
3. Disassemble valve in an orderly fashion paying careful attention to exploded view (Fig. 52) provided for identification of parts.
4. Remove retaining cap and slip the entire solenoid enclosure off the solenoid base subassembly.

⚠ CAUTION ⚠
When metal retaining clip disengages, it springs upwards.

5. Unscrew solenoid base sub-assembly and remove core, plug nut gasket, plug nut assembly and solenoid base gasket.
6. Remove the four bonnet screws and valve bonnet, disc holder subassembly, disc holder spring, diaphragm/spring subassembly and body gasket.
7. All parts are now accessible for cleaning or replacement. Replace worn or damaged parts with a complete spare part kit for best results.

⚠ CAUTION ⚠
Do not damage valve seat in any manner, as its sealing feature will be affected, thus resulting in continuous leakage.

10.5.4 Valve Reassembly

1. Reassemble in reverse order of disassembly, paying careful attention to exploded view provided for identification and placement of parts (Fig. 52).
2. Replace body gasket and diaphragm/spring subassembly. Locate bleed hole in diaphragm/spring subassembly, approximately 45° from valve outlet.
3. Replace disc holder spring and holder subassembly.
4. Replace valve bonnet screws. Torque bonnet screws in a criss-cross manner to 95 ± 10 Lbf-inch.
5. Install solenoid base gasket, plugnut assembly and plugnut gasket. Position core (small end up for A-C construction) on plugnut assembly. For D-C construction, be sure plugnut assembly and core are installed with mated ends together.
6. Replace solenoid base subassembly and torque to 175 ± 25 Lbf-inch.
7. Refill heating system as previously stated under paragraph *"Filling Heating System"*, then bleed air from the driver's heating unit as stated previously under paragraph *"Bleeding heating system".*
8. After maintenance, operate the valve a few times to be sure of proper opening and closing.

NOTE
Should diaphragm/spring subassembly become disassembled, be sure to replace the diaphragm/spring support with lip facing upward towards the valve bonnet

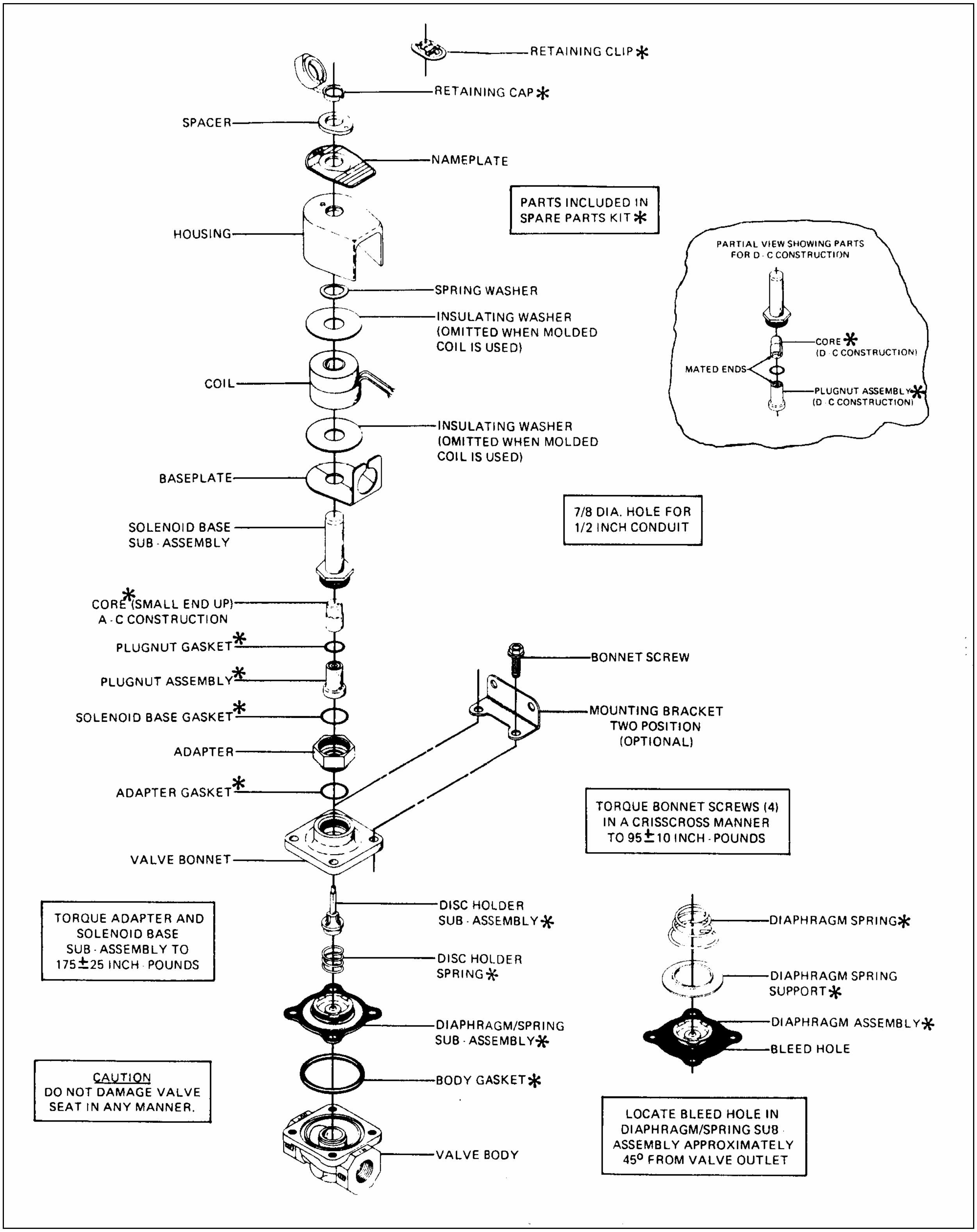


FIGURE 52: DRIVER'S WATER SOLENOID VALVE 22052

10.6 CENTRAL HOT WATER PNEUMATIC VALVE ASSEMBLY

10.6.1 Description

The flow of hot water to the vehicle's central heater core is controlled by a pneumatic NO 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 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.

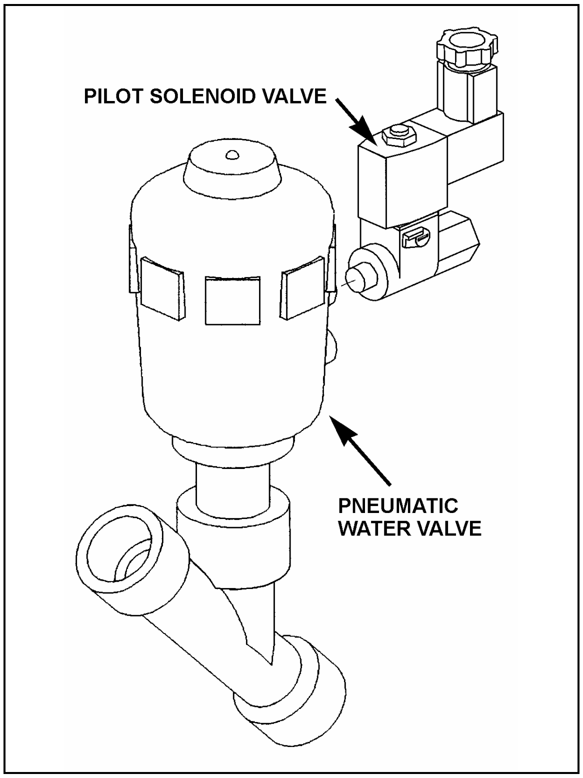


FIGURE 53: CENTRAL HOT WATER PNEUMATIC VALVE ASSEMBLY 22240

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.

10.6.2 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. 54).
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

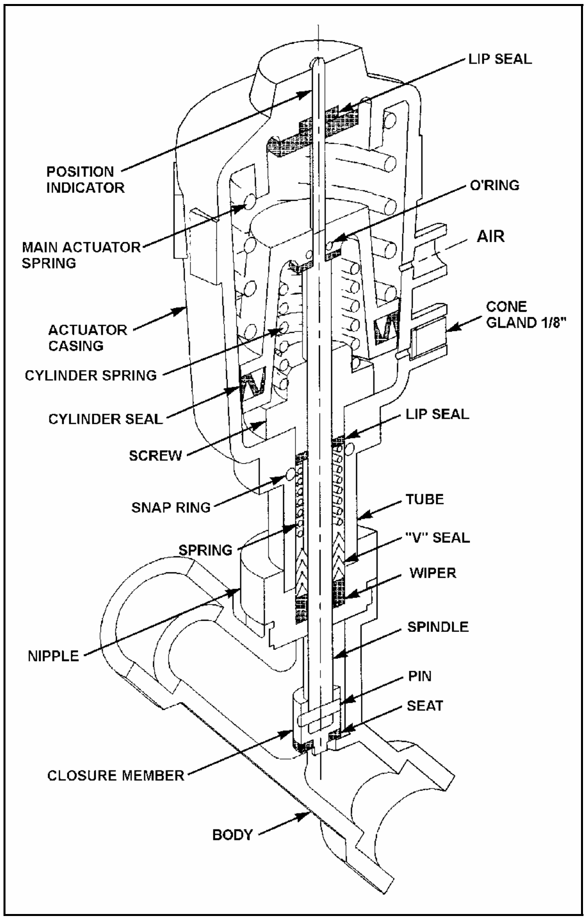


FIGURE 54: PNEUMATIC WATER VALVE 22241

10.6.3 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 54. Fasten pilot solenoid vale to the pneumatic water valve. Reconnect air supply pressure and electrical current to the pilot solenoid valve.
3. Check for proper operation.

10.6.4 Pilot Solenoid Valve

1. No maintenance is needed unless a malfunction occurs.
2. A pilot solenoid valve replacement seal kit is available: 871311.

10.6.5 Valve Troubleshooting

PROBLEM	PROCEDURE
Valve fails to close.	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.	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.

10.7 WATER RECIRCULATING PUMP

10.7.1 Converted Vehicles Equipped With Central A/C – System Description

This vehicle is provided with a water recirculating pump which is located in the evaporator compartment (Fig. 55). The water recirculating pump consists of a centrifugal pump and an electric motor which are mounted on a common shaft in a compact assembly. A pilot between the pump end and motor cover ensures proper alignment of the complete assembly.

The motor is equipped with prelubricated sealed ball bearings which require no maintenance. A self-adjusting mechanical shaft seal is incorporated in this assembly to prevent coolant leakage between the pump cavity and armature shaft. This seal derives its lubrication from the liquid pumped, and **it will be destroyed if permitted to operate dry.**

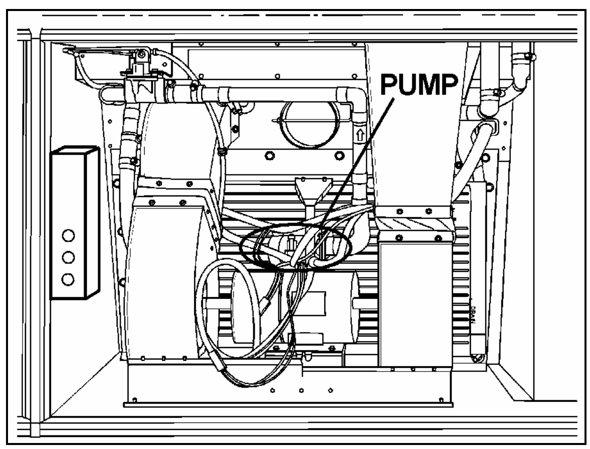


FIGURE 55: PUMP LOCATION (SHELL) 22178G

The pump requires no periodic maintenance other than replacement of motor brushes. Replacement of motor brushes can be performed without removing the pump assembly. Visual inspection of the pump, to determine if the shaft seal is intact, should be made while the pump is in operation. If there is evidence of coolant leakage, the unit must be disassembled for corrective measures.

Disassembly of the pump will be necessary only in the case of a seal leak, bearing failure, or motor failure.

10.7.1.1 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.

> ⚠ WARNING ⚠
>
> **Before proceeding with the following steps, check that coolant has cooled down.**

4. Disconnect water lines from pump at connections between hoses and copper pipes (leave hoses connected to pump).
5. Remove the two clamps holding the pump motor to its mounting bracket. Remove the pump with the motor as an assembly.

10.7.1.2 Disassembly

1. Remove two brush caps (5) and two brush assemblies (4). When removing brushes, note the position of the brush in the tube. Brush life is significantly decreased if brushes are not replaced properly.
2. Remove the pump cover (item #11) by first removing the 4 head screws. Remove cover carefully to prevent damaging the O-ring (12) (disconnect hoses from cover only if required).
3. Remove O-ring (12).
4. Remove two hex nuts (7) retaining pump assembly to motor.
5. Remove acorn nut (9) and gasket (10), then remove impeller (8) and components of the pump seal assembly (14).

> ⚠ CAUTION ⚠
>
> **Do not scratch or mar the sealing surface of this seat, as its sealing feature will be affected, thus resulting in continuous leakage.**

Inspection

Components removed from the recirculating pump and motor assembly should be compared with new parts to determine the degree of wear.

10.7.1.3 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.

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. New brushes have a six (6) degree angle. The brush should always be inserted so that the angle is open away from the pump end of the assembly (inset, Figs. 56).
   e. 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.

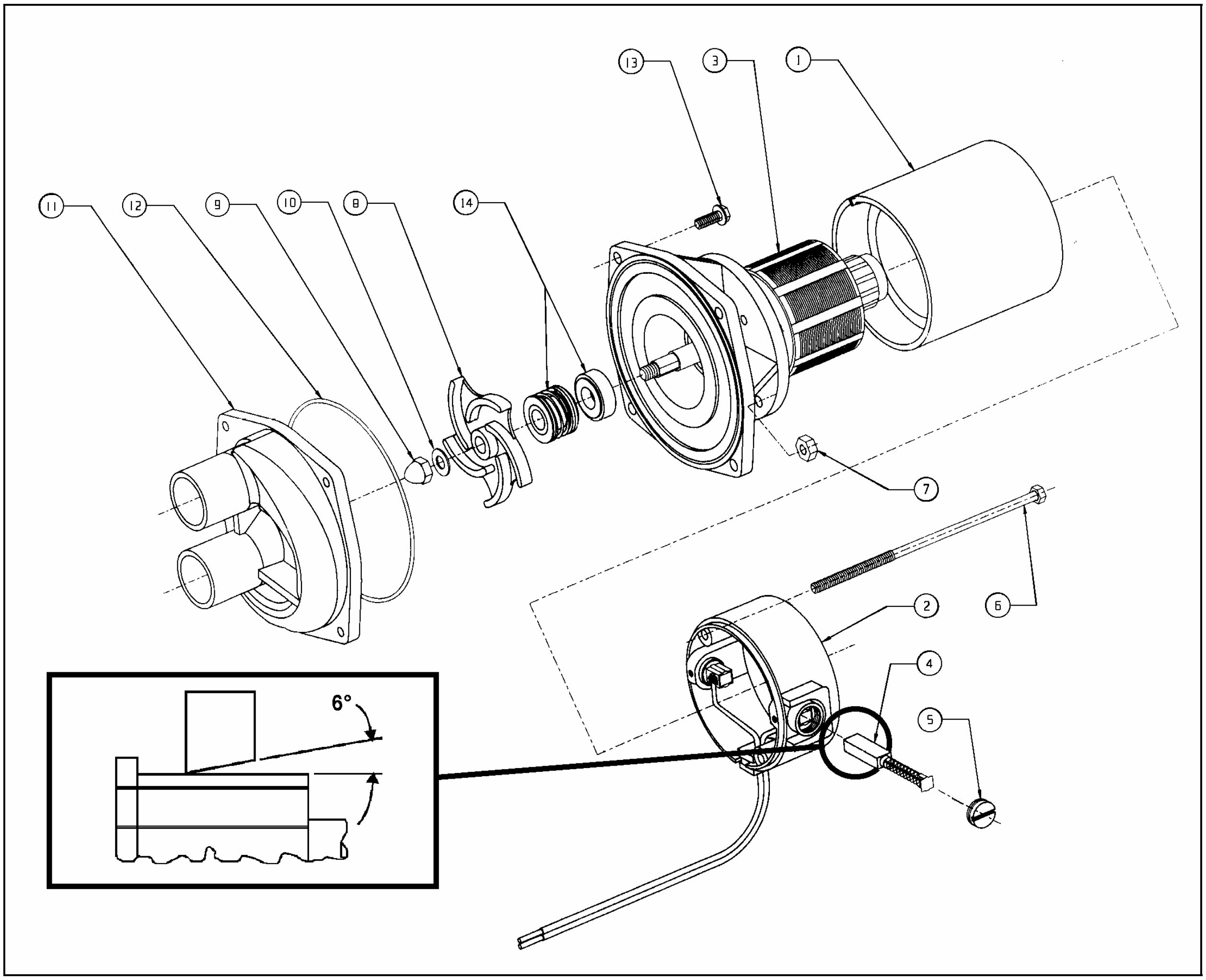


FIGURE 56: WATER RECIRCULATING PUMP (CONVERTED VEHICLE - CENTRAL A/C) 22091

ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
	MOTOR			**IMPELLER**	
	Motor Ass'y - Items 1-7	1	8	Impeller	1
1	Stator	1	9	Acorn Nut	1
2	End Frame Assembly	1	10	Gasket	1
3	Armature adapter Ass'y	1		**COVER**	
4	Brush Assembly	2	11	Cover - Housing	1
5	Cap (brush holder)	2	12	O-ring	1
6	Case bolt 10-32 X 5	2	13	Screw	4
7	10-32 Hex Nut	2		**SEAL**	
			14	Seal Assembly	1

10.7.1.4 Bearings

1. Rotate the motor shaft. If the ball bearings show evidence of wear, they should be replaced.

NOTE
When removing the armature from the motor, the number of washers and their arrangement should be noted. Improper numbers and/or installation of washers can cause improper tracking of brushes, which will result in excessive preloading of bearings and noisy operation.

2. To help prevent damaging the armature winding and/or the commutator, when removing the bearings, the use of a bearing puller is recommended.
3. Replacement bearings should be pressed into the same exact location as the original bearings.
4. It is recommended that a suitable sealant (such as Loctite or equivalent) be used between the shaft and the bearing, if the fit is not tight enough to prevent the shaft from spinning inside the inner race.
5. After replacing the bearings, check the position of the commutator in the motor by looking down into the brush tube. Neither the riser nor the edge of the commutator should be visible.

10.7.1.5 Commutator

1. The commutator is a precise assembly. Although it is solidly built and made of a fairly tough material, it can be easily ruined by careless handling.
2. The commutator should be refinished only on equipment which provides good concentricity and the proper finish.
3. The commutator should be refinished if a micrometer reading shows a difference between *"in track"* and *"off track"* diameter of 0.187" (4,7 mm) or more.
4. The commutator should be carefully undercut with a 0.025" (0,6 mm) or less slot width.
5. A 25 to 50 micromesh finish is desirable on a new or refinished commutator.
6. The commutator should not be touched with the fingers since sweat and body oils will rapidly discolor and oxidize its surface.

10.7.1.6 Miscellaneous

Inspect seal assemblies (14) to determine wear. If the seal has leaked, or is badly worn, it is recommended that a complete new seal assembly be installed.

10.7.1.7 Assembly

1. Install seal assembly (14).
2. Insert impeller (8) and secure with acorn nut (9) and gasket (10).
3. Install O-ring (12).
4. Attach cover (11) to the pump body using four screws (13).
5. Install motor brushes assembly (4) and brush caps (5).

10.7.1.8 Installation

1. Connect water lines to pump (hoses to copper pipes). Use a soapy water solution to help insert water lines.
2. Position the pump and motor assembly on the mounting bracket. Position the mounting clamps over the motor and secure with mounting bolts.
3. Connect electrical wiring to the pump motor.
4. Open shutoff valves. Refer to *"05 COOLING"* under heading *"Draining Cooling System"* for location of valves.
5. Fill the cooling system as previously instructed in this section under *"10.2 Filling Heating System"*, then bleed the system as previously instructed in this section under *"10.3 Bleeding Heating System"*.

10.7.2 Coaches Equipped With Central A/C or Driver's A/C – System Description

This vehicle is provided with a water recirculating pump which is located in the evaporator compartment (Fig. 57) or in the reclining bumper compartment (optional with driver's system). The water recirculating pump consists of a centrifugal pump and an electric motor which are mounted in a compact assembly.

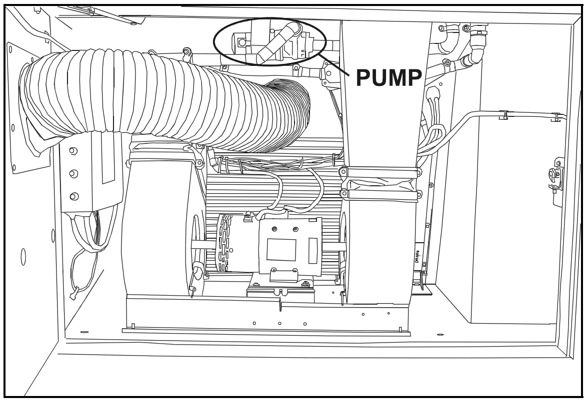


FIGURE 57: PUMP LOCATION (CENTRAL A/C) 22281

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.

10.7.2.1 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.

> **⚠ WARNING ⚠**
>
> **Before proceeding with the following steps, check that coolant has cooled down.**

> *NOTE*
>
> *On driver's A/C system, remove residual coolant through coolant strainer. Also check strainer's condition; clean or replace if necessary.*

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.

10.7.2.2 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.

10.7.2.3 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. <u>Wear</u>
   Replace the brushes if less than 25% of the usable brush is left (less than 0.300 inch [8 mm]).

   b. <u>Chipped edges</u>
   Chips can be caused by improper handling or installation. Badly chipped brushes should be replaced regardless of their length.

   c. <u>Annealed brush spring</u>
   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. <u>Frayed or broken pigtail</u>
   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.

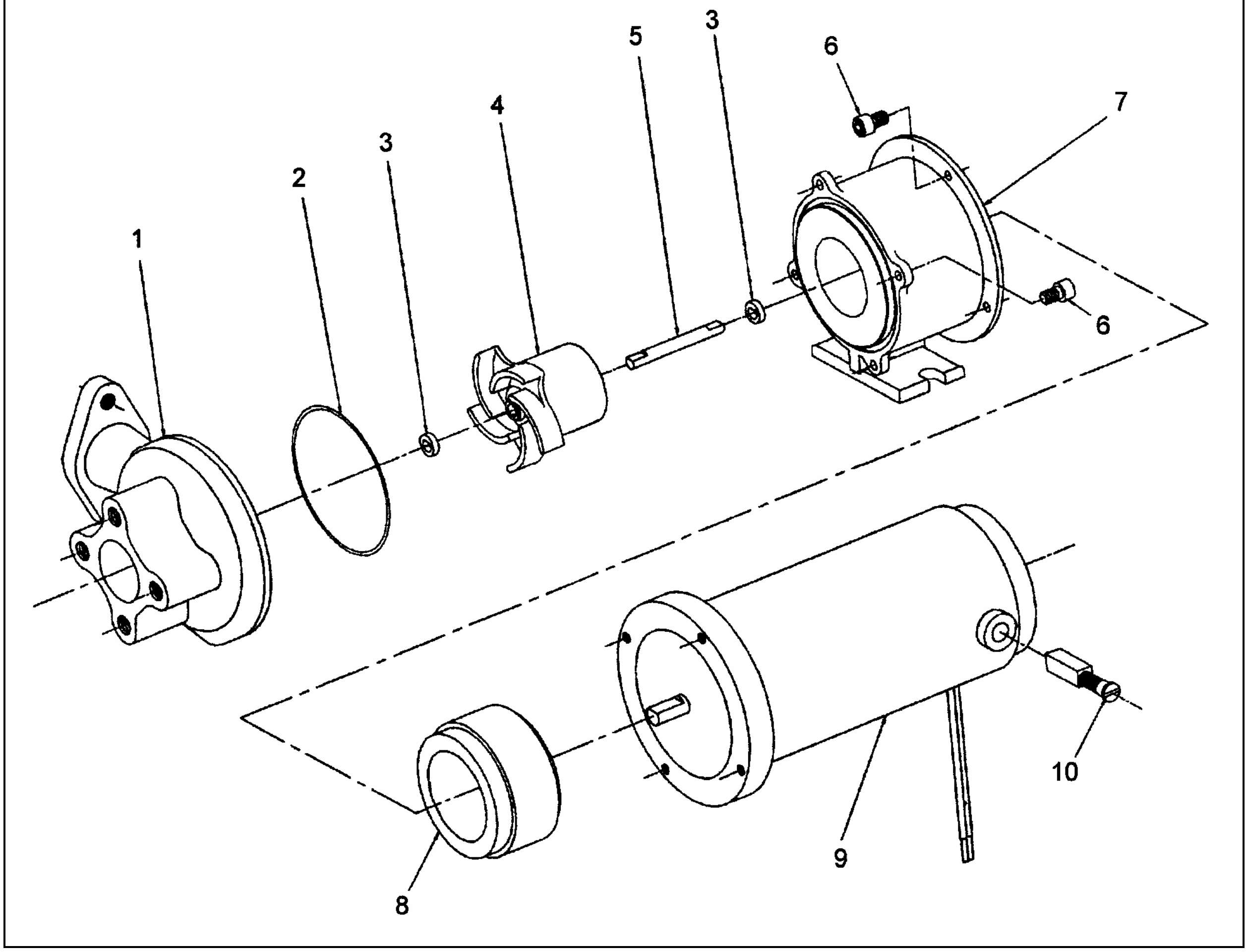


FIGURE 58: WATER RECIRCULATING PUMP (COACH - CENTRAL A/C OR DRIVER'S A/C)

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.

10.7.2.4 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).

10.7.2.5 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 *"10.2 Filling Heating System"*, then bleed the system as previously instructed in this section under *"10.3 Bleeding Heating System"*.

10.8 WATER FILTER

10.8.1 Description

This vehicle is provided with a cleanable water filter, which is located in the evaporator compartment behind the R.H. side air duct. The filter uses the micronic principle of filtration which utilizes an accordion -pleated design for a maximum filtering area. A relief valve integrated to the filter element allows bypass of the filter in case of heavy restrictions.

Vehicles equipped with driver's A/C system only are provided with a water filter located in reclining bumper compartment.

10.8.2 Maintenance

Filter maintenance consists in changing the element at break-in 3000 miles (4 800 km), and subsequently every 50,000 miles (80 000 km) or once a year, whichever comes first.

NOTE
Service water filter each time soldering is performed at any point on coolant piping; operate heating system a few minutes first, so that soldering residues are routed to the strainer.

10.8.3 Servicing (Vehicles with central A/C system)

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.

⚠ WARNING ⚠
Before proceeding with the following steps, check that coolant has cooled down.

3. Rotate bowl (Fig. 59) counterclockwise and remove.
4. Remove filter element (Fig. 59) from housing.
5. Place new/clean element in housing, centering it on location in the head.
6. Inspect bowl seal and replace if necessary.
7. Replace bowl. Rotate clockwise and handtighten.

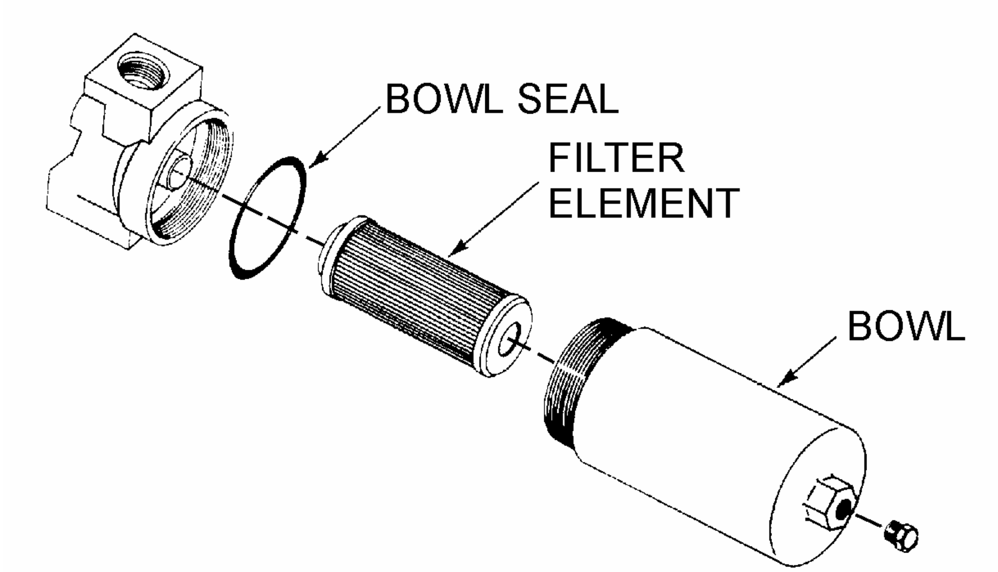


FIGURE 59: WATER FILTER 22057

8. Correct coolant level in surge tank as instructed previously in this section under *"Filling Heating System"*.

10.8.4 Servicing (Vehicles with driver's A/C system)

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.

⚠ WARNING ⚠
Before proceeding with the following steps, check that coolant has cooled down.

3. Unscrew the filter retaining plug.
4. Remove strainer, then clean inside strainer housing.
5. Using water under pressure, flush the strainer from the outside.
6. Reinstall strainer, then tighten the retaining plug.
7. Open shut-off valves.
8. Correct coolant level in surge tank as instructed previously in this section under *"10.2 Filling Heating System"*.

10.9 BY-PASS SOLENOID WATER VALVE (OPTIONAL)

This valve is optional and is installed only on vehicles equipped with a preheater. The valve is located in the evaporator compartment. This valve is similar to the driver's solenoid valve (refer to Fig. 52 for part names).

10.9.1 To Remove or Change the Coil

* Stop engine and allow engine coolant time to cool.
* Close shutoff valves. Refer to *"05 COOLING"* under heading *"4.7 Draining Cooling System"* for location of valves.

<u>To remove the solenoid coil:</u>

First take out the retaining screw at the top of the coil housing. The entire coil assembly can be lifted off the enclosing tube.

<u>To reassemble:</u>

Make sure that the parts are placed on the enclosing tube in the following order:

1. Be sure to change electrical data plate according to coil specifications change.
2. Place coil and yoke assembly on the enclosing tube. Lay data identification plate in place.

3. Insert the coil retaining screw, rotate housing to proper position and tighten screw securely.

10.9.2 To Take the Valve Apart

To disassemble:

This valve may be taken apart by removing the socket head screws which hold the body and bonnet together. After removing the screws, carefully lift off the bonnet assembly (upper part of the valve). Don't drop the plunger. The diaphragm can now be lifted out. Be careful not to damage the machined faces while the valve is apart.

NOTE
The above procedure must be followed before brazing solder type bodies into the line.

To reassemble:

Place the diaphragm in the body with the pilot port extension up. Hold the plunger with the synthetic seat against the pilot port. Make sure the bonnet O-rings are in place, the bonnet assembly over the plunger, and that the locating sleeve in the bonnet enters the mating hole in the body. Insert body screws and tighten uniformly.

10.10 PREHEATING SYSTEM (OPTIONAL ON COACHES ONLY)

The preheater is located inside engine compartment and is accessible through L.H. side rear service compartment (refer to figure 60).

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.

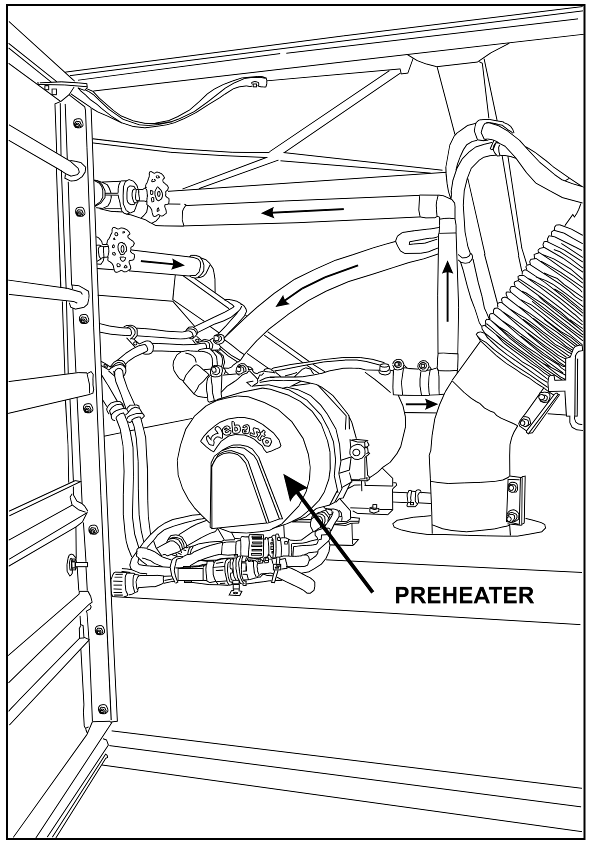


FIGURE 60: L.H. SIDE REAR SERVICE COMPART. 22245A

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.

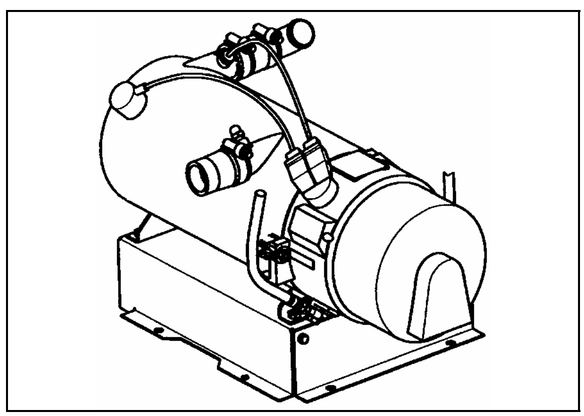


FIGURE 61: WEBASTO PREHEATER (104,000 BTU) 22224

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.

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.

10.10.1 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° ± 6°F (75° ± 3°C) and turns it on at 154° ± 9°F (68° ± 5°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.

10.10.2 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.

⚠ WARNING ⚠
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.

10.10.3 Timer Operating Instructions (Webasto)

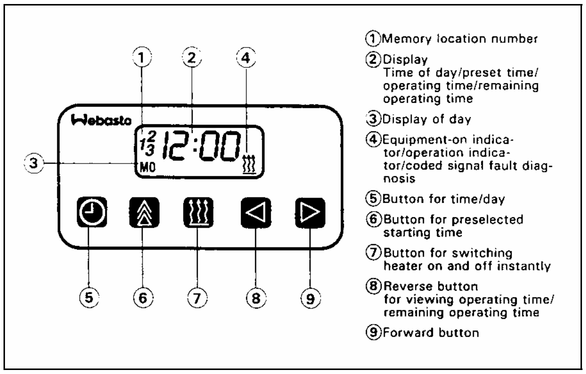


FIGURE 62: WEBASTO 18327

These instructions refer to the timer illustrated in figure 62. 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.

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
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.

10.10.4 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.

⚠ WARNING ⚠

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.

11. SPECIFICATIONS

Main evaporator motor

Make....................US MOTOR
Type....................T-17
Voltage....................27.5 V DC
Current draw....................68 amps
Horsepower....................2
Revolution.................... 1st :1400 rpm, 2nd : 1880 rpm nominal
Insulation....................Class F
Motor Life....................20 000 hours
Brush life....................10 000 hours
Motor supplier number....................D5092VPRC8
Motor Prevost number....................563008
Brush Prevost number....................562951

Condenser fan motors

Make....................US MOTOR
Type....................TF-12
Voltage....................28.5 V DC
Current draw....................20 amps
Horsepower....................0.57
Revolution....................1950 rpm
Insulation....................Class F
Motor....................20 000 hours
Brush life....................10 000 hours
Qty....................2
Supplier number....................D591Y440PRC2
Prevost number....................562579
Brush supplier number....................9DB21003
Brush Prevost number....................561914

Evaporator air filters (Central system) (Coach)

Make .... Permatron Corp.
Type .... Polypropylene
Supplier number .... IN 1X10X37 EXACT
Prevost number .... All vehicles (Top) 373336
Prevost number .... XL-40 vehicles (Bottom) 373338
Prevost number .... XL-45 vehicles (Bottom) 373337

Evaporator air filters (Central system) (Shell)

Make .... Permatron Corp.
Supplier number .... IN 13X21X1 NOMINAL
Prevost number .... (Qty = 3) 871034

Driver's unit evaporator motors

Make .... MCC
Voltage .... 24 V DC
Quantity 1
Supplier number 25-0250
Prevost number 871135

Driver's unit evaporator air filter

Make .... MCC
TYPE .... Recirculating air 6-¼" x 28" Washable
Supplier number 260593
Prevost number 871147

Make .... MCC
TYPE .... Fresh air 3-5/8" X 5-1/4" Washable
Supplier number 260594
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 lubrification)...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)
Supplier number, option R-134a 68PD541-104-38
Supplier number, option R-22 .... 68PD537-104-39
Prevost number, option R-134a 950314
Prevost number, option R-22 950207

A/C Compressor (Driver's and auxiliary systems)

Make……………………………………………………………………………………..Seltec
Model…………………………………………………………………………………..TM-16HD
Weight .... 10.9 lbs (4,9 kg)
Supplier number..18-00074-11
Prevost number.. 950372

<u>Approved oil</u> .... ZXL100PG (PAG)
Prevost number.. 950382

Compressor unloader valve

Make.. Carrier Transicold
Type .... Electric (AMC)
Voltage .... 24 V DC)
Watts 15
Supplier number (without coil) 17-40407-20
Prevost number (without coil) 950095
Coil supplier number 22-50030 (1)
Coil Prevost numbert.. 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
Supplier number.. 50-01122-90
Prevost number.. 950204

Compressor V belts

Make.. Dayco
Model (matching set of 2) BX97
Prevost number (with Delco 270/300 Amp Alternator) 506664

Compressor V belt

Make.. Dayco
Model.. BX100
Prevost number (with two BOSH Alternators) 506681

Condenser coil (Driver's and auxiliary systems)

Make.. Valeo
Supplier number..
Prevost number..

Condenser coil (Central system) (XL2-40 vehicles and, XL2-45 & 45E Shells)

Make.. Carrier Transicold

Aluminum

Supplier number..68GF67-194-2

Prevost number... 870654

Copper

Supplier number..68GF67-194-3

Prevost number... 870729

Condenser coil (Central system) (XL2-45 Coach)

Make.. Carrier Transicold

Aluminum

Supplier number..68BC2-107

Prevost number... 950259

Copper

Supplier number..68BC2-107-1

Prevost number... 950260

Evaporator coil (Central system)

Make.. Carrier Transicold

Supplier number.. 68BE2-105

Prevost number... 871070

Receiver tank (with sight glasses)

Make.. HENRY

Maximum pressure... 450 psig

Supplier number..ARL-1217

Prevost number... 950261

Filter Dryer assembly

Make.. AC&R HENRY

Supplier number...815031-XH9

Prevost number... 950262

Moisture indicator

Make.. Henry

Supplier number.. MI-30-7/8S

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

Supplier number (without coil) RB9MP3-MM
Prevost number (without coil) 95-0054

Coil supplier number .... R23MM 24 V DC-CB

Coil Prevost number.. 950055

Repair kit Prevost number 950056

Driver's hot water solenoid valve

Make.. Asco

Type .... Normally open (without manual bypass)

Voltage .... 24 V DC

Current draw .... 0.47 amp.

Watts 11.2

Pressure range... 0 to 100 psi

Max. temperature .... 220^{o}F

Supplier number (with coil) 106-269-1

Prevost number (with coil) 870812

Coil Prevost number.. 870960

Repair kit Prevost number 870872

Hot water solenoid valve (Central system)

Make.. Burkert

Type .... Normally open

Voltage .... 24 V DC

Supplier number... SYST-2000-456023-6012-427923B

Prevost number 871252
Seal kit, Water Side 871311
Seal kit, Actuator Side 871312
Seal kit, Pilot Solenoid Valve 871313

Water recirculating pump (Central system - Coach) & (Driver's system - Shell)

Make .... M.P. pumps
Voltage .... 24 V DC
Supplier number 30011
Prevost number 871342

Water recirculating pump (Central system - Shell)

Make .... M.P. pumps
Voltage .... 24 V DC
Housing .... Aluminum
Supplier number 29232
Prevost number 871032

Water filter (Central system)

Make .... Parker
Supplier number (with element) 15CN1238WP
Prevost number (with element) 871028
Element supplier number 925566
Element Prevost number 871029

Water filter (small A/C system)

Make .... BRAUKMANN
Supplier number T300B
Prevost number 870807

Driver’s expansion valve

Supplier number, option R-134a 26-0190
Supplier number, option R-22 26-0384
Prevost number, option R-134a 950221
Prevost number, option R-22 950282

Expansion valve (Central system)

Make.. Alco
Model..TCLE 5-1/2
Supplier number 21059366
Prevost number 950320

Bypass solenoid water valve

Make... Parker Hanninfin
Bypass supplier number RB21ME7-MM
Bypass Prevost number 870886
Coil supplier number R-23MM24VDC-CB
Coil Prevost number... 870886
Repair kit supplier number 76754
Repair kit Prevost number 870980

Preheating system

Make... WEBASTO
Model .... THERMO 300
Capacity .... 104 000 Btu/h (30 kW)
Heating medium .... Coolant
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)
Supplier number 9002092A
Prevost number 871202

ILLUSTRATIONS

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 sections: driver's and Central (passenger) sections. Vehicles equipped with a Central System are provided with a special air duct which allows a variable percentage of outside fresh air to be drawn into the vehicle and then mixed with recirculated air.

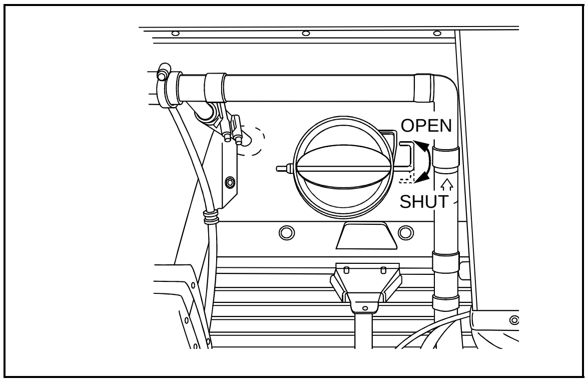


FIGURE 1: ADJUSTABLE AIR DUCT 22175

The adjustable air intake damper is located in the evaporator compartment (see *"18. BODY"* for compartment location). The damper should normally be left open. However, under extreme temperature conditions, it can be closed to block the addition of ambient air and heat or cool the air inside vehicle as desired. As soon as extreme heating or cooling is no longer required, the damper should be reopened. The interior of vehicle should always be slightly pressurized to prevent dust and moisture from entering vehicle. The HVAC systems have been designed to allow circulation of some outside fresh air, so windows should be kept closed at all times. In the event of ventilation failure, emergency escape hatch(es) (see *"18. BODY"*) can be used to provide air circulation, by simply pushing hatch upwards.

NOTE

Auxiliary A/C system (if so equipped) operates independently from main system, it has its own condenser, evaporator and compressor.

NOTE

Driver's HVAC system operates independently from main system, even though it uses the same compressor.

NOTE

Vehicles equipped with a TM-16HD Seltec compressor (driver's or auxiliary A/C) have a time delay relay installed on the electrical circuit with a reaction time of 48 seconds before magnetic clutch is engaged.

2. AIR CIRCULATION

2.1 DRIVER'S AREA

Fresh air is taken from a plenum behind the front bumper and enters the mixing box through an adjustable damper. Returning air is taken through a front dash panel into the mixing box. The "Driver A/C-Heating Recirc.-Fresh Air" control is located on the R.H. dashboard control panel. 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, with the "Main Windshield Defroster" control divert some air flow to the console, from which he can direct air to his knees and/or upper body with adjustable HVAC vents and to his feet with the appropriate button (see operator's manual).

Two additional air outlets are installed on vehicles equipped with the Central HVAC ducting system. One is located in the stepwell for snow melting. The other air outlet is located behind the driver, on his L.H. side. This air outlet can be rotated to direct Air flow.

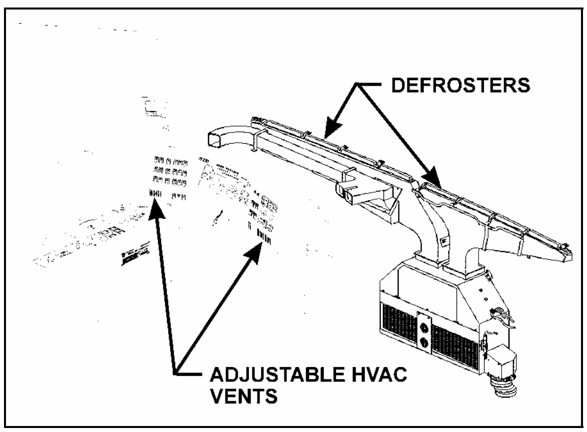


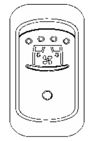
FIGURE 2: DRIVER'S AIR CIRCULATION 22171

2.2 CENTRAL AREA

(Passenger/Cabin)

Fresh air enters the vehicle on the L.H. side, through the manually adjustable damper (Fig. 1) located in evaporator compartment. The damper can be fully opened for normal operation or closed for extreme weather or highly polluted areas (Refer to the XL2 Operator's Manual for more details). Return air is drawn from inside the vehicle through the register duct (Fig. 3).

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.

XL2 coaches are also equipped with a parcel rack ventilation system, a three-position rocker switch  (0FF - 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 parcel rack fan; discharge air is fed to the rotating registers through the ventilation duct.

The parcel rack 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.

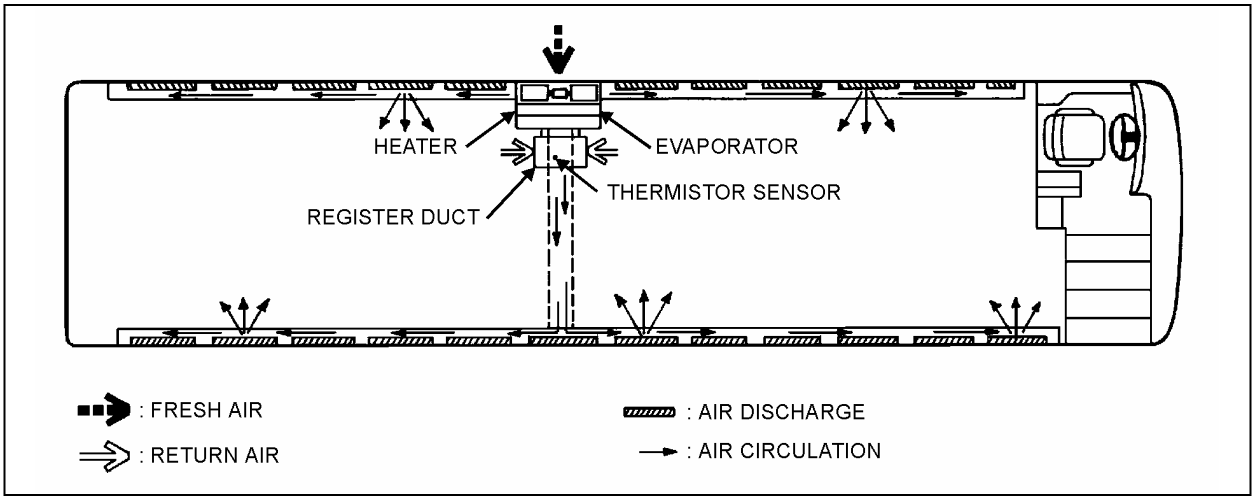


FIGURE 3: CENTRAL HVAC SYSTEM AIR CIRCULATION 22063

3. DRIVER'S HVAC SYSTEM OPERATION

The temperature control in the driver's area is provided directly by the HVAC control unit mounted on the dashboard R.H. panel (Fig. 4 and 5).

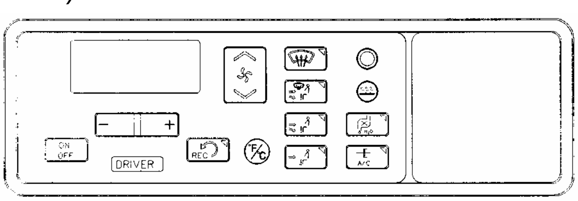


FIGURE 4: DRIVER'S HVAC SYSTEM CONTROL UNIT 22184

NOTE
The driver's area air temperature sensor is located behind the grill of the R.H. side console or inside the footwell, at the ceiling at the right of the steering column (Refer to fig.12).

3.1 VEHICLES EQUIPPED WITH A TM-16HD SELTEC COMPRESSOR

This system is completely independent, it has its own condenser, evaporator and compressor.

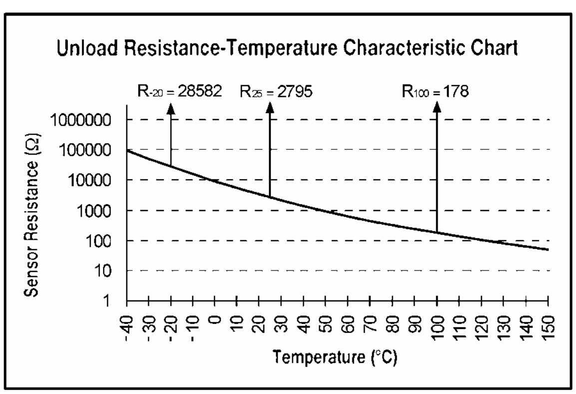
3.2 VEHICLES EQUIPPED WITH A CENTRAL SYSTEM

The driver's HVAC unit piping is paralleled with the main HVAC unit piping. Both units use the same refrigerant and coolant, and are linked to the same condenser and compressor, even if they are individually controlled. It requires the main HVAC unit to engage the A/C compressor magnetic clutch. Consequently, the driver's unit cannot be operated in the A/C mode alone.

3.3 DRIVER'S AREA AIR TEMPERATURE SENSOR RESISTANCE CHART

The following table and 2% error chart can be used to troubleshoot the driver's area air temperature sensor.

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



4. CENTRAL HVAC SYSTEM OPERATION

The HVAC control unit located on the dashboard R.H. panel, enables the selection of the temperature in the passenger area (or the living space for a converted vehicle) (refer to the Operator's Manual for details).

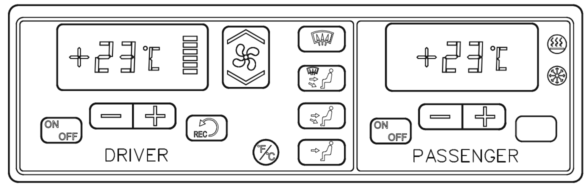


FIGURE 5: CENTRAL HVAC SYSTEM CONTROL UNIT 22274

Temperature control is provided in conjunction with a thermistor sensor inside register duct, located amidships on L.H. side of vehicle (Figs. 3 & 6).

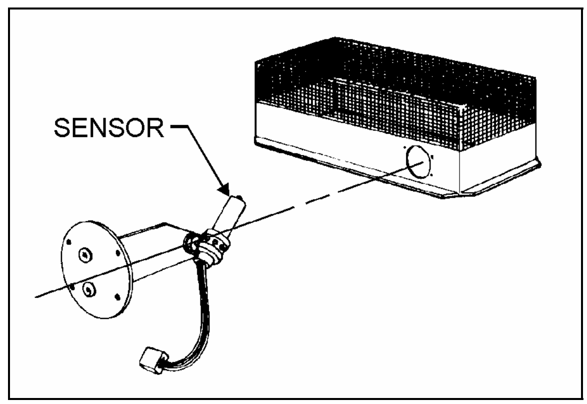


FIGURE 6: THERMISTOR SENSOR 22064

The flow of water to the vehicle's main heater core is controlled by an electric water valve which is open or closed 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 evaporator compartment, is protected by a 120 amps, manually resettable circuit breaker. The condenser fans, located in the condenser compartment, also have circuit protection via 40 amps manually resettable circuit breakers. The breakers are located in the A/C junction box in the evaporator compartment.

NOTE
The outside temperature sensor is located behind the front bumper on the L.H. side.

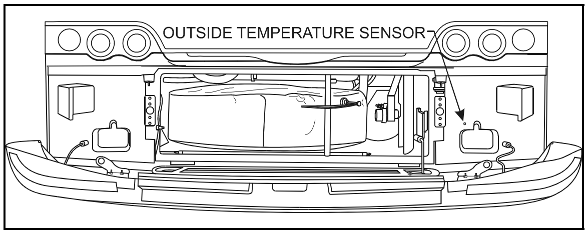


FIGURE 7: LOCATION OF OUTSIDE TEMPERATURE SENSOR

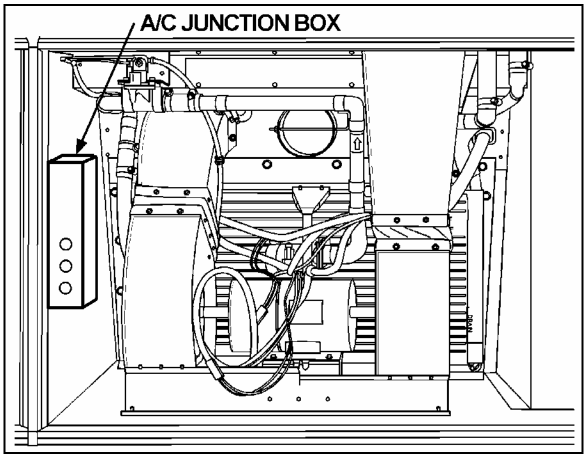


FIGURE 8: LOCATION OF A/C JUNCTION BOX IN EVAPORATOR COMPARTMENT 22178F

In order to operate the A/C system when vehicle is stationary, run the engine at fast idle. During operation of A/C system, windows should be kept closed and door(s) not left open longer than necessary. In order to prevent battery discharge, A/C & heating system will not operate when charging system is malfunctioning.

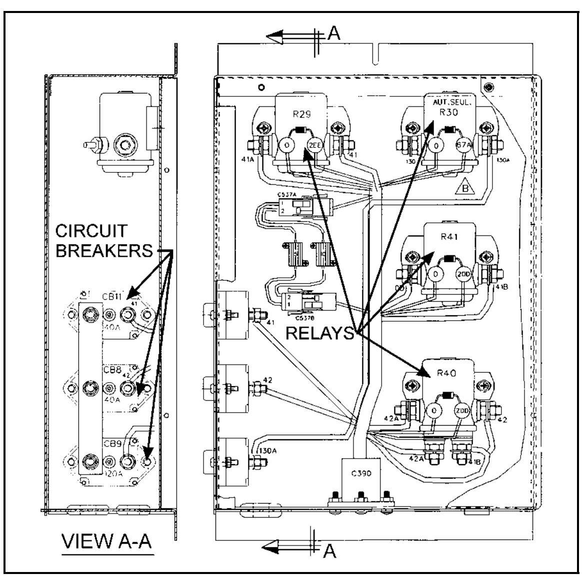


FIGURE 9: A/C JUNCTION BOX 06317

4.1 PARCEL RACK A/C (XL2 COACHES)

Optional small A/C evaporator coils may be added to both parcel racks existing air system. These auxiliary A/C system components are separate and completely independent of driver's and central systems 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.

5. HVAC UNIT MAINTENANCE

No special maintenance is required on the central, 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.

5.1 COIL CLEANING

NOTE
Squeeze rubber hose located underneath the appropriate compartment to eliminate the accumulated water and dirt when you make routine maintenance.

Check the external surface of the coil at regular intervals for dirt or any foreign matter.

For the driver's HVAC unit, flush the coil from inside. For the evaporator, back flush the coil (Fig. 10) every 12,500 miles (20 000 km) or once a year, whichever comes first.

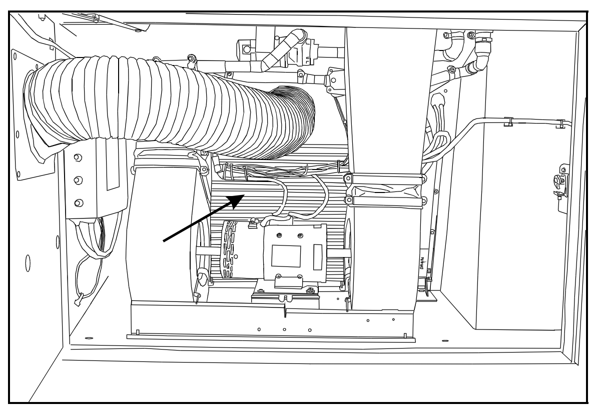


FIGURE 10: EVAPORATOR COIL CLEANING 22244

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.

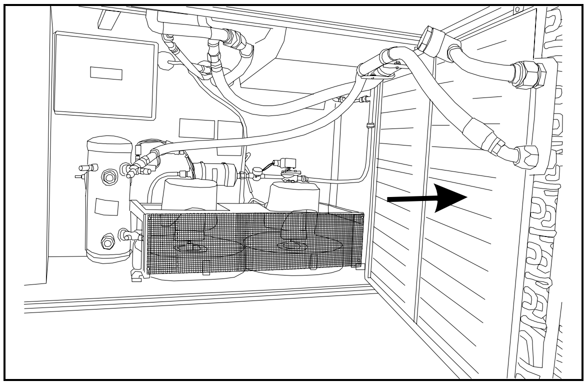


FIGURE 11: CONDENSER COIL CLEANING 22243A

⚠ 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.

5.2 DRIVER'S HVAC UNIT AIR FILTER

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 R/A and F/A filters. To clean filters back flush with water, then dry with air, every 12,000 miles (20 000 km) or once a year, which-ever comes first (Fig. 12).

NOTE

If the windshield is continuously fogged, check that the driver's air filter is not clogged.

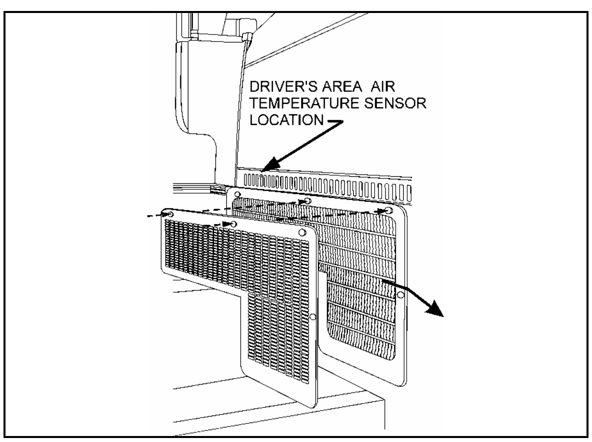


FIGURE 12: DRIVER'S AREA AIR FILTERS 22193

5.3 MAIN HVAC UNIT AIR FILTER

The main or cabin air filter is located in the evaporator compartment. To access the filter on XL2 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. 13). On MTH, to gain access, open evaporator compartment door. Remove filter panel by unscrewing the six fixing screws. Slide out the filter for cleaning (Fig. 14). To clean filter, back flush with water or soapy water, then dry with air every 12,000 miles (20 000 km) or once a year, whichever comes first.

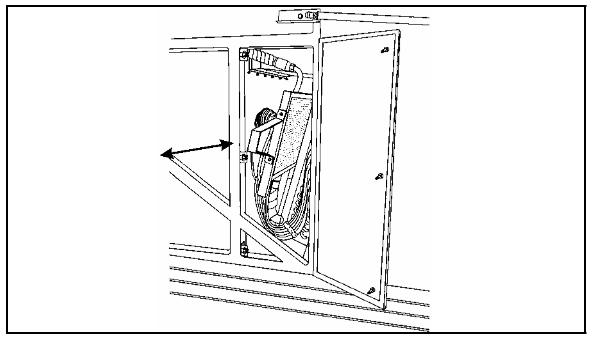


FIGURE 13: MAIN HVAC UNIT AIR FILTER 22179

⚠ CAUTION ⚠

Do not use high pressure water jet to avoid damaging filter.

⚠ CAUTION ⚠

Be sure not to reverse filter upon installation.

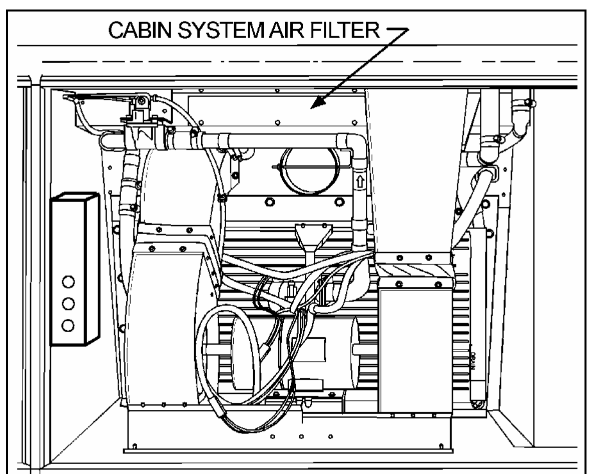


FIGURE 14: CABIN SYSTEM AIR FILTER REMOVAL 22178E

5.4 PARCEL RACK FAN AIR FILTER

A/C evaporator coils may be installed in both parcel rack air systems. Only the air filters are serviceable. The air filters are accessible from inside the parcel racks. Slide out the filters, then back flush with water, dry with air and replace. This procedure should be done every 12,000 miles (20,000 km) or once a year, whichever come first.

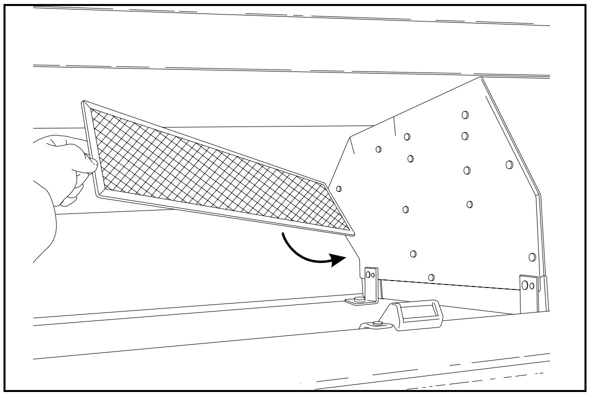


FIGURE 15: PARCEL RACK FAN AIR FILTER 22201

For A/C unit, ball valves are added on supply and return lines in the condenser compartment. They have service port to evacuate the A/C parcel rack 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.

6. EVAPORATOR MOTOR

(Central HVAC system only)

The evaporator motor is installed in the evaporator compartment (L.H. side of vehicle) (Fig. 16). It is a 27.5 volt, 2 HP (1.5 kW) motor which activates a double blower fan unit.

6.1 REMOVAL

1. Set the battery master switch to the *"OFF"* position.
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. Identify the L.H. side discharge duct inside compartment and remove the Phillips head screws retaining the flexible member to duct.
4. Repeat step 3 for the R.H. side air duct.

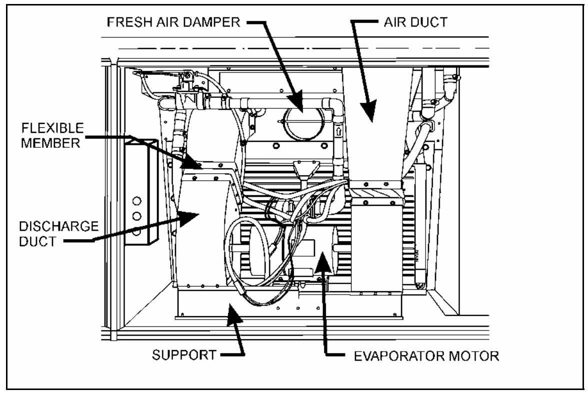


FIGURE 16: HVAC COMPARTMENT 22178

5. Disconnect the discharge air sensor connector. Remove the cable tie securing wire.
6. From under the vehicle, remove the eight bolts retaining the evaporator fan motor support. Remove the complete unit from the evaporator compartment (Fig. 17).

⚠ CAUTION ⚠
Never support evaporator motor by its output shafts while moving it.

7. 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.

6.2 INSTALLATION

To reinstall the evaporator motor, reverse "Evaporator Motor Removal" procedure.

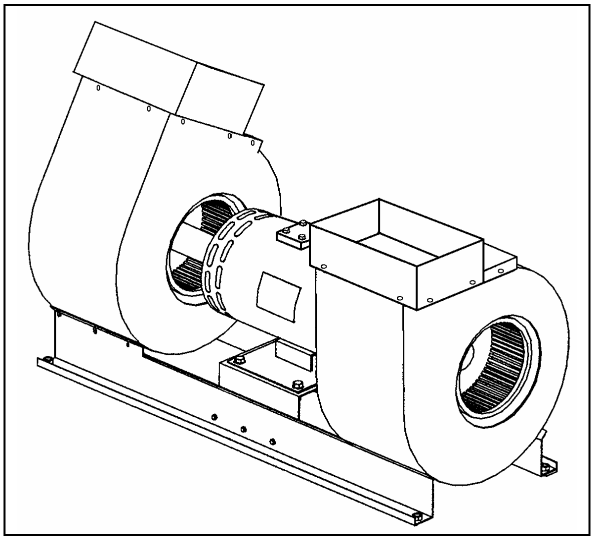


FIGURE 17: EVAPORATOR MOTOR ASSEMBLY 22208

6.3 CHECKING OPERATION OF BRUSH IN HOLDER

Lift brush slightly 1/8 inch (3 mm) and release it. Brush must produce a dry noise.

6.4 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 ¾ inch (19 mm). New brush length is 1-¼ inch. Clean brushes with a clean cloth impregnated with gasoline or alcohol.

⚠ WARNING ⚠
Cleaning products are flammable and may explode under certain conditions. Always handle in a well ventilated area.

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 standard procedure.
4. Reverse installation procedure.

6.5 BRUSH OLDER ADJUSTMENT

NOTE
The brush holders are mounted on a support that can rotate. Rotating that support will move all the brush holders at the same time.

1. Remove the screws securing the grille and remove the grille. Locate the 2 bolts fixing the mechanism permitting the rotation of the brush holder support.
2. Loosen (do not remove) the bolts just enough to release the mechanism.
3. Move gently the exposed brush holder in order to have a maximum distance of 10 mm (3/8 inch) between the brush holder face and a reference line passing through the center of the 2 bolts on the motor housing.

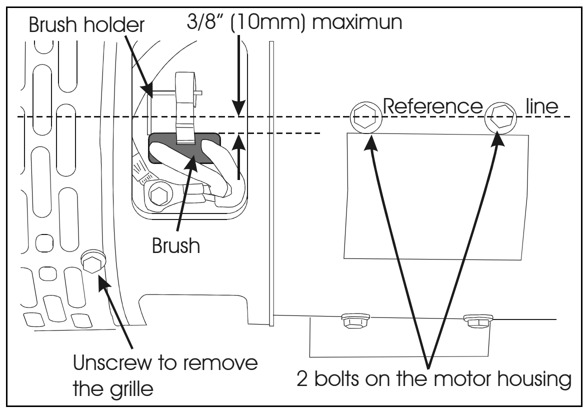


FIGURE 18: EVAPORATOR MOTOR

6.6 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. CENTRAL AIR CONDITIONING SYSTEM

The schematic of Figure 19 shows the central and auxiliary A/C system and their components. The central system is equipped with a 6 cylinder, 05G-134A Carrier compressor with an air conditioning capacity of 7½ tons. The receiver tank and filter dryer are mounted inside the condenser compartment.

XL2 Coaches may be supplied with central and auxiliary A/C system (Fig. 19). XL2 Converted vehicles (Shells) may be supplied with central or driver's A/C system only (Fig. 19 and 20). Auxiliary and driver's A/C systems come with a 6 cylinder, TM-16HD Seltec compressor with an air conditioning capacity of 2 tons.

7.1 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 Figures 19 and 20.

The air conditioning system used on XL2 series vehicle 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 back to the condenser sub-cooler. It leaves the condenser and 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 main 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 in^2 (5162 mm^2) could easily neutralize the total capacity of the system.
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.

7.2 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.

⚠ WARNING ⚠
Refrigerant in itself is nonflammable, but if it comes in contact with an open flame, it will decompose.

7.2.1 Procurement

Refrigerant is shipped and stored in metal cylinders. It is serviced in 30 and 100 pound (13,6 and 45 kg) cylinders. Approximately 24 pounds (10,9 kg) are used in the system. If vehicle is equipped with only a driver's A/C system, then 7.0 lbs (3,2 kg) (W0) or 7.5 lbs (3,4 kg) (W5 and WE) are used and approximately 5.5 lbs (2,5 kg) are used in an auxiliary A/C system.

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.

7.2.2 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^{o}F (52^{o}C) water. Never heat above 125^{o}F (52^{o}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^{o}F (-40^{o}C). If refrigerant comes in contact with the eyes, serious injury could result. Always wear goggles to protect the eyes when opening refrigerant connections.

7.2.3 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.

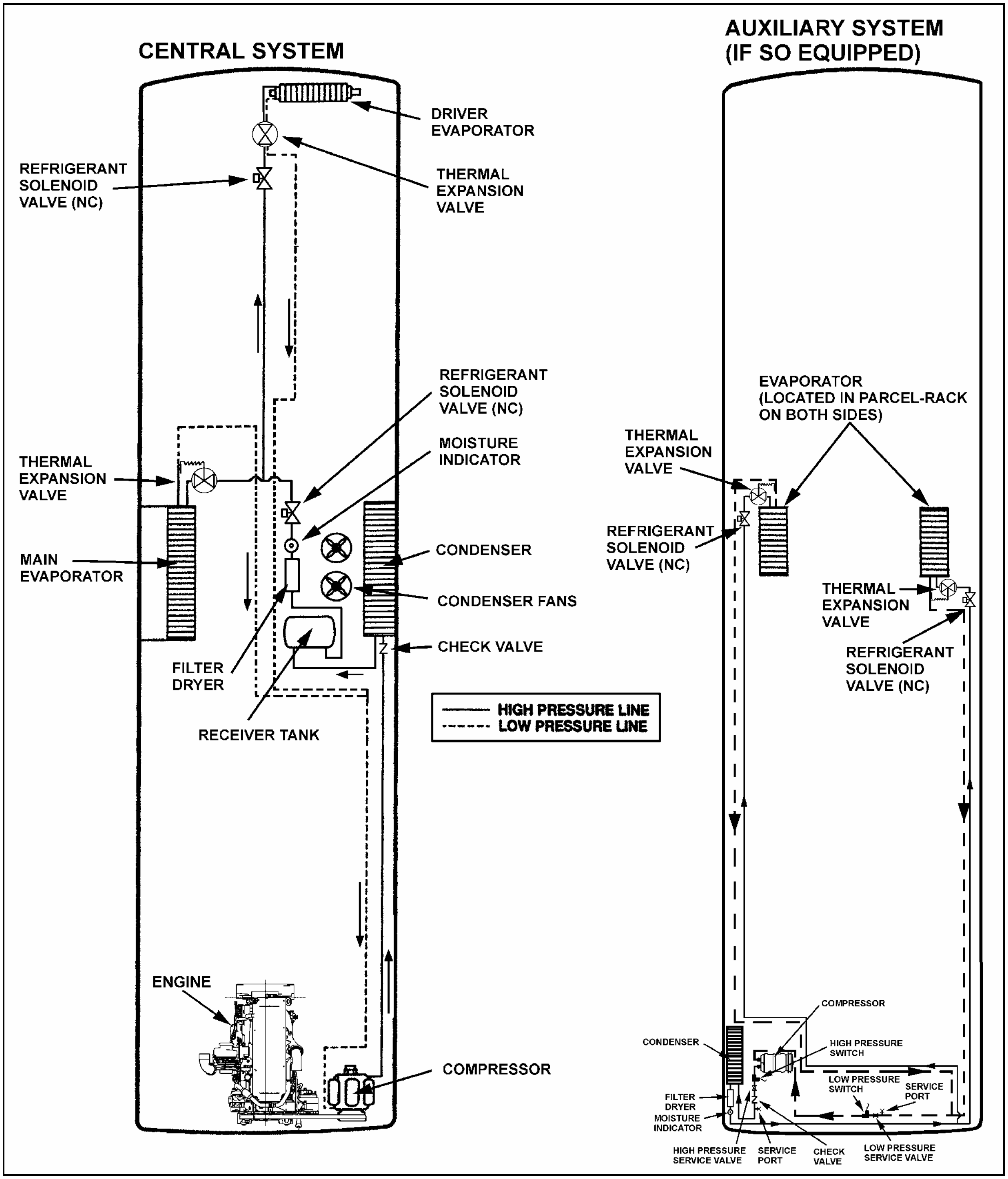


FIGURE 19: REFRIGERANT CIRCUIT (CENTRAL AND AUXILIARY SYSTEMS) 22247

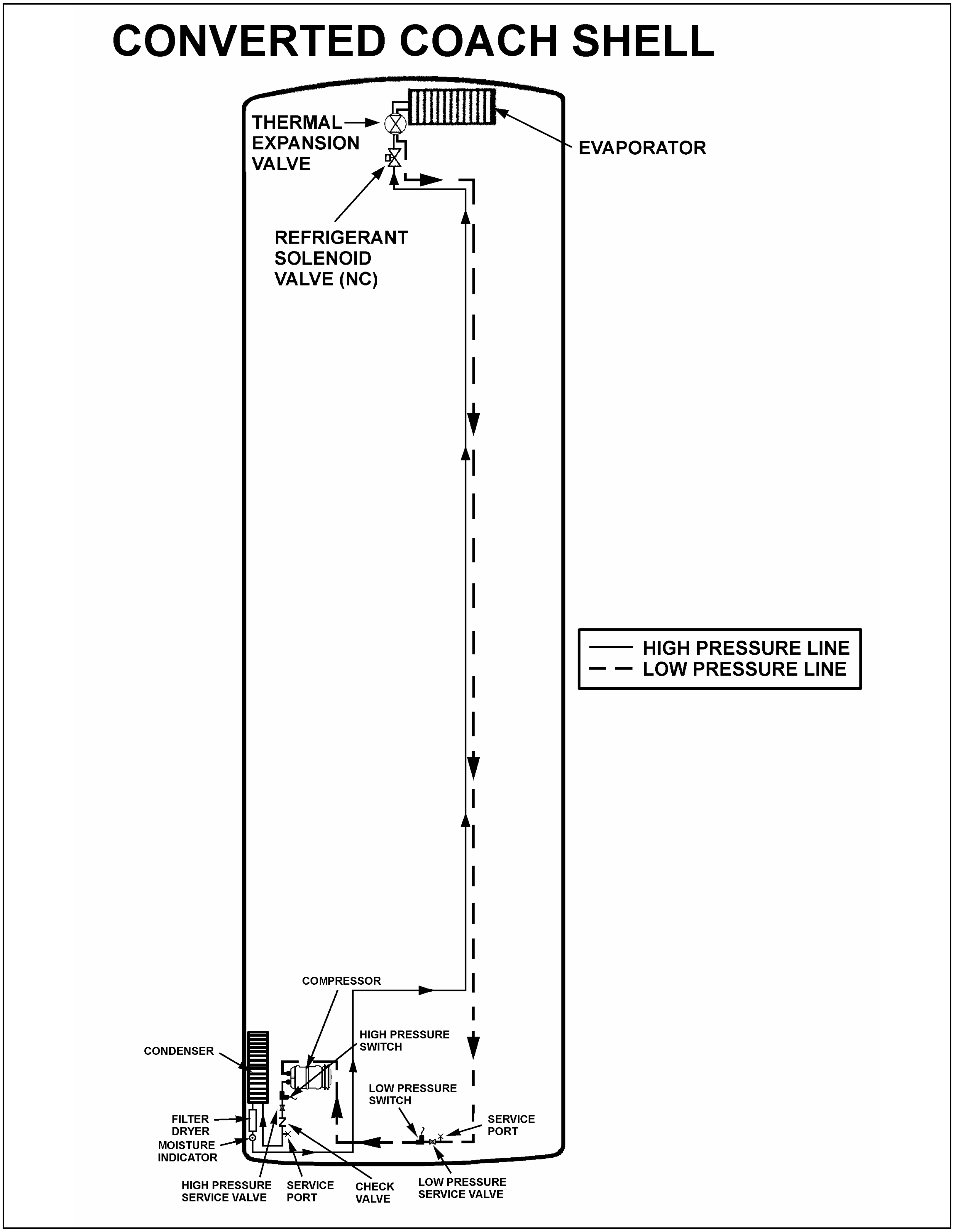


FIGURE 20: REFRIGERANT CIRCUIT (DRIVER'S AUXILIARY SYSTEM) 22246

7.2.4 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 reduced 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.

7.2.5 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.

7.3 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 or driver's A/C system only, refer to "Auxiliary Air Conditioning system and components": paragraph 9.9 "OIL RETURN OPERATION" and 9.3.4 "Refrigerant Recovery", further in this section.

⚠ 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 passenger side 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 the A/C switch, adjust *"A/C 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.

7.4 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.

7.5 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.

7.5.1 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.

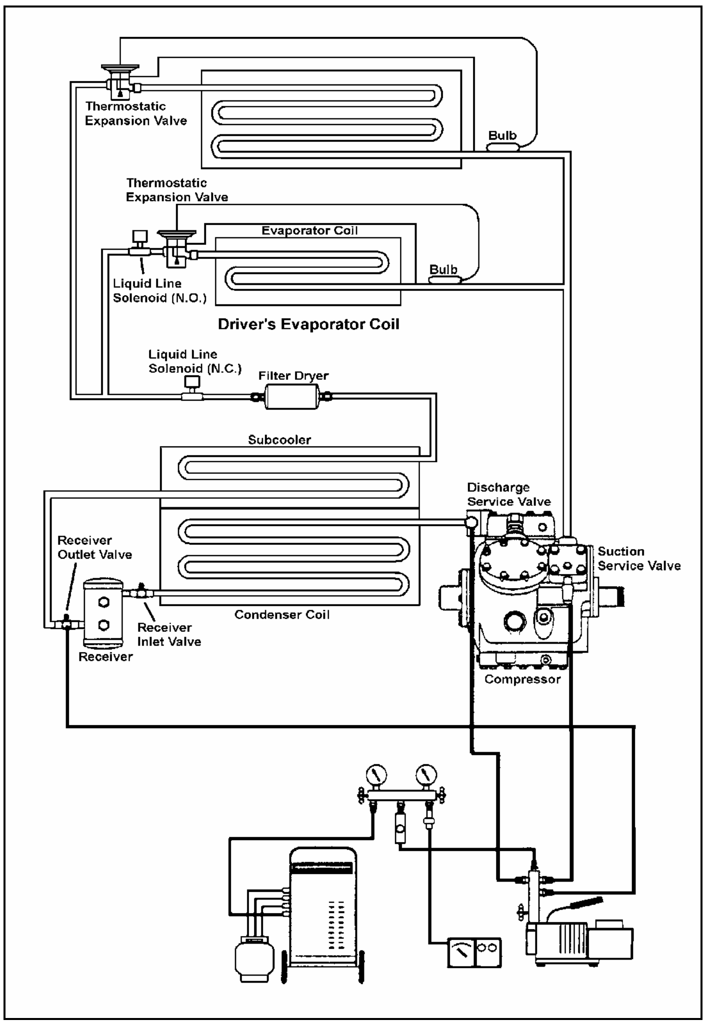


FIGURE 21: DOUBLE SWEEP EVACUATION SET-UP

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.

7.6 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), if the vehicle is equipped with a driver's system only, the system requires 7.0 lbs (3,2 kg) (W0) or 7.5 lbs (3,4 kg) (W5 and WE).

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.

7.7 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.

7.7.1 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.

7.7.2 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.

7.7.3 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.

8. CENTRAL A/C SYSTEM COMPONENTS

8.1 COMPRESSOR (CENTRAL SYSTEM)

8.1.1 Belt Replacement

⚠ WARNING ⚠

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. 22), 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. Slip the old belts off and the new ones on.
3. Reset belt tensioner pressure releasing valve (Fig. 22) to 50 psi (345 kPa) for coaches and to 45 psi (310 kPa) for MTH 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.

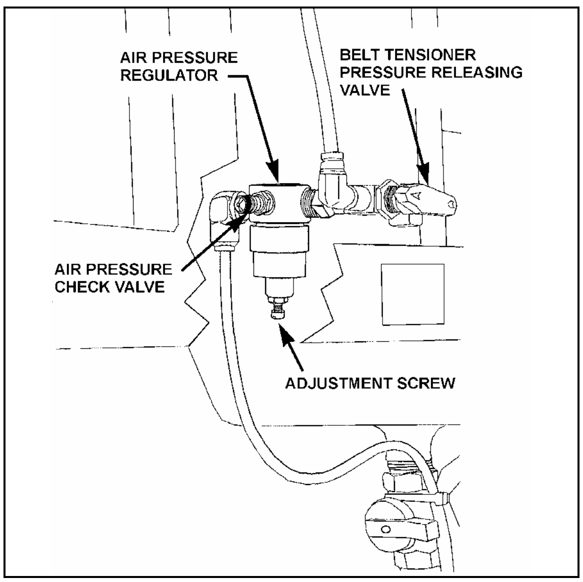


FIGURE 22: AIR PRESSURE REGULATOR 12200

NOTE
*For proper operation of the air bellows, adjust the **upper** tensioning bracket to provide a ¼ inch (7 mm) gap between stopper and bracket with the pneumatic system under normal pressure and the air pressure regulator set as per paragraph #3 (Fig. 23).*

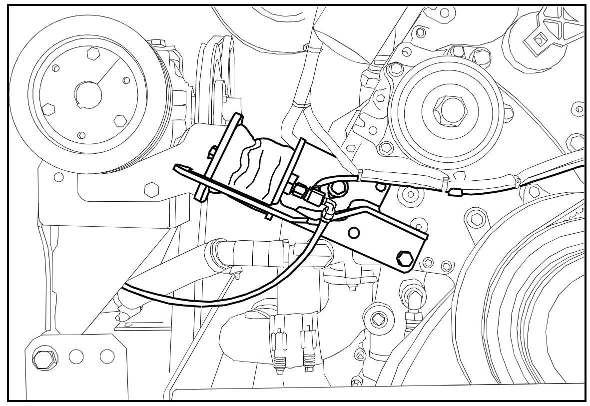


FIGURE 23: BELT TENSIONER 01059

8.1.2 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 tensioners by means of the air pressure releasing valve. After completing these procedures reset belt tensioner air pressure regulator to 50 psi (345 kPa) or 45 psi (310 kPa).

8.1.3 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. 24 & 26).
2. Check the distance between each extremity of straight edge (1. Fig. 26) 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.

8.1.4 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. 26) 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.

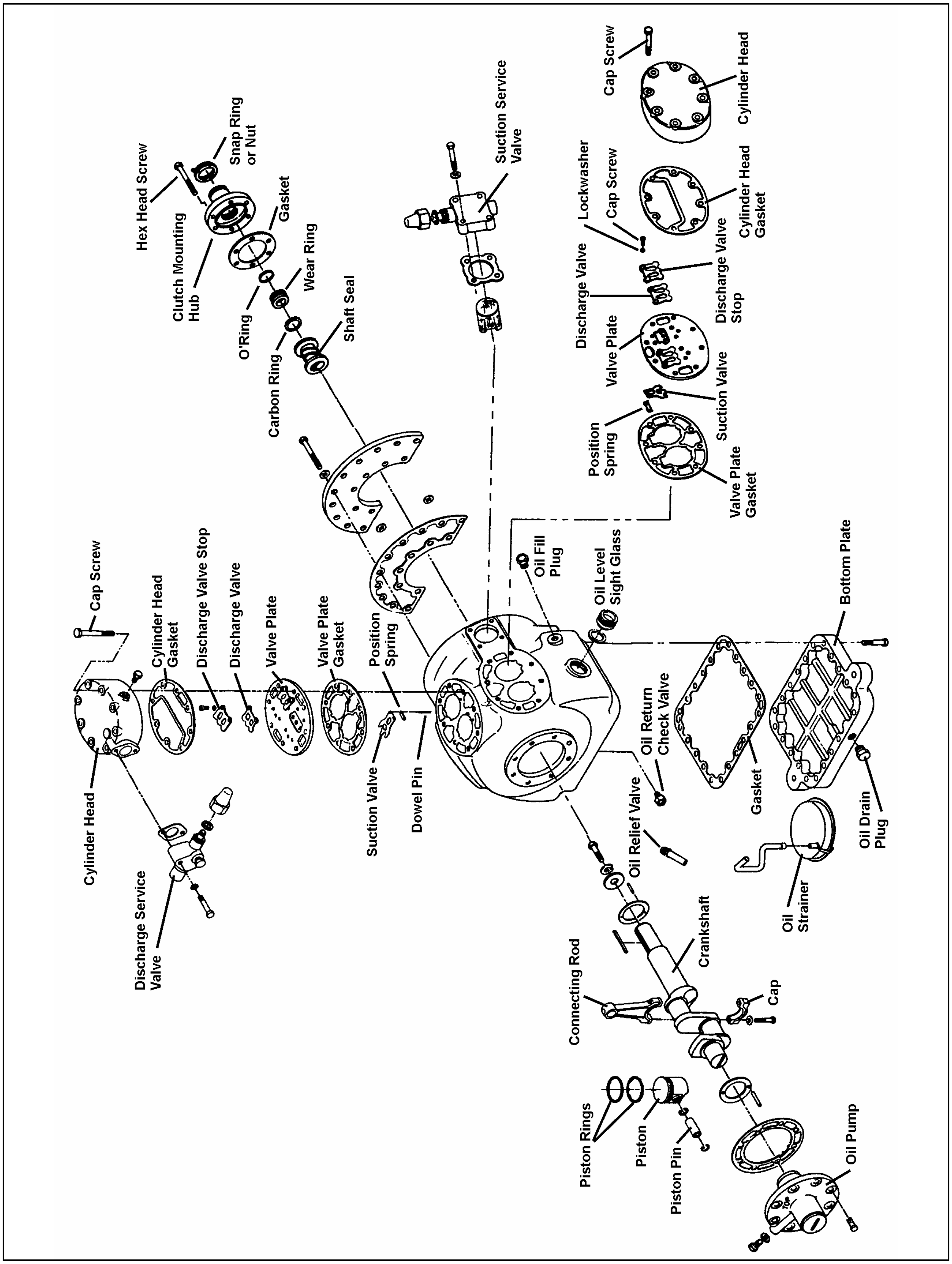


FIGURE 24: EXPLODED VIEW OF 05G COMPRESSOR

22214

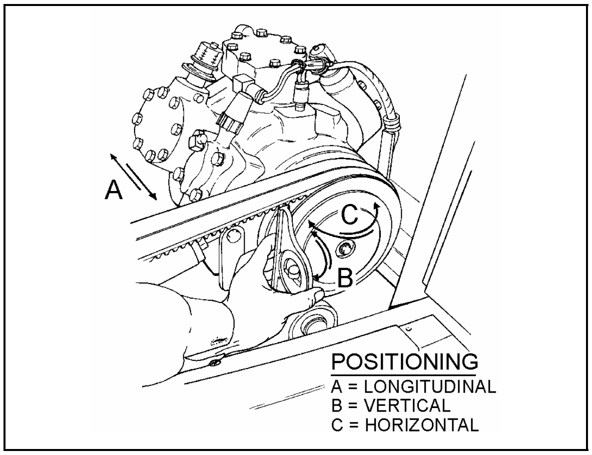


FIGURE 25: COMPRESSOR ALIGNMENT 22072

8.1.5 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^o and check if the compressor pulley is at same angle (Figs. 24 & 26). If it is not the same, shim under the appropriate pillow block in order to obtain the correct angle.

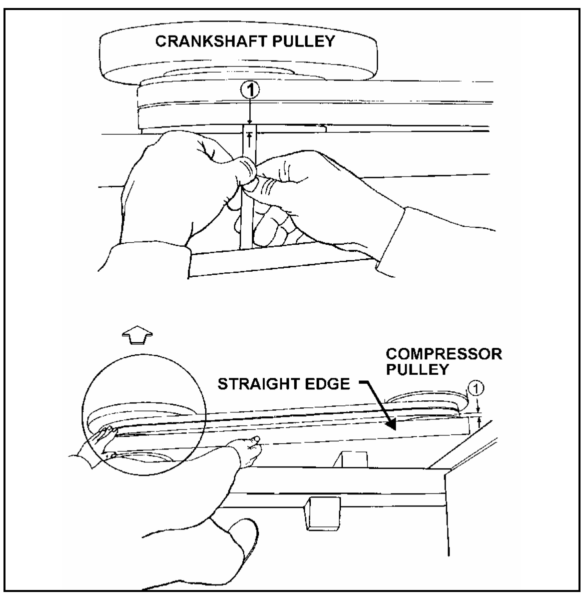


FIGURE 26: COMPRESSOR ALIGNMENT 22040

8.1.6 Compressor Maintenance

For the maintenance of the A/C compressor, see the *“Carrier Compressor Operation and Service Manual”* included at the end of this section.

⚠ CAUTION ⚠
Use only Castrol SW 68 (POE) oils with refrigerant 134a.

8.1.7 Troubleshooting Guide

A preliminary check may be made by simply feeling the cylinder heads with the unit in operation at ambient temperatures of 35^oF (2^oC) 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.

8.2 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.

8.3 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. 28). The condenser coil, for vehicles equipped with an auxiliary or a driver's A/C system only, 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.

8.3.1 Condenser Fan Motors

Two fan motors (Fig. 27), 28.5 V - (0.6 HP - 0.42 kW) and cages 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 floor. 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.

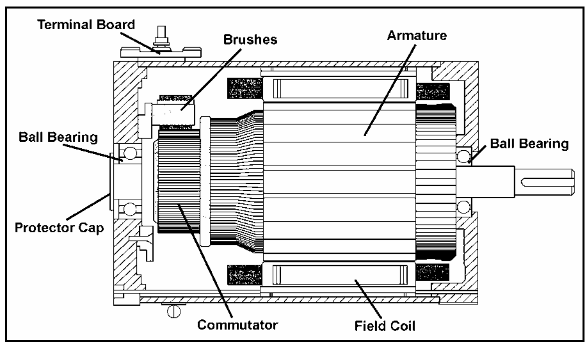


FIGURE 27: CONDENSER FAN MOTOR 22234

8.3.2 Condenser Fan Motor Removal

1. Set the battery master switch to the *“Off”* position.

2. Remove the two *“Phillips”* head screws retaining the fan motor protective cover to the square tubing. Remove the protective grill from mounting support.

3. Disconnect wiring from terminals on motor. Tag each wire to aid in identification at time of reconnection.

4. Support motor, and remove bolts which attach motor to mounting bracket. Remove the motor.

8.3.3 Preliminary Disassembly

1. Remove the brushes.
2. Unscrew the flange retaining screws on the shaft end side (opposite to the commutator end frame), and separate flange from frame (Fig. 27).
3. Remove flange and armature assembly by pushing bearing shaft toward the commutator end frame.
4. Separate flange from armature.

8.3.4 Disassembly

1. Perform preliminary disassembly.
2. Carefully note the position of the brush holder ring and the connections on the flange support.
3. Unscrew and remove the flange on the commutator end frame.
4. Remove the brush holder ring.
5. Finally, separate the following parts: brush holders, brush boxes, terminal board, bearings, etc.

8.4 RECEIVER TANK

The receiver tank is located in the condenser compartment (Fig. 28). 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.

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.

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.

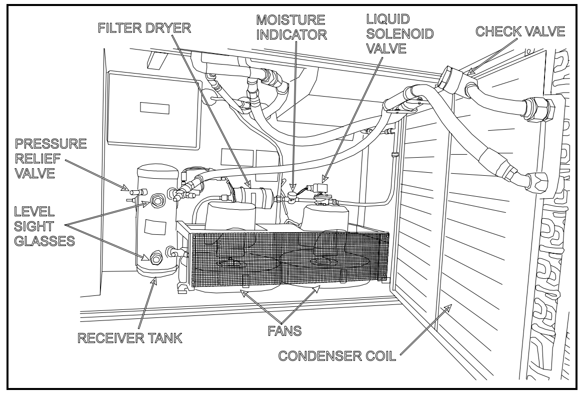


FIGURE 28: A/C CONDENSER COMPARTMENT 22243B

8.5 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 engine compartment L.H. side rear door, is installed on vehicles equipped with an auxiliary A/C system or a driver's system only. Its function is similar to that of filter used on main systems. Replace only when system is opened or a problem occurs.

8.5.1 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 ⚠

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.

⚠ WARNING ⚠

Cleaning products are flammable and may explode under certain conditions. Always handle in a well ventilated area.

8.5.2 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.

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)			

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.

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.

8.6 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.

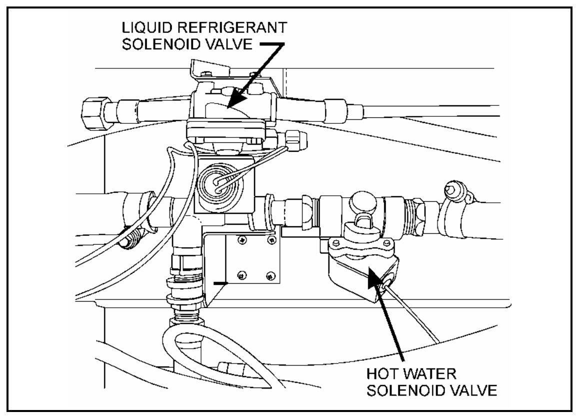


FIGURE 29: DRIVER'S EVAPORATOR LIQUID SOLENOID VALVE 22181

NOTE

An identical refrigerant solenoid valve is used on the auxiliary A/C system and is located near the auxiliary A/C unit.

8.6.1 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 ½ turn counterclockwise. To manually close valve, turn stem clockwise until tight against seat. Manual stem must be in closed position for automatic electric operation.

8.6.2 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.

8.6.3 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. 30).
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.

8.6.4 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.
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.

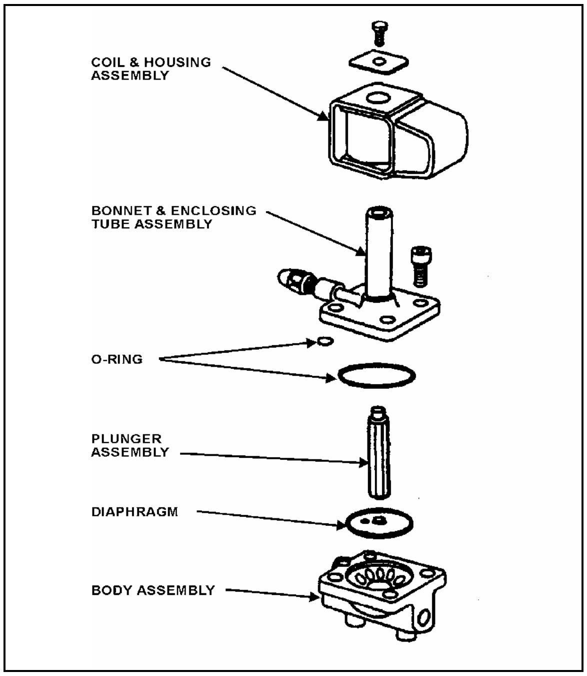


FIGURE 30: REFRIGERANT SOLENOID VALVE 22044

8.7 EXPANSION VALVE

8.7.1 Central System

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. 13 & 31). 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.

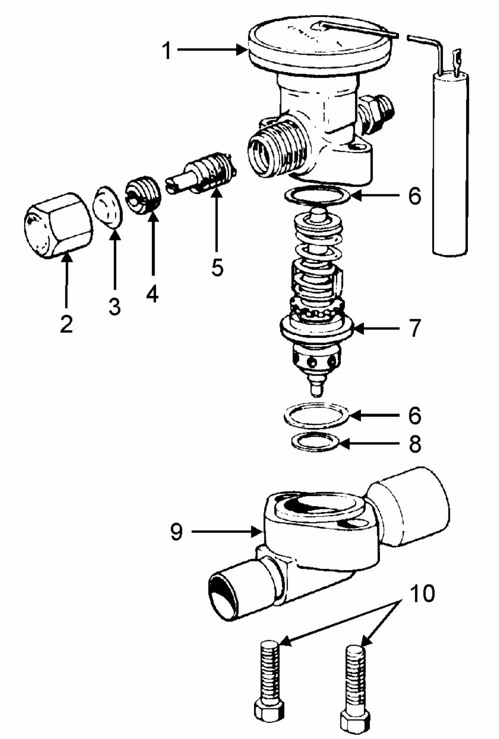
The remote bulb and power assembly is a closed system. The pressure within the remote bulb and power assembly corresponds to the saturation pressure of the refrigerant temperature leaving the evaporator and moves the valve pin in the opening direction. Opposed to this force, on the under side of the 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.

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^{o} F (-11.1 to -8.8 ^{o} 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.



1. POWER ELEMENT
2. CAP - SEAL NUT
3. BONNET - SEAL (FLARE)
4. PACKING NUT
5. ADJUSTING STEM & PACKING ASSY
6. GASKET
7. CAGE ASSY
8. GASKET
9. BODY FLANGE
10. CAPSCREW

FIGURE 31: EXPANSION VALVE 22045

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. 32). 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^{o}F (27,7^{o}C), Then set temperature to minimum to keep the compressor on 6 cylinders.

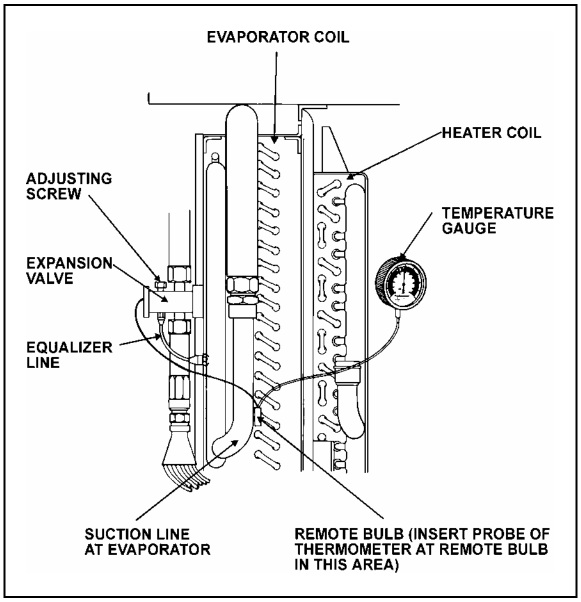


FIGURE 32: SUPERHEAT ADJUSTMENT INSTALLATION 22046

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.
3. Install a remote reading thermometer to the evaporator outlet line near the existing remote bulb (Fig. 32).
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.
6. Check approximately 5 readings of pressure at 2-minute intervals and convert to temperature using the temperatures & pressures table (page 31). 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. 33).

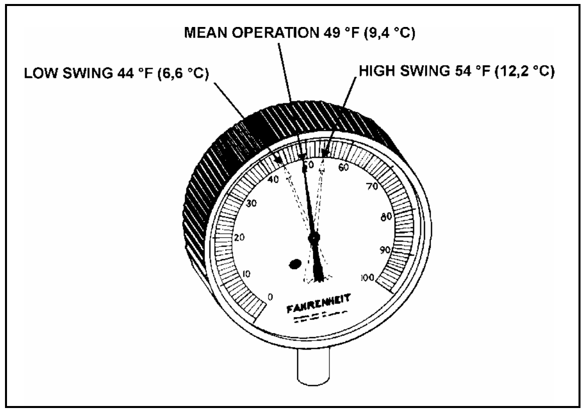


FIGURE 33: HIGH & LOW SWING TEMPERATURE AT REMOTE BULB 22047

Example of readings taken at fig. 33:

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.

6. 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

1. Pump down the system as previously indicated in this section.
2. 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.
3. Remove the two cap screws holding the power assembly to the valve body flange. Lift off the power assembly and remove the cage assembly.
4. 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.
5. Check for leaks.

Safety Instructions

1. Make sure the valve is installed with the flow arrow on the valve body corresponding to the flow direction through the piping system.
2. 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.

8.7.2 Driver's System

The function and operation of the expansion valve for the driver'' system are similar to the main system, but no superheat adjustment is required (see figures 19 and 20).

8.8 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.

⚠ WARNING ⚠
Before welding any part of refrigeration system, make sure the area is well ventilated.

8.9 TROUBLESHOOTING

8.9.1 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.

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.

8.9.2 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.

<table>
<tr><th>TROUBLE</th><th>CAUSE</th></tr>
<tr><td>Frequent starting and stopping on low pressure control switch.</td><td>Lack of refrigerant. Check for leaks. Recharge.</td></tr>
<tr><td>Compressor intermittently starts and stops.</td><td>Intermittent contact in electrical control circuit. Compressor valves not in operating position.</td></tr>
<tr><td>Non-condensable in the refrigeration system.</td><td>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.

(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.)

An evaporator just does a proper cooling job without sufficient air. Shortage of air can be caused by the following:

* Dirty filters; or
* Dirty coils.</td></tr>
<tr><td colspan="2">Testing condenser pressure.

Note: R-134A pressure is function of the temperature variation.

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:

Reduced air quantity. This may be due to:
* 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.</td></tr>
</table>

8.10 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

VAPOR-PRESSURE			
TEMPERATURE		PRESSURE	
°F	°C	psi	kPa
180	82.2	385.9	2660.8
190	87.8	433.6	2989.7
200	93.3	485.0	3344.1
210	98.9	540.3	3725.4

8.11 LEAK TESTING

Some methods such as nitrogen pressure and 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:

⚠ WARNING ⚠

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.

9. AUXILIARY AIR CONDITIONING SYSTEM AND COMPONENTS

9.1 COMPRESSOR

MODEL	TM-16HD
TYPE	Swash-plate type
Number of cylinders	6
Bore	36 mm (1.42”)
Stroke	26.7 mm (1.05”)
Displacement	163 cm³ (10cu.in)
Permissible speed	700-6000 rpm
Refrigerant	HFC-134a
Lubricant	ZXL100PG 180 cm³
Mass	4.9 kg (10.9 lbs)

9.2 MAGNETIC CLUTCH

TYPE	Electromagnetic single-plate dry clutch
Rated Voltage	24 volts DC
Current consumption	3.75 amperes (max)
Stalling torque	49 Nm (36.1 Lbf-ft) min.
Rotation	CW/CCW
Mass	2.2 kg (4.9 lbs)

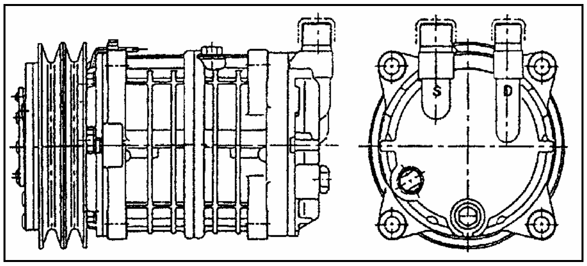


FIGURE 34: SELTEC TM-16HD COMPRESSOR

9.3 MAINTENANCE PRECAUTIONS

9.3.1 Work Area

Because the components of air conditioning systems are especially sensitive to moisture, dirt and dust, always observe the following procedures:

* Work indoors whenever possible.
* Select a level work area.
* Keep work area clean.
* Select a work area with adequate ventilation.

WARNING

Refrigerant itself is not harmful, but excessive accumulation in a closed area can cause oxygen deficiency.

* Keep open flame and flammables away from the vehicle in which the air conditioning system is being serviced. **Open flame is especially dangerous during Freon leak testing.**

WARNING

Contact with flame and high temperatures can generate toxic gases.

9.3.2 Refrigerant Handling

Never directly heat refrigerant cylinder or put in hot water heated above 40°C (104°F) since it may cause release of the safety plug or the cylinder may burst. When it is necessary to heat refrigerant cylinder for charging in cold weather, use warm water at a temperature below 40°C (104°F).

WARNING

Do not put the charge valve in the warm water.

* Never store refrigerant cylinder in direct sunlight, near flame, or where the temperature exceeds 40°C (104°F). Always store refrigerant cylinder in a cool dry place.
* Never throw or strike refrigerant cylinder and never handle roughly.

9.3.3 PAG Oil Handling

Whenever a part replacement has to be done on the system, additional task about PAG oil will have to be performed.

The compressor has little reserve and is lubricated by the oil refrigerant mixture. To perform correctly, the compressor needs the mixture to be from 3% to 6% of Poly Alkaline Glycol (PAG) oil.

When a compressor has to be top off due to a severe lost, the amount of oil to be added should be evaluated with the refrigerant charge or a compressor oil change should be performed to rise up the compressor oil charge to 180 ml or the written charge on the nameplate.

* The oil should be free from moisture, dust, metal shavings, etc.
* Do not mix with other oils.
* The moisture content of the oil increases when exposed to the air for prolonged period. Therefore, after use, seal the container immediately.

DO NOT MIX PAG AND POE OR MINERAL OILS!

9.3.4 Refrigerant Recovery

Some air conditioning system refrigerant compounds are chlorofluorocarbons, and therefore may be damaging the earth's ozone layer. Consequently, the release of refrigerant into the atmosphere must be avoided. Whenever refrigerant is to be released from the air conditioning system, a refrigerant recovery unit must be used to recover the refrigerant. This refrigerant can then be recycled and reused, which is both environmentally safe and economical.

For complete system recovery, any of the High and Low service ports can be used (Refer to fig. 19 & 20). Energize liquid solenoid valve and measure the quantity of oil recovered. For the compressor only, use the service valve port and close the valves. The service valves open permits full flow of refrigerant to service port. Service valve closed permits flow of refrigerant from compressor to service port.

9.3.5 Compressor Handling

Do not strike, drop or turn the compressor upside down. If the compressor is knocked over or turned upside down, rotate the compressor's magnetic clutch 5 to 6 times by hand to circulate the oil which has settled in the cylinder. Sudden rotation with oil in the cylinder can cause valve damage and adversely affect durability.

9.4 COMPRESSOR REMOVAL

9.4.1 When the compressor is operational

* Perform the "OIL RETURN OPERATION" (Refer to paragraph 10.9).

9.4.2 When the compressor is inoperable

* Perform the "Refrigerant Recovery" operation (Refer to paragraph 10.3.4).
* Slacken bolts A (Refer to figure 35).
* Remove bolts B & C (Refer to figure 35).
* Remove the compressor.

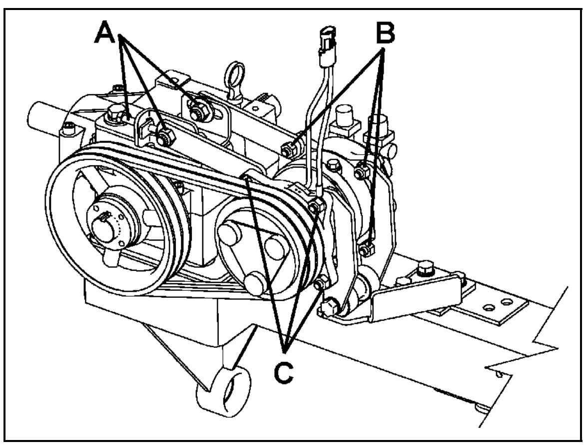


FIGURE 35: COMPRESSOR REMOVAL OR INSTALLATION 22285

9.5 INSTALLATION PRECAUTIONS

The new compressor is filled with the specified quantity of compressor oil and nitrogen gas (N²). When mounting the compressor on the vehicle, take the following steps:

* Loosen the discharge side connector's cap and gently release N² from compressor (Refer to figure 36).

NOTE
Take care not to let the oil escape.

* Slowly rotate the compressor's magnetic clutch several times by hand to distribute the oil which has settled in the cylinders (Refer to figure 37).

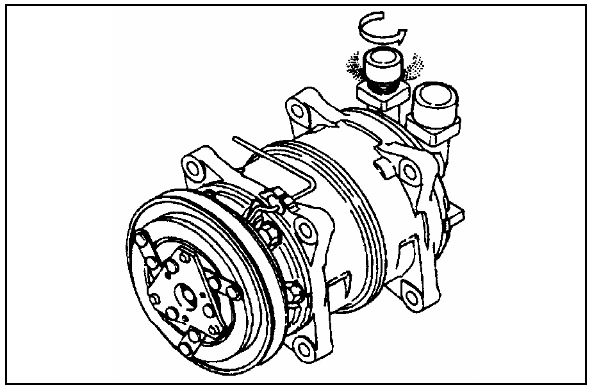


FIGURE 36: LOOSENING THE DISCHARGE SIDE CONNECTOR'S CAP

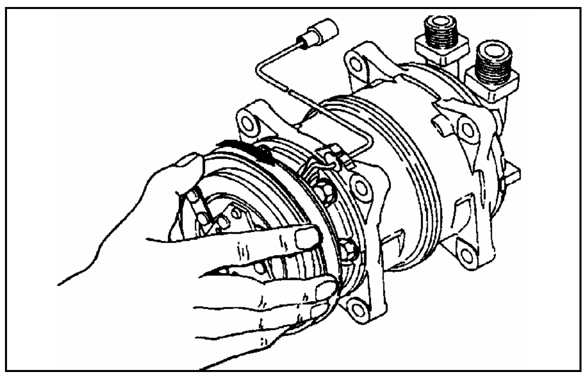


FIGURE 37: ROTATING MAGNETIC CLUTCH

* When using the old compressor in the system, the compressor should be installed after changing the oil.

9.6 COMPRESSOR OIL CHANGE

Each compressor is delivered filled with the specified quantity of compressor oil, depending on the type of air conditioning system. A label describing the amount/type of compressor oil is attached to the compressor.

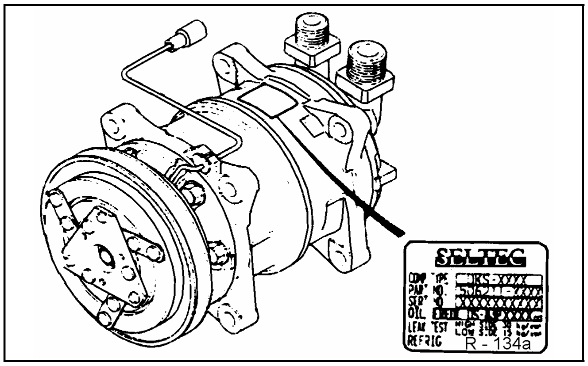


FIGURE 38: COMPRESSOR OIL LABEL

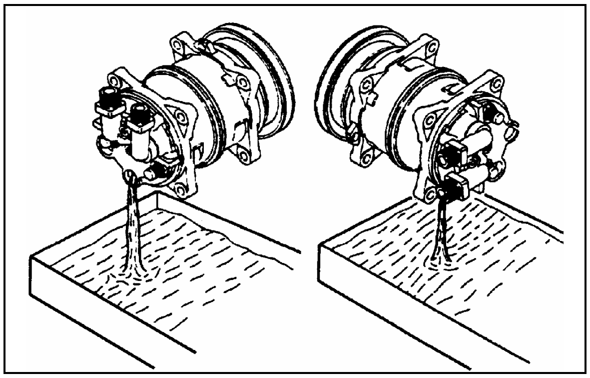


FIGURE 39: DRAINING THE OIL

* Check oil for contamination. Refer to PARAGRAPH 10.8: “COMPRESSOR OIL CONTAMINATION”.
* Tighten the oil drain plug with a new o-ring lightly coated with clean compressor oil to specified torque.

Torque: 13-15 Nm (9.4-10.8 Lbf-ft)

* Add new compressor oil through the suction-side connector with the amount specified on the label (180 ml).

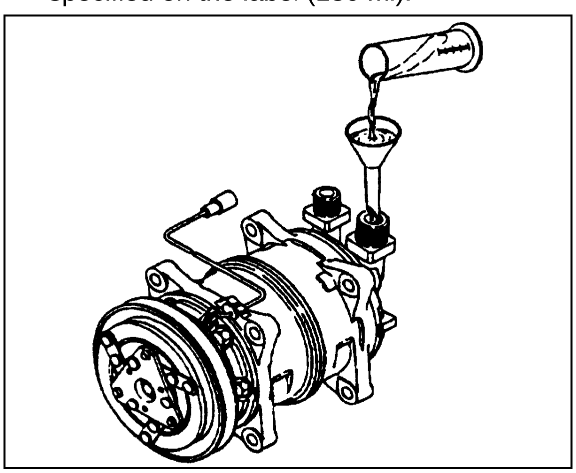


FIGURE 40: ADDING NEW COMPRESSOR OIL

9.6.1 Evacuating System Before Adding Refrigerant (Driver’s or Auxiliary System)

When a system has been opened for repairs, change the filter dryer and evacuate the system. XL2-45 coaches equipped with an auxiliary system or XL2 MTH equipped with a driver’s system must use high-pressure service port located on the other side of check valve and low-pressure port located alongside rear truss. (Figs. 19 and 20). 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.

9.7 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.

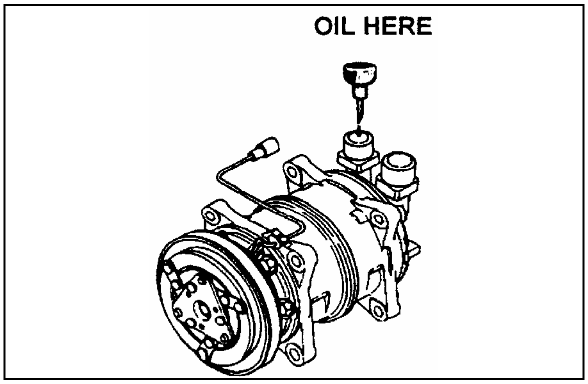


FIGURE 41: ADDING OIL AFTER REPLACING A COMPONENT

9.8 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 paragraph 10.6: “COMPRESSOR OIL CHANGE”.

9.9 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.

9.10 OIL CHECK INTERVAL

Unlike engine oil, it is not necessary to frequently check or change the compressor oil. However, it is necessary to check and replenish or replace the compressor oil in the following cases:

* Whenever the compressor, evaporator, condenser or filter-dryer is replaced.
* Whenever refrigerant has leaked from the system, evaluate the amount of oily spot.
* Whenever refrigerant is suddenly released from the cooling cycle, replenish the compressor (180 ml) plus 150 ml.
* Whenever any oil-related problems occur in the cooling cycle.

9.11 LEAK TEST PROCEDURE WITH COMPRESSOR REMOVED

When a compressor is repaired, it must be checked prior to installation.

* Install the discharge and suction caps to the connector.

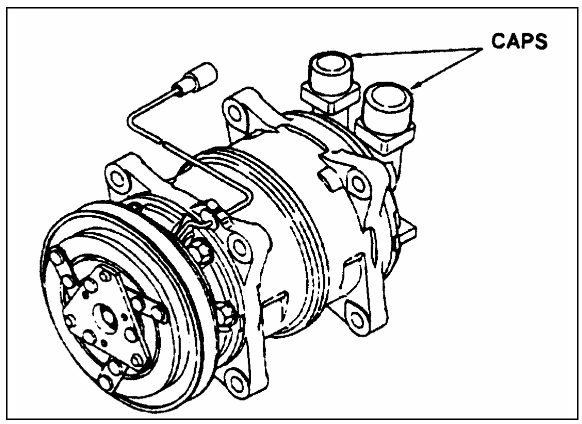


FIGURE 42: DISCHARGE AND SUCTION CAPS

* Fill the compressor with refrigerant through connector’s suction port raising the pressure to at least 0.5 Mpa (70 psi).
* Check the compressor for leaks using a leak detector.

NOTE
Never leave the compressor upside down for longer than 30 seconds. This is because the oil inside the compressor will enter the cylinders, causing liquid compression which will damage the compressor’s suction and delivery valves.

9.12 TIGHTENING TORQUES

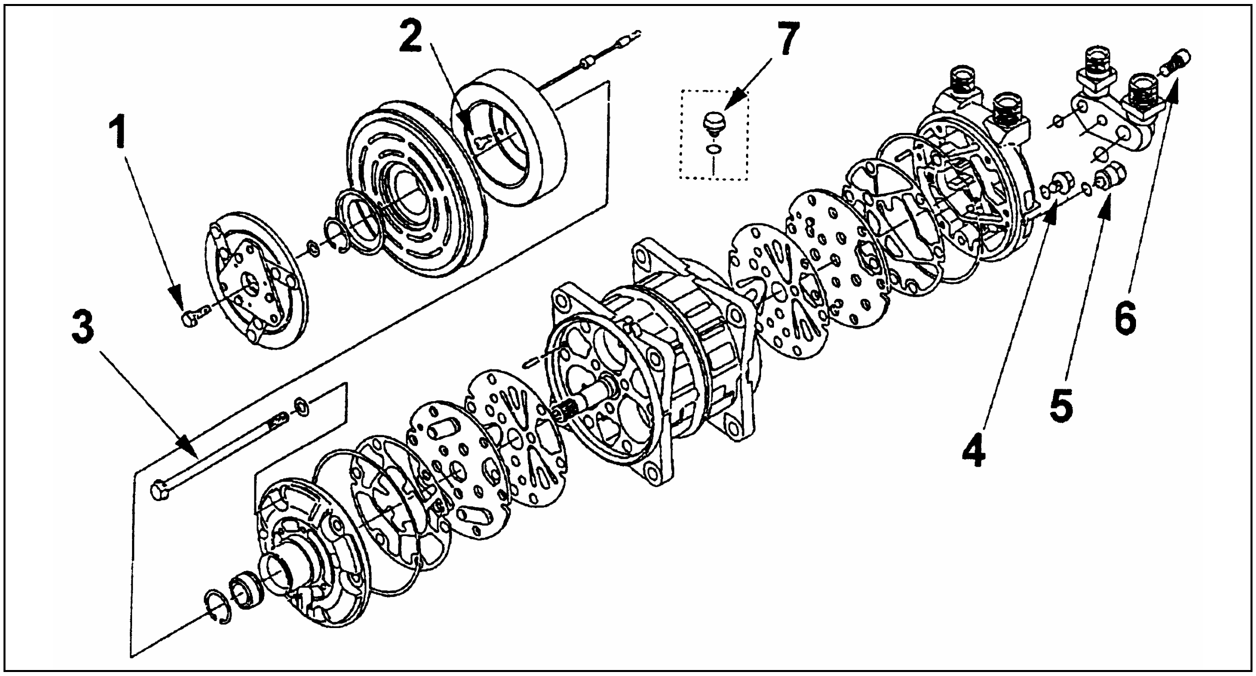


FIGURE 43: TIGHTENING TORQUES

PART	THREAD SIZE	TIGHTENING TORQUE
1. Bolt Armature	M6 x 1.0	12 - 14 Nm (8.7 - 10.1 Lbf-Ft)
2. Field Coil Screw	M5 x 0.8	4 - 6 Nm (2.9 - 4.3 Lbf-Ft)
3. Body Bolt	M8 x 1.25	20 – 24 Nm (14.5 – 17.3 Lbf-Ft)
4. Oil Drain Plug	M8 x 1.25	13 – 15 Nm (9.4 – 10.8 Lbf-Ft)
5. Pressure Relief Valve	3/8 – 24UNF	13 – 15 Nm (9.4 – 10.8 Lbf-Ft)
6. Connector Bolt	M8 x 1.25	20 – 24 Nm (14.5 – 17.3 Lbf-Ft)
7. Oil Filler Plug	M8 x 1.25	13 – 15 Nm (9.4 – 10.8 Lbf-Ft)

10. HEATING SYSTEM

The schematics of Figures 44 and 45 show respectively, the central heating system and the driver's heating system with their components.

In addition to the normal heating provided by the engine, a preheating system (104,000 Btu/hr) (optional on coaches only) may have been installed in the vehicle.

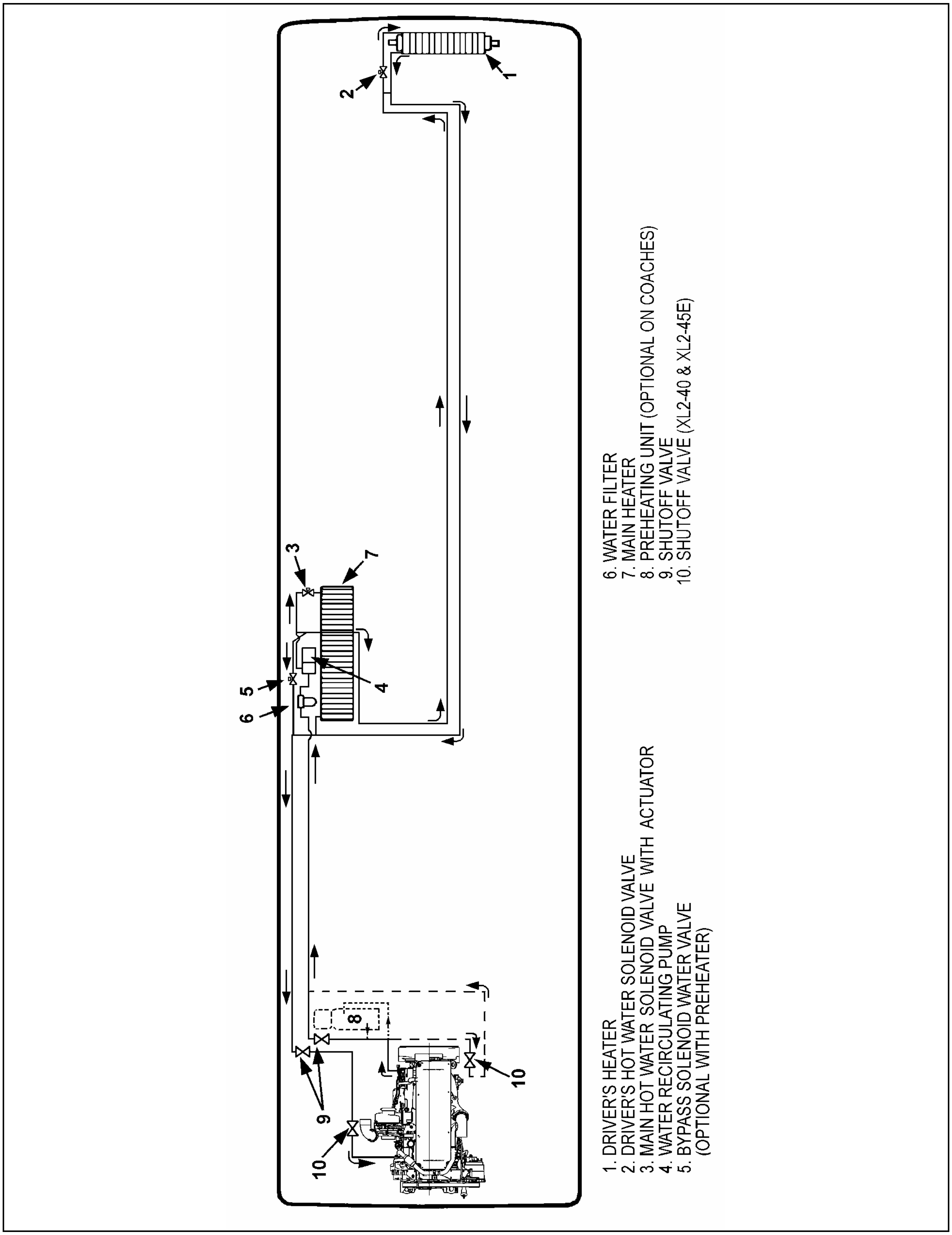


FIGURE 44: CENTRAL HEATING SYSTEM COMPONENTS 22237

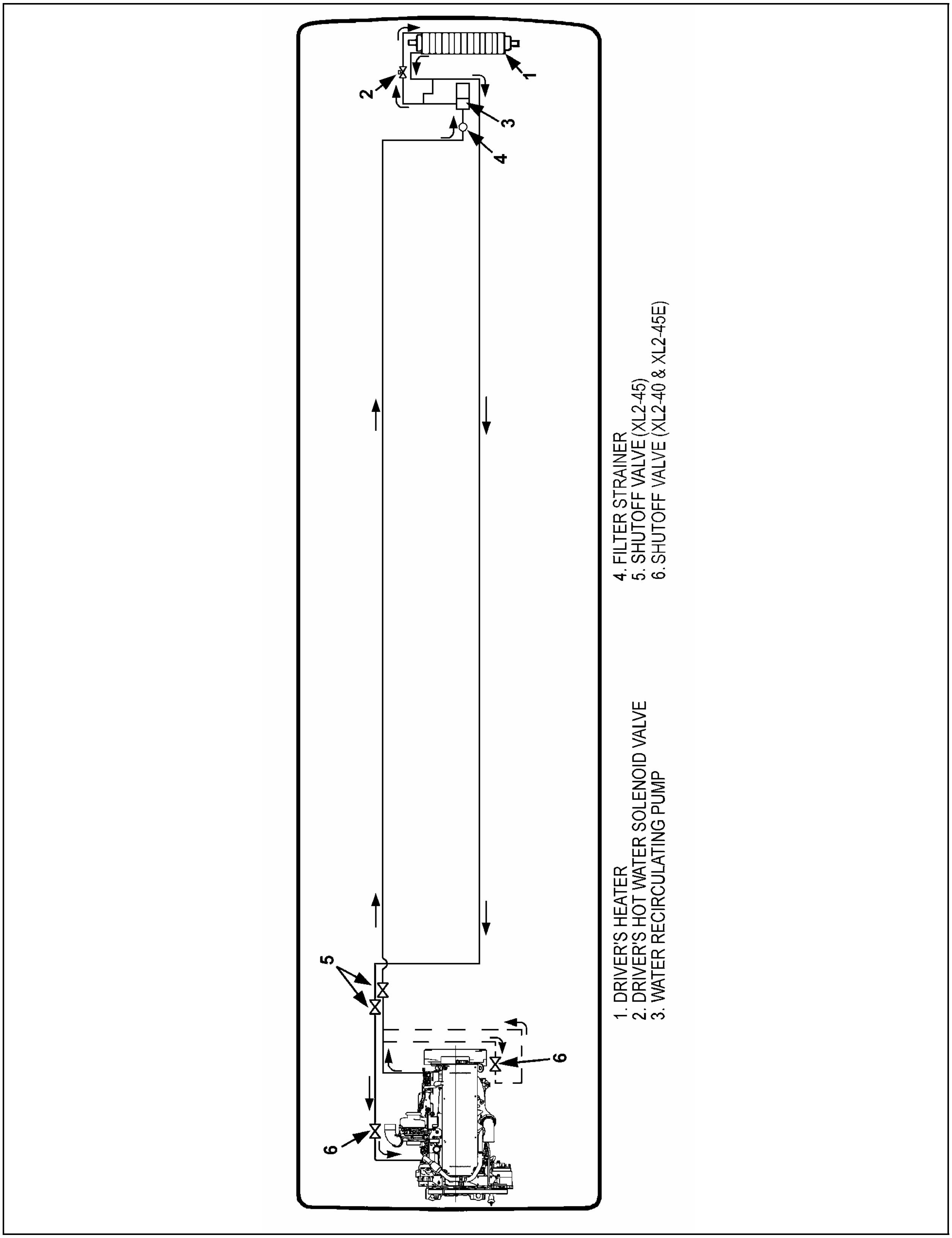


FIGURE 45: DRIVER'S HEATING SYSTEM COMPONENTS (VEHICLES EQUIPPED WITH DRIVER'S SYSTEM ONLY) 22238

10.1 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.

10.1.1 Draining Driver's Heater Core

1. Stop engine and allow engine coolant to cool.
2. Locate the normally open water solenoid valve on the ceiling of the spare wheel compartment (Fig. 46), disconnect its wiring connector, then connect a 24-volt external power source, using jumper cables, to close 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. 47) to ensure an efficient draining.

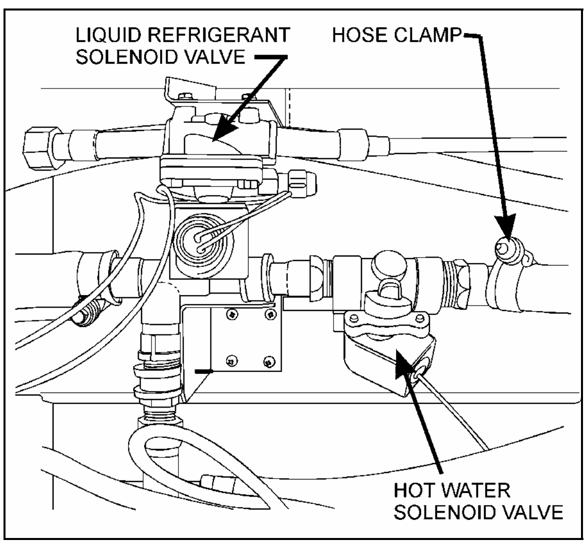


FIGURE 46: CEILING OF THE SPARE WHEEL COMPARTMENT 22181

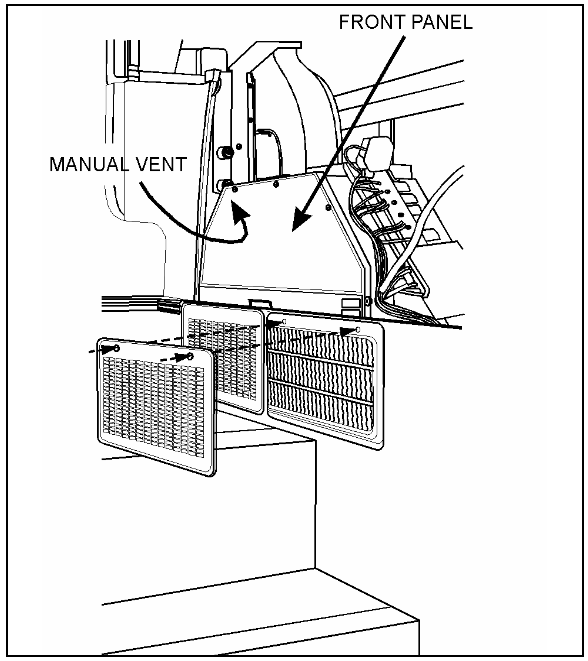


FIGURE 47: DRIVER'S HVAC UNIT 22172

10.1.2 Draining Main Heater Core

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

On XL2-40 & 45E vehicles, the valves are located in engine compartment. One is on the R.H. side of compartment and is accessible through engine compartment R.H. side door (Fig. 48).

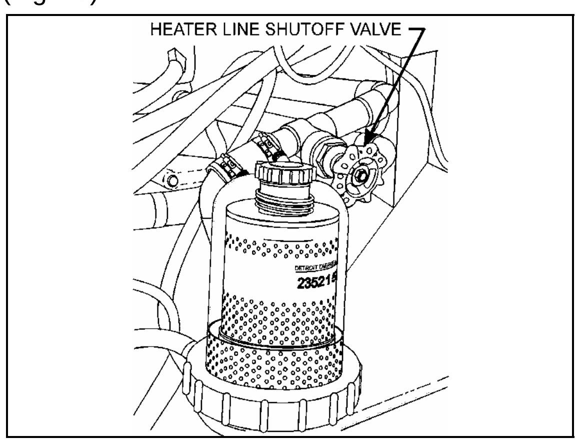


FIGURE 48: HEATER LINE SHUTOFF VALVE 05070

Another valve is located in the engine compartment under the radiator fan gearbox (Fig. 49).

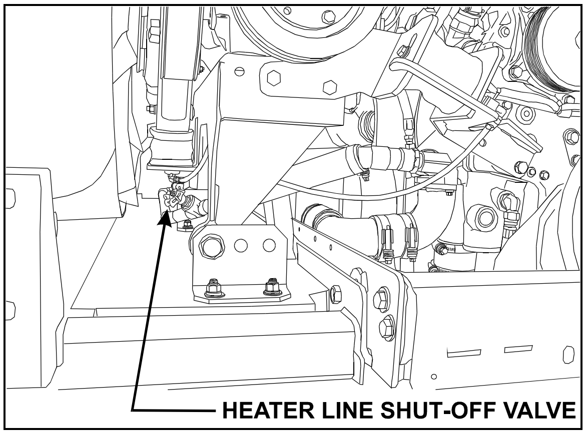


FIGURE 49: ENGINE COMPARTMENT 05078

On XL2-45 vehicles, one valve is located in the engine compartment, under the radiator fan gearbox (Fig. 49), another valve is located in the engine compartment behind splash guard panel at rear of vehicle (behind L.H. side tag axle wheel) (Fig. 50).

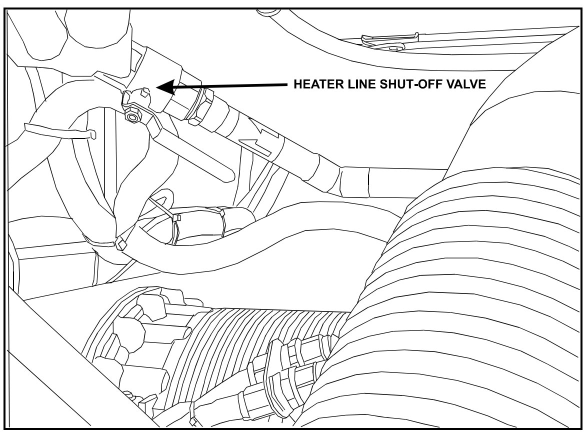


FIGURE 50: HEATER LINE SHUT-OFF VALVES 05067

3. Open the last L.H. side baggage compartment door, and then pull the black release button located on the L.H. side in order to unlock and open the evaporator compartment door.

⚠ WARNING ⚠

Before proceeding with the following step, check that coolant has cooled down.

4. Open drain cock in bottom of heater core, then open manual vent located on top of heater core (Fig. 51) in order to allow air to enter while draining.

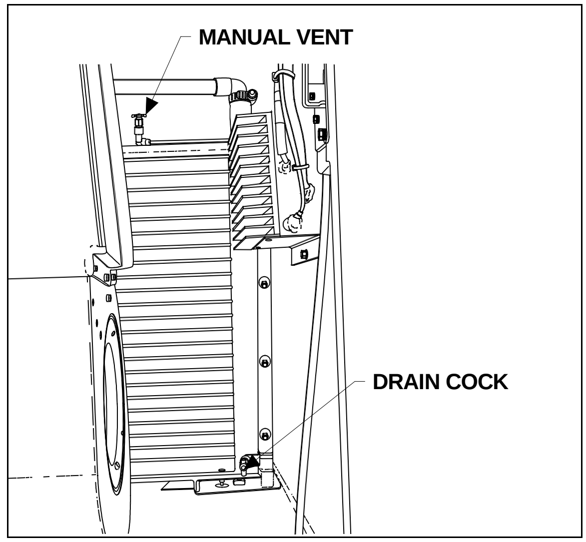


FIGURE 51: EVAPORATOR COMPARTMENT 22128

10.2 FILLING HEATING SYSTEM

1. Ensure that the drain hose is reconnected and the manual vents 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 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.

10.3 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 vents illustrated in Figures 47 and 51, and open them momentarily until no air escapes from the lines.

10.4 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.

10.5 DRIVER'S WATER SOLENOID VALVE

A two-way normally open, internal pilot-operated solenoid valve designed for smooth closing is used to control the coolant flow through the driver's heating unit. It is mounted on the coolant inlet line of the driver's heating unit, and is accessible through the spare wheel compartment (see fig. 46). The valve cannot be manually bypassed.

10.5.1 Improper Operation

1. Faulty control circuit: Check the electric system by energizing the solenoid. A metallic clicking noise indicates that the solenoid is operating. Absence of clicking indicates a loss of power or a defective solenoid. Check for open breaker, open-circuited or grounded coil, broken lead wires.
2. Burned-out coil: Check for open-circuited coil. Replace coil if necessary.
3. Low voltage: Check voltage across the coil leads. Voltage must be at least 85% of nameplate rating.
4. Excessive leakage: Disassemble valve and clean all parts. Replace worn or damaged parts with a complete spare part kit for best results.

10.5.2 Coil Replacement

Turn off electrical power supply and disconnect lead wires. Proceed in the following manner:

1. Remove retaining cap or clip, spacer, name plate and housing.
2. Slip spring washer, insulating washer, coil and insulating washer off the solenoid base sub-assembly. Insulating washers are omitted when a molded coil is used.
3. Coil is now accessible for replacement. Reassemble by reversing sequence of disassembly. Refer to exploded view (Fig. 52) for identification and location of parts.

NOTE

Solenoid must be completely reassembled, as the housing and internal parts complete the magnetic circuit.

⚠ CAUTION ⚠

When metal retaining clip disengages, it springs upwards.

10.5.3 Valve Disassembly

1. Drain driver's heating unit as previously explained in this section under paragraph *"Draining Heating System".*
2. Disconnect connector from coil connector.
3. Disassemble valve in an orderly fashion paying careful attention to exploded view (Fig. 52) provided for identification of parts.
4. Remove retaining cap and slip the entire solenoid enclosure off the solenoid base subassembly.

⚠ CAUTION ⚠

When metal retaining clip disengages, it springs upwards.

5. Unscrew solenoid base sub-assembly and remove core, plug nut gasket, plug nut assembly and solenoid base gasket.
6. Remove the four bonnet screws and valve bonnet, disc holder subassembly, disc holder spring, diaphragm/spring subassembly and body gasket.
7. All parts are now accessible for cleaning or replacement. Replace worn or damaged parts with a complete spare part kit for best results.

⚠ CAUTION ⚠

Do not damage valve seat in any manner, as its sealing feature will be affected, thus resulting in continuous leakage.

10.5.4 Valve Reassembly

1. Reassemble in reverse order of disassembly, paying careful attention to exploded view provided for identification and placement of parts (Fig. 52).
2. Replace body gasket and diaphragm/spring subassembly. Locate bleed hole in diaphragm/spring subassembly, approximately 45° from valve outlet.
3. Replace disc holder spring and holder subassembly.
4. Replace valve bonnet screws. Torque bonnet screws in a criss-cross manner to 95 ± 10 Lbf-inch.
5. Install solenoid base gasket, plugnut assembly and plugnut gasket. Position core (small end up for A-C construction) on plugnut assembly. For D-C construction, be sure plugnut assembly and core are installed with mated ends together.
6. Replace solenoid base subassembly and torque to 175 ± 25 Lbf-inch.
7. Refill heating system as previously stated under paragraph *"Filling Heating System*", then bleed air from the driver's heating unit as stated previously under paragraph *"Bleeding heating system".*
8. After maintenance, operate the valve a few times to be sure of proper opening and closing.

NOTE
Should diaphragm/spring subassembly become disassembled, be sure to replace the diaphragm/spring support with lip facing upward towards the valve bonnet

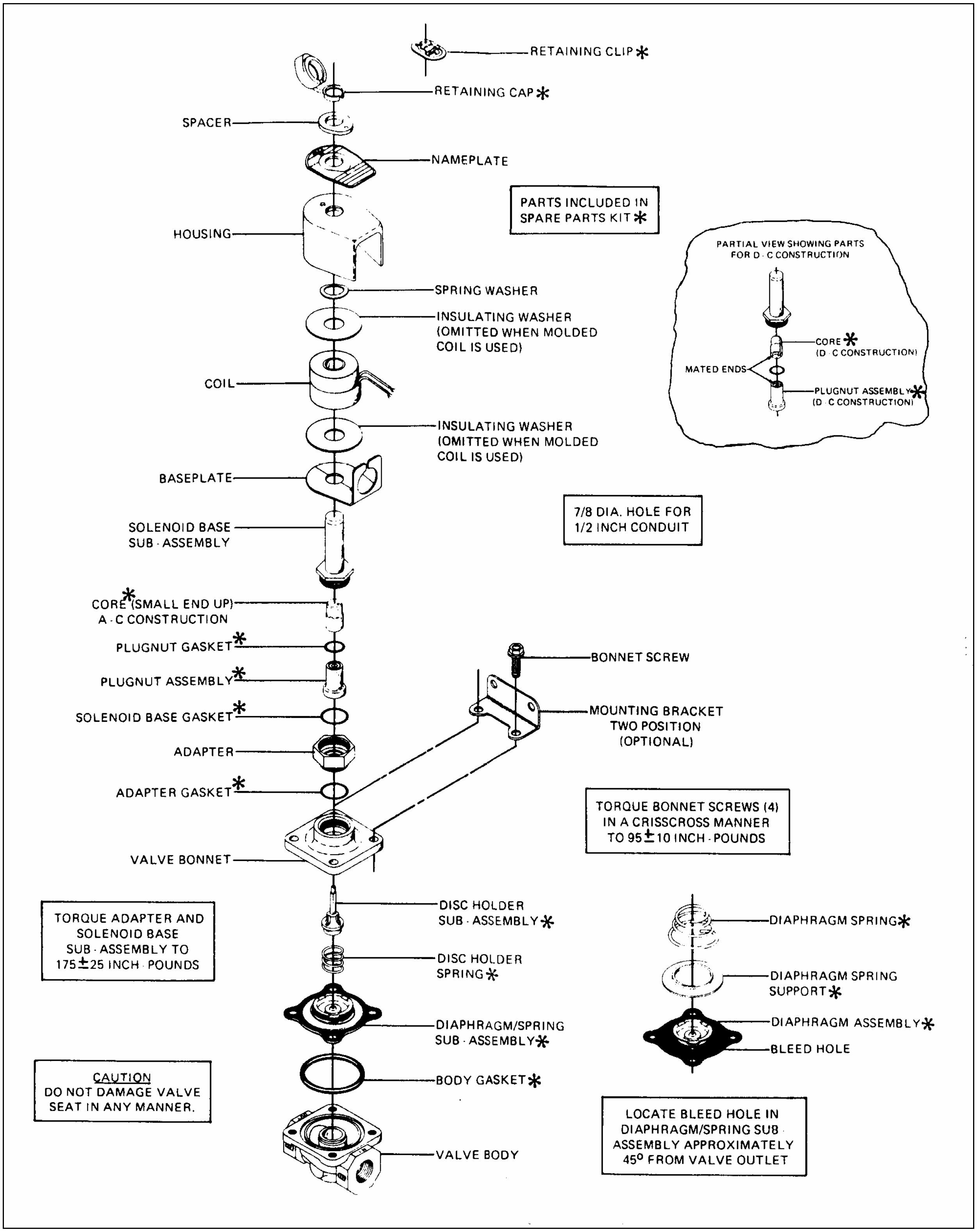


FIGURE 52: DRIVER'S WATER SOLENOID VALVE 22052

10.6 CENTRAL HOT WATER PNEUMATIC VALVE ASSEMBLY

10.6.1 Description

The flow of hot water to the vehicle's central heater core is controlled by a pneumatic NO 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 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.

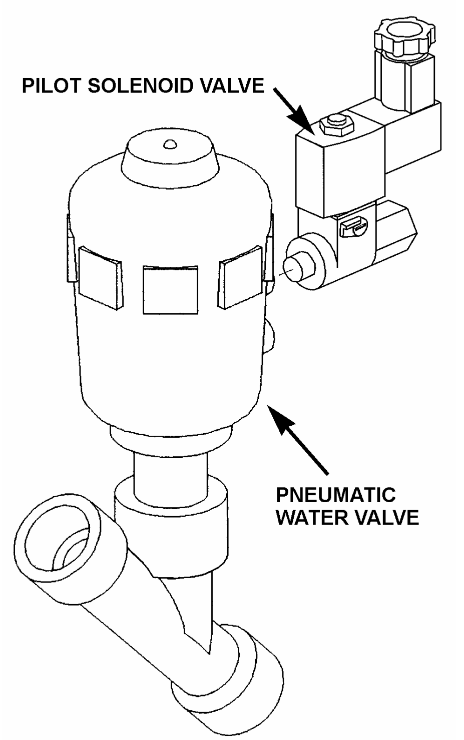


FIGURE 53: CENTRAL HOT WATER PNEUMATIC VALVE ASSEMBLY 22240

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.

10.6.2 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. 54).
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

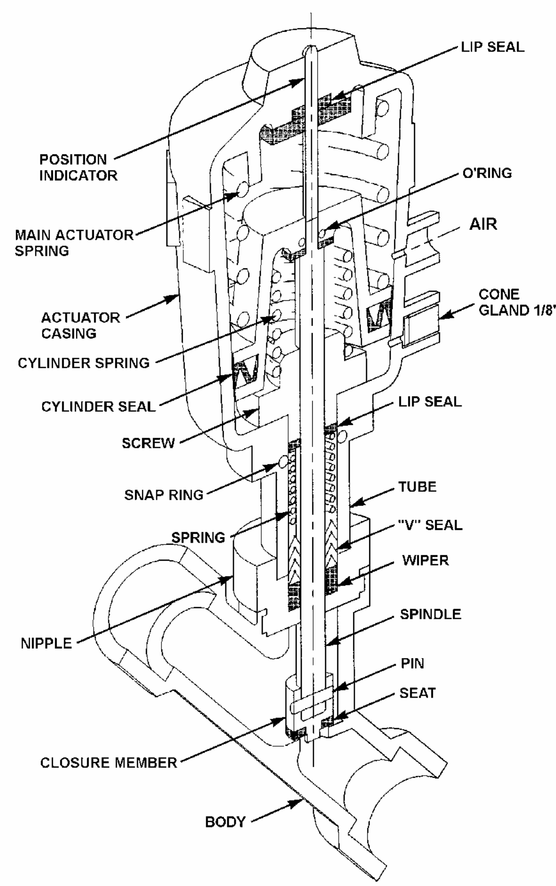


FIGURE 54: PNEUMATIC WATER VALVE 22241

10.6.3 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 54. Fasten pilot solenoid vale to the pneumatic water valve. Reconnect air supply pressure and electrical current to the pilot solenoid valve.
3. Check for proper operation.

10.6.4 Pilot Solenoid Valve

1. No maintenance is needed unless a malfunction occurs.
2. A pilot solenoid valve replacement seal kit is available: 871311.

10.6.5 Valve Troubleshooting

PROBLEM	PROCEDURE
Valve fails to close.	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.	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.

10.7 WATER RECIRCULATING PUMP

10.7.1 Converted Vehicles Equipped With Central A/C – System Description

This vehicle is provided with a water recirculating pump which is located in the evaporator compartment (Fig. 55). The water recirculating pump consists of a centrifugal pump and an electric motor which are mounted on a common shaft in a compact assembly. A pilot between the pump end and motor cover ensures proper alignment of the complete assembly.

The motor is equipped with prelubricated sealed ball bearings which require no maintenance. A self-adjusting mechanical shaft seal is incorporated in this assembly to prevent coolant leakage between the pump cavity and armature shaft. This seal derives its lubrication from the liquid pumped, and **it will be destroyed if permitted to operate dry.**

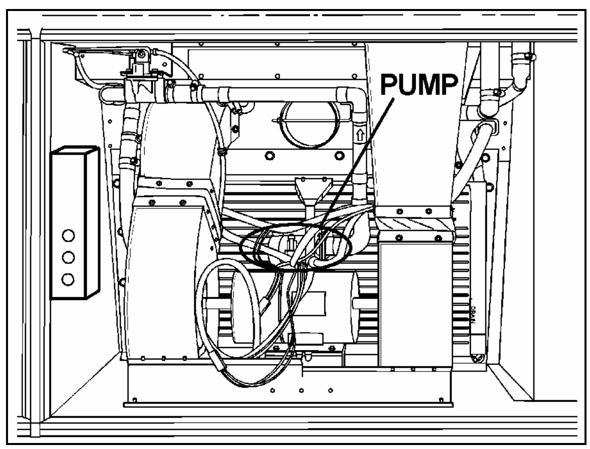


FIGURE 55: PUMP LOCATION (SHELL) 22178G

The pump requires no periodic maintenance other than replacement of motor brushes. Replacement of motor brushes can be performed without removing the pump assembly. Visual inspection of the pump, to determine if the shaft seal is intact, should be made while the pump is in operation. If there is evidence of coolant leakage, the unit must be disassembled for corrective measures.

Disassembly of the pump will be necessary only in the case of a seal leak, bearing failure, or motor failure.

10.7.1.1 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.

⚠ WARNING ⚠
Before proceeding with the following steps, check that coolant has cooled down.

4. Disconnect water lines from pump at connections between hoses and copper pipes (leave hoses connected to pump).
5. Remove the two clamps holding the pump motor to its mounting bracket. Remove the pump with the motor as an assembly.

10.7.1.2 Disassembly

1. Remove two brush caps (5) and two brush assemblies (4). When removing brushes, note the position of the brush in the tube. Brush life is significantly decreased if brushes are not replaced properly.
2. Remove the pump cover (item #11) by first removing the 4 head screws. Remove cover carefully to prevent damaging the O-ring (12) (disconnect hoses from cover only if required).
3. Remove O-ring (12).
4. Remove two hex nuts (7) retaining pump assembly to motor.
5. Remove acorn nut (9) and gasket (10), then remove impeller (8) and components of the pump seal assembly (14).

⚠ CAUTION ⚠
Do not scratch or mar the sealing surface of this seat, as its sealing feature will be affected, thus resulting in continuous leakage.

Inspection

Components removed from the recirculating pump and motor assembly should be compared with new parts to determine the degree of wear.

10.7.1.3 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.

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. New brushes have a six (6) degree angle. The brush should always be inserted so that the angle is open away from the pump end of the assembly (inset, Figs. 56).

   e. 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.

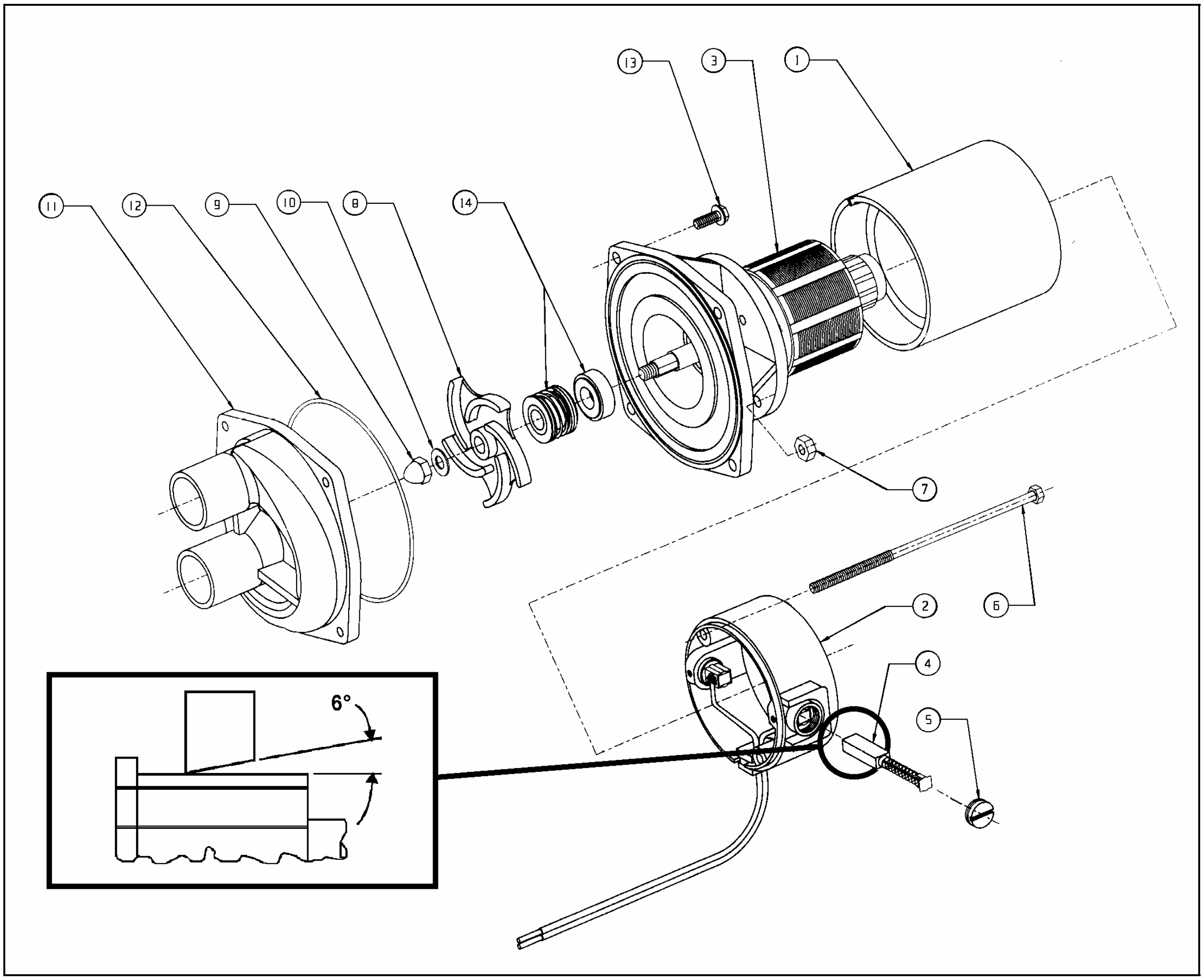


FIGURE 56: WATER RECIRCULATING PUMP (CONVERTED VEHICLE - CENTRAL A/C) 22091

ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
	MOTOR			**IMPELLER**	
	Motor Ass'y - Items 1-7	1	8	Impeller	1
1	Stator	1	9	Acorn Nut	1
2	End Frame Assembly	1	10	Gasket	1
3	Armature adapter Ass'y	1		**COVER**	
4	Brush Assembly	2	11	Cover - Housing	1
5	Cap (brush holder)	2	12	O-ring	1
6	Case bolt 10-32 X 5	2	13	Screw	4
7	10-32 Hex Nut	2		**SEAL**	
			14	Seal Assembly	1

10.7.1.4 Bearings

1. Rotate the motor shaft. If the ball bearings show evidence of wear, they should be replaced.

NOTE
When removing the armature from the motor, the number of washers and their arrangement should be noted. Improper numbers and/or installation of washers can cause improper tracking of brushes, which will result in excessive preloading of bearings and noisy operation.

2. To help prevent damaging the armature winding and/or the commutator, when removing the bearings, the use of a bearing puller is recommended.
3. Replacement bearings should be pressed into the same exact location as the original bearings.
4. It is recommended that a suitable sealant (such as Loctite or equivalent) be used between the shaft and the bearing, if the fit is not tight enough to prevent the shaft from spinning inside the inner race.
5. After replacing the bearings, check the position of the commutator in the motor by looking down into the brush tube. Neither the riser nor the edge of the commutator should be visible.

10.7.1.5 Commutator

1. The commutator is a precise assembly. Although it is solidly built and made of a fairly tough material, it can be easily ruined by careless handling.
2. The commutator should be refinished only on equipment which provides good concentricity and the proper finish.
3. The commutator should be refinished if a micrometer reading shows a difference between *"in track"* and *"off track"* diameter of 0.187" (4,7 mm) or more.
4. The commutator should be carefully undercut with a 0.025" (0,6 mm) or less slot width.
5. A 25 to 50 micromesh finish is desirable on a new or refinished commutator.
6. The commutator should not be touched with the fingers since sweat and body oils will rapidly discolor and oxidize its surface.

10.7.1.6 Miscellaneous

Inspect seal assemblies (14) to determine wear. If the seal has leaked, or is badly worn, it is recommended that a complete new seal assembly be installed.

10.7.1.7 Assembly

1. Install seal assembly (14).
2. Insert impeller (8) and secure with acorn nut (9) and gasket (10).
3. Install O-ring (12).
4. Attach cover (11) to the pump body using four screws (13).
5. Install motor brushes assembly (4) and brush caps (5).

10.7.1.8 Installation

1. Connect water lines to pump (hoses to copper pipes). Use a soapy water solution to help insert water lines.
2. Position the pump and motor assembly on the mounting bracket. Position the mounting clamps over the motor and secure with mounting bolts.
3. Connect electrical wiring to the pump motor.
4. Open shutoff valves. Refer to *"05 COOLING"* under heading *"Draining Cooling System"* for location of valves.
5. Fill the cooling system as previously instructed in this section under *"10.2 Filling Heating System"*, then bleed the system as previously instructed in this section under *"10.3 Bleeding Heating System"*.

10.7.2 Coaches Equipped With Central A/C or Driver’s A/C – System Description

This vehicle is provided with a water recirculating pump which is located in the evaporator compartment (Fig. 57) or in the reclining bumper compartment (optional with driver's system). The water recirculating pump consists of a centrifugal pump and an electric motor which are mounted in a compact assembly.

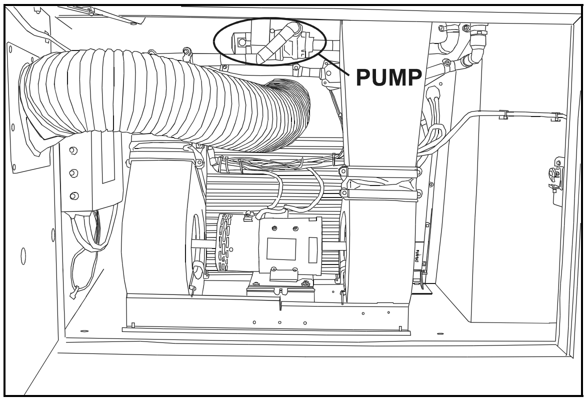


FIGURE 57: PUMP LOCATION (CENTRAL A/C) 22281

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.

10.7.2.1 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.

⚠ WARNING ⚠
Before proceeding with the following steps, check that coolant has cooled down.

NOTE
On driver's A/C system, remove residual coolant through coolant strainer. Also check strainer's condition; clean or replace if necessary.

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.

10.7.2.2 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.

10.7.2.3 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.

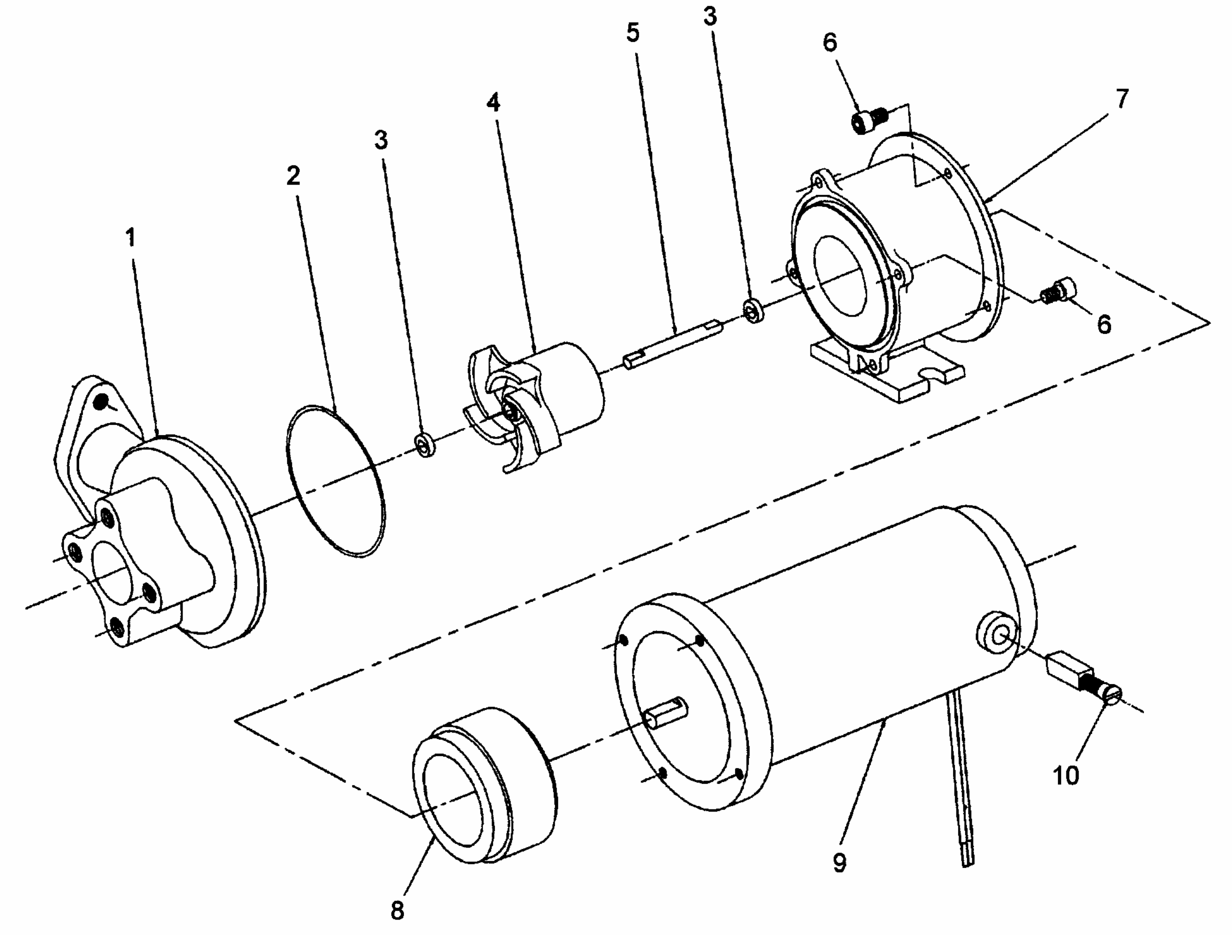


FIGURE 58: WATER RECIRCULATING PUMP (COACH - CENTRAL A/C OR DRIVER'S A/C) 22282

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.

10.7.2.4 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).

10.7.2.5 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 *"10.2 Filling Heating System"*, then bleed the system as previously instructed in this section under *"10.3 Bleeding Heating System"*.

10.8 WATER FILTER

10.8.1 Description

This vehicle is provided with a cleanable water filter, which is located in the evaporator compartment behind the R.H. side air duct. The filter uses the micronic principle of filtration which utilizes an accordion -pleated design for a maximum filtering area. A relief valve integrated to the filter element allows bypass of the filter in case of heavy restrictions.

Vehicles equipped with driver's A/C system only are provided with a water filter located in reclining bumper compartment.

10.8.2 Maintenance

Filter maintenance consists in changing the element at break-in 3000 miles (4 800 km), and subsequently every 50,000 miles (80 000 km) or once a year, whichever comes first.

NOTE
Service water filter each time soldering is performed at any point on coolant piping; operate heating system a few minutes first, so that soldering residues are routed to the strainer.

10.8.3 Servicing (Vehicles with central A/C system)

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.

WARNING
Before proceeding with the following steps, check that coolant has cooled down.

3. Rotate bowl (Fig. 59) counterclockwise and remove.
4. Remove filter element (Fig. 59) from housing.
5. Place new/clean element in housing, centering it on location in the head.
6. Inspect bowl seal and replace if necessary.
7. Replace bowl. Rotate clockwise and handtighten.

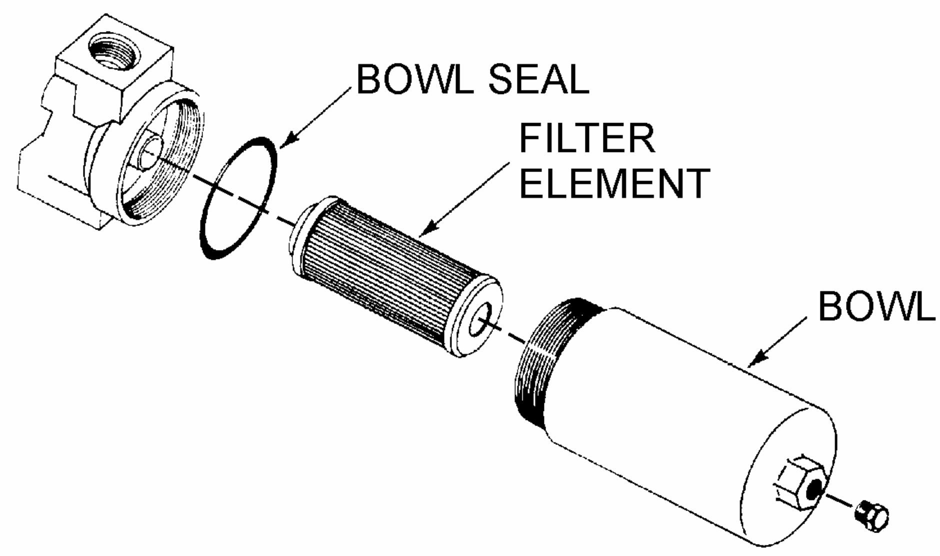


FIGURE 59: WATER FILTER 22057

8. Correct coolant level in surge tank as instructed previously in this section under *"Filling Heating System"*.

10.8.4 Servicing (Vehicles with driver's A/C system)

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.

⚠ WARNING ⚠

Before proceeding with the following steps, check that coolant has cooled down.

3. Unscrew the filter retaining plug.
4. Remove strainer, then clean inside strainer housing.
5. Using water under pressure, flush the strainer from the outside.
6. Reinstall strainer, then tighten the retaining plug.
7. Open shut-off valves.
8. Correct coolant level in surge tank as instructed previously in this section under *"10.2 Filling Heating System"*.

10.9 BY-PASS SOLENOID WATER VALVE (OPTIONAL)

This valve is optional and is installed only on vehicles equipped with a preheater. The valve is located in the evaporator compartment. This valve is similar to the driver’s solenoid valve (refer to Fig. 52 for part names).

10.9.1 To Remove or Change the Coil

* Stop engine and allow engine coolant time to cool.
* Close shutoff valves. Refer to *"05 COOLING"* under heading *"4.7 Draining Cooling System"* for location of valves.

<u>To remove the solenoid coil:</u>

First take out the retaining screw at the top of the coil housing. The entire coil assembly can be lifted off the enclosing tube.

<u>To reassemble:</u>

Make sure that the parts are placed on the enclosing tube in the following order:

1. Be sure to change electrical data plate according to coil specifications change.
2. Place coil and yoke assembly on the enclosing tube. Lay data identification plate in place.

3. Insert the coil retaining screw, rotate housing to proper position and tighten screw securely.

10.9.2 To Take the Valve Apart

To disassemble:

This valve may be taken apart by removing the socket head screws which hold the body and bonnet together. After removing the screws, carefully lift off the bonnet assembly (upper part of the valve). Don't drop the plunger. The diaphragm can now be lifted out. Be careful not to damage the machined faces while the valve is apart.

NOTE
The above procedure must be followed before brazing solder type bodies into the line.

To reassemble:

Place the diaphragm in the body with the pilot port extension up. Hold the plunger with the synthetic seat against the pilot port. Make sure the bonnet O-rings are in place, the bonnet assembly over the plunger, and that the locating sleeve in the bonnet enters the mating hole in the body. Insert body screws and tighten uniformly.

10.10 PREHEATING SYSTEM (OPTIONAL ON COACHES ONLY)

The preheater is located inside engine compartment and is accessible through L.H. side rear service compartment (refer to figure 60).

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.

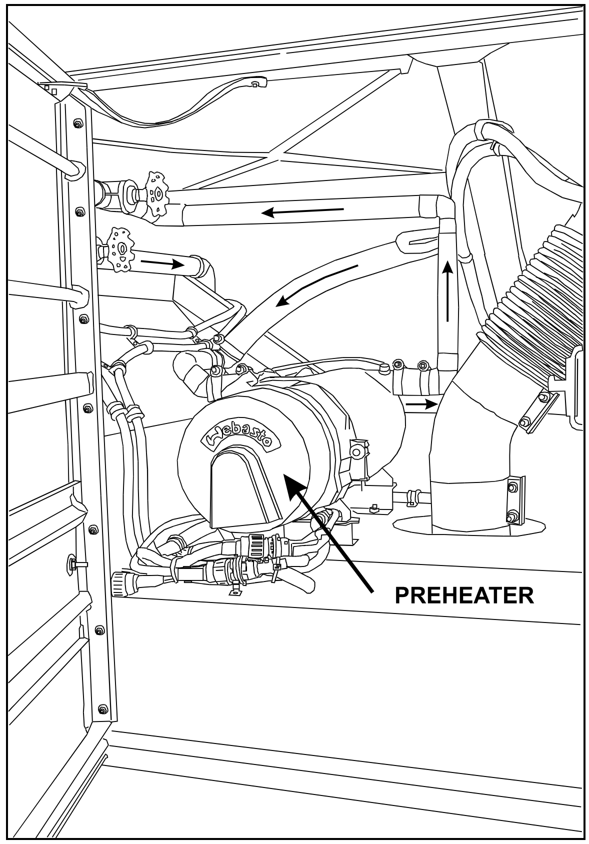


FIGURE 60: L.H. SIDE REAR SERVICE COMPART. 22245A

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.

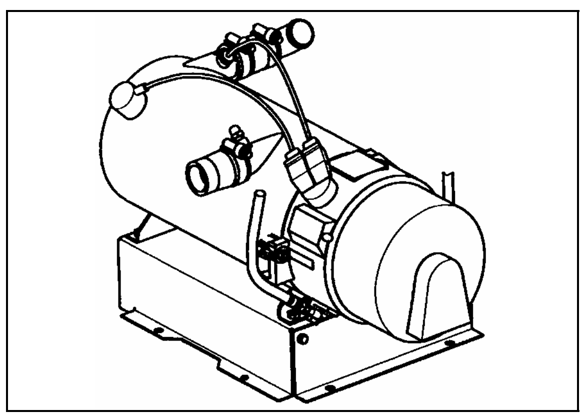


FIGURE 61: WEBASTO PREHEATER (104,000 BTU) 22224

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.

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.

10.10.1 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° ± 6°F (75° ± 3°C) and turns it on at 154° ± 9°F (68° ± 5°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.

10.10.2 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.

⚠ WARNING ⚠
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.

10.10.3 Timer Operating Instructions (Webasto)

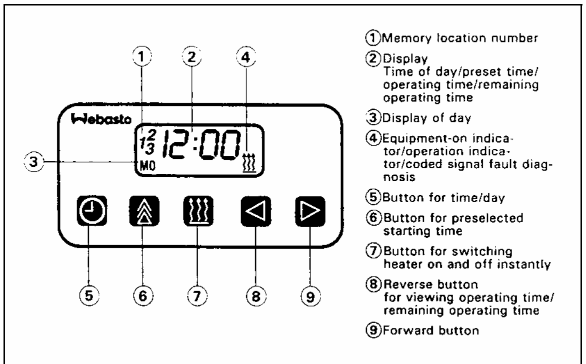


FIGURE 62: WEBASTO 18327

These instructions refer to the timer illustrated in figure 62. 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.

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
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.

10.10.4 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.

⚠ WARNING ⚠

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.

11. SPECIFICATIONS

Main evaporator motor

Make........US MOTOR
Type........T-17
Voltage........27.5 V DC
Current draw........68 amps
Horsepower........2
Revolution........1st :1400 rpm, 2nd : 1880 rpm nominal
Insulation........Class F
Motor Life........20 000 hours
Brush life........10 000 hours
Motor supplier number........D5092VPRC8
Motor Prevost number........563008
Brush Prevost number........562951

Condenser fan motors

Make........US MOTOR
Type........TF-12
Voltage........28.5 V DC
Current draw........20 amps
Horsepower........0.57
Revolution........1950 rpm
Insulation........Class F
Motor........20 000 hours
Brush life........10 000 hours
Qty........2
Supplier number........D591Y440PRC2
Prevost number........562579
Brush supplier number........9DB21003
Brush Prevost number........561914

Evaporator air filters (Central system) (Coach)

Make .... Permatron Corp.
Type .... Polypropylene
Supplier number .... IN 1X10X37 EXACT
Prevost number .... All vehicles (Top) 373336
Prevost number .... XL-40 vehicles (Bottom) 373338
Prevost number .... XL-45 vehicles (Bottom) 373337

Evaporator air filters (Central system) (Shell)

Make .... Permatron Corp.
Supplier number .... IN 13X21X1 NOMINAL
Prevost number .... (Qty = 3) 871034

Driver's unit evaporator motors

Make .... MCC
Voltage .... 24 V DC
Quantity 1
Supplier number 25-0250
Prevost number 871135

Driver's unit evaporator air filter

Make .... MCC
TYPE .... Recirculating air 6-¼" x 28" Washable
Supplier number 260593
Prevost number 871147

Make .... MCC
TYPE .... Fresh air 3-5/8" X 5-1/4" Washable
Supplier number 260594
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 lubrification)..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)
Supplier number, option R-134a 68PD541-104-38
Supplier number, option R-22 .... 68PD537-104-39
Prevost number, option R-134a 950314
Prevost number, option R-22 950207

A/C Compressor (Driver's and auxiliary systems)

Make……………………………………………………………………………………………………..Seltec
Model…………………………………………………………………………………………………..TM-16HD
Weight .... 10.9 lbs (4,9 kg)
Supplier number...18-00074-11
Prevost number.. 950372

Approved oil .... ZXL100PG (PAG)
Prevost number.. 950382

Compressor unloader valve

Make.. Carrier Transicold
Type ....Electric (AMC)
Voltage .... 24 V DC)
Watts 15
Supplier number (without coil) 17-40407-20
Prevost number (without coil) 950095
Coil supplier number 22-50030 (1)
Coil Prevost numbert.. 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
Supplier number.. 50-01122-90
Prevost number.. 950204

Compressor V belts

Make..Dayco
Model (matching set of 2) BX97
Prevost number (with Delco 270/300 Amp Alternator) 506664

Compressor V belt

Make..Dayco
Model.. BX100
Prevost number (with two BOSH Alternators) 506681

Condenser coil (Driver's and auxiliary systems)

Make..Valeo
Supplier number..
Prevost number..

Condenser coil (Central system) (XL2-40 vehicles and, XL2-45 & 45E Shells)

Make.. Carrier Transicold

Aluminum

Supplier number..68GF67-194-2

Prevost number.. 870654

Copper

Supplier number..68GF67-194-3

Prevost number.. 870729

Condenser coil (Central system) (XL2-45 Coach)

Make.. Carrier Transicold

Aluminum

Supplier number...68BC2-107

Prevost number.. 950259

Copper

Supplier number..68BC2-107-1

Prevost number.. 950260

Evaporator coil (Central system)

Make.. Carrier Transicold

Supplier number... 68BE2-105

Prevost number.. 871070

Receiver tank (with sight glasses)

Make.. HENRY

Maximum pressure... 450 psig

Supplier number...ARL-1217

Prevost number.. 950261

Filter Dryer assembly

Make.. AC&R HENRY

Supplier number...815031-XH9

Prevost number.. 950262

Moisture indicator

Make .... Henry

Supplier number MI-30-7/8S

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

Supplier number (without coil) RB9MP3-MM
Prevost number (without coil) 95-0054

Coil supplier number .... R23MM 24 V DC-CB

Coil Prevost number 950055

Repair kit Prevost number 950056

Driver's hot water solenoid valve

Make .... Asco

Type .... Normally open (without manual bypass)

Voltage .... 24 V DC

Current draw .... 0.47 amp.

Watts 11.2

Pressure range .... 0 to 100 psi

Max. temperature .... 220°F

Supplier number (with coil) 106-269-1

Prevost number (with coil) 870812

Coil Prevost number 870960

Repair kit Prevost number 870872

Hot water solenoid valve (Central system)

Make .... Burkert

Type .... Normally open

Voltage .... 24 V DC

Supplier number SYST-2000-456023-6012-427923B

Prevost number 871252
Seal kit, Water Side 871311
Seal kit, Actuator Side 871312
Seal kit, Pilot Solenoid Valve 871313

Water recirculating pump (Central system - Coach) & (Driver's system - Shell)

Make .... M.P. pumps
Voltage .... 24 V DC
Supplier number 30011
Prevost number 871342

Water recirculating pump (Central system - Shell)

Make .... M.P. pumps
Voltage .... 24 V DC
Housing .... Aluminum
Supplier number 29232
Prevost number 871032

Water filter (Central system)

Make .... Parker
Supplier number (with element) 15CN1238WP
Prevost number (with element) 871028
Element supplier number 925566
Element Prevost number 871029

Water filter (small A/C system)

Make .... BRAUKMANN
Supplier number T300B
Prevost number 870807

Driver’s expansion valve

Supplier number, option R-134a 26-0190
Supplier number, option R-22 26-0384
Prevost number, option R-134a 950221
Prevost number, option R-22 950282

Expansion valve (Central system)

Make..Alco
Model..TCLE 5-1/2
Supplier number...21059366
Prevost number...950320

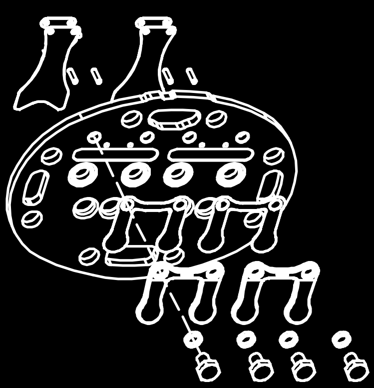
Bypass solenoid water valve

Make..Parker Hanninfin
Bypass supplier number RB21ME7-MM
Bypass Prevost number..870886
Coil supplier number R-23MM24VDC-CB
Coil Prevost number...870886
Repair kit supplier number 76754
Repair kit Prevost number 870980

Preheating system

Make...WEBASTO
Model... THERMO 300
Capacity ....104 000 Btu/h (30 kW)
Heating medium ....Coolant
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)
Supplier number...9002092A
Prevost number...871202

Compressor



WORKSHOP MANUAL

for

MODEL 05G TWIN PORT COMPRESSOR

62–11052 Rev A

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

DANGER – warns against an immediate hazard which WILL result in severe personal injury or death.

WARNING

WARNING – warns against hazards or unsafe conditions which COULD result in severe personal injury or death.

CAUTION

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.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

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).

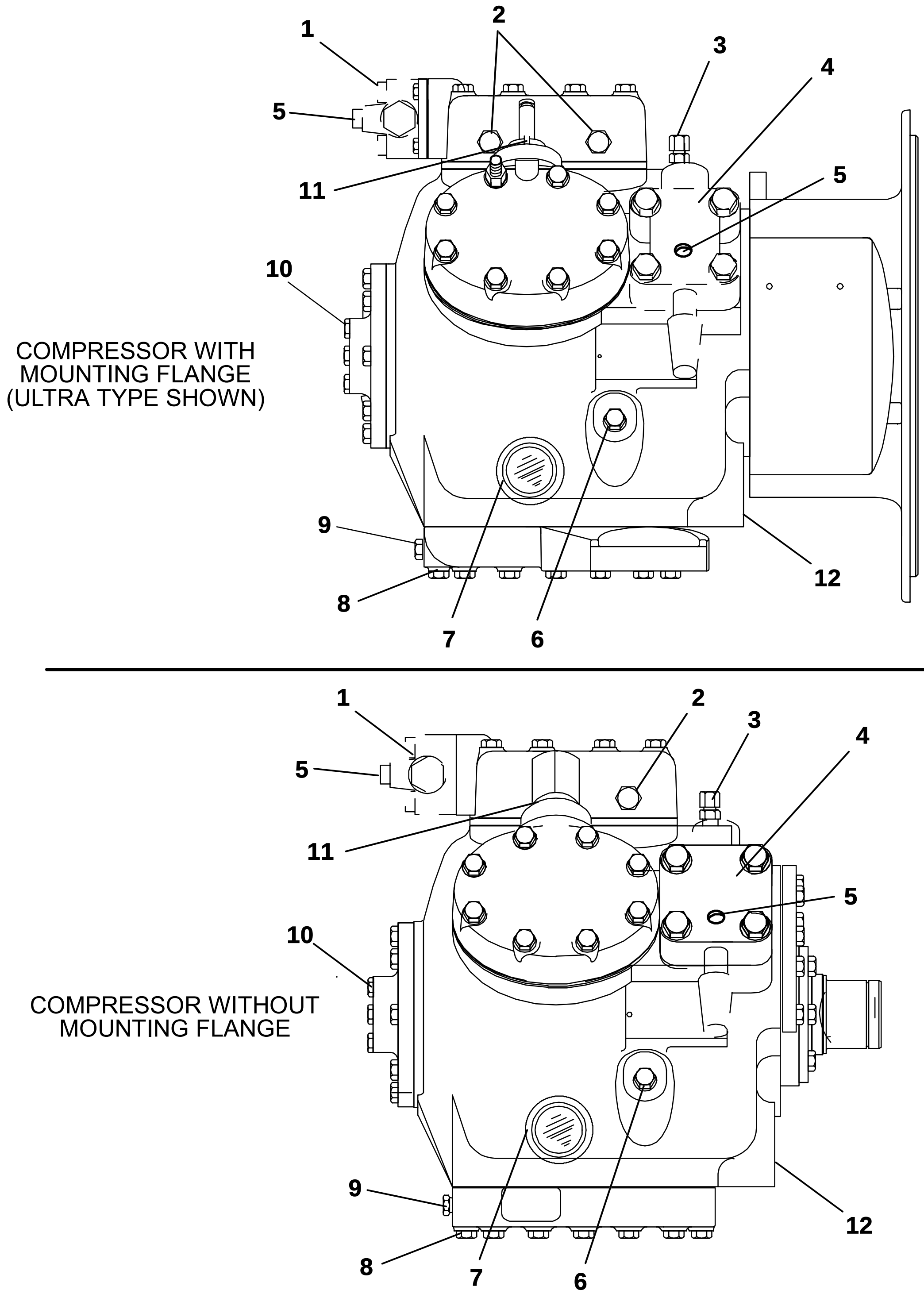
Table 1-2. Oils

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.



1. Discharge Service Valve
2. High Pressure Connection
3. Low Pressure Connection
4. Suction Service Valve
5. Guage Connection
6. Oil Fill Plug
7. Oil Level Sight Glass
8. Bottom Plate
9. Oil Drain Plug
10. Oil Pump (See Figure 1-3)
11. Unloader
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.

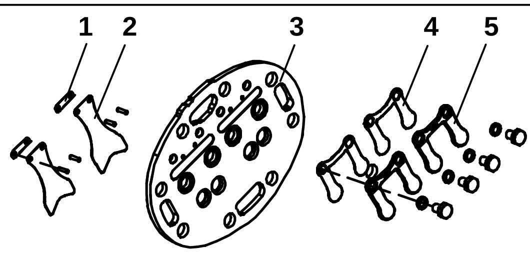
Turning the valve stem clockwise (all the way forward) will *frontseat* the valve to close off the suction or discharge line to isolate the compressor and open the gauge connection.

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 it's temperature and pressure. The compressed gas is prevented from re-entering the cylinder on it's next downstroke by the compressor discharge valve. (See Figure 1-2)



1. Valve Spring
2. Suction Valve
3. Valve Plate
4. Discharge Valve
5. Discharge Valve Backer

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.

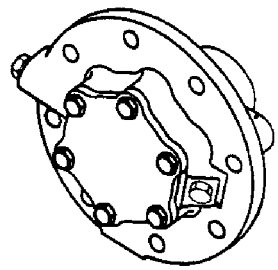


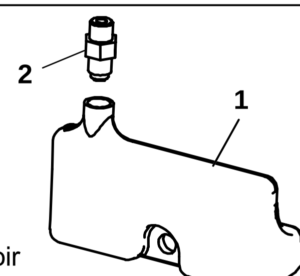
Figure 1-3. Oil Pump

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



1. Shaft Seal Reservoir
2. Access Valve (Coreless)

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.

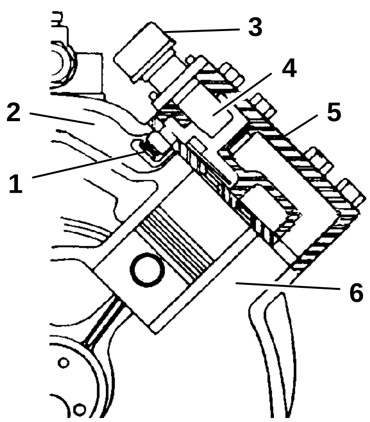
1.5 COMPRESSOR UNLOADERS

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.



1. Discharge Check Valve
2. Discharge Manifold
3. Solenoid Valve
4. Piston Bypass Control Valve
5. Cylinder Head
6. Suction Manifold

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.

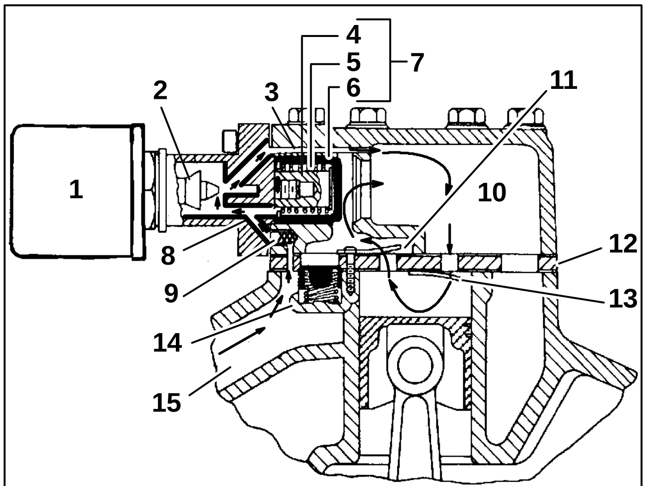
With the solenoid valve (1) *energized* the solenoid valve stem (2) will *open* the gas bypass port (3).

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.



1. Solenoid Valve
2. Valve Stem
3. Gas Bypass Port
4. Spring Guide
5. Spring
6. Piston
7. Piston Bypass Valve
8. Bleed Orifice
9. Strainer
10. Suction Cavity
11. Cylinder Discharge Valve
12. Valve Plate
13. Cylinder Suction Valve
14. Discharge Piston Check Valve Assembly
15. Discharge Manifold

Figure 1-6. Electric-Operated Unloader- Unloaded Operation

c. Loaded Operation

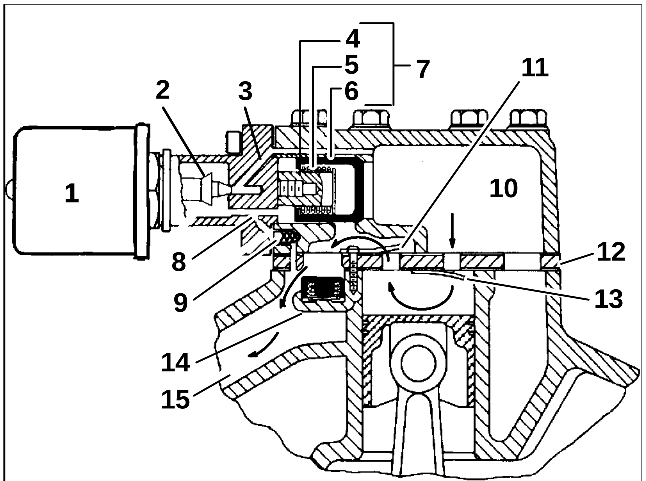
Discharge pressure bleeds from the discharge manifold (Figure 1-7, item 15) through the strainer (9) and bleed orifice (8) to the solenoid valve stem (2) chamber and the back of the piston bypass valve (7).

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.



1. Solenoid Valve
2 Valve Stem
3. Gas Bypass Port
4. Spring Guide
5. Spring
6. Piston
7. Piston Bypass Valve
8. Bleed Orifice
9. Strainer
10. Suction Cavity
11. Cylinder Discharge Valve
12. Valve Plate
13. Cylinder Suction Valve
14. Discharge Piston Check Valve Assembly
15. Discharge Manifold

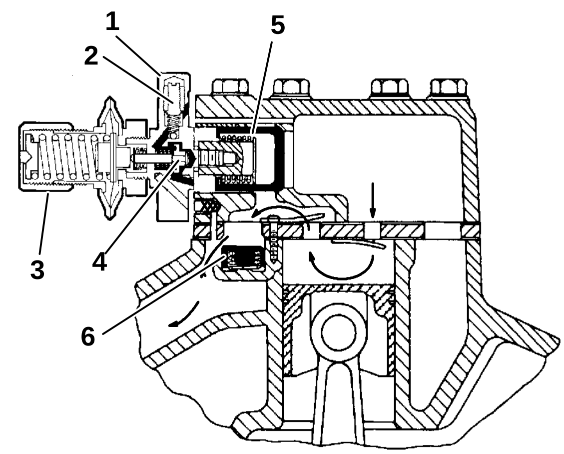
Figure 1-7. Electric-Operated Unloader- Loaded Operation

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).

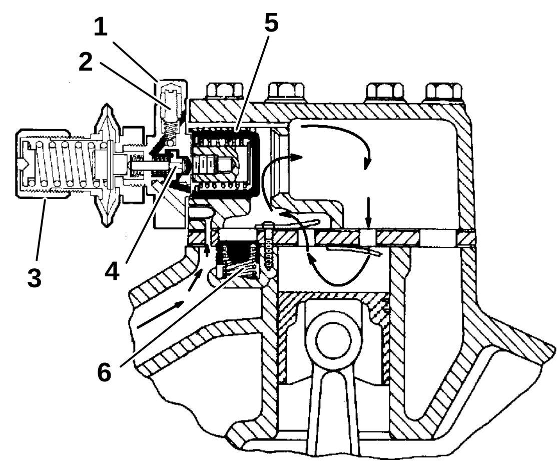
During *loaded operation*, (Figure 1-8) when suction pressure is above the valve control point, the poppet valve (4) will close. Discharge gas bleeds into the valve chamber; the pressure closes the piston bypass valve (5) and the cylinder bank loads up. Discharge gas pressure forces the discharge piston 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.



1. Sealing Cap
2. Pressure Differential Adjustment Screw
3. Control Set Point Adjustment Nut
4. Poppet Valve
5. Piston Bypass Valve
6. Discharge Piston Check Valve

Figure 1-8. Pressure-Operated Unloader Loaded Operation



1. Sealing Cap
2. Pressure Differential Adjustment Screw
3. Control Set Point Adjustment Nut
4. Poppet Valve
5. Piston Bypass Valve
6. Discharge Piston Check Valve

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.

a. 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.

b. Ensure power source is removed from any controls installed on the compressor.

c. Remove refrigerant from the compressor using a refrigerant recovery system.

d. Disconnect refrigerant lines at service valve flange connections on the compressor; retain hardware.

e. Remove any components necessary to gain access to the compressor or to enable removal.

f. Disconnect the drive mechanism at the compressor.

g. Remove mounting hardware and remove compressor from unit.

h. 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.

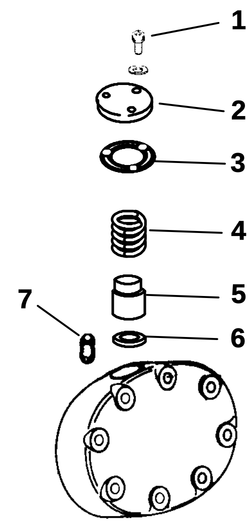
Service replacement compressors are furnished without suction and discharge service valves and unloader valves. The service valves are normally retained on the unit to isolate the refrigerant lines during compressor replacement. Blank-off pads are installed on the service replacement compressor valve 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

a. Remove the three socket head capscrews holding piston plug to cylinder head of the replacement compressor. See Figure 2-1.



1. Capscrews
2. Flange Cover
3. Gasket
4. Spring
5. Bypass Piston Plug
6. Seat Ring
7. Strainer

Figure 2-1. Removal of Piston Plug

b. 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.

c. 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.

d. 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.

e. 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).

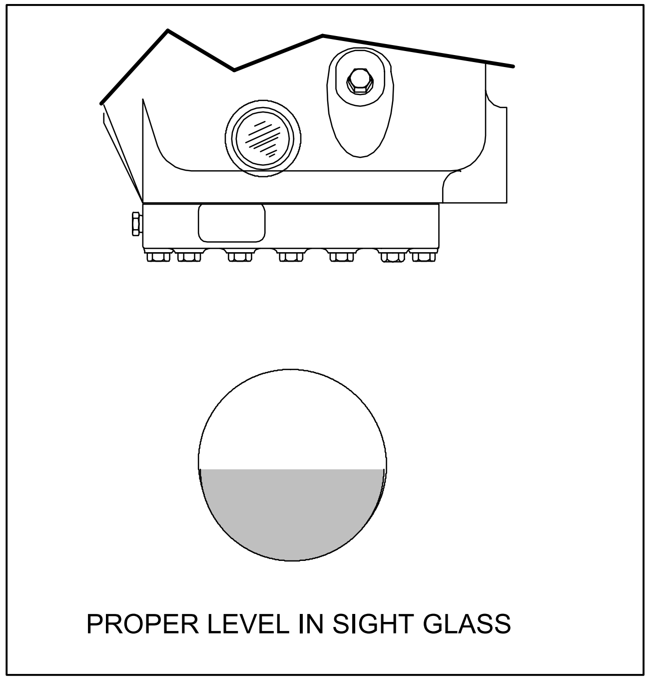


Figure 2-2. Oil Level in Sight Glass

SECTION 3

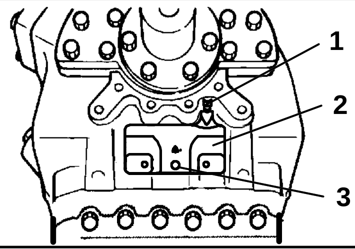
COMPRESSOR MAINTENANCE

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:

a. Remove the capscrew and washer that secures the reservoir to the crankcase.

b. Remove the reservoir and properly dispense of the contents.



1 Access Valve
2 Reservoir
3 Capscrew and Washer

Figure 3-1. Shaft Seal Reservoir

NOTE

Do not return this oil to the compresser. This oil is contaminated. Dispose this oil in an environmentally correct manner.

c. Return the reservoir to its mounting location insuring that the neck of the reservoir is seated over the access valve.

d. 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

a. Clean all parts with an approved solvent. Use a stiff bristle brush to remove dirt from grooves and crevices.

b. Inspect all parts for wear and overall condition. Replace any defective or excessively worn parts.

c. Inspect suction and discharge valve seats (on valve plate).

d. If unloaders are installed, inspect operation of unloader.

e. After cleaning, ensure all moving parts are coated with compressor oil before reassembly.

f. 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

WARNING

Do not unscrew capscrews all the way before breaking seal. Entrapped pressure could result in injury.

a. 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)

b. Remove the discharge valve capscrews, lock washers, stops, and valves.

c. 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.

d. Discard valves and gaskets. Use only new valves and gaskets when assembling cylinder head and valve plate assemblies.

3.4.2 Reassembly

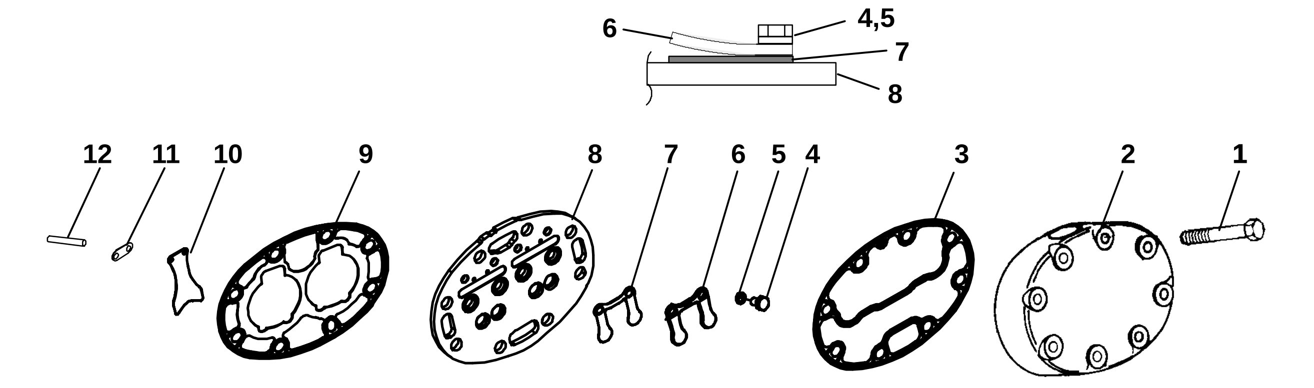
Install only new valves and gaskets, do not interchange valves.

a. 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.

b. Turn the valve plate over.

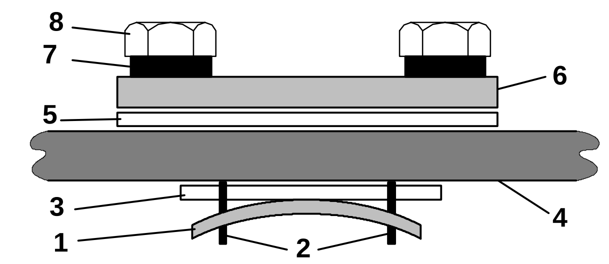
c. Place suction valve on dowel pins.

d. Install the suction valve spring on the dowel pins with the spring ends bearing away from the cylinder head. (See Figure 3-3)



1 Capscrew
2 Cylinder Head
3 Cylinder Head Gasket
4 Capscrew
5 Lockwasher
6 Discharge Valve Backer
7 Discharge Valve
8 Valve Plate
9 Valve Plate Gasket
10 Suction Valve
11 Suction Valve Spring
12 Dowel Pin

Figure 3-2. Cylinder Head & Valve Plate



1. Valve Spring
2. Dowel Pin
3. Suction Valve
4. Valve Plate
5. Discharge Valve
6. Discharge Valve Backer
7. Lockwasher
8. Capscrew

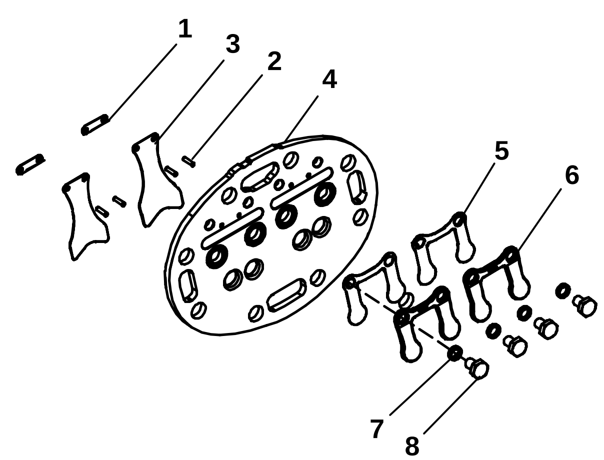


Figure 3-3. Installing Suction Valves

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 capscrews, 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 capscrews, in a diagonal pattern, to a value shown in Table 3-1.

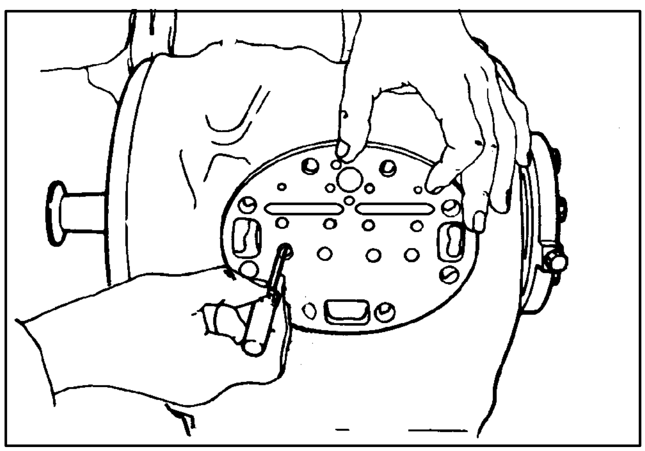


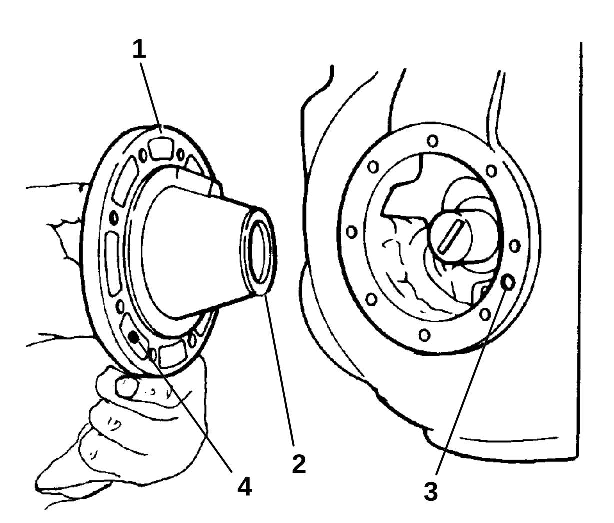
Figure 3-4. Checking Suction Valve

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.)

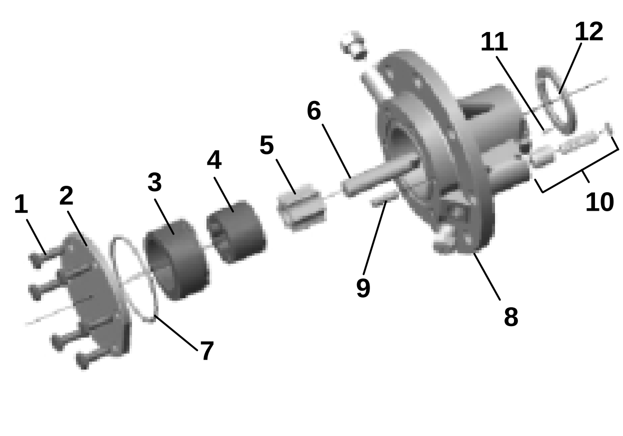


1. Oil Pump & Bearing Head
2. Thrust Washer
3. Oil Pickup Tube
4. Oil Inlet Port

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.)

⚠ CAUTION

Ensure that thrust washer does not fall off dowel pins while installing oil pump.

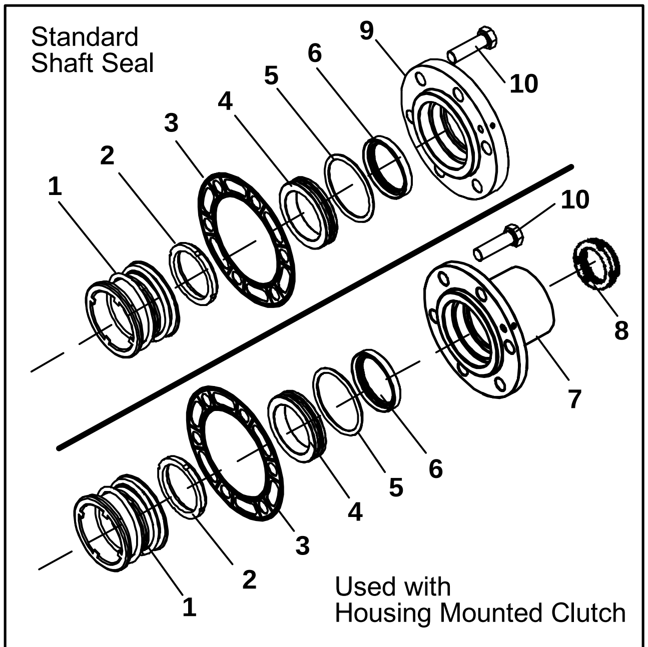
b. Install the bearing head assembly with a new gasket on the compressor crankshaft. Carefully push oil pump on by hand ensuring that the thrust washer remains on the dowel pins, the tang on the end of the drive engages the slot in the crankshaft, and the oil inlet port on the pump is aligned with the 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)

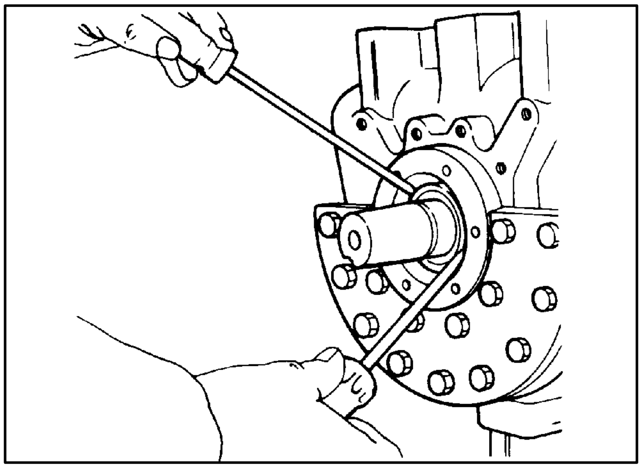


Figure 3-8. Shaft Seal Removal

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 lipseal 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).

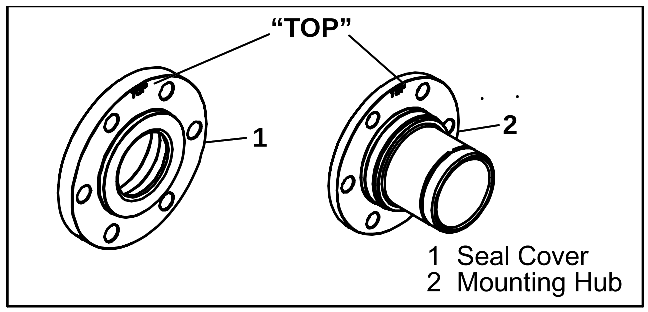


Figure 3-9. TOP Orientation

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 aseemblies, 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.

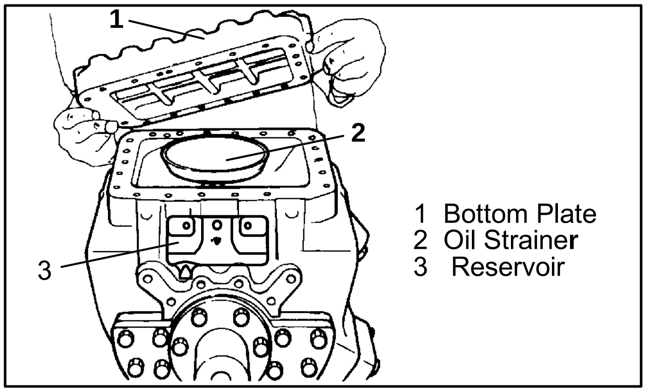


Figure 3-10. Bottom Plate Removal

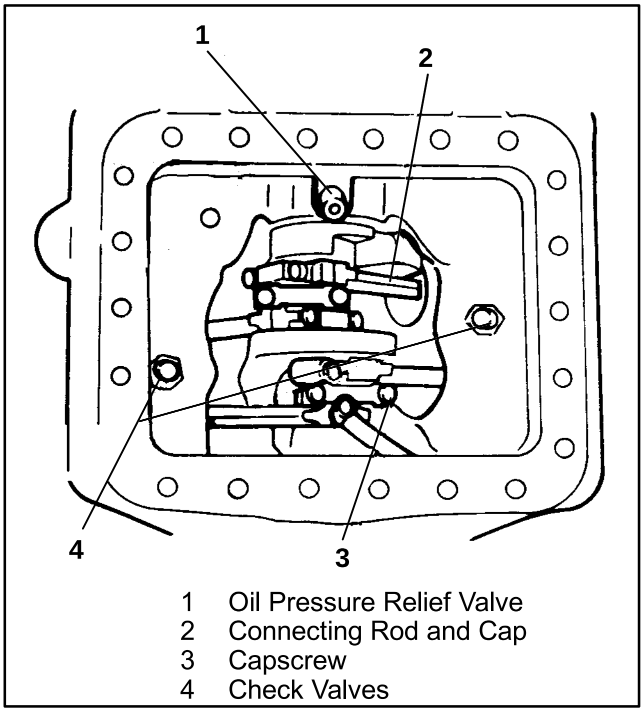


Figure 3-11. Bottom Plate and Oil Strainer Removed

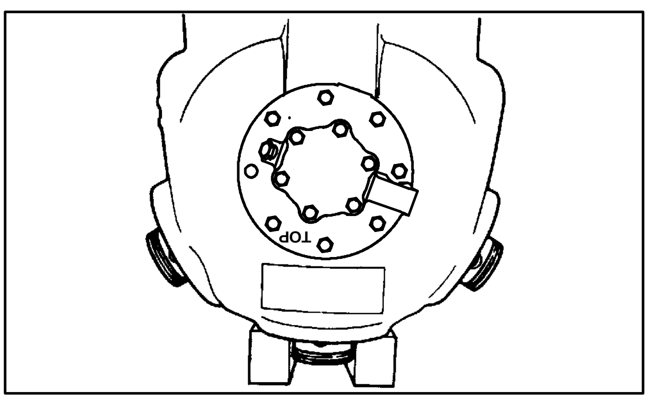


Figure 3-12. Piston Rings Removed

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

⚠ CAUTION

Do not allow crankshaft to drop on connecting rods inside the crankcase when removing the crankshaft.

a. Push piston rod assemblies out of the way and remove crankshaft and seal end thrust washer.

b. 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.

c. 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.

d. Remove piston rod assemblies.

3.7.3 Pistons, Rods, and Rings

a. 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.

b. Match mark and disassemble pistons, pins, connecting rods, and caps. (See Figure 3-13)

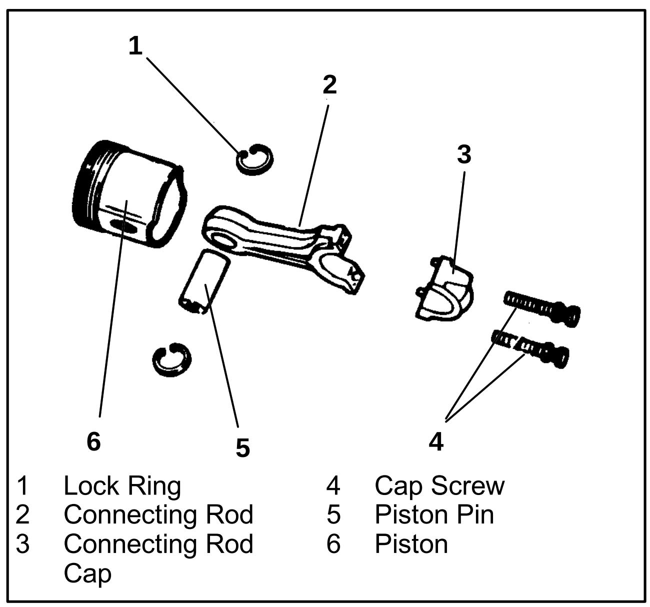


Figure 3-13. Connecting Rod, Piston, and Pin

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.

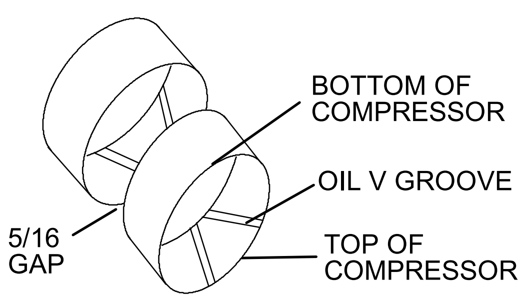


Figure 3-14. Seal End Main Bearings

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.

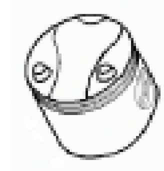


Figure 3-15. Piston

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.

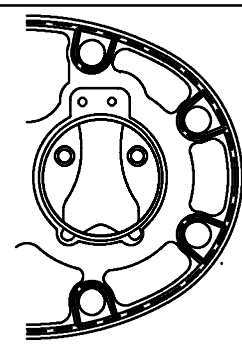


Figure 3-16. Correct Piston in Cylinder Orientation

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)

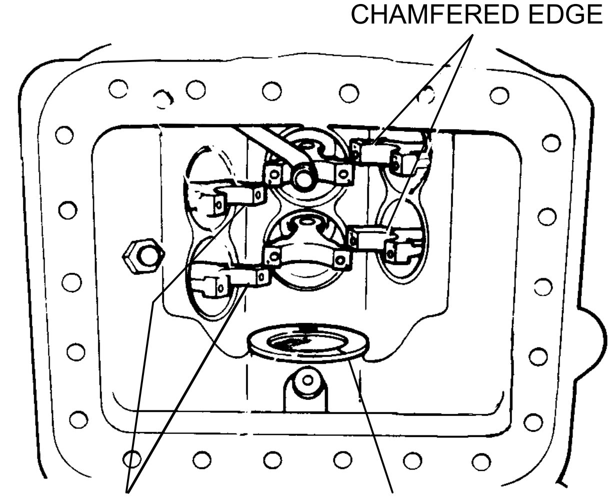


Figure 3-17. Installing Piston Rod Assemblies and Seal End Thrust Washer

c. The compressor will be fitted with double ring pistons.

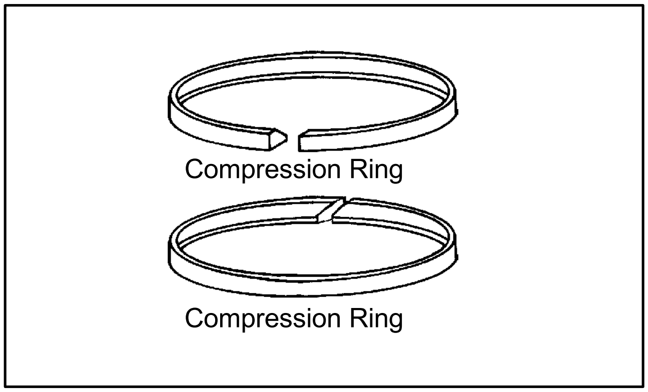


Figure 3-18. Piston Rings

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

a. 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).

b. 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

a. 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.

b. 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.

c. 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.

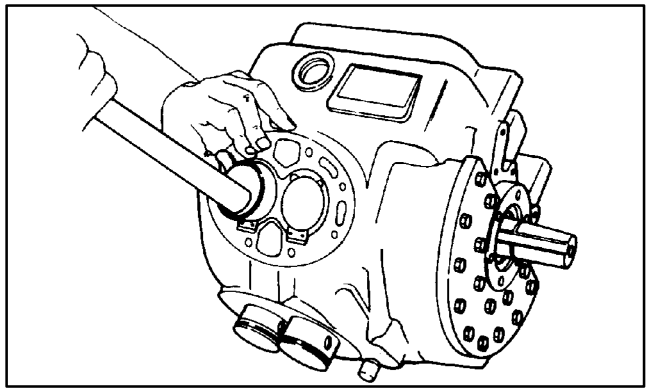


Figure 3-19. Installing Pistons

d. Clean and reinstall the oil strainer.

e. 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.

f. 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.

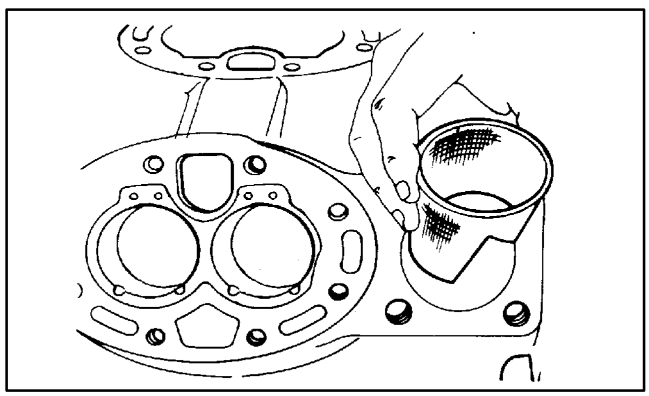


Figure 3-20. Installing Suction Strainer

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 FT-LB	TORQUE RANGE MKG	USAGE
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
1/4	20	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
1/4	28	8 to 18	1.1 to 2.5	Unloader Valve
1/4	28	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
5/16	18	20 to 30	2.8 to 4.1	Discharge Service Valve
3/8	16	8 to 15	1.1 to 2.1	Oil Reservoir
3/8	16	30 to 50	4.1 to 6.9	Bottom Plate – Crankcase
3/8	16	30 to 50	4.1 to 6.9	End Flange – Crankcase
3/8	16	30 to 50	4.1 to 6.9	Shaft Seal Cover
3/8	16	30 to 50	4.1 to 6.9	Pump End Bearing Head
3/8	16	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

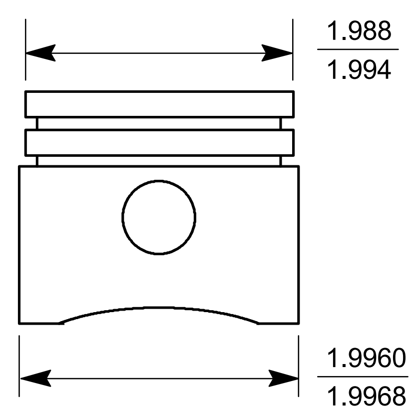


Figure 3-21. Piston Dimension (Wear Limits)

INDEX

C

L

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P

R

S

T

U

W

Carrier Transport Air Conditioning
50 Grumbacher Road
York PA 17402 USA
Tel: 1-800-673-2431
Fax: 1-717-764-0401

North America
Carrier Transicold
700 Olympic Drive
Athens, GA 30601 USA
Tel: 1-706-357-7223
Fax: 1-706-355-5435

Central America and Mexico
Ejercito Nacional No. 418
Piso 9, Torre Yumal
Col. Chapultepec Morales
11570 Mexico, D.F.
Tel: (5255) 9126.0300
Fax: (5255) 9126.0373

Carrier
A United Technologies Company

Carrier Transicold Division,
Carrier Corporation
Truck/Trailer Products Group
P.O. Box 4805
Syracuse, N.Y. 13221 U.S A

www.carrier.transicold.com

Carrier
TRANSICOLD

Housing-Mounted Clutch Installation

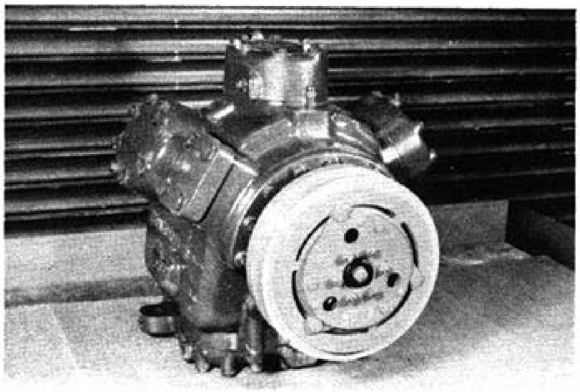
The procedure on the attached pages should be followed carefully when servicing the Carrier Transicold housing-mounted clutch. The following tools are recommended when removing and replacing this clutch:

TOOL LIST

DESCRIPTION	CTC PART NO. (WHERE APPLICABLE)
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

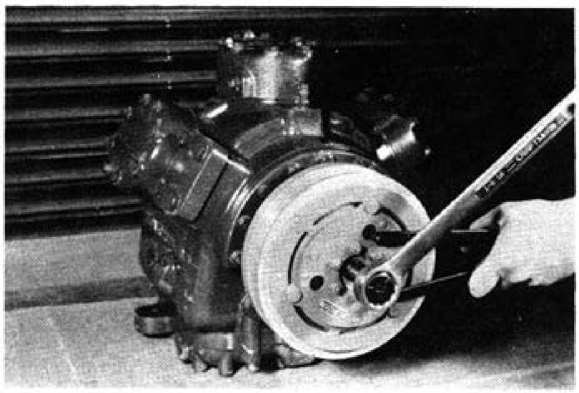
The new housing-mounted electric clutch, HMC, eliminates drive belt loading on the 05G crankshaft, and applies this load directly to the crankcase of the compressor. The following procedure should be followed carefully whenever it becomes necessary to remove and replace the HMC.



Housing-Mounted Clutch Removal

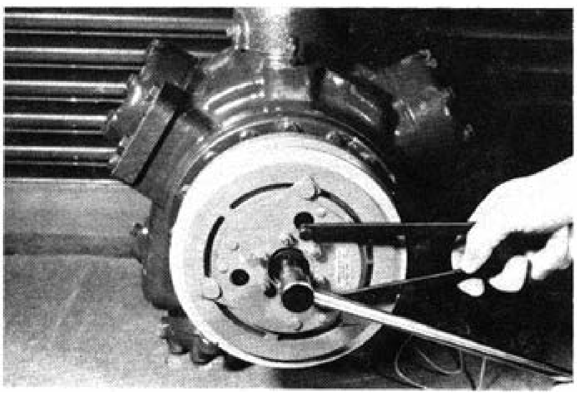
CAUTION: Remove drive belt before attempting to remove clutch.

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.

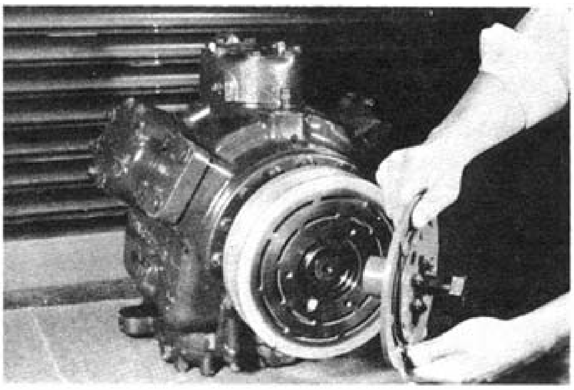


2. Install a 7/8-14 x 2″ capscrew into the center hole of the armature assembly. Use this capscrew as a jacking bolt to remove the armature assembly. Use tool 07-00240-01 as in Step 1 to prevent crankshaft rotation.

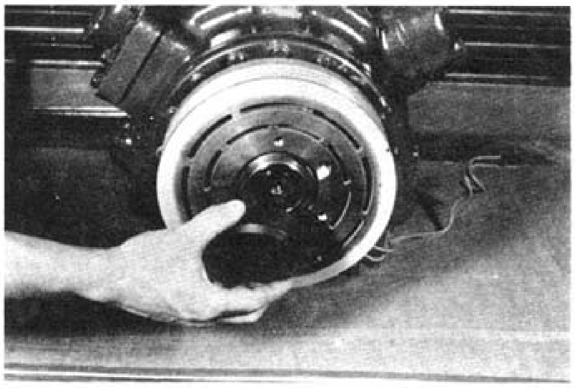
Note: Do not use a puller or pry against the armature hub or bumper plate, as this could cause damage to these parts.

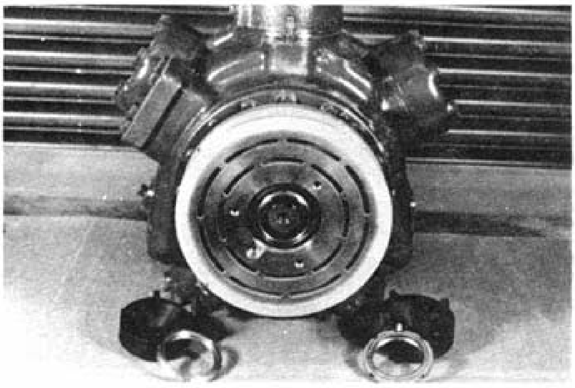


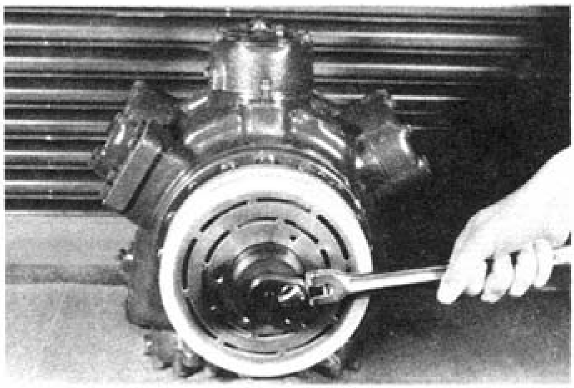
3. Remove the clutch armature assembly from the compressor crankshaft as a complete assembly, as shown.



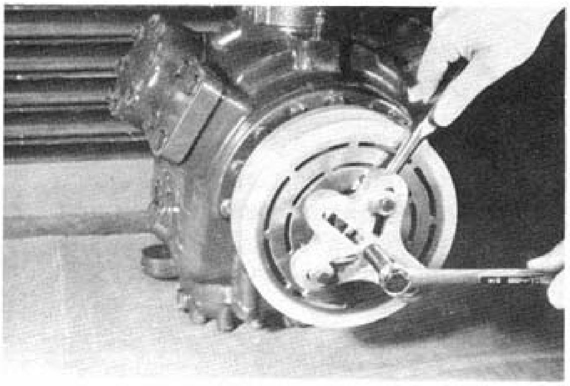
4. Remove the rotor retaining nut with special CTD tool P/N 07-00242-01.





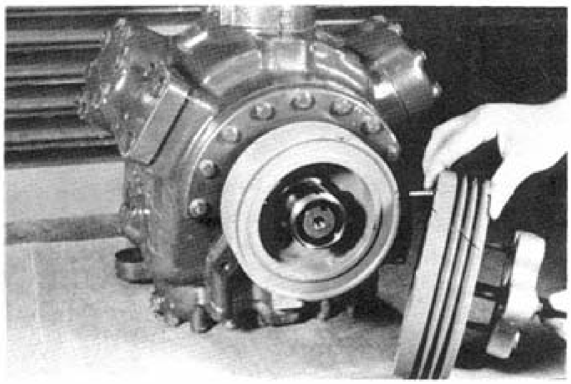


5. Install a flange-type gear puller into the three 5/16-18 tapped holes in the clutch rotor assembly, as shown.

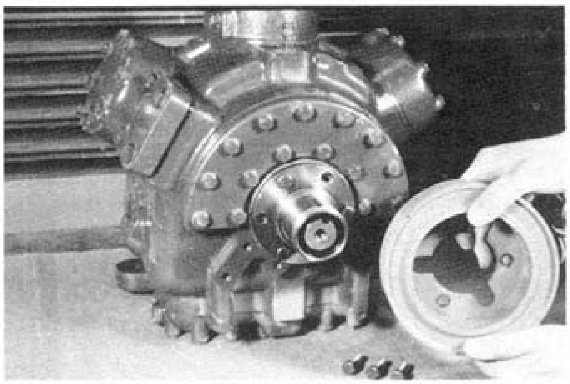


CAUTION: Use a washer or other protective device to prevent damage to crankshaft and threaded hole in the crankshaft by the puller. Never use a puller in the belt grooves, as damage to the rotor may result. Use a pry bar as shown to prevent rotation of the clutch rotor.

6. Once the rotor has been pulled from the clutch bearing mounting hub, carefully lift the rotor assembly away from the compressor, as shown.

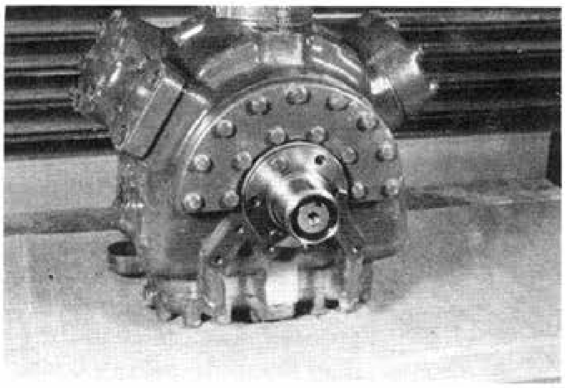


7. To remove the clutch coil, disconnect the coil's electrical cable from the wiring harness. Then remove only the three 3/8-16 capscrews holding the coil to the flange of the clutch bearing mounting hub, and carefully remove the coil, pulling straight out from the flange. Do not pry coil off, as it 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.



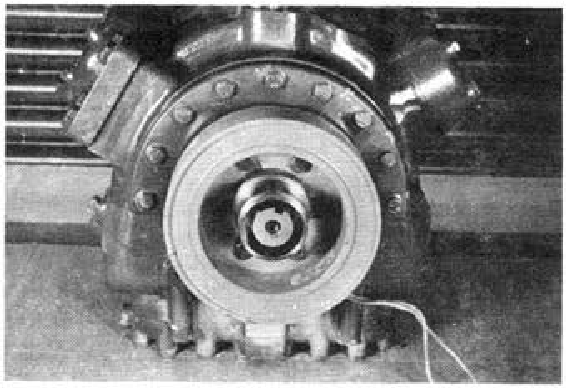
2. Inspect coil for damaged power leads, bent or cracked mounting plate, or burned or cracked potting material.

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.



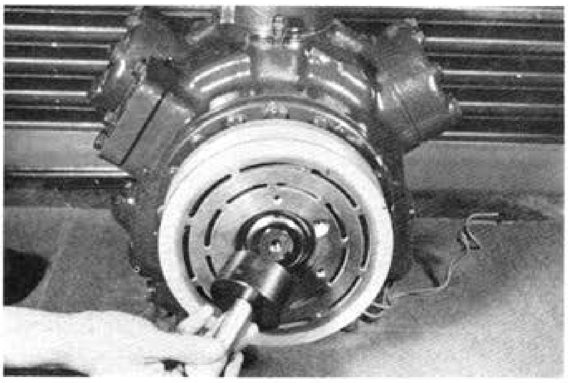
5. Secure the coil to the bearing mounting hub flange with the three 3/8-16 capscrews removed in Step 7 of Clutch Removal. Torque capscrews to 25-30 ft-lb (3.46-4.15 MKG).

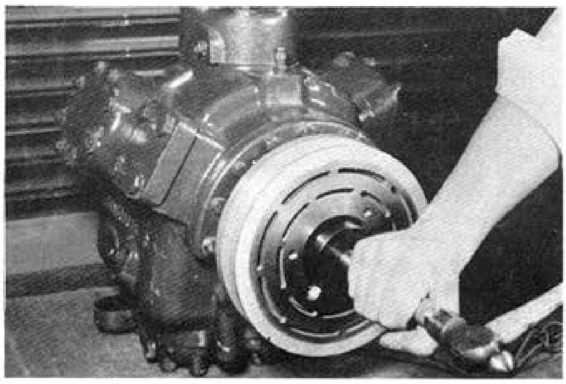
CAUTION: Do not draw coil onto the clutch bearing mounting hub flange with the capscrews, as this may distort the coil.

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.

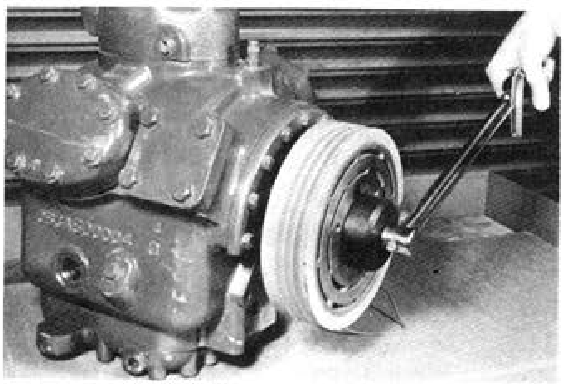




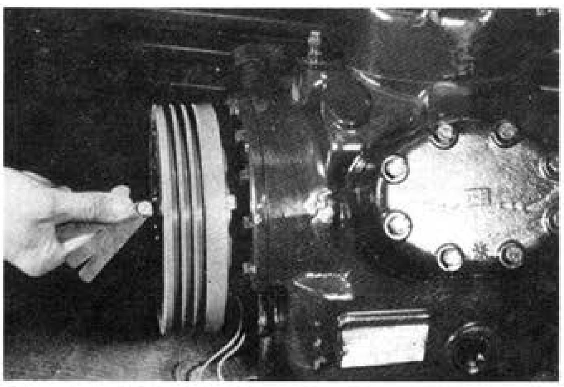
8. Install bearing retaining nut on clutch mounting hub and use torque wrench to tighten.

   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.

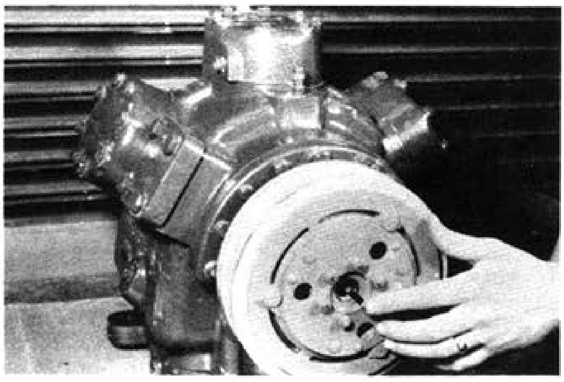


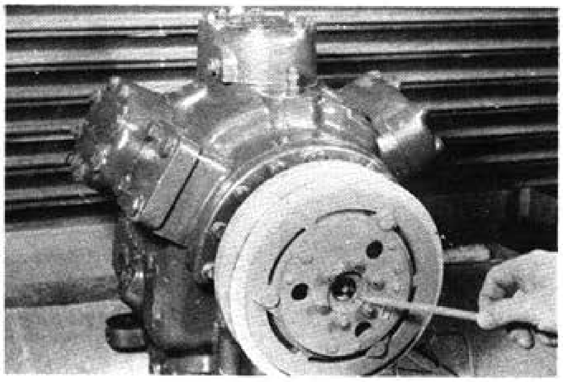
9. Check coil to rotor clearance by inserting .020 thick by .156 wide (max.) feeler gauge through an outer slot in rotor, as shown. Insert the feeler gauge so it extends beyond the rear face of the rotor and rotate the rotor one full turn. There should be no rubbing or binding.



10. Place armature and hub assembly onto the compressor crankshaft and insure the hub seats on the crankshaft properly.

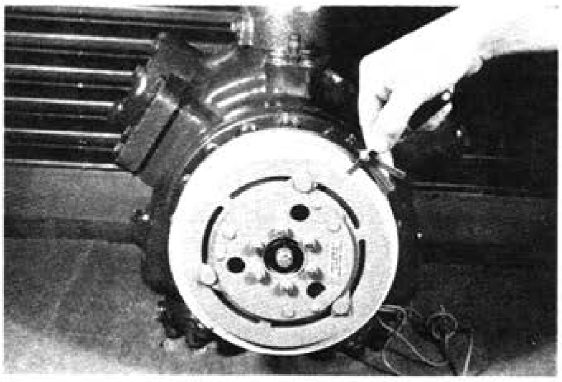
11. Insert the special key CTD P/N 68G2-9072 (1.75 x .250 x .199) in the keyway until outer end of key is flush with the hub's counter bore, as shown.





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.

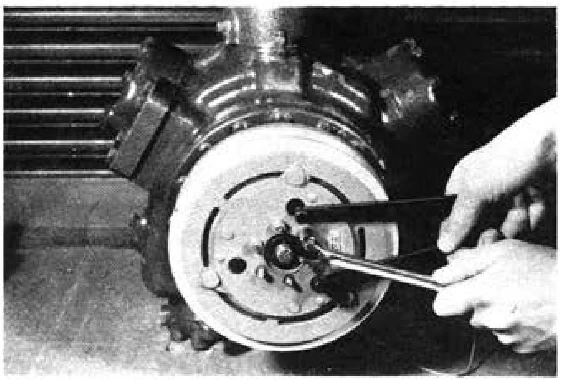
Steps 13-19 are for new clutch installation only. After the initial adjustment, shim stack should not be changed.



13. Measure the air gap between the armature and rotor surfaces, as shown.

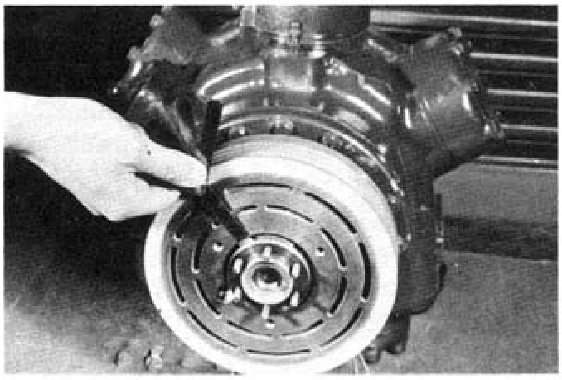
14. Record this measurement and determine the amount of shims that must be removed to obtain a 030/.060 air gap. The shims consist of (one) .010 and (six) .020 shims.

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).

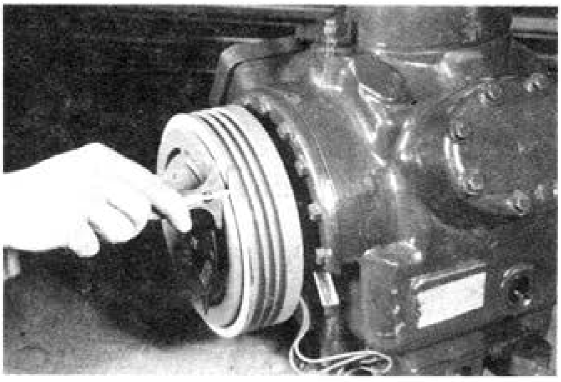
CAUTION: Do not give extra strokes "for good measure" as premature clutch performance degradation may result.

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.

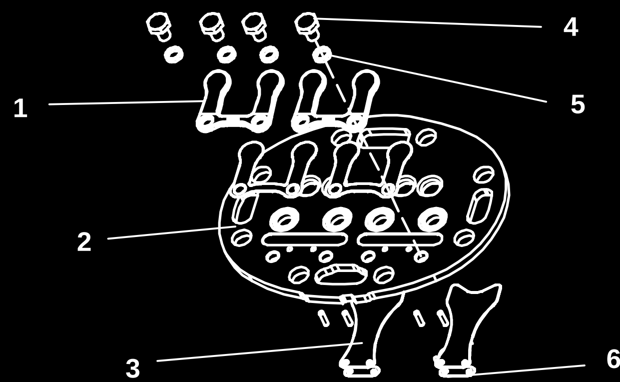
NOTE: Do not attempt to readjust the armature travel by removing shims. A catastrophic clutch failure may result. After initial (new) air gap adjustment the shim stack should never be changed.

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 replaced.

C) If raised ribs on friction face are worn flat or nearly flat, replace armature and rotor assemblies.

Compressor



SERVICE PARTS LIST

for

MODEL 05G TWIN PORT COMPRESSOR

62-11053 Rev A

Service Parts List

Model
05G Twin Port Compressor

CONTENTS

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 O5G 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
18-00091-104	6GDG00BUA0313A	18-00059-128RM	Ultra Bottom Cover, **37 CFM**, Contoured Pistons, Ultra Flange With Clutch Hub, 2 Electric Unloaders, No Oil	Trailer With Standby
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)
18-00091-150	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.

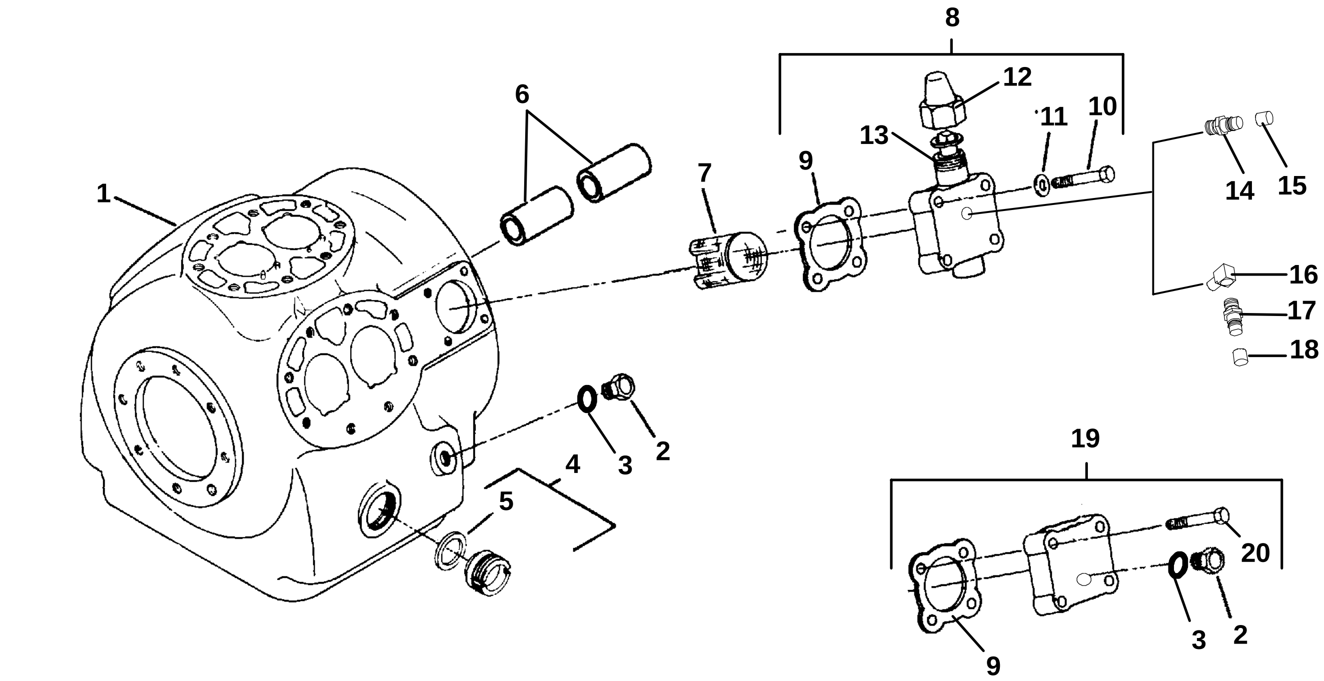
COMPRESSOR OIL CHART

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

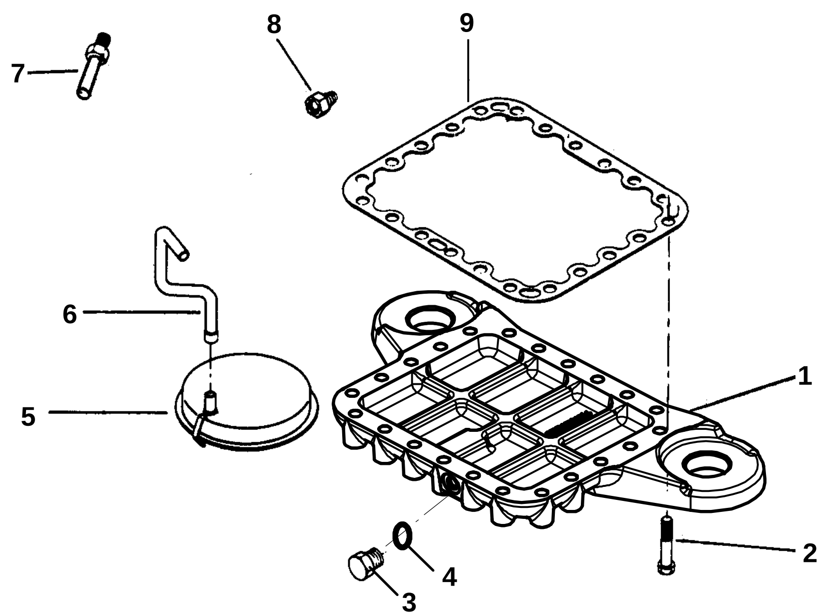
Refer to the unit operation and service manual for the correct procedure for checking compressor oil level.

1 CRANKCASE AND SUCTION SERVICE VALVE



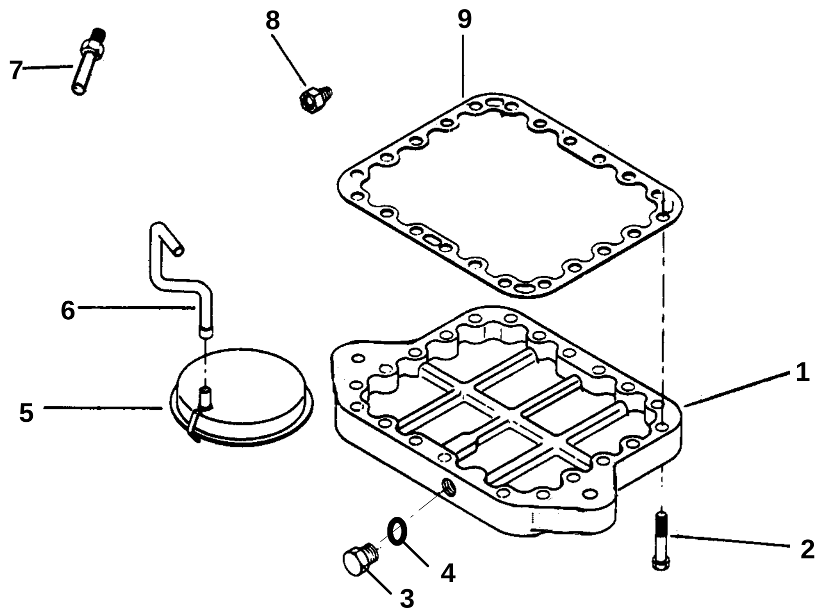
Item	Part Number	Description	Qty
1	NSA	Crankcase	1
2	17-44037-00	Plug, O-Ring, 7/16-20 - Includes:	1
3	42-00243-07	O-Ring	1
4	17-10218-00	Sight Glass, Oil Level - Includes:	2
5	17-10218-02	Gasket (Fiber)	1
	17-44021-00	Gasket (Metal)	1
6	17-44015-00	Bearing, Main Seal End (Requires Line Boring)	2
7	17-44005-00	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:	1
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)	1
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



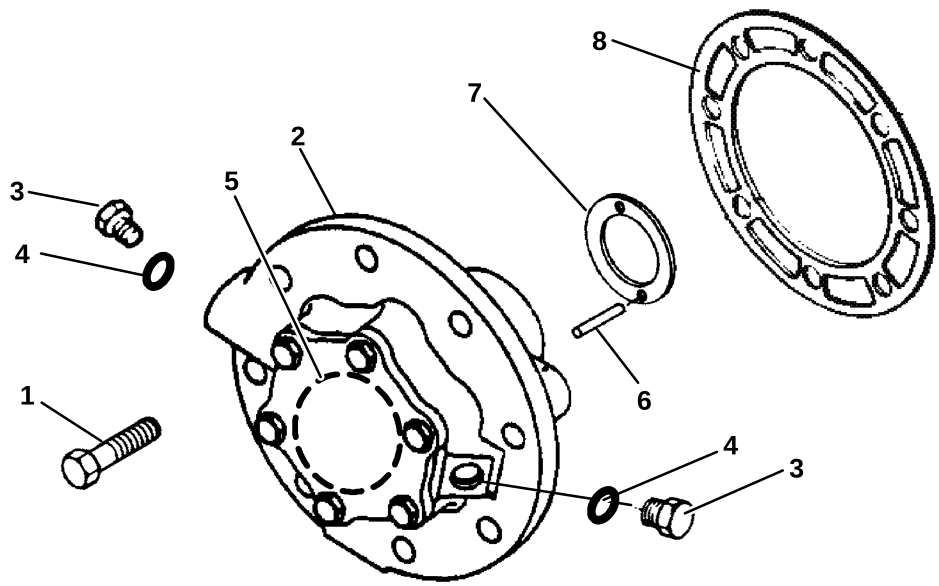
Item	Part Number	Description	Qty
1	17-44026-00	Plate, Bottom, Aluminum, (Ultra Style Compressors)	1
2	17-44117-00	Capscrew, Hex Head, 3/8-16 x 2-1/4 Inches Long - SAE Grade 8	22
3	17-44037-00	Plug, O-Ring, 7/16-20 - Includes:	1
4	42-00243-07	O-Ring	1
5	17-40020-00	Oil Filter Screen Assembly	1
6	17-40021-00	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



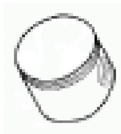
Item	Part Number	Description	Qty
1	17-44035-00	Plate, Bottom, Aluminum, (Non-Ultra Style Compressors)	1
2	17-44117-00	Capscrew, Hex Head, 3/8-16 x 2-1/4 Inches Long - SAE Grade 8	22
3	17-44037-00	Plug, O-Ring, 7/16-20 - Includes:	1
4	42-00243-07	O-Ring	1
5	17-40020-00	Oil Filter Screen Assembly	1
6	17-40021-00	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

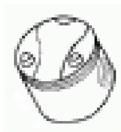
4 BEARING HEAD AND OIL PUMP

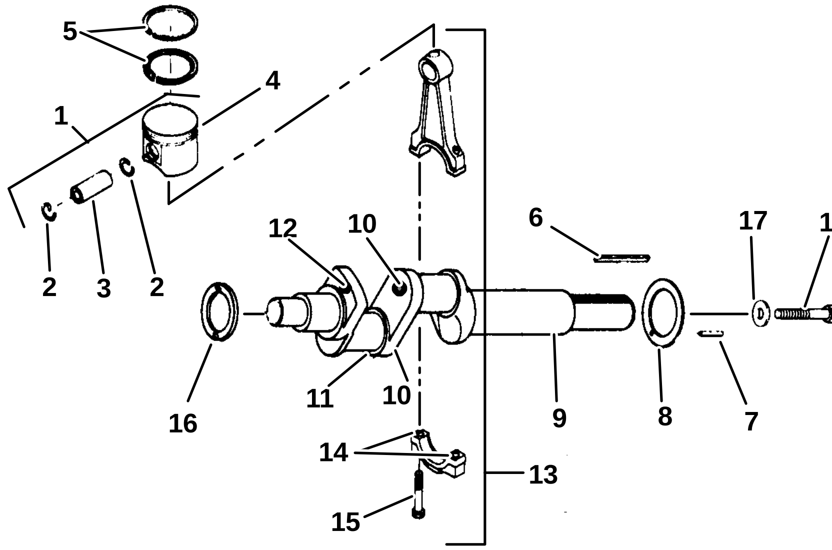


Item	Part Number	Description	Qty
1	17-10308-00	Capscrew, Hex Head, 3/8-16 x 1-1/4 Inches Long - SAE Grade 5	8
2	17-44137-00	Oil Pump and Bearing Head - Includes:	1
3	17-44037-00	Plug, O-Ring, 7/16-20 - Includes:	2
4	42-00243-07	O-Ring	2
5	17-44139-00	O-Ring, Pump Cover Plate	1
6	17-40204-00	Pin, Roll, 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)	1

5 CRANKSHAFT, ROD AND PISTON GROUP

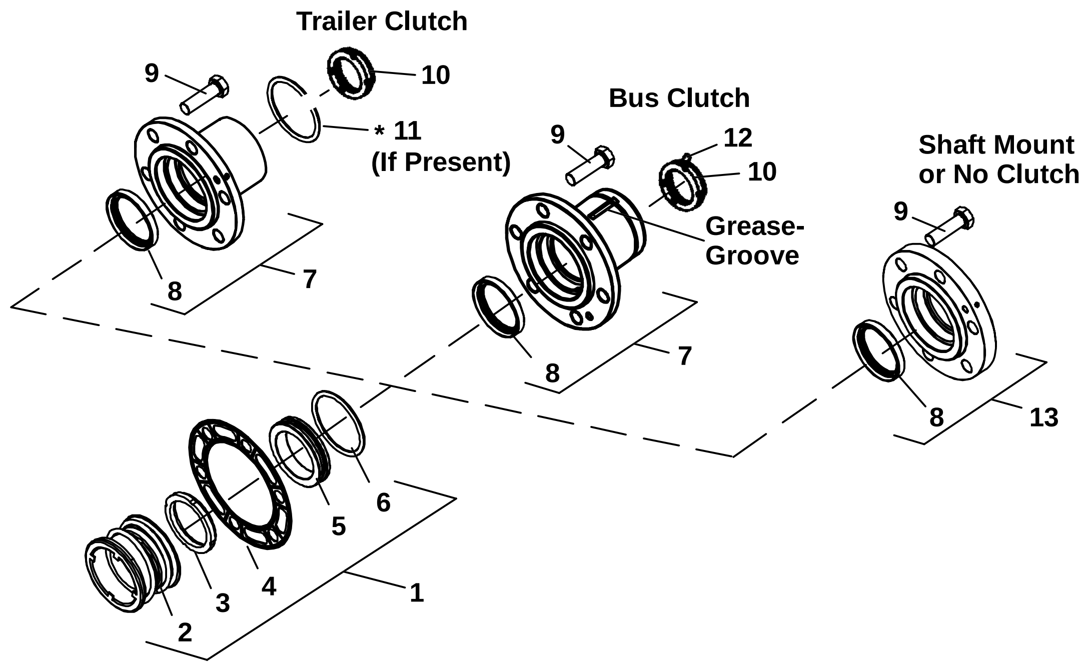

Flat (Bus)


Contoured (Truck/Trailer)



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:	6
	17-44121-01	Piston, 05G41 CFM, **Flat**, Standard - Includes:	6
	17-44122-01	Piston, 05G41 CFM, **Flat**, .020 Inch Oversize - Includes:	6
1	17-44070-00	Piston, 05G37 CFM, **Contoured**, Standard - Includes:	6
	17-44071-00	Piston, 05G37 CFM, **Contoured**, .020 Inch Oversize - Includes:	6
	17-44072-00	Piston, 05G41 CFM, **Contoured**, Standard - Includes:	6
	17-44073-00	Piston, 05G41 CFM, **Contoured**, .020 Inch Oversize - Includes:	6
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)	1
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:	1
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

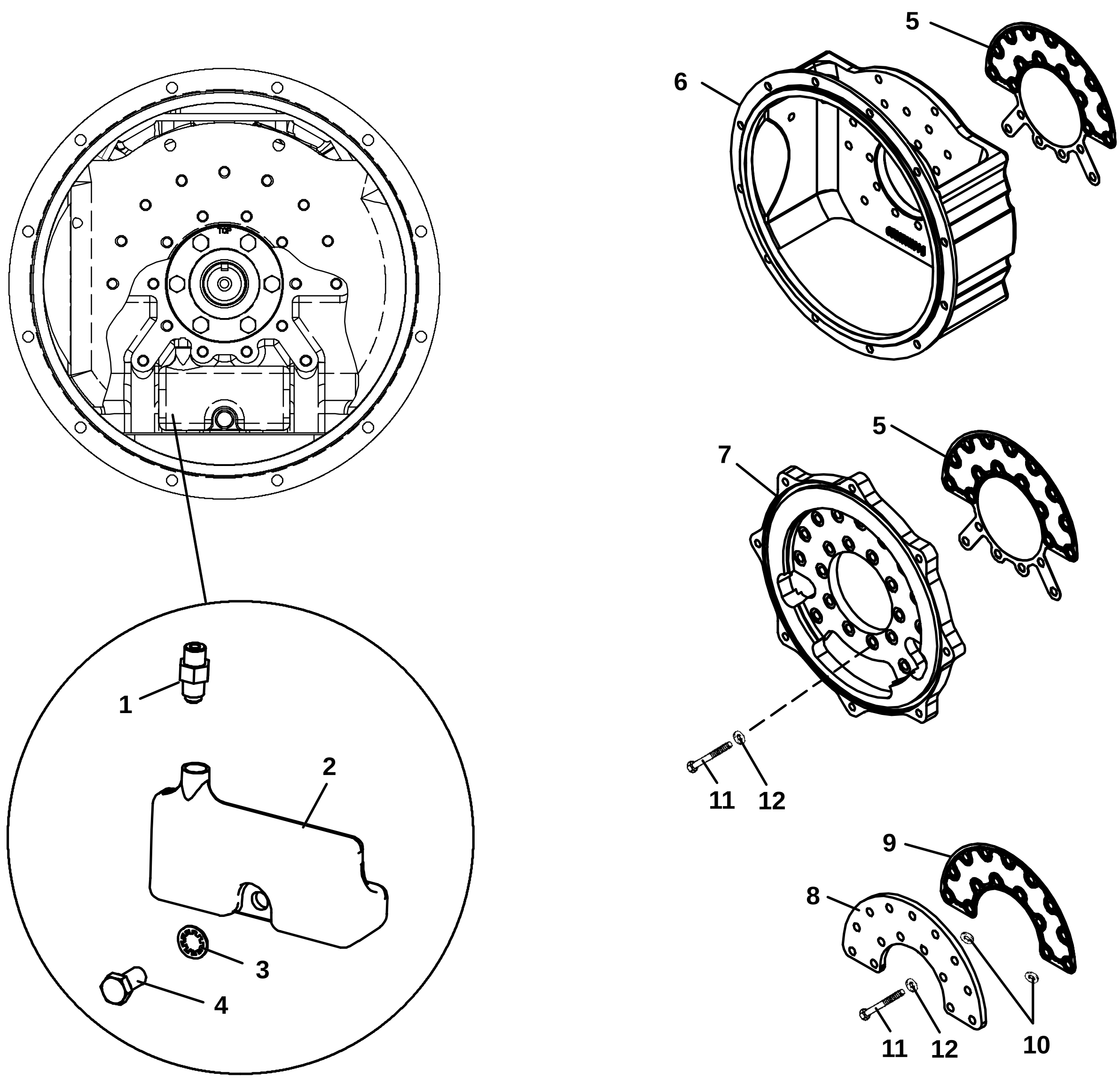
6 SHAFT END GROUP



*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).

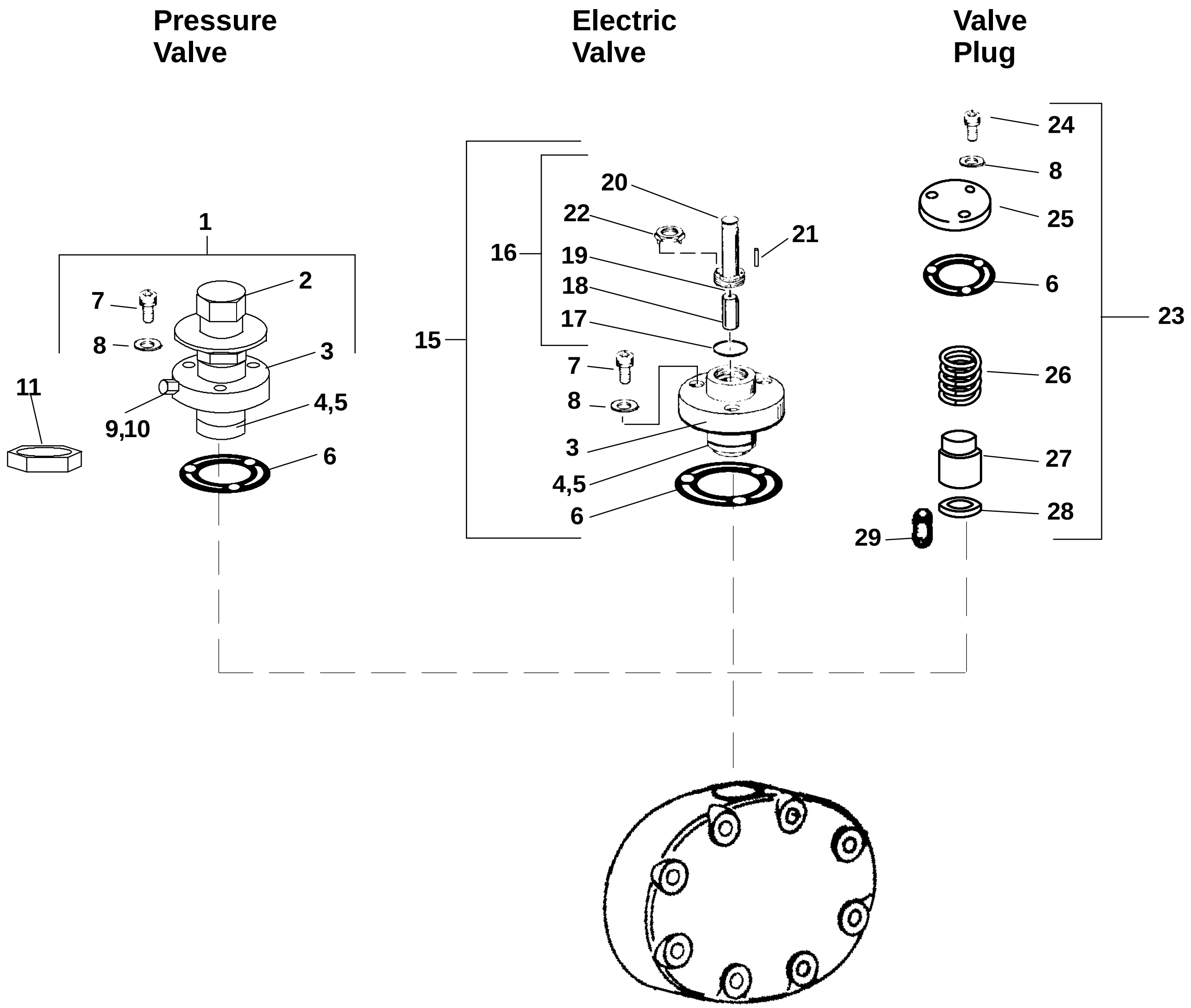
Item	Part Number	Description	Qty
1	17-44770-00	Seal Assembly (Shaft) - Includes:	1
2	NSS	Spring And Bellows Assembly, Shaft Seal	1
3	17-44768-00	Rotor, Seal	1
4	17-44004-06	Gasket, Seal Cover - (Metal)	1
5	NSS	Stator, Seal, (Wear Ring)	1
6	17-44773-00	O-Ring, Stator	1
7	17-44766-00	Hub Assembly, Housing Mounted Clutch, Threaded, No Groove - **Trailer** - Includes:	1
	17-44767-00	Hub Assembly, Housing Mounted Clutch, Threaded, W/Grease Groove - **Bus** - Includes:	1
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**	1
	34-01161-00	Nut, Hub, With Grease Fitting Port - **(Fitting Not Included) Bus**	1
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

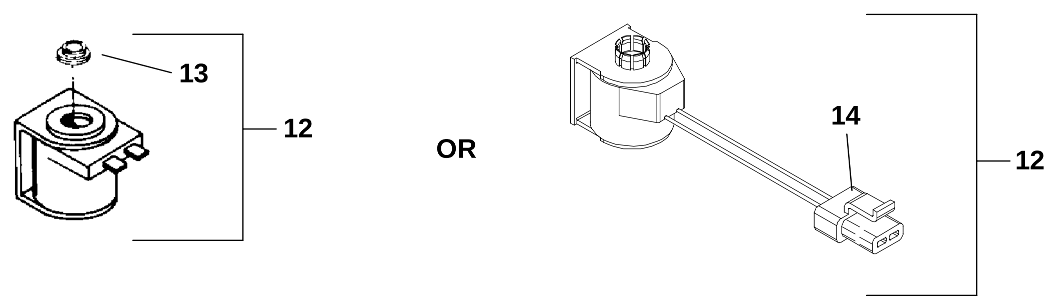


Item	Part Number	Description	Qty
1	05GA503-724	Access Valve, **Coreless**, 7/16-20, With O-Ring	1
2	17-44771-00	Reservoir, Shaft Seal	1
3	05GA503-734	Washer, Internal Tooth, 3/8 Inch, Plated	1
4	AA06GS228	Cap Screw, Hex Head, 3/8-16 X 0.75 Inch Long, Grade 8	1
5	17-44119-00	Gasket, End Flange, Ultra 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

8 UNLOADERS

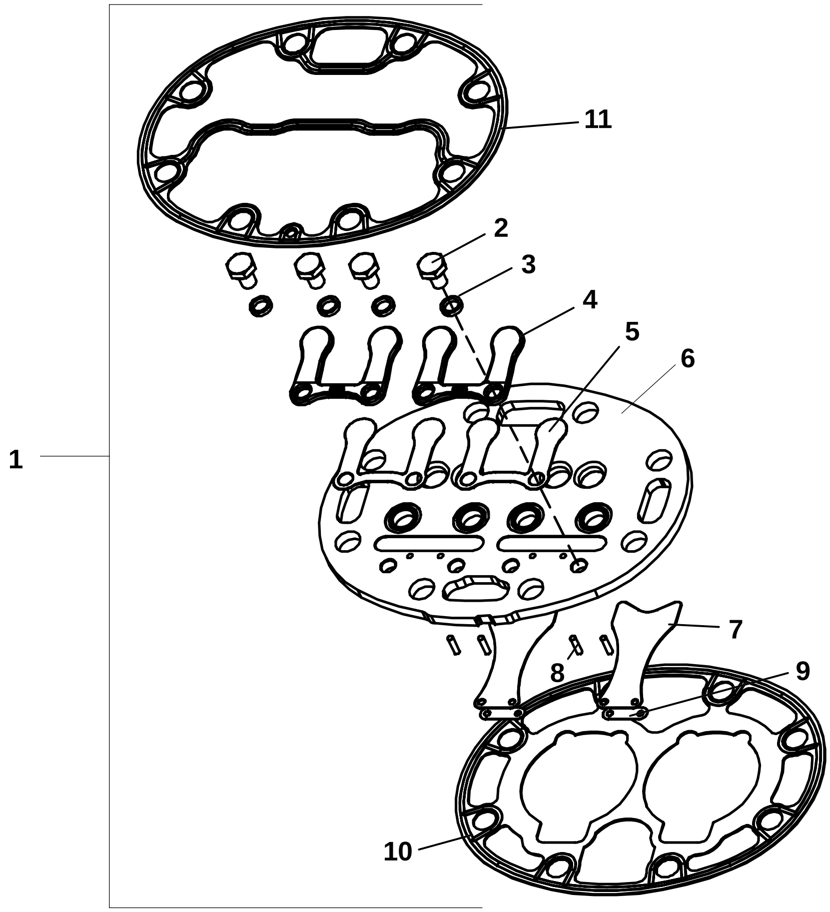


COILS



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:	A/R
	14-00143-07	Coil, Valve, 12 VDC With 6 inch wire leads - Includes:	A/R
	22-50030-00	Coil, Valve, 24 VDC With 42 inch wire leads - Includes:	A/R
	22-02567-01	Coil, Valve, 24 VAC With Spade Terminal - Includes:	A/R
	16-00149-00	Coil, Valve, 115 VAC With 42 inch Wire Leads - Includes:	A/R
	17-10829-00	Coil, Valve, 230 VAC With 42 inch Wire Leads - Includes:	A/R
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	17-55022-00	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

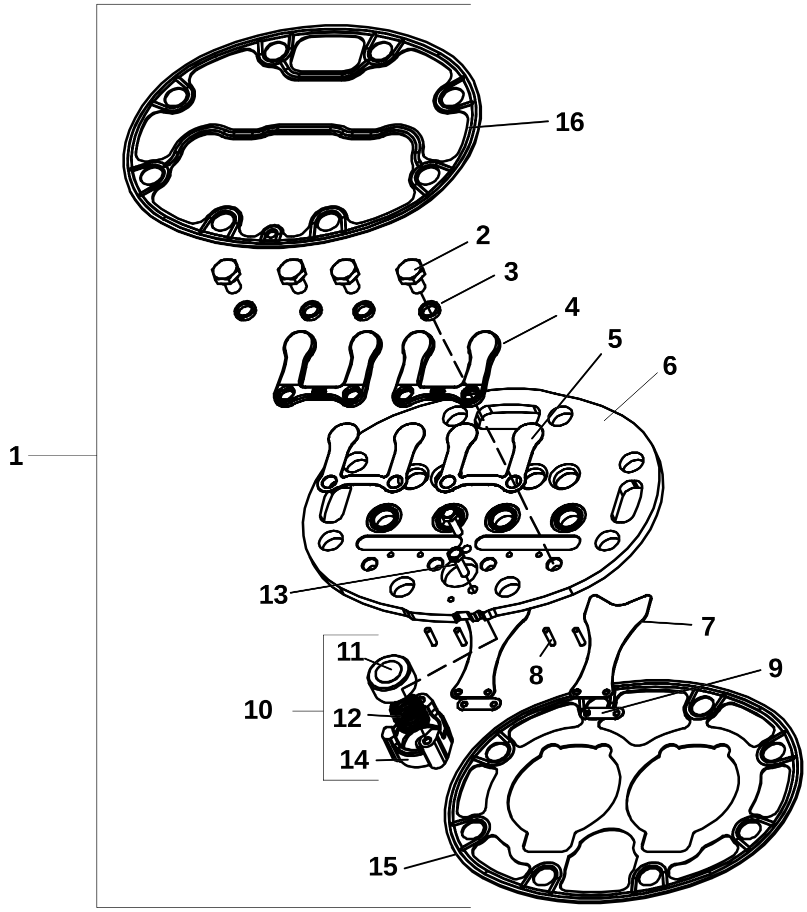
9 VALVE PLATE ASSEMBLY



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

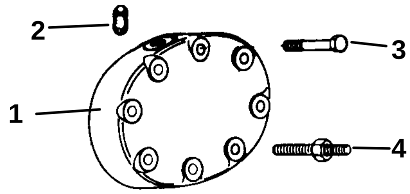
10 UNLOADER VALVE PLATE ASSEMBLY



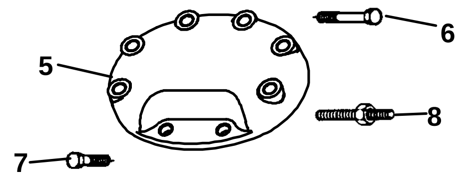
CAUTION: The above valve plate can only be used on the Twin Port 05G compressor.
It will not function in the previous design (3 port) 05G compressor.

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)



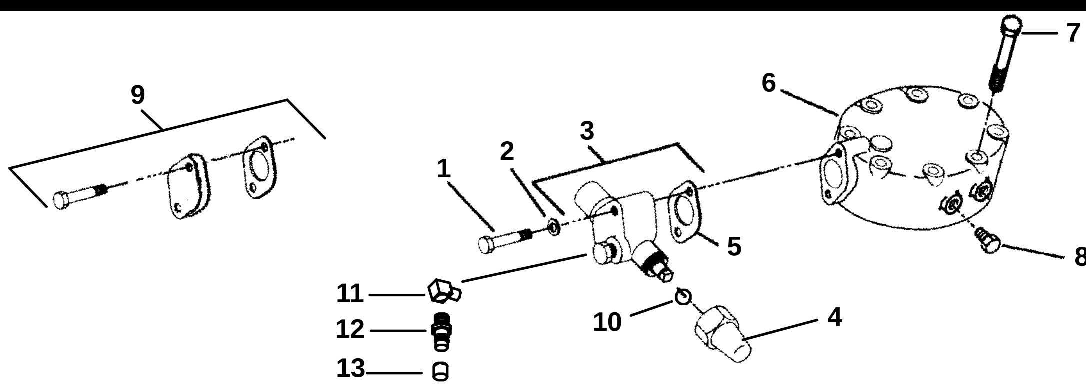
UNLOADER CYLINDER HEAD



STANDARD SHAVED CYLINDER HEAD

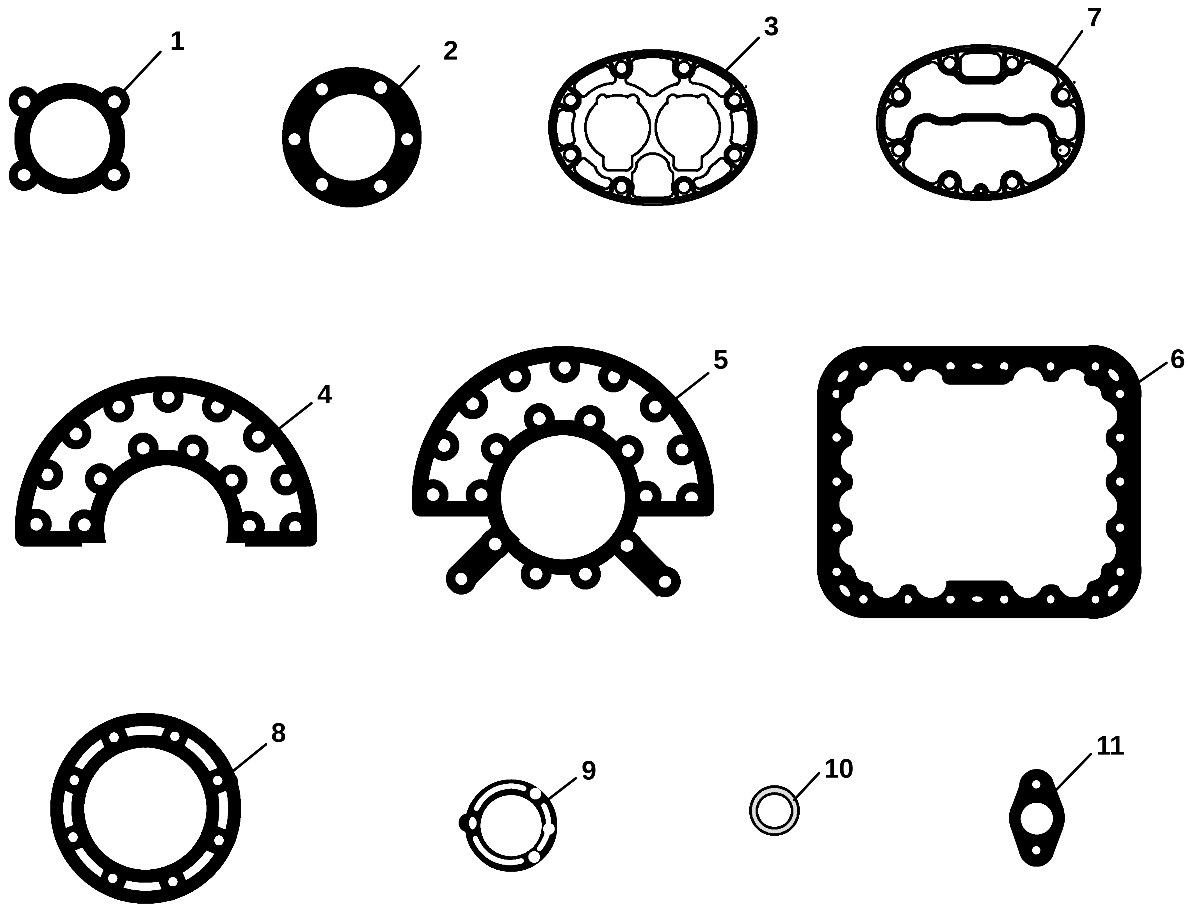
Item	Part Number	Description	Qty
1	17-44743-00	Cylinder Head, Unloader - Side Banks	2
2	17-40108-00	Strainer	1
3	17-10224-05	Capscrew, Hex Head, 3/8 -16 x 3-1/4 Inches Long - SAE Grade 8	8
4	17-44017-00	Stud, Cylinder Head (Unloader or Center), 3/8 -16 x 4-1/4 Inches Long	A/R
5	17-44753-00	Cylinder Head - 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)



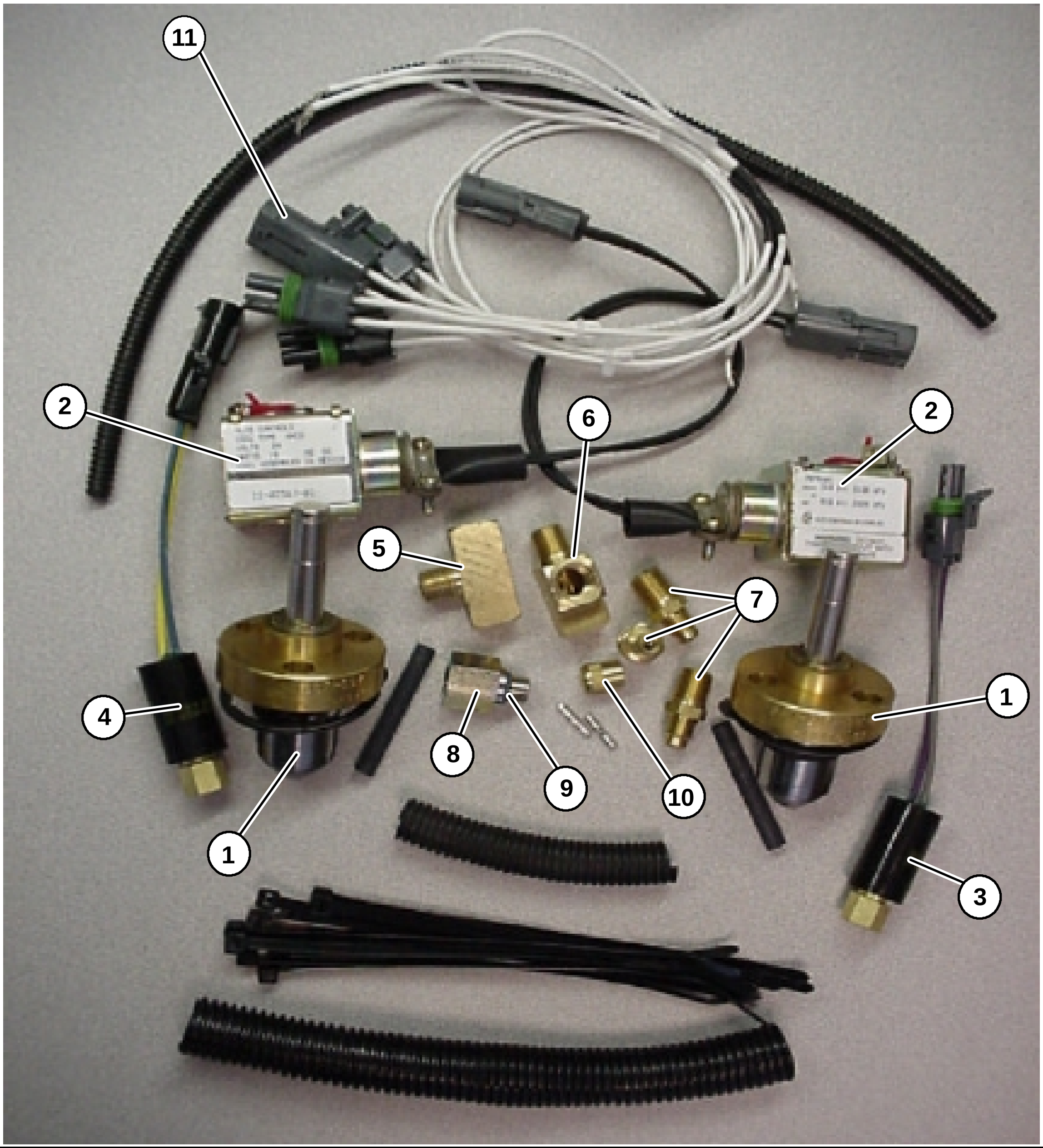
Item	Part Number	Description	Qty
1	17-40012-00	Capscrew, Hex Head, 5/16 -18 x 2 Inches Long - SAE Grade 8	2
2	17-40013-00	Gasket, Capscrew, 5/16 Inch	2
3	17-01042-04	Valve, Service 7/8 Inch ODF (1/8 Inch FPT Gauge Port)- Includes:	1
	14-00206-01	Valve, Service 7/8 Inch ODF (M15 Gauge Port For R-134a) - 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 UNLOADER KITS, BUS - PRESSURE TO ELECTRIC



14 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

14 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
14 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
14 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

PART NUMBER INDEX

PART NUMBER INDEX

A

C

D

Carrier
A United Technologies Company

Carrier Transicold Division,
Carrier Corporation
Replacement Components Group
P.O. Box 4805
Syracuse, N.Y. 13221 U.S A

www.carrier.transicold.com

PREVOST

ENREGISTRÉ - REGISTERED
ISO 9001 & ISO 14001

MAINTENANCE INFORMATION

Mi00-24

DATE : October 2000	SECTION : 22 - HVAC
SUBJECT : HEATING, VENTILATION AND AIR CONDITIONING (HVAC) SYSTEM MAINTENANCE	

Important Notice: This maintenance is recommended by Prévost Car to increase your vehicle's performance. Note that no reimbursement will be awarded for carrying out maintenance.

APPLICATION

Model
H3 series Coaches & Bus Shells Model Year : 1998 up
XL series Coaches & Bus Shells Model Year : 1998 up
XLII series Coaches & Bus Shells Model Year : 1999 up

DESCRIPTION

This is a reminder about the maintenance required for the heating, ventilation and air conditioning system. For more details on the system and its components, consult the operator's or the owner 's manuals (care and maintenance) plus the maintenance manual (section 22).

HVAC SYSTEM MAINTENANCE SCHEDULE

Service every 6,250 miles (10 000 Km) or twice a year, whichever comes first.

DESCRIPTION	REMARKS	LUBRICANT &/OR PART (depending on options, specifications may change. Consult your maintenance manual)
Refrigerant Moisture Indicator	Replace filter dryer unit according to moisture indicator (as needed)	**Filter : #950262** *Coaches:* H3, XL-40, XL-45, XLII-40, XLII-45 *Bus Shells:* XL-40, XL-45E XLII-40, XLII-45E **Filter : #950231** *Bus Shells:* XL-45, XLII-45 **Filter : #950220** (auxiliary A/C system)

A/C Compressor	Check oil level, add if necessary	Polyolester Oil, HFC 134a compatible: Castrol SW-68 (POE) or equivalent
A/C Receiver Tank	Check refrigerant level, add if necessary	HFC 134a
Condenser coil	Clean with water	--------
A/C And Heating Air Filters	Replace elements (twice a year), clean every month	XLII +H3 Driver's : #871144 *(fresh air)* #871147*(return air)* Passenger's : #871051 XL Coaches Driver's: #871049 Passenger's : #871069 XL Bus Shells Driver's: #871049 Passenger's : #871034

Service every 12,500 miles (20 000 Km) or once a year, whichever comes first.

DESCRIPTION	REMARKS	LUBRICANT &/OR PART (depending on options, specifications may change. Consult your maintenance manual)
Parcel rack fan air filter	Clean	#871159
Evaporator coil	Clean with water	----------
Driver's evaporator coil	Clean with air	----------

Service every 50,000miles (80 000 Km) or once a year, whichever comes first.

DESCRIPTION	REMARKS	LUBRICANT &/OR PART
Flexible hoses	Inspect flexible hoses regularly	----------

Miscellaneous Service

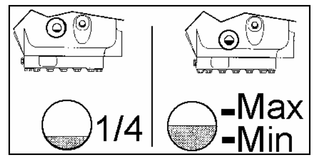
DESCRIPTION	REMARKS	LUBRICANT &/OR PART (depending on options, specifications may change. Consult your maintenance manual)
Discharge Tubes*	Every three months: Check 2 condenser's discharge tubes Check 6 evaporator's discharge tubes Check 2 front discharge tubes	----------
* Discharge tubes are rubber tubes located under vehicle.		
A/C system compressor drive belts	Check the drive belts conditions	Gates BX100 (Bosch Alternator) #506864 (set of 2) (mainly XLII Coaches, H3 Coaches from X2901)

DESCRIPTION	REMARKS	LUBRICANT &/OR PART (depending on options, specifications may change. Consult your maintenance manual)
		Gates BX97 (Delco Alternator) #506664 (set of 2) (mainly XLII Bus Shells, XL coaches & Bus Shells, H3 VIP, H3 Coaches up to X2900)

HVAC SYSTEM MAINTENANCE

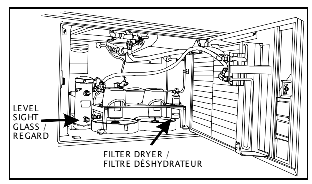
A/C COMPRESSOR OIL LEVEL

Using the level sight glass, check the oil level. Depending on the sight glass location, oil level should be approximately at the first quarter or the mid-point. The oil fill plug is located on R.H. side of sight glass.



RECEIVER TANK

The receiver tank is located in the condenser compartment. 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.

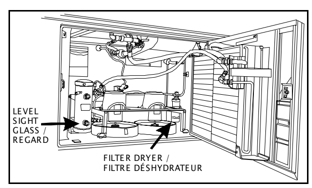


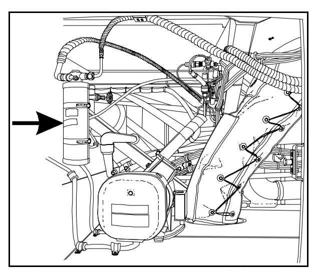
FILTER DRYER

A filter dryer is located in the condenser compartment. The filter should be replaced if the system has been opened or after a prolonged exposure, when the moisture indicator sight glass turns to yellow.

A receiver-filter, located close to engine compartment L.H. side rear door, is installed on vehicles equipped with an auxiliary A/C system or a driver's system only. Its function is similar to that of filter and receiver used on main systems. Replace only when system is opened or a problem occurs.

Note: On XL2-45 vehicles, the receiver-filter is installed on wheel housing, inside L.H. side rear service compartment.





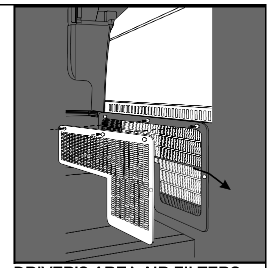
RECEIVER-FILTER LOCATION (XL2-45)

A/C And Heating System Air Filters

For maximum air conditioning and heating system efficiency, air filters should be inspected and cleaned as required in maintenance schedule to ensure proper ventilation of the evaporator and heating radiator cores. To clean filters, back flush with water, then dry with air.

Caution: Do not use high pressure water jet to avoid damaging filter.

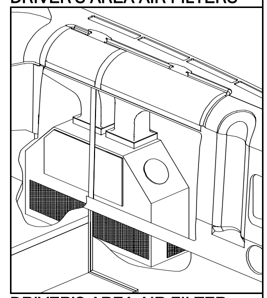
Caution: Be sure not to reverse filter upon installation.



DRIVER'S AREA AIR FILTERS

Driver's HVAC Unit Air Filter (XL, XLII, H3)

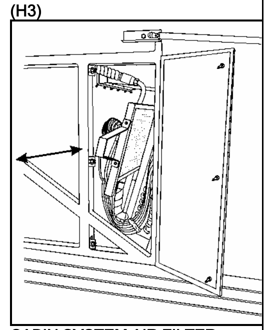
The driver HVAC system is located behind the dashboard's R.H. side lateral plastic panel. To gain access to the A/C filters, unscrew the R.H. lateral console's grill located at the top step of the entrance door steps. Slide out the R/A and F/A filters. Remove the filters for cleaning or replacement.



DRIVER'S AREA AIR FILTER (H3)

Cabin Air Filter (XL & XLII coaches)

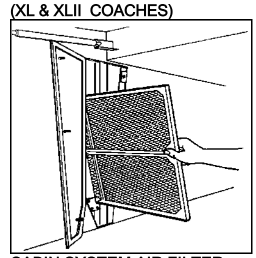
The central HVAC system's uses two air filters. They are located in the evaporator compartment on driver's side of the vehicle. To access, open the baggage compartment forward of the evaporator compartment. An access door held shut by three retaining screws is located in the wall separating the baggage compartment from the evaporator compartment. Slide out the upper filter first, then slide out the lower filter.



CABIN SYSTEM AIR FILTER (XL & XLII COACHES)

Cabin System Air (H3 coaches + bus shells)

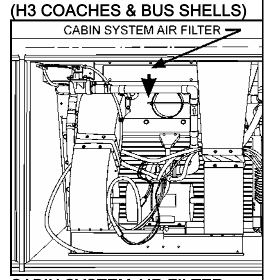
The central HVAC system's air filter is located in the A/C and heating compartment on L.H. side of the vehicle. To gain access, locate access panel in one of the baggage compartment adjacent to the A/C and heating compartment. Open panel by unscrewing (¼ turn) the three screws of either panel, unsnap both fasteners on top of filter and slide out the filter for cleaning.



CABIN SYSTEM AIR FILTER (H3 COACHES & BUS SHELLS)

Main HVAC Unit Air Filters (XL & XLII bus shells)

The main or cabin air filters are located in the evaporator compartment. To gain access, open evaporator compartment door. Remove filter panel by unscrewing the six fixing screws. Slide out the filters for cleaning or replacement.



CABIN SYSTEM AIR FILTER REMOVAL (XL & XLII BUS SHELLS)

Parcel Rack fan Air Filter

A/C condenser coils may be installed in both parcel rack air systems. Only the air filters are serviceable. The air filters are accessible from inside the parcel racks. Slide out the filters for cleaning or replacement.

COIL CLEANING

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.

Central A/C system evaporator coil

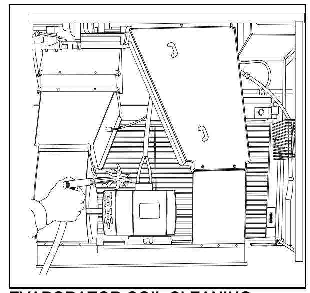
To gain access to the evaporator coil, open evaporator compartment door on L.H. side of vehicle. Check the external surface of the coil at regular intervals for dirt or any foreign matter. Clean with water jet.

Central A/C system condenser coil

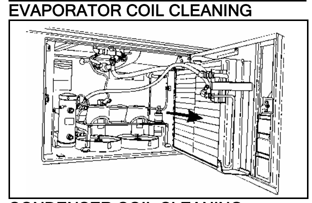
To gain access to the condenser coil, open condenser compartment door on R.H. side of vehicle. Check the external surface of the coil at regular intervals for dirt or any foreign matter. Clean with water jet.

Driver's A/C system evaporator coil

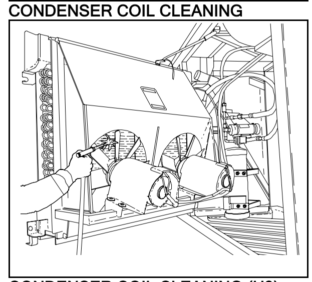
If necessary, clean with air.



EVAPORATOR COIL CLEANING



CONDENSER COIL CLEANING



CONDENSER COIL CLEANING (H3)

Waste disposal :

Discard according to applicable environmental regulations (Municipal/State[Prov.]/ Federal)

SECTION 23: ACCESSORIES

CONTENTS

ILLUSTRATIONS

1. AUDIO AND VIDEO EQUIPMENT DESCRIPTION

The power amplifier is mounted on a sound system junction plate which is located in the first baggage compartment, L.H. side (Fig. 1), to access, open the first baggage compartment. In addition to the public address (PA) systems, options for AM/FM stereo radio and cassette player, CD changer, karaoke, wireless microphone, video system with monitors, scenic viewer and digital processor controller may be featured.

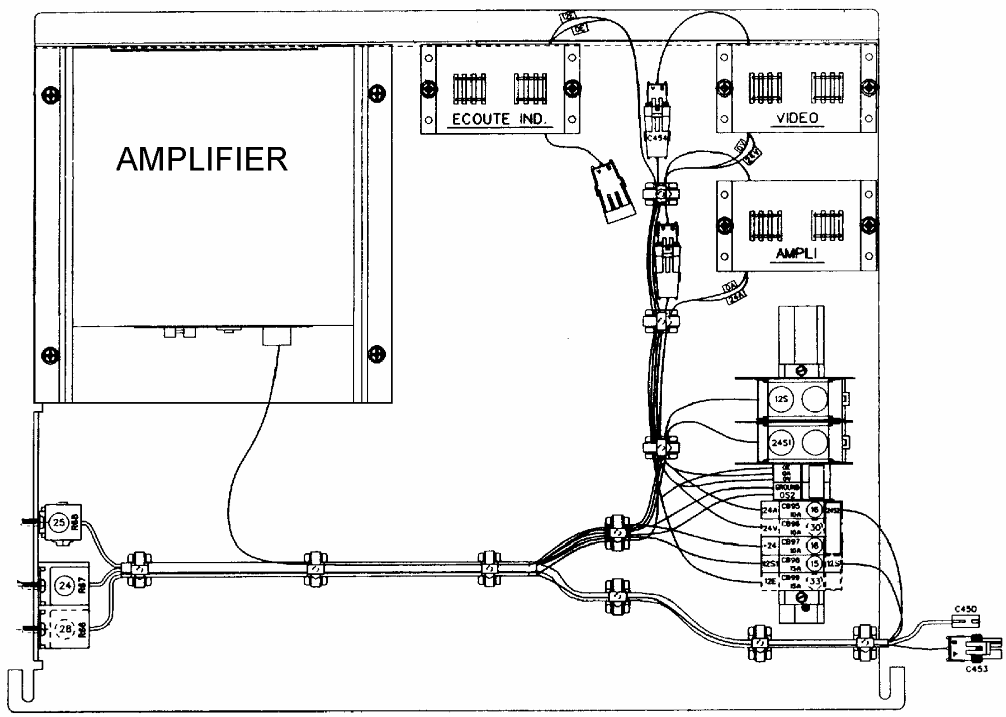


FIGURE 1: SOUND SYSTEM JUNCTION PLATE 23059

Each service module mounted to the underside of the parcel racks contains a 40-watt speaker. The fifteen 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.

1.1 AMP-3000 (HIGH POWER AMPLIFIER)

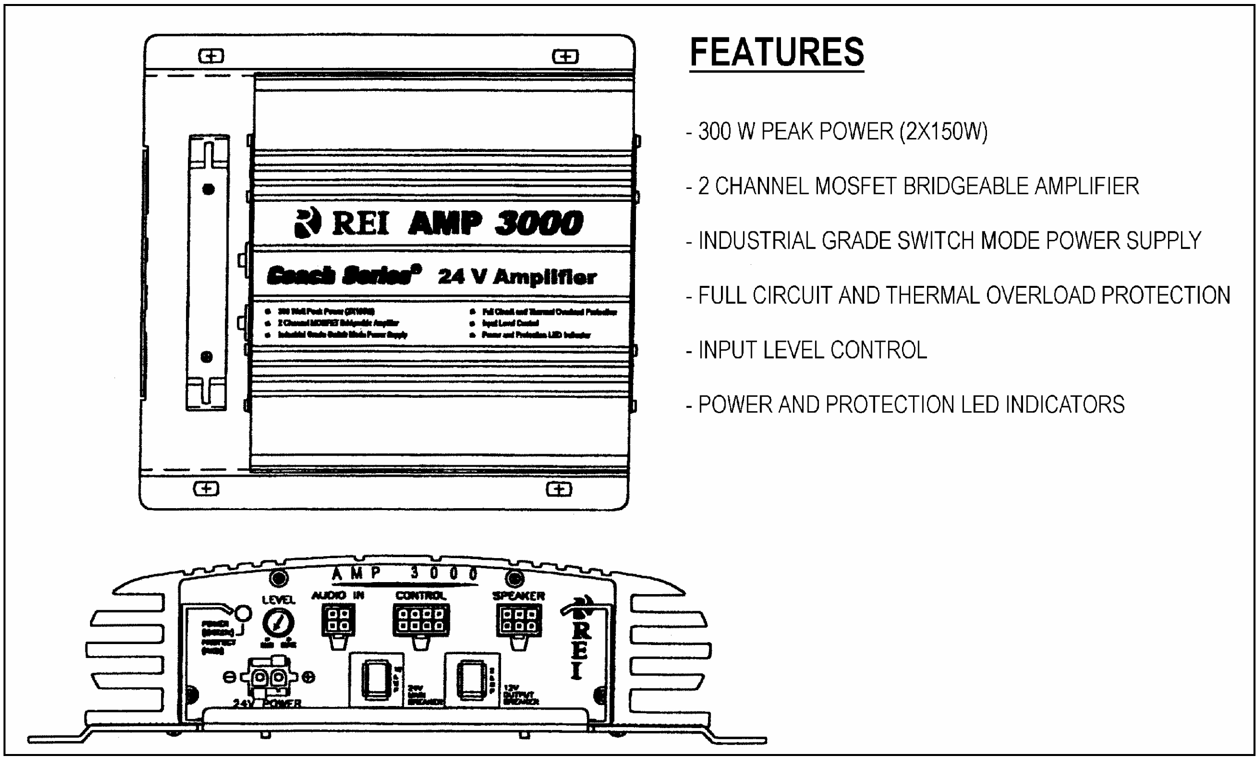


FIGURE 2: AMP-3000 AMPLIFIER 23318

The AMP-3000 brings an added dimension to your stereo equipment and increases the total output of the system. The amplifier will perform with any unit operating in a 24-volt with negative ground electric system. The AMP-3000 is located on the first baggage compartment ceiling. To access, open the first baggage compartment door.

Set the volume control on the radio, then adjust the input control on the amplifier for an average listening level. This gives the best balance between radio output and system signal-to-noise ratio (Fig. 2).

⚠ CAUTION ⚠
The low level input adjustment for this amplifier has been preset according to system specifications.

1.1.1 Removal

Remove the amplifier as follows:

1. Set the battery master switch to the ''OFF'' position. Refer to Section 6: ''Electrical System'' for switch location.
2. Remove the sound system junction plate from its location. To perform this step, disconnect wiring connectors, remove cable ties and remove the bolts retaining the sound system junction plate.
3. Remove the four screws retaining the amplifier to its sound system junction plate.
4. Reverse the removal procedure to install the amplifier.

1.2 AM/FM RADIO

1.2.1 AM/FM Radio Cassette and Disc CD Changer

The audio system is composed of an AM/FM radio cassette player ''Panasonic, model CQ-R145CAHH (Fig. 3). Also, the vehicle may be equipped with a 8 disc CD changer and two additional Hi-Fi speakers in the driver's area. A roof antenna as well as different microphone outlets, can be installed as optional equipment.

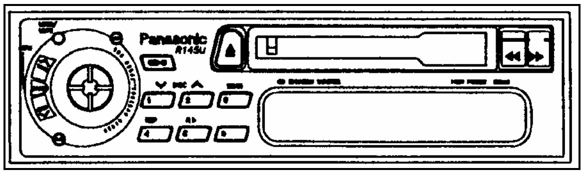


FIGURE 3: PANASONIC CQ-R145CAHH 23329

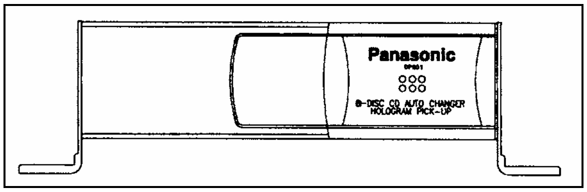


FIGURE 4: 8-DISC CD CHANGER 23332

1.2.2 AM/FM Radio / CD 1 Disc

This audio system is composed of an AM/FM radio CD player Panasonic model CP-DP101U (Fig. 5). Also, the vehicle may be equipped with two additional Hi-Fi speakers in the driver's area. A roof antenna as well as different microphone outlets, can be installed as optional equipment.

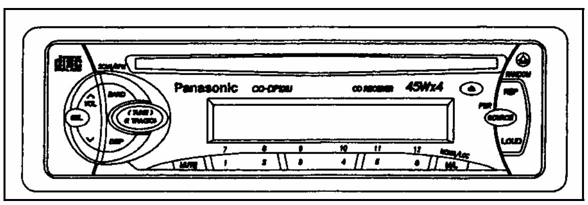


FIGURE 5: PANASONIC CP-DP101U 23317

Note: *Before attempting to solve an electrical problem on the sound system, refer to the master wiring diagrams.*

Instructions for proper use of the radio are included in the *''Panasonic Owner's Manual''* which is provided in the technical publication box delivered with the vehicle. The radio is a serviceable component and should only be serviced by a qualified electronics technician. Refer to *''Panasonic Service Centers''* guide included in the technical publication box.

1.2.3 Removal

To remove the radio 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 radio and unfasten back plate securing screw.
4. To separate the radio from its support, push in the dismounting pins included with the Panasonic Owner's Manual.
5. Push the unit through the front instrumentation panel.
6. Install a new unit by reversing the procedure.

1.3 CONTROL HEAD

The system 2000 (Fig. 6) is designed exclusively for coach operations. A complete system will control the following equipment:

- A specially designed 70 watt per channel RMS amplifier, capable of driving up to twenty-six, four ohm speakers.
- Six, custom designed ten-inch color monitors that incorporate a unique anti-theft locking slide mount. This makes installation and removal very easy.
- A specially modified VHS video cassette player that allows the operator convenient control over its functions.
- A digital audio processor that incorporates a centralized system control. The system 2000 microprocessor allows the operator to control up to three audio selections, permitting custom tailoring of each channel's sound quality. There are three microphone inputs for the PUBLIC ADDRESS SYSTEM (PAS), which are switchable between internal and external speakers. The unit contains a separate video section for the VCP that allows the driver to control his own separate audio selections.

Instructions for proper use of the control head are included in the ''*REI Operator's Manual''* which is provided in the technical publication box delivered with the vehicle.

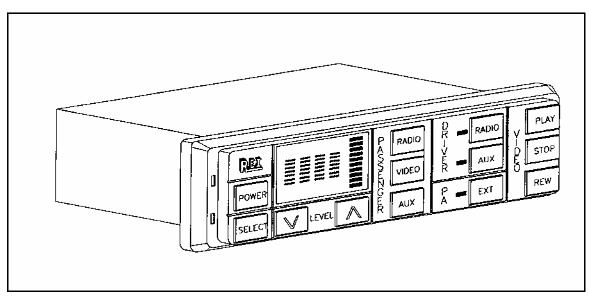


FIGURE 6: CONTROL HEAD 23070

1.3.1 Removal

To remove the control head 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 radio and unfasten back plate securing nut.
4. To separate the control head from its support, push in the dismounting pins included with the REI Operator's Manual.
5. Push the unit through the front instrumentation panel.
6. Install a new unit by reversing the procedure.

1.4 VIDEO CASSETTE PLAYER (VCP)

The VCP is located in the first parcel compartment on the driver's side (Fig 7 & 8). Instructions for proper use of the VCP are included in the *''Operator's Manual''* which is provided in the technical publication box.

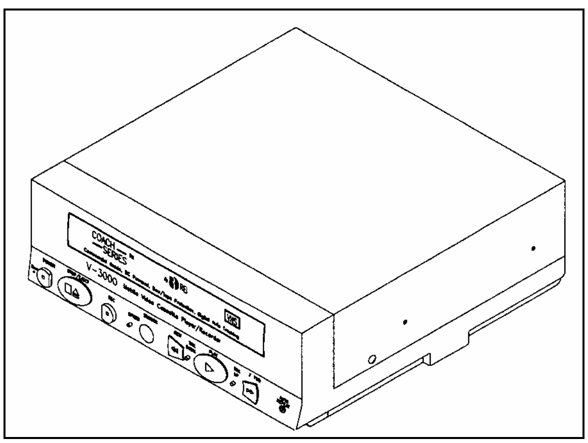


FIGURE 7: V-3000 VCP 23330

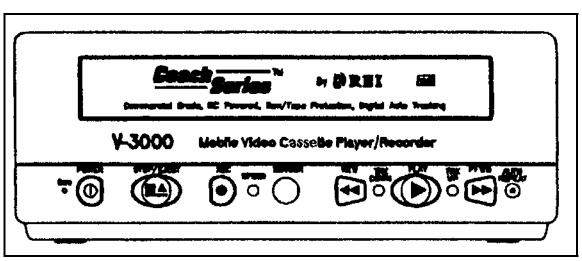


FIGURE 8: FRONT VIEW OF V-3000 VCP 23331

1.4.1 Removal

1. Place the battery master 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.

1.4.2 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.
4. Place the battery master switch in the ''ON'' position.

1.5 BOOM-TYPE MICROPHONE

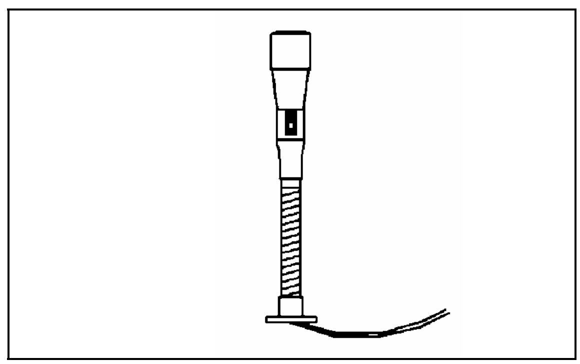


FIGURE 9: BOOM-TYPE MICROPHONE 23083

1.5.1 Removal

1. Place the battery master switch in the ''OFF'' position.
2. Remove the mounting screws at mounting flange.
3. Disconnect wiring.

1.5.2 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.

1.6 HANDHELD PRIORITY MICROPHONE

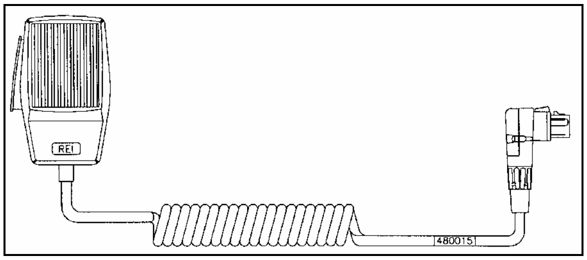


FIGURE 10: HANDHELD PRIORITY MICROPHONE 23216

1.7 RUBBER COATED MICROPHONE c/w 10 Feet cord and connector

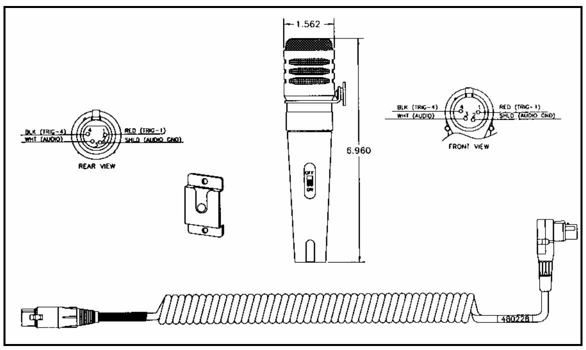


FIGURE 11: RUBBER COATED MICROPHONE 23217

1.8 WIRELESS MICROPHONE

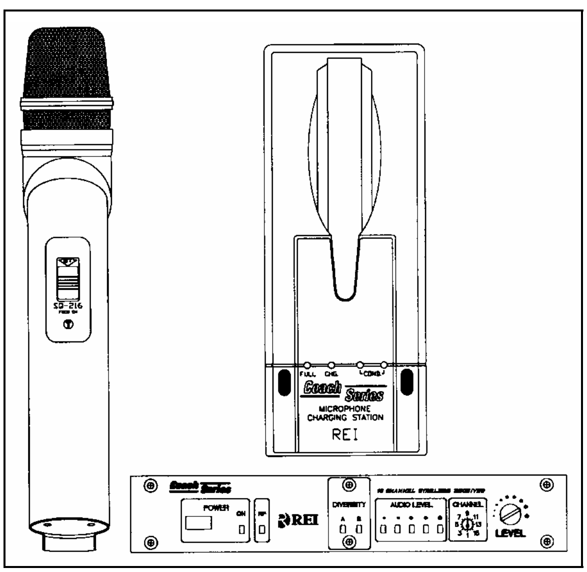


FIGURE 12: WIRELESS MICROPHONE 23226

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.

1.9 TV TUNER

For TV tuner control descriptions, refer to fig. 13.

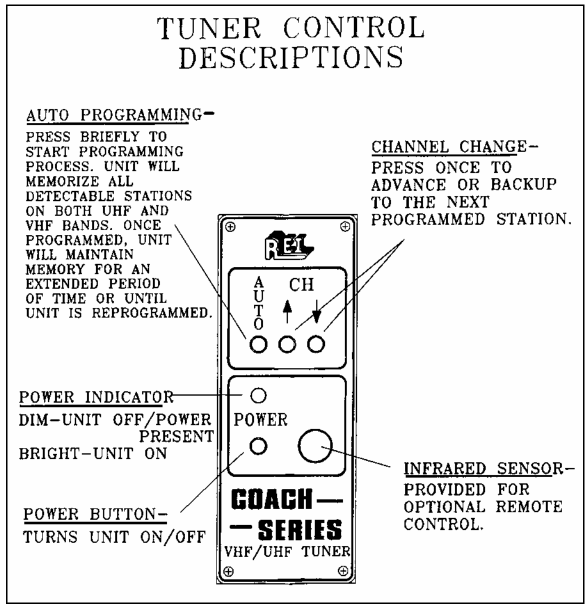


FIGURE 13: TUNER CONTROLS DESCRIPTION 23061

1.10 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.

1.10.1 Karaoke Panasonic Sound System – MOBILE DVD PLAYER DV1500

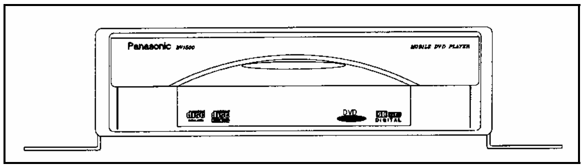


FIGURE 14: MOBILE DVD PLAYER DV1500 23214

1.11 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.

1.12 MONITOR

For monitor adjustment, refer to figure 15.

1.12.1 Removal

The front and side, ten-inch color monitors are slide mounted and retained by key locks. A LED indicator is provided on the back to indicate when the unit is ''ON''. The red button is the monitor ON/OFF switch and the pin style button is the circuit breaker reset button.

1. Place the battery master switch in the ''OFF'' position.
2. Unlock the monitor slide and pull towards the front of the monitor.
3. After removal, cover mount location using the monitor cover assembly and lock.

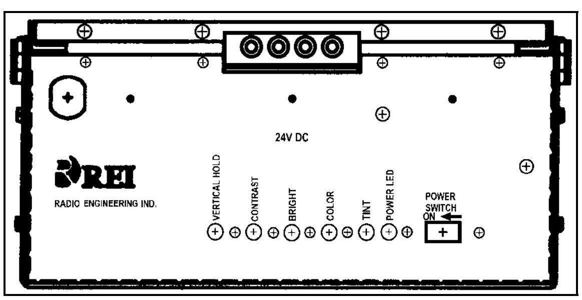


FIGURE 15: MONITOR HOUSING REAR PANEL 23333

1.12.2 Installation

1. Remove monitor cover assembly located over mounting bracket if needed.
2. Align the monitor mount with the slide and slide monitor into place.
3. Lock the monitor or cover to prevent removal.

NOTE
Make sure connections are not bent or damaged. If monitor is not being replaced, immediately install the mounting cover.

1.13 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 audio – video switching box located in the first parcel compartment on the driver's side (Figs. 16 & 17).

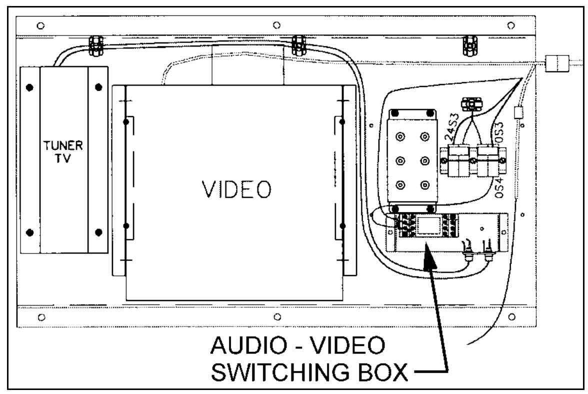


FIGURE 16: INSTALLATION IN PARCEL COMPARTMENT 23333

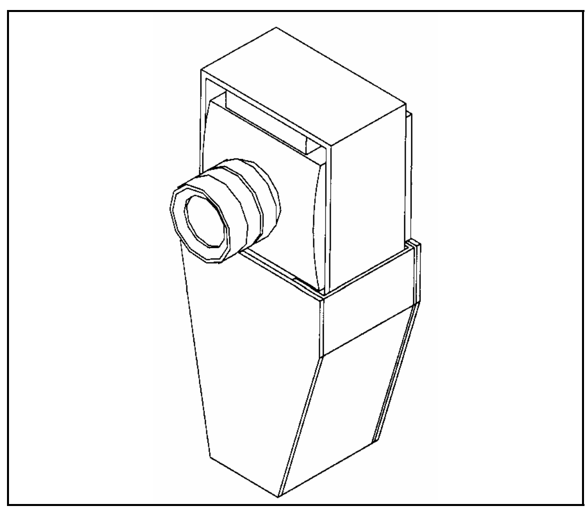


FIGURE 17: SCENIC VIEW CAMERA 23221

1.14 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 edge of the hole and the antenna base surface, wait at least two (2) minutes for chemical evaporation.
5. Apply new seal SIKA 221 on both, edge of the hole 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. 18) 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.

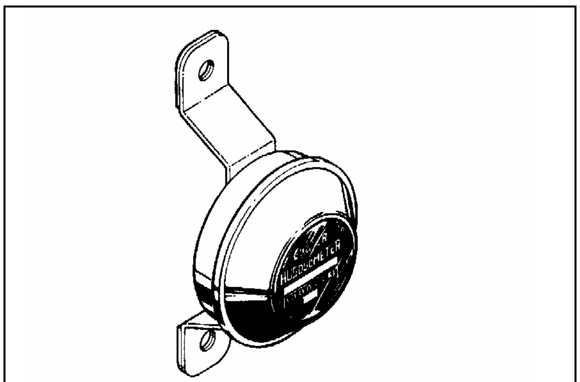


FIGURE 18: HUBODOMETER 23024

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. 19).

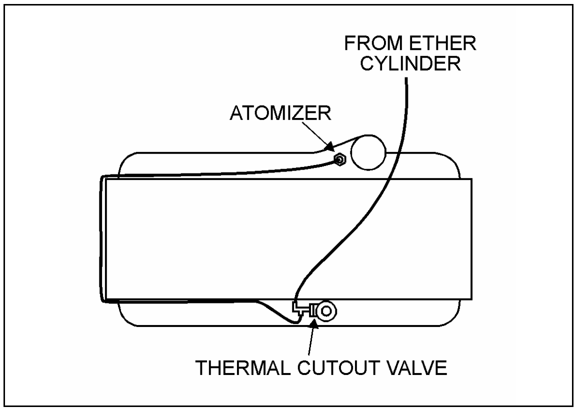


FIGURE 19: ENGINE 23032

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)

⚠ WARNING ⚠
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.

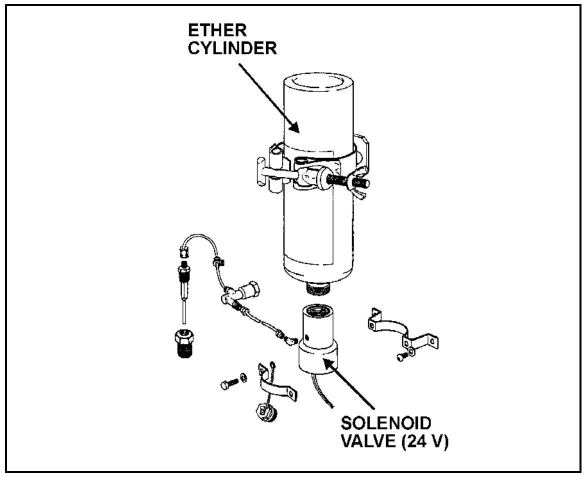


FIGURE 20: COLD STARTING AID 23048

1. Check cylinder for hand tightness and fuel supply (Fig. 20). 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.

5.3 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.

⚠ WARNING ⚠

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

DESCRIPTION

The destination sign is located at upper front of the vehicle. Two models are available.

5.1 ELECTRICAL DESTINATION SIGN (OPTIONAL)

The lighting is provided with a fluorescent tube, which is activated by means of a rocker switch located on the dashboard. The destination sign is electrically operated; two rocker switches mounted side by side on the destination sign control its motor. The unwinding speed control switch determines the rolling speed without actuating it. The selecting switch (momentary type) controls and actuates the rolling direction (fig. 21).

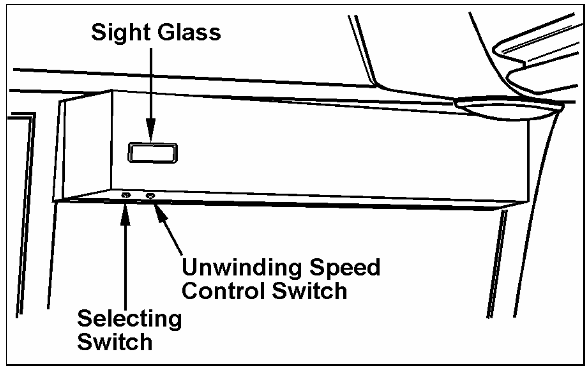


FIGURE 21: DESTINATION SIGN – ELECTRICAL 23122

5.1.1 Maintenance

Inspect the following items regularly:

1. Check for free and easy mechanism movement.
2. Check for loose items on the sign mechanism, such as wire, loose clips, hanging tape, etc.
3. Check tension and condition of the two drive belts and replace as required.
4. Periodic lubrication is **NOT** recommended.

5.1.2 Destination Sign Light Replacement

Refer to Section 06, Electrical System, paragraph "*13.4.7 Destination Sign Light - Bulb Removal and Replacement*" and "*13.4.8 Destination Sign - Fluorescent Removal and Replacement*".

5.1.3 Electric Motor Removal and Installation

To remove the electric motor:

1. Remove the six Phillips-head screws and washers retaining the destination sign cover, and then carefully remove the cover from its location.
2. Disconnect wires from electrical motor.
3. Remove both screws retaining motor to destination sign frame (Fig. 22).
4. Slide motor upwards, and then remove the drive belt.
5. Remove motor through the opening intended for this purpose.

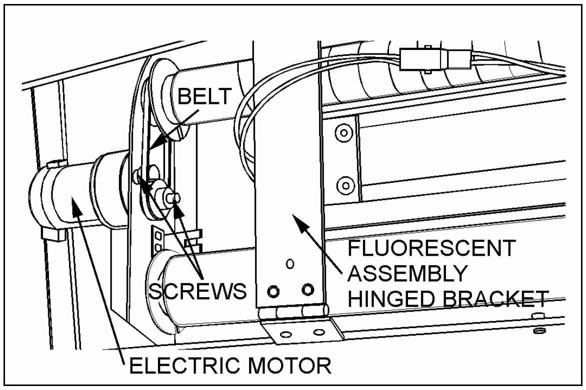


FIGURE 22: DESTINATION SIGN-ELECTRIC MOTOR 23034

6. Install the motor by reversing the above procedure.

5.1.4 Sign Curtain Repair

In the event a destination sign curtain is torn, it can be repaired with 3M polyester tape or any equivalent cellophane tape. When repairing a tear, the tape should be used on both sides of the curtain.

5.2 ELECTRONIC DESTINATION SIGN (OPTIONAL)

To change the destination, depress the selecting switches until the desired destination appears in the LCD display.

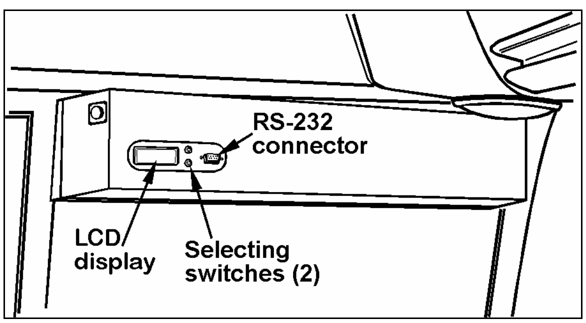


FIGURE 23; DESTINATION SIGN – ELECTRONIC 23123

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
All destination sign models are 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.

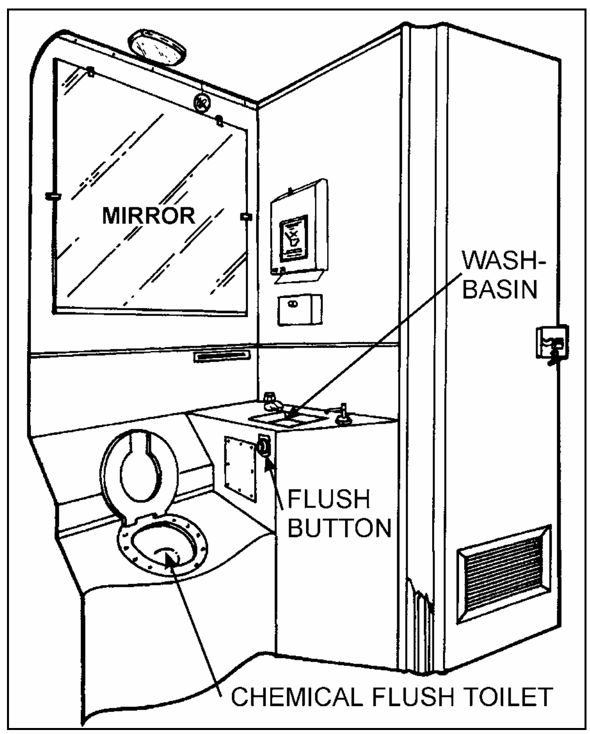


FIGURE 24: LAVATORY 23335

The lavatory has it's 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 R.H. side compartment (6, Fig. 27) while the other tube is connected to the fresh water fill connection which is also located in engine R.H. side compartment (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 R.H. side compartment.

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 objection-able odors and provides a constant air circula-tion 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.

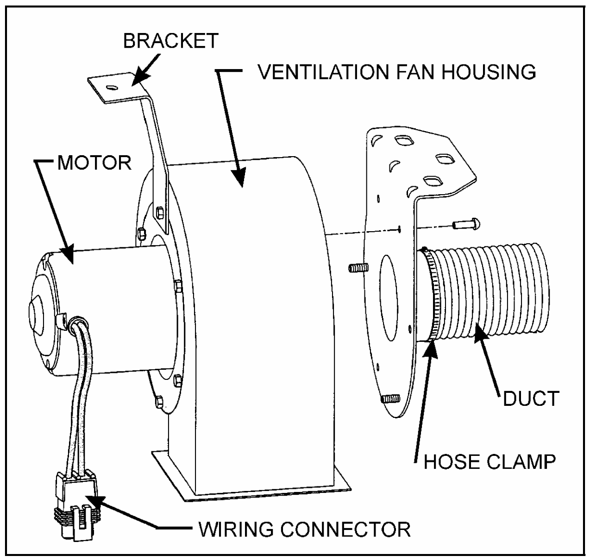


FIGURE 25: VENTILATION FAN INSTALLATION 23222

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.

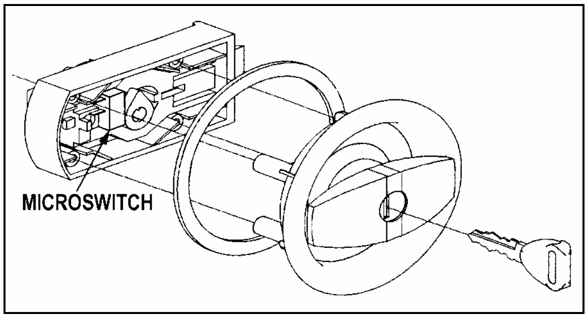


FIGURE 26: DOOR LOCK 23320

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 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 tubings, 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^{o}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.

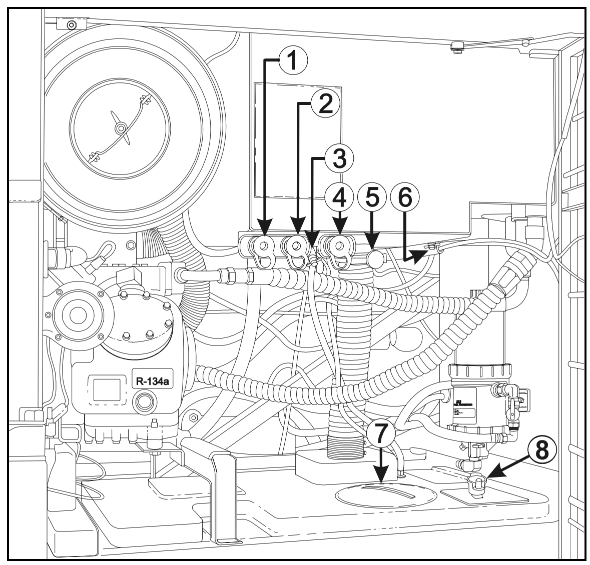


FIGURE 27: F/W TANK SERVICE VALVES 23317

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

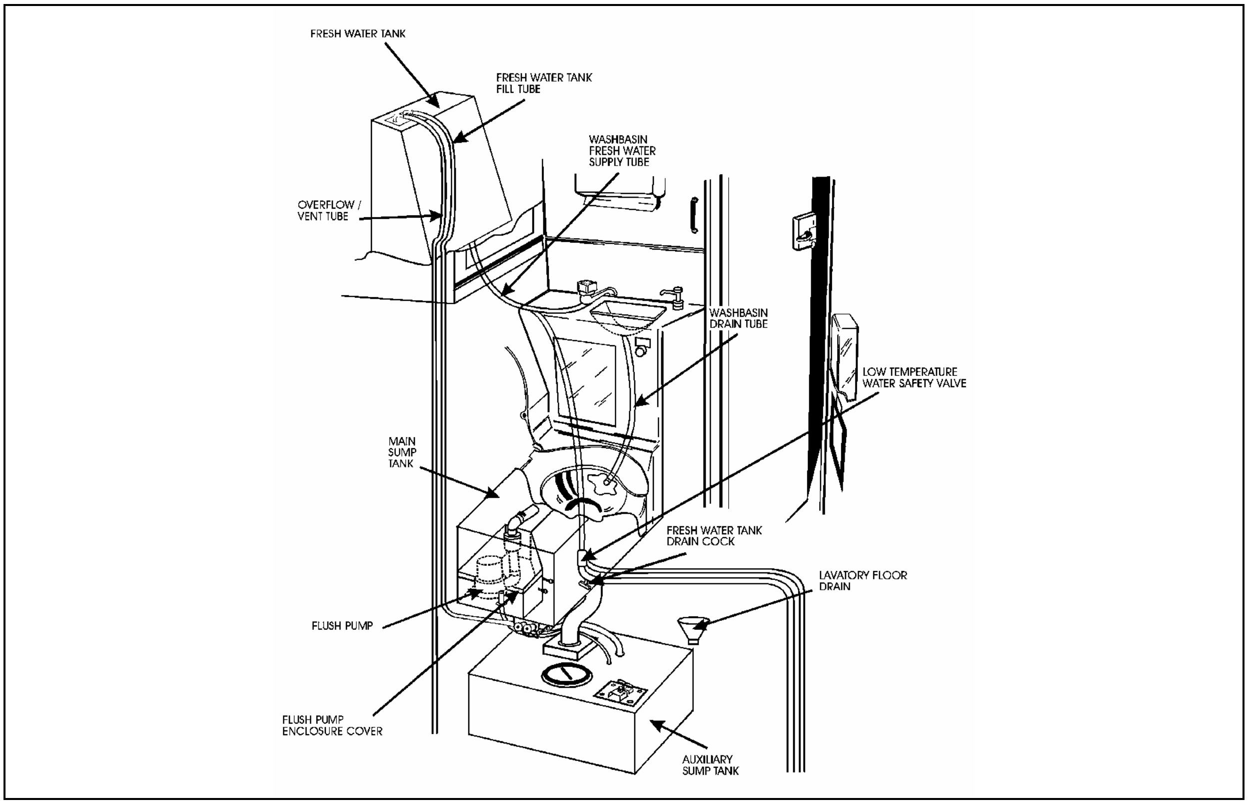


FIGURE 28: FUNCTIONING OF LAVATORY 23051

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 engine compartment. Fill the reservoir until the overflow tube leaks, signaling that the reservoir is full.

⚠ WARNING ⚠
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.

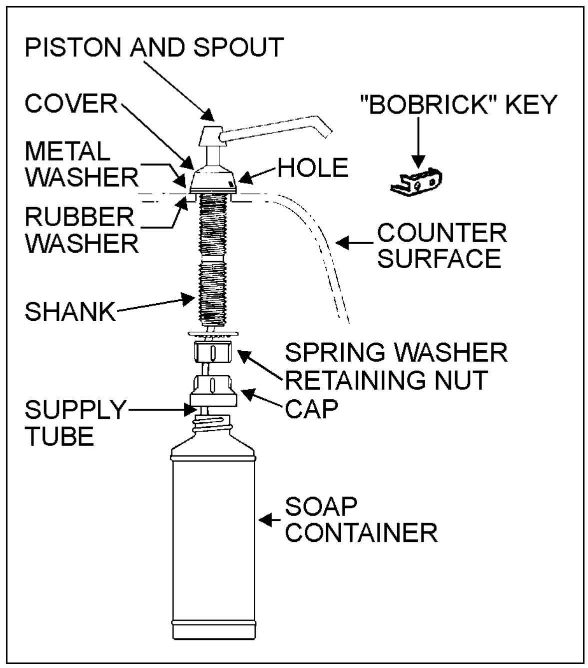


FIGURE 29: LIQUID SOAP DISPENSER 23039

2. Lift out piston and spout, cover and supply tube.

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 ⚠
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.

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 ⚠
In cold weather, add 2 gallons (9 liters) of antifreeze (e.g.: ethylene glycol) in the toilet before filling main tank.

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 ⚠
Lavatory tanks should be serviced only at suitably equipped stations.

NOTE
It is unlawful to dump sump tank contents in any location other than those designated as such.

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 ⚠
The toilet deodorant contains products that can be very irritating to skin. Use rubber gloves when handling and then clean toilet seat.

⚠ WARNING ⚠
Antifreeze must comply with the effective environmental act.

⚠ CAUTION ⚠
When cold weather is expected and there is no antifreeze in the tank, both sump tanks must be drained.

NOTE
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.

NOTE
New coaches are delivered with the sump and fresh water tanks empty. Fill with water before putting the coach in service.

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.

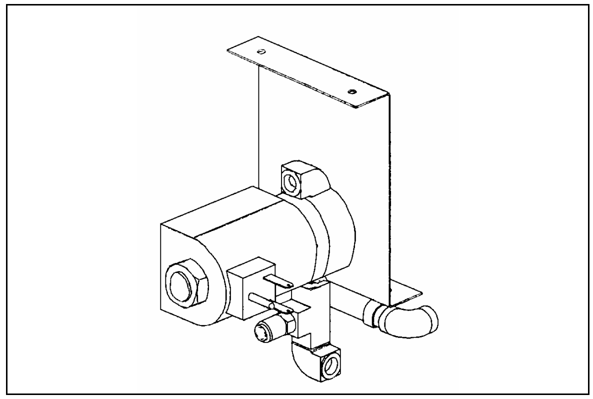


FIGURE 30: AIR HORN VALVE 23230

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. WINDSHIELD WIPERS AND WASHERS

8.1 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 31).

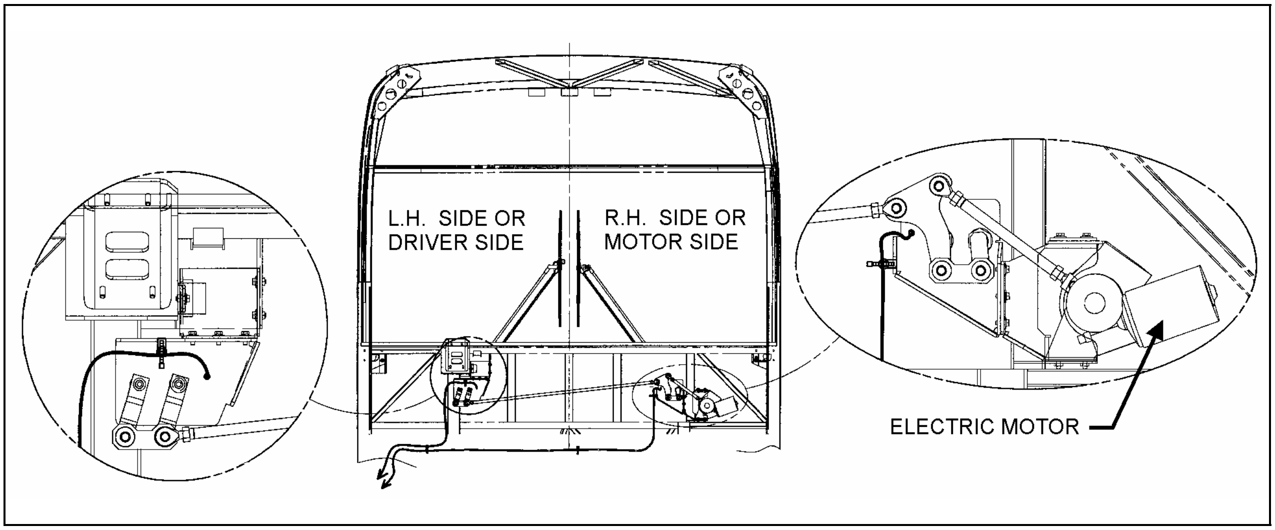


FIGURE 31: WINDSHIELD WIPER INSTALLATION 23287

Turn the multifunction lever forward to activate windshield wipers (item 2, fig. 32). 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.

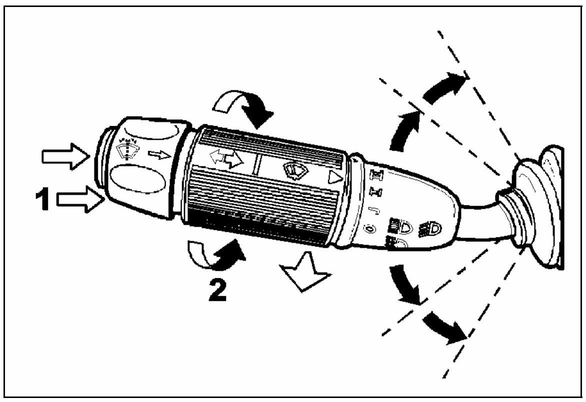


FIGURE 32: MULTIFUNCTION LEVER 23133

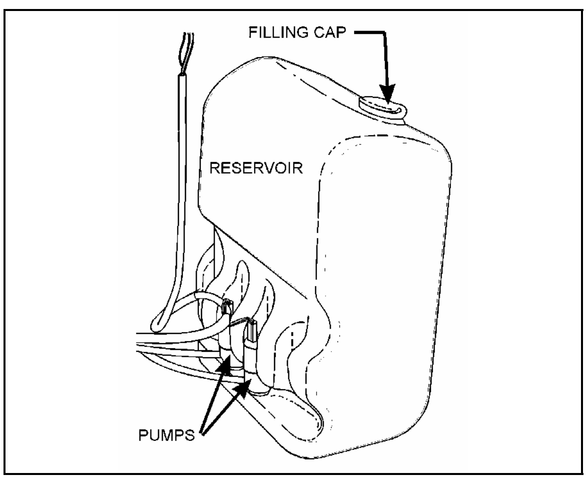


FIGURE 33: WINSHIELD WASHER RESERVOIR 23220

The windshield washer pumps are electrically operated and are controlled by a washer control ring on the multifunction lever (item 1, fig. 32).

The windshield washer reservoir is located in the front service compartment (Fig. 33). This unit pumps the washer liquid to the spray nozzles where it is dispersed across the windshield.

8.2 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.

8.2.1 Wiper Arms Positioning

1. Reinstall the wiper arms and position as shown in figure 38. 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 if falls back on the windshield

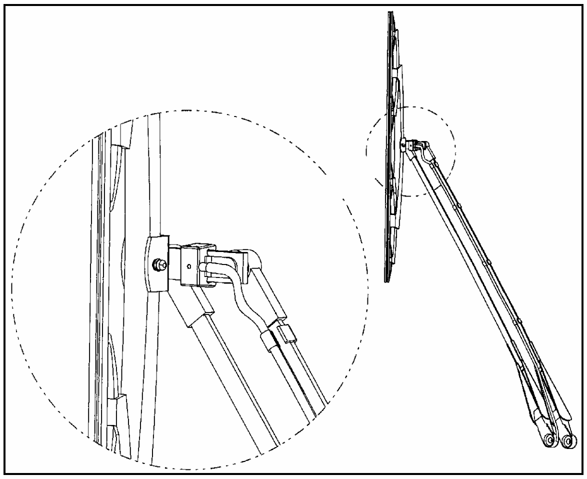


FIGURE 34: WINDSHIELD WIPER (MOTOR SIDE) 23335

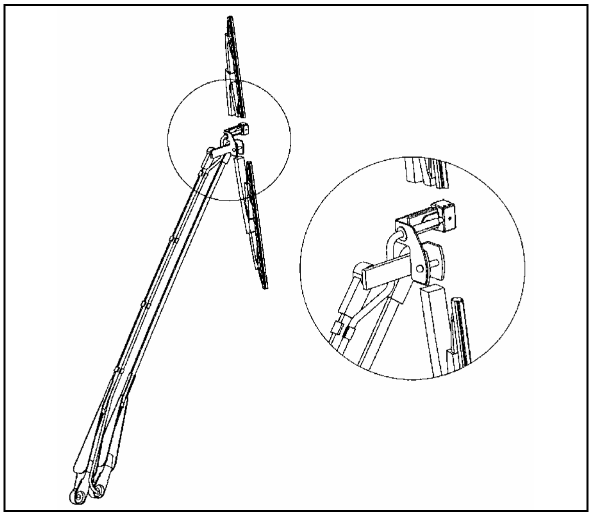


FIGURE 35: WINDSHIELD WIPER (DRIVER SIDE) 23334

3. 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.

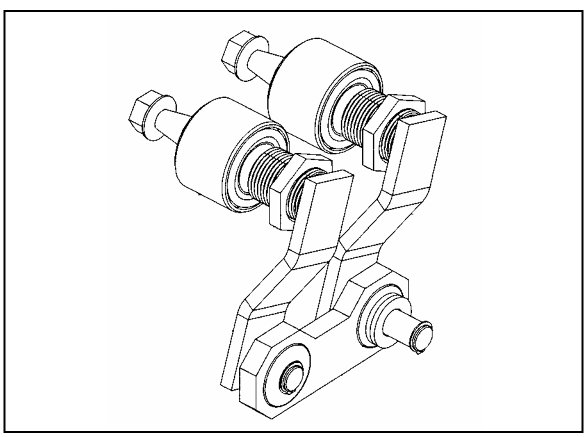


FIGURE 36: DRIVING MECHANISM (DRIVER SIDE) 23334

4. Lower the protective cover.
5. Connect the windshield washer tubing at the base of the wiper arm.
6. Check the adjustment on a wet windshield.

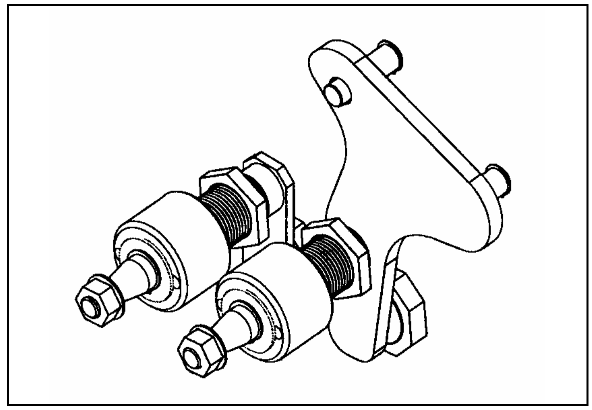


FIGURE 37: DRIVING MECHANISM (MOTOR SIDE) 23254

8.3 WINDSHIELD WIPER MOTOR

8.3.1 Windshield Wiper Motor Replacement

The windshield wiper motor is located at lower front of the vehicle, behind the defroster panel. Refer to figure 31 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.

1. Remove the Phillips-head screws retaining the defroster panels, and remove panels.
2. Disconnect wiring connector from the windshield wiper motor.
3. Loosen clamping screw retaining the lever at the end of the motor driving shaft.
4. Remove the three bolts holding the motor to the steel plate.
5. Remove the windshield wiper motor (Prévost #800328), reverse removal procedure to reinstall.

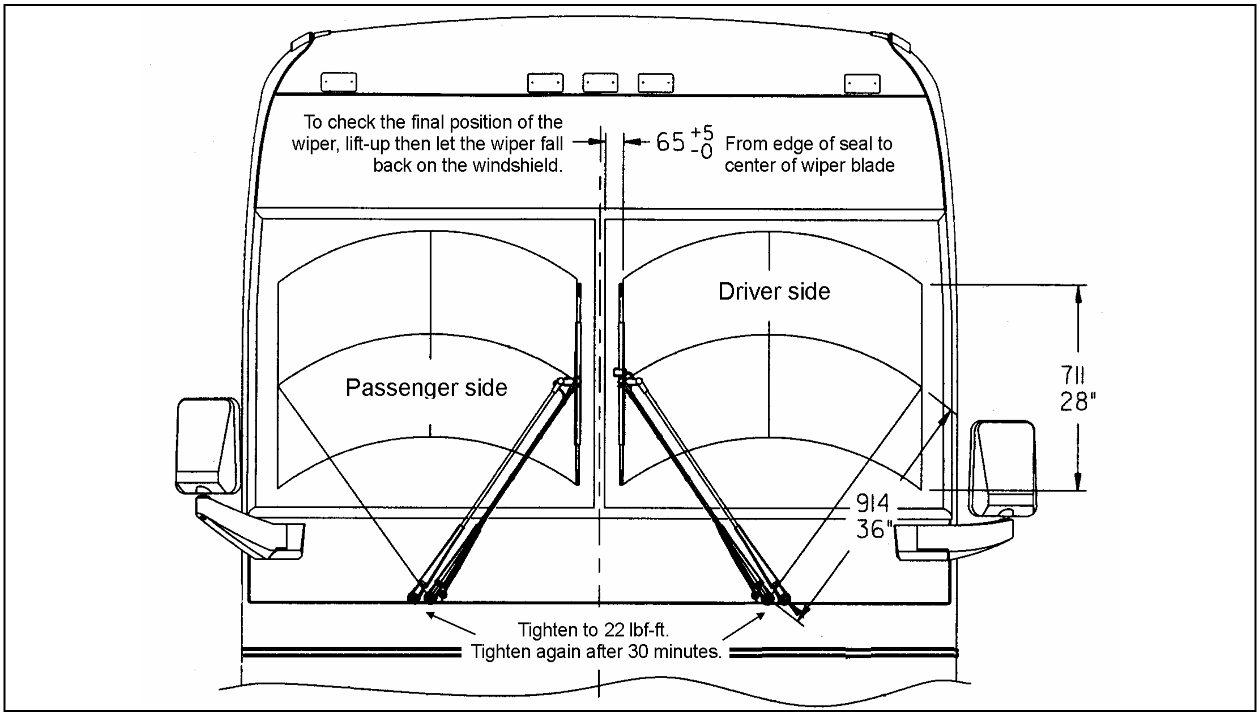


FIGURE 38: WIPER ARMS POSITIONING 23253

8.4 TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
FAIL TO SPRAY WASHER FLUID	A. Reservoir empty. B. If below 32°F (0°C), improper washer fluid frozen. C. Contamination in tubing or nozzles. D. Tubing damage. E. Tubing bent (kinked) or off one or more connections.	A. Add proper fluid. B. Store coach or parts in heated area, then purge system with low-temperature solution. C. Remove with compressed air, if severely clogged, replace items. D. Replace section. E. Realign tubing and/or refit. Trim end to ensure proper fit or replace.
INADEQUATE SPRAYING	A. Tubing failure.	A. Replace tubing.
SLOW OPERATION	A. Improper solution. B. Jet stream improperly directed. C. Check if valve is stuck in the open position.	A. Replace with proper type solution. B. Reposition nozzles. C. Remove, clean or replace.

9. SPECIFICATIONS

AMPLIFIER

Make.. R.E.I.
Model.. AMP-3000
Power source .... 24 volts DC Negative ground
Current .... 8 Amps maximum
Frequency Response .... 10-30,000 Hz
Output.. 90 watts/channel maximum power
.... 65 watts/channel RMS at 4 ohm @ 0.5 T.H.D.
Signal to noise ratio.. 86 dB
Supplier number.. 700771
Prévost number.. 901056

AM/FM RADIO CASSETTE PLAYER

Make.. Panasonic
Model.. CQ-R145CAHH
Power source .... 12 volts
Supplier number.. 700760
Prévost number.. 901032

8 DISC CD CHANGER

Make.. R.E.I.
Supplier number.. 700739
Prévost number.. 901057

AM/FM RADIO CD PLAYER

Make.. Panasonic
Model.. CP-DP101U
Power source .... 12 volts
Supplier number.. 700788
Prévost number.. 901053

SPEAKER

Make.. Robert Bosch
Max. power.. 90 watts
RMS power .... 40 watts
Freq. response.. 45 Hz - 24 kHz
Sensitivity .... 92 dB
Impedance .... 4 ohms
Supplier number.. RPSPKR54
Prévost number.. 900765

CONTROL HEAD

Make.. R.E.I.
Model.. C-2000
Supplier number.. 700227
Prévost number.. 900803

VIDEO CASSETTE PLAYER (VCP)

Make.. R.E.I.
Model.. V-3000
Supplier number.. 700749
Prévost number.. 901030

BOOM-TYPE MICROPHONE
Make.. R.E.I.
Supplier number.. 480076BK
Prévost number.. 900763

HANDHELD PRIORITY MICROPHONE
Make.. R.E.I.
Supplier number.. 480015
Prévost number.. 900808

RUBBER COATED MICROPHONE
Make.. R.E.I.
Supplier number.. 480228
Prévost number.. 900745

16 CHANNEL WIRELESS MICROPHONE
Make.. R.E.I.
Supplier number.. 700598
Prévost number.. 900954

16 CHANNEL WIRELESS MICROPHONE CHARGING STATION
Make.. R.E.I.
Supplier number.. 700532
Prévost number.. 900953

16 CHANNEL WIRELESS MICROPHONE RECEIVER
Make.. R.E.I.
Supplier number.. 700599
Prévost number.. 900952

TV TUNER
Make.. R.E.I.
Power source 24V
Supplier number.. 700471
Prévost number.. 900814

KARAOKE
Make.. Panasonic
Model.. MOBILE DVD PLAYER DV1500
Supplier number.. 700761
Prévost number.. 901033

TV MONITOR
Make.. R.E.I.
Power source 24V
Supplier number.. 700800
Prévost number.. 901070

HUBODOMETER (US model: miles)
Make..Stemco
Supplier number...650-0593
Prévost number.. 650002

HUBODOMETER (Canada model: km)

Make....................Stemco
Supplier number....................650-0025
Prévost 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
Supplier number....................F30T8 CW4
Prévost number....................830120

ELECTRONIC DESTINATION SIGN

Make....................Pocatec
Supplier number....................9000230
Prévost number....................940050

LAVATORY VENTILATION FAN MOTOR

Make....................Aurora
Type....................RG500EF
Voltage....................24 volts DC
Rotation....................R.H.
Supplier number....................131.40.50
Prévost number....................870844

LAVATORY FLUORESCENT TUBES

Make....................General Electric
Model....................F15T8CW
Length....................18" (45 cm)
Wattage....................15
Quantity....................2
Prévost number....................830102

EMERGENCY BUZZER SWITCH (PUSH BUTTON)

Make....................Cole Hersee Co.
Voltage....................24 V
Supplier number....................40224
Prévost number....................562117

FRESH WATER TANK

Make....................Prévost
Capacity....................18 US gal (68 liters)
Prévost number....................401591

FLUSH PUSH BUTTON PNEUMATIC TIMER

Make....................Furnas
Type....................Resettable
Time....................0,2 to 180 seconds
Supplier number....................55-AA
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.
Supplier number... 101493
Prévost number.. 640093

AIR HORN VALVE
Make.. Allied Signal Inc.
Supplier number... 228672
Prévost number.. 640128

WINDSHIELD WIPER MOTOR
Make.. BOSCH
Supplier number... 0390442401
Prévost number.. 800328

WIPER (BLADE)
Make.. BOSCH
Supplier number... 3398110095
Prévost number.. 800329

WIPER ARM
Make.. BOSCH
Supplier number... 6002UWA060
Prévost number.. 800331

SECTION 24: LUBRICATION

CONTENTS

ILLUSTRATIONS

1. LUBRICATION

The efficiency and life expectancy of mechanical equipment is largely dependent upon 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.

1.1 FIRST SERVICE ON NEW VEHICLE

Perform the following maintenance procedures after the first 3,000 miles (5 000 km) of operation (unless otherwise specified). Once initial maintenance is performed, refer to recommended intervals in the lubrication schedule.

Repeat a component's initial maintenance procedure when it has undergone a major repair.

1.1.1 Differential

No initial oil or filter change necessary. Refer to regular lubrication and servicing schedule.

1.1.2 Coolant Strainer

The coolant strainer is designed to recover the soldering residues trapped inside the coolant lines during their initial assembly; perform initial cleaning once vehicle has run approximately 3,000 miles (5 000 km), then according to the lubrication and servicing schedule.

NOTE
If additional soldering has been performed on any point of coolant piping, clean coolant system strainer as outlined for a new vehicle at 3,000 miles (5 000 km).

1.1.3 Allison World Automatic Transmission

Change main filter cartridge after first 5,000 miles (8,000 km) of initial operation, then change filters and fluid according to the lubrication and servicing schedule.

1.1.4 ZF-ASTRONICTransmission

No initial oil or filter change necessary. Refer to regular lubrication and servicing schedule.

1.1.5 Engine

Since engine break-in has been done in factory, there is no special break-in, so oil should be changed according to the lubrication and servicing schedule intervals. Since some oil consumption by engine is normal, check oil level daily with engine stopped and add to FULL mark on dipstick if necessary. Furthermore, the engine oil filter should be replaced each time the engine oil is changed.

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 ENGINE OIL CHANGE INTERVALS

The engine oil change intervals are related to the operating conditions, such as vehicle load, speed, etc., and may vary. It is recommended however, that the oil change be performed after every 12,500 miles (20 000 km).

The drain intervals may then be gradually increased or decreased with experience on a specific lubricant, considering the recommendations of the oil supplier (analysis of drained oil can be helpful), until the most practical service condition has been established.

Solvents should not be used as flushing oils. Dilution of the fresh refill oil supply can occur, which may be detrimental for the engine.

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 Service Manual"* under heading *"Lubricating Oil for Detroit Diesel Engines"*.

2.1.1 Engine Oil Reserve Tank

An oil reserve tank with a capacity of 8.4 US quarts (8,0 liters) (optional) is connected to the crankcase by a hose with a shutoff valve, allowing oil to be added to crankcase by opening valve. Comparison of oil levels in sight gauge, before and after adding oil to crankcase, shows approximately how much oil has been added.

Filling of this tank can be made by opening the rear engine doors. The tank is mounted on R.H. side of engine compartment, over the A/C compressor.

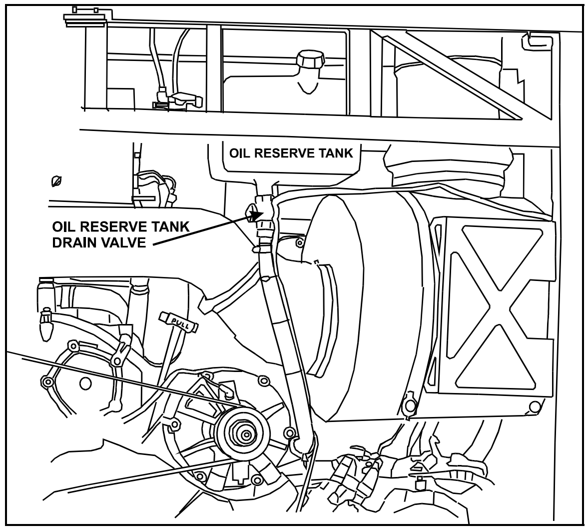


FIGURE 1: ENGINE OIL RESERVE TANK 01063

2.2 COLD WEATHER OPERATION

The proper selection of the engine oil grade will ease cold weather starting (refer to the lubrication and servicing schedule for the engine oil grade recommendation). Other practical considerations, such as the use of batteries, cables and connectors of adequate size, proper setting of voltage regulator, ether starting aid, oil and coolant heater systems, and proper fuel selection will ease cold weather starting.

2.3 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.

2.3.1 Pre-Starting 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.

2.3.2 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.

⚠ CAUTION ⚠

Personal injury and/or property damage may result from fire due to the leakage of flammable fluids, such as fuel or lube oil.

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.

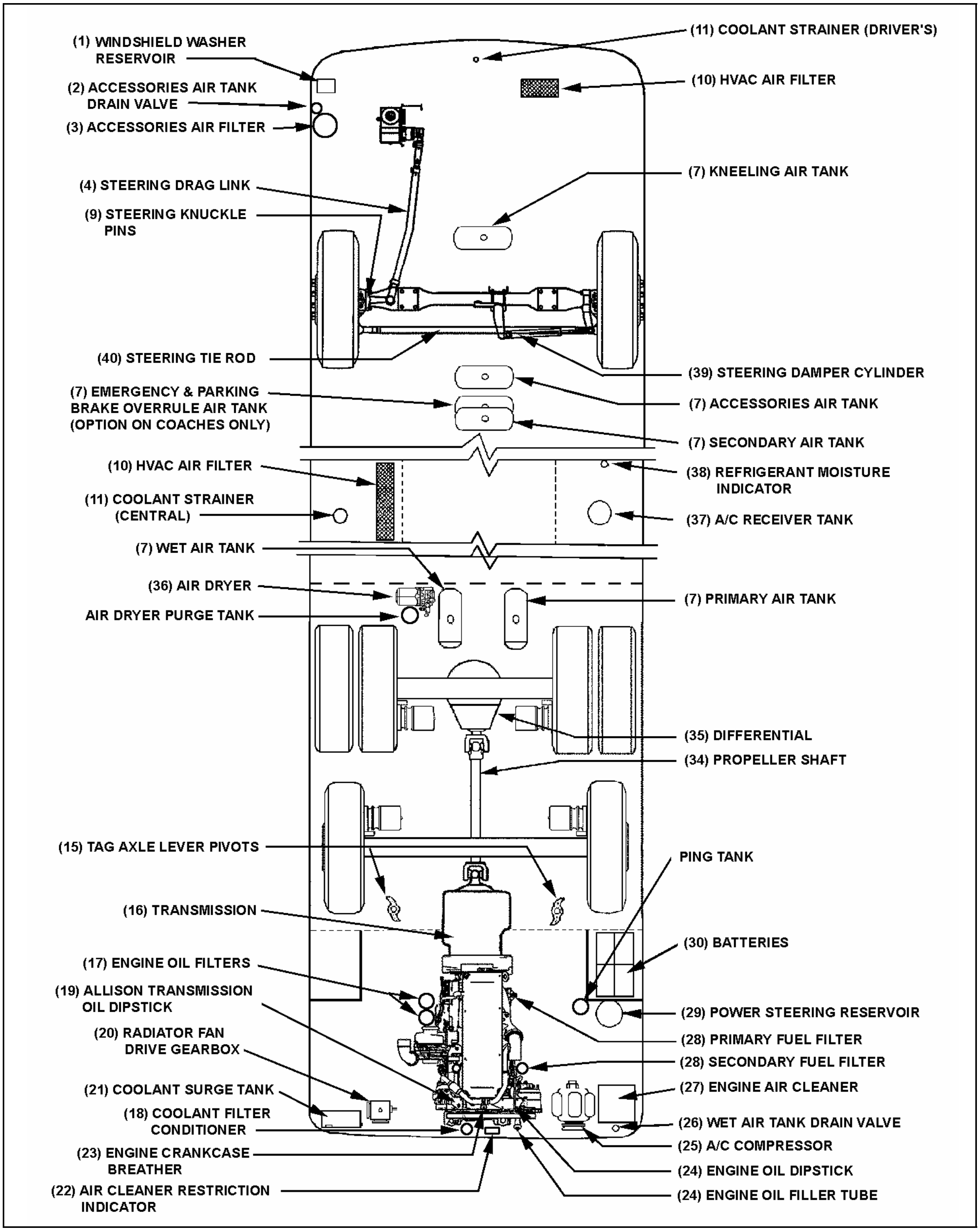


FIGURE 2: LUBRICATION AND SERVICING POINTS ON I-BEAM FRONT SUSPENSION VEHICLES 24023

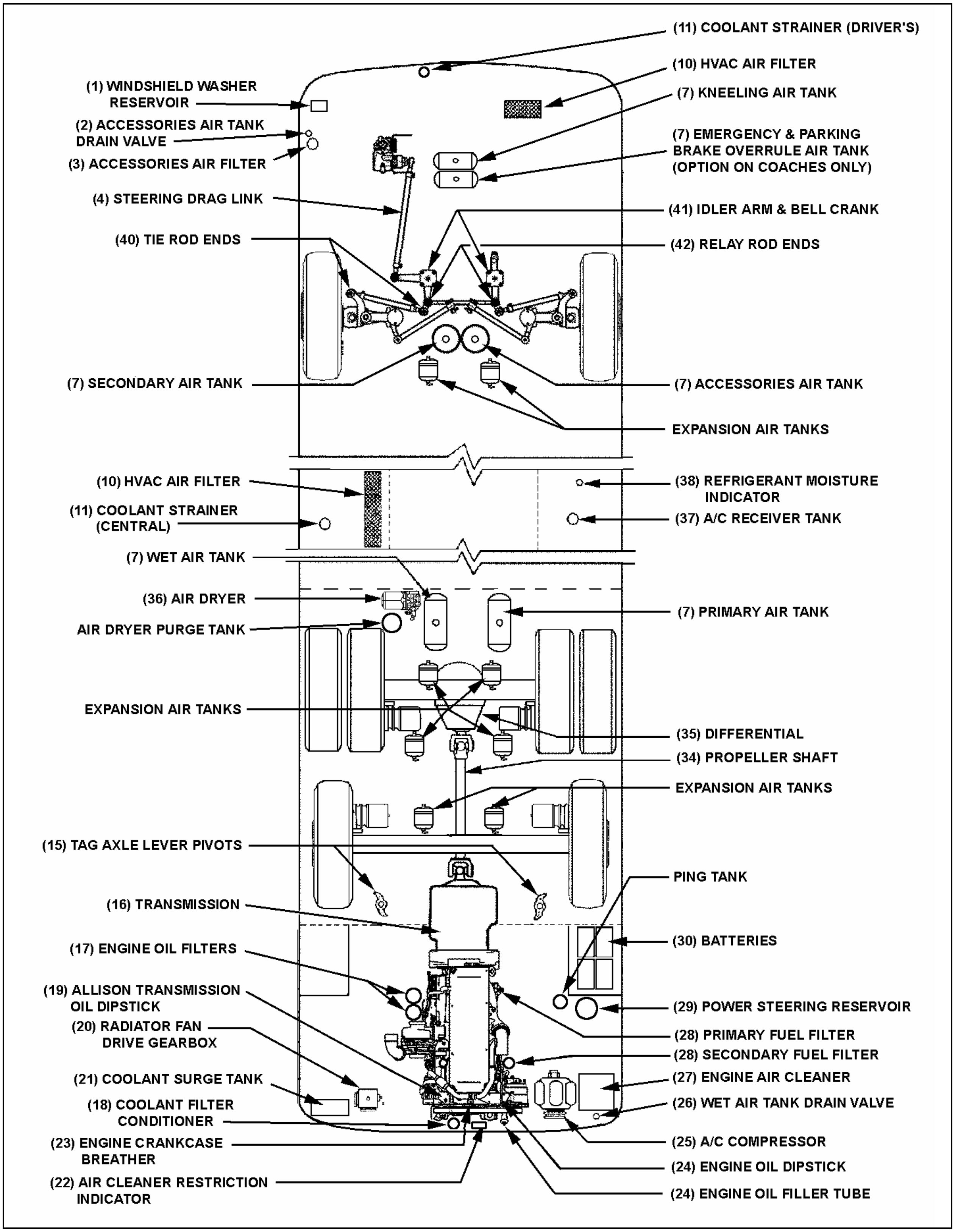


FIGURE 3: LUBRICATION AND SERVICING POINTS ON INDEPENDENT FRONT SUSPENSION VEHICLES 24024

2.4 WALK-AROUND INSPECTION

It is good practice to make a basic visual inspection of key areas on the vehicle every day (or before every trip for private coaches) and to correct any problem found.

OUTSIDE THE VEHICLE	
ITEM*	DESCRIPTION
---	Check for leaks under vehicle and in engine compartment.
---	Check that baggage and service compartment doors close properly.
---	Inspect tires and wheels for correct tire pressure, wear or damage and for missing wheel studs and nuts.
1	Check windshield washer fluid level and add if necessary.
---	Check condition of windshield wiper blades.
---	Verify proper operation of all road lights, signal lights, brake lights, marker lights and back-up lights; Replace light bulbs as required.
2, 26	Drain accumulated water in accessory and wet air tanks.

ENGINE COMPARTMENT	
ITEM*	DESCRIPTION
24	Check engine crankcase oil level; Add if necessary.
19	Check Allison transmission oil level (can be checked from push-button shift selector); Add if necessary.
29	Check power steering reservoir fluid level; Add if necessary.
21	Check coolant surge tank fluid level; Add if necessary.
28	Drain accumulated water in primary fuel filter/water separator (if equipped). Visually check fuel filter cartridge (Fuel-Pro 382 equipped vehicles only).
22, 27	Check air cleaner restriction indicator; Replace air cleaner when red signals locks in full view.

INSIDE THE VEHICLE	
ITEM*	DESCRIPTION
---	Check for proper operation of the entrance door.
---	Check that emergency exit windows and roof escape hatches can be opened, then close all windows and hatches securely.
---	Verify proper operation of windshield wiper/washer.
---	Adjust and clean mirrors as needed for adequate rear-view vision.
---	Start engine and check for proper operation of all gauges and indicator lights.
---	Check for proper operation of electric and air horns and back-up alarm.
---	Perform a brake test. Check both primary and secondary pressure gauges.

* Item numbers refer to figures 2 and 3.

2.5 LUBRICATION AND SERVICING SCHEDULE

2.6 LUBRICANT AND COOLANT SPECIFICATIONS

ITEM*	DESCRIPTION	SPECIFICATIONS
24	Engine Oil	SAE Viscosity Grade: 15W40 API Classification: CI-4
29	Power Steering Oil	Automatic Transmission Oil (Dexron-IIE or Dexron-III)
18, 21	Engine Coolant	Low silicate, ethylene glycol coolant 50% antifreeze/water solution is normally used Antifreeze concentration should be between 30% and 67%
25	A/C Compressor Oil	Polyolester Oil, HFC 134a compatible: Castrol SW-68 (POE) or equivalent
35	Differential Oil	Multigrade gear oil meeting MIL-L-2105-D: 85W/140. 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.)
20	Fan Gearbox Oil	Synthetic oil: Mobil SHC 630
19	Allison Automatic Transmission Oil	Dexron-III/VI or TranSynd
19	ZF-ASTronic Transmission Oil	Castrol Syntrans Grade SAE 75W-85 (Synthetic)
---	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

* Item numbers refer to figures 2 and 3.

2.7 PART NUMBER SPECIFICATIONS

ITEM*	DESCRIPTION	PRÉVOST NO
17	Engine Oil Filters	#510458
29	Power Steering Reservoir Oil Filter	#660528
27	Engine Air Cleaner Filter	#530197
38	Refrigerant Filter Dryer Unit	#950262
28	Engine Primary Fuel Filter	#510137
28	Engine Primary Fuel Filter With Water Separator (Optional)	#531407
28	Engine Secondary Fuel Filter	#510128
28	Secondary “Racor” Fuel Filter	#531390
18	Engine Coolant Precharge Unit	#550629
18	Engine Coolant Filter/Conditioner	#550630
10	A/C And Heating Driver's Air Filter	#871147--871144
10	A/C And Heating Cabin's Air Filter	#871051
16	Allison World (WT) Automatic Transmission Oil Filter Kit	#571709
11	Coolant Strainer	#871029
3	Accessories Air Filter	#641340
36	Air Dryer Cartridge	#641244
---	Alternator drive belt, 85-1/2 in. (2 alternators)	#5060055
---	Alternator drive belt, 72 in. (1 alternator, limp home)	#5060056
---	Fan gearbox drive belt	#506688
---	Compressor drive belt BX100	#506864
---	Windshield wiper blade	#800329

* Item numbers refer to figures 2 and 3.

LUBRICATION AND SERVICING SCHEDULE	Item	Months	DISTANCE TRAVELED[1] (miles/km)																																LUBRICANT &/OR PART[2]
			6 250 / 10 000	12 500 / 20 000	18 750 / 30 000	25 000 / 40 000	31 250 / 50 000	37 500 / 60 000	43 750 / 70 000	50 000 / 80 000	56 250 / 90 000	62 500 / 100 000	68 750 / 110 000	75 000 / 120 000	81 250 / 130 000	87 500 / 140 000	93 750 / 150 000	100 000 / 160 000	106 250 / 170 000	112 500 / 180 000	118 750 / 190 000	125 000 / 200 000	131 250 / 210 000	137 500 / 220 000	143 750 / 230 000	150 000 / 240 000	156250 / 250 000	162 500 / 260 000	168 750 / 270 000	175 000 / 280 000	181 250 / 290 000	187 500 / 300 000	193 750 / 310 000	200 000 / 320 000	
GENERAL																																			
Flexible hoses, thoroughly inspect all hoses	-	12								•								•								•								•	-------
Front discharge tube, qty:2, check to see if clogged [3]	-	3																																	-------
01 ENGINE																																			
Air cleaner, inspect, clean, replace element if required	27	6	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	Filter #530197
Engine, change oil and filters. Oil SAE 15W40, API CI-4	17	12		•		•		•		•		•		•		•		•		•		•		•		•		•		•		•		•	Filter #510458
Engine crankcase breather, clean breather steel mesh	23	12								•								•								•								•	-------
03 FUEL																																			
Change primary & secondary fuel filters, fill with clean fuel before installation	28	12		•		•		•		•		•		•		•		•		•		•		•		•		•		•		•		•	Primary #510137 ; prim. w/sep #531390 ; secondary #510128
05 COOLING																																			
Radiator fan drive gearbox,check oil level, add if necessary	20	6	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	Mobil SHC 630 #180217
Radiator fan drive gearbox, change oil	20	12								•								•								•								•	Mobil SHC 630 #180217
Coolant filter/Conditioner, replace element	18	12		•		•		•		•		•		•		•		•		•		•		•		•		•		•		•		•	Filter #550630
Coolant surge tank, test coolant solution	21	12		•		•		•		•		•		•		•		•		•		•		•		•		•		•		•		•	-------
Cooling system, drain, flush and refill	18/21	24																																•	Engine coolant
06 ELECTRICAL																																			
Battery terminals, clean and coat terminals	30	12																																	Battery terminal coating
Bosch alternators, replace brushes & voltage regulator		24																•																•	Regulator #562981 Brush set #562983
Bosch alternators, replace bearings		48																																•	Bearing, Ball #562972 Bearing, Roller #562976

[1] Proceed to maintenance operation at distance indicated on odometer or specified number of month, whichever comes first.
[2] See paragraph 2.5 & 2.6 of this section for lubricant and part number specifications.
[3] Discharge tubes are rubber tubes located under vehicle

LUBRICATION AND SERVICING SCHEDULE	Item	Months	DISTANCE TRAVELED[1] (miles/km)																																	LUBRICANT &/OR PART[2]
			6 250 / 10 000	12 500 / 20 000	18 750 / 30 000	25 000 / 40 000	31 250 / 50 000	37 500 / 60 000	43 750 / 70 000	50 000 / 80 000	56 250 / 90 000	62 500 / 100 000	68 750 / 110 000	75 000 / 120 000	81 250 / 130 000	87 500 / 140 000	93 750 / 150 000	100 000 / 160 000	106 250 / 170 000	112 500 / 180 000	118 750 / 190 000	125 000 / 200 000	131 250 / 210 000	137 500 / 220 000	143 750 / 230 000	150 000 / 240 000	156250 / 250 000	162 500 / 260 000	168 750 / 270 000	175 000 / 280 000	181 250 / 290 000	187 500 / 300 000	193 750 / 310 000	200 000 / 320 000	250 000 / 400 000	
07 TRANSMISSION																																				
Allison World Automatic transmission equipped with retarder, change oil (standard oil) and filters	16	6		•		•		•		•		•		•		•		•		•		•		•		•		•		•		•		•		Oil Dexron-III/VI
Allison World Automatic transmission without retarder, change oil (standard oil) and filters	16	12				•				•				•				•				•				•				•				•		Oil Dexron-III/VI
Allison World Automatic transmission equipped with retarder, change oil (TranSynd synthetic fluid)	16	24								•								•								•								•		TranSynd Synthetic Fluid
Allison World Automatic transmission with or without retarder, change filters (TranSynd synthetic fluid)	16	24								•								•								•								•		Filters #571709
Allison World Automatic transmission without retarder, change oil (TranSynd synthetic fluid)	16	48																								•										TranSynd Synthetic Fluid
ZF-Astronic Automatic Transmission, change oil & filter after 185 000 miles (300 000 km)	16	24																														•				Castrol Syntrans grade SAE 75W-85
Transmission oil cooler, replace unit if vehicle is equipped with transmission retarder	43	24																																		Prévost #550712
09 PROPELLER SHAFT																																				
Grease one fitting on each universal joint and slip joint	34	6	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		Multipurpose grease
11 REAR AXLE																																				
Differential, check oil level, add if necessary	35					•				•				•				•				•				•				•				•		Same type of oil used
Differential, change oil, clean breathers	35	12																•																•		Multigrade gear oil
Differential, change oil, clean breathers	35	48																																	•	Full synthetic gear oil
Tag axle lever pivot, grease one fitting on each pivot	15	6	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		Multi purpose grease
12 BRAKE & AIR																																				
Air tanks, drain water from all tanks	7	12		•		•		•		•		•		•		•		•		•		•		•		•		•		•		•		•		-------
Accessories air filter, change filter element	3	24																•																•		Filter element #641340
Air dryer, change cartridge	36	24																•																•		Cartridge #641244 or 641278

[1] Proceed to maintenance operation at distance indicated on odometer or specified number of month, whichever comes first.
[2] See paragraph 2.5 & 2.6 of this section for lubricant and part number specifications.

LUBRICATION AND SERVICING SCHEDULE	Item	Months	DISTANCE TRAVELED[1] (miles/km)																																LUBRICANT &/OR PART[2]
			6 250 / 10 000	12 500 / 20 000	18 750 / 30 000	25 000 / 40 000	31 250 / 50 000	37 500 / 60 000	43 750 / 70 000	50 000 / 80 000	56 250 / 90 000	62 500 / 100 000	68 750 / 110 000	75 000 / 120 000	81 250 / 130 000	87 500 / 140 000	93 750 / 150 000	100 000 / 160 000	106 250 / 170 000	112 500 / 180 000	118 750 / 190 000	125 000 / 200 000	131 250 / 210 000	137 500 / 220 000	143 750 / 230 000	150 000 / 240 000	156250 / 250 000	162 500 / 260 000	168 750 / 270 000	175 000 / 280 000	181 250 / 290 000	187 500 / 300 000	193 750 / 310 000	200 000 / 320 000	
14 STEERING																																			
Drag link ends, grease one fitting at each end	4	6	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	Multi purpose grease
Relay rod ends, grease one fitting at each end	36	6	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	Multi purpose grease
Steering tie rod ends, grease one fitting at each end	40	6	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	Multi purpose grease
Idler arm, grease fitting	41	6	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	Multi purpose grease
Bell crank, grease fitting	41	6	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	Multi purpose grease
Steering damper cylinder, grease one fitting at rod end	39	6	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	Multi purpose grease
Steering knuckle pins, grease two fittings per knuckle	9	6	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	Multi purpose grease
Power steering reservoir, replace oil and filter cartridges	29	12								•								•								•								•	Cartridge #660987
16 SUSPENSION																																			
Upper A-Arm Ball Joint, grease fitting	42	6	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	Molykote longterm 2/78 grease (preferably) or lithium NLGI no2 or no1
22 HEATING & AIR CONDITIONING																																			
A/C compressor, check oil level, add if necessary	25	6	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	Polyolester oil
A/C receiver tank, check refrigerant level, add if necessary	37	6	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	HFC 134A
Refrigerant moisture indicator, replace filter dryer unit according to moisture indicator (as needed)	38	6	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	Filter #950262
A/C and Heating air filters, clean or replace all elements	10	6		•		•		•		•		•		•		•		•		•		•		•		•		•		•		•		•	Driver #871147 , passenger #871051
Coolant strainer, check, clean, change cartridge if required	11	12								•								•								•								•	Cartridge #871029
Condenser discharge tube, qty:2, check to see if clogged [3]	-	3																																	-------
Evaporator discharge tube, qty:6, check to see if clogged [3]	-	3																																	-------
Evaporator motor, condenser motor, recirculating pump drive motor, inspect brush, replace if necessary	-	12								•								•								•								•	Refer to parts manual

[1] Proceed to maintenance operation at distance indicated on odometer or specified number of month, whichever comes first.
[2] See paragraph 2.5 & 2.6 of this section for lubricant and part number specifications.

CONTENTS

LIST OF ILLUSTRATIONS

1 SLIDE-OUT

1.1 INNER STOPPER

The front slide-out is equipped with six inner stoppers laid out in the following way: two stoppers on the top horizontal member of the slide-out, and two stoppers on each vertical upright, while the rear slide-out is equipped with only three stoppers (figure 1 and figure 2). The upper inner stoppers are used to provide a support to position perpendicularly the slide-out with the vehicle structure.

The side inner stoppers are used to block the extension of the slide-out. They act as ultimate physical limits but take note that when the "out limit" sensors are properly adjusted, the slide-out extension stops before the side inner stoppers reach the side structure keys (figure 1 & 2).

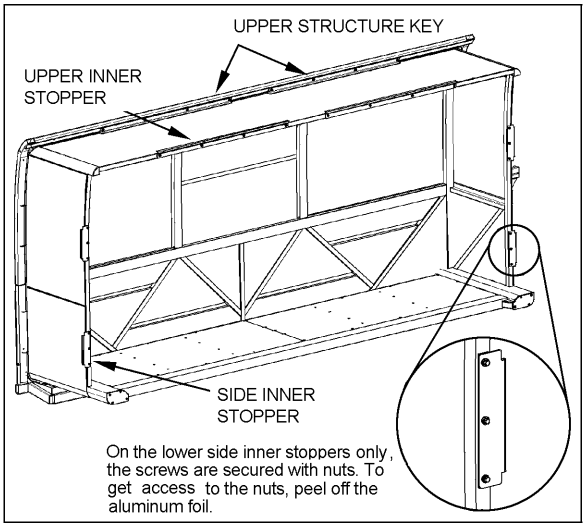


FIGURE 1 : FRONT SLIDE-OUT

1.1.1 Maintenance

Check that the inner stopper screws are tight and that no damage or deformation has taken place for both the side and the upper stoppers.

1.1.2 Adjustment

1. Adjust the side inner stoppers at 1/8" from the vehicle side structure keys, and tighten the screws. Make sure there is a minimum gap of 2mm (0.079") between the side inner stopper and the side window pane (figure 3). Use shim as required.

2. Adjust the upper structure key and the upper inner stoppers according to FIGURE 4 with the seal deflated. When inflating, the seal presses the roof structure upward and at that moment, the upper inner stopper comes into contact with the upper structure key

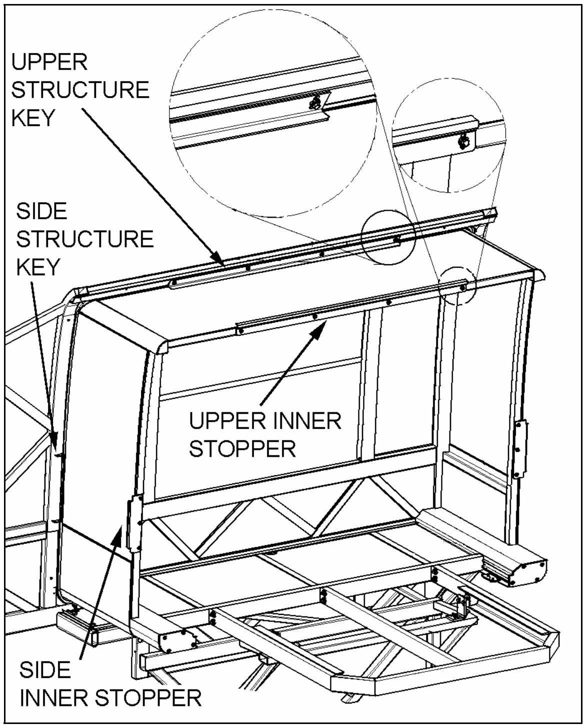


FIGURE 2 : REAR SLIDE-OUT

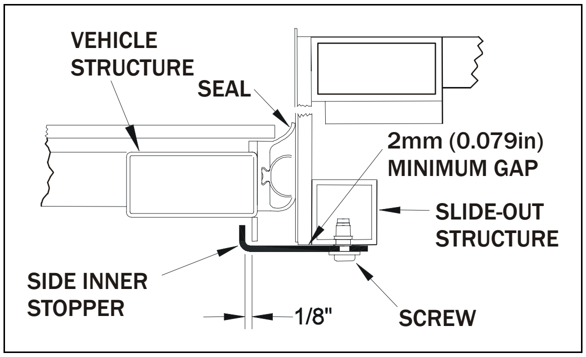


FIGURE 3 : SIDE INNER STOPPER ADJUSTMENT

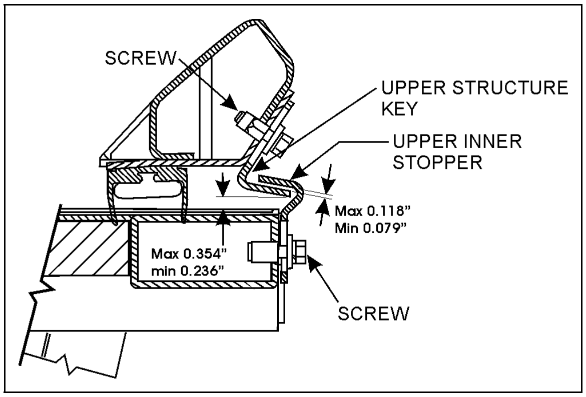


FIGURE 4: UPPER INNER STOPPERS ADJUSTMENT

1.2 "IN LIMIT" STOPPER

Each slide-out has four "in limit" stoppers. Two "in limit" stoppers are mounted on the exterior extrusion at the top of the slide-out (FIGURE 6) and two other "in limit" stoppers are mounted under the slide-out, next to the rail (Figure 5). These stoppers are use to position the outer face of the slide-out flush with the vehicle body when retracted.

1.2.1 Maintenance

Check that the "in limit" stoppers are clean and that there is no foreign matter accumulated between the stopper and their bearing surface. Check that the screws and set screws (where applicable) locking the stoppers in proper position are tight.

1.2.2 Adjustment

NOTE
To properly adjust the "in limit" stoppers, the slide-out system must be turned off to prevent the "in limit" sensors from stopping the slide-out movement before having the "in limit" stoppers contacting their bearing surface.

1. Extend the slide-out partially.
2. Set the ignition switch to the OFF position.
3. To adjust the lower "in limit" stoppers, loosen the set screw and then rotate the stopper CW or CCW to move it back or forward depending on the required adjustment. To adjust the upper plastic "in limit" stoppers, add or remove shims as required between the stopper and the extrusion.
4. Using the manual override procedure (section 18), move the slide-out up to its full "in" position.
5. Using a straight edge, check if the outer face of the slide-out is flush with the vehicle body with the stoppers contacting their bearing surface. Readjust the stoppers if necessary.
6. Readjust the "in limit" sensor.

NOTE
To make sure that the lower "in limit" stoppers are contacting their bearing surface (the acetal plastic blocks) when the slide-out is closed, put white paint on the "in limit" stopper before and check if the acetal plastic blocks are marked with paint.

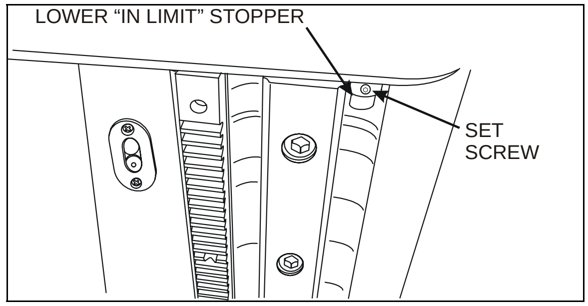


FIGURE 5: LOWER "IN LIMIT" STOPPER

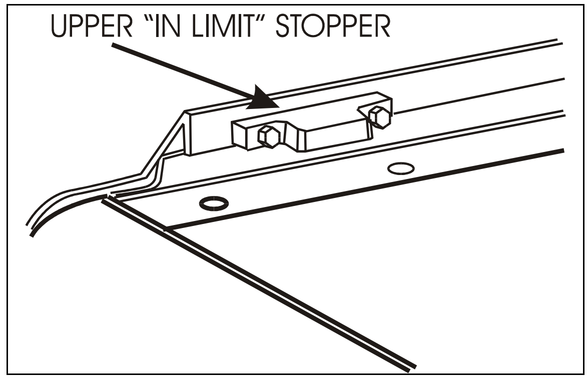


FIGURE 6: UPPER "IN LIMIT" STOPPER

1.3 EXTERIOR EXTRUSION

The exterior extrusion function is to provide a leaning surface for the inflatable seal. When inflating, the seal leans against the extrusion and presses the roof structure upward until it rests on the inner side of the extrusion.

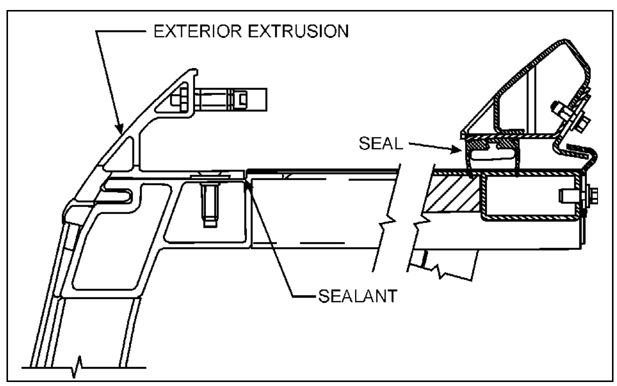


FIGURE 7 : EXTERIOR EXTRUSION

1.3.1 Maintenance

Inspect the exterior extrusion for any deformation or deterioration. Check that the screws are tight. Inspect the sealant condition on screw head and between the extrusion and the vehicle structure, and also at both ends of the extrusion. If needed, clean old sealant and replace with Sika 221 sealant or equivalent product.

2 SECURITY PIN

During normal ride, the slide-out cannot extend by itself because the 740:1 ratio speed reduction worm gear type gearbox system is not reversible, the output shafts are self-locking. The security pin purpose is to lock the slide-out in retracted position if an accident occurs. It is built to stand a great lateral acceleration of the slide-out.

The system consists of a stainless steel pin connected to a single action/spring return pneumatic cylinder (FIGURE 8). The pin engages in the slide-out receptacle with releasing of the parking brake. A knocking sound may be heard at this moment. An O-ring is located at the base of the pin housing to reduce knocking when the pin retracts. The lower hole on the pin housing permits water to drain. The upper hole permits to insert a small screwdriver to prevent the pin from rotating when the air cylinder has to be removed.

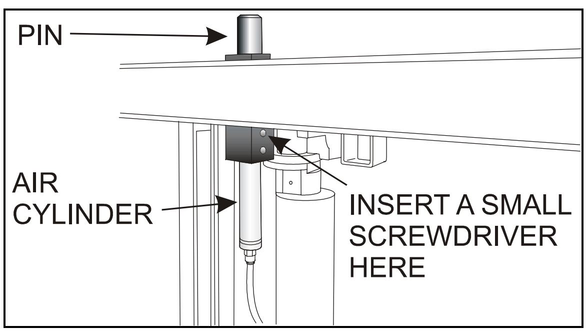


FIGURE 8: SECURITY PIN AIR CYLINDER REMOVAL

2.1 MAINTENANCE

Inspect air cylinder and fitting for air leaks. Periodically, check that the pin retracts and engages in the receptacle as it should when the parking brake is applied or released. To do slide-out, the slide-out must be in its full “IN” position with the engine running. If the pin produces excessive knocking when it engages with releasing of the parking brake, reduce air cylinder speed by adjusting the air flow regulator on the pneumatic control panel (FIGURE 29, item 11).

2.2 AIR CYLINDER REPLACEMENT

1. Assure the parking brake is applied.
2. Disconnect the cylinder air tubing from the 2nd baggage compartment (front slide-out) or under the bed structure (rear slide-out).
3. Using a wrench at its lower end, unscrew the air cylinder from the pin housing.
4. Insert a small screwdriver through the pin and housing to prevent rotation of the pin an then, unscrew the cylinder rod from the pin.
5. Transfer the fitting on the new cylinder. Place Teflon on threads.
6. Cylinder installation is like removal but in reverse order.

3 ROOF REINFORCING ROD

⚠ CAUTION ⚠
The front slide-out roof reinforcing rod may have to be adjusted after a load variation inside the vehicle or on the top of the vehicle.

⚠ CAUTION ⚠
Always lock the turnbuckle using the jam nut to prevent loosening.

The roof reinforcing rod is located on the upper horizontal member of the front slide-out opening and is welded on the roof arches (figure 9).

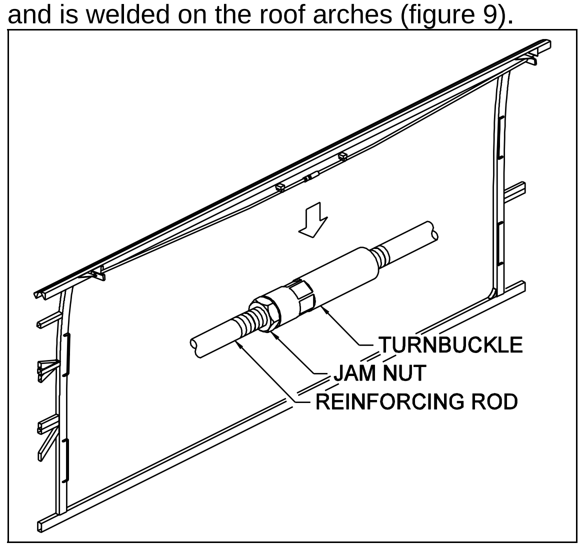


FIGURE 9 : FRONT SLIDE-OUT ROOF REINFORCING ROD

This rod allows an adjustment between the slide-out horizontal member and the roof. When screwing the turnbuckle, the roof is moved upward, and vice versa. Use this rod to adjust the horizontal member parallel to the slide-out. A member not parallel with the slide-out may cause the inflatable seal to leave the wiper seal or may reduce the inflatable seal and wiper seal efficiency.

4 RACK

Slide-out movement is made by a system of racks and pinions. There are two racks on each slide-out.

4.1 MAINTENANCE

Once a year, check the racks for broken or worn tooth, especially the front slide-out racks. Also, check the rack fastening hole teeth that are weaker and might break (figure 10). Replace the racks if excessive wear is present. Clean racks from sand or other debris. Check that the racks are properly secured. Check the backlash between the gear and the rack. Excessive backlash indicates rack wear.

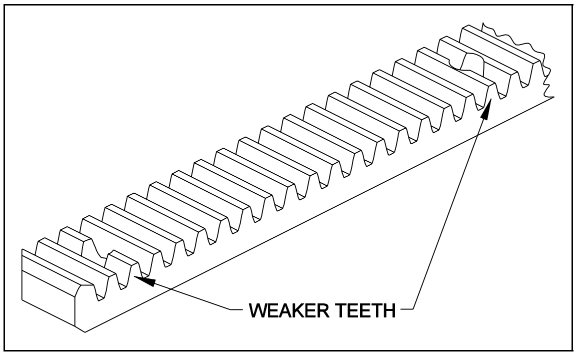


FIGURE 10 : RACK

4.2 FRONT SLIDE-OUT RACK REPLACEMENT

1. Remove the slide-out from the vehicle (removal must be performed according to the Slide-Out Removal Procedure. Ask to your Prevost service representative).
2. From under the slide-out, unscrew all the rack screws and remove the rack.
3. Install a new rack. Tighten the screws to a <u>maximum torque of 2 ft-lbs</u>. Use Loctite™ 242 or equivalent product on threads.

⚠ CAUTION ⚠
The counterborings required for recessed screw heads reduce plastic thickness. Do not torque higher than specified.

4. Reinstall the front slide-out inside the vehicle.

4.3 REAR SLIDE-OUT RACK REPLACEMENT

1. Using the slide-out handheld control or the manual override procedure (section 18, if using the manual override procedure, do not forget to deflate the inflatable seal completely), extend the slide-out about one foot.
2. From outside, unscrew and remove only the first two screws of the rack to be changed.
3. Using the manual override procedure (section 18) only, retract the slide-out to its fully closed position.
4. Loosen the pinion keyless bushing of the rack to be changed.
5. From under the slide-out, unscrew all the rack screws and remove the rack.
6. Install a new rack between the slide out structural rack seat and the pinion. Tighten the screws to a <u>maximum torque of 2 ft-lbs</u>. Use Loctite™ 242 or equivalent product.

⚠ CAUTION ⚠
The counterborings required for recessed screw heads reduce plastic thickness. Do not torque higher than specified.

7. Tighten the pinion keyless bushing as described in section 5.4.
8. Using the slide-out manual override procedure only, extend the slide-out about one foot.
9. Tighten the two remaining crews to a <u>maximum torque of 2 ft-lbs</u>. Use Loctite™ 242 or equivalent product.
10. Using the slide-out handheld control switch or the manual override procedure, retract the slide-out to its fully closed position.
11. Re-inflate the air seal at 10 psi.

5 PINION

⚠ CAUTION ⚠

Make sure all keyless bushings are tightened to 125 lb-ft before moving the slide-out. Refer to section 5.4 for torque wrench settings. A lower torque value may cause the bushing to slip on the shaft, and a higher torque value may break the bushing.

5.1 PINION AND KEYLESS BUSHING POSITIONING

For proper functioning, respect the positioning shown on the following figure.

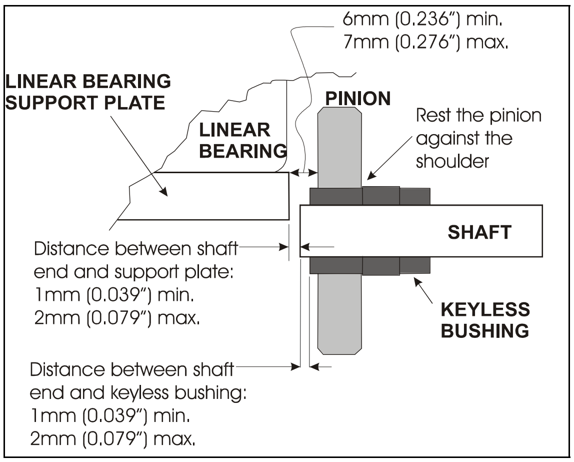


FIGURE 11: PINION AND KEYLESS BUSHING POSITIONING

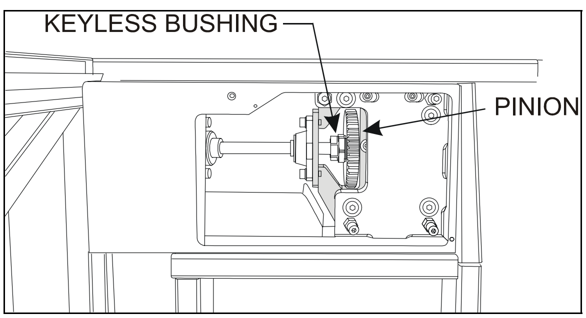


FIGURE 12: PINION AND KEYLESS BUSHING AS SEEN FROM EVAPORATOR COMPARTMENT

5.2 FRONT SLIDE-OUT SHAFT PINION REPLACEMENT

⚠ CAUTION ⚠

Before reinstalling the pinion, clean the following surfaces with alcohol to prevent slippage.
- **Pinion bore;**
- **Keyless bushing I.D. and O.D.;**
- **Shaft.**

Before proceeding with the front slide-out shaft pinion replacement, check the following conditions:
- The locking collars located on the side of the pinion being replaced are disengaged;
- The drive motor/gearbox assembly is removed (see section 7.2);

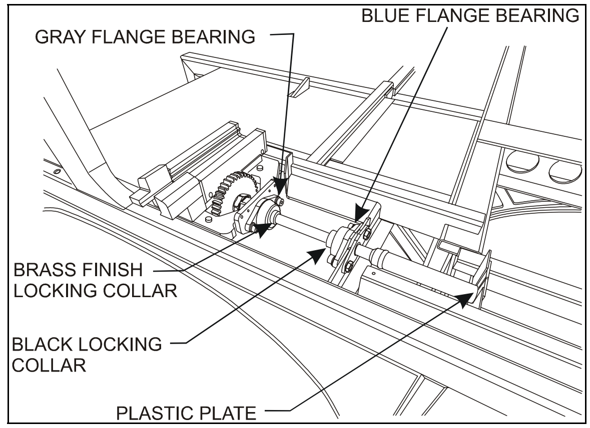


FIGURE 13: MECHANICAL COMPONENTS (TYPICAL)

1. Loosen the keyless bushing (see section 5.4) of the pinion to be replaced. Slide the pinion and its bushing out of the shaft. Check the keyless bushing condition and replace if needed.

NOTE

If necessary, loosen the blue and gray flange bearing to move the pinion away from the rack.

2. Assemble new pinion on the keyless bushing and then slide on the shaft. Do not tighten the bushing at this moment.
3. Properly position the shaft end in relation to the linear bearing support plate (see FIGURE 11) and then tighten the locking collars to maintain the shaft in that position.
4. Position pinion and keyless bushing as shown on FIGURE 11 and tighten the keyless bushing as described in section 5.4.
5. Reinstall the drive motor/gearbox assembly.

⚠ CAUTION ⚠

Make sure the keyless bushing is tightened to 125 lb-ft before moving the slide-out. Refer to section 5.4.1 for torque wrench settings.

5.3 REAR SLIDE-OUT SHAFT PINION REPLACEMENT

The procedure is similar to the front slide-out shaft pinion replacement. Gain access to the mechanism from under the bed structure. Refer to section 5.2.

5.4 KEYLESS BUSHING

The keyless bushings need a specific tightening torque value to ensure proper pinion transmitting torque. They also need specific tools to be tightened.

To tighten or loosen the keyless bushing, use those specific tools:

- crowfoot wrench 1 ½";
- torque wrench;
- combination wrench 1 ¾";
- pipe wrench;
- drive extension 5";
- socket 1 ½".

5.4.1 Installation

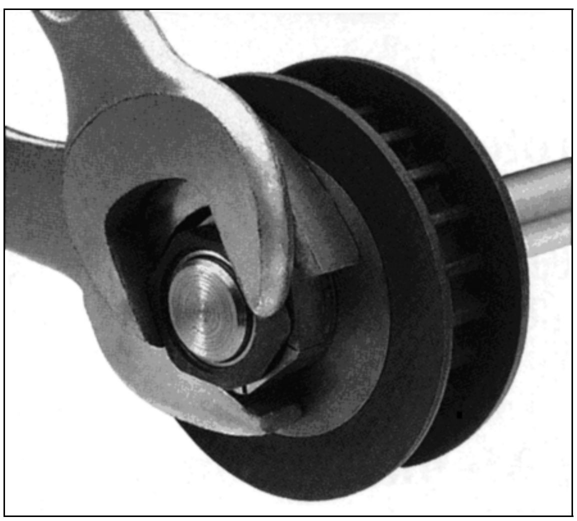


FIGURE 14 : KEYLESS BUSHING TIGHTENING

To tighten the keyless bushing, use a special open-end wrench to retain the yellow part and another wrench to tighten the black part. Figure 20 shows how to tighten the keyless bushing.

When tightening, make sure the pinion does not move or rotate.

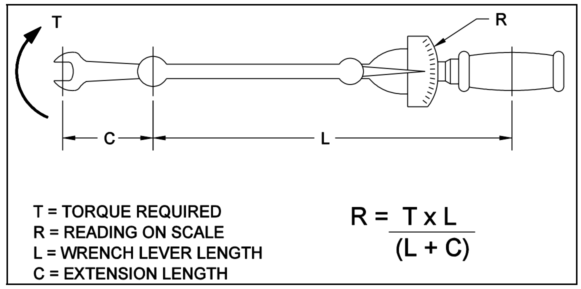
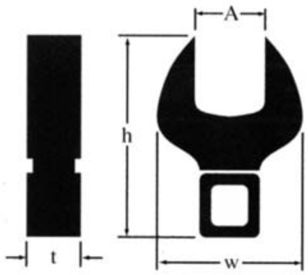


FIGURE 15 : TORQUE WRENCH FORMULA

⚠ CAUTION ⚠
Make sure all keyless bushings are tightened to 125 lb-ft before moving the slide-out. A lower torque value may cause the bushing to slip on the shaft, and a higher torque value may break the bushing. The torque may need to be recalculated depending of the wrench size. Refer to figure 15 for wrench size compensation.

Take note that when the keyless bushing nut is tightened, the pinion moves about 1/16" to 3/32" toward the slide-out center.

NOTE
On the front slide-out, the driver side keyless bushing is not accessible for tightening or removal unless you remove the front left wheel. If the slide-out has been removed, this keyless bushing should be tightened before reinstalling the slide-out.



Style C
Installation Nut

WRENCHES FOR INSTALLATION

Fenner Drives offers a complete line of high-quality crowfoot wrenches for installation and to provide counter-torque. These wrenches are much narrower than earlier designs and are specifically for use with Trantorque GT units. It is recommended that both wrenches be used when installing a Trantorque GT unit.

1/2" SQUARE DRIVE

Shaft Size	Part Number	Wrench Style	Dimensions (inches)			
			A	h	w	t
13/16 to 1	6202990024	C	1-1/2	3.44	2.75	0.75

INSTALLATION INSTRUCTIONS

A Trantorque GT Keyless Bushing offers flexible and easy installation while providing exceptional holding power. To ensure a Trantorque GT unit performs as specified, it must be installed properly.

Warning: Use no lubricants in this installation.

1. Shaft and component bore must be within ±0.003"(±0.08mm) [±0.0015"(±0.04mm)Mini Series] of stated bore diameter and must have a surface finish of 32-125 Ra (roughness average). If the surface finish is outside these specified values, consult Fenner Drives.

2. Both shaft and component bore must be completely free of paint, grease, oil, and dirt. If necessary, clean the surfaces with a non-petroleum based solvent, such as isopropyl alcohol.

Warning: Do not lubricate the Trantorque GT bushing or shaft. The use of any lubricant on the contact surfaces could result in bushing failure and will void all warranties.

3. Insert the Trantorque GT unit into the component to be mounted, making sure the mating hub is flush against the shoulder at the hex flats.

4. Position the assembly at the desired location on the shaft and hand-tighten the nut (clockwise) until the assembly becomes snug on the shaft.

Warning: Do not hammer or use any type of impact to force the Trantorque GT assembly along the shaft.

Warning: The shaft must fully engage the shaft gripping area (Figure 1) of the Trantorque GT unit. Figure 2 illustrates minimum shaft engagement.

5. Using a torque wrench, tighten the nut to the proper installation torque. See table for torque value. (Note: Fenner Drives has available crowfoot wrenches for square drives in sizes from 1/2" to 3-1/2".) The hex flats on the outer ring are provided for counter-torque, eliminating the need to hold the component or shaft while applying installation torque.

Note: At full installation torque, the assembly will have moved approximately ±0.075"(±1.9mm)[±0.045"(±1.1mm)Mini Series] axially along the shaft away from the nut. If axial position is critical it may be necessary to loosen the nut and reposition the assembly.

Warning: Over-tightening the nut could damage the Trantorque GT unit and/or the mounted component.

Do not use an impact wrench in the installation.

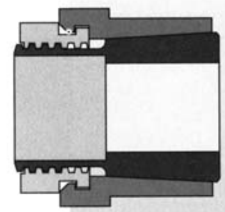


Figure 1

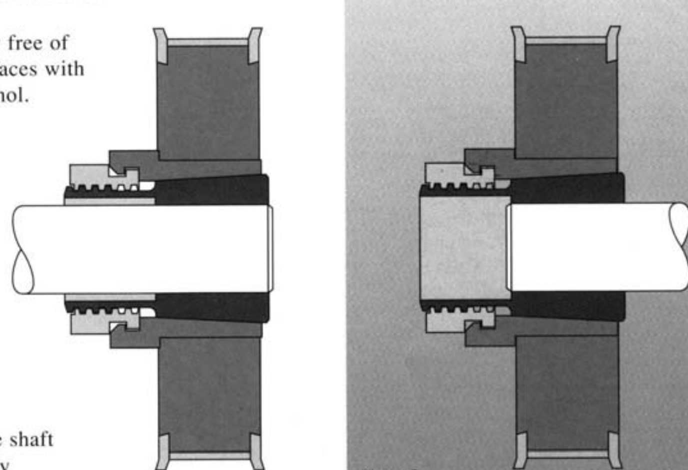


Figure 2

Installation Torque on Nut

	Inch Pound System		Metric System	
	Shaft Size	In.Lbs.	Shaft size	N-m
MINI SERIES	3/16–1/4	125	5–6mm	14.1
	5/16–3/8	150	7–9mm	17.0
	7/16–1/2	175	10–12mm	19.8
	9/16–5/8	200	14–16mm	22.6
	3/4	700	17mm	80.0
STANDARD SERIES	5/8–3/4	1200	15–19mm	136
	13/16–1	1500	20–25mm	170
	1-1/16–1-1/4	2000	28–32mm	225
	1-5/16–1-1/2	2300	34–38mm	260
	1-9/16–1-3/4	2800	40–42mm	316
	1-13/16–2	4900	45–50mm	554
LARGE SERIES	2-1/16–2-1/4	5300	55mm	600
	2-5/16–2-1/2	5600	60mm	635
	2-9/16–2-3/4	6000	65–70mm	680
	2-13/16–3	6600	75mm	750

FIGURE 16 : KEYLESS BUSHING INSTALLATION INSTRUCTION

6 ELECTRIC MOTOR

The power is supplied by a 24V 1/3 HP electric motor coupled with a speed reduction gearbox. Opposite to the gearbox, the motor is equipped with a 3/8 hexagonal socket shaft extension permitting to move the slide-out without using the handheld control. This is very useful when moving the slide-out very slowly is required like during the inner stoppers adjustment, the tilt adjustment or the 2" inside retraction. See section 18 for the manual override procedures.

⚠ CAUTION ⚠
When moving the slide-out with a cordless power drill as described in the manual override procedure, be careful as the slide-out approaches its opened or closed position, in order not to overload the mechanism.

6.1 MAINTENANCE

Inspect the electrical connections and their watertightness. Check that the mounting bolts are tight (FIGURE 18).

6.2 REPLACEMENT

1. The slide-out must be retracted.
2. Unplug the electric cable connector.

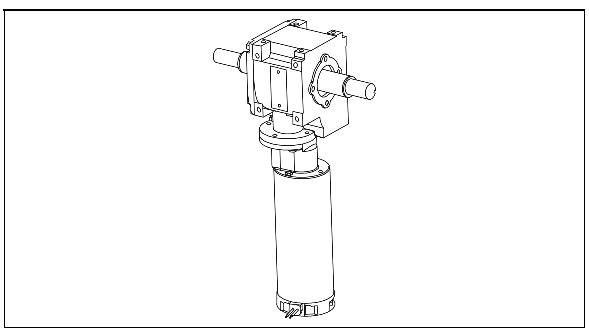


FIGURE 17: ELECTRIC MOTOR AND SPEED REDUCTION GEARBOX

3. Remove the motor from the gearbox.
4. Fasten the new motor to the gearbox using screws.
5. Re-connect the electric cable connector.

7 SPEED REDUCTION GEARBOX

The speed reduction gearbox used is a helical worm gear type. This gearbox has a 2-stage 740:1 ratio and the output shafts are self-locking. Keys on output shafts are glued into keyseats.

7.1 MAINTENANCE

Inspect the gearbox to check if there is any leakage or backlash in the box. Replace the gearbox if excessive wear is present. Check that all bolts are tight.

The gearbox is lubricated for life and the oil should not have to be changed.

7.2 GEARBOX REPLACEMENT

1. The slide-out must be retracted.
2. Disengage the shafts jaw couplings (refer to section 8: JAW COUPLING).
3. Remove the 4 cap screws securing the drive motor/gearbox assembly and dismount the assembly (see FIGURE 18).
4. Remove the gearbox from the motor and install the new one.
5. Reinstall the drive motor/gearbox assembly on the vehicle mounting bracket. Tighten mounting bolts to a torque of 18 lbf-ft in a criss-cross patern.

⚠ CAUTION ⚠
To prevent damaging threads, use your fingers to drive the bolts into the aluminum gearbox housing mounting holes.

6. Reinstall the jaw couplings.

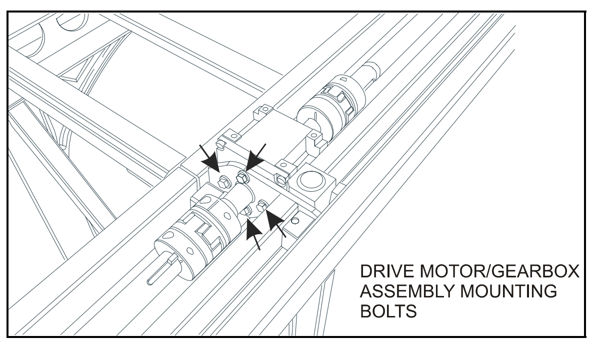


FIGURE 18: DRIVE MOTOR/GEARBOX ASSEMBLY MOUNTING BOLTS

8 JAW COUPLING

8.1 MAINTENANCE

Inspect the jaw couplings to check if there is backlash between the key and the keyway. Also, check the spider condition. Check that the clamping screws are tight.

8.2 REPLACEMENT & ADJUSTMENT

1. The slide-out must be retracted.
2. Disengage the jaw coupling: loosen the clamping screw on each clamping hub. If required, rotate the motor shaft extension as described in the manual override procedure (section 18) to get to the clamping screws.
3. Separate both clamping hubs.

NOTE
It may be necessary to loosen the blue flange bearings to move the shaft out of the way.

4. Clean and degrease the hub bore and the shaft.
5. Push the new clamping hubs onto the shaft (pinion side).
6. Install a clamping hub on one of the gearbox shaft (opposite side of gearbox mounting bolts) flush with the shaft extremity (FIGURE 19). Tighten the clamping screw to a torque of 18 lbf-ft.
7. Install the second clamping hub on the gearbox shaft. Position the clamping hubs so that they are flush with the shafts extremity (see FIGURE 19).

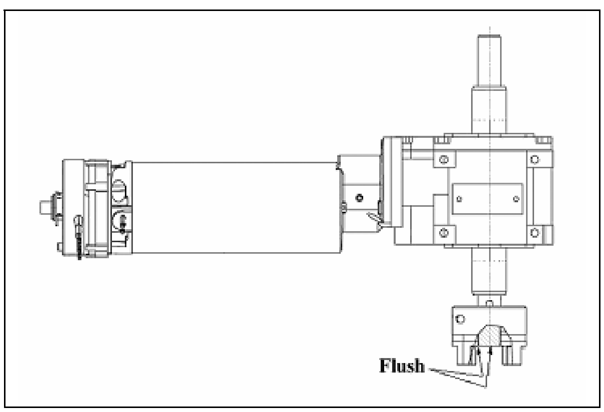


FIGURE 19: CLAMPING HUB POSITION ON GEARBOX SHAFT

8. Reconnect the clamping hubs with the spider. Leave a gap of 20mm (0.787inch) between each clamping hubs as shown on FIGURE 20. Use the motor hexagonal socket output shaft to align the keyways.
9. Tighten clamping screws to a torque of 18 lbf-ft.

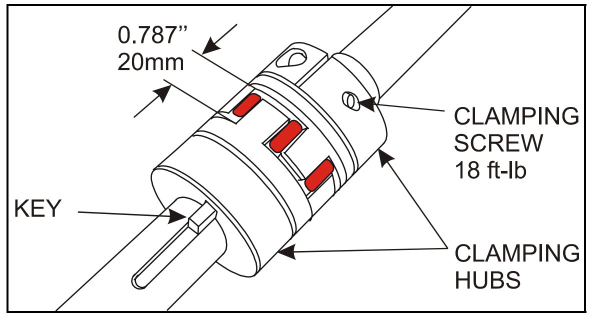


FIGURE 20: JAW COUPLING

9 FLANGE BEARING

There are two different types of flange bearing on the slide-out mechanism (FIGURE 13). Their purpose is to maintain the shaft in position while permitting rotation. The gray flange bearings are fixed to the linear bearing support plate and are not adjustable. The blue flange bearings are fixed to a support with oblong holes permitting to raise or lower the flange bearing as the linear bearing support plate level is being adjusted.

The flange bearings are pre-lubricated and no subsequent lubrication is required due to the very low extending and retracting speed of the slide-out system.

10 LOCKING COLLAR

The locking collar locks the shaft and the flange bearing together using friction. Once locked, it permits no axial translation of the shaft and prevents rotation of the shaft into the flange bearing bore.

10.1 INSTALLATION

Slide the locking collar along the shaft up to the flange bearing (FIGURE 13). Turn the locking collar clockwise while maintaining it pressed against the flange bearing. Knock the collar with a punch to lock it in place, there is a cavity on the collar made for that purpose. Tighten the set screw.

To remove, loosen the set screw and release the locking collar using channellock pliers or a small pipe wrench.

11 LINEAR BEARING

11.1 MAINTENANCE

Make every effort not to allow dust and foreign objects to enter inside the linear bearing.

The linear bearings are pre-lubricated and no subsequent lubrication is required due to the very low demanding use of the slide-out system.

11.2 REPLACEMENT & ADJUSTMENT

1. Remove the slide-out from the vehicle (removal must be performed according to the Slide-Out Removal Procedure. Ask to your Prevost service representative).
2. Disconnect the jaw coupling on the side of the linear bearing being replaced (refer to section 8).
3. Dismount the blue flange bearing.
4. From the mechanism access panel, remove the retaining screws A, B, C & D (see figure 22).
5. Now, you have access to the linear bearing mounting bolts if you turn its support up side down. Dismount the linear bearing and install the new one.
6. Tighten the mounting bolts in a criss-cross pattern to a torque of 60 ft-lb.
7. Reinstall the support plate, retaining screws, blue flange bearing and reengage the jaw coupling. Refer to the specific procedures.

11.3 LEVEL & TILT ADJUSTMENT

Leveling of the slide-out is done by changing the linear bearing support plate height using the leveling screws 1, 2, 3, 4 (figure 22). When proper level is attained, the retaining screws A, B, C & D maintain the support plate seated on the leveling screws. Also, the retaining screws prevent the slide-out from tipping inside the vehicle when it is retracted.

The slide-out is slightly tilted. When retracting, the upper "in limit" stoppers touch first the vehicle structure, followed by the lower "in limit" stoppers. Tilt adjustment is done by changing the linear bearing support plate inclination using the leveling screws 1 & 2 as pivot and 3 to adjust the angle (figure 22).

11.3.1 Procedure

NOTE

*For the **front slide-out**, the front linear bearing leveling screws are accessible from the access panel located over the front wheel while the rear linear bearing leveling screws are accessible from the access panel in the evaporator compartment. For the **rear slide-out**, access the linear bearing from under the bed structure or the radiator compartment.*

WARNING

The slide-out must be retracted when the level and tilt adjustment is performed.

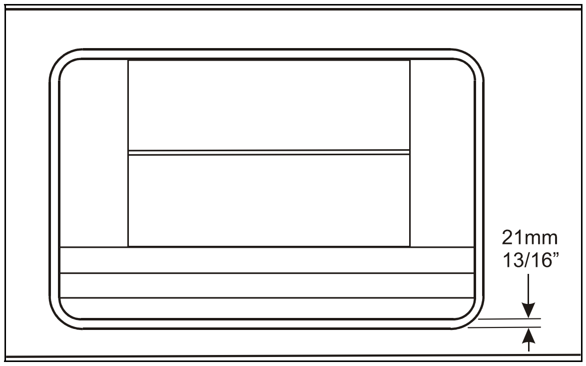


FIGURE 21: SLIDE-OUT LEVEL ADJUSTEMENT

Before proceeding with the level and tilt adjustment, check the following conditions:

- The slide-out is retracted;
- The 2 lower “in limit” stoppers are perfectly adjusted, that means that the lower edge of the slide-out outer panel is flush with the vehicle body when retracted;
- The 2 upper “in limit” stoppers are removed from the slide-out (see section1.2).

1. Loosen the blue flange bearings mounting screws (FIGURE 13).
2. For front slide-out only, loosen the two plastic plates mounting screws along the shafts (FIGURE 13).
3. With the lower edge of the slide-out outer panel flush with the vehicle body, adjust the slide-out level. The distance between the top of the horizontal member under the slide-out and the slide-out under panel must be 21mm (13/16” approximately).

⚠ WARNING ⚠
Never unscrew completely retaining screw A, B, C, D or the slide-out may tip inside.

To raise the linear bearing support plate, turn levelling screw 1 & 2 clockwise. Slightly and gradually, loosen the retaining screws A & B as the support plate elevates, but keep the retaining screws tighten.

To lower the linear bearing support plate, turn screw 1 & 2 counterclockwise. As the support plate goes down, maintain the retaining screw A & B tighten.

4. Loosen retaining screws C & D. Unscrew leveling screw 4. Now, the support plate should be resting on levelling screw 1, 2 & 3.
5. Using levelling screw 3, adjust the tilt in order to have the top of the slide-out recessed between 5mm and 10mm (7/32" and 3/8") (see FIGURE 23).
6. When proper tilt is attained, tighten leveling screw 4 so that it comes into contact with the support plate.
7. Loosen slightly levelling screw 3 and then tighten it so it is perfectly in contact with the support plate. Make sure screws 1, 2, 3 & 4 are in contact with the support plate.
8. Loosen retaining screw A & B.
9. Using a crisscross pattern, tighten progressively (3 rounds) the retaining screw A, B, C & D to a torque of 50 ft-lb.
10. Assure that the levelling screw 1, 2, 3 & 4 are firmly leaning on the support plate and then firmly tighten the jam nuts.
11. Verify that the tilt is still properly adjusted (between 7/32" and 3/8").

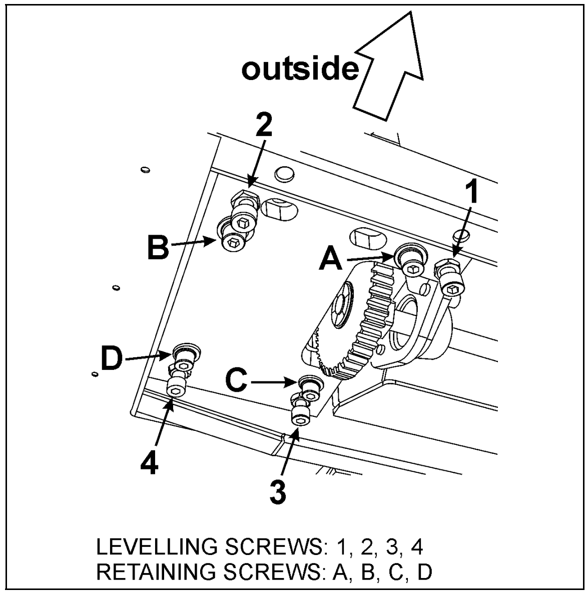


FIGURE 22 : SLIDE-OUT LEVELING

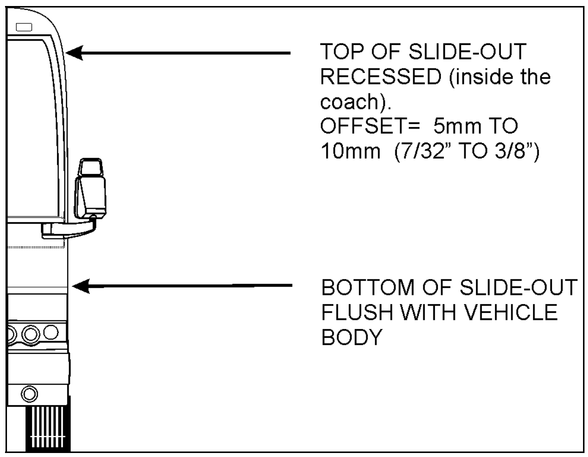


FIGURE 23: TILT ADJUSTMENT

12 RAIL

Rail and linear bearing system provide precise frictionless linear movement together with high load carrying capacity and high stiffness. These standardized equipments are fully interchangeable.

To prevent corrosion, an electrolytic black film treatment is performed to the rail. Do not strike the rail with metal tools, this could damage the treatment.

After the rail is mounted to the slide-out base, a cap is used to cover the bolt hole to prevent foreign matters from clogging up the hole or from entering into the ball slide. The cap for the bolt hole is made of synthetic resin which is superb in its resistance to oil and wear.

12.1 MAINTENANCE

Check that all the caps for the bolt hole are present. Missing caps must be replaced. To insert a cap into the rail bolt hole, use a flat tool. Pound the cap gradually until its height becomes flush with the rail top face.

Clean accumulated dirt from the rails with a soft cloth.

12.2 REPLACEMENT

1. Remove the slide-out from the vehicle (removal must be performed according to the Slide-Out Removal Procedure. Ask to your Prevost service representative).
2. Remove the bolt hole cap covers. To do so, pierce a hole in the center and hook them out. They will not be reusable.
3. Remove the rail mounting bolts.
4. Wipe off the rust preventive oil applied to the new rail. Remove burrs and small bumps on the slide-out mounting face with an oilstone.
5. Carefully place the rail on the bed on its mounting face.

NOTE
The rail is bolted to a flat bar on which weldnuts are mounted. The flat bar is inserted in the slide-out lower body extrusion and can be removed through the end cap (FIGURE 24).

6. Adjust the flat bar position to align the weldnuts with the rail mounting holes.
7. Temporarily tighten the bolts.
8. Adjust the rail position with as per FIGURE 24. For each rail, make sure the gap is the same both side of the rail.
9. For final tightening of the bolts, tighten on either end of the rail and then start to the other end. Tighten to a torque of 95 ft-lbf. Use blue Loctite ™ on threads.
10. Cap the bolt holes.

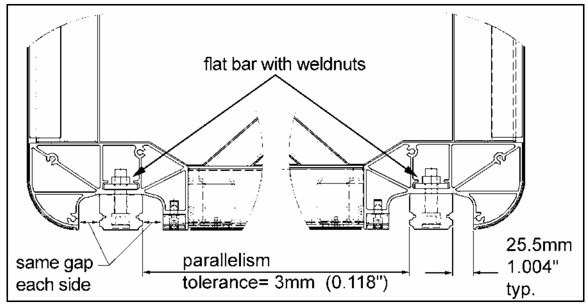


FIGURE 24 : RAIL POSITIONING

13 ACETAL PLASTIC BLOCKS

Three different acetal plastic blocks are installed next to each linear bearing to prevent dirt and foreign matter from entering inside the vehicle. They also serve as bearing surface for:

1. The inflatable seal each side of the rail.
2. The “in limit” stoppers.

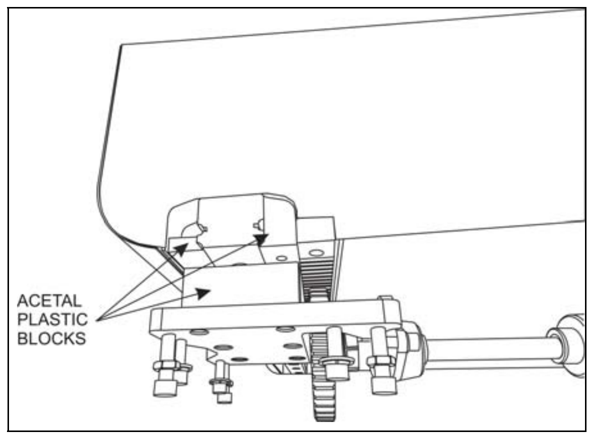


FIGURE 25: ACETAL PLASTIC BLOCKS

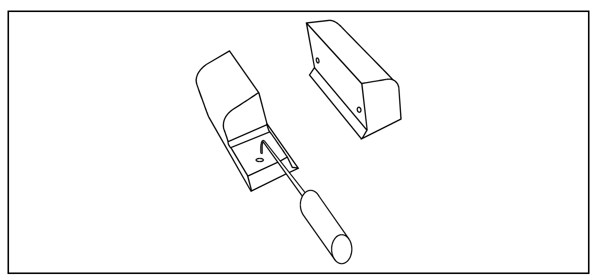


FIGURE 26: REMOVE THE UPPER ACETAL PLASTIC BLOCKS WITH A PICKING TOOL

13.1 REMOVAL / INSTALLATION

1. Gain access to the linear bearing support plate.
2. From under the support plate, remove the acetal plastic block mounting screws (see the oblong holes on figure 22).
3. Remove the 2 upper acetal plastic blocks. They have holes so they can be removed

with a picking tool (FIGURE 26) from outside the vehicle. If the acetal plastic blocks are too hard to reach, slightly extend the slide-out, the movement of the slide-out should bring them out.

4. To remove the lower acetal plastic block, gain access to the compartment under it. Slide the acetal plastic block toward the center of the slide-out. Proceed the same way to reinstall it.
5. Reinstalling the upper acetal plastic blocks. Fold the wiper seal toward the outside with a flat tool to ease installation (FIGURE 27). Tighten the mounting screws to a torque of 7 ft-lb. Leave no gap between the blocks and the rail.

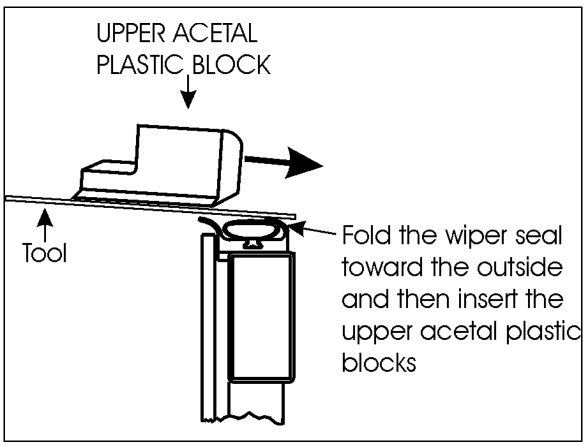


FIGURE 27: LOWER ACETAL PLASTIC BLOCK INSERTION

14 SLIDE-OUT PNEUMATIC SYSTEM

The slide-out is controlled by a pneumatic and electrical system. Mainly, the pneumatic system consists of electrically operated valves that control slide-out components and safety operations.

14.1 DESCRIPTION

AIR PRESSURE INLET VALVE

The slide-out air pressure comes from the air pressure inlet valve on the pneumatic panel in the front service compartment (figure 28).

INFLATABLE SEAL VALVE

The inflation and the deflation of a seal are done using a 5-port 2-position manifold valve with two solenoids. One solenoid is used for inflating of the seal and the other for deflating of the seal. When one of the solenoids is activated (seal deflating valve for example), the valve will keep its state even if the solenoid is deactivated. The inflating valve solenoid is activated to re-inflate the seal when the slide-out reaches its inner or outer limit. The inflatable seal pressure is set to 10 psi and in full “IN” or full “OUT” position, this pressure is continuously applied to the seal as long as the accessory air tank (which supply the slide-out) is not empty.

VACUUM GENERATOR

A vacuum generator using Venturi principle is controlled by a 5-port 2-position manifold valve and is used to evacuate the air faster from the seal and to ensure that the seal surface does not stay in contact with the slide-out.

The vacuum generator valve is activated simultaneously with seal deflating valve solenoid for 10 seconds. A pressure transducer will detect a seal, vacuum valve or generator failure if -5 psig is not reached after the 10 seconds delay. In that situation, an error code will be stored in the MCD (message center display). In normal operating condition, -5 psig is a necessary condition to consider the seal as deflated.

NOTE
When air pressure is relieved using the shut-off valve, the normal extending and retracting operation cycle is disabled, because the pressure transducer reads 0 psig and that is higher than -5 psig (vacuum). For that reason the slide-out cannot be moved with the handheld control.

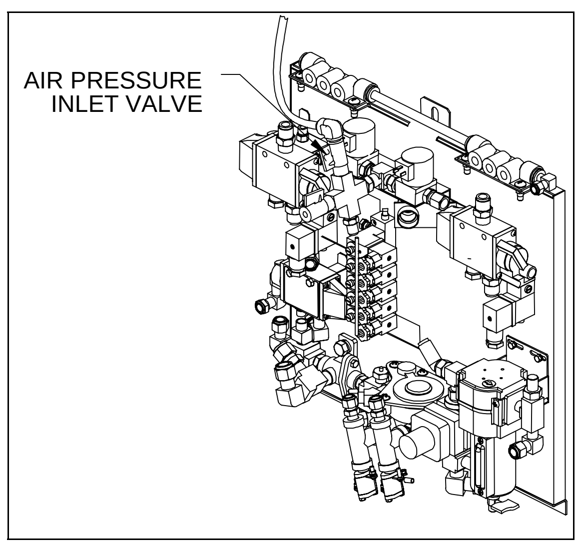


FIGURE 28 : FRONT SERVICE COMPARTMENT

14.2 MAINTENANCE

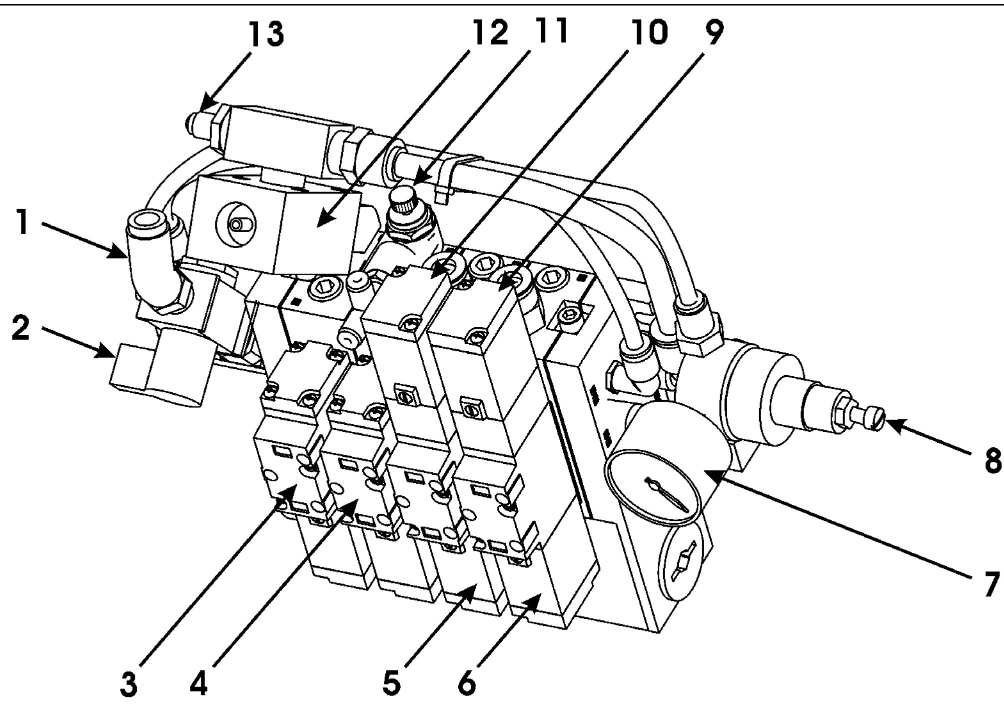
COMPRESSED AIR LINE

Inspect all compressed air line tubing for cut, swelling, kink or other damage or deterioration. Inspect the pneumatic fittings and components for any leak. The slide-out air supply is connected to the accessory air tank and the maintenance is specified in the “brake and air system” section from the Prevost maintenance manual.

INFLATABLE SEAL CIRCUIT

The efficiency of the seal could be affected by impurities, such as white powder in the pneumatic control valve. It is recommended to inspect the inflatable seal control components once a year to prevent malfunction. In this case, remove the seal valves and clean the interior valve components using a compressed air nozzle. Do the same thing with the vacuum generators.

The inflatable seal pressure must be set from 7 to 10 psi maximum. It is recommended to check the inflatable seal pressure once a month to ensure sealing efficiency and prevent any infiltration from outside.



1- AIR SUPPLY
2- RELIEVING SHUT-OFF VALVE & HANDLE
3- SEAL VACUUM VALVE
4- SECURITY PIN VALVE
5- FRONT SLIDE-OUT SEAL VALVE, DEFLATION SOLENOID
6- REAR SLIDE-OUT SEAL VALVE, DEFLATION SOLENOID
7- PRESSURE INDICATOR
8- PRESSURE REGULATOR
9- REAR SLIDE-OUT SEAL VALVE, INFLATION SOLENOID
10- FRONT SLIDE-OUT SEAL VALVE, INFLATION SOLENOID
11- SECURITY PIN AIR FLOW REGULATOR
12- VACUUM GENERATOR
13- PRESSURE TRANSDUCER

FIGURE 29: PNEUMATIC COMPONENT PANEL

14.3 SEAL

NOTE
Refer to the Prevost parts manual for descriptions of the sealant and adhesives used.

The slide-out sealing device is used to prevent any type of infiltration that may occur between the structure body and the slide-out itself. It is composed of an inflatable seal which is used as a primary sealing device for both retracted and extended slide-out position and a wiper seal as a secondary sealing device which is used to wipe water out and to ensure sealing during slide-out movement.

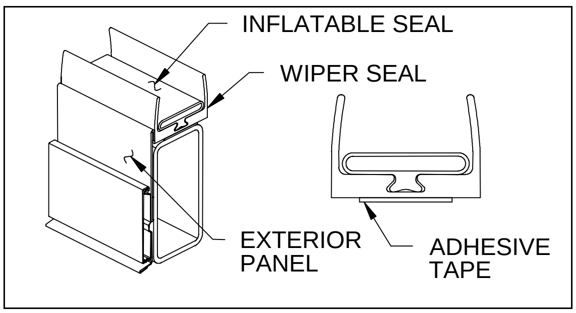


FIGURE 30 : SEAL ASSEMBLY

The seal deflation is done each time the slide-out moves. The deflating valve solenoid is activated before and during the slide-out movement. When the slide-out reaches its retracted or extended position, the deflating solenoid is deactivated before activation of the inflating solenoid to re-inflate the seal.

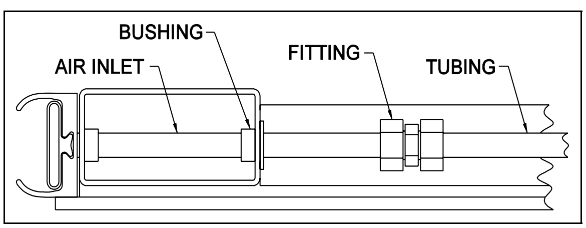


FIGURE 31: REAR SLIDE-OUT INFLATABLE SEAL AIR INLET

⚠ CAUTION ⚠
Make sure the inflatable seal is deflated when manually moving the slide-out during service maintenance. Deflate both inflatable seals completely by turning the relief shut-off valve handle clockwise (see FIGURE 29).

⚠ CAUTION ⚠
Check before using any cleaning or adhesive product on seal, panel or glass to prevent alteration or damage.

14.3.1 Maintenance

The inflatable seal pressure must be set to 10 psi maximum with the pressure regulator. It is recommended to check the inflatable seal pressure once a month to ensure sealing efficiency and prevent any infiltration from outside. Check both seals for air leaks or cracks. Check the sealant between the inflatable seal and the exterior panels and glasses. Add sealant if necessary.

14.3.2 Seal assembly removal

⚠ WARNING ⚠
Always wear the appropriate safety equipment. Maintain adequate ventilation at all time.

1. Retract the slide-out 2" inside the vehicle (section 14.3.4).
2. Unplug the tubing from the inflatable seal air inlet (FIGURE 31). Keep the bushing.
3. Unstick and remove the wiper seal from the structure.
4. Scrape remaining tape from the structure. Remove old sealant that was between the wiper seal and the exterior panels and glasses.

14.3.3 Seal assembly installation

NOTE
This procedure is to install the inflatable seal assembly on the structure.

⚠ CAUTION ⚠
Always apply product in the same direction to prevent dirt from being brought back.

⚠ CAUTION ⚠
Check before using any cleaning or adhesive product on seal, panel or glass to prevent alteration or damage.

NOTE
Refer to the slide-out parts manual for descriptions of primer, cleaner, sealant and adhesives used.

NOTE
Refer to the product specification for drying time.

1. Retract the slide-out 2" inside the vehicle (section 14.3.4).
2. Clean the part of the structure that will receive the inflatable seal and also the back of the exterior panel and glasses with a chix cloth and thinner. Use another cloth to dry the surfaces. Wait at least 2 minutes for drying.
3. Rub the structure and also the back of the exterior panel and glasses with a Scotch Brite (or equivalent product).
4. Clean another times the structure and the back of the exterior panel and glasses with a chix cloth and thinner. Use another cloth to dry the surfaces. Wait at least 2 minutes for drying.
5. Clean the structure and the back of the exterior panel and glasses with appropriate cleaner. Wait until the product is dry before proceeding.
6. Seal the gap between the structure and the exterior panels and the gap between the glasses and the fiberglass panels with appropriate sealant. Make sure not to put sealant on the structure surface where the inflatable seal will be placed. Wait until the product is dry before proceeding.
7. Install the inflatable seal on the structure, placing it as close as possible from the exterior side of the structure. Position the air inlet first. Then remove locally the inflatable seal adhesive tape protection, and press the upper corners on the structure and hold them in place for 90 to 120 seconds. Install the lower corners next, then the straight section. Press the straight inflatable seal sections on the structure for at least 15 seconds. Use a small roller to ensure a good adhesive contact on the structure.
8. Seal the gap between the inflatable seal and the exterior panels and the gap between the glasses and the fiberglass panels with appropriate sealant. Wait until the product is dry before proceeding. Remove excess sealant with appropriate cleaner.
9. Replace the bushing and plug the pneumatic tubing on the inflatable seal air inlet (FIGURE 31).

14.3.4 Slide-out 2" inside retraction

1. For both sides of the slide-out, remove the 2 upper acetal plastic blocks shown on FIGURE 26 (refer to section 13).
2. Manually deflate the seal completely by turning the relieving shut-off valve clockwise (FIGURE 29). Make sure the pressure indicator reading is "0 psi".
3. Turn the ignition to the off position. Using the manual override procedure (section 18), extend the slide-out a few inches so the exterior extrusion screws located on the top of the slide-out are accessible from outside (figure 7).
4. Using a knife cut the sealant between the extrusion and the roof (figure 7). Unscrew and remove the central exterior extrusion screws and the two end extrusion screws.

⚠ CAUTION ⚠
Do not use the slide-out handheld control to move the slide-out 2" inside the vehicle, because the limits are not recognized over the closed position. The slide-out will not stop and damage may occur.

5. Using the manual override procedure, move the slide-out 2" inside the vehicle, so the seal is accessible from outside (FIGURE 32).

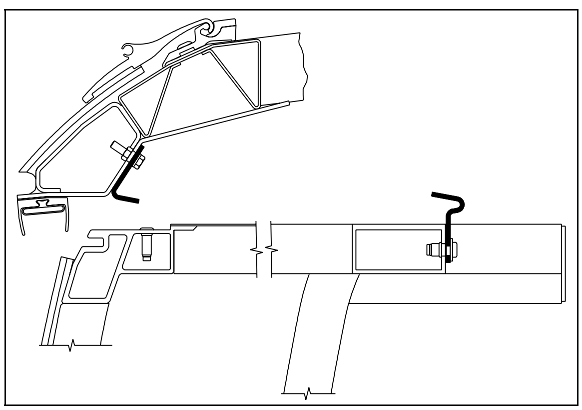


FIGURE 32: SLIDE-OUT 2" INSIDE – UPPER PART

6. Once completed, use the manual override procedure to extend the slide-out to reinstall the exterior extrusion. Apply appropriate sealant on the exterior extrusion screws and between the extrusion, the roof and the edges to prevent water infiltration (FIGURE 32).
7. Reinstall the acetal plastics blocks.
8. Using the manual override procedure, retract the slide-out to its closed position.
9. Finally, the seal can be re-inflated by turning the shut-off valve handle counterclockwise. Check the pressure gage on the inflatable seal regulator to see if the pressure is increasing to 10 psi.

15 SLIDE-OUT ELECTRICAL SYSTEM

WARNING

Never modify the slide-out electrical wiring without the Prevost Car approval. Any modifications may cause an unexpected slide-out action and could result in personal injuries.

The multiplexed slide-out electrical system is mainly composed of the Master ID module, the CECM module, the VEC module and two I/O-B modules.

Each slide-out has its own I/O-B module and two power relays. The I/O-B modules analyze the input signal conditions and activate outputs like the pneumatic valves, the retracting or extending programmed sequence, etc. The power relays are used to supply power coming from the I/O-B module to the electric motor and to change polarity to reverse motor rotation.

The I/O-B modules input signals are:

- Handheld control switch IN;
- Handheld control switch OUT;

Also, the following input signals are required for a safe operation of the slide-out:

- Pressure transducer;
- Parking brake;
- “in limit” sensor;
- “out limit” sensor;

The I/O-B modules output signals are:

- Handheld control green indicator light;
- Power relay current reversing;
- Seal valve inflating solenoid;
- Seal valve deflating solenoid;
- Vacuum generator valve solenoid;
- Security pin valve solenoid;
- Electric motor, first power output 15 amps;
- Electric motor, second power output 15 amps;

The CECM module output signals are:

- Dashboard telltale light;
- Transmission inhibit;

WARNING

Before working on the slide-out electrical system, turn the ignition key to the “OFF” position.

15.1 ELECTRICAL INTERCONNECTION WITH PREVOST VEHICLE

The slide-out power supply comes from the 24-volts circuit breaker (FIGURE 34) in the engine R.H. side access compartment. The other interconnections are located on the pneumatic panel and the electrical panel in the front service compartment. All the interconnections are shown on the electrical diagrams of your vehicle.

A blinking signal is added on the dashboard telltale panel (figure 33) to indicate that an error condition or a missing operation condition is present on a slide-out. The slide-out telltale light also illuminates to indicate that at least one of the slide-outs is extended.

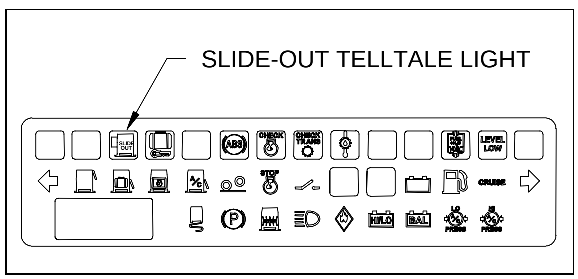


FIGURE 33 : DASHBOARD SLIDE-OUT TELLTALE LIGHT

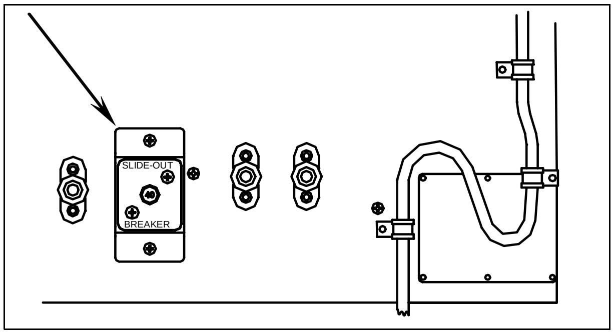


FIGURE 34: MAIN BREAKER IN ENGINE R.H. SIDE ACCESS COMPARTMENT

15.2 SLIDE-OUT BREAKERS / FUSES

The main breaker (for both slide-outs) is located in the engine R.H. side access compartment. All other slide-out breakers and hardware fuses are located inside the VEC, on the slide-out electrical component panel located in the third baggage compartment on the driver side (figure 35 and figure 36).

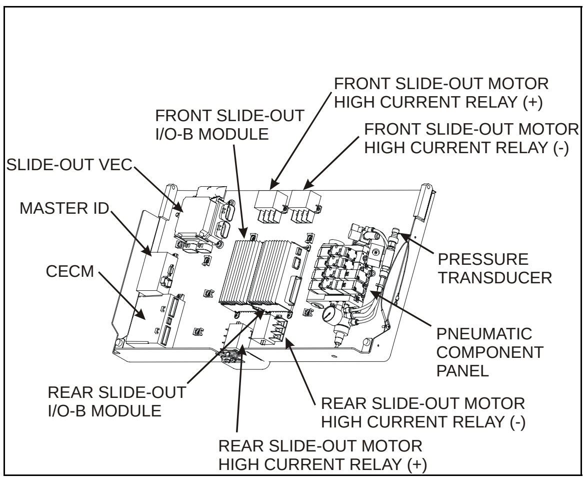


FIGURE 35 : SLIDE-OUT CONTROL PANEL

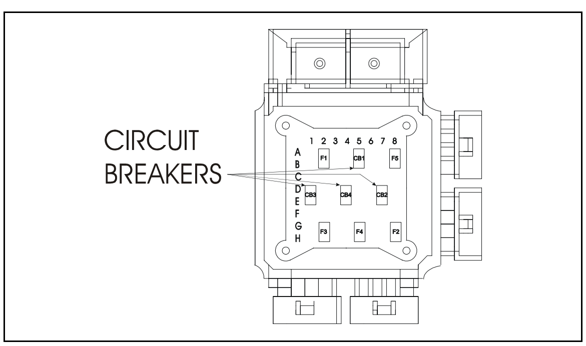


FIGURE 36 : VEC CIRCUIT BREAKERS & FUSES

15.2.1 Multiplex fuses

The multiplex module outputs are protected in current by an internal “soft-fuse”. Each output is programmed to 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".

⚠ CAUTION ⚠

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

15.3 PROBING VOLTAGE ON THE MULTIPLEX CIRCUITS

Multiplex modules are supplied by 24 volts.

Inactive Multiplex output = Residual voltage of 18% to 33% of supply voltage.

Inactive Multiplex input = Residual voltage of 50% of supply voltage.

NOTE

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.

15.4 MODULE REPLACEMENT

I/O-B and CECM multiplex modules can be replaced and reprogrammed without having to connect a computer to the vehicle.

15.4.1 I/O-B replacement

- Turn the ignition key to OFF.
- Replace the module (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).
- Turn the ignition key to the ON position. This engages the automatic reprogramming,
- The slide-out telltale light will turn on and stay on until the reprogramming is complete. Once completed, the slide-out telltale light will turn off or stay on (not blinking) if at least, one slide-out is extended.
- 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 (A56 or A57).

15.4.2 CECM module replacement

- Turn the ignition key to OFF.
- Replace the module.
- Turn the ignition key to the ON position. 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 slide-out telltale light will turn on and stay on for a while, and then will turn off. Wait until the slide-out telltale starts blinking each second. At this point, the MasterID module has finished loading the program in the CECM.
- Turn the ignition key to the OFF position and then turn it back to the ON position. This engages I/O's modules automatic reprogramming.
- The slide-out telltale light will turn on. Once completed, the slide-out telltale light will turn off or stay on (not blinking) if at least, one slide-out is extended.
- Check the SYSTEM DIAGNOSTIC menu of the message center display (MCD). Select FAULT DIAGNOSTIC and ELECTRICAL SYSTEM. You should read “no errors”. If an active error appears for a module, this one was not reprogrammed. In this case, repeat the procedure.

15.5 SLIDE-OUT LIMIT SENSORS

Two Hall-Effect sensors are used on each slide-out to define end limit positions. The "in limit" and "out limit" sensor detect two pairs of permanent magnets fixed on the slide-out underbody.

15.5.1 Maintenance and adjustment

The rear slide-out sensors are accessible from inside of the vehicle, under the bed structure while the front slide-out sensors can be reached from the 3rd baggage compartment access panel. To remove the sensors, unsnap them from the mounting bracket.

To adjust the "in limit" sensors:

Prior to adjust the “in limit” sensors, assure that the “in limit” stoppers are perfectly adjusted (see section 1.2.2).

1. Retract the slide-out to its full “IN” position with the “in limit” stoppers in contact with their bearing surface.
2. Loosen the “in limit” sensor mounting bracket screws and move back the sensor completely (toward the inside of the vehicle).
3. Bring slowly the sensor toward the outside of the vehicle until the light emitting diode (LED) turns on. When it does, move it 0.079” (2mm) further in the same direction and tighten the mounting bracket screws.
4. Check if the “in limit” sensor is properly adjusted. At the moment when the slide-out stops during normal retraction, the “in limit” stoppers must contact their bearing surface (lower acetal plastic block). Put white paint on the “in limit” stopper before and check if the acetal plastic blocks are marked with paint.

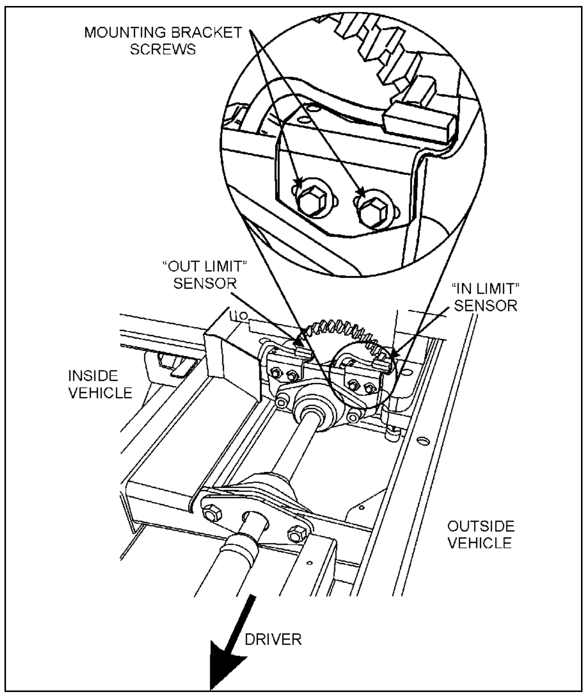


FIGURE 37 : FRONT SLIDE-OUT SENSORS

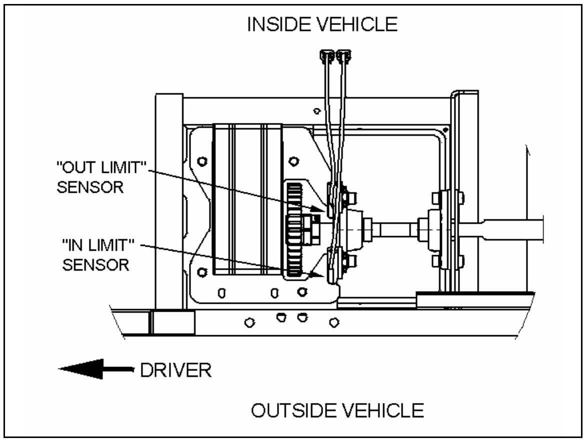


FIGURE 38: REAR SLIDE-OUT SENSORS

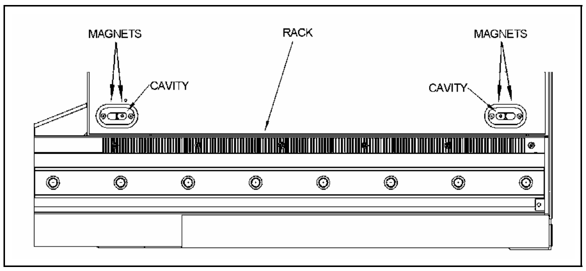


FIGURE 39 : MAGNETS ON SLIDE-OUT UNDERBODY

To adjust the "out limit" sensors:
Prior to adjust the “out limit” sensors, assure that the inner stoppers are perfectly adjusted (see section 1.1).

1. The slide-out is slightly tilted except when it is in its full “IN” or “OUT” position. Extend the slide-out near its full “OUT” position. When the slide-out straitens up and that it is perpendicular with the vehicle body, stop the slide-out.
2. Loosen the “out limit” sensor mounting bracket screws and move back the sensor completely (toward the inside of the vehicle).
3. Bring slowly the sensor toward the outside of the vehicle until the light emitting diode (LED) turns on. When it does, tighten the mounting bracket screws.

NOTE
When the “out limit” sensors are properly adjusted, the slide-out extension stops before the side inner stoppers reach the vehicle structure.

16 SLIDE-OUT EXTERIOR FINISHING PANELS & WINDOWS

NOTE
The removal and installation procedures are all based on standard service methods described in section 18: BOBY. Refer to this manual for procedures, tools, cleaner, adhesives and other product needed.

16.1 FACE PANEL REMOVAL

Use the same procedure as described in section 18: BODY for MTH side panel removal, and:

- Keep the slide-out retracted;
- Make sure not to damage the finishing molding supports to be able to re-use them;
- Remove the old adhesive on the finishing molding supports and clean them before re-using;
- Check where adhesive, sealant and double face adhesive tape are on the structure and the panel back side, in order to be able to stick the new panel in the same way;
- Check the tape width and use same width tape when installing new panels.

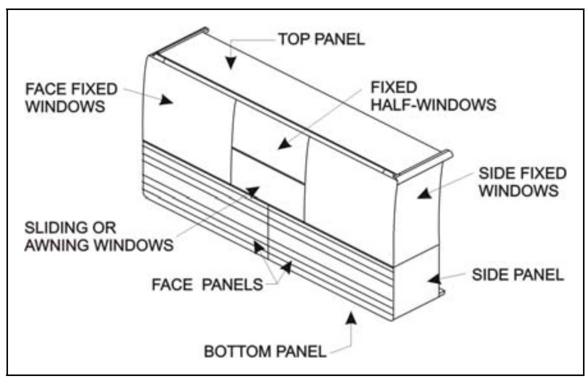


FIGURE 40 : SLIDE-OUT PANELS AND WINDOWS

16.2 FACE PANEL INSTALLATION

For surface cleaning, and preparation, panel installation and products needed, use the same procedure as the MTH side panel installation described in section 18: BODY.

- Keep the slide-out retracted for panel alignment;

- Make sure to apply sealant between the face panels and the side panels, and also between face panels and bottom and top panels. Apply sealant both inside and outside the slide-out panels.

16.3 SIDE PANELS REMOVAL

NOTE
The side panels are made of aluminum, or of stainless steel in option.

Caution: *Be careful not to damage the adjacent surfaces.*

1. Remove the slide-out (according to the Slide-Out Removal Procedure. Ask to your Prevost service representative).
2. Remove the side fixed windows from the slide-out first, as described in section 16.7.
3. Insert a flat screwdriver between the panel and the slide-out structure, in the top left and right corners of the panel, and unstick the panel from the structure.
4. Use C-clamp to peel the panel from the slide-out structure.
5. Check where adhesive, sealant and double face adhesive tape are on the structure and the panel back side, in order to be able to stick the new panel in the same way.
6. Check the tape width and use same width tape when installing new panels.

Caution: *Make sure the heat gun nozzle tip is at least 4" from surface.*

7. Use a heat gun and putty knife to remove the dried off adhesive and tape residue from the structure.

Warning: *Because of the adhesive toxicity, never use a buffer or other sanding method to remove it.*

16.4 SIDE PANELS INSTALLATION

NOTE
The side panels are made of aluminum, or of stainless steel in option. Use rivet of same material as the panels.

For surface cleaning and preparation, panel installation, and products needed, refer to the MTH side panel installation procedure described in section 18: BODY.

1. Protect adjacent surfaces with appropriate material;
2. Refer to figure 41 for 1/16x1/4 double face adhesive tape location on structure;
3. Apply Sika 206 G+P on the side panel as shown in figure 42 ;
4. Apply Sika Tack+Booster (triangular bead: 9mm width X 6mm high) as shown in Figure 43 and glue panel in place as shown in FIGURE 44;
5. Exert pressure and let dry for at least 90 minutes;
6. Smooth down the joint and remove glue in excess;
7. After drying, apply Sika 252 as a finishing joint;
8. Smooth down the joint.
9. Refer to section 16.11 for the finishing joint application procedure.

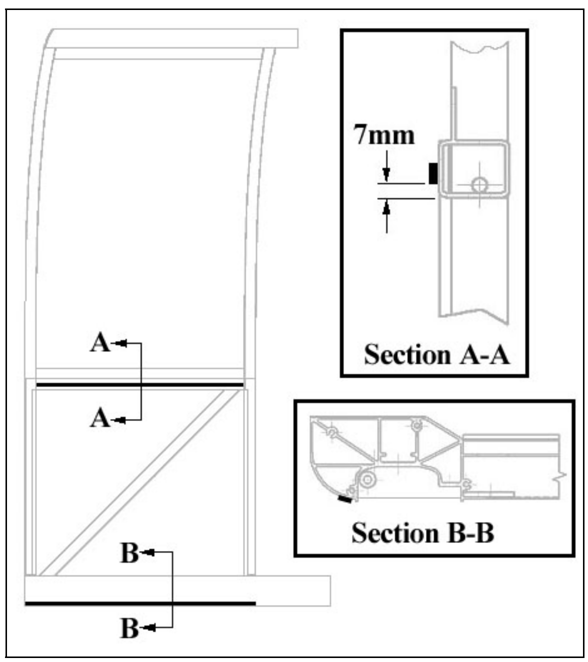


FIGURE 41 : SIDE PANEL INSTALLATION – DOUBLE FACE ADHESIVE TAPE APPLICATION ON THE SLIDE-OUT STRUCTURE

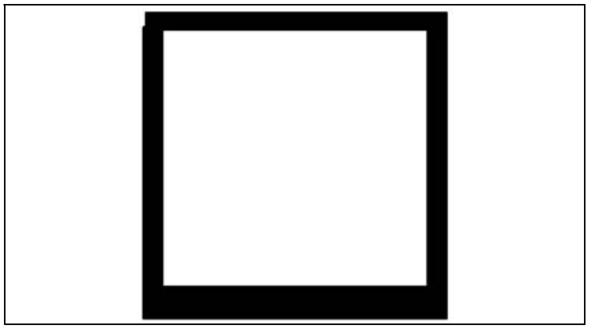


FIGURE 42 : SIDE PANEL INSTALLATION – SIKA 206 G+P APPLICATION

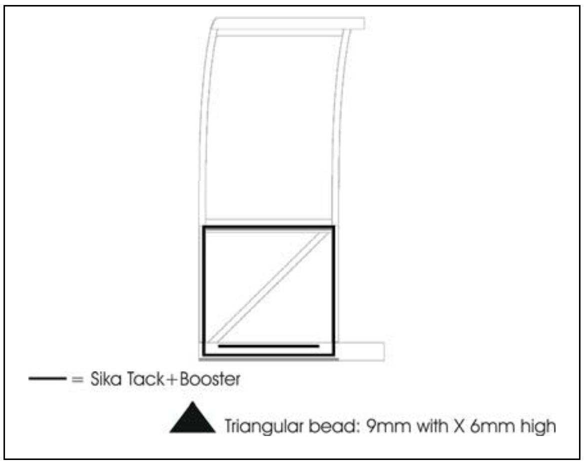


FIGURE 43 : SIDE PANEL INSTALLATION – SIKA TACK+BOOSTER APPLICATION

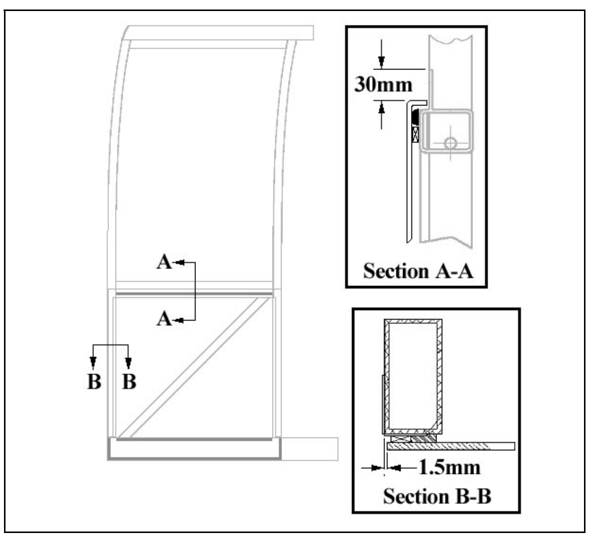


FIGURE 44 : SIDE PANEL INSTALLATION

16.5 TOP AND BOTTOM PANEL REMOVAL

NOTE
The top and bottom panels are made of aluminum sheets.

1. Remove the slide-out (according to the Slide-Out Removal Procedure. Ask to your Prevost service representative).
2. Insert a flat screwdriver between the panel and the slide-out structure, and unstick the panel from the structure.
3. Use C-clamp to peel the panel from the slide-out structure.
4. Check where adhesive, sealant and double face adhesive tape are on the structure and the panel back side, in order to be able to stick the new panel in the same way.
5. Check the tape width and use same width tape when installing new panels.
6. Use a heat gun and putty knife to remove the dried off adhesive and tape residue from the structure.

Warning: *Because of the adhesive toxicity, never use a buffer or other sanding method to remove it.*

16.6 TOP AND BOTTOM PANEL INSTALLATION

NOTE
The top and bottom panels are made of aluminum sheets and need aluminum rivet.

For surface cleaning, preparation, panel installation and products needed, refer to the MTH side panel installation procedure described in section 18: BODY.

1. Protect adjacent surfaces with appropriate material.
2. Refer to FIGURE 45 for 1/16x1/4 double face adhesive tape location on structure;
3. Apply Sika 206 G+P on panel as shown in FIGURE 46;
4. Apply Sika Tack+Booster (triangular bead: 9mm width X 6mm high) has shown in FIGURE 47 and glue panel in place as shown in figure 48 & figure 49 ;
5. Exert pressure and let dry for at least 90 minutes;
6. Smooth down the joint and remove glue in excess;
7. After drying, apply Sika 252 as a finishing joint;

8. Smooth down the joint.
9. Refer to section 16.11 for the finishing joint application procedure.

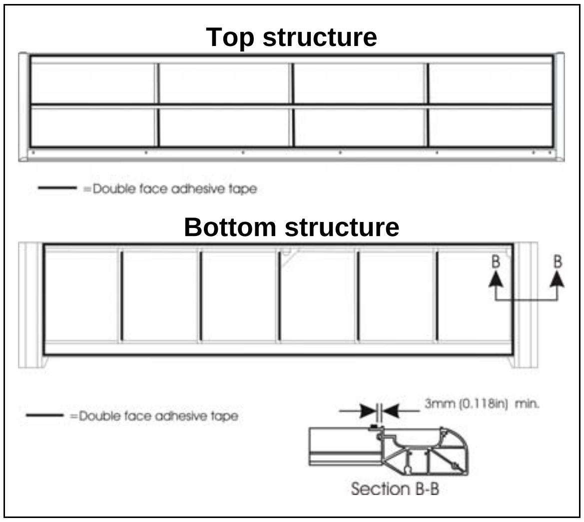


FIGURE 45 : TOP AND BOTTOM PANEL INSTALLATION - DOUBLE FACE ADHESIVE TAPE APPLICATION

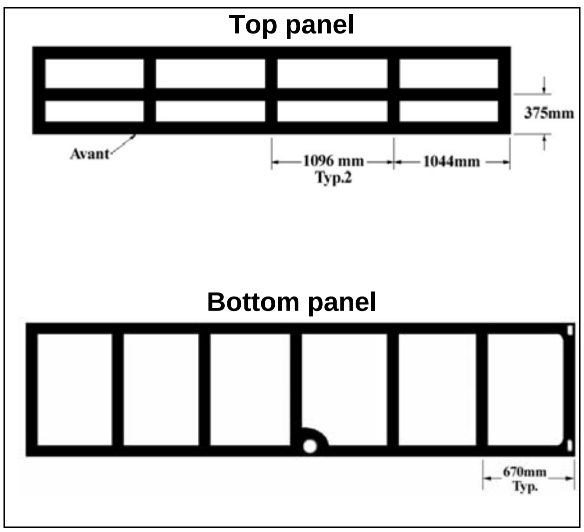
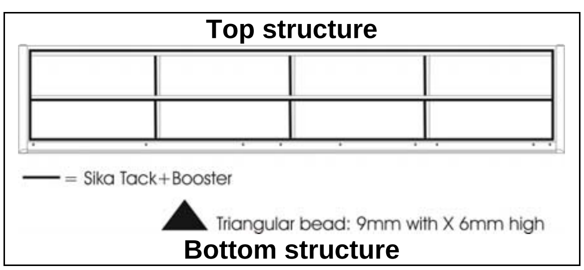


FIGURE 46 TOP AND BOTTOM PANEL INSTALLATION - SIKA 206 G+P APPLICATION



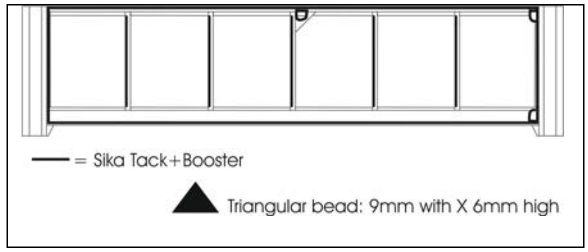


FIGURE 47 : TOP AND BOTTOM PANEL INSTALLATION - SIKA TACK+BOOSTER APPLICATION

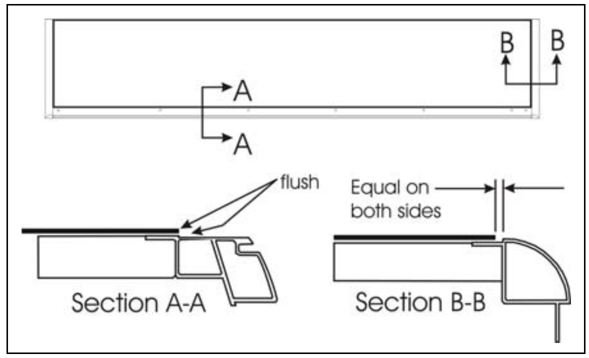


FIGURE 48 : TOP PANEL INSTALLATION

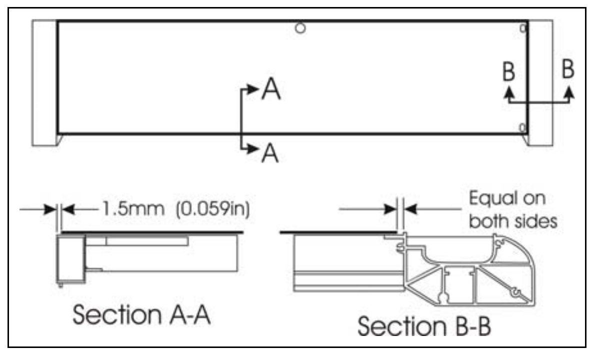


FIGURE 49 : BOTTOM PANEL INSTALLATION

NOTE
The removal and installation procedures are based on standard service methods described in section 18: BODY. Refer to these procedures for tools and adhesives specifications.

Warning: *Always wear safety equipment when working with glass and chemical adhesives.*

16.7 WINDOWS REMOVAL

1. Remove the slide-out.
2. If needed, remove the exterior extrusion as described in section 1.3.

Caution: *Be careful not to damage the adjacent surfaces.*

3. With a knife or a wire, cut the sealant and the adhesive between the windows and the structure. Make sure not to damage the rubber seal between the windows.
4. With a helper, remove the window from the slide-out.

16.8 FIXED WINDOWS INSTALLATION

Refer to procedures described in section 18: BODY of the maintenance manual for details.

1. Clean and prepare the windows and the slide-out structure surfaces with appropriate cleaner, abrasives and primers.
2. If necessary, install the rubber seals as per FIGURE 50 & FIGURE 51 . Press the seal against the structure with a roller.

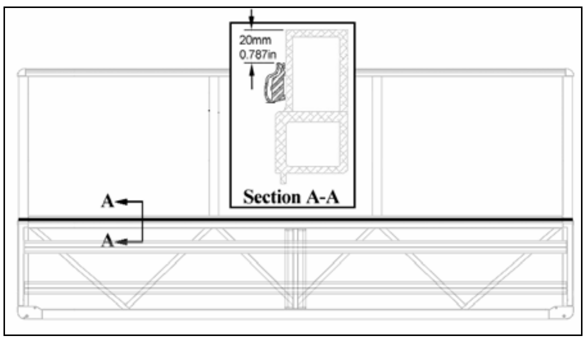


FIGURE 50 : FACE FIXED WINDOWS - RUBBER SEAL INSTALLATION

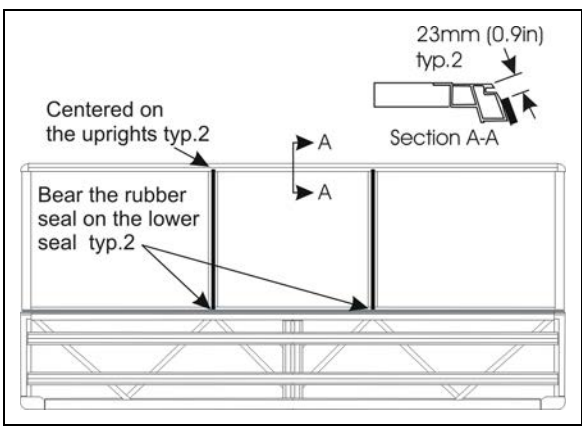


FIGURE 51 : FACE FIXED WINDOWS - RUBBER SEAL INSTALLATION

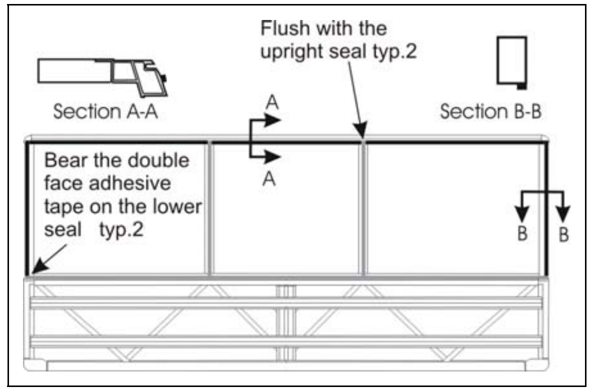


FIGURE 52 : FACE FIXED WINDOWS – 3/16 X 1/2 DOUBLE FACE ADHESIVE TAPE INSTALLATION

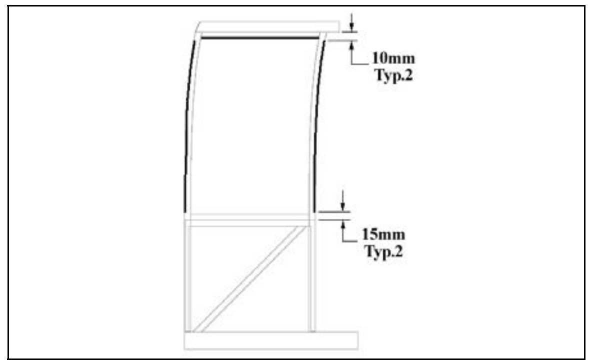


FIGURE 53 : SIDE FIXED WINDOW – ¼ X ½ DOUBLE FACE ADHESIVE TAPE INSTALLATION

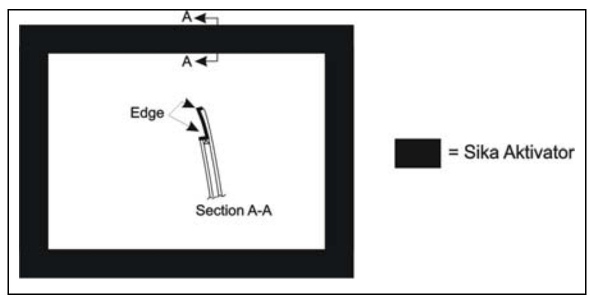


FIGURE 54 : FACE FIXED WINDOW AND HALF-WINDOW – SIKA AKTIVATOR

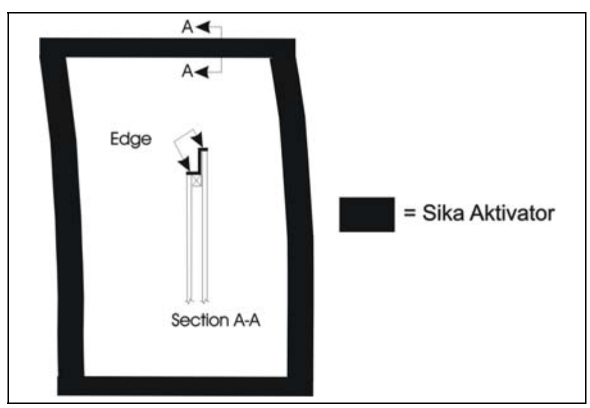


FIGURE 55 : SIDE FIXED WINDOW – SIKA AKTIVATOR

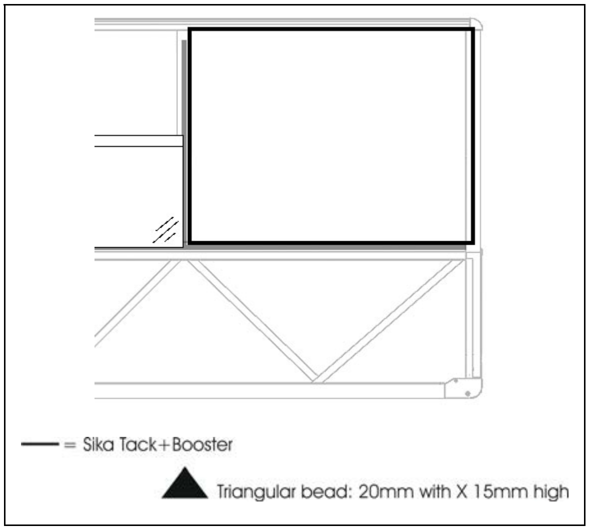


FIGURE 56 : FACE FIXED WINDOW INSTALLATION – SIKA TACK+BOOSTER

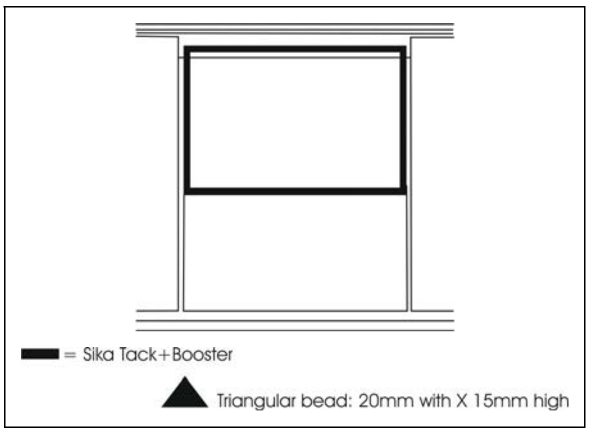


FIGURE 57 : FACE FIXED HALF-WINDOW INSTALLATION – SIKA TACK+BOOSTER

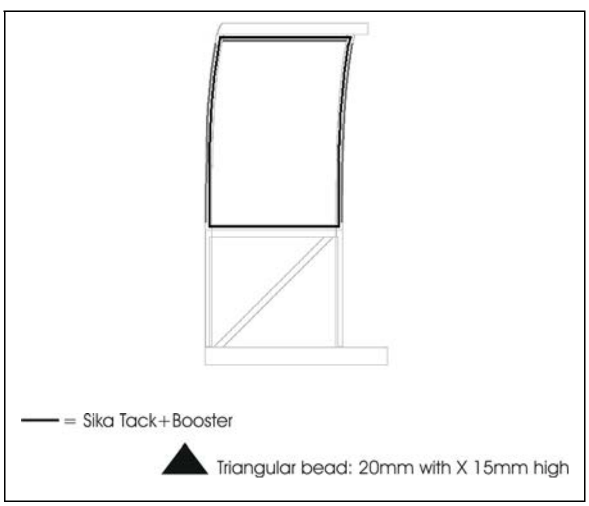


FIGURE 58 : SIDE FIXED WINDOW – SIKA TACK + BOOSTER

3. Apply appropriate double face self adhesive tape on the slide-out structure (sees FIGURE 52 for face fixed windows or FIGURE 53 for side fixed window).
4. Clean window with appropriate window cleaner.
5. Apply Sika Aktivator on the window pane as per FIGURE 54 or FIGURE 55.
6. Apply Sika Tack+Booster as per FIGURE 56 FIGURE 57 or FIGURE 58 (triangular bead: 20mm width X 15mm high).
7. Install the windows on the slide-out structure (see FIGURE 59 or FIGURE 60).
8. Press the jigs on the windows and wait for the adhesive to dry (90 minutes minimum).
9. After drying, apply Sika 221 as a finishing joint. Clean excess with Sika 208.
10. Refer to section 16.11 for the finishing joint application procedure.

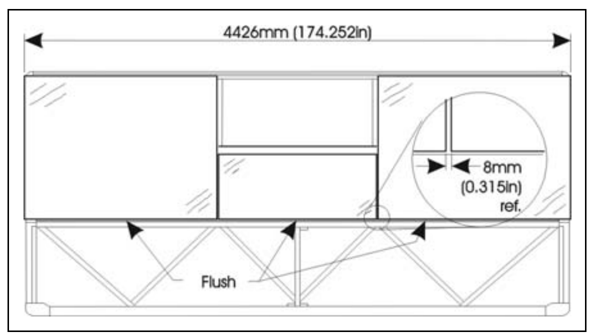


FIGURE 59 : FACE FIXED WINDOW INSTALLATION

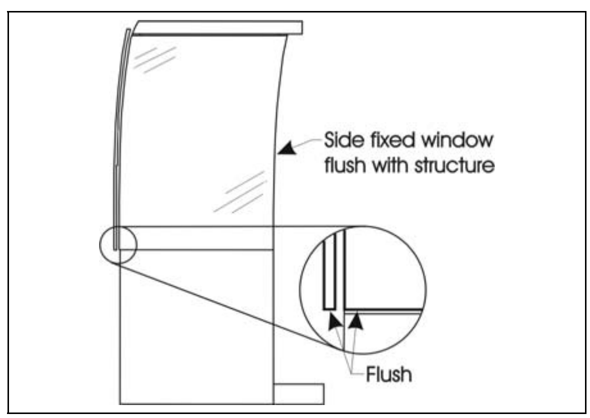


FIGURE 60 : SIDE FIXED WINDOW

16.9 AWNING WINDOW INSTALLATION

1. Clean and prepare the windows and the slide-out structure surfaces with appropriate cleaner, abrasives and primers.
2. Glue on the structure horizontal member, 4 rubber bumpers (#5061020), placing them 2 by 2 to have a total thickness of 1/16" (FIGURE 61).

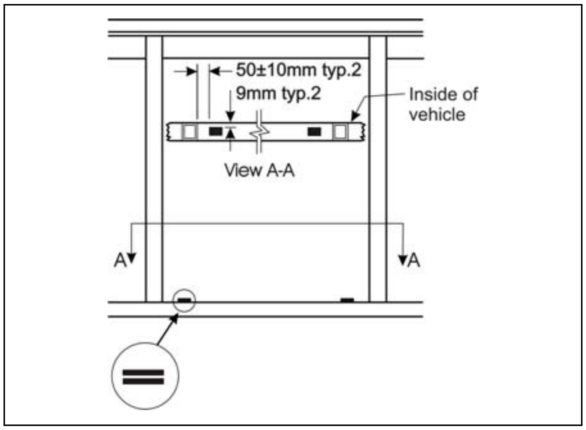


FIGURE 61: AWNING WINDOW - RUBBER BUMPER INSTALLATION

3. Glue 4 rubber bumpers (#790610) on the awning window frame as per FIGURE 62.

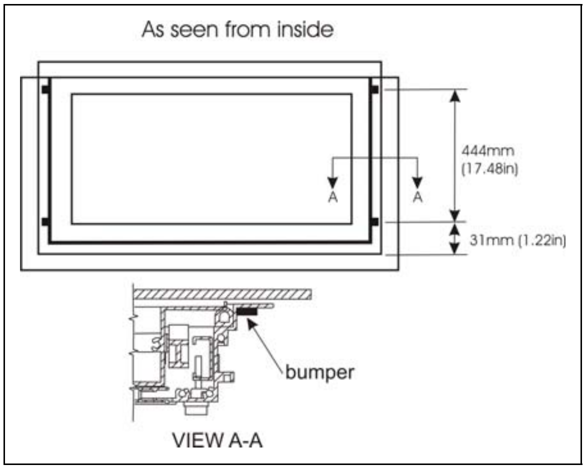


FIGURE 62: SIDE BUMPERS

4. Place masking tape on the inside of the frame as per FIGURE 63.

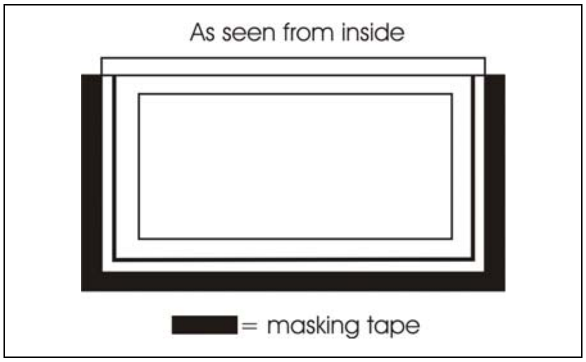


FIGURE 63: MASKING TAPE APPLICATION

5. Apply Sika 255 in the upper and lower frame corner as per FIGURE 64.

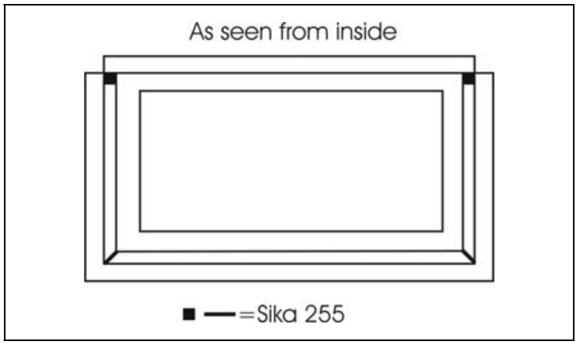


FIGURE 64: SIKA 255 APPLICATION

6. Apply Sika Aktivator as per FIGURE 65.
7. Apply Sika 255 as per FIGURE 66 (triangular bead: 10mm width X 10mm high).

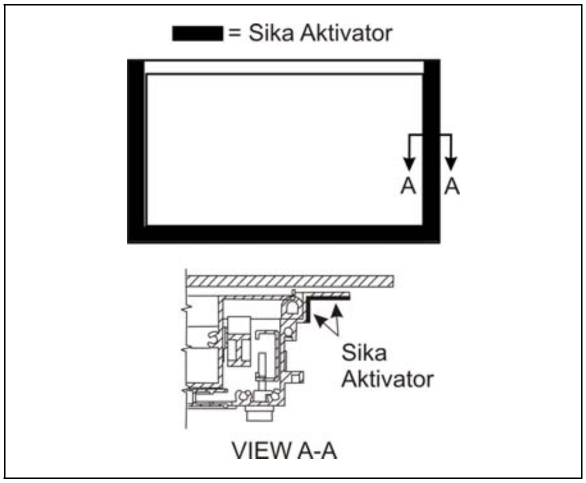


FIGURE 65 : AWNING WINDOW – SIKA AKTIVATOR

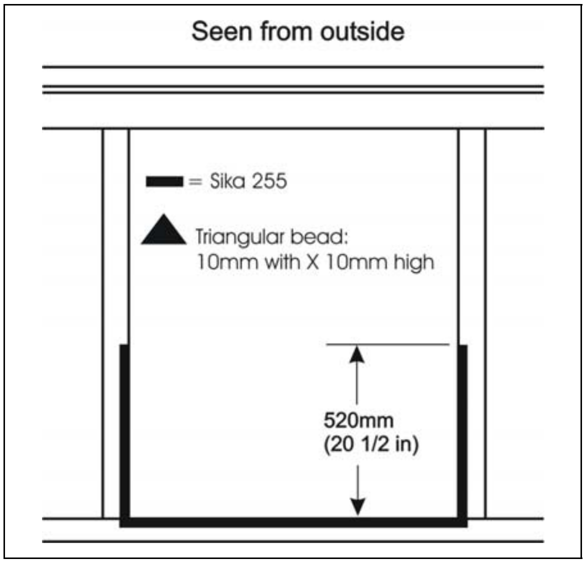


FIGURE 66: AWNING WINDOW – SIKA 255 APPLICATION

8. Install the awning window centered in the opening. Press the window slightly. The awning window must be kept closed.

9. While a helper is pressing on the window from outside, install the awning window clamping frame and tighten screws according to the sequence shown in FIGURE 67.

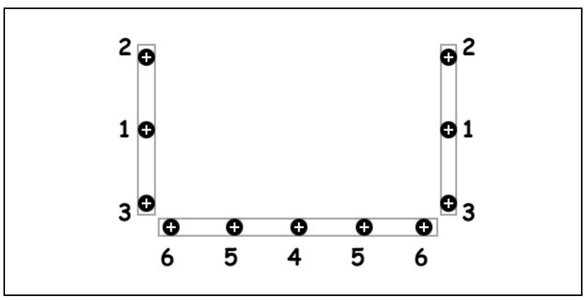


FIGURE 67 : CORRECT TIGHTENING SEQUENCE

10. Open the awning window manually and smooth down the joint (FIGURE 68) and remove glue in excess with Sika 208.

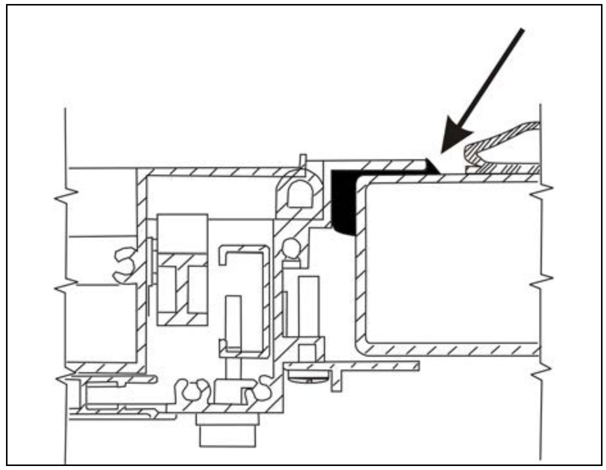


FIGURE 68 : SMOOTH DOWN THE JOINT

11. Using Sika 252 or 255, seal the upper corner of the awning window, both side (FIGURE 69).

12. Using Sika 252 or 255, seal the chink between the structure vertical member and the awning window, both side (FIGURE 70).

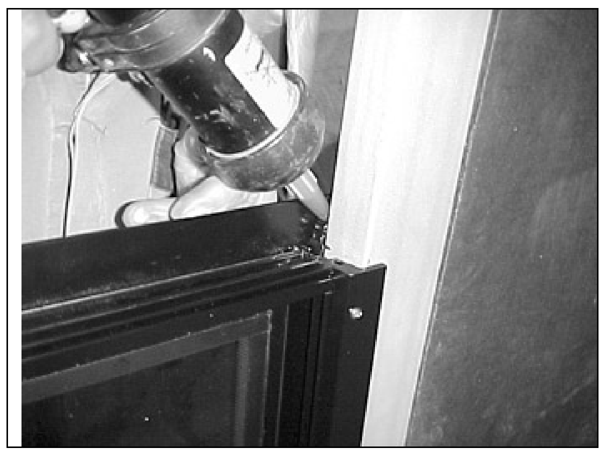


FIGURE 69 : AWNING WINDOW – SEAL THE UPPER CORNERS

FIGURE 70 : AWNING WINDOW – SEAL THE CHINK

16.10 SLIDING WINDOW INSTALLATION

1. Clean and prepare the windows and the slide-out structure surfaces with appropriate cleaner, abrasives and primers. Clean surfaces with anti-silicone.
2. Apply Sika Aktivator on sliding window as per FIGURE 71.
3. Apply Sika Aktivator on the structure as per FIGURE 72.
4. Apply Sika 252 as per FIGURE 73 (triangular bead: 20mm width X 10mm high).
5. Install the sliding window centered in the opening. Press the window slightly. The window must be kept closed.
6. While a helper is pressing on the window from outside, install the awning window clamping frame and tighten screws according to the sequence shown in FIGURE 74.
7. Remove glue in excess with Sika 208.
8. Using Sika 252 or 255, seal the inside upper corner of the sliding window, both side (FIGURE 75).
9. Using Sika 252 or 255, seal the chink between the structure vertical rubber seal and the sliding window, both side (FIGURE 76).

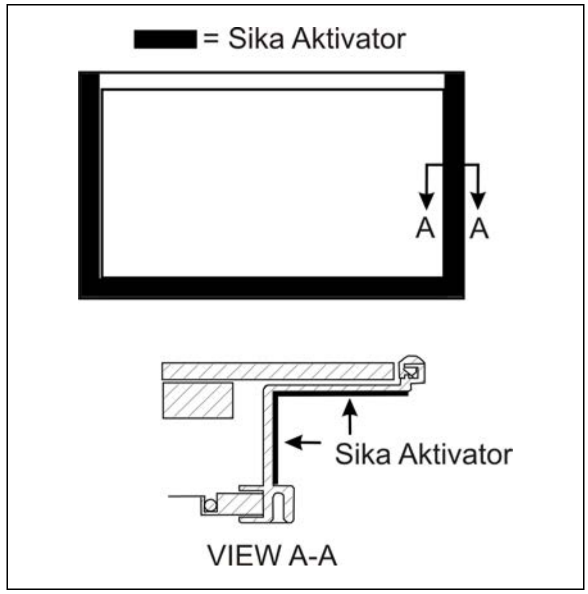


FIGURE 71 : SLIDING WINDOW - SIKA AKTIVATOR

FIGURE 72 : SLIDING WINDOW - SIKA AKTIVATOR

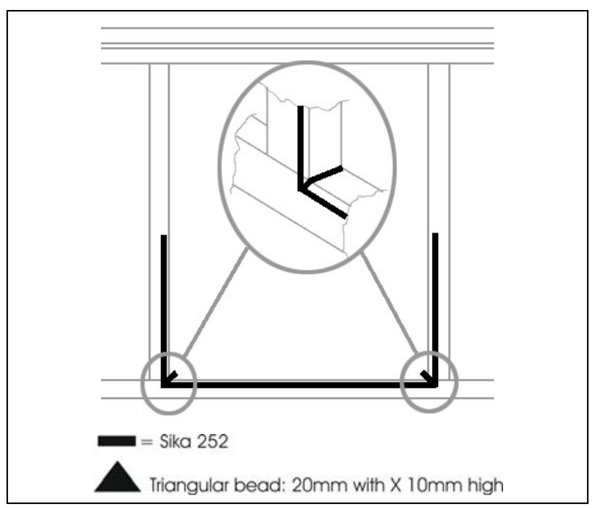


FIGURE 73: AWNING WINDOW – SIKA 252 APPLICATION

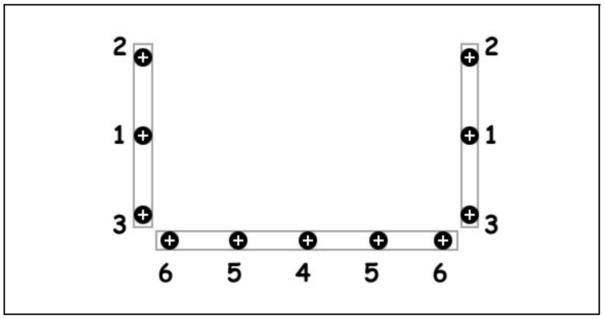


FIGURE 74 : CORRECT TIGHTENING SEQUENCE

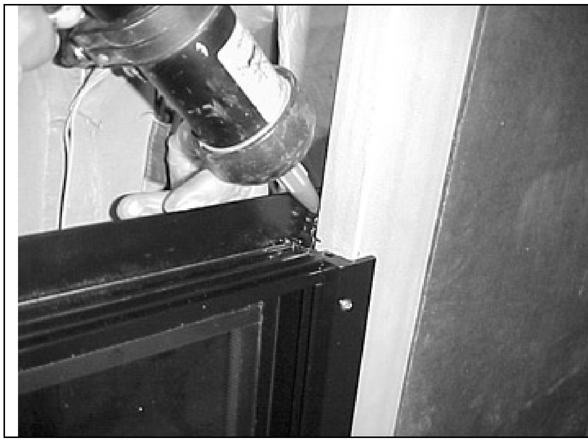


FIGURE 75 : SLIDING WINDOW – SEAL THE UPPER CORNERS

FIGURE 76 : SEAL

16.11 FINISHING JOINT

The following procedure applies to section 16.11.1 up to 16.11.4.

For surface cleaning and preparation, tools, cleaner, adhesives and other product needed, refer to the MTH side panel installation procedure described in section 18: BODY.

1. Place masking tape to protect surfaces from smudge.
2. Apply Sika 221.
3. Using soapy water, smooth down the joint with your finger (wear vinyl gloves).

16.11.1 Slide-out face

Apply Sika 221 between the face panel and the structural member

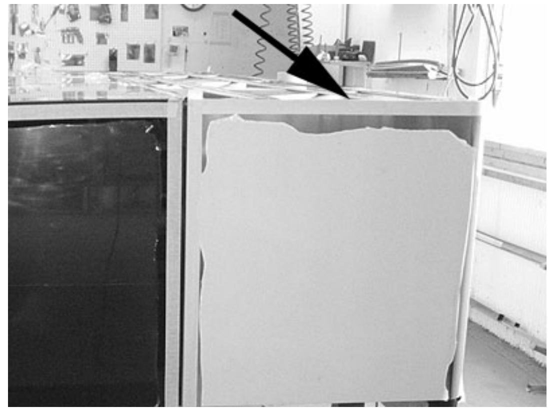


FIGURE 77

Apply Sika 221 between the top of face window and the structural member

FIGURE 78

16.11.2 Slide-out side

Apply Sika 221 between the top of side window and the structural member

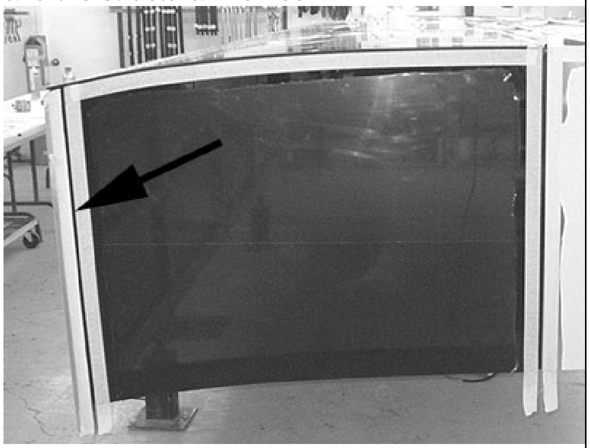


FIGURE 79

Apply Sika 221 between the bottom of side window and top of side panel

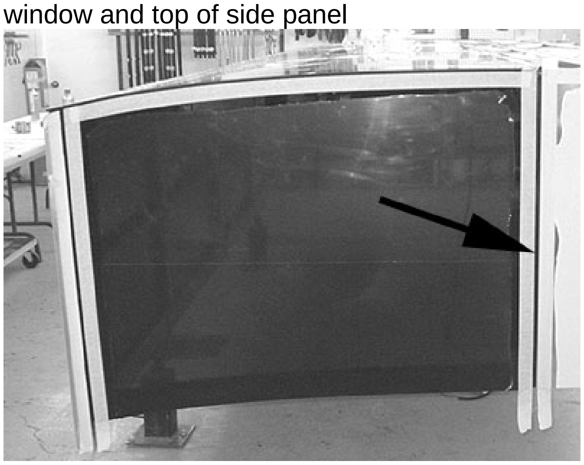


FIGURE 80

Apply Sika 221 between side window and top of face fixed window

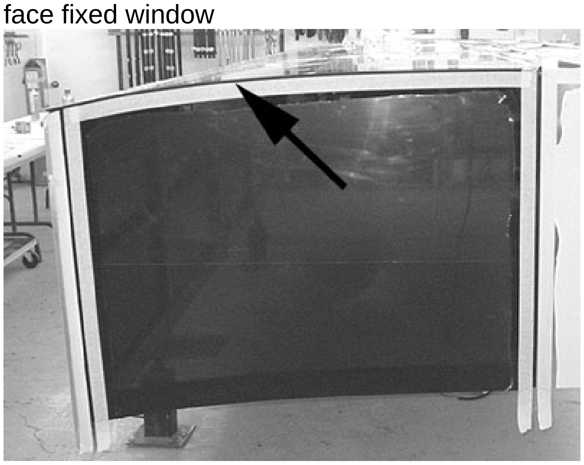


FIGURE 81

16.11.3 Slide-out bottom

Apply Sika 221 between bottom edge of side panel and structural member

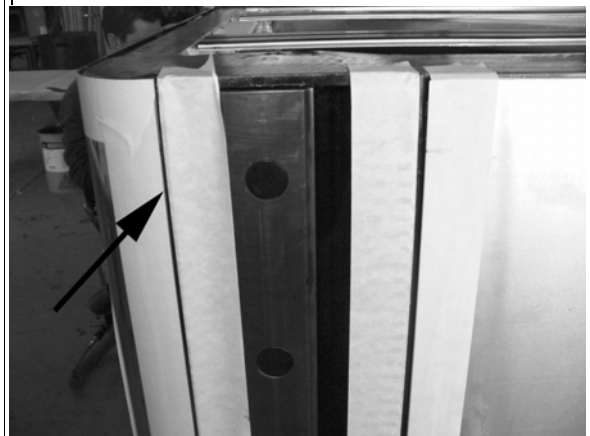


FIGURE 82

Apply Sika 221 between edge of bottom panel and structural member

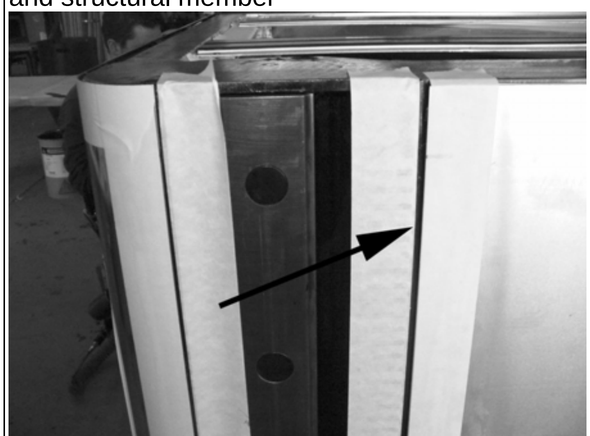


FIGURE 83

Apply Sika 221 between the bottom panel and the magnets

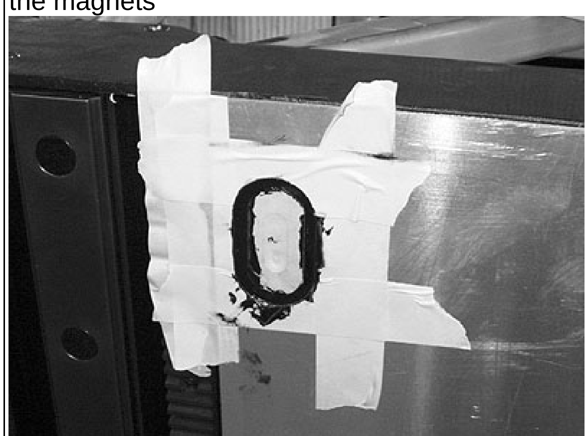


FIGURE 84

Apply Sika 221 around the security pin cavity

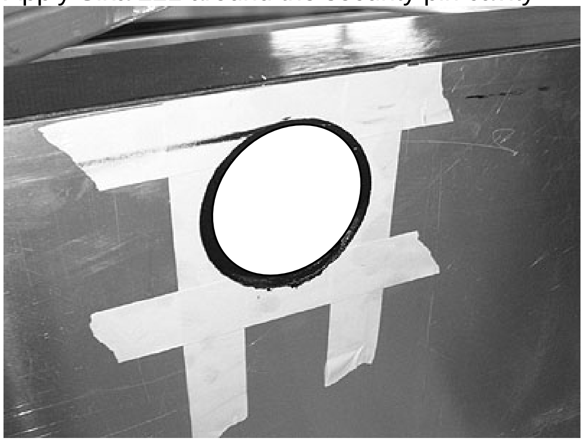


FIGURE 85

16.11.4 Top of Slide-out

Apply Sika 221 between edge of top panel and structural member

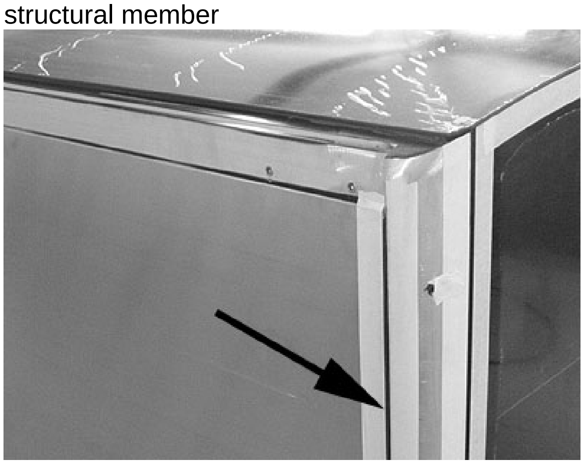


FIGURE 86

17 WELDING PRECAUTION

⚠ CAUTION ⚠

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

18 SLIDE-OUT MANUAL OVERRIDE PROCEDURES

In case of power retracting system failure, it is possible to use the manual override procedure to retract or extend the slide-out.

The manual override procedures consist in rotating the slide-out motor shaft extension using a cordless power drill with a 3/8" hexagonal bit.

However, it is very important to follow all the instructions very carefully to assure that the inflatable seal or the retraction mechanisms are not damaged.

18.1 PRELIMINARY CONDITIONS FOR MANUAL OVERRIDE PROCEDURE

Before using the slide-out manual override procedures, make sure that the problem cannot be solved by one of the following simple checks:

- Make sure that none of the breakers are tripped (the breakers are located inside the VEC on the slide-out control panel (FIGURE 88) and the main slide-out breaker is located in the engine R.H. side access compartment (FIGURE 89)).
- Make sure the barking brake is applied and that transmission is in the "NEUTRAL" position.
- Make sure the voltage is high enough by running the engine at fast idle or having the battery charger connected.

⚠ CAUTION ⚠

Before extending or retracting the slide-out, always open a window to avoid movement restriction and to prevent the motor from stopping in overcurrent because of a vacuum or pressure build up inside the vehicle.

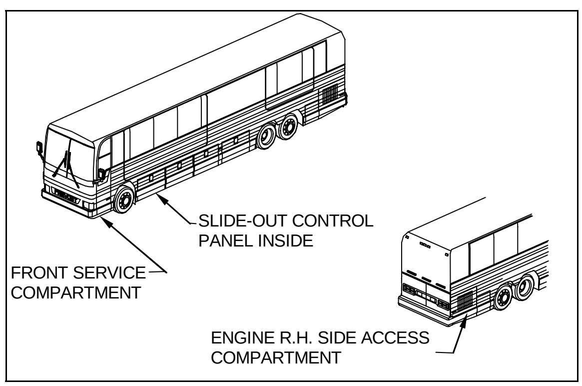


FIGURE 87: COMPARTMENTS LOCATION

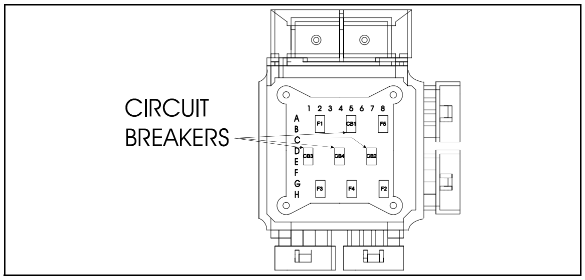


FIGURE 88: VEC CIRCUIT BREAKERS ON SLIDE-OUT CONTROL PANEL

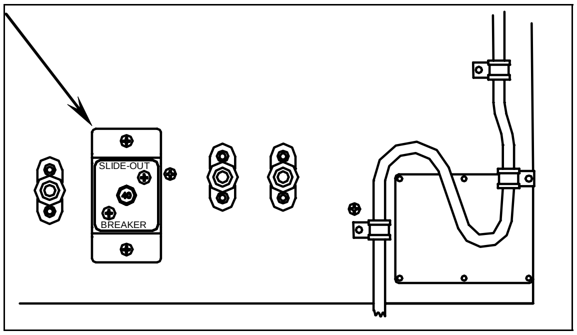


FIGURE 89: MAIN SLIDE-OUT BREAKER IN ENGINE R.H. SIDE ACCESS COMPARTMENT

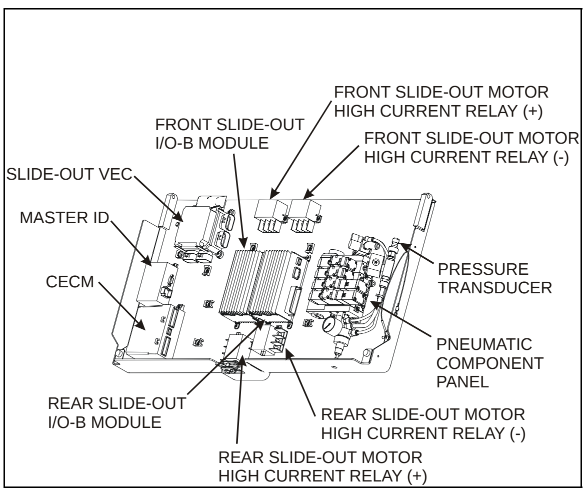


FIGURE 90: SLIDE-OUT CONTROL PANEL

18.1.1 Manual retracting procedure – Front and rear slide-out

1. Turn the ignition switch to the "OFF" position, and remove the ignition key for more safety.
2. Deflate the inflatable seal by using the relieving shut-off valve located on the pneumatic component panel (FIGURE 91).
3. Turn the handle clockwise to deflate the seal. Make sure the pressure indicator reading is "0 psi".

⚠ CAUTION ⚠

The pressure in the inflatable seal must be completely relieved to prevent any damage to the seal.

NOTE

When air pressure is relieved using the shut-off valve, the normal extending and retracting operation cycle is disabled, for that reason the slide-out cannot be moved using the handheld control.

4. To move the slide-out, use a cordless power drill with a 3/8" hexagonal bit on the shaft extension of the slide-out motor.
5. Rotate the slide-out motor shaft extension with the power drill until the slide-out comes to its closed position (FIGURE 92).
6. Once the slide-out room is lined up to its closed position, remove the tool from the motor.

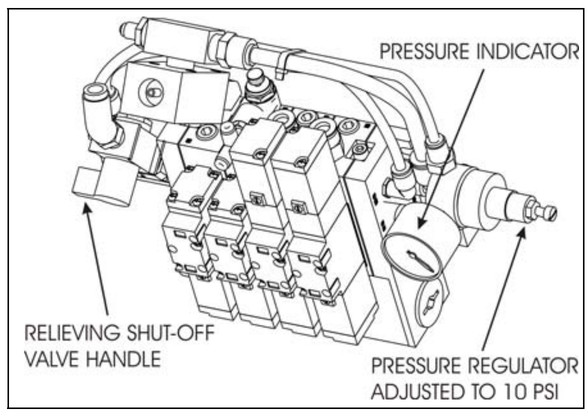


FIGURE 91: INFLATABLE SEAL RELIEVING SHUT-OFF VALVE

NOTE

*The **front slide-out motor** is located inside the 2nd baggage compartment while the **rear slide-out motor** is accessible from inside the vehicle, under the bed structure.*

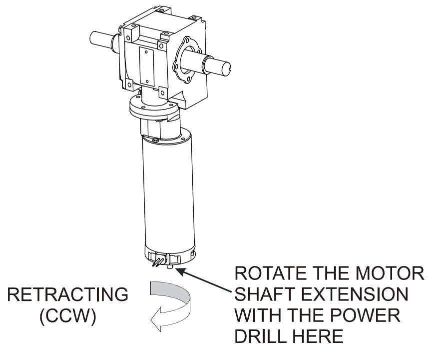


FIGURE 92: SLIDE-OUT MOTOR ROTATION

⚠ CAUTION ⚠

Slow down on the closing speed as the slide-out approaches its closed position. As soon as the "in limit" stoppers come in contact with their bearing surface, stop immediately the power drill rotating movement. Not doing so could overload the drive mechanism and cause damage to the reduction gearbox.

4. Finally, the inflatable seal can be re-inflated by turning the shut-off valve handle counterclockwise. Check the pressure gage on the inflatable seal regulator to see if the pressure is increasing to 10 psi (FIGURE 93).

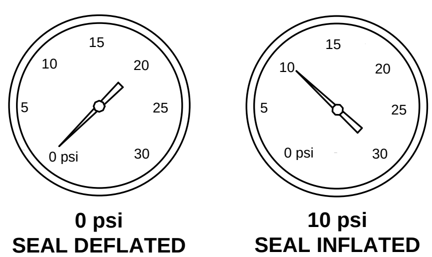


FIGURE 93: INFLATABLE SEAL PRESSURE GAGE

NOTE

The slide-out control system inhibits transmission range selection to prevent the vehicle from moving if the slide-out is not in its full "IN" position.

18.1.2 Manual extending procedure – Front and rear slide-out

1. Apply barking brake to disengage the security pin from the receptacle.
2. Turn the ignition switch to the "OFF" position, and remove the ignition key for more safety.
3. Deflate the inflatable seal by using the relieving shut-off valve located on the pneumatic component panel (FIGURE 91). Turn the handle clockwise to deflate the seal. Make sure the pressure indicator reading is "0 psi".

⚠ CAUTION ⚠

The pressure in the inflatable seal must be completely relieved to prevent any damage to the seal.

NOTE

When air pressure is relieved using the shut-off valve, the normal extending and retracting operation cycle is disabled, for that reason the slide-out cannot be moved with the handheld control.

4. To move the slide-out, use a cordless power drill with a 3/8" hexagonal bit on the shaft extension of the slide-out motor.
5. Rotate the slide-out motor shaft extension with the power drill until the slide-out comes to its opened position (FIGURE 94).
6. Once the slide-out is lined up to its opened position, remove the tool from the motor.

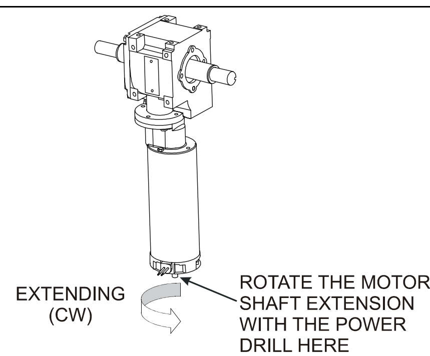


FIGURE 94: SLIDE-OUT MOTOR ROTATION

NOTE
*The **front slide-out motor** is located inside the 2nd baggage compartment while the **rear slide-out motor** is accessible from inside the vehicle, under the bed structure.*

⚠ CAUTION ⚠
Slow down on the closing speed as the slide-out approaches its extended position. As soon as the "out limit" stoppers come in contact with their bearing surface, stop immediately the power drill rotating movement. Not doing so could overload the drive mechanism and cause damage to the reduction gearbox.

7. Finally, the inflatable seal can be re-inflated by turning the shut-off valve handle counterclockwise. Check the pressure gage on the inflatable seal regulator to see if the pressure is increasing to 10 psi (FIGURE 94).

NOTE
The slide-out control system inhibits transmission range selection to prevent the vehicle from moving if the slide-out is not in its full "IN" position.

19 SLIDE-OUT MAXIMUM LOAD

Front slide-out:
Maximum load with vehicle at stand still (retracted or extended) …...1500 lb
Maximum load with vehicle moving or slide-out moving ……………...1200 lb[1]

Rear slide-out:
Maximum load with vehicle at stand still (retracted or extended) …..1500 lb
Maximum load with vehicle moving or slide-out moving …………….1000 lb [1]

NOTE
Maximum load includes people weight and equipment added by the converters in the slide-out

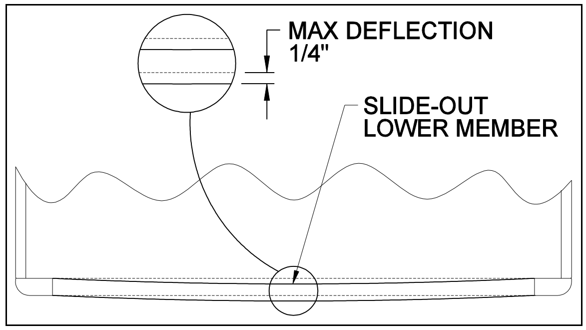
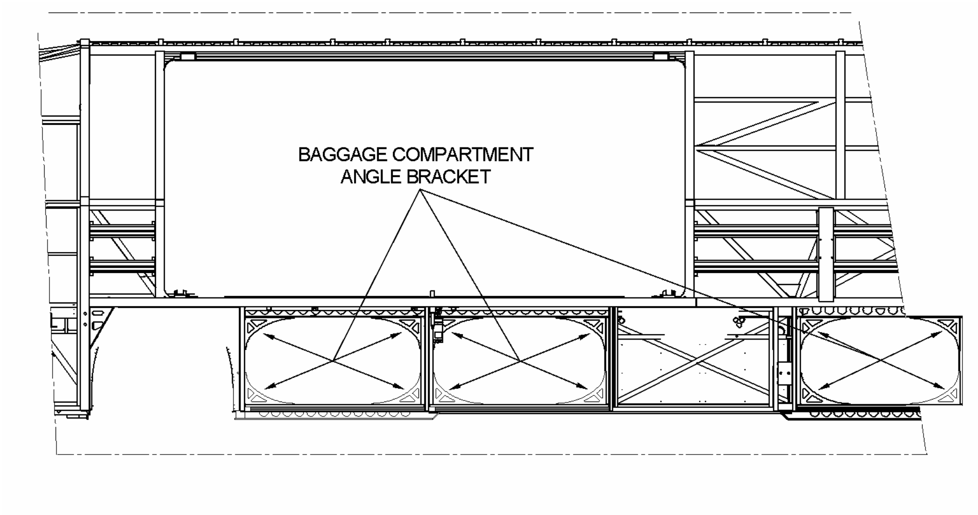


FIGURE 95 : FRONT SLIDE-OUT DEFLECTION

[1] When the load is distributed in the slide-out to prevent a deflection of the inside lower member over ¼" that could damage the seal.

CAUTION

Never remove the structural reinforcement angle brackets inside the baggage compartments. Doing so could lead to termination of the warranty coverage concerning the structural integrity.



20 CONVERSION CHECKLIST

The converter should check these points before closing the walls covering the roof reinforcing rod and the pinions:

1. Check that the front slide-out exterior panels are parallel with the vehicle panels when retracted. If not, readjust the tilt.
2. Check that the slide-out is straight when completely extended, and that it leans against all inner stoppers.
3. Make sure the vehicle upper member is parallel with the front slide-out structure. If not, readjust the roof reinforcing rod. This may be affected by the loading on the roof.
4. Make sure the front slide-out lower member deflection is within 1/4". If not, redistribute the slide-out load.
5. Check the whole slide-out mechanism good functioning. The slide-out should retract and extend smoothly without vibration.

Final check:

- Make sure the slide-out air pressure inlet valve is completely opened.

- Check the inflatable seal air pressure on the pressure regulator. The pressure should be 10 psi.

21 TROUBLESHOOTING

21.1 ERROR CONDITION OR MISSING OPERATION CONDITION

When an error condition or a missing operation condition is present on a slide-out, the green indicator light on its respective handheld control starts blinking upon releasing of the IN/OUT rocker switch.
Turning the ignition OFF and ON again, will stop the blinking and reset the fault. If the error condition or a missing operation condition is still present, the blinking will start again the next time that the slide-out is operated. So, to get a fault diagnostic, use the MCD right after operating the slide-out without cycling the ignition switch.

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.

Fault diagnostic

To get more specific information about the error condition or the missing operation condition, request a diagnostic from the slide-out CECM using the dashboard message center display (MCD). Check if there are active errors in the slide-out 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 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.
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.

21.2 TROUBLESHOOTING – OPERATING CONDITIONS & CONTROL

PROBLEM	CAUSE	CORRECTIVE ACTION
The slide-out functions normally but the handheld control green indicator light blinks	Something is defective and may eventually create an issue if not repaired. The problem may be: A. Faulty limit sensor causing the slide-out to stop in overcurrent; B. CAN network problem causing the transmission inhibit safety to be non-operational; C. Vacuum pressure transducer disconnected or damaged (vacuum is applied for a fixed time of 7 seconds); D. Seal inflating valve solenoid open circuit (the seal is not re-inflated and water can penetrate in the vehicle); E. Security pin valve solenoid open circuit (the security pin is not extended while vehicle is riding).	Request a diagnostic from the electrical system using the MCD SYSTEM DIAGNOSTIC menu and refer to the Fault Message list in section 21.4.

PROBLEM	CAUSE	CORRECTIVE ACTION
The slide-out does not extend	A. The parking brake is not seen by the controller as being applied; B. Not enough air pressure in the accessory air tank to permit proper operation of the vacuum generator; C. Faulty vacuum generator, connection to the vacuum generator open, seal deflating valve solenoid open circuit; D. I/O-B module output defective, regulated 5-volt supply to sensors shorted to ground, “out limit” sensor shorted to ground, connection to the motor negative relay solenoid open circuit;	A. Make sure the parking brake is applied. Confirm parking brake application with the parking brake light on the telltale panel. B. Run the engine at fast idle a few minutes to increase air pressure in the accessory air tank and try again. C. Turn the relieving shut-off valve handle clockwise to deflate the inflatable seal, disconnect the pressure transducer. Do not forget to reconnect the pressure transducer and to close the relieving shut-off valve. Failure to do so could damage the seal and lead to water infiltration; D. Operate the slide-out with the manual override procedures.
The slide-out does not retract	A. Not enough air pressure in the accessory air tank to permit proper operation of the vacuum generator; B. Faulty vacuum generator, connection to the vacuum generator open, seal deflating valve solenoid open circuit; C. I/O-B module output defective, “in limit” sensor shorted to ground, connection to the motor positive relay solenoid open circuit;	A. Run the engine at fast idle a few minutes to increase air pressure in the accessory air tank and try again. B. Turn the relieving shut-off valve handle clockwise to deflate the inflatable seal, disconnect the pressure transducer. CAUTION, do not forget to reconnect the pressure transducer and to close the relieving shut-off valve. Failure to do so could damage the seal and lead to water infiltration; C. Operate the slide-out with the manual override procedures.
When extending, the slide-out stops after having extended by 1 inch	A. The security pin valve solenoid circuit is shorted to (+) 24-volt and the pin remains engaged;	A. Disconnect air supply from the safety pin cylinder;
Transmission DRIVE range or REVERSE cannot be selected (the slide-out telltale light is illuminating).	A. Slide-out not in full "in" position; B. Faulty “in limit” sensor. The slide-out is retracted but the controller doesn’t not see it as retracted.	A. Retract slide-out. B. Confirm that all slide-out are retracted. On the slide-out control panel, disconnect the 5 pins green connector on the I/O-B module to disable the transmission inhibit. CAUTION, this is a temporary measure, the vehicle must be serviced as soon as possible.

21.3 TROUBLESHOOTING - MECHANICAL COMPONENTS

PROBLEM	CAUSE	CORRECTIVE ACTION
Slide-out does not retract or extend when depressing the control switch.	A. Electrical motor failure; B. Speed reduction gearbox failure; C. Security pin still engaged in receptacle;	A. Replace motor. B. Inspect gearbox components, particularly: bronze wheel or first reduction stage output shaft. Replace damaged components. C. Disengage pin and check if air cylinder is damaged.
Slide-out is not straight once retracted or during retracting or extending operation.	A. Broken rack tooth; B. Faulty rack attachment; C. Faulty shaft key at speed reduction gearbox or jaw coupling; D. Pinion keyless bushing slipping; E. Shaft breaking; F. Flange bearing attachment loosen;	A. Replace rack. B. Tighten mounting bolts, apply proper torque and use Loctite threadlocker (replace rack if necessary). C. Replace key or component having a damaged keyway. D. Realign slide-out and apply proper torque to keyless bushing. E. Replace shaft. F. Reposition shaft and tighten flange bearing mounting bolts.
Slide-out moves out slightly when vehicle is traveling.	A. Lower "in limit" stoppers are not leaning against the structure at the moment when the "in limit" sensor detects the magnet;	A. Adjust the sensor position in order to have contact of the stoppers against the structure at the time when the system stops the slide-out retraction.
Slide-out moves when vehicle is moving.	A. Inflatable seal not inflated	A. Check seal condition and seal air supply system.
Slide-out retracts or extends difficultly.	A. Foreign matters accumulated in the linear bearing;	A. Inspect the linear bearing end seals to see if they are in good condition. If not, replace the end seals and clean the inside of linear bearing.
Slide-out oscillates vertically when retracting or extending	A. Linear bearing balls hardened due to a too heavy load; B. Linear bearing mounting bolts loosen;	A. If balls clearance is excessive, replace linear bearing. B. Tighten mounting bolts.
Slide-out vibrating or noisy when extending or retracting	A. Acetal plastic block rubbing against the slide-out structure; B. Worn-out anti-friction coating on wiper seal around slide-out; C. Lower acetal plastic block rubbing against rail;	A. Realign acetal plastic block. B. Replace wiper seal. C. Remove lower acetal plastic block and machine down 1mm (0.039").
Top of slide-out moves sideways when vehicle is	A. Roof reinforcing rod misadjusted;	A. Readjust as per procedure.

PROBLEM	CAUSE	CORRECTIVE ACTION
moving		
Slide-out does not retract up to its full "in" position	A. Interference between the exterior extrusion and the vehicle upper horizontal member above the slide-out;	A. Check for straightness of horizontal member and adjust the roof reinforcing rod. B. Check for outer wiper seal lip straightness on the slide-out roof.
Bottom of slide-out not flush with vehicle body	A. Broken or misadjusted lower "in limit" stopper; B. Lower "in limit" stoppers are not leaning against the structure at the moment when the "in limit" sensor detects the magnet; C. Acetal plastic block serving as leaning surface for lower "in limit" stopper broken or moved;	A. Replace or adjust lower "in limit" stopper. B. Adjust the sensor position in order to have contact of the stoppers against the structure when slide-out is stopped. C. Replace or adjust acetal plastic block proper position.
Top of slide-out not flush with vehicle body	A. Broken or misadjusted leveling or retaining screw; B. Faulty upper "in limit" stopper;	A. Check and replace screw. B. Replace upper "in limit" stopper.
Lower edge of slide-out not parallel with vehicle body opening	A. Faulty leveling and retaining screw (8 screws each side).	A. Inspect screw, replace and adjust slide-out level.
Watertightness problem	A. Inflatable seal and/or wiper seal damaged or unstuck; B. Insufficient air pressure in the seal; C. No air pressure in the slide-out pneumatic system; D. Sealant missing; E. Wiper seal draining hole clogged; F. Faulty water recovery pan; G. Faulty internal gutter;	A. Check both seals condition. B. Check the pressure regulator, the relieving shut-off valve and the seal valve condition. C. Check the slide-out air pressure inlet valve condition and the accessory air tank pressure. D. Check the exterior extrusion screws, the windows and the exterior panels sealant condition. E. Unclog draining hole. F. Check the recovery pan. G. Check internal gutter.
Knocking sound at end of travel when extending slide-out	A. Inner stoppers misadjusted;	A. Readjust the inner stoppers.
Knocking sound when parking brake is released	A. Security pin retracts too rapidly;	A. Adjust security pin air flow regulator.

PROBLEM	CAUSE	CORRECTIVE ACTION
Inflatable seal damaged or removed, or wiper seal unstuck from the structure.	A. Slide-out has been retracted or extended with the manual procedure with the inflatable seal not deflated; B. Pressure transducer malfunction; C. Faulty roof reinforcing rod adjustment; D. Seal valve malfunction; E. Excessive load in the slide-out; F. Slide-out not centered in the structure opening;	A. Always deflate the seal when manually retracting or extending the slide-out. B. Check the pressure transducer condition, replace if necessary. C. Readjust the roof reinforcing rod. D. Check the seal valve condition. E. Reduce load or distribute load evenly in order to respect the deflection criterion and slide-out load capacity. F. Readjust the slide-out height and center horizontally in opening.
Friction at end of travel when in full OUT position or at beginning of retraction	A. Interference between upper structure key and upper inner stopper;	A. Readjust the upper inner stopper.

21.4 SLIDE-OUT FAULT MESSAGE ON MESSAGE CENTER DISPLAY (MCD)

SID #	FAULT MESSAGE	TEXT	PROBABLE CAUSE	CORRECTIVE ACTION
1	Voltage Module A56	Value Too Low	Module A56 sees a Voltage less than 18 V on its power supply connector. Breaker, fuse or wiring harness open.	Check/ reset circuit breaker CBSo and CBSo1. Check/ replace fuse FSo5 Fix wiring harness
2	No Response Mod A56	Data Error	CECM module does not receive CAN communication from module A56. CAN connector A56 J3 Disconnected or CAN wiring harness open, or module A56 is defective.	Check connection A56 J3 Fix CAN wiring harness Replace module A56
3	Voltage Module A57	Value Too Low	Module A57 sees a voltage less than 18 V on its power supply connector. Breaker, fuse or wiring harness open.	Check/ reset circuit breaker CBSo and CBSo2. Check/ replace fuse FSo2 Fix wiring harness
4	No Response Mod A57	Data Error	CECM module does not receive CAN communication from module A57. CAN connector A57 J3 disconnected or CAN wiring harness open or module A57 is defective.	Check connection A57 J3 Fix CAN wiring harness Replace module
5	SldO Vacuum Sensor	Open Circuit	Pressure transducer disconnected. Faulty pressure transducer. Connection or wiring harness open.	Check/ replace vacuum transducer Check/ reconnect the connector SESo1 Fix wiring harness
		Shorted High	Pressure transducer is faulty Wiring harness shorted to 12v or 24v	Check/ replace vacuum transducer Fix wiring harness
6	SldO Seal Deaf Vac	Mechanical Fault	Does not reach vacuum level (-5 PSIG). Slide-out seal damaged or air leak in the seal deflating pneumatic circuit.	Check the seals and the pneumatic circuit.
7	SldO Motor/Limit se	Mechanical Or Electrical Fault	Slide-Out motor is activated for more than 5 seconds and the limit sensor from the departing end is still seen as active. Either the motor is defective and the slide-out is not moving or the limit sensor from the departing end is broken active.	If the slide-Out is not moving, then check the motor and its wiring. If the slide-out is moving, then check the limit sensor from the departing end. (If problem occurs when extending, check the in-limit sensor. If the problem occurred when retracting, then check the out-limit sensor).
8	SldO Park Br Signal	Mechanical Or Electrical Fault	Parking brake is not applied. Wire between parking brake switch and CECM is open.	Make sure the parking brake is applied and the parking brake telltale illuminates. Check / replace parking brake switch. Fix wiring harness.

SID #	FAULT MESSAGE	TEXT	PROBABLE CAUSE	CORRECTIVE ACTION
		Shorted High	Wire between parking brake switch and CECM is shorted to 12v or 24v.	Fix wiring harness.
9	SldO Mot SpeedA Ctr	Shorted High	Wiring harness shorted to 12v or 24v	Fix wiring harness
		Current Above normal	Security pin or object stop the movement of a slide-out	Check / fix security pin functionality. Check / remove any object around the slide-out.
10	SldO Mot SpeedB Ctr	Shorted High	Wiring harness shorted to 12v or 24v	Fix wiring harness
		Current Above normal	Security pin or object stop the movement of a slide-out	Check / fix security pin functionality. Check / remove any object around the slide-out.
11	SldO Remote Led	Shorted High	LED or wiring harness shorted to 12v or 24v	Fix LED or wiring harness
		Shorted Low	Led or wiring harness shorted to ground	Fix LED or wiring harness
		Open Circuit	LED is broken. Bad connection on handheld control. Wiring harness is cut.	Check / fix remote LED or connection Check /fix wiring harness
		Current Above normal	Led or wiring harness shorted to 12v or 24v	Fix Led or wiring harness
12	SldO Seal Inf Sol	Shorted High	Solenoid or wiring harness shorted to 12v or 24v	Fix solenoid or wiring harness
		Shorted Low	Solenoid or wiring harness shorted to ground	Fix solenoid or wiring harness
		Open Circuit	Solenoid is broken or open. Bad connection on solenoid or bloc valve. Wiring harness is cut.	Check / fix solenoid or connection Check /fix wiring harness
		Current Above normal	Solenoid or wiring harness shorted to 12v or 24v	Fix solenoid or wiring harness
13	SldO Seal Def Sol	Shorted High	Solenoid or wiring harness shorted to 12v or 24v	Fix solenoid or wiring harness
		Shorted Low	Solenoid or wiring harness shorted to ground	Fix solenoid or wiring harness
		Open Circuit	Solenoid is broken or open. Bad connection on solenoid or bloc valve. Wiring harness is cut.	Check / fix solenoid or connection. Check /fix wiring harness
		Current Above normal	Solenoid or wiring harness shorted to 12v or 24v	Fix solenoid or wiring harness
14	SldO Vacc Gen Sol	Shorted High	Solenoid or wiring harness shorted to 12v or 24v	Fix solenoid or wiring harness
		Shorted Low	Solenoid or wiring harness Shorted to ground	Fix solenoid or wiring harness
		Open Circuit	Solenoid is broken or open. Bad connection on solenoid or bloc valve. Wiring harness is cut.	Check / fix solenoid or connection Check / fix wiring harness
		Current Above normal	Solenoid or wiring harness shorted to 12v or 24v	Fix Solenoid or wiring harness
15	SldO Mot Neg Rly	Shorted High	Relay coil or wiring harness shorted to 12v or 24v	Fix relay coil or wiring harness
		Shorted Low	Relay coil or wiring harness shorted to ground	Fix relay coil or wiring harness

SID #	FAULT MESSAGE	TEXT	PROBABLE CAUSE	CORRECTIVE ACTION
		Open Circuit	Relay coil is broken or open. Bad connection on relay. Wiring harness is cut.	Check / fix relay coil or connection Check / fix wiring harness
		Current Above normal	Relay coil or wiring harness shorted to 12v or 24v	Fix relay coil or wiring harness
16	SldO Mot Pos Rly	Shorted High	Relay coil or wiring harness shorted to 12v or 24v	Fix relay coil or wiring harness
		Shorted Low	Relay coil or wiring harness shorted to ground	Fix relay coil or wiring harness
		Open Circuit	Relay coil is broken or open. Bad connection on relay. Wiring harness is cut.	Check / fix relay coil or connection Check / fix wiring harness
		Current Above normal	Relay coil or wiring harness shorted to 12v or 24v	Fix relay coil or wiring harness
17	SldO Open Sw	Shorted High	Switch or wiring harness shorted to 12v or 24v	Fix switch or wiring harness
18	SldO Close Sw	Shorted High	Switch or wiring harness shorted to 12v or 24v	Fix switch or wiring harness
19	SldO Limit In Se	Shorted High	Sensor or wiring harness shorted to 12v or 24v	Fix sensor or wiring harness
20	SldO Limit Out Se	Shorted High	Sensor or wiring harness shorted to 12v or 24v	Fix sensor or wiring harness
21	SldO Secu Pin Sol	Shorted High	Solenoid or wiring harness shorted to 12v or 24v	Fix solenoid or wiring harness
		Shorted Low	Solenoid or wiring Harness shorted to ground	Fix solenoid or wiring harness
		Open Circuit	Solenoid is broken or open. Bad connection on solenoid or bloc valve. Wiring harness is cut.	Check / fix solenoid or connection. Check / fix wiring harness
		Current Above normal	Solenoid or wiring harness shorted to 12v or 24v	Fix solenoid or wiring harness
22	SldO Limit In Out	Mechanical Or Electrical Fault	In Limit and Out Limit are seen at the same time. In Limit or Out Limit problem.	Check / replace in limit or out limit sensors Fix wiring harness.
23	Limit Sensor 5 V supply	Shorted Low	5v IO-B output is less than 2v. Wiring harness is open or shorted to ground.	Check 5v output on IO-B / replace IO-B module. Fix wiring harness.