CHAPTER 1
GENERAL INFORMATION

PAGE

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INTRODUCTION

This MAINTENANCE MANUAL has been prepared by VAN HOOL for reference and use by technicians who have been trained to service and repair components and systems on heavy commercial vehicles.

VAN HOOL has excercized reasonable care and diligence to present accurate, clear and complete information regarding the VAN HOOL Commuter coaches. Before any work is undertaken on these units, the service information and procedures in this manual must be carefully read and fully understood. Service Bulletins pertaining to the job at hand must be consulted as well.

It is the responsibility of the technician performing the maintenance, repairs or service to:

a. Inspect parts and systems for abnormal wear and damage.

b. Choose a repair procedure which will not endanger his/her safety, the safety of others, the vehicle or the safe operation of the vehicle.

c. Fully inspect and test the operation of parts and systems to ensure that the repair or service has been properly performed.

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.

HOW TO USE THIS MANUAL

This manual is divided into twelve chapters. Each chapter treats a major component. All chapters are listed on the front page of this manual. The chapter is also shown at the top of each page, as well as the coach type for which the chapter is written.

Each chapter is divided into several sections. The sections of each chapter are listed on the front page of that chapter.

Each section consists of several subtitles and each subtitle is divided into several paragraphs. These paragraphs may be subdivided into yet other levels, in case this is necessary.

Example:

Chapter	:	Cooling System
Section	:	Engine Cooling System
Subtitle	:	Maintenance
Paragraph	:	Heating System Isolating Valves

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When necessary, VAN HOOL will make revisions of this manual. You can find the exact revision date at the bottom of each page.

For example: The date 5/97 indicates that (this part of) the manual was released in May 1997. Hence, you will be able to find out about every update automatically.

Coach operating information is provided in the OPERATOR'S GUIDE BOOK.

Information on spare parts is published in a separate SPARE PARTS MANUAL

More detailed information on engine and transmission maintenance and overhaul is contained in the applicable engine and transmission service manual published by the engine or transmission manufacturer.

SAFETY WARNINGS

You must follow your company safety procedures while repairing or servicing VAN HOOL coaches. In order to reduce the risk of personal injury, damage to property and equipment, this manual contains "CAUTIONS" and "NOTES".

- **CAUTION**: points out hazards or unsafe practices which could result in personal injury or death, product or property damage, malfunctioning of equipment or components.

- **NOTE**: indicates an operation, procedure or instruction that is important for proper service. It may also include information for quicker and easier service.

It is important to understand that these cautions and notes are not exhaustive, because it is impossible to warn personnel of all possible hazardous consequences that might result from failure to follow proper maintenance and service procedures.

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.

Specific safety features are dealt with in the relevant chapters.

SAFE SHOP PRACTICE

As stated under SAFETY WARNINGS, you must always follow your company safety procedures while repairing or servicing VAN HOOL coaches. Although sound judgement must always prevail while working on vehicles, VAN HOOL offers the following guidelines in order to promote safe shop practice.

- Before starting to work. Put "DO NOT OPERATE" tag on instrument panel.

- Don't take shortcuts with established work systems: follow the proper procedures.

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- Don't rush to finish a job.
- Know what to do in an emergency, and make sure that first aid equipment is on-site, accessible and available for immediate use.
- When working underneath the vehicle, make absolutely sure that the vehicle can not move. Do not operate the air suspension system.
- Don't rely on jacks when working underneath a vehicle. Always use reliable additional means of support, such as axle stands, securely placed under a part of the vehicle that you know will not give way.
- Don't lift, carry or move any load which is so heavy as to be likely to cause injury. Use a hoist or get assistance when lifting components that weigh 50 lbs or more. Make sure all lifting devices such as chains, hooks, or slings are in good condition and are of the right capacity. Make sure hooks are positioned correcty.
- Isolate the batteries if an electrical supply is not needed for the work being done.
- Some service procedures require special tools. Don't try to avoid their use by using chisels, hammers, screwdrivers, crowbars or makeshift tools. Always use tools that are in good condition. Make sure you understand how to use them before performing any service work. The same applies to testing equipment and lifting devices.
- Don't apply compressed air to any part of the body or clothing. This can cause injury. Wear adequate eye protection.
- Relieve all pressure in the air, oil and cooling systems, before any lines, fittings or related items are removed or disconnected. Be alert for possible pressure when disconnecting any device from a system that utilizes pressure. Don't check for pressure leaks with your hands. High pressure oil, fuel, air or refrigerant can cause personal injury.
- Be careful when inflating tires. Look for damage, cuts and blisters. Inspect the condition of the wheels.
- Test temperature before working on components which get hot. Remain alert to the location of the rotating fan, pulleys and belts. Rotating parts can cause cuts, mutilation or strangulation.
- Avoid making contact across the two terminals of a battery wich can result in severe arcing, or battery explosion.
- Exhaust gas contains poison. When testing a vehicle with the engine running, test in a well ventilated area, or vent the exhaust to the outside.

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- Do not smoke when refueling. Do not refuel when the engine is running. Do not overfill the fuel tank.

- Always wear protective glasses and protective shoes when working.

- Do not wear loose-fitting or thorn clothing. Remove all jewelry when working.

- When a job involves two are more workers, it is very important for them to communicate clearly.

- If an engine has been operating and the coolant is hot, allow the engine to cool before you slowly loosen the surge tank filler cap and relieve the pressure from the the cooling system.

- Do not weld or heat areas near fuel tanks, fuel lines and refrigerant lines. Use proper shielding around hydraulic lines and air lines.

- Organize your work area and keep it clean. Eliminate the possibility of fall by: wiping up oil spills and grease, and keeping tools and parts off the floor. Keep the work area dry, well lit, ventilated, free from ignition sources and hazardous substances.

- Cleaners, solvents, acids, paints, chemicals
  The following rules apply to one, some or all of the above:
    - When using chemical products, read the instructions carefully.
    - Never use substances from unmarked containers.
    - Certain fumes are highly toxic and can quickly cause unconsciousness and even death if inhaled to any extend; gasoline comes into this category, as do vapors from certain solvents.
    - Never clean with gasoline or carbon tetrachloride or paint thinner.
    - Always keep the work area adequately ventilated.
    - Never weld or grind in an area where fumes could be present.
    - Avoid contact with skin and eyes. Use a barrier cream and wear appropriate eye protection.
    - Avoid inhaling.
    - Avoid spilling on clothes.
    - After cleaning or servicing parts, wash your hands before you eat, drink, smoke or use the toilet. Shower after work. Dispose of contaminated clothes.
    - Cleaning products, gasoline, thinners are flammable and may explode under certain conditions.

- Do not perform any repair when fatigued or after consuming alcohol or drugs that can impair your functioning.

- Don't eat or drink in the work area or where there is any risk of exposure to a hazardous substance.

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- Before carrying out any electric welding on the vehicle, switch off the battery master switch and disconnect all the electronic control units. Position the earth return tongs as close as possible to the location of the weld.
- Never disconnect the electronic control units if the battery master switch is "on".
- When a vehicle has an encapsulated engine: after each maintenance or repair operation, check that there are no liquids or flammable objects at the bottom of the engine encapsulation.

DISPOSAL PROCEDURES

Various state and federal guidelines provide for proper disposal of oils, chemicals and other fluids. Be aware of potential of point source pollution and of other dangers to environment. Dispose of these materials at authorized disposal sites. Contact Environmental Protection Agency for advice.

HAZARDOUS MATERIALS

VAN HOOL coaches meet or exceed all governmental specifications for control of hazardous materials.

SERVICE BULLETINS

Service Bulletins are issued on a regular basis to supplement or supersede information in the Van Hool manuals. They are an essential part of these manuals and should be consulted as a matter of course to make sure that only the latest information available is used. Upon receipt, note Service Bulletin number, date and subject on the register at the end of the relevant chapter(s). File Service Bulletin separately for future reference.

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SERVICE ADDRESSES

IF YOU NEED ASSISTANCE, CALL YOUR NEAREST AUTHORIZED VAN HOOL SERVICE CENTER

U.S. Distributor of

COACH PRODUCTS
NATIONWIDE SALES,
SERVICE & SALES

Regional Service Centers

Location		Phone no.	Fax no.
CALIFORNIA	13261 Garden Grove Blvd., Garden Grove, CA 92843	(800) 322-2877 (714) 740-8888	(714) 663-9826
FLORIDA	17469 West Colonial Drive, Building A, Winter Garden, FL 34787	(800) 222-2871 (407) 656-7977	(407) 877-0855 (407) 656-9278
MINNESOTA	1506 30th Street NW, Faribault, MN 55021	(800) 222-2875 (507) 334-1871	(507) 334-8311
NEW JERSEY	1494 Federal Street, Camden, NJ 08105	(800) 222-2873 (609) 966-1500	(609) 966-0055
TEXAS	1702 S. Great Southwest Pkwy, Grand Prairie, TX 75051	(800) 222-2877 (817) 232-5994	(817) 232-2340
ILLINOIS	7128 North Barry, Rosemont, IL 60018	(877) 222-2878	

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CHAPTER 2

COOLING SYSTEM

PAGE

CUMMINS ENGINE COOLING SYSTEM

DETROIT DIESEL ENGINE COOLING SYSTEM

TRANSMISSION COOLING SYSTEM

COOLING FAN

CUMMINS ENGINE COOLING SYSTEM

DESCRIPTION

The engine is cooled by liquid circulated within a pressurized system. The cooling system components include an engine water pump, a radiator, a fan, a thermostat and a surge tank.

The coolant temperature is controlled by a thermostat. With a cold engine the thermostat is closed and prevents water from circulating through the radiator. Instead, the coolant passes through a by-pass where it is recirculated through the cylinder block, the cylinder head and the transmission oil cooler.

When the coolant reaches the opening temperature of the thermostat, the coolant begins to flow through the radiator. The surge tank above the radiator is equipped with a filler cap and a pressure relief cap. The filler cap also incorporates a pressure relief valve (in case the pressure relief cap fails).

The "ENGINE MAINT" warning light on the instrument panel warns in case the engine becomes overheated. The same warning light illuminates when the coolant level becomes critical.

An engine coolant temperature gauge is mounted on the dashboard.

SPECIFICATIONS

ENGINE COOLING AND HEATING SYSTEM CAPACITY ..... approx. 26 U.S.Gallons

THERMOSTATS

- Number used 1
- Make .... Cummins
- Starts to open at .... 180 °F ± 2 °F
- Fully open .... 0.435 inch at 202 °F

SURGE TANK

- **Pressure relief cap**
  Pressure valve
  opens at .... 8.7 psi overpressure
  Vacuum valve opens
  at ... 0.29 to 1.16 psi below atmospheric pressure
- **Filler cap**
  Pressure valve
  opens at .... 14.5 psi overpressure

MAINTENANCE

HEATING SYSTEM ISOLATING VALVES

If necessary, two isolating valves in the heating system pipes can be closed to completely separate the heating system from the engine cooling system.

There is no objection against the coach being driven in this condition, but the heating system or combustion heater should on no account be switched on with the isolating valves closed.

See Operator's Guide Book for location of isolating valves.

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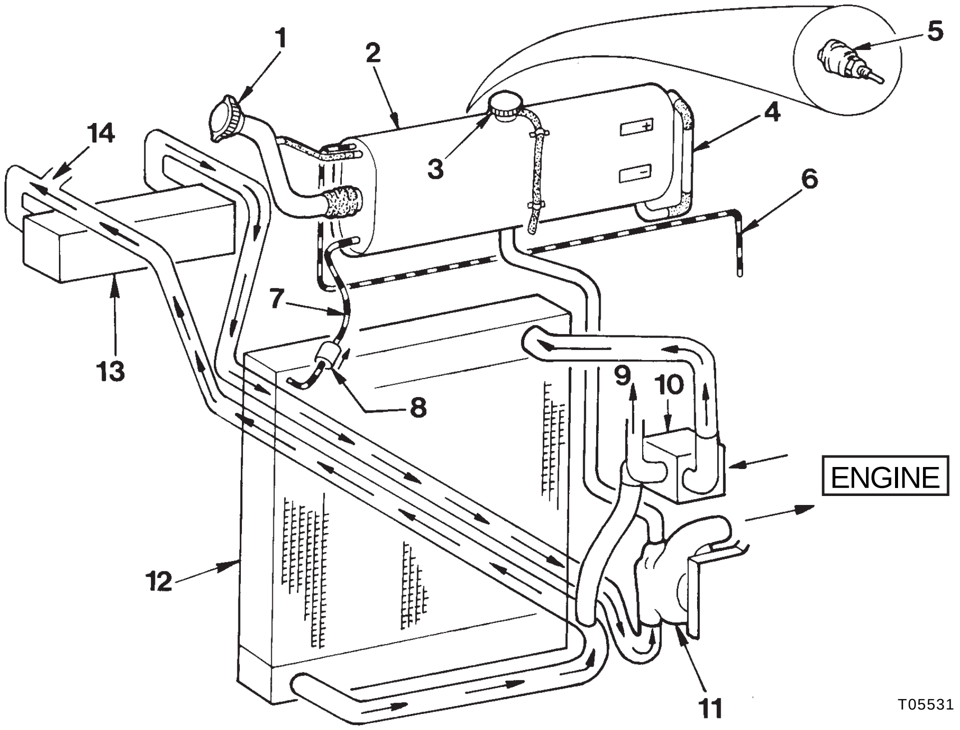

1. Filler cap
2. Surge tank
3. Pressure relief cap
4. Coolant level gauge glass
5. Low coolant level sensor
6. Engine deaeration line
7. Radiator deaeration line
8. Check valve
9. To heating system
10. Thermostat housing
11. Engine water pump
12. Radiator
13. Transmission oil cooler
14. From heating system

Figure 1: Engine cooling system diagram. Arrows indicate direction of coolant flow when thermostat is fully open.

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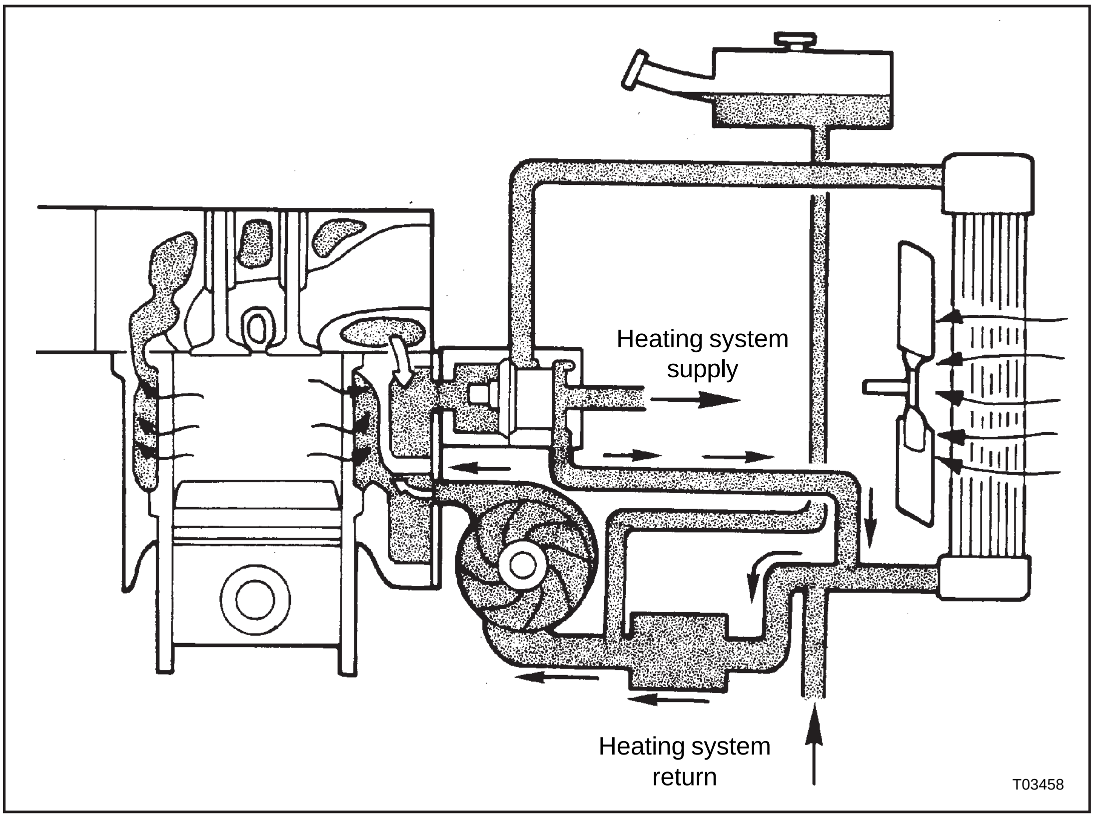

Figure 2: Coolant flow through cooling system with closed thermostat

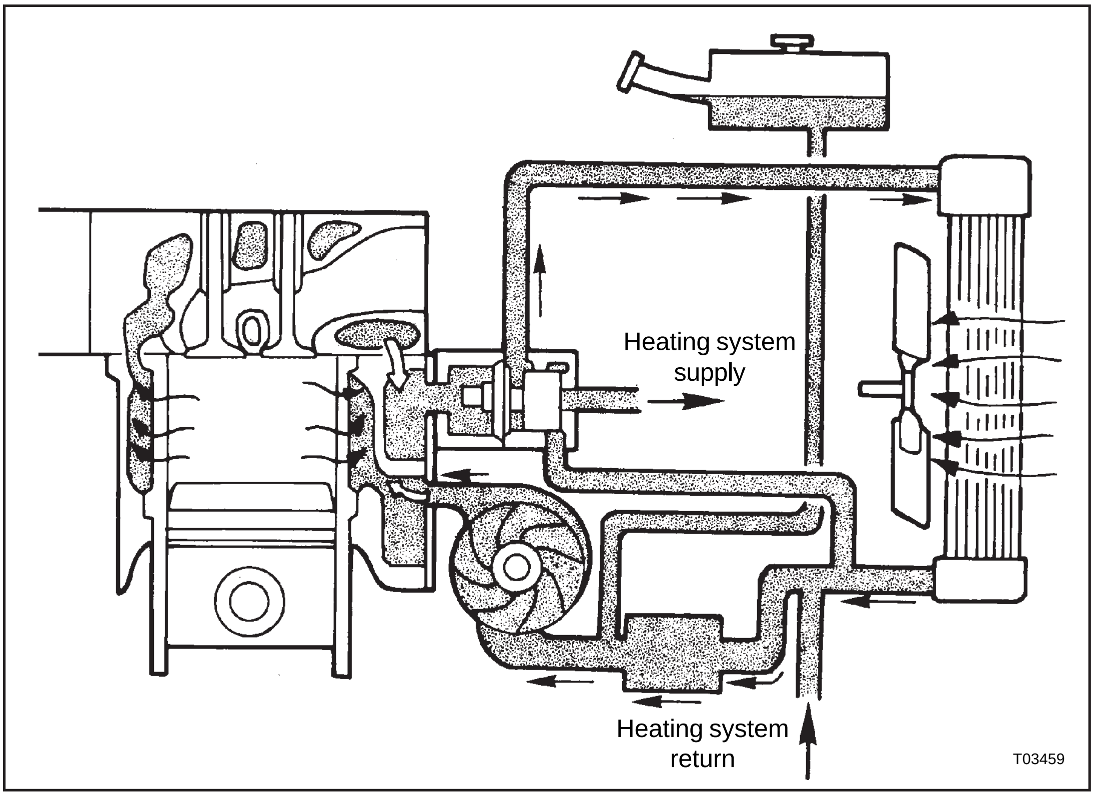

Figure 3: Coolant flow through cooling system with fully open thermostat

TO CHECK COOLANT LEVEL

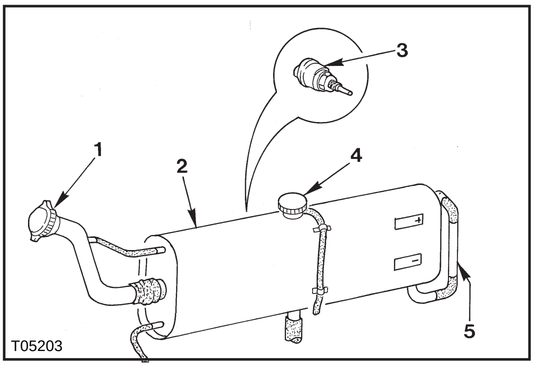

Figure 4 : Surge tank

1. **Filler cap**
2. **Surge tank**
3. **Low coolant level sensor**
4. **Pressure relief cap**
5. **Gauge glass**

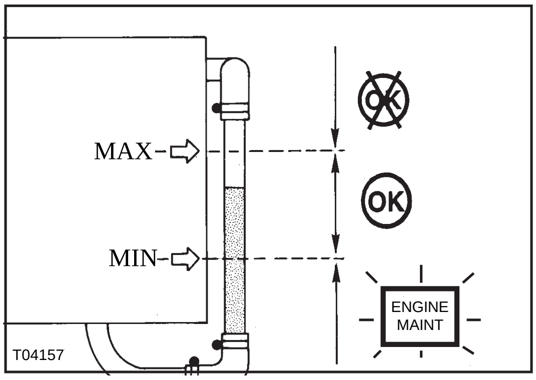

Figure 5 : Coolant level

With cold engine, check whether the coolant level is between the "MIN" and "MAX" indicators on the surge tank.
As necessary, fill the system until the coolant level is to the "MAX" indicator using the ethlyene form of "Fleetguard Compleat".
Do not add plain water, as this will cause the antifreeze/DCA-4 solution to become diluted, thus reducing the frost and corrosion protection properties.

!!! CAUTION !!!

NEVER REMOVE SURGE TANK FILLER CAP WHEN COOLANT TEMPERATURE IS ABOVE 120 °F. COOLANT AND STEAM MAY BE BLOWN OUT, POSSIBLY CAUSING PERSONAL INJURY.
IF FILLER CAP MUST BE OPENED WHILE THE ENGINE IS HOT, TURN IT CAREFULLY TO THE LEFT UNTIL FIRST STOP AND LET PRESSURE ESCAPE. THEN TURN TO SECOND STOP AND REMOVE CAP.

NEVER ADD COLD COOLANT WHEN ENGINE IS OVERHEATED DUE TO LACK OF COOLANT. CRACKS IN CYLINDER BLOCK MAY BE THE RESULT.

COOLANT

Cummins Engine company, Inc., recommends the use of fully formulated antifreeze or coolant containing a precharge of Supplemental Coolant Additives (SCA). The antifreeze must meet the specifications outlined in The Maintenance Council (TMC) Recommended Practice RP 329. The use of fully formulated antifreeze or coolant significantly simplifies cooling system maintenance. Copies of TMC specifications can be obtained through Cummins Engine Company.

Fully formulated *antifreeze* contains balanced amounts of antifreeze, SCA, and buffering compounds, but does NOT contain 50% water. Fully formulated *coolant* contains balanced amounts of antifreeze, SCA, and buffering compounds already premixed 50/50 with deionized water.
Cummins Engine Company recommends using Fleetguard Compleat. It is available in both glycol forms (ethlyene and propylene). Only the ethlyene form is permitted!

Good quality water

Fully formulated antifreeze must be mixed with good quality water at a 50/50 ratio (40 to 60 percent working range). Good quality water is important for cooling system performance. Excessive levels of calcium and magnesium contribute to scaling problems, and excessive levels

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MINERAL	MAXIMUM LIMIT
Calcium	170ppm
Magnesium	170ppm
Chloride	40ppm
Sulfate	100ppm

of chlorides and sulfates cause cooling system corrosion. Water added to the fully formulated antifreeze must meet specifications given in the chart above.

Antifreeze concentration

Antifreeze concentration must be checked using a refractometer (such as Fleetguard Part No. CC2800). Refer to the manufacturer's instructions for use of refractometer. "Floating Ball" type density testers or hydrometers are not accurate enough for use with heavy duty diesel cooling systems.

!!! CAUTION !!!

ANTIFREEZE AND COOLANT WITH ANTIFREEZE CONTAIN ETHYLENE GLYCOL, A TOXIC SUBSTANCE. DO NOT SWALLOW OR INHALE. ETHYLENE GLYCOL CAN IRRITATE THE EYES. IF THE SUBSTANCE IS SWALLOWED, THE VICTIM (IF CONSCIOUS) MUST BE MADE TO VOMIT. IN CASE OF INHALATION, LEAD VICTIM INTO THE OPEN AIR.

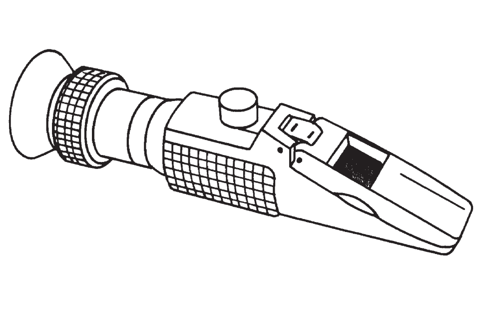

Figure 6 : Refractometer (Fleetguard part no. CC2800)

CALL A DOCTOR IN BOTH CASES AND CONTACT POISONING TREATMENT CENTER. IN CASE THE EYES ARE AFFECTED, RINSE THEM ABUNDANTLY WITH WATER AND CONSULT AN OCCULIST.

Dispose of antifreeze or coolant at authorized disposal sites only.

Supplemental coolant additives (SCA)

!!! CAUTION !!!

DCA-4 CONTAINS ALKALI. MAKE SURE IT DOES NOT COME INTO THE EYES. AVOID PROLONGED OR REPEATED CONTACT WITH THE SKIN. DO NOT SWALLOW. IN CASE OF CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND WATER. IN CASE OF CONTACT WITH EYES, IMMEDIATELY FLOOD EYES ABUNDANTLY WITH WATER DURING AT LEAST 15 MINUTES AND CALL A PHYSICIAN. KEEP OUT OF REACH OF CHILDREN.

Fully formulated products contain SCA (DCA-4) and are required to protect the cooling system from fouling, solder blooming, and general corrosion.

The recommended SCA concentration is 1.5 units per U.S. Gallon. The SCA concentration must never exceed 3 units per U.S. Gallon, nor fall below 1.2 units per U.S. Gallon. Use test kit CC-2606 to check SCA concentration.

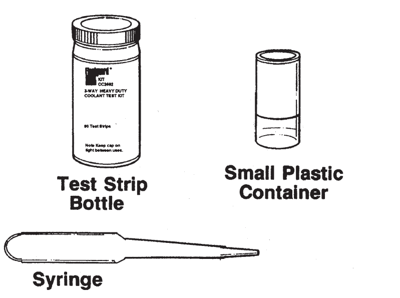

Figure 7 : Test kit CC-2606

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!!! CAUTION !!!
INADEQUATE CONCENTRATION OF SCA CAN RESULT IN MAJOR CORROSIVE DAMAGE TO COOLING SYSTEM COMPONENTS. OVERCONCENTRATION CAN CAUSE A HIGH LEVEL OF SOLIDS IN THE COOLING SYSTEM WHICH CAN RESULT IN WATER PUMP SEAL LEAKS, CORROSION SUCH AS SOLDER BLOOM, PLUGGING OF COOLANT PASSAGES, DEPOSITS ON HEAT TRANSFER SURFACES AND OVERHEATING.

The right SCA concentration must be maintained in the circuit by changing the coolant filter at the right interval (see "To change coolant filter").

TO DRAIN/FILL ENGINE COOLING AND HEATING SYSTEM

To drain

1. Make sure all hand isolating valves are open.

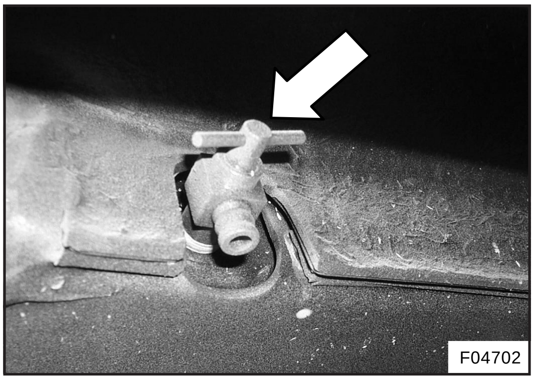

Figure 8 : Drain cock on the cooling radiator

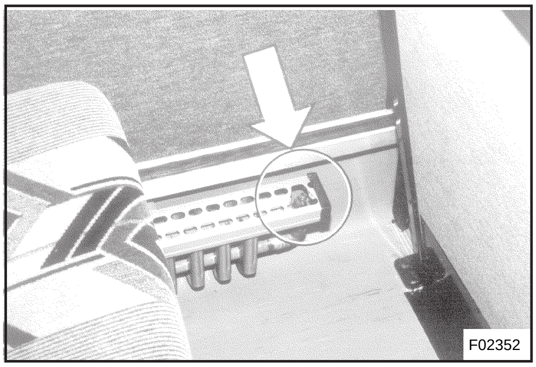

Figure 9 : Floor heater bleed screw

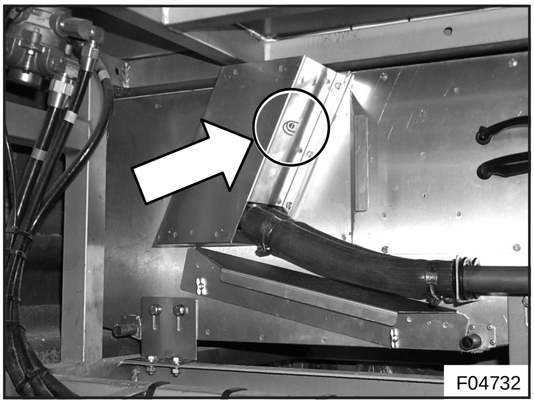

Figure 10 : Bleed screw of the driver's defroster/heater (located behind a protection cover, accessible via the frontmost left exterior access door)

2. Remove surge tank filler cap.
3. Unscrew drain plugs. Drain plugs (cocks) are provided on cooling radiator and main coolant pipes.
4. Toward end of draining open all bleed screws (on driver's defroster/heater and floor heaters).

NOTE
DISPOSE OF USED ANTIFREEZE AND COOLANT IN ACCORDANCE WITH FEDERAL, STATE, AND LOCAL ENVIRONMENTAL REGULATIONS.

To clean

!!! CAUTION !!!
DO NOT USE CAUSTIC CLEANERS IN THE COOLING/HEATING SYSTEM. ALUMINUM COMPONENTS WILL BE DAMAGED.

The cooling/heating system must be clean to work correctly and to eliminate buildup of harmful chemicals at the intervals given in the Maintenance Schedule, chapter 12.

"Restore" is a heavy duty cooling system cleaner which removes corrosion products, silicate gel and other deposits. The performance of

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Figure 11 : RESTORE and RESTORE PLUS

"Restore" is dependent on time, temperature, and concentration levels. An extremely scaled or flow restricted system, for example, can require higher concentrations of cleaners, higher temperatures, or longer cleaning times or the use of "Restore Plus". Up to twice the recommended concentration levels of "Restore" can be used safely. "Restore Plus" must be used only at its recommended concentration level. Extremely scaled or fouled systems can require more than one cleaning.

Do not allow the cooling/heating system to dry out after draining.

Do not remove the coolant filter.

!!! CAUTION !!!
"RESTORE" CONTAINS NO ANTIFREEZE. DO NOT ALLOW THE COOLING SYSTEM TO FREEZE DURING THE CLEANING OPERATION.

1. Immediately add 1 U.S. gallon of "Restore", "Restore Plus", or equivalent, for each 10 to 15 U.S. gallons of cooling/heating system capacity, and fill the system with plain water.
2. Carry out points 3,5,6 and 7 of "To fill" (see next heading).
3. Top up surge tank and reinstall filler cap.
4. Operate the engine at normal operating temperature, at least 185°F, for 1 to 11/2 hours.
5. Shut off the engine and drain the cooling/heating system (Refer to "To drain", previous heading).
6. If the water being drained is still dirty, the system must be flushed again until the water is clean.

To fill

1. Reinstall all drain plugs. Close all drain cocks and bleed screws.
2. Install new coolant filter WF 2074.
3. To prevent combustion heater operation, disconnect wire of combustion heater overheat breaker (see Figure 12).
4. Slowly fill surge tank with the ethlyene form of the fully formulated coolant "Fleetguard Compleat" until it flows out of filling tube.
5. Bleed engine cooling circuit:
   a. Close both heating system isolating valves.

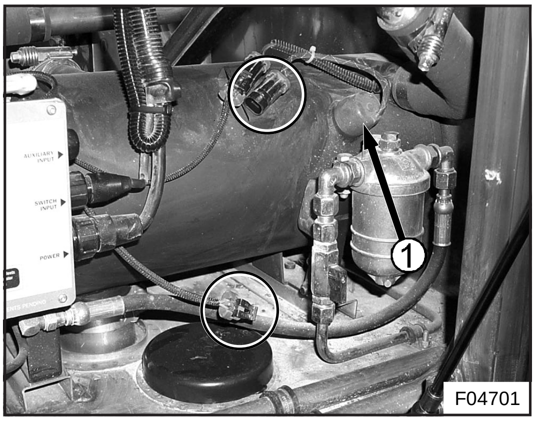

Figure 12 : Combustion heater overheat breaker wire connector

1. Overheat breaker

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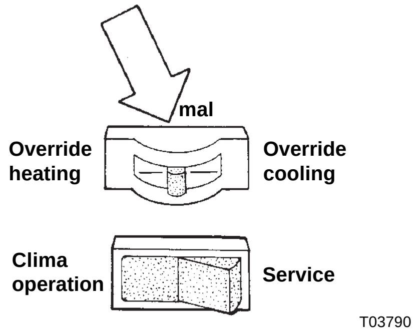

Figure 13 : Climate control override (in HVAC junction box)

b. Start engine and run at fast idle.

c. Add "Fleetguard Compleat" continuously to keep surge tank topped up.

d. Open both heating system isolating valves.

6. Bleed defroster/heater circuit:

a. Turn defroster/heater rotary knob on dashboard fully clockwise.

b. Open air bleed screw of defroster/heater unit until air-free coolant comes out.

c. Turn defroster/heater rotary knob on dashboard fully counterclockwise.

7. Bleed passenger's compartment heating circuit:

a. Set climate control switch on dashboard to "ON" position.

b. Switch override switch to "OVERRIDE HEATING" position (Figure 13).

c. Continuously add "Fleetguard Compleat" to keep surge tank topped up.

d. Open air bleed screws of floor heaters one by one until air-free coolant comes out.

8. Top up surge tank and reinstall filler cap. Reconnect combustion heater overheat breaker.

9. Drive coach until engine reaches operating temperature. Stop engine, allow to cool down and recheck coolant level.

10. Switch HVAC-override switch (see Figure 13) back to "NORMAL" position.

TO CHANGE COOLANT FILTER

Check the SCA concentration at the interval given in the Maintenance Schedule.

The following action is required after testing coolant:

- Below 1.2 units per gallon: replace coolant filter and add 1 pint of DCA-4 liquid (5 units) for each 4 gallons of coolant.
- 1.2 to 3 units per gallon: continue to replace coolant filter.
- Above 3 units per gallon: do not replace coolant filter until DCA-4 level falls below 3 units per gallon.

Coolant filter change procedure

!!! CAUTION !!!
NEVER REMOVE SURGE TANK FILLER CAP IF COOLANT IS ABOVE 120°F. COOLANT STEAM MAY BE BLOWN OUT, POSSIBLY CAUSING PERSONAL INJURY.

1. Remove surge tank filler cap and turn coolant filter shut-off valve on top of filter to "OFF" position.

2. Remove and discard filter. Clean new coolant filter gasket surface.

3. Apply a light film of clean 15W-40 lubricating oil to gasket sealing

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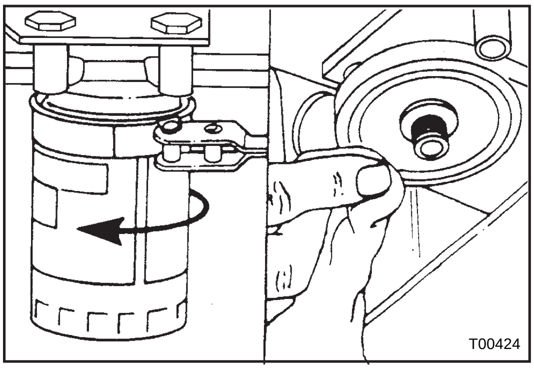

Figure 14 : Coolant filter removal

surface before installing coolant filter.

!!! CAUTION !!!
MECHANICAL OVERTIGHTENING MAY DISTORT THREADS OR DAMAGE COOLANT FILTER HEAD.

Install filter as specified by filter manufacturer.

4. Turn coolant filter shut-off valve to "ON" position.

!!! CAUTION !!!
FAILURE TO OPEN SHUT-OFF VALVE CAN RESULT IN SEVERE ENGINE DAMAGE.

TO CHECK/CLEAN RADIATOR AIR INTAKE SCREEN

The body opening through which cooling air to the radiator enters is fitted with a filtering screen of woven metal wire which excludes the larger dirt particles drawn by the fan. In accordance with the nature of the dirt, the screen can be cleaned with a vacuum cleaner, compressed air or a jet of water or steam.

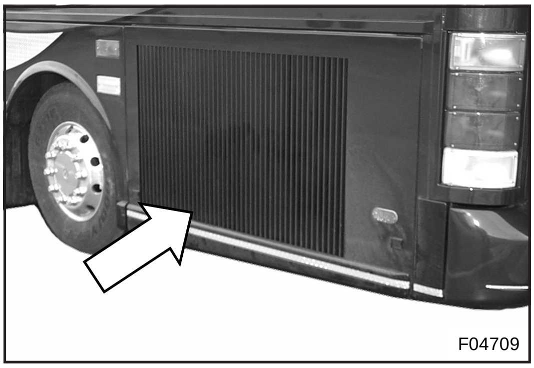

Figure 15 : Filter screen upstream of radiator

TO CLEAN EXTERIOR OF RADIATOR AND CHARGE - AIR COOLER

Dirt obstructing the air passage through the radiator core reduces engine cooling capacity. This can cause engine overheating and consequent damage to the engine (e.g. piston seizure). The charge-air will be insufficiently cooled due to a clogged charge-air cooler. This causes power loss. To prevent the above occurring, the external cleanliness of radiator and charge-air cooler core must be checked at regular intervals.

VAN HOOL supply a T-headed spraylance (VH N° 10527208) for radiator and charge-air cleaning purposes. This tool can be connected to an air hose or to a high pressure washer.

Cleaning procedure (see Figure 16):

!!! CAUTION !!!
ALWAYS WEAR A DUST MASK WHEN CLEANING WITH COMPRESSED AIR.

1. Open the radiator compartment door.
2. Remove the collected dirt between radiator and charge-air cooler with an air gun.
3. If you have to clean with water, adjust the high-pressure cleaner at 140 to 176 °F and make sure that the pressure does not exceed 1400 psi.

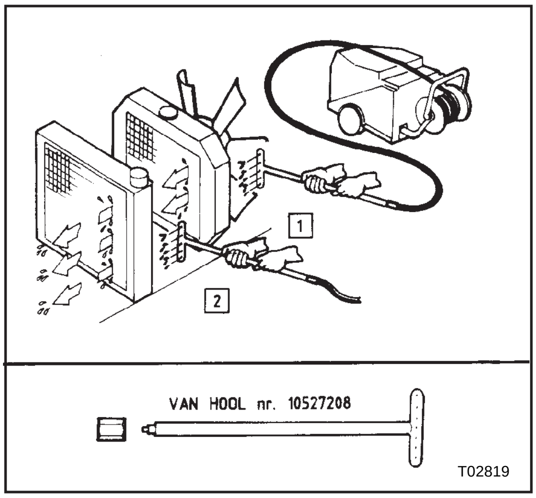

Figure 16 : Cleaning radiator and charge-air cooler

4. To clean the radiator:

   Insert the spraylance (with the holes towards the radiator, this means to the front of the coach) into the slots (covered by a rubber strip) of the fan shroud. Move the lance back and forth, parallel to the core surface.

5. Remove the dirt between radiator and charge-air cooler.

6. To clean the charge-air cooler:

   a. Insert the spraylance (with the holes towards the charge-air cooler, this means to the front of the coach) into the gap between radiator and charge-air cooler.

   b. Hold the tool flat against the front of the radiator and open the pressure supply.

!!!CAUTION!!!
IF THE CLEANING TOOL IS NOT FLAT AGAINST THE RADIATOR SURFACE WHEN YOU OPEN THE PRESSURE SUPPLY, THE REACTION FORCE OF THE PRESSURE JETS WILL MAKE THE TOOL LASH BACKWARD AND THE RADIATOR WILL BE DAMAGED.

   c. Move the lance, flat against the radiator, back and forth parallel to the core surface.

Repeat step 6 with the holes of the spraylance towards the radiator. Make sure that the tool is flat against the rear of the charge-air cooler before you open the pressure supply. Move the lance, flat against the charge-air cooler, back and forth to the core surface.

Dry dust can easily be removed with compressed air of approx. 115 psi pressure. If the core is clogged with tenacious dirt, the air passages will have to be cleared out with a detergent such as P3-Grato 12 (by HENKEL). The cleaning procedure using P3-Grato 12 is as follows:

1. Mix a quantity of P3-Grato 12 with an equal volume of hot water.
2. Using the T-headed spraylance, inject detergent solution between the cooling fins at high pressure (DO NOT exceed 1400 psi).
3. Allow 5 minutes for the detergent to loosen the deposits.
4. With the T-headed spraylance, flush the matrix with plain water under high pressure to remove the dirt.

Repeat the operation until air passages are open.

According to its manufacturer, P3-Grato 12 detergent contains no corrosive nor toxic ingredients.

!!! CAUTION !!!
DANGER TO BEND COOLING FINS IF CLEANING PRESSURE IS TOO HIGH.

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PIPING ACCESSORIES

To check hoses

Inspect all hoses for cracks, cuts and collapsing. Replace if necessary.

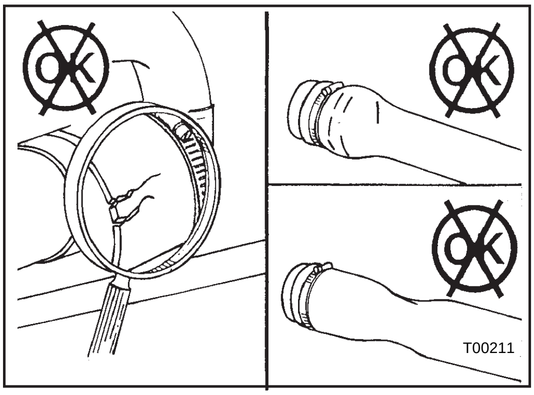

Figure 17 : To check hoses

To check fluid lines for leaks

In the cold season, regularly check the coolant lines for leakage. This check is to be performed with the electric circulating pump(s) running and coolant at operating temperature.
If necessary, retighten hose clamps.

Tighten the *standard* hose clamps to a torque of 2.6 to 3.3 ft.lbf for hoses with an O.D. between 0.75 and 1.4 inch; 2.95 to 3.7 ft.lbf for hoses with an O.D. between 1.5 and 3.1 inch.

Most hose clamps, used on the heating and cooling systems are of the "constant torque" type. They are worm driven, and provided with a series of spring washers. They feature an extended integral liner that covers the band slots, protecting the silicone hoses from damage. The liner also helps maintaining a consistent sealing pressure. The constant torque hose clamp is designed to automatically adjust its diameter to compensate for the normal expansion and contraction of hose and piping during vehicle

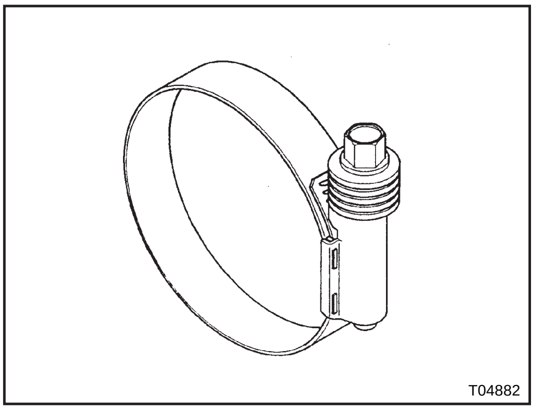

Figure 18: Constant torque hose clamp

operation and shutdown. Coolant losses are virtually eliminated and clamp maintenance is greatly minimized.

Use a torque wrench for proper installation. The recommended torque for hose clamps type A (9/16" wide and four spring washers) is 40 to 70 in.lbf. Hose clamps type B (5/8" wide and five spring washers) should be torqued with 90 to 125 in.lbf. The spring washer stack should be nearly collapsed flat. The screw tip of the hose clamps type A should extend 7/32" in beyond the housing when properly torqued. The screw tip of hose clamps type B should extend 1/4" beyond the housing.

Since the constant torque clamp is self-adjusting to keep a consistent

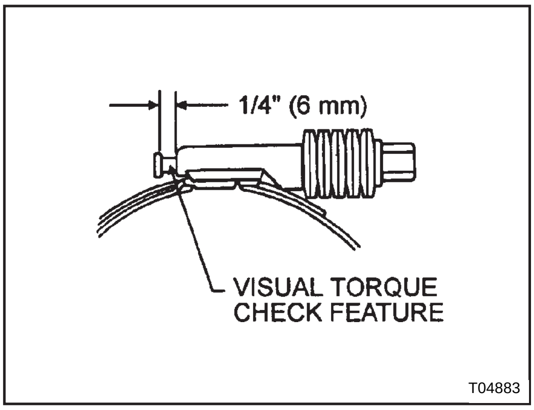

Figure 19: Visual torque check feature on constant torque hose clamps (B type clamp)

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sealing pressure, there is no need to retorque the hose clamp on a regular basis. When the tip of the screw is extending out of the housing, by the correct amount, the clamp is properly installed and maintains a leak proof connection. Proper torque installation should be checked at room temperature.

!!! CAUTION !!!
THE HOSE CLAMP WILL BREAK IF OVERTORQUED. DO NOT OVERTIGHTEN, ESPECIALLY DURING COLD WEATHER WHEN THE HOSE HAS CONTRACTED.

THERMOSTAT

The thermostat and thermostat seal must operate properly so as to have the engine running in the most efficient heat range. Overheating and overcooling will shorten engine life.

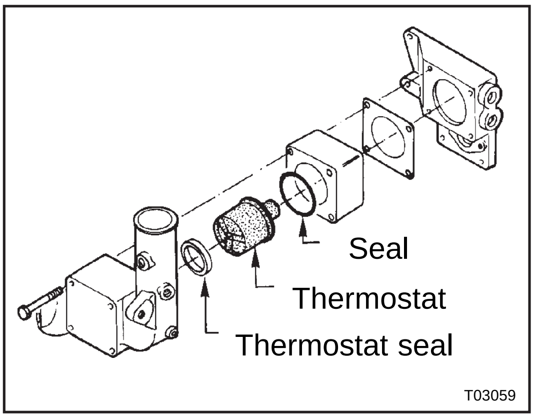

Figure 20 : Thermostat housing

To test thermostat "in-chassis"

!!! CAUTION !!!
COMPLETE THIS TEST WITH THE ENGINE COOLANT TEMPERATURE BELOW 120 °F. HOT STEAM CAN CAUSE SERIOUS PERSONAL INJURY.

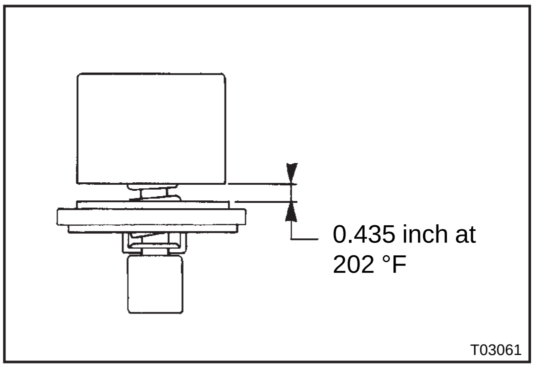

Figure 21 : Thermostat fully open distance

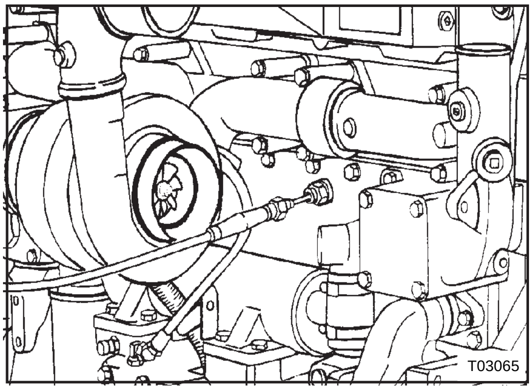

Figure 22 : Temperature gauge in water header plate

1. Remove the radiator hose from the thermostat housing.
2. Install a temperature gauge which is known to be accurate in the water header plate or engine side of the thermostat housing (see Figure 22).
3. Install a hose of the same size on the thermostat housing outlet long enough to reach a remote dry container used to collect coolant.
4. Install and tighten the hose clamp on the housing outlet.
5. Place the other end of the hose in a dry container.
6. Operate the engine at rated RPM for one minute.
7. Shut off the engine and measure the amount of coolant collected in the

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container. The amount of coolant collected must not exceed 3.3 fl. ounces.

8. If over 3.3 fl. ounces of coolant is collected, the thermostat or thermostat seal is leaking and must be replaced.

9. Complete the following test in-chassis to test the thermostat opening temperature.

   a. Start the engine and monitor the water temperature gauge and the container. The thermostat initial opening temperature is 178 to 182°F.

   b. Shut off the engine when the coolant starts to flow.

   c. If coolant does not start flowing into the container during the initial temperature range, the thermostat must be replaced.

To remove thermostat

1. Drain the cooling system.
2. Remove all hoses from thermostat housing.
3. Remove the four thermostat housing mounting capscrews and the thermostat housing.
4. Remove the thermostat from the housing.

To inspect thermostat

1. Visually inspect the thermostat for damage.
2. Suspend the thermostat and a 212 °F thermometer in a container of water.

NOTE
DO NOT ALLOW THE THERMOSTAT OR THERMOMETER TO TOUCH THE CONTAINER.

3. Heat the water and check the thermostat as follows (nominal operating temperature is stamped on the thermostat):
   - Thermostat must begin to open within 2 °F of nominal temperature;
   - Thermostat must be fully open within 22 °F of nominal temperature.

   The fully open distance between the thermostat flange and housing is 0.435 inch.

   If the thermostat operates properly and over 3.3 fl. ounces of leakage is detected during in-chassis test, replace the thermostat seal.

To remove thermostat seal

!!! CAUTION !!!
DO NOT DAMAGE THE THERMOSTAT HOUSING WHEN REMOVING THE THERMOSTAT SEAL.

Use a punch and hammer to remove the seal from the housing.

To clean and inspect thermostat housing

Use solvent to clean the thermostat housing. Dry with compressed air. Visually inspect the thermostat housing for cracks, pitting or other damage.

To install thermostat seal

When installing a new seal, the flat side of the seal must be facing the mandrel. Use thermostat seal mandrel, Cummins Part No. ST-1225, and a hammer to install the seal.

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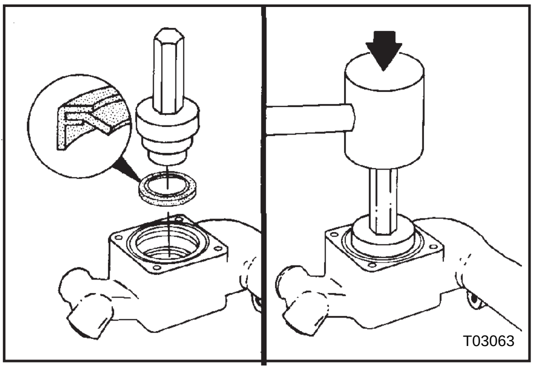

Figure 23 : To install thermostat seal

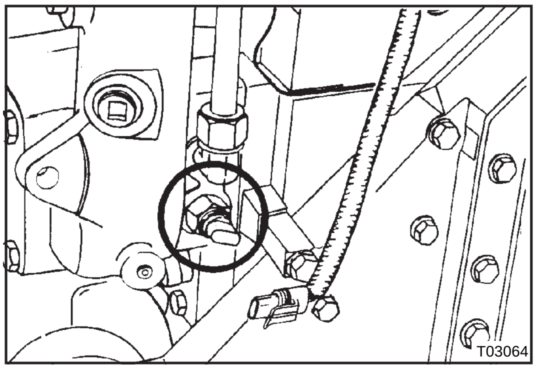

Figure 24 : Engine coolant temperature sensor of ISM system

To install thermostat

1. Install the thermostat in the housing.
2. Install a new seal on the thermostat housing mounting surface.
3. Install the thermostat housing and four mounting capscrews.
   Torque value: 40 ft. lbf.
4. Connect the water hoses to the thermostat housing. Tighten all hose clamps.
   Torque value: 30 in. lbf.

ENGINE COOLANT TEMPERATURE SENSOR OF ISM SYSTEM

The coolant temperature sensor of the ISM system sends coolant temperature data to the ECM to adjust injection timing for emissions reduction. The sensor is also used for the engine protection system. The sensor is located in front of the engine at the rocker lever housing.

1. Disconnect the sensor from the sensor wiring harness.
2. Use a VOM to measure the resistance between the two terminals of the coolant temperature sensor. The resistance must be from 175 ohms to 244 ohms* (refer to table below). If the resistance is not correct, replace the coolant temperature sensor. If the resistance is correct, the sensor must still be checked for a short to ground.
3. Measure the resistance from one of the pins of the coolant temperature sensor to the engine block. The VOM must show an open circuit (more than 100 K ohms). If the circuit is not open, replace the coolant temperature sensor.
4. To replace the coolant temperature sensor of the ISM system:

   a. Drain the cooling system before removing the sensor.

* The resistance value is inversely proportional to the temperature as follows:

Temp °F	Acceptable Resistance Range
32	30 K to 36 K ohms
77	9 K to 11 K ohms
122	3 K to 4 K ohms
167	1 350 to 1 500 ohms
212	600 to 675 ohms

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b. Lift up on the locking tab and pull the electrical connector apart. Remove the sensor from the engine.

c. Install the new sensor in the engine. Tighten the sensor to 25 ft.lbf. Make sure the new sensor has an O-ring.

d. Push the connectors together until they lock.

e. Fill the cooling system and check for leaks.

SENSOR OF COOLANT TEMPERATURE GAUGE ON INSTRUMENT PANEL

The temperature sending unit is threaded in the engine cylinder block. It combines a temperature switch with a temperature sensor in a sealed metal housing. Note that the temperature switch is not connected on your coach. The sensor sends a temperature dependent signal to the coolant temperature gauge located on the instrument panel. If a faulty temperature sensor is suspected, measure resistance as follows.

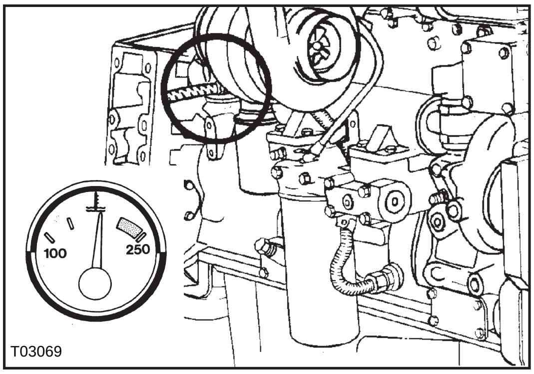

Figure 25: Location of temperature sending unit

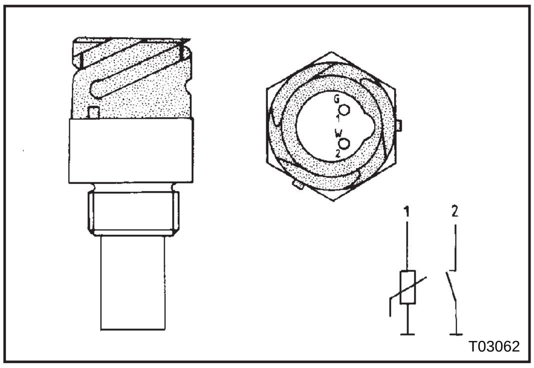

Figure 26 : Temperature sending unit

Temp °F	Acceptable Resistance Range
68 140 212	624 to 772 ohms 132 to 156 ohms 36,6 to 42,6 ohms

1. Disconnect the temperature sending unit from its wiring harness.

2. Use a VOM to measure the resistance between terminal 1 and the engine block. The resistance value is temperature dependent (see table above). If the resistance is not correct, replace the temperature sending unit.

NOTE
DO NOT USE A THREAD SEALER WHEN INSTALLING SENDING UNIT. THE SEALER MAY INSULATE THE UNIT FROM THE ENGINE CYLINDER BLOCK.

LOW COOLANT LEVEL SENSOR

This device provides a warning when coolant level is too low. It is an electronic switch which operates on the electrostatic or capacitance sensing principle. The probe of the component extends into the liquid and produces a change in electrical capacitance, when liquid displaces the air in the immediate

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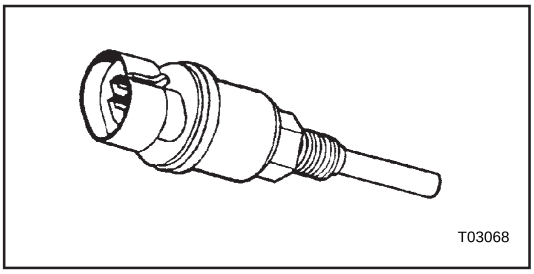

Figure 27 : Low coolant level sensor screwed in surge tank

surroundings of the probe. The change is converted within the component into an on/off solid-state switch closure and indicates the absence or presence of liquid. The probe is electrically insulated providing a slick, non-fouling surface as well as good electrical characteristics to prevent electric current from flowing through the liquid.

TO CHECK SURGE TANK CAPS

Visually inspect the rubber seal of the caps for damage. Visually inspect the surge tank filler neck for cracks or other damage. Pressure test the surge tank caps. Renew the cap, if the maximum pressure attained is outside the specified limit.

Filler cap test limit: 13.3 to 17.4 psi.
Pressure relief cap test limit: 8.7 to 10.1 psi.

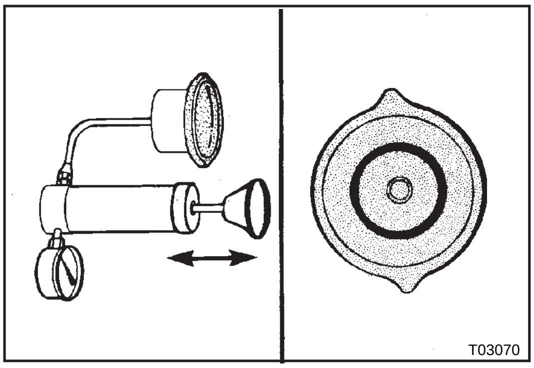

Figure 28 : Pressure test surge tank caps

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TROUBLESHOOTING

COOLANT LOSS - EXTERNAL

Cause	Correction
Coolant level is above specifications.	Check coolant level.
OK ↓	
Surge tank caps incorrect or malfunctioning.	Check the surge pressure caps.
OK ↓	
Contact a Van Hool Authorized repair facility.	

COOLANT TEMPERATURE ABOVE NORMAL - GRADUAL OVERHEAT

Cause	Correction
Coolant level is below specifications.	Inspect the engine and radiator for external coolant leaks. Add coolant.
OK ↓	
Charge-air cooler fins or radiator fins damaged, or obstructed with debris.	Inspect charge-air cooler and radiator fins. Clean if necessary.
OK ↓	
Radiator hose is collapsed, restricted or leaking.	Inspect hoses.
OK ↓	
Fan drive belt loose.	Check belt tension and tighten if necessary.
OK ↓	
Cooling fan shroud damaged or missing.	Inspect shroud and repair, replace or install.
OK ↓	
Surge tank cap incorrect or malfunctioning. Cap rated pressure too low.	Check surge tank pressure relief cap.
OK ↓	
Overconcentration of antifreeze and/or supplemental coolant additives.	Check the SCA level. Verify the antifreeze concentration.
OK ↓	
Contact a Van Hool Authorized repair facility.	

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COOLANT TEMPERATURE ABOVE NORMAL - SUDDEN OVERHEAT

Cause	Correction
Electronic fault codes active	Refer to Operator's Guide Book for instructions to read active fault codes. If fault codes are active, contact a Van Hool authorized repair location.
OK ↓	
Fan drive belt broken.	Replace belt.
OK ↓	
Coolant level low.	Inspect for external leaks on engine and radiator and make repairs. Add coolant.
OK ↓	
Contact a Van Hool Authorized repair facility.	

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COOLANT TEMPERATURE BELOW NORMAL

Cause	Correction
Eelctronic fault codes active - coolant temperature sensor.	Refer to Operator's Guide Book for instructions to read active fault codes. If fault codes are active, contact a Van Hool authorized repair location.
OK ↓	
Continuously operating in low ambient temperature.	Refer to Cummins Cold Weather Operation, bulletin no. 3387266.
OK ↓	
Temperature gauge and/or sensor malfunctioning.	Test the gauge and the sensor. Repair or replace if necessary.
OK ↓	
Contact a Van Hool Authorized repair facility.	

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DETROIT DIESEL ENGINE COOLING SYSTEM

DESCRIPTION

Engine is cooled by liquid circulated within a pressurized system. Cooling system components include engine water pump, radiator, fan, thermostats and surge tank.

Coolant temperature is controlled by two thermostats. With a cold engine the thermostats are closed and prevent water from circulating through the radiator. Instead, the coolant passes through a by-pass where it is recirculated through cylinder block, cylinder head, engine oil cooler and transmission oil cooler.

When coolant reaches opening temperature of thermostats, coolant begins to flow through radiator. The surge tank above the radiator is equipped with a filler cap and a pressure relief cap. The filler cap also incorporates a pressure relief valve (in case pressure relief cap fails).

The engine protection system activates when the coolant temperature reaches a critical temperature which is set at the factory. The "CHECK ENGINE" light on the instrument panel will illuminate. If the temperature continues to rise and an upper critical limit is reached, the "STOP ENGINE" light will illuminate and the 30 second shutdown sequence will begin. An engine coolant temperature gauge is mounted on the dashboard.

SPECIFICATIONS

ENGINE COOLING AND HEATING SYSTEM CAPACITY ..... approx. 26 U.S.Gallons

COOLANT...... POWERCOOL+WATER

THERMOSTATS

- Number used 2
- Make .... Detroit Diesel
- Start to open at .... 186-193°F
- Fully open .... 0.375 inch at 207°F

SURGE TANK

- **Pressure relief cap**
  Pressure valve
  opens at ....8.7 psi overpressure
  Vacuum valve opens
  at ... 0.29 to 1.16 psi below atmospheric pressure
- **Filler cap**
  Pressure valve
  opens at ....14.5 psi overpressure

MAINTENANCE

HEATING SYSTEM ISOLATING VALVES

If necessary, two isolating valves in heating system pipes can be closed to completely separate the heating system from the engine cooling system.

There is no objection against the coach being driven in this condition, but the heating system or combustion heater should on no account be switched on with the isolating valves closed.

See Operator's Guide Book for location of isolating valves.

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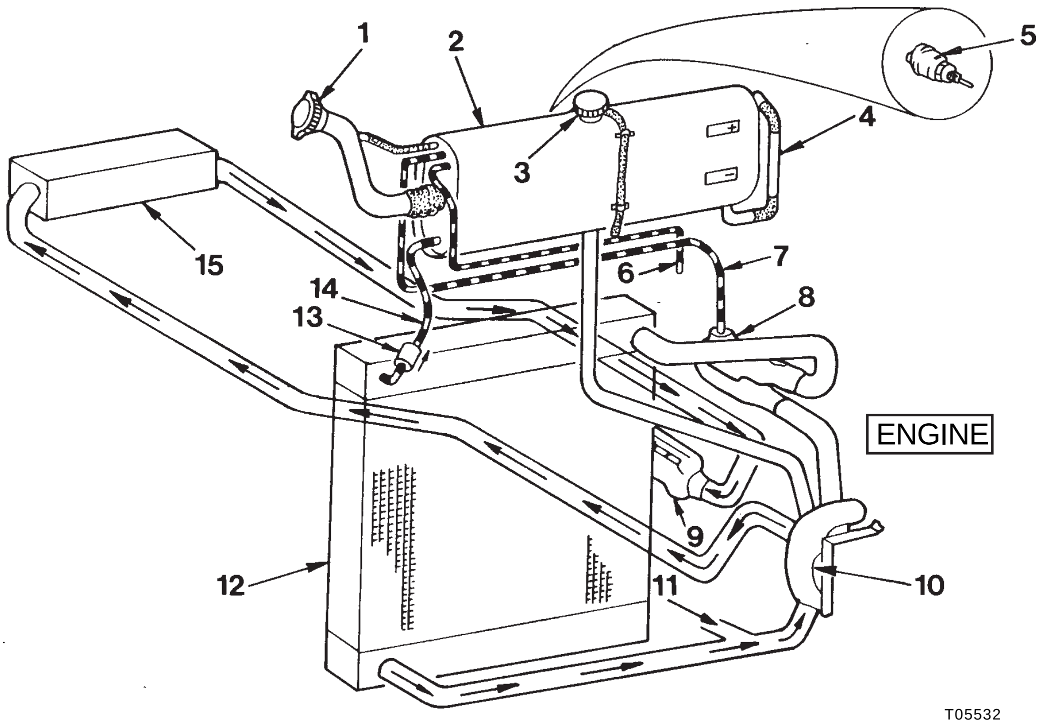

1. Filler cap
2. Surge tank
3. Pressure relief cap
4. Coolant level gauge glass
5. Low coolant level sensor
6. Engine deaeration line
7. Thermostat housing deaeration line
8. Thermostat housing
9. Engine oil cooler
10. Engine water pump
11. Heating system return
12. Radiator
13. Check valve
14. Radiator deaeration line
15. Transmission oil cooler

Figure 1: Engine cooling system diagram. Arrows indicate direction of coolant flow when thermostats are fully open.

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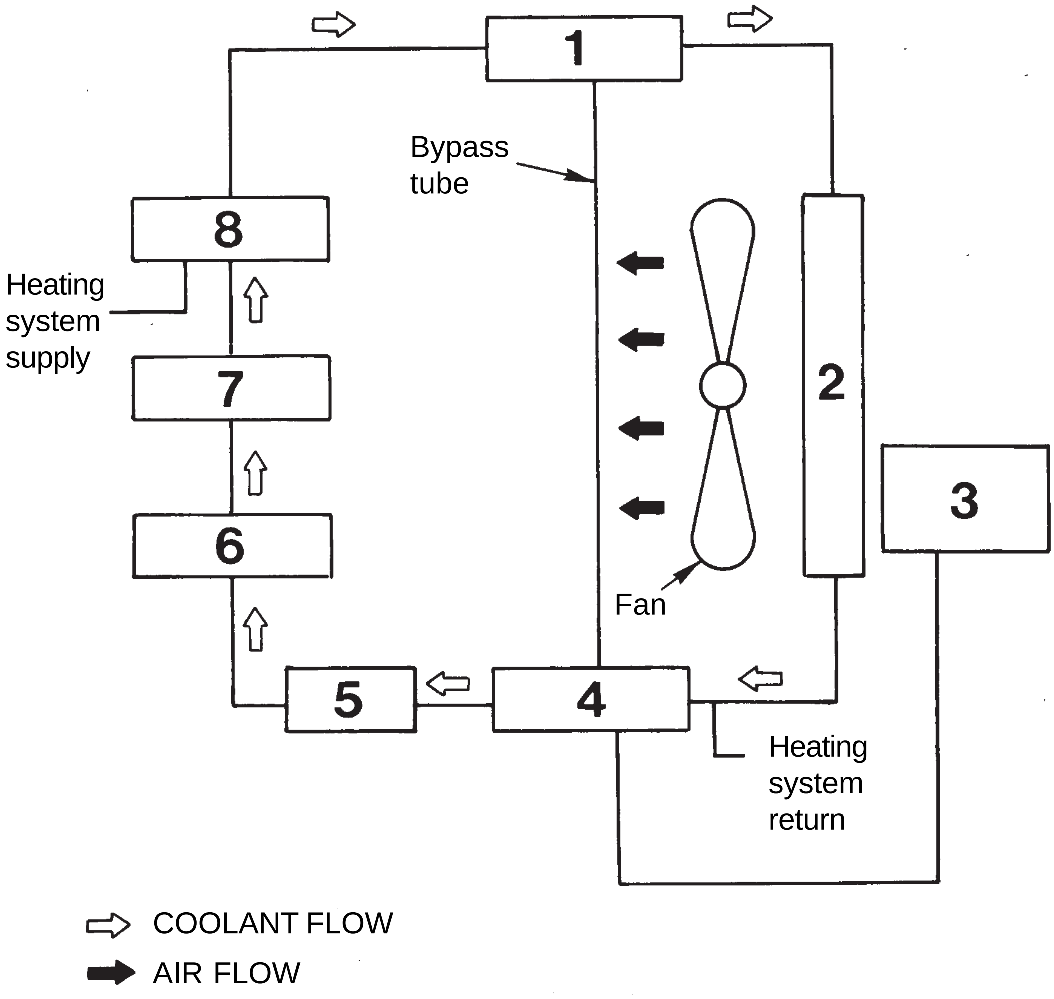

1. Thermostat housing
2. Radiator
3. Surge tank
4. Water pump
5. Transmission oil cooler
6. Engine oil cooler
7. Engine cylinder block
8. Engine cylinder head

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Figure 2: Coolant flow through cooling system with fully open thermostats

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TO CHECK COOLANT LEVEL

!!! CAUTION !!!
NEVER REMOVE SURGE TANK FILLER CAP WHEN COOLANT TEMPERATURE IS ABOVE 120 °F. COOLANT AND STEAM MAY BE BLOWN OUT, POSSIBLY CAUSING PERSONAL INJURY.
IF FILLER CAP MUST BE OPENED WHILE THE ENGINE IS HOT, TURN IT CAREFULLY TO THE LEFT UNTIL FIRST STOP AND LET PRESSURE ESCAPE. THEN TURN TO SECOND STOP AND REMOVE CAP.
NEVER ADD COLD COOLANT WHEN ENGINE IS OVERHEATED DUE TO LACK OF COOLANT. CRACKS IN CYLINDER BLOCK MAY BE THE RESULT. ALLOW THE ENGINE TO COOL TO BELOW 120°F BEFORE ADDING COOLANT.

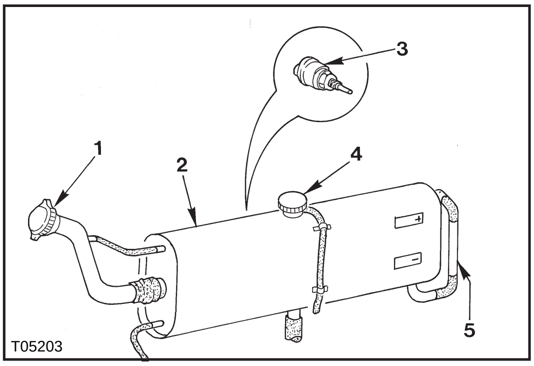

Figure 3 : Surge tank

1. **Filler cap**
2. **Surge tank**
3. **Low coolant level sensor**
4. **Pressure relief cap**
5. **Gauge glass**

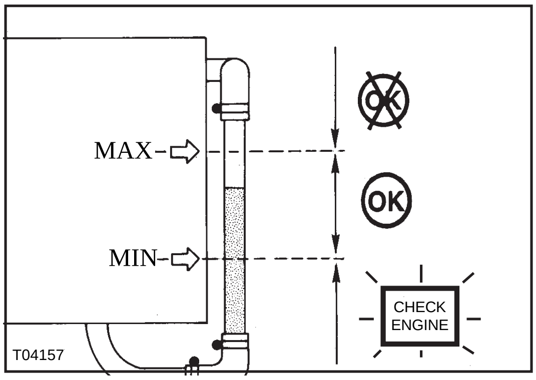

Figure 4 : Coolant level

With cold engine, check whether coolant level is between the "MIN" and "MAX" indicators on the surge tank. As necessary, fill the system until the coolant level is to the "MAX" indicator using water mixed with "Power Cool" (= fully formulated, inhibited ethylene glycol based antifreeze). Do not add plain water, as this will cause the antifreeze/SCA (supplemental coolant additives) solution to become diluted, causing a reduction of the frost and corrosion protection prevention properties.

COOLANT

The coolant in the Detroit Diesel engine cooling system should be a proper mixture of water and "Power Cool" (= fully formulated, inhibited ethylene glycol based antifreeze).

Water

Water is the best practical medium for heat transfer. However, water alone can cause corrosion and inherently contains minerals that can produce scale deposits on internal cooling system surfaces.

Chlorides, sulfates, magnesium and calcium dissolved in water can cause scale deposits, sludge deposits and/or corrosion.

Maximum allowable limits for minerals in water		
	Parts per million	Grains per gallon
•Chlorides	40	2.5
•Sulfates	100	5.8
•Total dissolved solids	340	20
•Total hardness magnesium &calcium	170	10

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Distilled and de-ionized water is preferred to minimize the adverse effects for minerals in water. The maximum allowable limits for minerals in water are given in the table above.

Antifreeze

Use genuine Detroit Diesel "Power Cool".

Antifreeze must be used in any climate for both freeze and boiling point protection. Detroit Diesel recommend a 50 percent "Power Cool" antifreeze / water solution in most climates. Concentrations over 67 percent are not recommended because of the poor heat transfer, reduced freeze protection and possible silicate dropout. A concentration below 33 percent offers little freeze or corrosion protection and is not recommended.

Supplemental Coolant Additives (SCA)

Nitrite concentration is an indication of the SCA concentration in the coolant. Coolant test kits and test strips are available from authorized Detroit Diesel service outlets. The nitrite concentration of the coolant must be tested with a "PowerTrac 3-way Test Strip" at the intervals shown in the Maintenance Schedule. SCA levels must be within the ranges shown in the table.

SCA concentration limitations		
	Minimum PPM	Maximum PPM
Boron (B)	125	500
Nitrite (NO_2)	800	2,400
Nitrates (NO_3)	200	750
Silicon (Si)	50	250
Phosphorous (P)	0	0
pH	8.0	10.5

Maintenance dosage of SCA must only be added if nitrite concentration is less than 800 PPM. If nitrite concentration is higher than 800 PPM, do not add additional SCA. NALCOOL® 3000 is the recommended SCA for all Detroit Diesel engines.

TO DRAIN/FILL ENGINE COOLING AND HEATING SYSTEM

To drain

1. Make sure all hand isolating valves are open.
2. Remove surge tank filler cap.
3. Unscrew drain plugs. Drain plugs (cocks) are provided on cooling radiator and main coolant pipes. Remove the drain screw at the bottom of the thermostat housing to drain the coolant trapped above the thermostats.
4. Toward end of draining open all

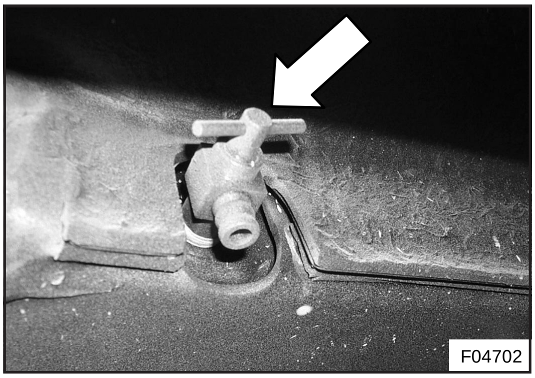

Figure 5: Drain cock on cooling radiator

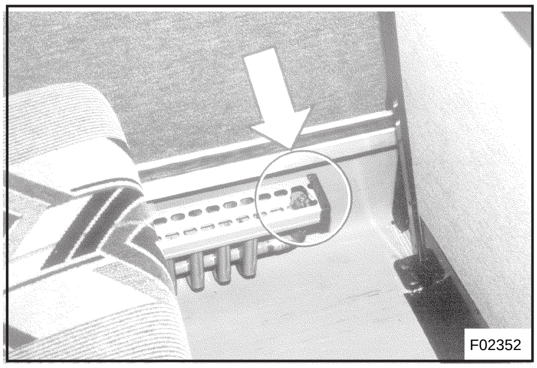

Figure 6: Floor heater bleed screw

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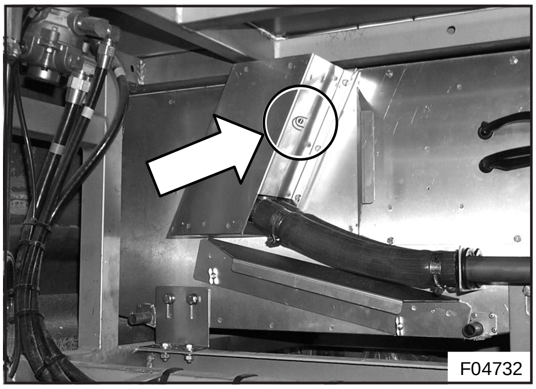

Figure 7: Bleed screw of the driver's defroster/heater (located behind a protection cover, accessible via the frontmost left exterior access door)

bleed screws (on driver's defroster/ heater unit and floor heaters).

NOTE
DISPOSE OF USED ANTIFREEZE AND COOLANT IN ACCORDANCE WITH FEDERAL, STATE, AND LOCAL ENVIRONMENTAL REGULATIONS.

To clean

1. Refill the cooling system with clean, soft water and a good cooling system cleaning compound, such as Nalprep®. If the engine is warm, fill slowly to prevent the rapid cooling and distortion of the metal castings.
2. Start the engine and operate it for fifteen minutes to circulate the solution thoroughly.
3. Stop the engine and allow it to cool.
4. With the engine cool, drain the cooling system completely.
5. Refill the cooling system with clean, soft water and operate it for fifteen minutes.
6. Stop the engine and allow it to cool.
7. With the engine cool, drain the cleaner residue from the cooling system.

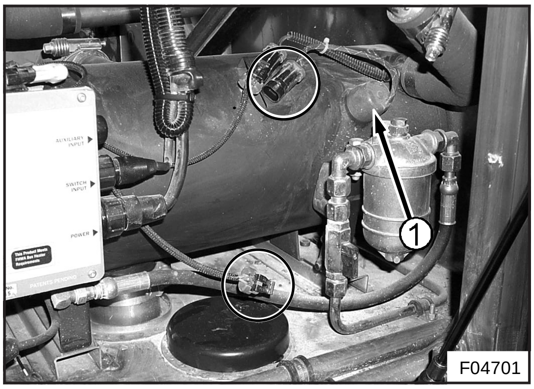

Figure 8: Combustion heater overheat breaker (1) wire connector

To fill

1. Reinstall all drain plugs. Close all drain cocks and bleed screws.
2. Follow correct order for mixing coolant. This will prevent additive dropout during mixing process.
   a. Pour 14 gallons of water into a container.
   b. Add 14 gallons of "Power Cool".
   c. Blend the components thoroughly.
3. Install a new "Nalcool Need Release" coolant filter. The "Nalcool Need Release" coolant filter contains a membrane which releases SCAs before the coolant approaches a corrosive condition.
4. To prevent combustion heater operation, disconnect wire of combustion heater overheat breaker (see Figure 8).
5. Slowly fill surge tank with coolant until it flows out of filling tube.
6. Bleed engine cooling circuit:
   a. Close both heating system isolating valves.
   b. Start engine and run at fast idle.

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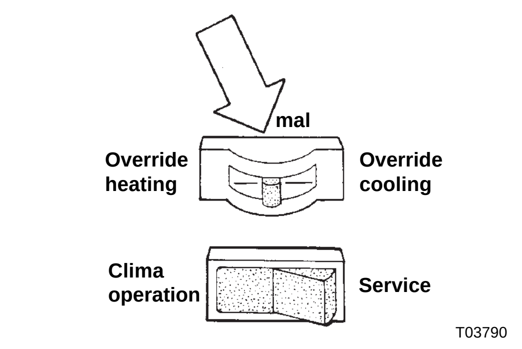

Figure 9 : Climate control override (in HVAC junction box)

c. Add coolant continuously to keep surge tank topped up.

d. Open both heating system isolating valves.

7. Bleed defroster/heater circuit:

a. Turn defroster/heater rotary knob on dashboard fully clockwise.

b. Open air bleed screw of defroster/heater unit until air-free coolant comes out.

c. Turn defroster/heater rotary knob on dashboard fully counterclockwise.

8. Bleed passenger's compartment heating circuit:

a. Set climate control switch to "ON" position.

b. Switch override switch to "OVERRIDE HEATING" position (Figure 9).

c. Continuously add coolant to keep surge tank topped up.

d. Open air bleed screws of floor heaters one by one until air-free coolant comes out.

9. Top up surge tank and reinstall filler cap. Reconnect combustion heater overheat breaker.

10. Drive coach until engine reaches operating temperature. Stop engine, allow to cool down and recheck coolant level.

11. Switch HVAC-override switch (Figure 9) back to "NORMAL" position.

TO CHECK SUPPLEMENTAL COOLANT ADDITIVES (SCA) LEVEL

SCAs become depleted through normal operation and additional SCAs must be added to the coolant as required to maintain original strength levels.

NOTE
OVERINHIBITING WITH SUPPLEMENTAL COOLANT ADDITIVES CAN CAUSE ADDITIVE DROPOUT.

Initial fill

Powercool already contains the required SCAs. Overconcentration will result if SCAs are added to the coolant at the time of the initial fill.

Maintenance

The coolant must be tested for required SCAs at the interval given in the Maintenance Schedule. Additional SCAs must be added to the coolant when the nitrite concentration is less than 800ppm. If the nitrite concentration is greater than 800ppm, do not add SCAs. Maintenance dosage of SCA is added by replacing the "Nalcool Need Release" coolant filter.

TO CHANGE COOLANT FILTER

The coolant filter must be replaced when the nitrite concentration is less than 800ppm (see previous heading).

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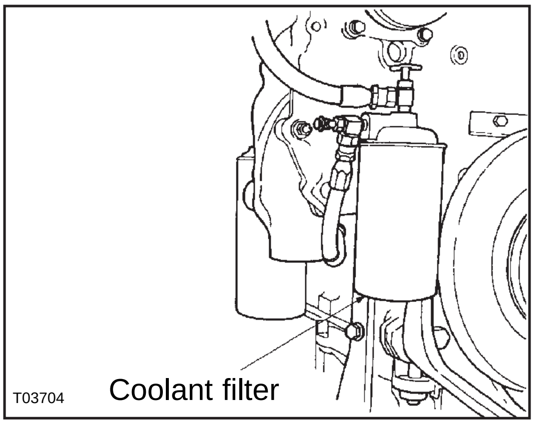

Figure 10: Coolant filter

Procedure:

1. Close the two shutoff cocks at the filter mounting head.
2. Remove and discard the filter.
3. Clean the filter adapter with a clean, lint-free cloth.
4. Coat surface of gasket with oil. Tighten 2/3 to 1 turn after gasket contacts base.
5. Open the two shutoff cocks at filter.
6. Start engine and check for leaks.

TO CHECK/CLEAN RADIATOR AIR INTAKE SCREEN

The body opening through which cooling air to the radiator enters is fitted with a filtering screen of woven metal wire which excludes the larger dirt particles drawn by the fan. In accordance with the nature of the dirt, the screen can be cleaned with a vacuum cleaner, compressed air or a jet of water or steam.

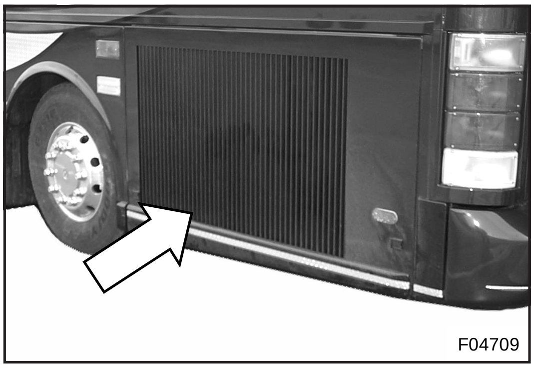

Figure 11: Filter screen upstream of radiator

TO CLEAN EXTERIOR OF RADIATOR AND CHARGE - AIR COOLER

Dirt obstructing the air passage through the radiator core reduces engine cooling capacity. This can cause engine overheating and consequent damage to the engine (e.g. piston seizure). The charge-air will be insufficiently cooled due to a clogged charge-air cooler. This causes power loss. To prevent the above occurring, the external cleanliness of radiator and charge-air cooler core must be checked at regular intervals.

VAN HOOL supply a T-headed spraylance (VH N° 10527208) for radiator and charge-air cleaning purposes. This tool can be connected to an air hose or to a high pressure washer.

Cleaning procedure (see Figure 12):

!!! CAUTION !!!
ALWAYS WEAR A DUST MASK WHEN CLEANING WITH COMPRESSED AIR.

1. Open the radiator compartment door.
2. Remove the collected dirt between radiator and charge-air cooler with an air gun.
3. If you have to clean with water, adjust the high-pressure cleaner at 140 to 176 °F and make sure that the pressure does not exceed 1400 psi.

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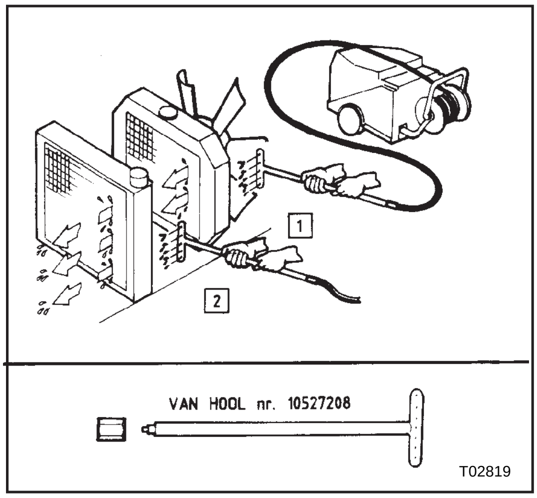

Figure 12 : Cleaning radiator and charge-air cooler

4. To clean the radiator:

   Insert the spraylance (with the holes towards the radiator, this means to the front of the coach) into the slots (covered by a rubber strip) of the fan shroud. Move the lance back and forth, parallel to the core surface.

5. Remove the dirt between radiator and charge-air cooler.

6. To clean the charge-air cooler:

   a. Insert the spraylance (with the holes towards the charge-air cooler, this means to the front of the coach) into the gap between radiator and charge-air cooler.

   b. Hold the tool flat against the front of the radiator and open the pressure supply.

!!!CAUTION!!!

IF THE CLEANING TOOL IS NOT FLAT AGAINST THE RADIATOR SURFACE WHEN YOU OPEN THE PRESSURE SUPPLY, THE REACTION FORCE OF THE PRESSURE JETS WILL MAKE THE TOOL LASH BACKWARD AND THE RADIATOR WILL BE DAMAGED.

   c. Move the lance, flat against the radiator, back and forth parallel to the core surface.

Repeat step 6 with the holes of the spraylance towards the radiator. Make sure that the tool is flat against the rear of the charge-air cooler before you open the pressure supply. Move the lance, flat against the charge-air cooler, back and forth to the core surface.

Dry dust can easily be removed with compressed air of approx. 115 psi pressure. If the core is clogged with tenacious dirt, the air passages will have to be cleared out with a detergent such as P3-Grato 12 (by HENKEL). The cleaning procedure using P3-grato 12 is as follows:

1. Mix a quantity of P3-Grato 12 with a similar volume of hot water.
2. Using the T-headed spraylance, inject detergent solution between the cooling fins at high pressure (DO NOT exceed 1400 psi).
3. Allow 5 minutes for the detergent to loosen the deposits.
4. With the T-headed spraylance, flush the matrix with plain water under high pressure to remove the dirt.

Repeat the operation until air passages are open.

According to its manufacturer, P3-Grato 12 detergent contains no corrosive nor toxic ingredients.

!!! CAUTION !!!

DANGER TO BEND COOLING FINS IF CLEANING PRESSURE IS TOO HIGH.

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PIPING ACCESSORIES

To check hoses

Inspect all hoses for cracks, cuts and collapsing. Replace if necessary.

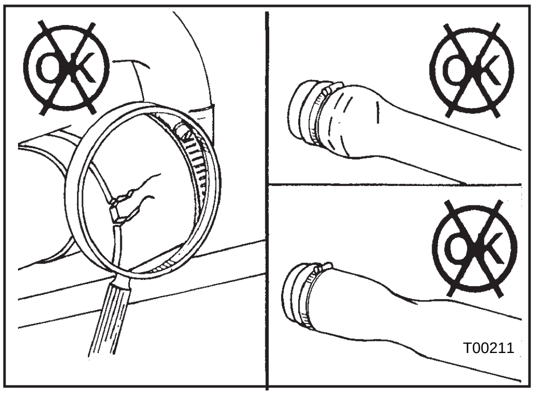

Figure 13 : To check hoses

To check fluid lines for leaks

In the cold season, regularly check the coolant lines for leakage. This check is to be performed with the electric circulating pump(s) running and coolant at operating temperature.
If necessary, retighten hose clamps.

Tighten the *standard* hose clamps to a torque of 2.6 to 3.3 ft.lbf for hoses with an O.D. between 0.75 and 1.4 inch; 2.95 to 3.7 ft.lbf for hoses with an O.D. between 1.5 and 3.1 inch.

Most hose clamps, used on the heating and cooling systems are of the "constant torque" type. They are worm driven, and provided with a series of spring washers. They feature an extended integral liner that covers the band slots, protecting the silicone hoses from damage. The liner also helps maintaining a consistent sealing pressure. The constant torque hose clamp is designed to automatically adjust its diameter to compensate for the normal expansion and contraction

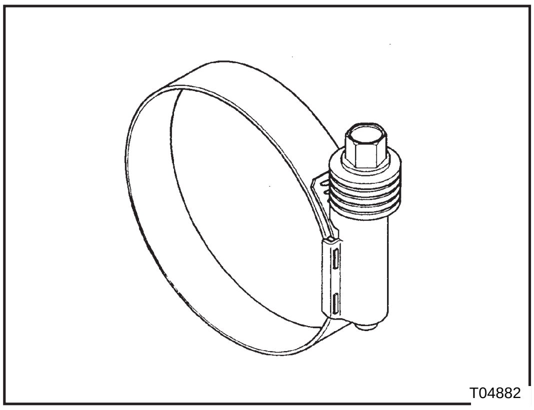

Figure 14: Constant torque hose clamp

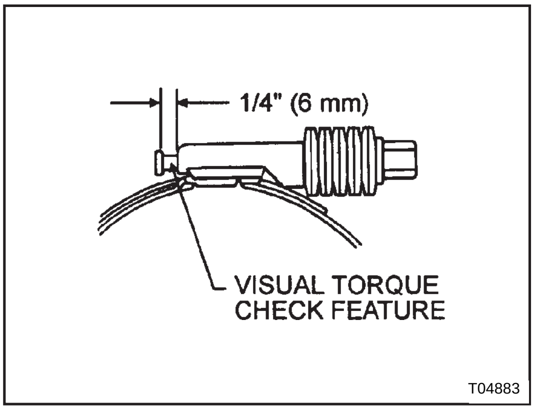

Figure 15: Visual torque check feature on constant torque hose clamps (B type clamp)

of hose and piping during vehicle operation and shutdown. Coolant losses are virtually eliminated and clamp maintenance is greatly minimized.

Use a torque wrench for proper installation. The recommended torque for hose clamps type A (9/16" wide and four spring washers) is 40 to 70 in.lbf. Hose clamps type B (5/8" wide and five spring washers) should be torqued with 90 to 125 in.lbf. The spring washer stack should be nearly collapsed flat. The screw tip of the hose clamps type A should extend 7/32" in beyond the housing when properly torqued. The screw tip of hose clamps type B should extend 1/4" beyond the housing.

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Since the constant torque clamp is self-adjusting to keep a consistent sealing pressure, there is no need to retorque the hose clamp on a regular basis. When the tip of the screw is extending out of the housing, by the correct amount, the clamp is properly installed and maintains a leak proof connection. Proper torque installation should be checked at room temperature.

!!! CAUTION !!!
THE HOSE CLAMP WILL BREAK IF OVERTORQUED. DO NOT OVERTIGHTEN, ESPECIALLY DURING COLD WEATHER WHEN THE HOSE HAS CONTRACTED.

TO TEST THERMOSTATS

Properly operating thermostats are essential for efficient operation of the engine. If the engine operating temperature deviates from the normal range of 186-210°F, remove, inspect and replace the thermostats if necessary.

To remove thermostats

!!! CAUTION !!!
USE EXTREME CARE WHEN REMOVING THE SURGE TANK FILLER CAP. REMOVE THE CAP SLOWLY AFTER THE ENGINE HAS COOLED. THE SUDDEN RELEASE OF PRESSURE FROM A HEATED COOLING SYSTEM CAN RESULT IN PERSONAL INJURY.

1. Slowly open the surge tank filler cap.
2. Remove the drain screw located on the bottom of the thermostat housing.
3. Drain the cooling system so that the coolant is below the thermostat level.

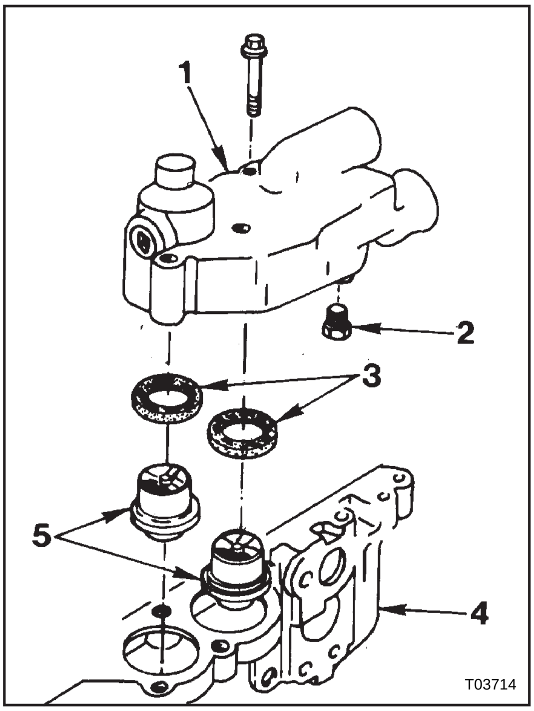

Figure 16: Thermostat housing

1. **Thermostat housing**
2. **Drain screw**
3. **Thermostat housing seals**
4. **Cylinder head**
5. **Thermostats**

4. Loosen the hose clamps on the coolant hoses connected to the thermostat housing.
5. Slide the hoses off the housing.
6. Disconnect the vent line and any other lines which are connected to the thermostat housing.
7. Remove the four thermostat housing-to-cylinder head attaching bolts.
8. Remove the thermostat housing assembly from the engine.
9. Remove the thermostats from the thermostat housing.
10. Remove and discard the thermostat housing seals.

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To inspect thermostats

1. Clean all the parts in clean fuel oil.

!!! CAUTION !!!

TO AVOID PERSONAL INJURY WHEN BLOW DRYING, WEAR ADEQUATE EYE PROTECTION AND DO NOT EXCEED 40 PSI AIR PRESSURE.

2. Dry all parts with compressed air.
3. Inspect all parts for wear or damage. If damaged, replace parts.
4. Inspect thermostat body seal for damage, cracks or nicks. If any damage is noted, replace seal.

To test thermostats

1. Immerse the thermostat in a metal container of water.
2. Place a thermometer in the container using care not to allow the thermometer to touch the bottom or sides of the container.
3. While slowly agitating the water to maintain an even temperature, apply heat to the container. Allow at least 10 minutes for the thermostats to react before determining if the thermostats are opening in the correct temperature range and are fully opened at 207°F.

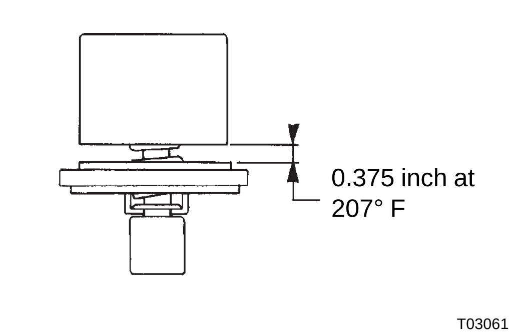

Figure 17: Thermostat fully open distance

!!! CAUTION !!!

USE CAUTION WHEN PERFORMING THIS PROCEDURE. PERSONAL INJURY (SCALDING) MAY RESULT FROM CONTACT WITH HOT LIQUID.

4. As the water is heated, the thermostat should begin to open between 186-193°F. The thermostat is fully open at 207°F.
5. Replace thermostat if it does not operate properly.

To install thermostats

1. Position the new seal onto seal installer (DD Tool No. J 8550), and handle (DD Tool No. J 7079-2) (see Figure 18).
2. Support the thermostat housing on a work bench so that it is level (see Figure 19).
3. Insert the seal driver, with seal installed, into the thermostat housing.
4. Drive the seal into the bore with a hammer, until the installation tool bottoms on the housing (see Figure 20). Rotate the tool during installation to ensure that the seal is installed straight. Remove tools J 7079-2 and J 8550.
5. Repeat step 1 through step 4 for the other seal.
6. Coat the lip of the seals with clean engine oil.
7. Place the thermostats, spring up, into the thermostat housing.
8. Press down on the thermostats to seat them (see Figure 21).
9. Be sure that the machined surface of the thermostat housing, where it

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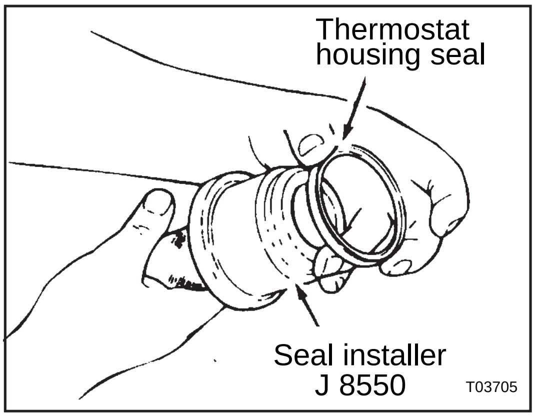

Figure 18: Position the seal onto the seal installer

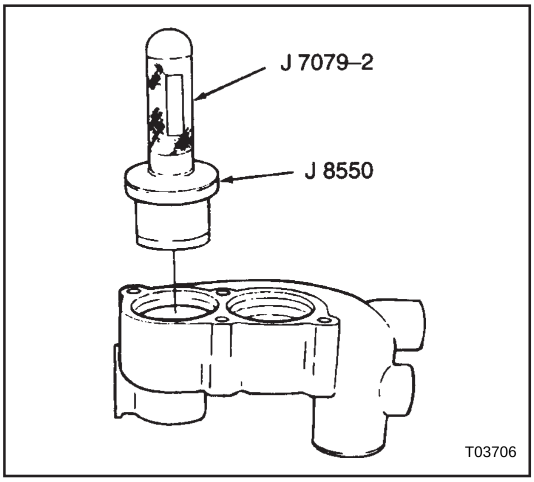

Figure 19: Thermostat housing seal insertion

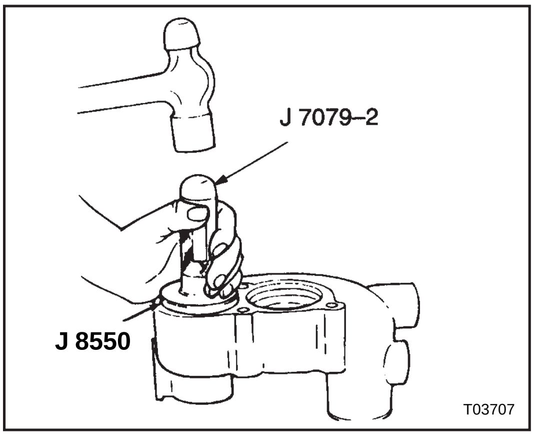

Figure 20: Thermostat housing seal installation

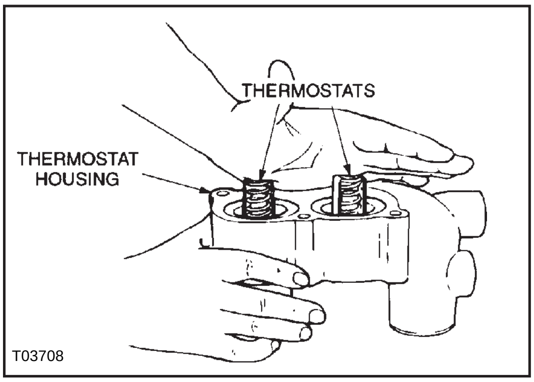

Figure 21: To seat thermostats

contacts the cylinder head, is clean and dry.

10. Install the thermostat housing to the cylinder head with the four attaching bolts. Tighten the bolts to 43-54 ft.lbf.

11. Install the coolant hoses to the thermostat housing. Tighten the hose clamps.

12. Apply a coating of LOCTITE "Pipe Sealer with Teflon" (DD No. J 26558-92) or equivalent to the threads of the drain screw.

13. Install and tighten the drain screw.

14. Install any other components removed for this operation.

15. Install the thermostat housing vent line and any other lines that were removed from the housing.

16. Fill the cooling system.

ENGINE COOLANT TEMPERATURE SENSOR OF DDEC SYSTEM

Refer to Detroit Diesel literature.

SENSOR OF COOLANT TEMPERATURE GAUGE ON INSTRUMENT PANEL

The temperature sending unit is threaded in the engine cylinder head. It combines a temperature switch with a temperature sensor in a sealed metal

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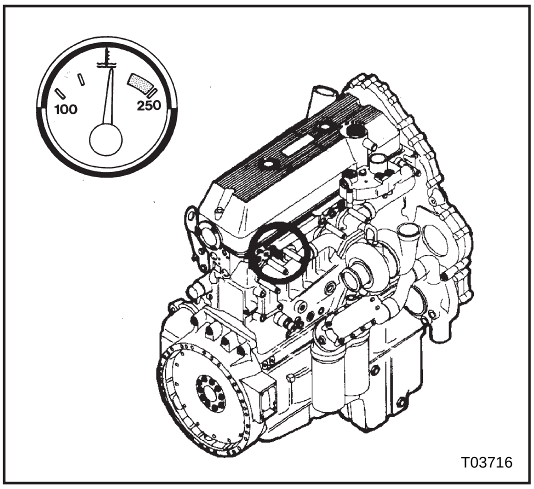

Figure 22: Location of temperature sending unit

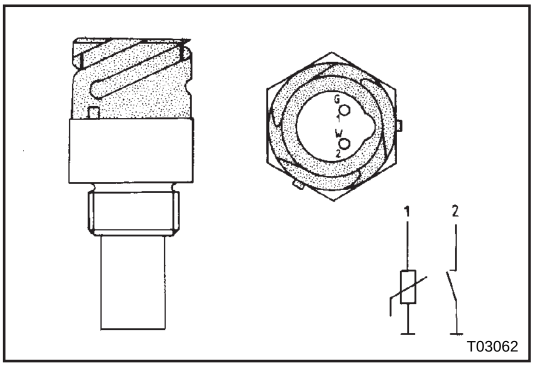

Figure 23: Temperature sending unit

housing. Note that the temperature switch is not connected on your coach. The sensor sends a temperature dependent signal to the coolant temperature gauge on the dashboard.

If a faulty temperature sensor is suspected, measure resistance as follows.

1. Disconnect the temperature sending unit from its wiring harness.
2. Use a VOM to measure the resistance between terminal 1 and the engine block. The resistance value is temperature dependent (see table). If the resistance is not correct, replace the temperature sending unit.

Temp °F	Acceptable Resistance Range
68	624 to 772 ohms
140	132 to 156 ohms
212	36,6 to 42,6 ohms

NOTE
DO NOT USE A THREAD SEALER WHEN INSTALLING SENDING UNIT. THE SEALER MAY INSULATE THE UNIT FROM THE ENGINE CYLINDER HEAD.

LOW COOLANT LEVEL SENSOR

The purpose of the low coolant level sensor is to provide an input to the engine protection system and warn the operator if an unsafe coolant level has been reached.

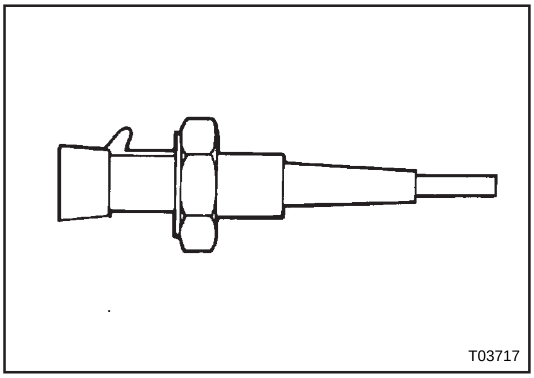

Figure 24: Low coolant level sensor screwed in surge tank

TO CHECK SURGE TANK CAPS

Visually inspect the rubber seal of the caps for damage. Visually inspect the surge tank filler neck for cracks or other damage. Pressure test the surge tank caps. Renew the cap, if the maximum pressure attained is outside the specified limit.

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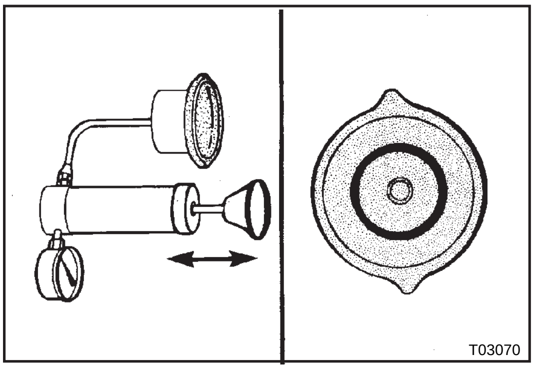

Figure 25: Pressure test surge tank caps

Filler cap test limit: 13.3 to 17.4 psi.
Pressure relief cap test limit: 8.7 to 10.1 psi.

TROUBLESHOOTING

Refer to Detroit Diesel literature.

US0210AH

TRANSMISSION COOLING SYSTEM

DESCRIPTION

The heat generated by the transmission is absorbed by the fluid. The fluid flows through the oil cooler where heat is transferred to engine coolant.

MAINTENANCE

Periodic checks for leaks are the only maintenance required. If transmission fluid is found in the cooling system, the cooler must be removed, tested and repaired. If there are excessive amounts of debris from a damaged transmission oil cooler, it must be replaced.

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COOLING FAN

LINNIG FAN DRIVE (WITH ELECTROMAGNETIC CLUTCH)

COACHES WITH CUMMINS ENGINE

The engagement and disengagement of the fan clutch is controlled by the engine coolant temperature and engine intake manifold air temperature.

When either the engine coolant or intake manifold air temperatures reach a predetermined limit, the engine ECM will provide +0 V to turn the fan on. When both the coolant and intake manifold air temperatures fall below their limit, the engine ECM will provide 24 V to turn the fan off. Since the coolant and intake manifold temperature sensors are required for the fuel control function of the engine; no additional temperature sensors are installed.

- The intake manifold air temperature sensor is mounted on the engine intake manifold.
- The engine coolant temperature sensor is located in front of the engine at the rocker lever housing.

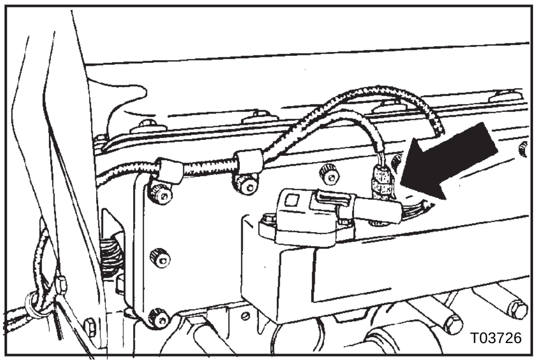

Figure 1: Intake manifold air temperature of Cummins engine fuel system (drawing shows M11+ engine)

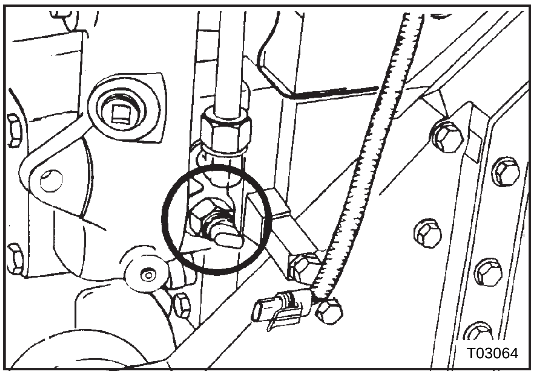

Figure 2: Engine coolant temperature sensor of Cummins engine fuel system

COACHES WITH DETROIT DIESEL ENGINE

Refer to "DETROIT DIESEL SERIES 60 SERVICE MANUAL" for information about fan control.

MAINTENANCE

No special maintenance required.

MECHANICAL LOCKING DEVICE

In case of an electrical power or fan clutch failure, the fan clutch can be mechanically locked as follows:

!!! CAUTION !!!
SET THE OVERRIDE SWITCH IN THE ENGINE COMPARTMENT TO THE "OFF" POSITION TO PREVENT ACCIDENTAL STARTING OF THE ENGINE.

1. Set the starter override switch in the engine compartment to the "off" position to prevent accidental starting of the engine.

2. Loosen the locking nuts of the two screws (wrench size: 13 mm) located at the front of the fan clutch (see Figure 3).

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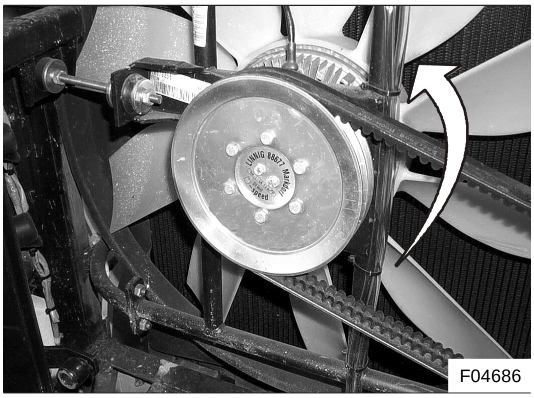


Figure 3: Location of screws to mechanically lock the fan clutch

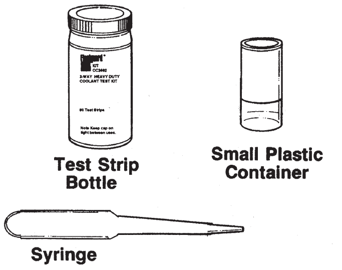
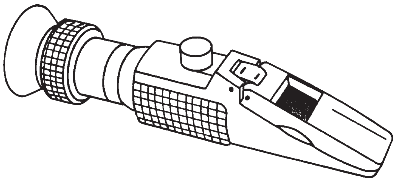
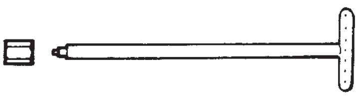
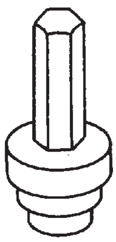
3. Tighten both screws until the fan can not be turned by hand anymore. Tightening torque screws: 18 ft.lbf.

4. Tighten the locking nuts again.

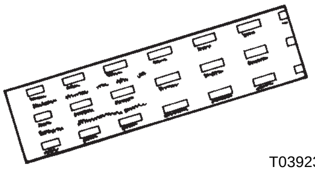
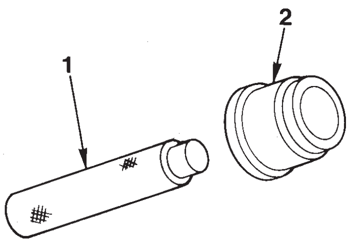
!!! CAUTION !!!
THIS IS ONLY A TEMPORARY REPAIR. ALWAYS USE BOTH LOCKING SCREWS.

US0230AF

SPECIAL SERVICE TOOLS

TOOL NO. + ILLUSTRATION	DESCRIPTION
Fleetguard CC-2606  T04973	**Cummins cooling system test kit** To check DCA-4 concentration in the cooling system.
Fleetguard CC-2800  T02766	**Refractometer** To measure the freeze point protection and antifreeze concentration.
Van Hool 10527208  T03662	**T-headed spraylance** To clean radiator and charge-air cooler.
Cummins ST-1225  T03846	**Cummins thermostat seal mandrel** To install the thermostat seal in the thermostat housing.

TOOL02AC

TOOL NO. + ILLUSTRATION	DESCRIPTION
Detroit Diesel 23519401  T03923	**Detroit Diesel coolant test strip** To check nitrite, molybdate & Glycol levels in the cooling system.
1. Detroit Diesel J 7079-2 2. Detroit Diesel J 8550  T03922	**Detroit Diesel thermostat seal installer set** To install the thermostat seal in the thermostat housing.

TOOL02AC

SERVICE BULLETINS

Service Bulletins are issued to supplement or supersede information in the Van Hool manuals. Note below number, date and subject of Bulletins pertaining to this chapter. File Bulletins separately by number for future reference.

Number	Date	Subject

CHAPTER 3

DRIVE TRAIN

PAGE

CUMMINS ISM - ENGINE

MAIN03AF

DETROIT DIESEL SERIES 60 - ENGINE

MAIN03AF

CUMMINS ENGINE CONTROLS

DETROIT DIESEL ENGINE CONTROLS

WT B500 AUTOMATIC TRANSMISSION (WTEC III)

ZF ASTRONIC TRANSMISSION

PROPELLER SHAFT

CUMMINS ISM- ENGINE

ENGINE DATA

Manufacturer .... Cummins
Type .... 4-cycle, in-line, 6-cylinder
Aspiration .... turbocharged/charge-air cooled
Bore & stroke .... 4.92 in x 5.79 in
Displacement .... 661 in^3
Compression ratio 16.1:1
Firing order 1-5-3-6-2-4
Peak power
- ISM 350 .... 365 BHPat 1,600 rpm
- ISM 370 .... 385 BHP at 1,600 rpm
- ISM 400 .... 400 BHP between 1,500 and 1,800 rpm
- ISM 450 .... 450 BHP at 1,800 rpm

Peak torque
- ISM 350 .... 1,350 ft.lbf. between 1,200 and 1,300 rpm
- ISM 370 .... 1,350 ft.lbf. between 1,200 and 1,400 rpm
- ISM 400 .... 1,450 ft.lbf. at 1,200 rpm
- ISM 450 .... 1,450 ft.lbf. at 1,200 rpm

IDENTIFICATION

ENGINE DATAPLATE - Figure 1

The engine dataplate contains specific information about your engine. The plate is located on the fuel pump side of the rocker housing.

ELECTRONIC CONTROL MODULE (ECM) DATAPLATE - Figure 2

The ECM dataplate is located on the front of the ECM.

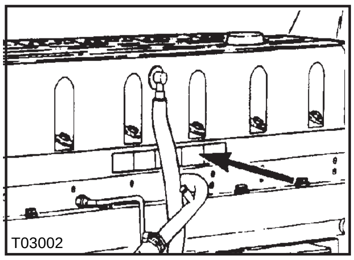


Figure 1: Engine dataplate

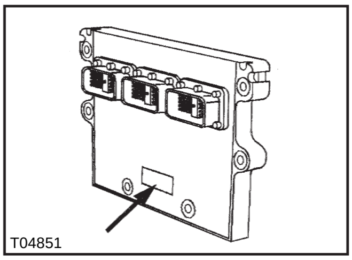


Figure 2: Electronic control module dataplate

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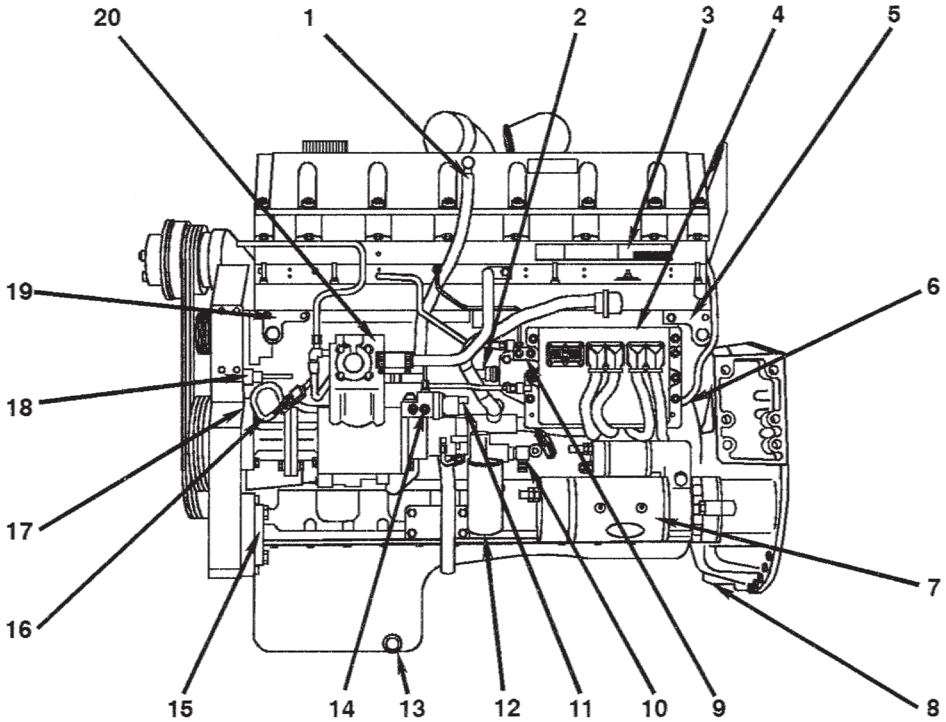

1. Blowby measurement
2. Ambient air pressure sensor
3. Engine data tag
4. Electronic control module (ECM)
5. Engine serial number
6. Cooling plate
7. Starter
8. Flywheel ring gear sensor
9. Fuel return to tank
10. Fuel inlet to pump
11. Fuel vacuum
12. Fuel filter
13. Side oil drain
14. Fuel rail pressure
15. Power steering pump mounting location
16. Oil pressure and temperature sensor
17. Oil pressure
18. Engine position sensor
19. Freon compressor mounting location
20. Compressor air discharge

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Figure 3: ISM-engine diagram (Fuel pump side)

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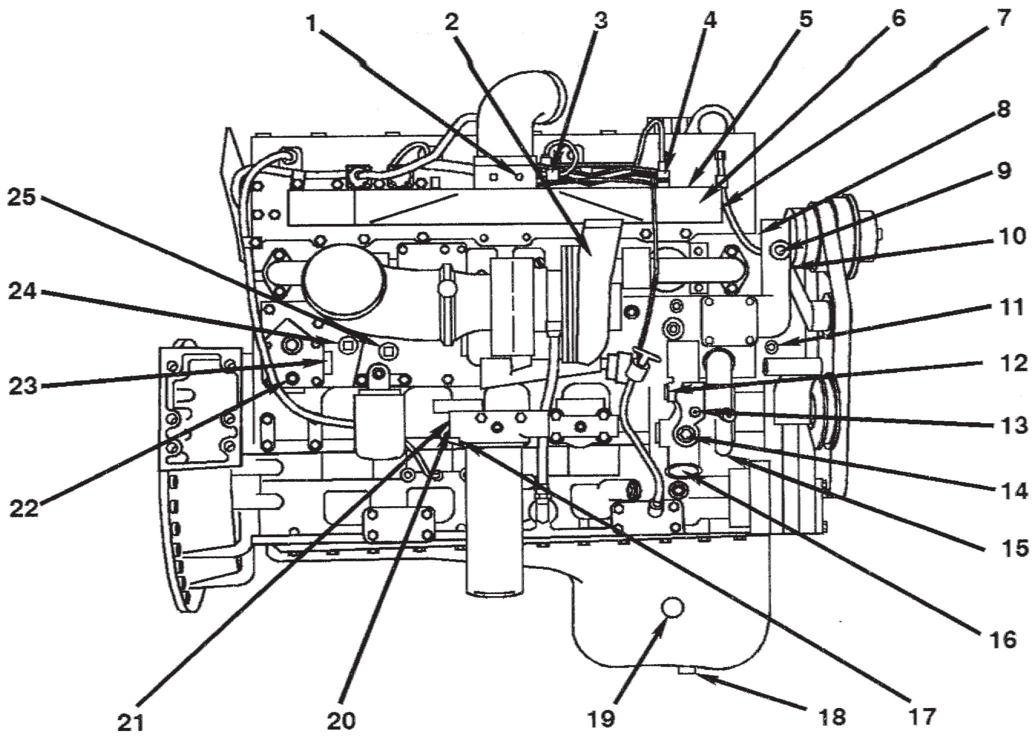

1. Ether hook-up
2. Before charge air cooler
3. Intake manifold air cooler
4. Intake manifold pressure sensor
5. After charge air cooler
6. Fan stat
7. Shutter stat
8. Engine vent (coolant)
9. Shutter stat
10. Fan sensor
11. Coolant temperature sensor
12. Heater return
13. Water pump inlet pressure
14. Make-up line from radiator
15. Water pump pressure
16. Coolant inlet
17. Engine brake oil supply
18. Oil drain
19. Oil pan sump heater
20. Oil pressure after filter
21. Oil pressure before filter
22. Block coolant pressure
23. Coolant heater
24. Heater supply
25. Coolant temperature pick-up

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Figure 4: ISM-engine diagram (Exhaust side)

LUBRICATING OIL SYSTEM

OIL RECOMMENDATIONS

See section 12.3 "Lubricants and Fluids".

TO CHECK OIL LEVEL

The vehicle *must* be level when checking the oil level to make sure the measurement is correct.

Wait at least ten minutes after shutting off the engine to check the oil. This allows time for the oil to drain to the oil pan.

Never operate the engine with the oil level below the "L" (Low) mark or above the "H" (High) mark on the dipstick.

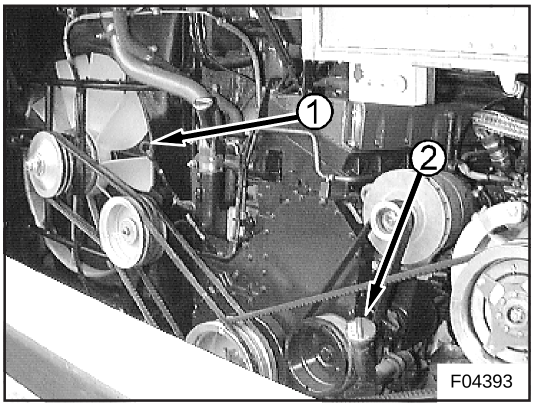

Figure 5: Engine oil dipstick and filler tube

1. Dipstick
2. Filler tube

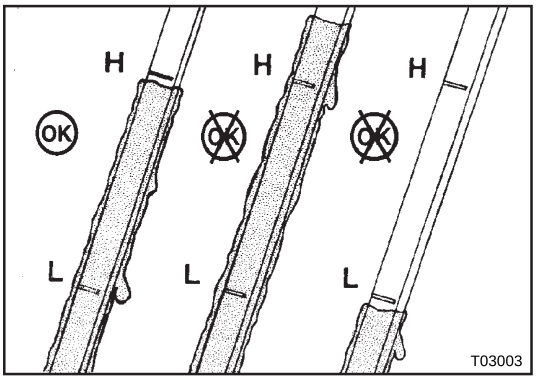

Figure 6: Dipstick readings

If necessary, add oil until it reaches the "H" (High) mark on the dipstick.

TO CHANGE OIL AND OIL FILTER

!!! CAUTION !!!
SOME STATE AND FEDERAL AGENCIES IN THE UNITED STATES OF AMERICA HAVE DETERMINED THAT USED ENGINE OIL CAN BE CARCINOGENIC AND CAN CAUSE REPRODUCTIVE TOXICITY. AVOID INHALATION OF VAPORS, INGESTION, AND PROLONGED CONTACT WITH USED ENGINE OIL. AVOID DIRECT CONTACT OF HOT OIL WITH YOUR SKIN. HOT LUBRICATING OIL CAN CAUSE PERSONAL INJURY.

1. Operate engine until coolant temperature reaches 140°F. Shut off engine. Remove lubricating oil drain plug from the bottom of the oil pan (see Figure 7).

2. Clean area around lubricating oil filter head. Remove filter. Clean gasket surface of filter head. O-ring can stick on filter head. Make sure it is removed.

!!! CAUTION !!!
THE LACK OF LUBRICATION DURING THE DELAY UNTIL THE FILTER IS PUMPED FULL OF OIL AT START-UP IS HARMFUL TO THE ENGINE.

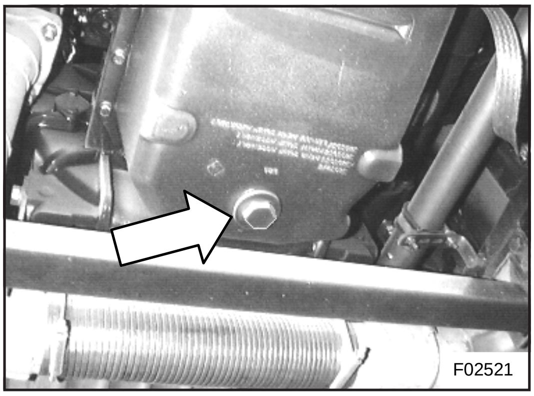

Figure 7: Lubricating oil drain plug

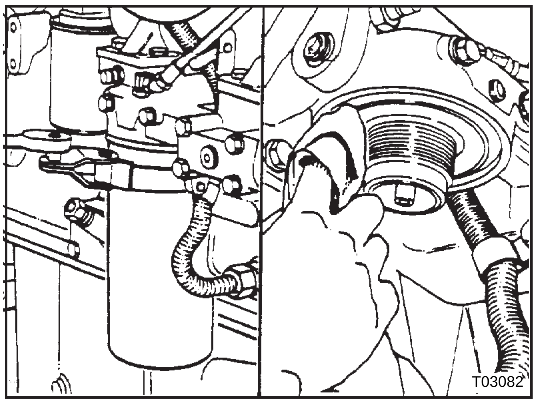

Figure 8: Oil filter removal

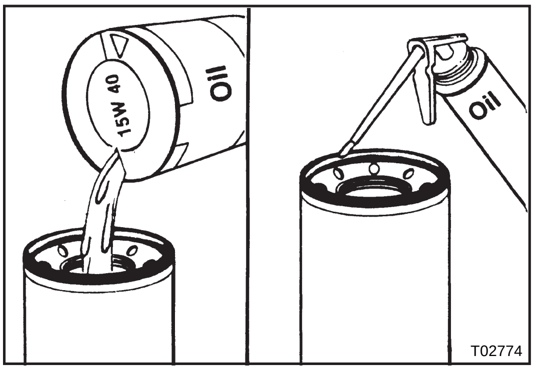

Figure 9: Fill filter with clean lubricating oil and apply light film of lubricating oil to gasket sealing surface

3. Fill the filter with clean lubricating oil.

!!! CAUTION !!!
MECHANICAL OVERTIGHTENING MAY DISTORT THREADS OR DAMAGE FILTER ELEMENT SEAL.

4. Apply a light film of lubricating oil to the gasket sealing surface before installing the new filter.

5. Install lubricating oil filter on the filter head. Turn the filter until the gasket contacts the filter head surface. Tighten the filter or as specified by the filter manufacturer.

6. Clean and check lubricating oil drain plug threads and seal surface. Install lubricating oil pan drain plug. Tightening torque: 65 ft.lbf.

7. Fill engine with clean lubricating oil to proper level.

8. Operate engine at idle to inspect for leaks at lubricating oil filter and drain plug.

9. Stop engine. Wait approximately 10 minutes to let lubricating oil drain from upper parts of engine. Check level again. Add oil as necessary to bring the oil level to the H (High) mark on the dipstick.

SENSOR OF OIL PRESSURE GAUGE ON INSTRUMENT PANEL

The pressure sending unit is threaded in the engine oil filter head. It combines a pressure switch with a pressure sensor in a sealed metal housing. Note that the pressure switch is not connected to your coach. The sensor sends a pressure depending signal to the oil pressure gauge on the instrument panel.

If you suspect a faulty pressure sensor, measure the resistance as follows:

1. Disconnect the pressure sending unit from its wiring harness.

2. Use a VOM to measure the resistance between terminal 1 and the engine block. The resistance is

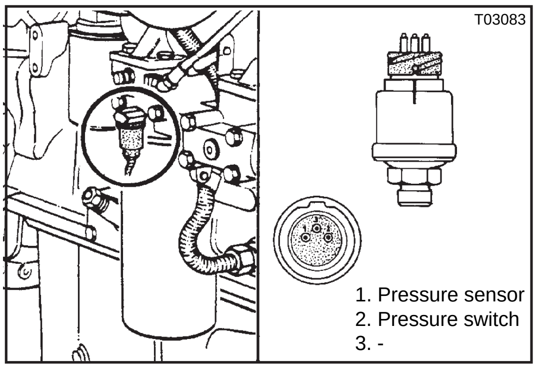

Figure 10: Oil pressure sensor located in engine oil filter head

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Overpressure	Acceptable Resistance Range
0 psi	10^{+3}_{-5} Ohm
14.5 psi	48 ± 4 Ohm
29 psi	82 ± 4 Ohm
43.5 psi	116 ± 5 Ohm

pressure-dependent (see table). If the resistance is not correct, replace the pressure sending unit.

Pressure range
sending unit: 0 to 72 psi overpressure

NOTE
DO NOT USE A THREAD SEALER WHEN INSTALLING SENDING UNIT. THE SEALER MAY INSULATE THE UNIT FROM THE ENGINE.

OIL PRESSURE SENSOR OF ISM FUEL SYSTEM

Refer to Cummins "ISM fuel system Troubleshooting and Repair Manual".

OIL TEMPERATURE SENSOR OF ISM FUEL SYSTEM

Refer to Cummins "ISM fuel system Troubleshooting and Repair Manual ".

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AIR INTAKE SYSTEM

INSPECTIONS

Inspect intake piping for cracked hoses, loose clamps or punctures which may damage engine. Also, visually check charge air cooler for dirt and debris blocking the fins.

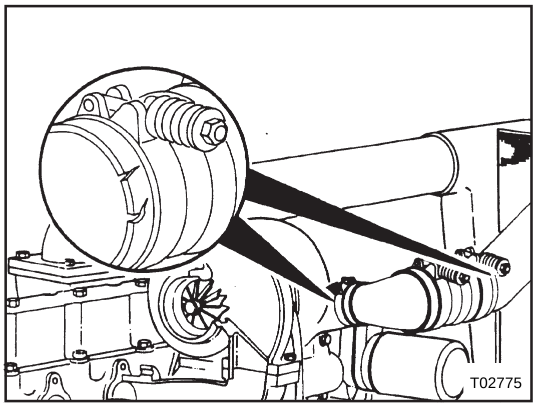

Figure 11: Air intake inspection

Tighten or replace parts as necessary to make sure air intake system does not leak.

Refer to Cummins "Operation and Maintenance Manual ISM Series Engines" for more information.

AIR CLEANER

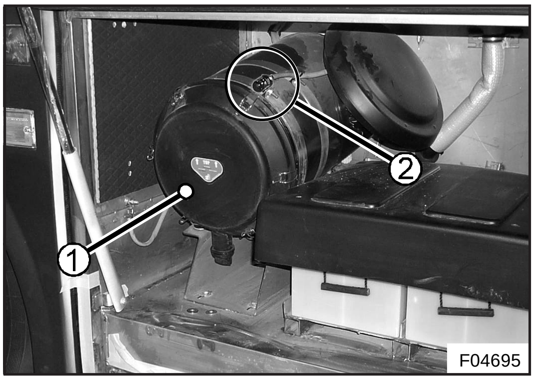

Figure 12: Behind the rearmost left outside access door

1. Engine air-cleaner

2. Engine air-cleaner restriction indicator

To check condition

Check the condition of the air-cleaner element daily by observing the restriction indicator. If a red plunger appears in window (2) with the engine off, the air-cleaner element should be replaced as soon as possible. After the element has been replaced, push the reset button (1) to release the red plunger.

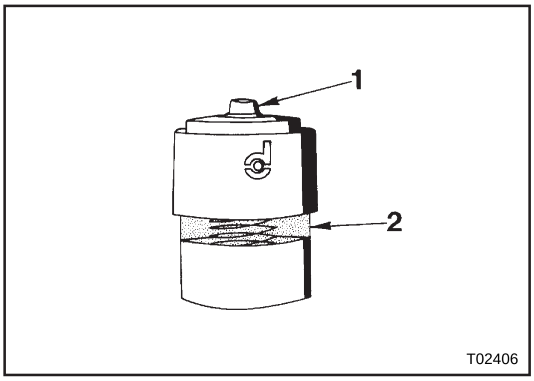

Figure 13: Air-cleaner restriction indicator

1. Reset button

2. Window

To check restriction indicator

Undo the restriction indicator hose at the air-cleaner outlet. Connect the hose end to a small vacuum pump (available from the retail trade).

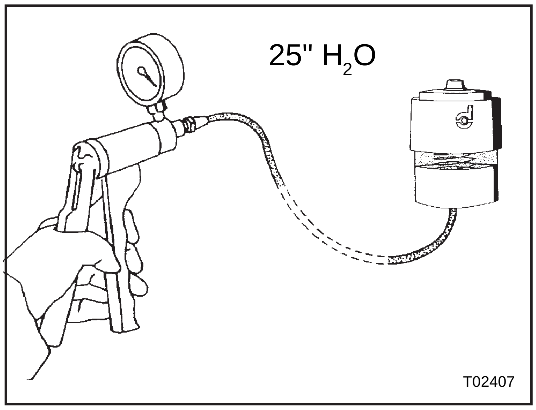

Figure 14: To check restriction indicator

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Actuate the pump until the pressure gauge registers the pressure indicated in Figure 14. A red plunger should rise into window (2, Figure 13) and stay there when atmospheric pressure is restored at the restriction indicator connection. If the red plunger responds too soon, too late or not at all, replace the restriction indicator.

Dump valve

The cleaner is equipped with a rubber dump valve (5,Figure 15). While the engine is running, this valve automatically expels dirt collected in the air-cleaner dust pan. From time to time, squeeze the valve body by hand in order to prevent the valve slit from sticking shut due to the presence of moisture in the air.

To change air-cleaner element

Change the air-cleaner element when the restriction indicator shows a red plunger after engine shutdown. Regardless of restriction indication, the element should be discarded after one year.

To change the element:

1. Stop the engine. Release toggle clips (4) and remove dust pan (3).
2. Gently pull element (2) off the outlet tube and out of housing (1). Avoid knocking the element against the housing. The element fits tightly over the outlet tube, creating the critical seal on the inside diameter of the air-cleaner end cap. The element should be removed gently to reduce the amount of dust dislodged. There will be some initial resistance, similar to breaking the seal on a jar. Gently twist the element clockwise and counterclockwise to disengage the seal.

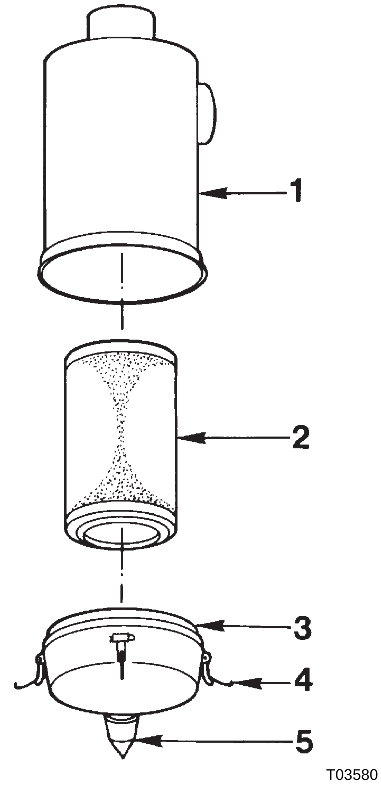

Figure 15: Air cleaner

3. Check the old element. This could help you detect foreign material on the sealing surface that is causing leakage. A streak of dust on the clean air side of the element is the tell-tale sign. If it exists, be sure the cause is removed before installing a new element.
4. Always clean the inside of the air-cleaner housing and outlet tube with a clean, damp cloth. Dirt accidentally transferred to the inside of the outlet tube will reach the engine and cause wear. Be careful not to damage the element sealing area on the tube.
5. Inspect the new element for damage. Always look for possible shipping or handling damage. Pay particular attention to the inside of the open end (the sealing area). Check for cuts, etc. Do not install a damaged element.

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6. Install new element. The radial seal area is on the inside of the open end of the element. This critical sealing area will stretch slightly, adjust itself and distribute the sealing pressure evenly onto the outlet tube as the element is installed. To complete a tight seal, apply firm pressure at the outer rim of the element, not the flexible center. Due to its unique design, cover pressure is not necessary to compress the element seal.

7. Install dust cover so that dump valve (5) is downward and close toggle clips (4).

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FUEL SYSTEM

FUEL RECOMMENDATIONS

See section "Lubricants and Fluids".

TO DRAIN FUEL FILTER

NOTE
THE WATER AND SEDIMENT CAN CONTAIN PETROLEUM PRODUCTS. PLEASE CONSULT THE LOCAL ENVIRONMENTAL AGENCY FOR RECOMMENDED DISPOSAL GUIDELINES.

1. Shut off engine.
2. Use your hand to open the drain valve.
3. Turn valve counterclockwise approximately 3½ turns until valve drops down one inch and draining occurs. Drain the fuel filter of water and sediment until clear fuel is visible.

!!! CAUTION !!!
WHEN CLOSING DO NOT OVERTIGHTEN THE DRAIN VALVE. OVERTIGHTENING CAN DAMAGE THE THREADS.

4. To close the valve, lift the valve and turn clockwise until it is handtight.

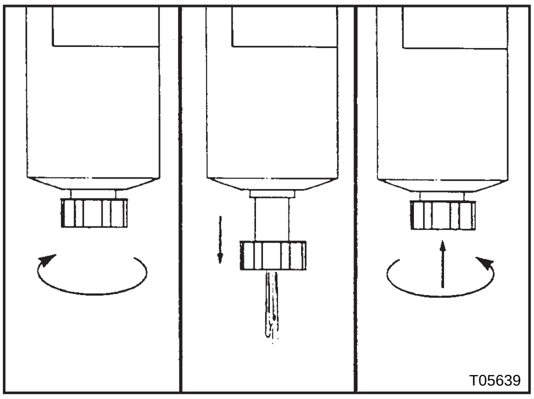

Figure 16: To drain fuel filter

TO CHANGE FUEL FILTER

1. Clean the area around fuel filter head and filter. Remove the fuel filter.
2. Remove the thread adapter sealing ring.
3. Use a clean, lint-free towel to clean the filter head gasket surface.
4. Install a new thread adapter sealing ring supplied wiith the new filter.
5. Apply a thin coat of clean engine oil to the filter gasket surface.
6. Fill the filter with clean fuel.

!!! CAUTION !!!
MECHANICAL OVERTIGHTENING OF THE FILTER CAN DISTORT THE THREADS OR DAMAGE THE FILTER ELEMENT SEAL.

7. Install the fuel filter on the filter head. Turn the filter until the gasket contacts the filter head surface. Tighten the filter an additional one-half to three-fourths of a turn after the gasket contacts the filter head surface or as specified by the fuel filter manufacturer.

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DRIVE BELTS

Figure 17 shows belt types which can be found on Van Hool vehicles.

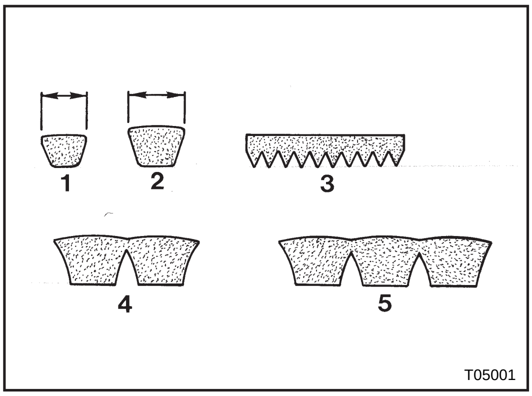

Figure 17: Belt types

1. Single V-belt (3/8" wide)
2. Single V-belt (1/2" wide)
3. V-ribbed belt
4. Joined V-belt (two-strand)
5. Joined V-belt (three-strand)

TO INSPECT V-BELTS

Change belts when they look frayed (worn) or when you notice one of the following defects:

1. Cracks in sides or bottom.
2. Soft, sticky sides, sometimes flaking. Swollen profile (rubber affected by grease or oil).
3. Glazed (burnt) sides.
4. Incisions or tears.

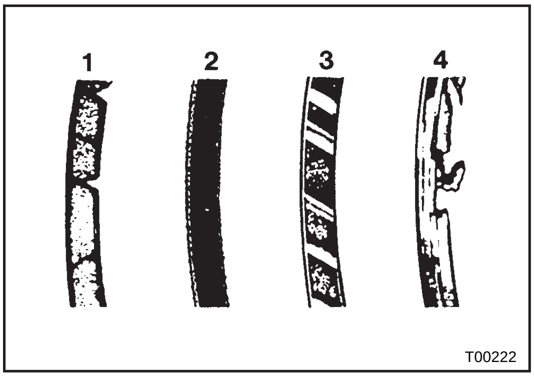

Figure 18: V-belts defects

TO INSPECT V-RIBBED BELT

Check them for intersecting cracks.Transverse (across the belt width) cracks are acceptable. Longitudinal (direction of belt length) cracks intersecting with transverse cracks are not acceptable. Replace belt if it is frayed or has pieces of material missing.

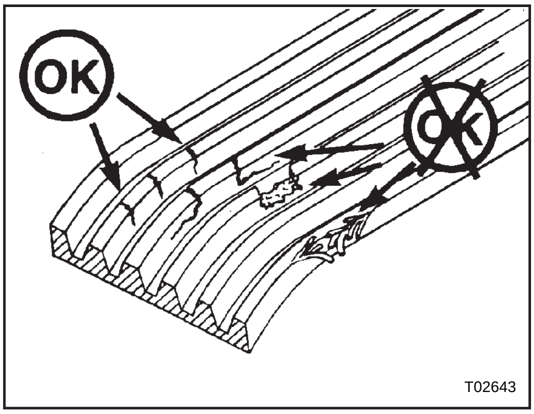

Figure 19: V-ribbed belt defects

TO CHANGE BELTS

Always replace belts of same drive as a pair. Always pull back tensioning device as far as possible when removing or installing belts. Never pry or roll belt over edge of pully. Even this action does not cause any immediately visible damage, belt-life is shortened by it. Once installed, the belts are tensioned according to the data in figure 32. During run-in, the new belt will stretch and part of the tension will be lost. Therefore, readjust belt tension to its initial value after first 20 minutes of operation.

TO USE BELT TENSION GAUGES

Click-type tension gauge (Krikit I)

NOTE
THE "KRIKIT I" IS CALIBRATED TO MEASURE SINGLE V-BELT TENSIONS ONLY.

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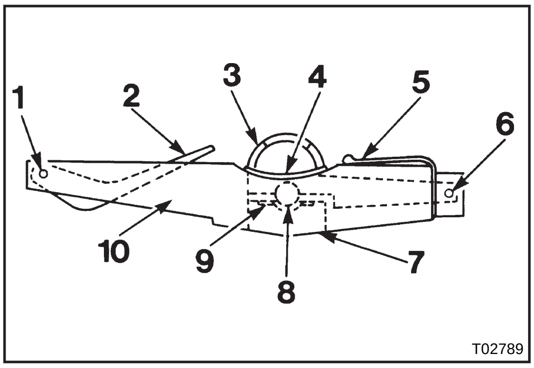

Figure 20: Click-type gauge (Krikit I)

1. **Pivot pin**
2. **Indicator arm**
3. **Finger loop**
4. **Pressure pad**
5. **Pocket clip**
6. **Pivot pin**
7. **Positioning flange**
8. **Spring**
9. **Ball bearing**
10. **Body**

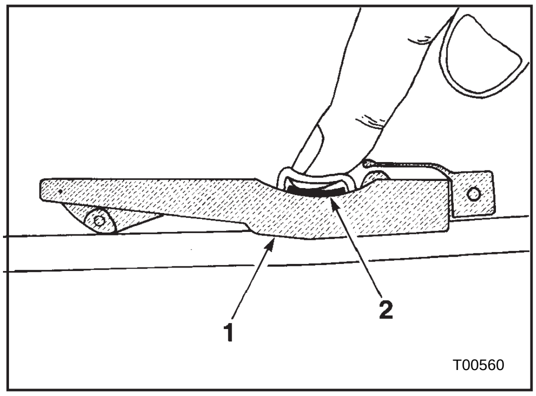

Figure 21: Holding the gauge

1. Flange 2. Pressure pad

1. Place "Krikit" on belt as shown in figure 21.
2. Push indicator arm (1, Figure 22) as far as possible inside gauge.
3. Center gauge between two pulleys. Flange (1, Figure 21) must be flat against top edge of belt.
4. Push pressure pad (2, Figure 21) very slowly at a right angle to top of belt until you hear or feel click release of tension spring under pad. IMMEDIATELY STOP PUSHING. Any more pressure will give you an inaccurate reading.

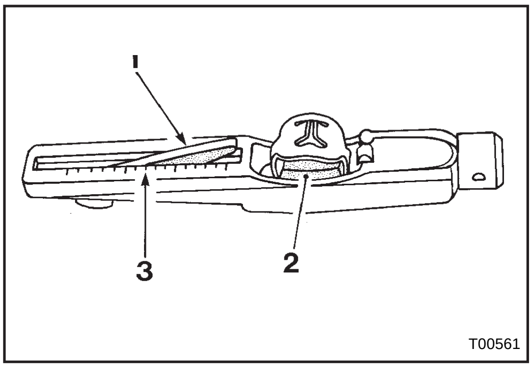

Figure 22: Reading the gauge
1. **Indicator arm**
2. **Pressure pad**
3. **Reading the correct tension here**

5. Read correct tension at spot where top of indicator arm (1, Figure 22) crossed the numbered scale at top of gauge body (see Figure 22).

Click-type tension gauge (Krikit II)

The "Krikit II" belt tension gauge, with the brightly colored pressure pad and indicator arm is calibrated to measure V-ribbed belt tensions.

NOTE
THERE IS NO FLANGE ON THE BOTTOM OF THE "KRIKIT II" TO ALIGN THE GAUGE PARALLEL TO THE EDGE OF THE BELT. PLACE THE GAUGE IN THE CENTER OF THE BELT AND ALIGN THE SIDES OF THE GAUGE PARALLEL TO THE EDGES OF THE BELT. BELT TENSION ACCURACY IS DEPENDENT ON THIS PROCEDURE.

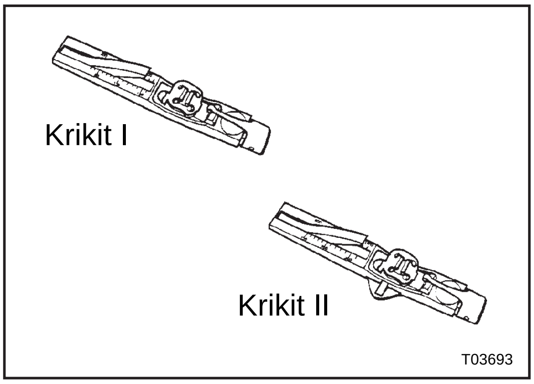

Figure 23: Differences between Krikit I and Krikit II

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1. Place "Krikit II" on the center of the V-ribbed belt so that the sides of the gauge are parallel to the edges of the belt and mid-way between any two pulleys.

2. Push slowly on the colored pad to get an accurate reading. When you feel and hear the "click", immediately stop pressing and remove the gauge carefully in order not to move the indicator arm.

3. How to read "Krikit II" accurately:

   a. Turn the gauge sideways to see the exact spot where the top of the indicator arm intersects the scale.

   b. Mark this spot with your thumbnail and turn the gauge to read the scale accurately.

   c. It is recommended that more than one tension reading be taken to assure repeatable measurements.

NOTE
THE "KRIKIT II" GAUGE SHOULD NOT BE USED ON BELTS WIDER THAN THE BOTTOM SURFACE OF THE GAUGE.

TO ADJUST BELT TENSION

Alternator at RHS of engine -Figure 24

!!! CAUTION !!!
BEFORE INSTALLING AN ALTERNATOR, CHECK BUSH IN SWIVEL BRACKET FOR EASY SLIDING.

1. Loosen alternator pivot bolt (1).

2. Slacken alternator mounting bolt (2).

3. Slacken locknuts (3 and 5).

4. Turn adjusting nut (4) until correct tension is obtained.

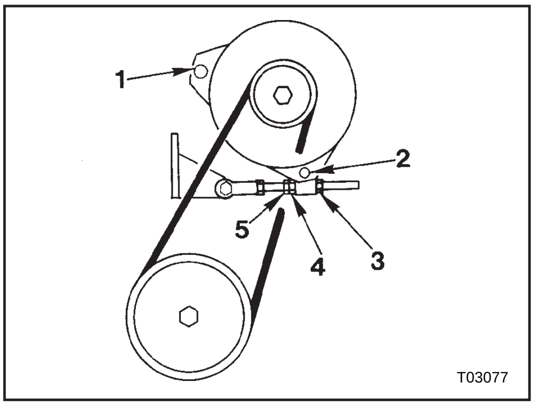

Figure 24: Adjusting alternator V-ribbed belt

5. Retighten mounting bolt (2), pivot bolt (1) and locknuts (3 and 5).

Fan drive - Figure 25

1. Loosen pulley hub nut (1).

2. Turn hexagon head (2) of threaded adjusting rod to increase or reduce tension.

3. Retighten nut (1) to 50 ± 7 ft.lbf torque.

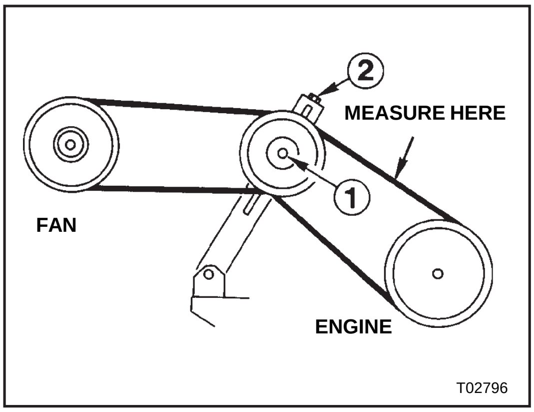

Figure 25: Adjusting fan drive belts

Alternator at RHS of HVAC compressor - Figure 27

1. Loosen alternator pivot screw (1, Figure 26) and alternator pivot bolt (2, Figure 26).

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2. Slacken alternator mounting bolt (4).
3. Slacken locknuts (1 and 3)
4. Turn adjusting nut (2) until correct tension is obtained.
5. Retighten mounting bolt (4), pivot screw (1,Figure 26), pivot bolt (2,Figure 26) and locknuts (1 and 3).

!!! CAUTION !!!
BEFORE INSTALLING AN ALTERNATOR, CHECK BUSH IN ALTERNATOR SUPPORT FOR EASY SLIDING.

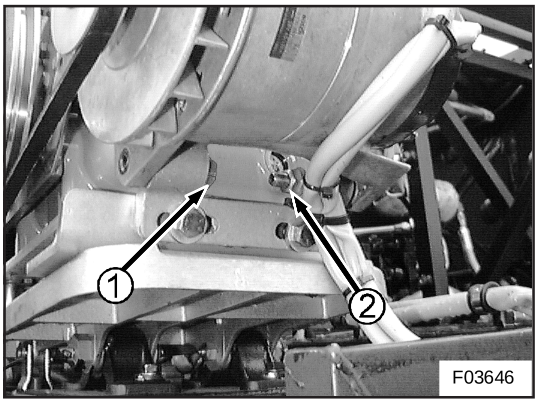

Figure 26: Alternator pivot points

1. Alternator pivot screw
2. Alternator pivot bolt

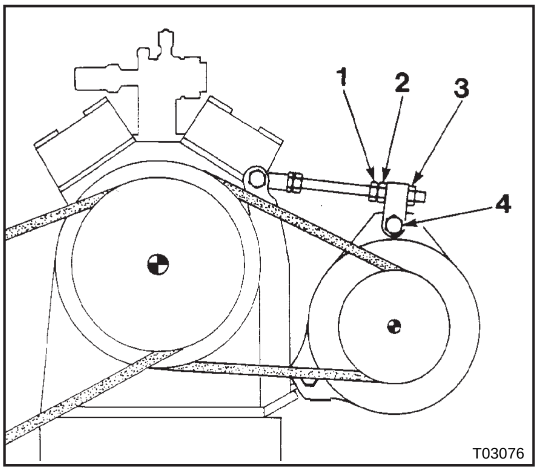

Figure 27: Adjusting alternator belt

HVAC compressor

Tensioning system (Figure 28)

The HVAC compressor belts are tensioned by air bellows (6) which receives regulated air pressure from air pressure regulator (2). Air release valve (5) is provided to release air pressure from air bellows (6) during belt replacement.
A rubber bumper (7) is mounted under compressor mounting plate. This provides adequate belt tension when there is no air pressure and provides also a dampening effect during normal running conditions.
It is important that rubber bumper (7) makes full contact with bottom of compressor mounting plate, enough to slightly compress the rubber. Periodic adjustment of rubber bumper is required after new V-belts are installed to ensure proper contact.

Belt replacement (Figure 28)

With air pressure applied to air bellows (6), remove rubber bumper (7) from under compressor mounting plate . Release air pressure with release valve (5). Allow compressor to pivot towards engine and remove belts.

NOTE
BEFORE INSTALLING THE NEW V-BELTS, IT IS RECOMMENDED TO CHECK COMPRESSOR CLUTCH/BEARING FOR EXCESSIVE PLAY.

Install new belts and re-apply air pressure with release valve (5). Compressor mounting plate should now be positioned horizontally. If not, loosen the four compressor mounting bolts (8). Slide compressor left or right to achieve horizontal running position.

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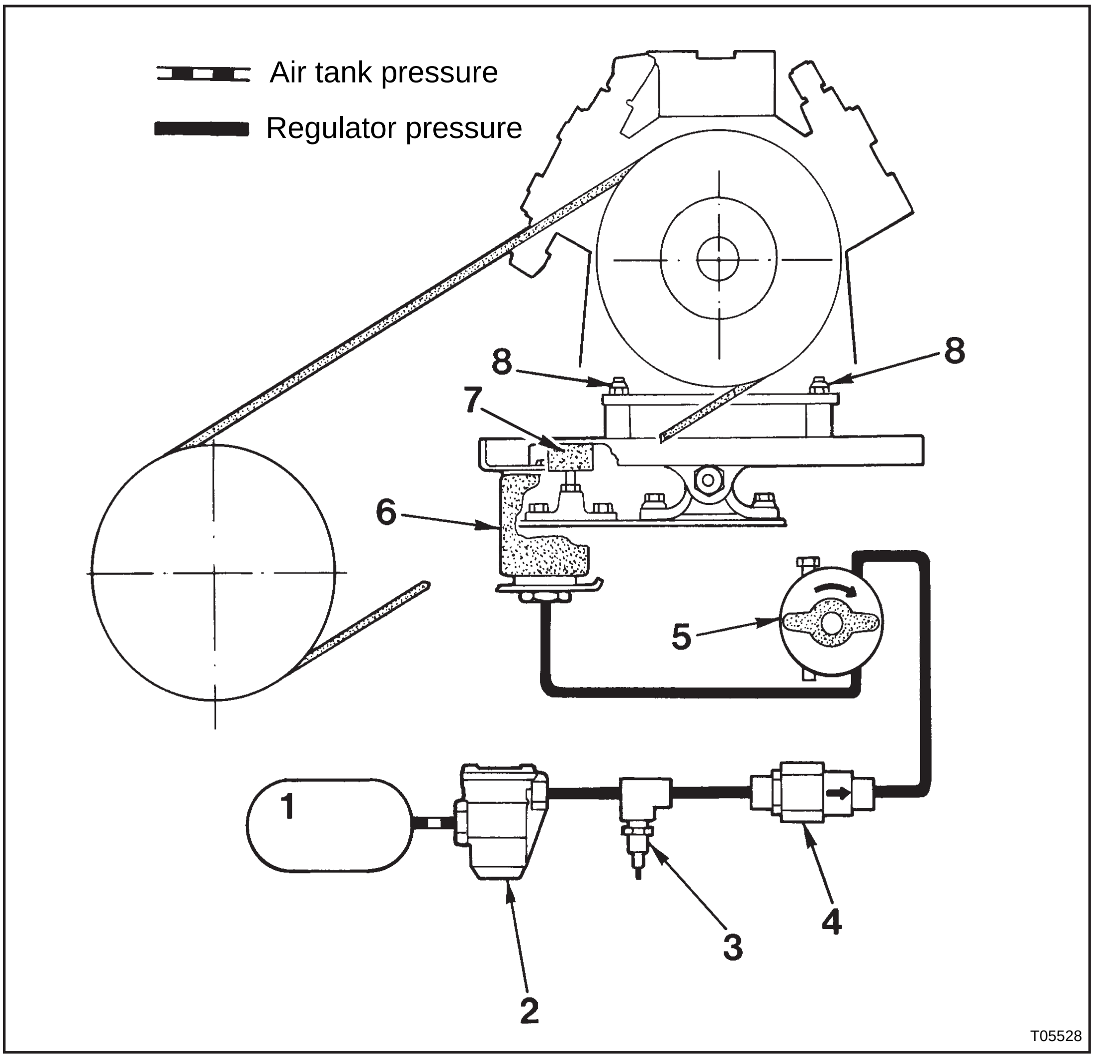

Figure 28: HVAC compressor belt tensioning system

1. Air tank
2. Pressure regulator
3. Test coupling
4. Single check valve
5. Air release valve
6. Air bellows
7. Rubber bumper
8. Mounting bolts

Install rubber bumper (7) and adjust it to make full contact with underside of compressor mounting plate (enough to have slight contact with rubber).

Compressor mounting pivot (Figure 29)

Grease pivot bushings and check for play at intervals given in Maintenance Schedule.

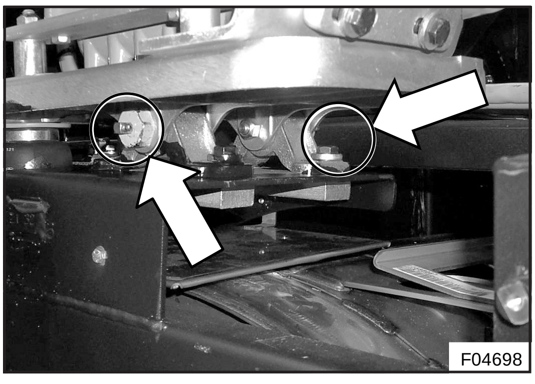

Figure 29: Compressor mounting pivot points

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Air pressure regulator (Figure 28)

Air pressure regulator (2) provides regulated air pressure to air bellows (6).

If belt tension is not correct:

1. Remove bottom cover (1, Figure 30)
2. Turn screw (2, Figure 30) :
   - clockwise to increase air pressure
   - counterclockwise to decrease air pressure
3. Install bottom protection cover.

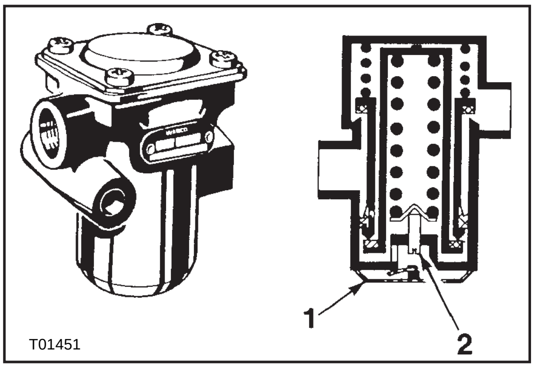

Figure 30: Air pressure regulator

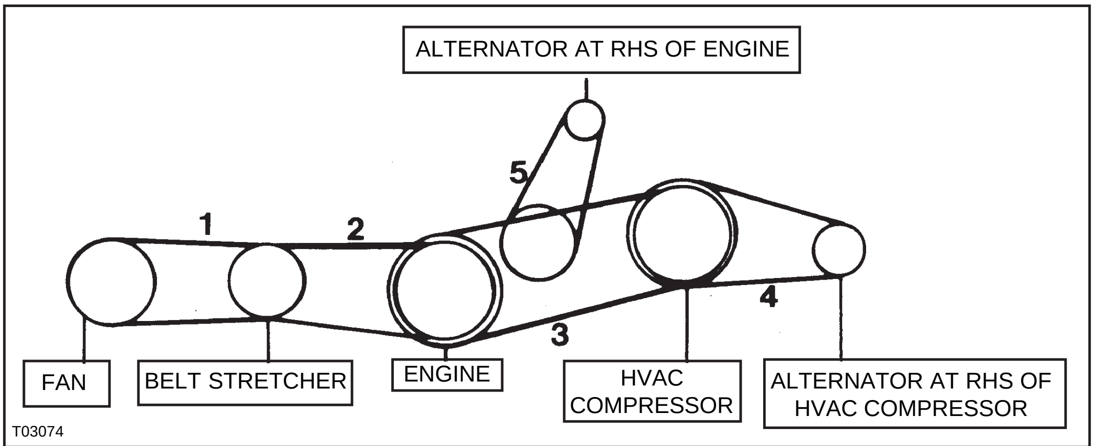

Figure 31: Drive belt diagram

NUMBER (See Fig.31)	BELT TENSION GAUGE	INSTALL AT		MAINTAIN TENSION AT	
		Newton	Lbf	Newton	Lbf
1	Krikit I	500-600	110-130	450-550	100-120
2	Krikit I	500-600	110-130	450-550	100-120
3	Krikit I	450-550	100-120	450-550	100-120
4	Krikit I	400-500	90-110	350-450	80-100
5 (7-ribs)	Krikit II	740-940	170-210	600-800	135-180
5 (10-ribs)	Krikit II	1100-1300	250-290	900-1100	200-250

Figure 32: Drive belt tension chart

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ENGINE MOUNTING

TO CHECK TIGHTENING TORQUES

Check, at intervals given in Maintenance Schedule, torque of bolts and nuts (for tightening torques, see Figure 33). Inspect rubber for deterioration and age hardening. Replace any broken or lost bolts and screws. Replace any damaged rubber.

TO ADJUST REAR ENGINE MOUNTS

Check distances "A" (see figure 34) at the intervals given in the Maintenance Schedule. Distances "A" should be equal (approx. 0.01 inch). This can be checked by using a self-fabricated strip(0.01 x 1.18 x 4 inch).

If distances "A" aren't equal, reset as follows:

1. Slacken the three self-locking nuts(4) and pull movement limitation bracket down.
2. Insert self-fabricated strip in the gap between movement limitation bracket and engine mount.
4. Push movement limitation bracket fully up.
5. Tighten the three self-locking nuts to a torque of 66 ft.lbf.
6. Remove metal strip.

1. 80-105 ft.lbf
2. 40-50 ft.lbf
3. 40-50 ft.lbf
4. 40-50 ft.lbf
5. 120-160 ft.lbf
6. 70-90 ft.lbf
7. 50-60 ft.lbf
8. 50-60 ft.lbf
9. 80-105 ft.lbf
10. 115-150 ft.lbf

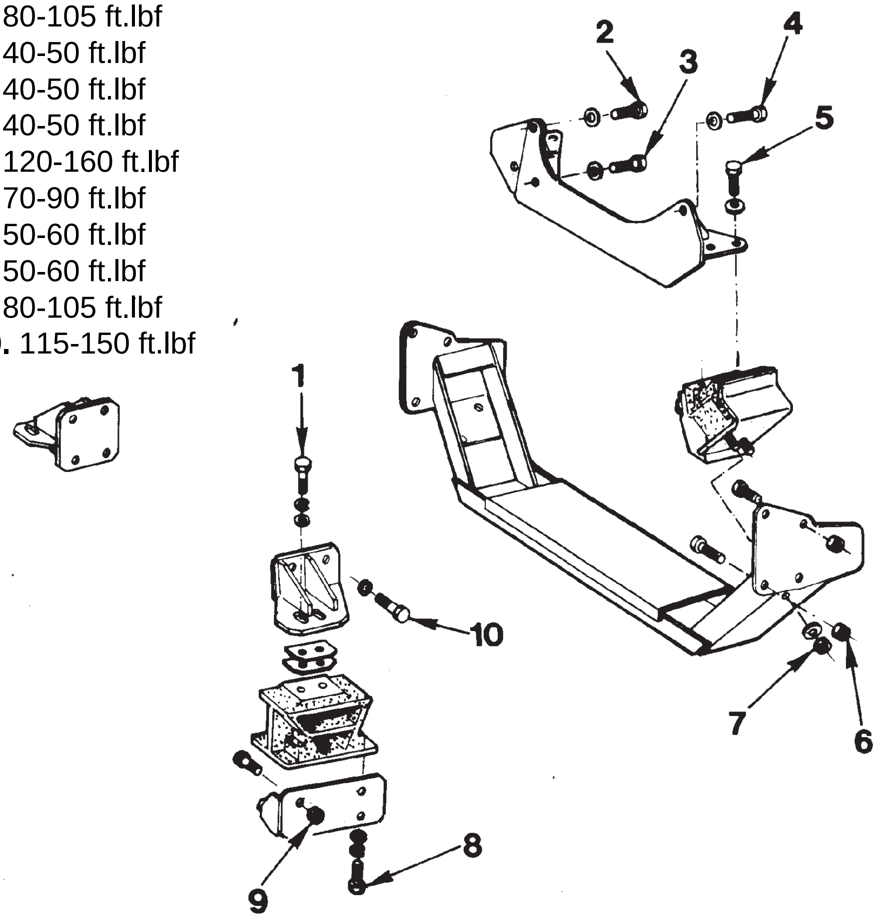

Figure 33: Engine mounting tightening torques

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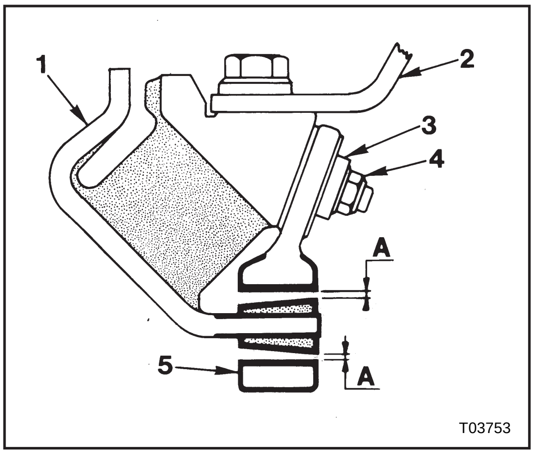

Figure 34: Engine rear mounting

1. Engine mount
2. Engine bracket
3. Washer
4. Self-locking nut
5. Movement limitation bracket

MISCELLANEOUS MAINTENANCE

TO INSPECT CRANKCASE BREATHER TUBE

Check the crankcase breather tube daily during cold weather operations for ice buildup which could obstruct the tube.

If an ice buildup is present, remove the breather tube, if necessary, and clean the obstruction.

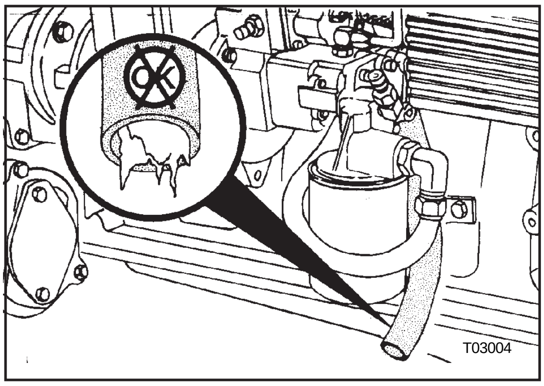

Figure 35: Location of crankcase breather tube

TO ADJUST VALVES AND INJECTORS

Refer to Cummins "Operation and Maintenance Manual ISM Series Engines".

TO INSPECT WATER PUMP

Refer to Cummins "Operation and Maintenance Manual ISM series engines".

TO INSPECT TURBOCHARGER

- Check the turbocharger mounting nuts. Tightening torque: 50 ft.lbf.
- Check the turbine housing sealing surface for exhaust leaks. If a leak is found, tighten the turbine housing capscrews or V-band clamp (tightening torque V-band nut: 140 in.lbf).
- Check the compressor housing sealing surface for leaks. If a leak is found, tighten the compressor housing V-band clamp nut (tightening torque: 75 in.lbf.).

TO STEAM CLEAN ENGINE

!!! CAUTION !!!
WHEN USING A STEAM CLEANER, WEAR PROTECTIVE CLOTHING AND SAFETY GLASSES OR A FACE SHIELD. HOT STEAM WILL CAUSE SERIOUS PERSONAL INJURY.

To steam clean is the best method to clean a dirty engine. If a steam cleaner is not available, use a solvent. Protect all electrical components, openings and wiring from the full force of the cleaner spray nozzle.

TO INSPECT VIBRATION DAMPER

Refer to Cummins "Operation and Maintenance Manual ISM Series Engines".

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TO INSPECT AIR COMPRESSOR

Refer to Chapter 6.1 "Air compressor".

OVERHAUL

TO ASSEMBLE FAN DRIVE IDLER PULLEY-Figure 36

1. Clean pulley thoroughly with solvent. Dry with compressed air.

NOTE:
DO NOT USE GREASE DURING INSTALLATION.

2. Install dust cover (1). Note direction of cover.
3. Press in bearing (2) with special VH drift (see Figure 37) or equivalent. If using equivalent tool, make sure bearing is pressed in by the outer race.
4. Install gold colored spacer ring (3).
5. Press in bearing (4) with special VH drift (see Figure 37) or equivalent. If using equivalent tool, make sure bearing is pressed in by the outer race.
6. Install dust cover (5). Note direction of cover.
7. Install aluminum colored spacer ring (6) with countersunk side facing up-wards.
8. Install snap ring (7).
9. Clean the inner race of both bearings and the pulley shaft with Loctite 7061 or equivalent.
10. Apply Loctite 603 evenly to the inner race of both bearings and the pulley shaft.

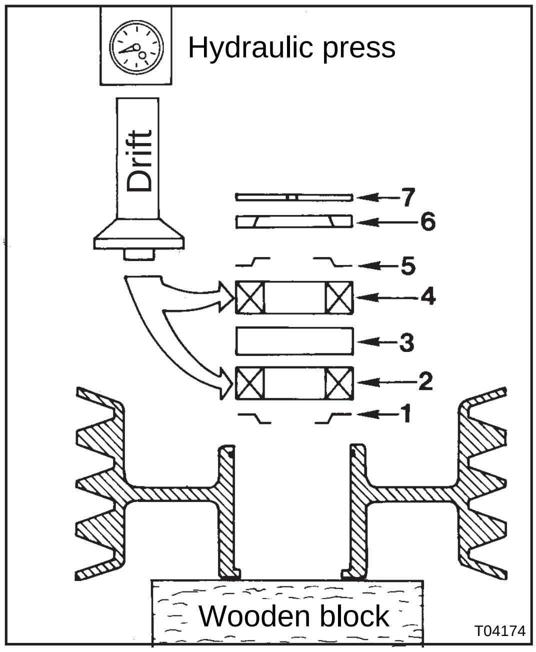

Figure 36: To assemble idler pulley

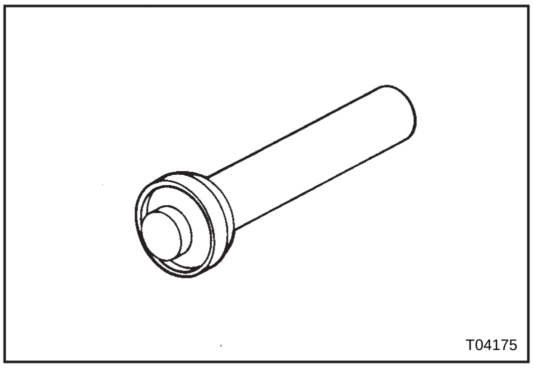

Figure 37: Bearing installation drift (VH 10616471)

11. Slide pulley shaft in by hand starting from the opposite side of the snap ring.
12. Move the shaft back and forth to spread Loctite 603 evenly.
13. Push shaft fully in.
14. Wipe off excess Loctite.
15. Allow to dry for 6 hours before installing on coach.

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DETROIT DIESEL SERIES 60-ENGINE

ENGINE DATA

Manufacturer .... DETROIT DIESEL
Type .... 4-cycle, in-line, 6-cylinder
Aspiration .... turbocharged/charge-air cooled
Bore & Stroke .... 5.12 in x 6.30 in
Displacement .... 778 in^3
Compression ratio 15:1
Firing order 1-5-3-6-2-4
Maximum power (SAE J 1995)
•Series 60-430 .... 430 BHP at 2,100 rpm
•Series 60-500 .... 500 BHP at 2,100 rpm
Max torque (SAE J 1995)
•Series 60-430 .... 1,450 ft.lbf. at 1,200 rpm
•Series 60-500 .... 1,450 ft.lbf. at 1,200 rpm

IDENTIFICATION

ENGINE MODEL, SERIAL NUMBER AND OPTION LABELS

The engine serial and model numbers are stamped on the block.

Option labels attached to the valve rocker cover contain the engine serial and model numbers and list any optional equipment used on the engine (see Figure 2).

The engine model number should be given with any parts order. In addition, if a type number is shown on the option plate covering the equipment required, this number should also be included on the parts order.

All groups or parts used on a unit are standard for the engine model unless otherwise listed on the option plate.

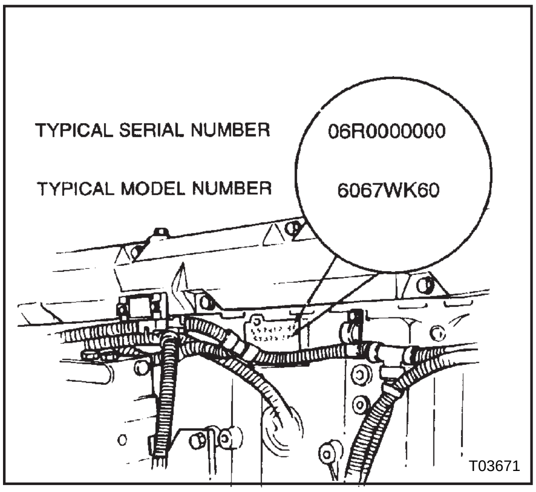

Figure 1: Location of Engine Serial and Model Number on block

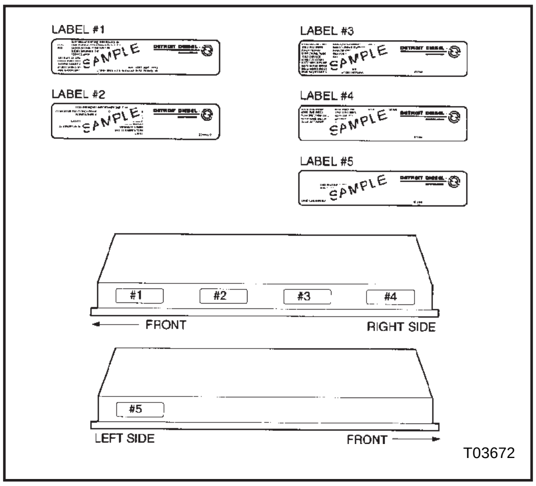

Figure 2: Rocker cover with Option Label

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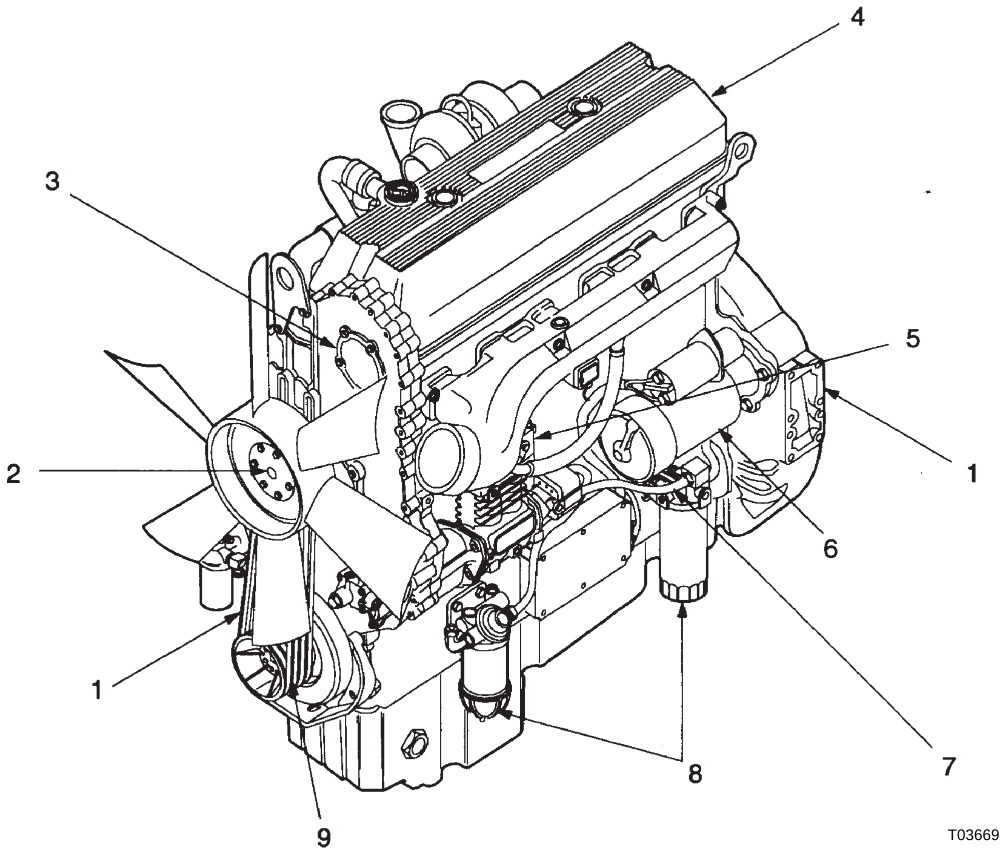

1. Engine / transmission mounts
2. Fan hub (not applicable)
3. Tachometer drive (not applicable)
4. Rocker cover
5. Air compressor
6. Starter motor
7. Fuel lines and flexible hoses
8. Fuel filters
9. Drive belts

Figure 3: Location of components and systems to be maintained

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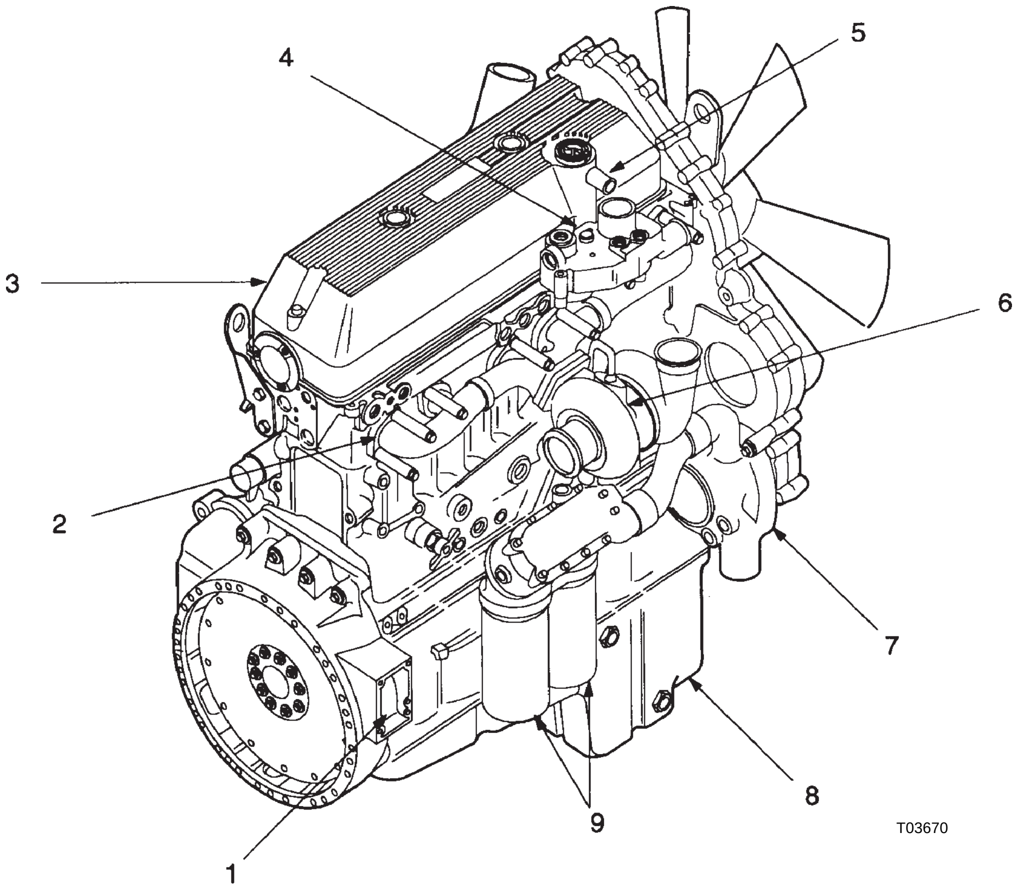

1. Engine mounts
2. Exhaust system
3. Rocker cover
4. Thermostats and seals
5. Crankcase breather
6. Turbocharger
7. Water pump
8. Oil pan
9. Lubricating oil filters

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Figure 4: Location of components and systems to be maintained

LUBRICATING OIL SYSTEM

OIL RECOMMENDATIONS

See section "Lubricants and Fluids".

TO CHECK OIL LEVEL

Check the oil level with the engine stopped and the coach on level ground. If the engine has just been stopped and is warm, wait approximately 20 minutes to allow the oil to drain back to the oil pan.

Never operate the engine with oil level below the "L" (Low) mark or above the "F" (Full) mark on the dipstick.
If necessary, add oil until it reaches the "F" (Full) mark on the dipstick. The difference between the "L" (Low) mark and the "F" (Full) mark on the dipstick amounts to 6 U.S. Qts.

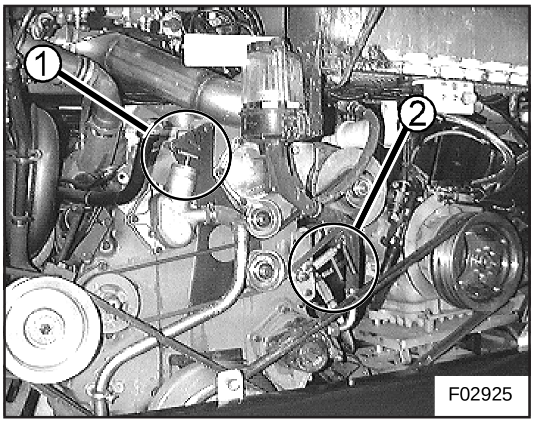

Figure 5: Engine oil filler tube and dipstick

1. Filler tube
2. Dipstick

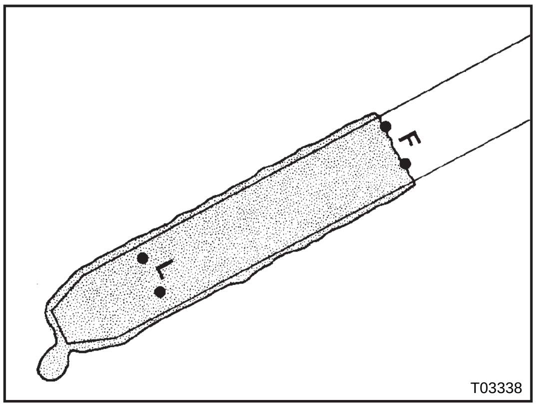

Figure 6: Dipstick marks

TO CHANGE OIL AND OIL FILTER

!!! CAUTION !!!
AVOID DIRECT CONTACT OF HOT OIL WITH YOUR SKIN. HOT LUBRICATING OIL CAN CAUSE PERSONAL INJURY.

1. Position the coach on level ground.
2. If the engine is cold, run until it is warm.

NOTE
WHEN REMOVING OR INSTALLING A SIDE PLUG, HOLD THE FLATS OF THE INSERT WITH A 2 1/8 IN., OR LARGER, OPEN END ADJUSTABLE WRENCH TO KEEP IT FROM TURNING. IF THE INSERT IS LOOSENED, IT MAY BE NECESSARY TO REMOVE THE OIL PAN, AND RETIGHTEN THE NUT TO PREVENT A POSSIBLE OIL LEAK.

3. Remove the drain plug on the bottom of the oil pan. Drain lube oil into a suitable container. Always dispose of used lubrication oil in an environmentally responsible manner, according to EPA and state recommendations.

4. Coat drain plug (s) with Loctite PT 7271 sealant (or equivalent). Install and tighten to 33-41 ft.lbf.

5. Remove the spin-on filter cartridges using a strap wrench tool.

6. Dispose of the used oil and filters in an environmentally responsible manner, according to EPA and state recommendations.

7. Clean the filter adaptor with a clean, lint-free cloth.

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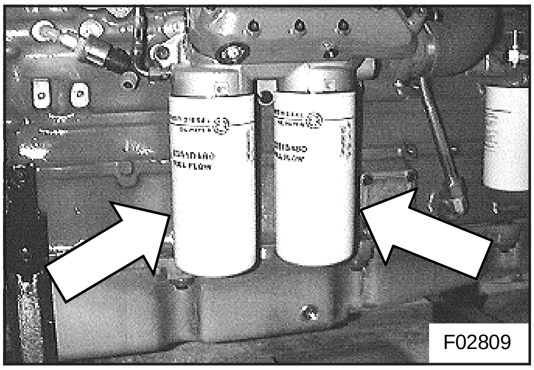

Figure 7: Lubricating oil filters

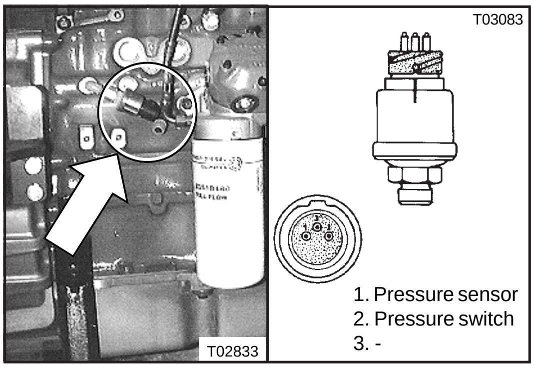

Figure 8: Oil pressure sensor located near lubricating oil filters

8. Lightly coat the filter gaskets with clean engine oil.
9. Start the new filters on the adaptor, and tighten by hand until the gaskets touch the mounting adaptor head. Tighten filters an additional two-thirds turn by hand.
10. Add oil as required to bring the level to the "Full" mark on the dipstick.
11. Start and run the engine for a short period, and check for leaks. After leaks have been corrected, stop the engine long enough for the oil to drain back into the oil pan (approx. 20 minutes). Add oil as required to bring the level to the proper mark on the dipstick.

SENSOR OF OIL PRESSURE GAUGE ON INSTRUMENT PANEL

The pressure sending unit is located near the lubricating oil filters. It combines a pressure switch with a pressure sensor in a sealed metal housing. Note that the pressure switch is not connected to your coach. The sensor sends a pressure depending signal to the oil pressure gauge on the instrument panel.

If you suspect a faulty pressure sensor, measure the resistance as follows:

1. Disconnect the pressure sending unit from its wiring harness.
2. Use a VOM to measure the resistance between terminal 1 and the engine block. The resistance is pressure-dependent (see table). If the resistance is not correct, replace the pressure sending unit.

Overpressure	Acceptable Resistance Range
0 psi	10^{+3}_{-5} Ohm
14.5 psi	48 ± 4 Ohm
29 psi	82 ± 4 Ohm
43.5 psi	116 ± 5 Ohm

Pressure range
sending unit: 0 to 72 psi overpressure

NOTE
DO NOT USE A THREAD SEALER WHEN INSTALLING SENDING UNIT. THE SEALER MAY INSULATE THE UNIT FROM THE ENGINE.

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OIL PRESSURE SENSOR OF DDEC SYSTEM

Refer to "Detroit Diesel Series 60 Service Manual".

OIL TEMPERATURE SENSOR OF DDEC SYSTEM

Refer to "Detroit Diesel Series 60 Service Manual".

AIR INTAKE SYSTEM

INSPECTIONS

Inspect intake piping for cracked hoses, loose clamps or punctures which may damage engine. Also, visually check charge air cooler for dirt and debris blocking the fins.

Tighten or replace parts as necessary to make sure air intake system does not leak.

AIR CLEANER

To check condition

Check the condition of the air-cleaner element daily the observing restriction indicator. If a red plunger appears in window (2) with the engine off, the air-cleaner element should be replaced as soon as possible. After the element has been replaced, push the reset button (1) to release the red plunger.

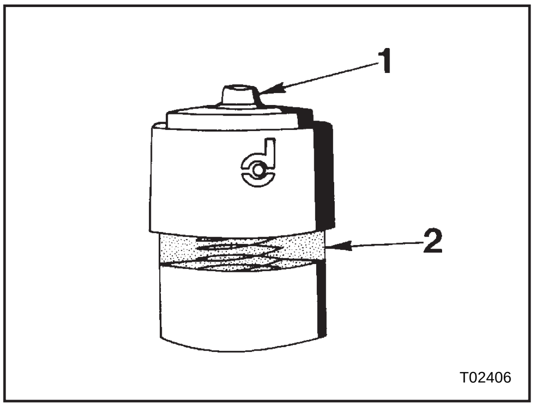

Figure 9: Air-cleaner restriction indicator

1. Reset button
2. Window

To check restriction indicator

Undo the restriction indicator hose at the air-cleaner outlet. Connect the hose end to a small vacuum pump (available from the retail trade). Actuate the pump until the pressure gauge registers the pressure indicated in Figure 10. A red plunger should rise into window (2, Figure 9) and stay there when the atmospheric pressure is restored at the restriction indicator connection. If the red plunger responds too soon, too late or not at all, replace the restriction indicator.

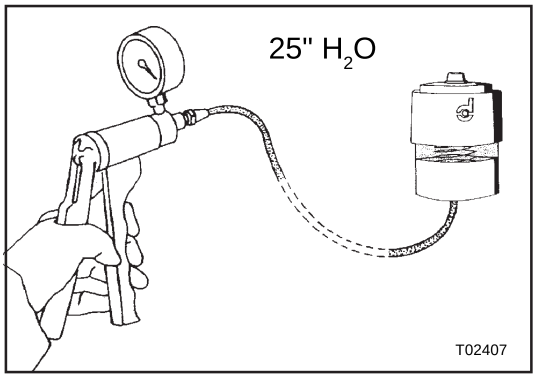

Figure 10: To check restriction indicator

Dump valve

The cleaner is equipped with a rubber dump valve(5, Figure 11). While the engine is running, this valve automatically expels dirt collected in the air-cleaner dust pan. From time to time, squeeze the valve body by hand in order to prevent the valve slit from sticking shut due to the presence of moisture in the air.

To change air-cleaner element

Change the air-cleaner element when the restriction indicator shows a red plunger after engine shutdown.

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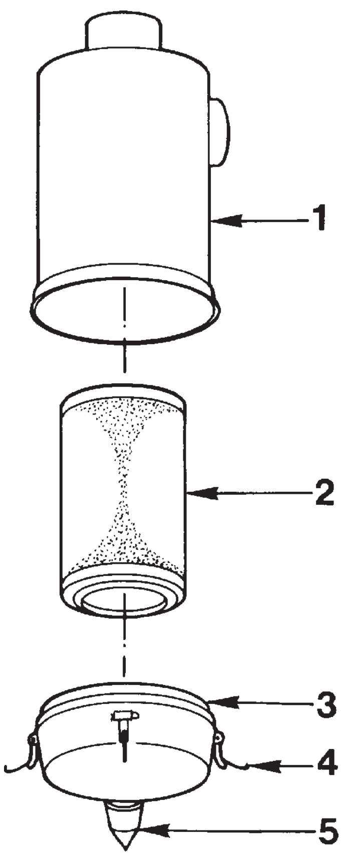

Figure 11: Air cleaner

Regardless of restriction indication, the element should be discarded after one year.

To change the element:

1. Stop the engine. Release toggle clips (4) and remove dust pan (3).

2. Gently pull element (2) off the outlet tube and out of housing (1). Avoid knocking the element against the housing. The element fits tightly over the outlet tube, creating the critical seal on the inside diameter of the air-cleaner end cap. The element should be removed gently to reduce the amount of dust dislodged. There will be some initial resistance, similar to breaking the seal on a jar. Gently twist the element clockwise and counterclockwise to disengage the seal.

3. Check the old element. This could help you detect foreign material on the sealing surface that is causing leakage. A streak of dust on the clean air side of the element is the tell-tale sign. If it exists, be sure the cause is removed before installing a new element.

4. Always clean the inside of the air-cleaner housing and outlet tube with a clean, damp cloth. Dirt accidentally transferred to the inside of the outlet tube will reach the engine and cause wear. Be careful not to damage the element sealing area on the tube.

5. Inspect the new element for damage. Always look for possible shipping or handling damage. Pay particular attention to the inside of the open end (the sealing area). Check for cuts, etc. Do not install a damaged element.

6. Install new element. The radial seal area is on the inside of the open end of the element. This critical sealing area will stretch slightly, adjust itself and distribute the sealing pressure evenly onto the outlet tube as the element is installed. To complete a tight seal, apply firm pressure at the outer rim of the element, not the flexible center. Due to its unique design, cover pressure is not necessary to compress the element seal.

7. Install dust cover so that dump valve (5) is downward and close toggle clips (4).

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FUEL SYSTEM

FUEL RECOMMENDATIONS

See section "Lubricants and Fluids".

TO DRAIN FUEL / WATER SEPARATOR

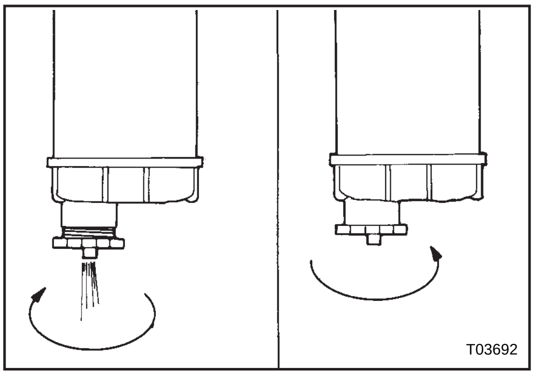

Figure 12: To drain fuel/water separator

1. Shut off engine.
2. Turn drain valve counterclockwise until draining occurs. Drain filter of water and sediment until clear fuel is visible.

!!! CAUTION !!!
DO NOT OVERTIGHTEN VALVE. OVERTIGHTENING CAN DAMAGE THE THREADS.

3. Turn valve clockwise to close drain valve.

TO CHANGE FUEL FILTERS

1. With the engine shut down, place a suitable container under the fuel/ water separator and the secondary fuel filter.
2. A fuel shutoff valve is installed on the discharge side of the secondary fuel filter. Turn the handle on the shutoff valve to the closed position (perpendicular to the valve).

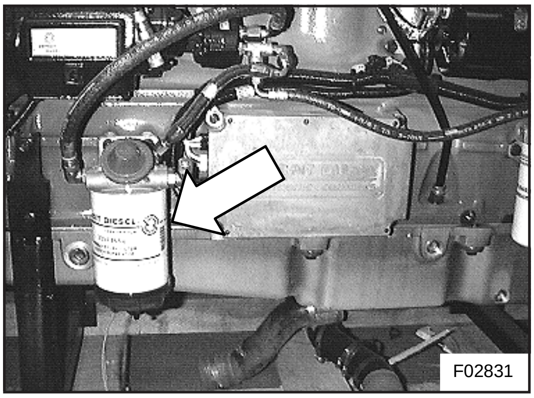

Figure 13: Fuel/water separator

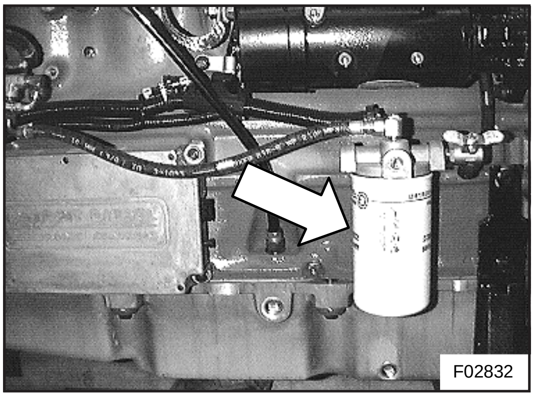

Figure 14: Secondary fuel filter

3. Using a suitable band type filter wrench, remove the secondary fuel filter.
4. Drain some fuel from the fuel/water separator by opening the drain valve. Using a strap wrench, remove the fuel/water separator element and bowl together. Remove the bowl from the element. The filter and bowl have standard right-hand threads, so turn counterclockwise to remove.
5. Dispose of the filters in an environmentally responsible manner, according to state and federal (EPA) recommendations.

NOTE
TO IMPROVE ENGINE STARTING, HAVE THE REPLACEMENT FILTERS FILLED WITH FUEL AND READY TO

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INSTALL IMMEDIATELY AFTER THE USED FILTER HAS BEEN REMOVED. THIS WILL PREVENT POSSIBLE SIPHONING AND FUEL SYSTEM AERATION.

6. To install secondary fuel filter.
   a. Fill new filter with clean fuel, and coat the gasket lightly with clean fuel.

NOTE
OVERTIGHTENING MAY CRACK OR DISTORT THE ADAPTOR.

   b. Thread the new filter onto the adaptor until it makes full contact with the gasket and no side movement is evident. Then rotate an additional one-half turn by hand.

7. To install fuel/water separator
   a. Clean the bowl and the O-ring seal.

NOTE
TO AVOID DAMAGING THE BOWL OR THE FILTER, DO NOT USE TOOLS WHEN TIGHTENING.

   b. Apply a light coating of clean fuel or grease to the O-ring seal, spin the bowl onto the new filter and tighten by hand.

   c. Fill the filter with clean fuel. Apply a light coating of clean fuel or grease to the new O-ring seal on the top of the filter. Spin the filter and the bowl assembly onto the filter head, and tighten by hand until snug.

8. Turn the handle on the shutoff valve to the open position (in line with the valve).

9. To eliminate air from the secondary filter and the fuel/water separator, operate the primer pump on the fuel/water separator head until the fuel purges at the filter assembly.

10. Start the engine and check for leaks. Correct any leaks with the engine off.

NOTE
UNDER NO CIRCUMSTANCES SHOULD THE STARTING MOTOR AND FUEL PUMP BE USED TO PRIME THE FUEL FILTERS. PROLONGED USE OF THE STARTING MOTOR AND FUEL PUMP TO PRIME THE FUEL SYSTEM CAN RESULT IN DAMAGE TO THE STARTER, FUEL PUMP, AND INJECTORS AND CAUSE ERRONEOUS RUNNING OF THE ENGINE BECAUSE OF AIR IN THE LINES AND FILTERS.

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DRIVE BELTS

Figure 15 shows belt types which can be found on Van Hool vehicles.

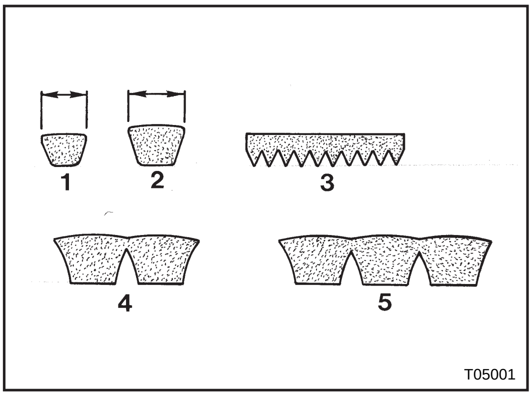

Figure 15: Belt types

1. Single V-belt (3/8" wide)
2. Single V-belt (1/2" wide)
3. V-ribbed belt
4. Joined V-belt (two-strand)
5. Joined V-belt (three-strand)

TO INSPECT V-BELTS

Change belts when they look frayed (worn) or when you notice one of the following defects:

1. Cracks in sides or bottom.
2. Soft, sticky sides, sometimes flaking. Swollen profile (rubber affected by grease or oil).
3. Glazed (burnt) sides.
4. Incisions or tears.

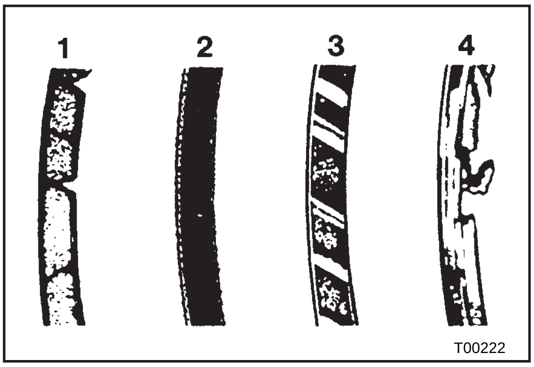

Figure 16: V-belt defects

TO INSPECT V-RIBBED BELT

Check them for intersecting cracks.Transverse (across the belt width) cracks are acceptable. Longitudinal (direction of belt length) cracks intersecting with transverse cracks are not acceptable. Replace belt if it is frayed or has pieces of material missing.

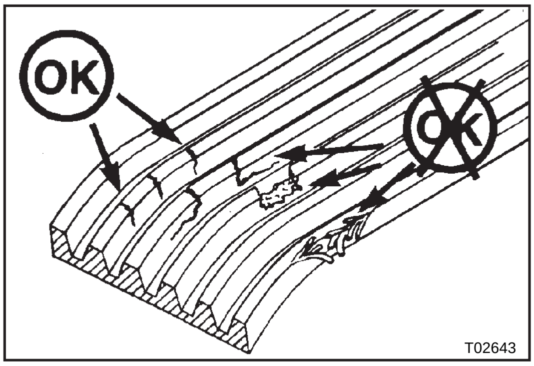

Figure 17: V-ribbed belt defects

TO CHANGE BELTS

Always replace belts of same drive as a pair. Always pull back tensioning device as far as possible when removing or installing belts. Never pry or roll belt over edge of pully. Even this action does not cause any immediately visible damage, belt-life is shortened by it. Once installed, the belts are tensioned according to the data in figure 27. During run-in, the new belt will stretch and part of the tension will be lost. Therefore, readjust belt tension to its initial value after first 20 minutes of operation.

TO USE BELT TENSION GAUGES

Click-type tension gauge (Krikit I)

NOTE
THE "KRIKIT I" IS CALIBRATED TO MEASURE V-BELT TENSIONS ONLY.

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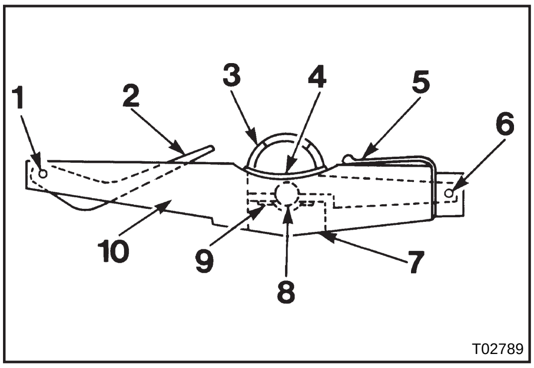

Figure 18: Click-type gauge (Krikit I)

1. **Pivot pin**
2. **Indicator arm**
3. **Finger loop**
4. **Pressure pad**
5. **Pocket clip**
6. **Pivot pin**
7. **Positioning flange**
8. **Spring**
9. **Ball bearing**
10. **Body**

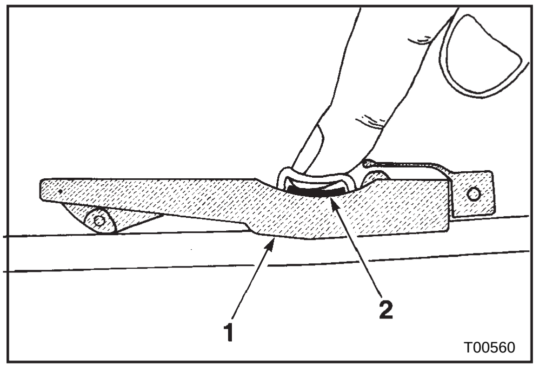

Figure 19: Holding the gauge

1. Flange
2. Pressure pad

1. Place "Krikit" on belt as shown in figure 19.
2. Push indicator arm (1, Figure 20) as far as possible inside gauge.
3. Center gauge between two pulleys. Flange (1, Figure 19) must be flat against top edge of belt.
4. Push pressure pad (2, Figure 19) very slowly at a right angle to top of belt until you hear or feel click release of tension spring under pad. IMMEDIATELY STOP PUSHING. Any more pressure will give you an inaccurate reading.

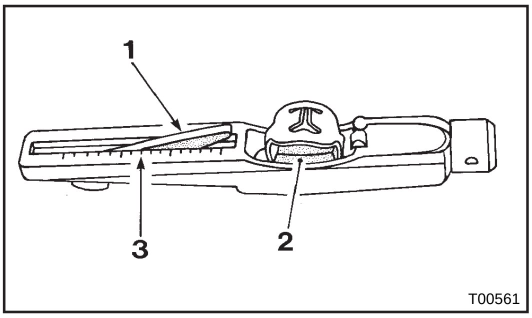

Figure 20: Reading the gauge

1. **Indicator arm**
2. **Pressure pad**
3. **Reading the correct tension here**

5. Read correct tension at spot where top of indicator arm (1, Figure 20) crossed the numbered scale at top of gauge body (see Figure 20).

Click-type tension gauge (Krikit II)

The "Krikit II" belt tension gauge, with the brightly colored pressure pad and indicator arm is calibrated to measure V-ribbed belt tensions.

NOTE
THERE IS NO FLANGE ON THE BOTTOM OF THE "KRIKIT II" TO ALIGN THE GAUGE PARALLEL TO THE EDGE OF THE BELT. PLACE THE GAUGE IN THE CENTER OF THE BELT AND ALIGN THE SIDES OF THE GAUGE PARALLEL TO THE EDGES OF THE BELT. BELT TENSION ACCURACY IS DEPENDENT ON THIS PROCEDURE.

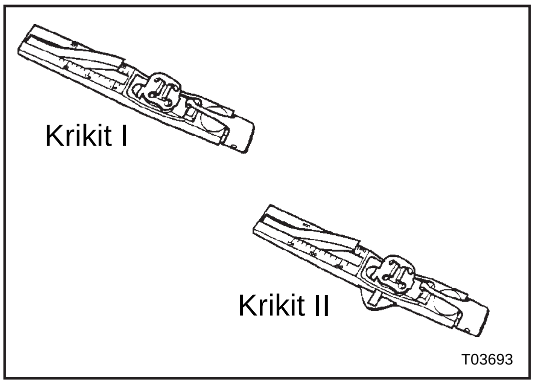

Figure 21: Differences between Krikit I and Krikit II

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1. Place "Krikit II" on the center of the V-ribbed belt so that the sides of the gauge are parallel to the edges of the belt and mid-way between any two pulleys.
2. Push slowly on the colored pad to get an accurate reading. When you feel and hear the "click", immediately stop pressing and remove the gauge carefully in order not to move the indicator arm.
3. How to read "Krikit II" accurately:
   a. Turn the gauge sideways to see the exact spot where the top of the indicator arm intersects the scale.
   b. Mark this spot with your thumbnail and turn the gauge to read the scale accurately.
   c. It is recommended that more than one tension reading be taken to assure repeatable measurements.

NOTE
THE "KRIKIT II" GAUGE SHOULD NOT BE USED ON BELTS WIDER THAN THE BOTTOM SURFACE OF THE GAUGE.

TO ADJUST BELT TENSION

Fan drive - Figure 22

1. Loosen pulley hub nut (1).

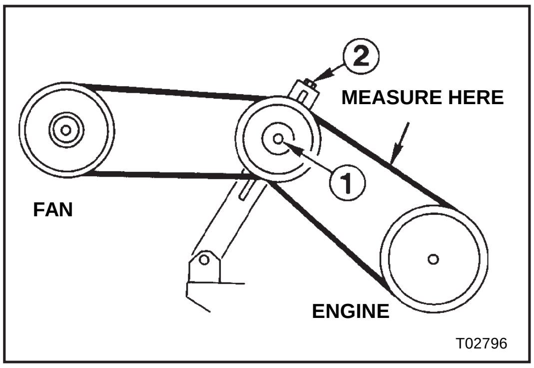

Figure 22: Adjusting fan drive belts

2. Turn hexagon head (2) of threaded adjusting rod to increase or reduce tension.
3. Retighten nut (1) to 50 ± 7 ft.lbf. torque.

HVAC compressor

Tensioning system (Figure 23)

The HVAC compressor belts are tensioned by air bellows (6) which receives regulated air pressure from air pressure regulator (2). Air release valve (5) is provided to release air pressure from air bellows (6) during belt replacement.

A rubber bumper (7) is mounted under compressor mounting plate. This provides adequate belt tension when there is no air pressure and provides also a dampening effect during normal running conditions.

It is important that rubber bumper (7) makes full contact with bottom of compressor mounting plate, enough to slightly compress the rubber. Periodic adjustment of rubber bumper is required after new V-belts are installed to ensure proper contact.

Belt replacement (Figure 23)

With air pressure applied to air bellows (6), remove rubber bumper (7) from under compressor mounting plate . Release air pressure with release valve (5). Allow compressor to pivot towards engine and remove belts.

NOTE
BEFORE INSTALLING THE NEW V-BELTS, IT IS RECOMMENDED TO CHECK COMPRESSOR CLUTCH/BEARING FOR EXCESSIVE PLAY.

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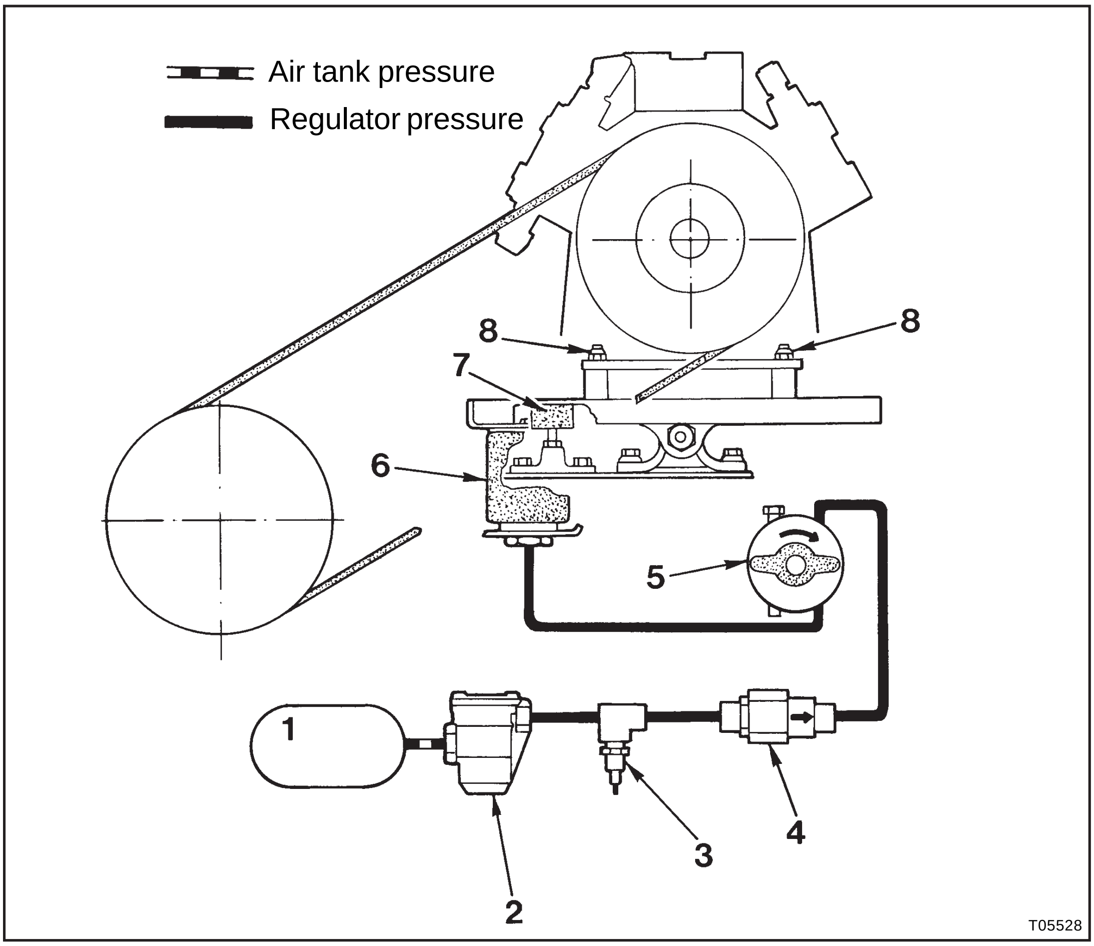

Figure 23: HVAC compressor belt tensioning system

1. Air tank
2. Pressure regulator
3. Test coupling
4. Single check valve
5. Air release valve
6. Air bellows
7. Rubber bumper
8. Mounting bolts

Install new belts and re-apply air pressure with release valve (5). Compressor mounting plate should now be positioned horizontally. If not, loosen the four compressor mounting bolts (8). Slide compressor left or right to achieve horizontal running position. Install rubber bumper (7) and adjust it to make full contact with underside of compressor mounting plate (enough to have slight contact with rubber).

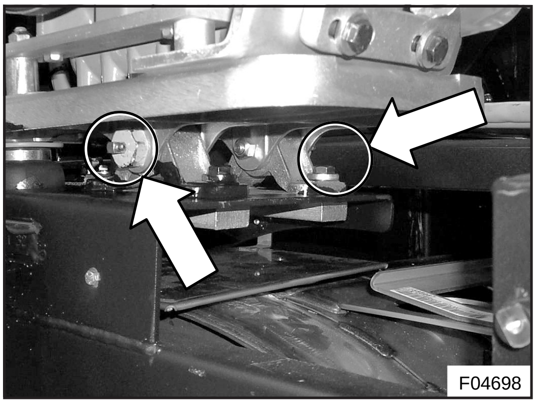

Figure 24: Compressor mounting pivot points

Compressor mounting pivot - Figure 24

Grease pivot bushings and check for play at intervals given in Maintenance Schedule.

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Air pressure regulator - Figure 23

Air pressure regulator (2) provides regulated air pressure to air bellows (6).

If belt tension is not correct:

1. Remove bottom cover (1, Figure 25)

2. Turn screw (2, Figure 25) :
- clockwise to increase air pressure
- counterclockwise to decrease air pressure

3. Install bottom protection cover.

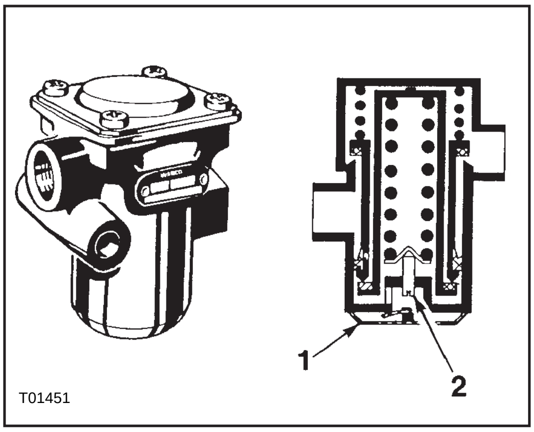

Figure 25: Air pressure regulator

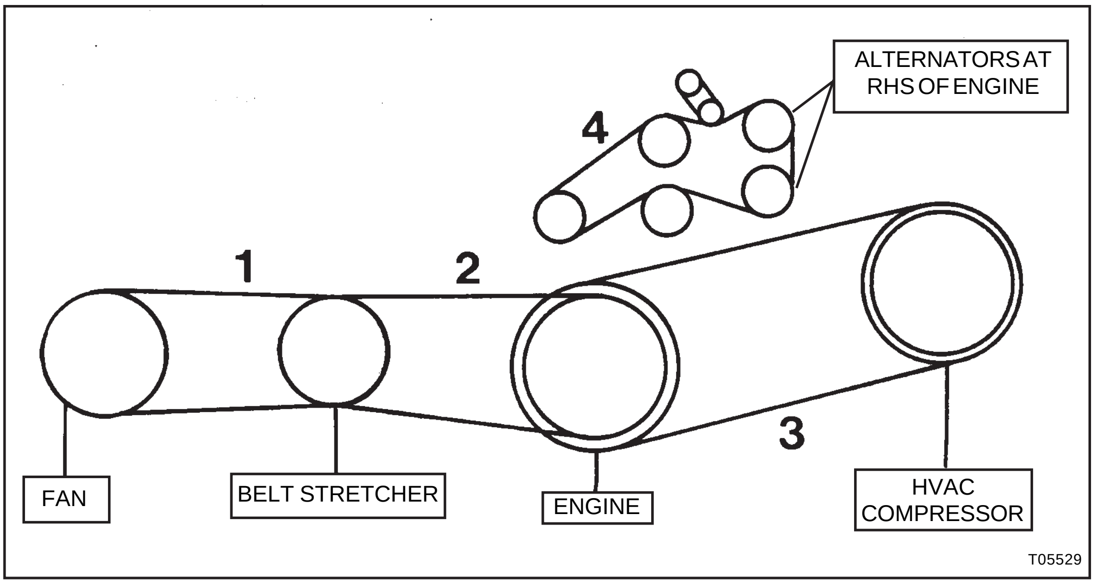

Figure 26: Drive belt diagram

NUMBER (See Figure 26)	BELT TENSION GAUGE	INSTALL AT		MAINTAIN TENSION AT	
		Newton	Lbf	Newton	Lbf
1	Krikit I	500-600	110-130	450-550	100-120
2	Krikit I	500-600	110-130	450-550	100-120
3	Krikit I	450-550	100-120	450-550	100-120
4	Automatic Belt Tensioner				

Figure 27: Drive belt tension chart

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ENGINE MOUNTING

TO CHECK TIGHTENING TORQUES

Check, at intervals given in Maintenance Schedule, torque of bolts and nuts (for tightening torques, see Figure 28). Inspect rubber for deterioration and age hardening. Replace any broken or lost bolts and screws. Replace any damaged rubber.

TO ADJUST REAR ENGINE MOUNTS

Check distances "A" (see figure 29) at the intervals given in the Maintenance Schedule. Distances "A" should be equal (approx. 0.01 inch). This can be checked by using a self-fabricated strip(0.01 x 1.18 x 4 inch).

If distances "A" aren't equal, reset as follows:

1. Slacken the three self-locking nuts (4) and pull movement limitation bracket down.
2. Insert self-fabricated strip in the gap between movement limitation bracket and engine mount.
4. Push movement limitation bracket fully up.
5. Tighten the three self-locking nuts to a torque of 66 ft.lbf.
6. Remove metal strip.

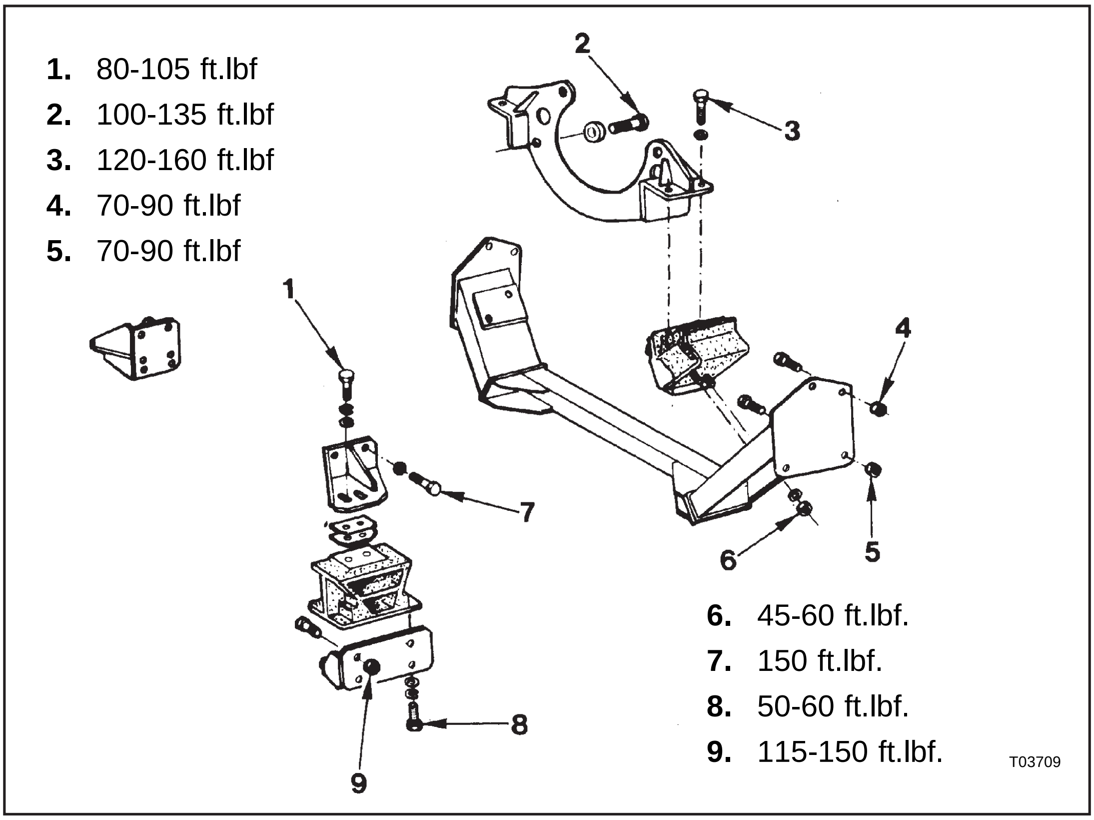

Figure 28: Engine mounting tightening torques

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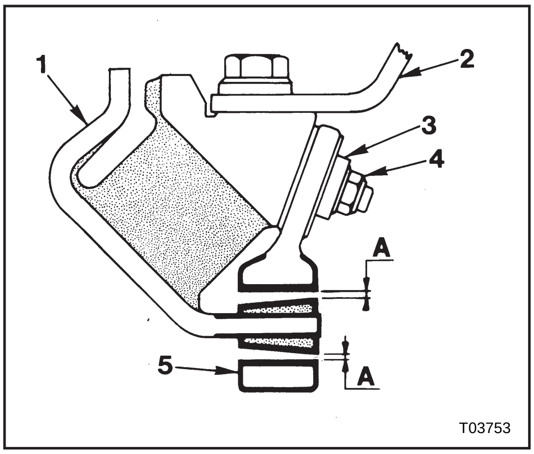

Figure 29: Engine rear mounting

1. Engine mount
2. Engine bracket
3. Washer
4. Self-locking nut
5. Movement limitation bracket

MISCELLANEOUS MAINTENANCE

TO CLEAN STEEL MESH PAD OF CRANKCASE BREATHER ASSEMBLY

Refer to "Detroit Diesel Series 60 Service Manual".

TO CHECK CRANKCASE PRESSURE

Refer to "Detroit Diesel Series 60 Troubleshooting Manual".

TO CHECK EXHAUST SYSTEM

Have the exhaust manifold retaining bolts and other connections checked for tightness.

TO CHECK VIBRATION DAMPER

The viscous vibration damper should be inspected periodically and replaced if dented or leaking. Heat from normal engine operation may, over a period of time, cause the fluid within the viscous vibration damper to break down and lose it dampening properties.

TO STEAM CLEAN THE ENGINE

NOTE
DO NOT APPLY STEAM OR SOLVENT DIRECTLY TO THE ALTERNATOR, STARTING MOTOR, DDEC COMPONENTS, SENSORS OR OTHER ELECTRICAL COMPONENTS, AS DAMAGE TO ELECTRICAL EQUIPMENT MAY RESULT.

TO INSPECT AIR COMPRESSOR

Refer to chapter 6.1 "Air compressor".

PURAGUARD FILTER

Only installed on vehicles with Exhaust Gas Recirculation system (EGR).

The filter is installed in the air line to the EGR valve.

To drain PuraGuard filter

1. Park the vehicle on a level surface and chock the wheels.
2. Completely drain the entire air system by using the drain cocks on the air tanks.
3. Drain the contents of the sump into a suitable container for disposal and then re-close the drain valve.

To change PuraGuard filter element

1. Park the vehicle on a level surface and chock the wheels.

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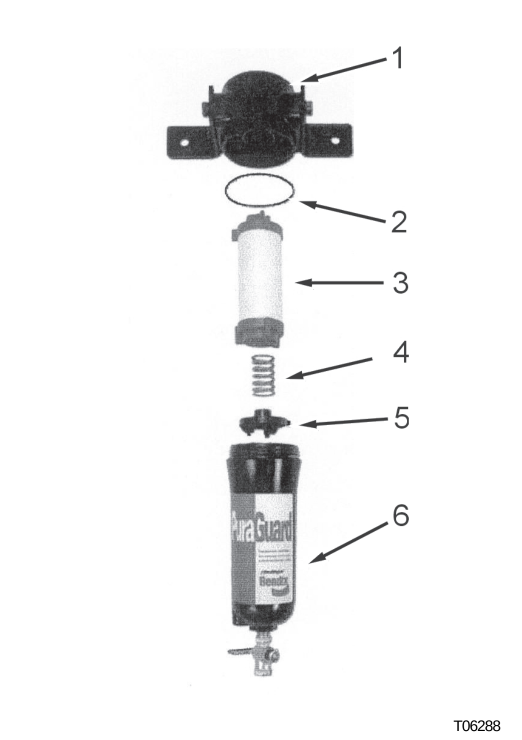

Figure 30: PuraGuard filter

1. **Filter head**
2. **Large O-ring**
3. **Filter element**
4. **Spring**
5. **Spring locator**
6. **Sump housing**

2. Completely drain the entire air system by using the drain cocks on the air tanks.

3. Drain the contents of the sump into a suitable container for disposal and then re-close the drain valve.

4. Using detergent and water, clean the exterior of the filter.

5. Unscrew the sump housing. If necessary, use a strap wrench to assist this process.

6. Remove and discard the filter and O-ring.

7. Inspect the filter for broken or missing parts. Replace as necessary.

8. Inspect the drain valve for any build-up that could impair its function. Clean as necessary.

9. Install the replacement O-ring into the channel in the filter head.

10. Insert the replacement filter (guide lands uppermost) into the sump with its base resting on the spring.

11. Coat the threads of the sump housing using barium or lithium grease. Sufficient torque to install the sump will be produced by turning the housing by hand until fully hand-tight. Take care not to damage the large O-ring when installing the sump housing.

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OVERHAUL

TO ASSEMBLY FAN DRIVE IDLER PULLEY- Figure 31

1. Clean pulley thoroughly with solvent. Dry with compressed air.

NOTE:
DO NOT USE GREASE DURING INSTALLATION.

2. Install dust cover (1). Note direction of cover.
3. Press in bearing (2) with special VH drift (see Figure 32) or equivalent. If using equivalent tool, make sure bearing is pressed in by the outer race.
4. Install gold colored spacer ring (3).
5. Press in bearing (4) with special VH drift (see Figure 32) or equivalent. If using equivalent tool, make sure bearing is pressed in by the outer race.
6. Install dust cover (5). Note direction of cover.
7. Install aluminum colored spacer ring (6) with countersunk side facing upwards.
8. Install snap ring (7).
9. Clean the inner race of both bearings and the pulley shaft with Loctite 7061 or equivalent.
10. Apply Loctite 603 evenly to the inner race of both bearings and the pulley shaft.
11. Slide pulley shaft in by hand starting from the opposite side of the snap ring.

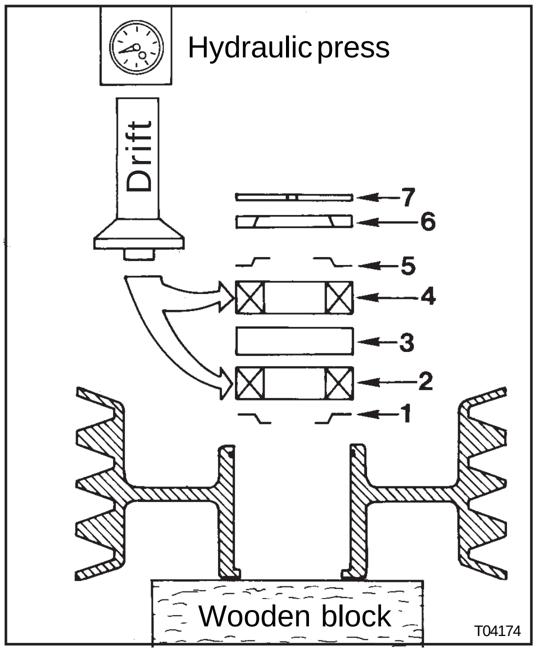

Figure 31: To assemble idler pulley

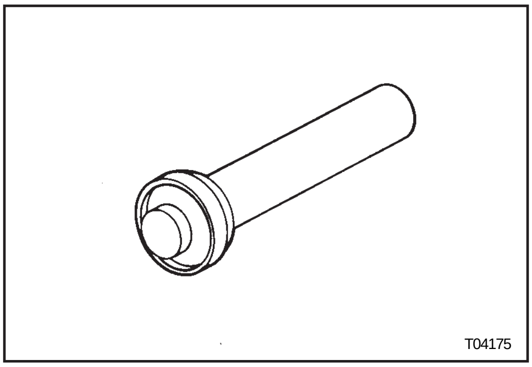

Figure 32: Bearing installation drift (VH 10616471)

12. Move the shaft back and forth to spread Loctite 603 evenly.
13. Push shaft fully in.
14. Wipe off excess Loctite.
15. Allow to dry for 6 hours before installing on coach.

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CUMMINS ENGINE CONTROLS

ELECTRONIC FUEL INJECTION SYSTEM OF CUMMINS ISM ENGINE

DESCRIPTION

The Cummins ISM system is an electronically controlled fuel injection system which increases fuel economy and reduces exhaust emissions. It does this by controlling the torque and horsepower curve, air fuel control (AFC) function, engine high speed, low idle and maximum road speed.
The heart of the ISM system is a microprocessor called the electronic control module (ECM). The ECM gathers vital information regarding the engine's operating conditions through the sensor harness and the OEM harness. The ECM calculates this information and immediately controls the electro-mechanical injectors through the actuator harness where fuel metering and timing are regulated.

The ISM system also incorporates adjustable controls for the low idle, fast idle, cruise control, engine brake (optional), fan clutch, and road speed.

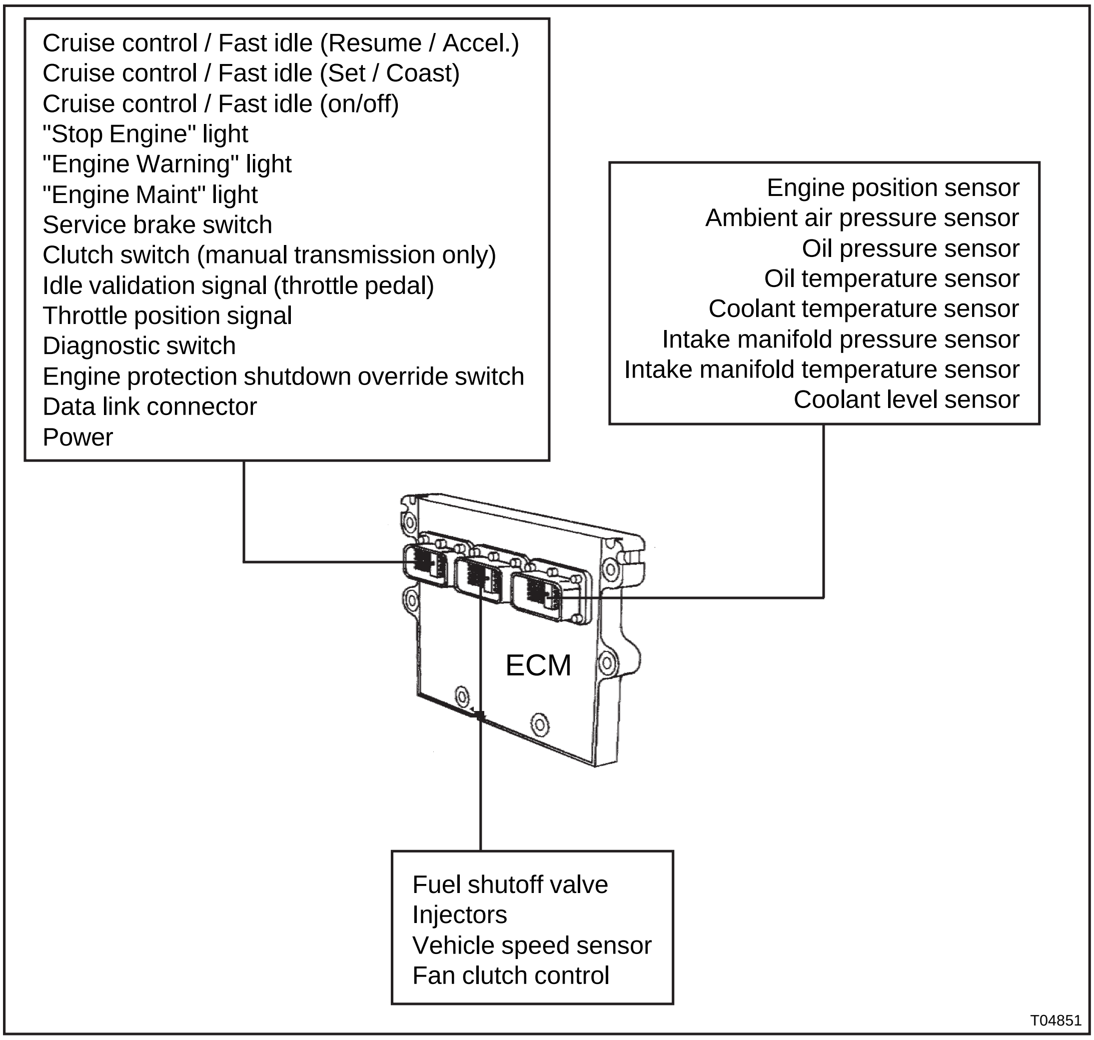

Figure 1: ISM system layout

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ADJUSTMENTS

Refer to the Cummins literature for information regarding adjustments to the features and parameters of the ISM system.

DIAGNOSTIC FAULT CODES

If something should happen to one of the sensors, or if the engine is operated outside normal operating conditions, the ISM system will show and record the problem as a fault code.

If a system fault should occur, one of the following warning lights on the instrument panel will illuminate. If the light stays on it means that the fault is "active" and the fault code can be blinked out with the warning lights. If the light goes out it means that the fault is "inactive", however the ECM will record the information and it can be checked by a Cummins diagnostic tool.

ENGINE MAINT

The "ENGINE MAINT" light will come on at the occurrence of any of the following out-of limit conditions:

- coolant temperature;
- oil temperature;
- intake manifold air temperature;
- oil pressure;
- coolant level.

The lamp will remain on as long as the fault exists, and engine power and speed will gradually be reduced. If the out-of-range conditions continue, the light will start to flash or blink.
A 30 second shutdown (=stepped, powerdown sequence until it shuts down completely) sequence will begin. Momentarily depress the "Protection-override" dashswitch to override the emergency shutdown during a 30 second period. To obtain a subsequent override of 30 seconds, the switch must be recycled.

!!! CAUTION !!!
THE STOP ENGINE OVERRIDE MUST BE USED ONLY IN EMERGENCY, SUCH AS MOVING THE VEHICLE OUT OF TRAFFIC. EXCESSIVE USE COULD CAUSE SEVERE ENGINE DAMAGE.

ENGINE WARNING

The "ENGINE WARNING" light will illuminate if the system or one of the components has a problem. The vehicle can still be driven safely however the fault must be corrected as soon as possible.

STOP ENGINE

The "STOP ENGINE" warning light will illuminate if a serious system failure has occurred. The vehicle should be stopped as safely as possible and the engine shut down. The vehicle must remain parked as long as the fault exists.

CRUISE CONTROL AND FAST IDLE

The cruise control switches located on the dashboard serve a dual purpose. They are designed to control both the cruise control and fast idle systems.

Cruise control

The cruise control can be operated providing the following conditons are met:

- Service brake released
- Jake Brake OFF
- Engine speed above 1,000 rpm
- Vehicle speed above 30 mph

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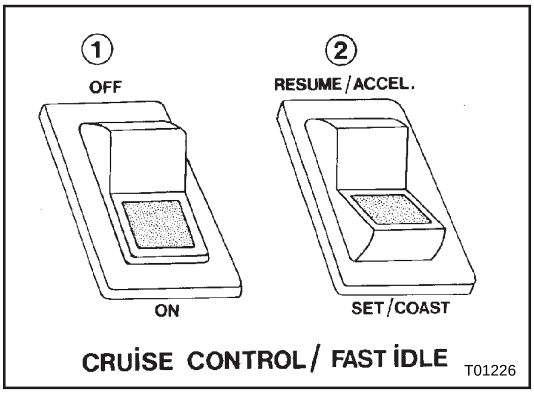

Figure 2: Cruise control / fast idle switches

Fast idle

The fast idle can be operated provided the following conditions are met:

- Park brake applied
- Service brake released
- Transmission in neutral
- Jake Brake OFF
- Throttle pedal released

It is important to operate the fast idle when operating the HVAC system while parked in order to maintain sufficient electrical power.

With switch (1) in the "ON" position, push and release switch (2) in the:

- "RESUME / ACCEL." position to maintain a 1,200 rpm fast idle speed;

- "SET / COAST" position to maintain a 900 rpm fast idle speed.

By holding switch (2) in the "RESUME / ACCEL." position, the fast idle will gradually increase to a maximum speed of 1,400 rpm.

By holding switch (2) in the "SET / COAST" position, the fast idle will gradually decrease to a minimum speed of 850 rpm.

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TO RETRIEVE ACTIVE FAULT CODES

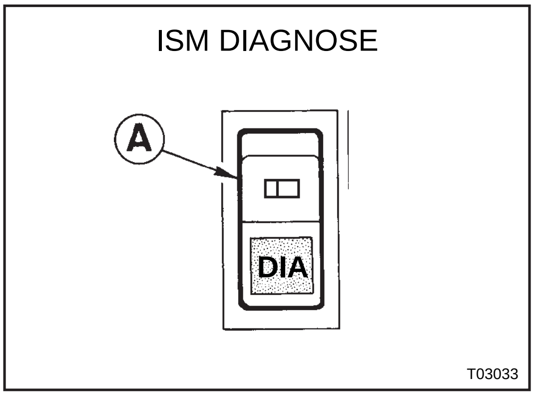

Figure 3: Engine diagnostic switch on instrument panel

Active fault codes can be blinked out of the warning lights. This is done by operating the diagnostic switch located on the instrument panel.

1. Unlock switch "A" and push lower part.
2. Insert ignition switch key and turn ignition "on".
3. If any fault codes were active during system power down, the "engine warning" and "stop engine" lights will begin to flash the code of the recorded faults. If no fault codes are recorded, the lights will not flash but be be illuminated.

The fault code will flash in the following sequence:

First, the "ENGINE WARNING" light will flash. There will be a short pause, lasting for one to two seconds. After that the flashing of the "STOP ENGINE" light will indicate the number of the recorded fault. there will be an one- or two-second pause between two consecutive numbers. Then the "Engine warning" light will come on, signaling that the end of the fault code number has been reached. The three-digit code code number will continue repeating itself until the system is instructed otherwise.

To go to the next fault code, momentarily push switch (2, Figure 2) into the "RESUME/ACCEL" position. This takes you to the fault code recorded next. You can return to the previous fault code by momentarily pushing this switch into the "SET/COAST" position. If only one fault code has been recorded, the ISM system will continuously display the same fault code, when lower or upper part of this switch is momentarily pushed.

!!! CAUTION !!!
DO NOT FORGET TO SWITCH OFF (UPPER PART PUSHED) SWITCH "A" WHEN NOT USING THE DIAGNOSTIC SYSTEM.

Road relay option

Active fault codes can also be displayed by the "Road Relay" (option). If a fault code is active, the Road Relay will display a fault / alarm message. The fault codes can be viewed by depressing and holding down the "wrench" button. If more than one fault code is active, the codes will scroll every three to five seconds. Refer to next page for fault code list.

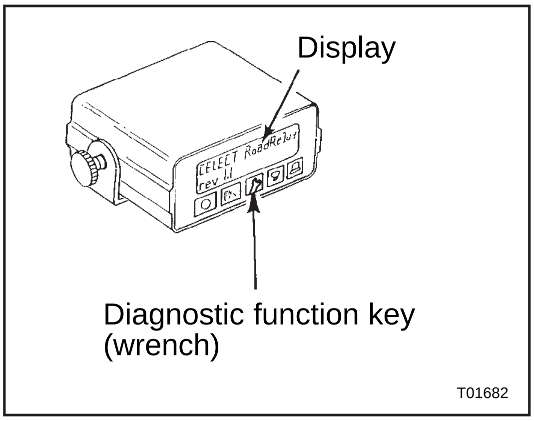

Figure 4: Road relay

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ISM FAULT CODE INFORMATION

Fault code	Lamp	PID (P) SID (S)	FMI	SPN	Reason	Effect
111	Red	S254	12	629	Error internal to the ECM related to memory hardware failures or internal ECM voltage supply circuits.	Engine will not start.
115	Red	P190	2	190	No engine speed signal detected at BOTH engine position sensor circuits.	Engine will die and will not start.
121	Yellow	P190	10	190	No engine speed signal detected at one of the engine position sensor circuits.	None on performance.
122	Yellow	P102	3	102	High voltage detected at intake manifold pressure circuit.	Derate in power output of the engine.
123	Yellow	P102	4	102	Low voltage detected at intake manifold pressure circuit.	Derate in power output of the engine.
131	Red	P091	3	91	High voltage detected at throttle position signal circuit.	Severe derate (power and speed). Limp home power only.
132	Red	P091	4	91	Low voltage detected at throttle position signal circuit.	Severe derate (power and speed). Limp home power only.
133	Red	P029	3	29	High voltage detected at remote throttle position signal circuit.	None on performance if remote throttle is not used.
134	Red	P029	4	29	Low voltage detected at remote throttle position signal circuit.	None on performance if remote throttle is not used.
135	Yellow	P100	3	100	High voltage detected at oil pressure circuit.	No engine protection for oil pressure.
141	Yellow	P100	4	100	Low voltage detected at oil pressure circuit.	No engine protection for oil pressure.

Fault code	Lamp	PID (P) SID (S)	FMI	SPN	Reason	Effect
143	Maint	P100	1	100	Oil pressure signal indicates oil pressure below the low oil pressure engine protection limit.	Progressive power derate with increasing time from alert. If Engine protection shutdown feature is enabled, engine will shut down 30 seconds after warning lamp starts flashing.
144	Yellow	P110	3	110	High voltage detected at coolant temperature circuit.	Possible white smoke. Fan will stay ON if controlled by ECM. No engine protection for coolant temperature.
145	Yellow	P110	4	110	Low voltage detected at coolant temperature circuit.	Possible white smoke. Fan will stay ON if controlled by ECM. No engine protection for coolant temperature.
151	Maint	P110	0	110	Coolant temperature signal indicates coolant temperature above 220 °F.	Progressive power derate with increasing time from alert. If Engine protection shutdown feature is enabled, engine will shut down 30 seconds after warning lamp starts flashing.
153	Yellow	P105	3	105	High voltage detected at intake manifold temperature circuit.	Possible white smoke. Fan will stay ON if controlled by ECM. No engine protection for intake manifold temperature.
154	Yellow	P105	4	105	Low voltage detected at intake manifold temperature circuit.	Possible white smoke. Fan will stay ON if controlled by ECM. No engine protection for intake manifold temperature.
155	Maint	P105	0	105	Intake manifold temperature signal indicates intake manifold temperature above 190 °F.	Progressive power derate with increasing time from alert. If Engine protection shutdown feature is enabled, engine will shut down 30 seconds after warning lamp starts flashing.
187	Yellow	S232	4	620	Low voltage detected on the ECM voltage supply line to some sensors.	Engine will run derated. No engine protection for oil pressure and coolant level.

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Fault code	Lamp	PID (P) SID (S)	FMI	SPN	Reason	Effect
212	Yellow	P175	3	175	High voltage detected at oil temperature circuit.	No engine protection for oil temperature.
213	Yellow	P175	4	175	Low voltage detected at oil temperature circuit.	No engine protection for oil temperature.
214	Maint	P175	0	175	Oil temperature signal indicates oil temperature above 255 °F.	Progressive power derate with increasing time from alert. If Engine protection shutdown feature is enabled, engine will shut down 30 seconds after warning lamp starts flashing.
216	Yellow	P046	3	46	High voltage detected at air compressor tank pressure signal circuit.	Air compressor will run continuously.
217	Yellow	P046	4	46	Low voltage detected at air compressor tank pressure signal circuit.	Air compressor will run continuously.
218	Yellow	P046	2	46	Voltage at air compressor tank pressure signal indicates air compressor tank pressure is too high or too low.	Air compressor will run continuously.
219	Maint	P098	1	98	Low oil level was detected in the Centinel makeup oil tank.	None on performance. Centinel system deactivated.
221	Yellow	P108	3	108	High voltage detected at ambient air pressure circuit.	Derate in power output of the engine.
222	Yellow	P108	4	108	Low voltage detected at ambient air pressure circuit.	Derate in power output of the engine.
223	Yellow	S154	11	614	Incorrect voltage detected on the Centinel actuator circuit by the ECM.	None on performance. Centinel system deactivated.
227	Yellow	S232	3	620	High voltage detected on the ECM voltage supply line to some sensors.	Engine will run derated. No engine protection for oil pressure and coolant level.

Fault code	Lamp	PID (P) SID (S)	FMI	SPN	Reason	Effect
234	Red	P190	0	190	Engine speed signal indicates engine speed greater than 2730 rpm.	Fuel shutoff valve closed until engine speed falls to 2184 rpm.
235	Maint	P111	1	111	Coolant level signal indicates coolant level is below normal range.	Progressive power derate with increasing time from alert. If Engine protection shutdown feature is enabled, engine will shut down 30 seconds after warning lamp starts flashing.
241	Yellow	P084	2	84	The ECM lost the vehicle speed signal.	Engine speed limited to maximum vehicle speed w/o VSS parameter value. Cruise control, Gear-Down Protection, and Road Speed Governor will not work.
242	Yellow	P084	10	84	Invalid or inappropriate vehicle speed signal detected. Signal indicates an intermittent connection or VSS tampering.	Engine speed limited to maximum vehicle speed w/o VSS parameter value. Cruise control, Gear-Down Protection, and Road Speed Governor will not work.
245	Yellow	S033	4	647	Less than 6 volts detected at Fan clutch circuit when on indicates an excessive current draw from the ECM or faulty ECM output circuit.	The fan may stay on at all times.
249	Yellow	P171	3	171	High voltage detected on the ambient air temperature circuit.	None on performance. The idle shutdown ambient air temperature override feature will use the intake air temperature sensor value to determine idle shutdown and availability of override.
254	Red	S017	4	632	Less than 6 volts detected at FSO circuit when on indicates an excessive current draw from the ECM or faulty ECM output circuit.	The ECM turns off FSO supply voltage. The engine will shutdown.
255	Yellow	S026	3	701	Externally supplied voltage detected going to the Fuel Shutoff supply circuit.	None on performance. FSO stays open.

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Fault code	Lamp	PID (P) SID (S)	FMI	SPN	Reason	Effect
256	Yellow	P171	4	171	Low voltage detected on the ambient air temperature circuit.	None on performance. The idle shutdown ambient air temperature override feature will use the intake air temperature sensor value to determine idle shutdown and availability of override.
285	Yellow	S231	9	639	The ECM expected information from a multiplexed device but did not receive it soon enough or did not receive it at all.	At least one multiplexed device will not operate properly.
286	Yellow	S231	13	639	The ECM expected information from a multiplexed device but only received a portion of the necessary information.	At least one multiplexed device will not operate properly.
287	Red	S091	2	91	The OEM vehicle electronic control unit (VECU) detected a fault with its throttle pedal.	The engine will only idle.
288	Red	S029	2	29	The OEM vehicle electronic control unit (VECU) detected a fault with the remote throttle.	The engine will not respond to the remote throttle.
295	Yellow	P108	11	108	An error in the ambient air pressure sensor signal was detected by the ECM.	Engine is derated to no-air setting.
311	Yellow	S001	6	651	Current detected at the injector for cylinder 1 when voltage is turned off.	The injector for cylinder 1 is turned off.
312	Yellow	S005	6	655	Current detected at the injector for cylinder 5 when voltage is turned off.	The injector for cylinder 5 is turned off.
313	Yellow	S003	6	653	Current detected at the injector for cylinder 3 when voltage is turned off.	The injector for cylinder 3 is turned off.
314	Yellow	S006	6	656	Current detected at the injector for cylinder 6 when voltage is turned off.	The injector for cylinder 6 is turned off.

Fault code	Lamp	PID (P) SID (S)	FMI	SPN	Reason	Effect
315	Yellow	S002	6	652	Current detected at the injector for cylinder 2 when voltage is turned off.	The injector for cylinder 2 is turned off.
319	Maint	P251	2	251	Real time clock lost power .	None on performance. Data in the ECM will not have accurate time and date information.
321	Yellow	S004	6	654	Current detected at the injector for cylinder 4 when voltage is turned off.	The injector for cylinder 4 is turned off.
322	Yellow	S001	5	651	No current detected at the injector for cylinder 1 when voltage is turned on.	The injector for cylinder 1 is turned off.
323	Yellow	S005	5	655	No current detected at the injector for cylinder 5 when voltage is turned on.	The injector for cylinder 5 is turned off.
324	Yellow	S003	5	653	No current detected at the injector for cylinder 3 when voltage is turned on.	The injector for cylinder 3 is turned off.
325	Yellow	S006	5	656	No current detected at the injector for cylinder 6 when voltage is turned on.	The injector for cylinder 6 is turned off.
331	Yellow	S002	5	652	No current detected at the injector for cylinder 2 when voltage is turned on.	The injector for cylinder 2 is turned off.
332	Yellow	S004	5	654	No current detected at the injector for cylinder 4 when voltage is turned on.	The injector for cylinder 4 is turned off.
338	Yellow	S151	3	611	Voltage detected on the Idle Shutdown Vehicle Accessory Relay circuit when no voltage was being supplied by the ECM.	Vehicle accessories controlled by the Idle Shutdown Vehicle Accessory Relay will not power down.

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Fault code	Lamp	PID (P) SID (S)	FMI	SPN	Reason	Effect
339	Yellow	S151	4	611	Less than 6 volts detected at the Idle Shutdown Vehicle Accessory Relay circuit when on indicates an excessive current draw from the ECM or faulty ECM output circuit.	Vehicle accessories controlled by the Idle Shutdown Vehicle Accessory Relay will not power down.
341	Yellow	S254	12	629	Severe loss of data from the ECM.	Possible no noticeable performance effects or engine dying or hard starting. Fault information, trip information, and maintenance monitor data may be inaccurate.
343	Yellow	S254	12	629	Internal ECM error.	Possible none on performance or severe derate.
352	Yellow	S232	4	620	Low voltage detected on the ECM voltage supply line to some sensors.	Engine is derated to no-air setting.
386	Yellow	S232	3	620	High voltage detected on the ECM voltage supply line to some sensors.	Engine is derated to no-air setting.
387	Yellow	P091	3	91	High voltage detected on the ECM voltage supply line to the throttle(s).	Engine will only idle.
388	Yellow	S079	11	1072	Less than 6 volts detected at engine brake circuit 1 when on indicates an excessive current draw from the ECM or faulty ECM output circuit.	Engine brake 1 can not be activated.
392	Yellow	S080	11	1073	Less than 6 volts detected at engine brake circuit 2 when on indicates an excessive current draw from the ECM or faulty ECM output circuit.	Engine brake 2 can not be activated.
412	None	S250	3	608	The ECM cannot transmit over the J1587 datalink.	None on performance. J1587 devices may not operate.
414	None	S250	9	608	The ECM expected information over the J1587 datalink but did not receive it soon enough.	None on performance. J1587 devices may not operate.

Fault code	Lamp	PID (P) SID (S)	FMI	SPN	Reason	Effect
415	Red	P100	1	100	Oil pressure signal indicates oil pressure below the very low oil pressure engine protection limit.	Possible no noticeable performance effects or engine dying or hard starting. Fault information, trip information, and maintenance monitor data may be inaccurate.
418	Maint	P097	0	97	Water has been detected in the fuel filter.	Possible white smoke, loss of power, or hard starting
419	Yellow	P102	11	102	An error in the intake manifold pressure sensor signal was detected by the ECM.	Engine is derated to no-air setting.
422	Yellow	P111	2	111	Voltage detected simultaneously on both the coolant level high and low signal circuits or no voltage detected on both circuits.	No engine protection for coolant level.
426	None	S231	3	639	Communication between the ECM and another device on the J1939 datalink has been lost.	None on performance. J1939 devices may not operate.
428	Yellow	P097	3	97	High voltage detected at water-in-fuel sensor circuit.	None on performance.
429	Yellow	P097	4	97	Low voltage detected at water-in-fuel sensor circuit.	None on performance.
431	Yellow	P091	2	91	Voltage detected simultaneously on both the idle validation off-idle and on-idle circuits.	None on performance.
432	Red	P091	13	91	Voltage detected at idle validation on-idle circuit when voltage at throttle position circuit indicates the pedal is not at idle or voltage detected at idle validation off-idle circuit when voltage at throttle position circuit indicates the pedal is at reset	Engine will only idle.

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Fault code	Lamp	PID (P) SID (S)	FMI	SPN	Reason	Effect
433	Yellow	P102	2	102	Voltage signal at intake manifold pressure circuit indicates high intake manifold pressure but other engine characteristics indicate intake manifold pressure must be low.	Derate to no-air setting.
434	Yellow	S251	2	627	Supply voltage to the ECM fell below 6.2 volts for a fraction of a second or the ECM was not allowed to power down correctly (retain battery voltage for 30 seconds after key OFF).	Possible no noticeable performance effects or engine dying or hard starting. Fault information, trip information, and maintenance monitor data may be inaccurate.
435	Yellow	P100	11	100	An error in the oil pressure sensor signal was detected by the ECM.	None on performance. No engine protection for oil pressure.
441	Yellow	P168	1	168	Battery voltage below normal operating level.	Possible rough idle or no noticeable performance effects.
442	Yellow	P168	0	168	Battery voltage above normal operating level.	None on performance.
443	Yellow	S232	1	620	Low voltage detected on the ECM voltage supply line to the throttle(s).	Engine will only idle.
465	Yellow	S032	3	1188	High voltage detected at the wastegate actuator #1 circuit when no voltage was being supplied by the ECM.	Engine will run derated.
466	Yellow	S032	4	1188	Less than 6 volts detected at the wastegate actuator #1 circuit when on indicates an excessive current draw from the ECM or faulty ECM output circuit.	Engine will run derated.
471	Yellow	P098	1	98	Low crankcase oil level was detected by the ECM.	None on performance. Centinel system deactivated.

Fault code	Lamp	PID (P) SID (S)	FMI	SPN	Reason	Effect
472	Maint	P098	2	98	Either high or low voltage was detected on the crankcase oil level sensor circuit by the ECM.	None on performance. Centinel system deactivated.
474	Yellow	S237	2	1321	Either low voltage detected on starter lockout relay circuit when 12 volts are commanded or voltage detected when no voltage is commanded.	Either engine will not start or engine will not have starter lockout protection.
475	Yellow	S152	4	612	Less than 6 volts detected at the electronic air compressor governor circuit when on indicates an excessive current draw from the ECM or faulty ECM output circuit.	Air compressor may not operate.
476	Yellow	S152	3	612	High voltage detected at the electronic air compressor governor actuator circuit by the ECM.	Air compressor will run continuously.
491	Yellow	S032	3	1189	High voltage detected at the wastegate actuator #2 circuit when no voltage was being supplied by the ECM.	Engine will run derated.
492	Yellow	S032	4	1189	Less than 6 volts detected at the wastegate actuator #2 when on indicates an excessive current draw from the ECM or faulty ECM output circuit.	Engine will run derated.
536	Yellow	S040	11	718	Either low voltage detected on autoshift low gear actuator circuit when 12 volts are commanded or voltage detected when no voltage is commanded.	Top2 shift solenoid will not function properly. Transmission will not shift properly.
537	Yellow	S051	11	717	Either low voltage detected on autoshift high gear actuator circuit when 12 volts are commanded or voltage detected when no voltage is commanded.	Top2 shift solenoid will not function properly. Transmission will not shift properly.

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Fault code	Lamp	PID (P) SID (S)	FMI	SPN	Reason	Effect
538	Yellow	S045	11	719	Either low voltage detected on autoshift neutral actuator circuit when 12 volts are commanded or voltage detected when no voltage is commanded.	Top2 neutral actuator will not function properly. Transmission will not shift properly.
544	Yellow	S191	7	611	Autoshift failure; at least three shift attempts were missed.	Top2 transmission will not be controlled correctly. Transmission remains in manual mode.
551	Red	P091	4	91	No voltage detected simultaneously on both the idle validation off-idle and on-idle circuits.	Engine will only idle.

COLD STARTING AID (OPTION)

!!! CAUTION !!!

ETHER IS FLAMMABLE AND TOXIC. AVOID CONTACT WITH SKIN, EYES OR MOUTH. DO NOT BREATHE FUMES. IF SWALLOWED, CALL A PHYSICIAN IMMEDIATELY. DO NOT INDUCE VOMITING.

IF ETHER ENTERS EYES OR FUMES IRRITATE EYES, WASH EYES WITH LARGE AMOUNTS OF WATER FOR AT LEAST 15 MINUTES. SEE A DOCTOR AS SOON AS POSSIBLE.

Figure 7: Ether injection cylinder in air cleaner compartment

GENERAL

The ether injection system is used to assist the engine in starting under severe cold.

When the ether injection switch on the instrument panel is depressed, a solenoid valve causes a measured amount of ether to be injected directly into the intake manifold via a replaceable pressurized cylinder located in the air cleaner compartment. Ether injection can only take place while the starter is engaged.

MAINTENANCE

1. Check all fittings for leaks.
2. Check all moutings bolts to make sure they are tight.
3. Periodically test unit for operation.

REPAIR

Ether injection cylinder

NOTE

A common cause of problems with these systems is dirt in the electric valve. This dirt often comes in when the cylinder is changed.
Be extremely careful when changing cylinders.

1. The cylinder must be hand-tight and screwed down all the way.
2. Check the fluid supply. A full cylinder weighs about 33 ounces, and an empty one about 16 ounces.
3. **Always check the valve gasket under the cylinder**. Whenever a fuel cylinder is changed, change this gasket.

!!! CAUTION !!!

MAKE SURE TO WORK IN A WELL-VENTILATED AREA AWAY FROM HEAT, OPEN FLAMES AND SPARKS. WEAR GOGGLES AND MAKE SURE THAT THE OPENINGS OF THE VALVE, TUBE OR ATOMIZER ARE POINTED AWAY FROM YOU WHEN TESTING.

Atomizer

1. Remove atomizer from the engine.
2. Activate the system.
3. If no ether sprays out of the atomizer, disconnect it from the tubing.

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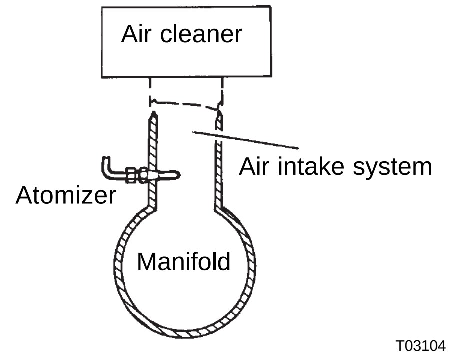

Figure 8: Location of atomizer

4. Activate the system. If ether now flows out of tubing, replace plugged atomizer.

Tubing

1. If ether does not flow out of the tubing after removing the atomizer, disconnect the tubing from the valve.

2. If ether now flows out of the valve when the system is activated, the tubing is obstructed and should be replaced.

Electric valve

1. Activate the valve. If no ether is dispensed, remove the ether injection cylinder.

2. If the plunger does not move up and stay up when the valve is activated, follow this procedure:

   a. When the starter is engaged and the switch is activated, there should be 24 Volts at the electric valve.

   b. If 24 Volts are not present, check wiring for shorts or opens and for solid ground at the electric valve.

   c. If the valve still does not work, replace it.

!!! CAUTION !!!

DO NOT STORE CYLINDERS AT TEMPERATURES ABOVE 160°F. CONTENTS UNDER PRESSURE. DO NOT INCINERATE, PUNCTURE OR ATTEMPT TO REMOVE THE CENTER CORE OR SIDE SAFETY VALVES.

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THROTTLE CONTROL

Cummins ISM engines are equipped with an electronic throttle pedal assembly. There is no mechanical link between the pedal assembly and the engine.

The pedal assembly consists of a throttle position sensor (G514), an idle validation switch (MS510) and a transmission modulator control switch (KD).

THROTTLE POSITION SENSOR (G514)

The G514 delivers a 0 to 5 VDC signal to the electronic control module (ECM) of the engine in response to the driver's request for power.

IDLE VALIDATION SWITCH (MS510)

The MS510 delivers a 5 VDC signal to the ECM of the engine when the throttle pedal is in idle position.

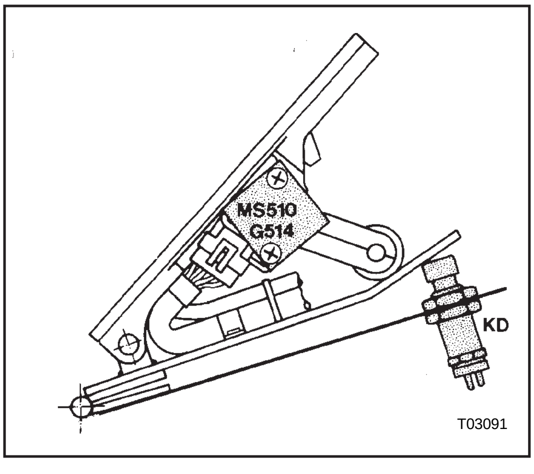

Figure 9: Throttle pedal assembly

G514: **Throttle position sensor**

MS510: **Idle validation switch**

KD: **Transmission modulator control switch (Kick-down)**

TRANSMISSION MODULATOR CONTROL SWITCH (KD)

The contacts of the KD are closed when the pedal is in the full throttle position. This activates the "'Kick-Down" system.

TO CHECK RESISTANCE OF THROTTLE PEDAL SWITCHES AND SENSOR

Disconnect the 6-pin connector at the throttle pedal

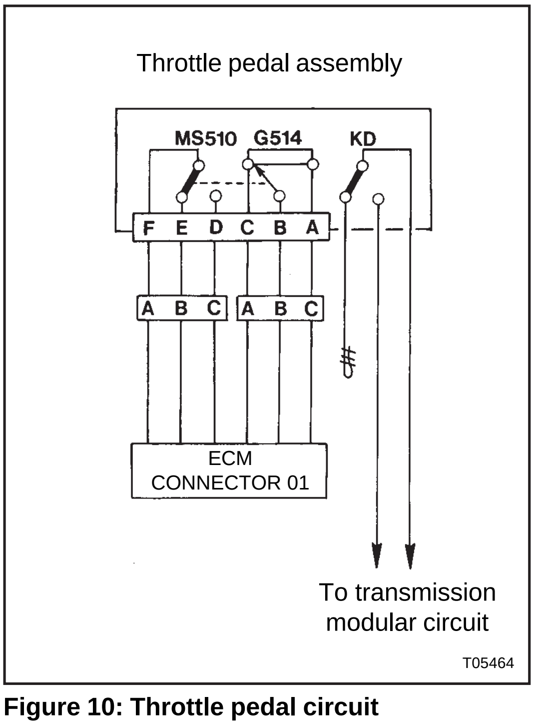

Figure 10: Throttle pedal circuit

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IDLE VALIDATION SWITCH

MEASURE BETWEEN	ACCEPTABLE RESISTANCE RANGE
Pins E and F	
• Idle..........	less than 125 Ohms (closed circuit)
• After 10° of pedal travel..........	100 K Ohms or more (open circuit)

THROTTLE POSITION SENSOR

MEASURE BETWEEN	ACCEPTABLE RESISTANCE RANGE
Pins A and C...	2000 to 3000 Ohms
Pins A and B	
• Idle..........	1500 to 3000 Ohms
• Full..........	200 to 1500 Ohms

NOTE

Difference between idle and full throttle position must be at least 1000 Ohms.

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DETROIT DIESEL ENGINE CONTROLS

DETROIT DIESEL ELECTRONIC CONTROL SYSTEM (DDEC)

The Detroit Diesel Electronic Control System (DDEC) is an advanced technological electronic fuel injection and control system. The system optimizes control of critical engine functions which affect fuel economy and emissions.
The system provides the capability to protect the engine from serious damage resulting from conditions such as high engine temperatures or low oil pressure.

The major subsystems of DDEC include:

- Electronic control module (ECM)
- Electronic unit injectors (EUI)
- Engine sensors

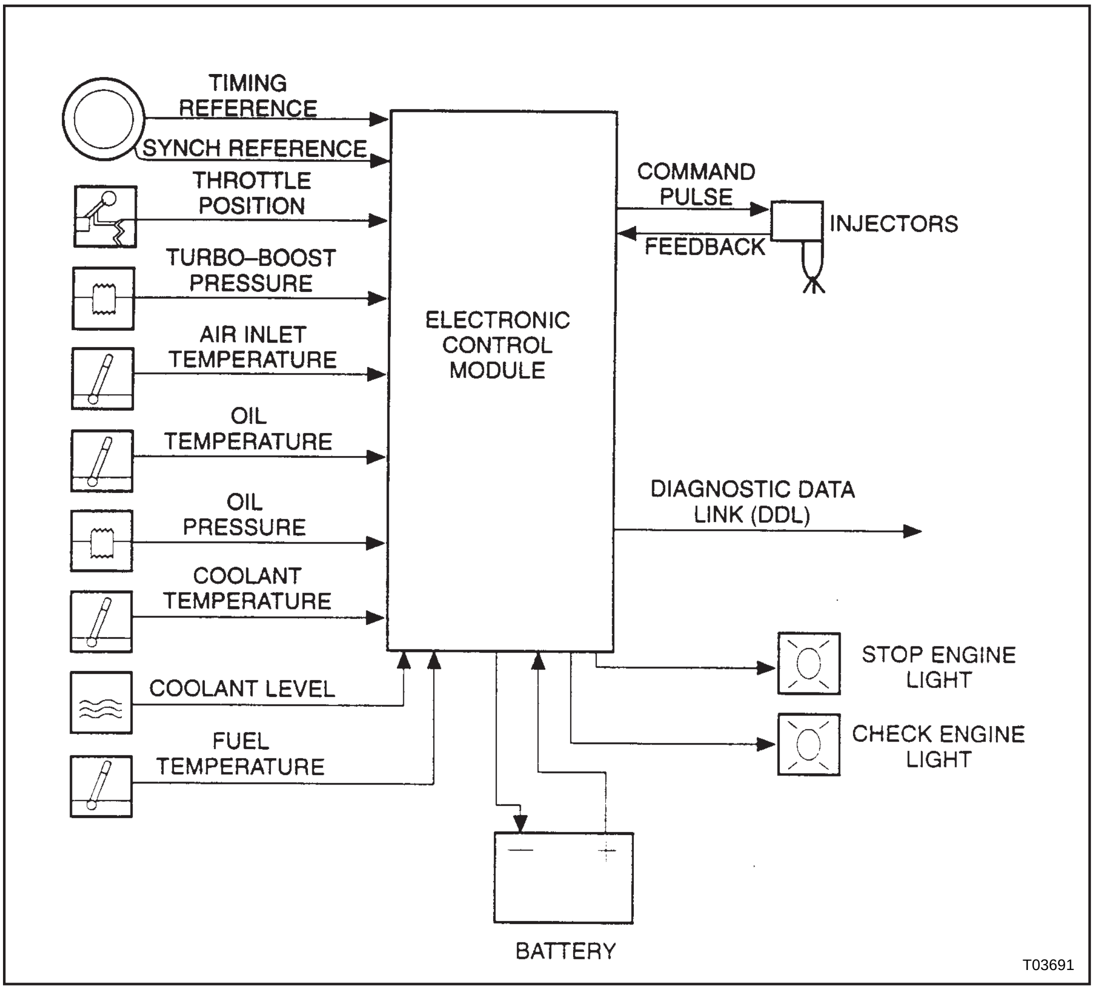

Figure 1: Schematic diagram of DDEC IV

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The ECM receives electronic inputs from sensors on the engine and vehicle, and uses the information to control engine operation. It computes fuel timing and fuel quantity based upon predetermined calibration tables in its memory.

Fuel is delivered to the cylinders by the electronic unit injectors, which are cam-driven to provide the mechanical input for pressurization of the fuel. The ECM controls solenoid operated valves in the EUIs to provide precise fuel delivery.

Portable equipment facilitates access to DDEC III's diagnostic capabilities. The Diagnostic Data Reader (DDR) requests and receives engine data and diagnostic codes. This equipment provides many unique capabilities including cylinder cutout, parameter vs. engine speed (or time), printer output, and data snapshot. The DDR also provides limited programming capability.

DIAGNOSTIC FAULT CODES

DDEC IV provides an indication of engine and coach malfunctions. The ECM continually monitors the DDEC IV system.

Any fault that occurs is stored as a code in the ECM memory. These codes can be accessed in any of these three ways:

- A diagnostic data reader (DDR) can be used to read the codes.
- A personal computer (PC) connected to the ECM through a translator device.
- The "CHECK ENGINE" light (CEL) or the "STOP ENGINE" light (SEL) is illuminated on the instrument panel.

CHECK ENGINE

Should the "CHECK ENGINE" light come on for any reason, the coach can still be operated as you proceed to your destination. This condition should be reported to a DDEC technician as soon as possible.

STOP ENGINE

When the "STOP ENGINE" light comes on, the DDEC computer has detected a major malfunction in the engine that requires immediate attention. It is your responsibility to shut down the engine to avoid serious damage. The conditions that will cause the "STOP ENGINE" light to come on are:

- High coolant temperature
- Low coolant level
- High oil temperature
- Low oil pressure

If the "STOP ENGINE" light illuminates, a 30 second shutdown (= stepped, powerdown sequence until it shuts down completely) sequence will begin.

Momentarily depress the "DIA" dashboard switch to override the emergency shutdown during a 30 second period. To obtain a subsequent override, the switch must be recycled after 5 seconds. The ECM will record the number of times the override is activated after a fault has occurred.

!!! CAUTION !!!
THE STOP ENGINE OVERRIDE MUST BE USED ONLY IN EMERGENCY, SUCH AS MOVING THE COACH OUT OF TRAFFIC. EXCESSIVE USE COULD CAUSE SEVERE ENGINE DAMAGE.

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CRUISE CONTROL AND FAST IDLE

The cruise control switches located on the dashboard serve a dual purpose. They are designed to control both the cruise control and fast idle systems.

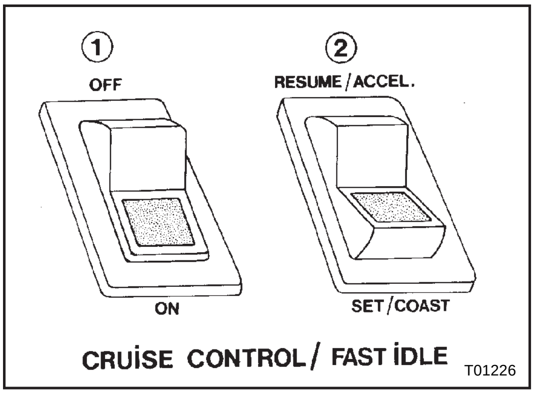

Figure 2: Cruise control / fast idle switches

Cruise control

The cruise control can be operated providing the following conditons are met:

- Service brake released
- Jake Brake OFF
- Engine speed above 1,100 rpm
- Vehicle speed above 20 mph

Fast idle

The fast idle can be operated provided the following conditions are met:

- Park brake applied
- Service brake released
- Transmission in neutral
- Jake Brake OFF
- Throttle pedal released

It is important to operate the fast idle when operating the HVAC system while parked in order to maintain sufficient electrical power.

With switch (1) in the "ON" position, push and release switch (2) in the "RESUME / ACCEL." position to bring the fast idle to 1000 rpm.

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Than push and release switch (2) in the:

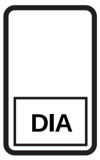
- "RESUME / ACCEL." position to increase the fast idle speed with 25 rpm. This happens every time the switch is momentarily pushed in the "RESUME / ACCEL." position. The maximum idle speed is 1,600 rpm.
- "SET / COAST" position to decrease the fast idle speed with 25 rpm. This happens every time the switch is momentarily pushed in the "SET/ COAST" position. The minimum fast idle speed is 600 rpm.

Fast idle is deactivated in several ways: the brake pedal or throttle pedal is pressed, switch (1) is placed in the "OFF" position or Jake Brake is activated.

TO READ FAULT CODES

It is important to point out that whenever the "CHECK ENGINE" light (CEL) or the "STOP ENGINE" light (SEL) comes on, the DDEC computer will determine where the problem is, and will then store this information in its memory.

If the malfunction is intermittent, the lights will come on and go off as the computer senses the changing engine condition.



With the engine shut off and the ignition on, momentarily depress the "DIA" switch.

"CHECK ENGINE" light (CEL) will flash a code number. It will for example flash twice...pause...flash five times... pause, thus in this case flash code number 25. Code 25 indicates that all systems are working satisfactorily.

The active codes will be flashed on the "STOP ENGINE" light (SEL) in the order of the most recent to the least recent occurrence based on engine hours. If there are no active codes, a code "25" will be flashed.

The inactive codes wil be flashed on the "CHECK ENGINE" light (CEL) in the order of the most recent to the least recent occurrence based on engine hours. If there are no inactive codes, a code "25" will be flashed.

Note that only one light will be flashing codes at any time. When code flashing is initiated, the active codes (or code "25") will be flashed on the SEL. Then the inactive codes (or code "25") will be flashed on the CEL. When all the inactive codes (or code "25") have been flashed, the process of flashing all the active codes followed by all the inactive codes will repeat until the conditions for code flashing are no longer satisfied.

The codes will continue to flash until the "DIA" switch is momentarily depressed.

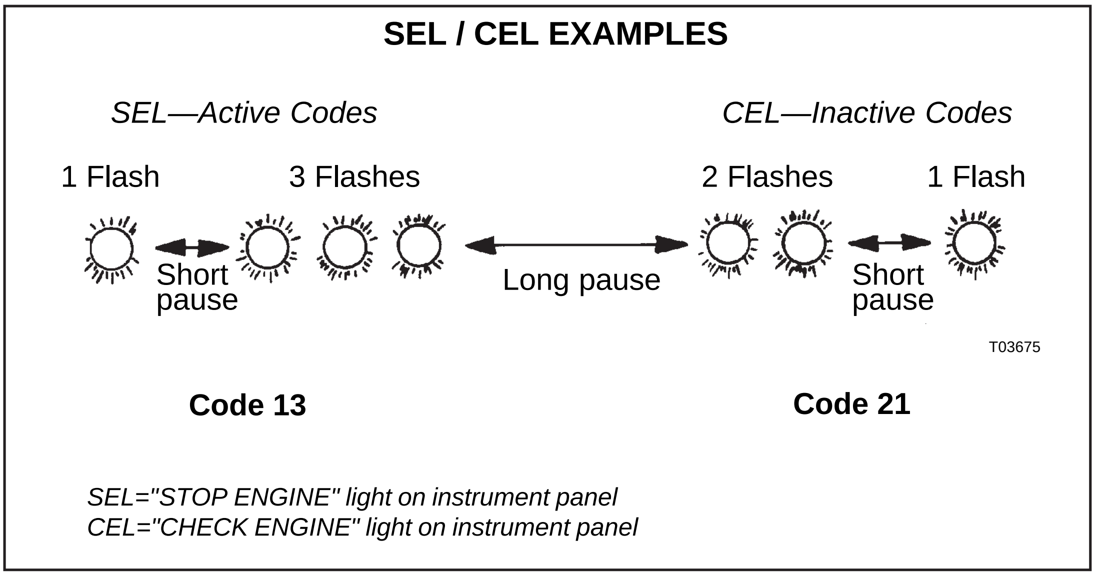


Figure 3: Examples of fault codes

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DDEC IV Diagnostic Codes

Flash code	DDEC IV Description
11	VSG sensor input voltage low
12	VSG sensor input voltage high
13	Coolant level sensor input voltage low
14	Oil or coolant temperature sensor input voltage high
15	Oil or coolant temperature sensor input voltage low
16	Coolant level sensor input voltage high
17	Throttle valve position sensor input voltage high
18	Throttle valve position sensor input voltage low
21	TPS input voltage high
22	TPS input voltage low
23	Fuel temperature sensor input voltage high
24	Fuel temperature sensor input voltage low
25	No active codes
26	Aux. engine shutdown #1 or #2, input active
27	Air inlet or intake air, temperature sensor input voltage high
28	Air inlet or intake air, temperature sensor input voltage low
31	Aux. high side output open circuit or short to ground
32	CEL or SEL short to battery (+) or open circuit
33	Turbo boost sensor input voltage high
34	Turbo boost input voltage low
35	Oil pressure sensor input voltage high
36	Oil pressure sensor input voltage low
37	Fuel pressure sensor input voltage high
38	Fuel pressure sensor input voltage low
41	Too many SRS (missing TRS)
42	Too few SRS (missing SRS)
43	Coolant level low
44	Oil or coolant or intake air, temperature high
45	Oil pressure low
46	ECM battery voltage low
47	Fuel, air inlet, or turbo boost, pressure high
48	Fuel or air inlet pressure low
52	ECM A/D conversion fail
53	ECM non volatile memory fault
54	Vehicle speed sensor fault
55	J1939 data link fault
56	J1587 data link fault
57	J1922 data link fault
61	Injector response time long
62	Aux. output short to battery (+) or open circuit, or mech. fault
63	PWM drive short to battery (+) or open circuit
64	Turbo speed sensor input fault
65	Throttle valve position input fault
66	Engine knock sensor input fault
67	Air inlet pressure sensor input voltage fault
68	TPS idle validation switch open circuit or short to ground
71	Injector response time short
72	Vehicle overspeed
73	Gas valve position input fault or ESS fault
74	Optimized idle safety loop short to ground
75	ECM battery voltage high
76	Engine overspeed with engine brake

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DDEC IV Diagnostic Codes

Flash code	DDEC IV Description
77	Fuel temperature high
85	Engine overspeed
86	External pump pressure sensor input voltage high
87	External pump pressure sensor input voltage low

THROTTLE CONTROL

Detroit Diesel DDEC engines are equipped with an electronic throttle pedal assembly. There is no mechanical link between the pedal assembly and the engine.

The pedal assembly consists of a throttle position sensor (G514), an idle validation switch (MS510) and a transmission modulator control switch (KD).

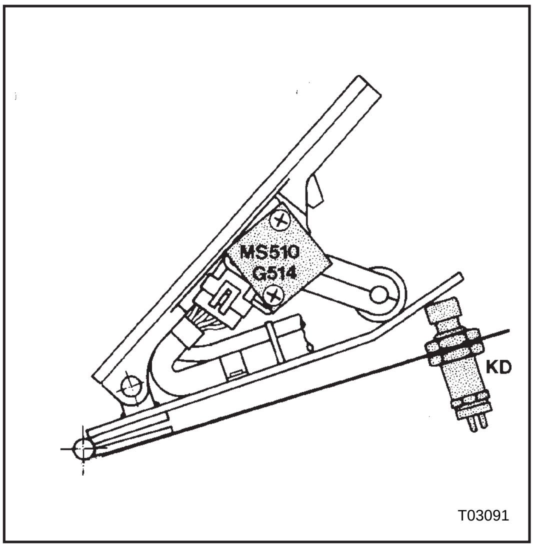

Figure 4: Throttle pedal assembly

G514 : Throttle position sensor
MS510 : Idle validation switch
KD : Transmission modulator control switch (Kick-down)

THROTTLE POSITION SENSOR (G514)

The G514 delivers a 0 to 5 VDC signal to the electronic control module (ECM) of the engine in response to the driver's request for power.

IDLE VALIDATION SWITCH (MS510)

The MS510 delivers a 5 VDC signal to the ECM of the engine when the throttle pedal is not in the idle position.

TRANSMISSION MODULATOR CONTROL SWITCH (KD)

The contacts of the KD are closed when the pedal is in the full throttle position. This activates the "'Kick-Down" system.

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WT B500 AUTOMATIC TRANSMISSION (WTEC III)

GENERAL DESCRIPTION

The B500 is a member of the World Transmission (WT) family designed by Allison Transmission Division of General Motors Corporation. The B500 Electronic Controls system features closed-loop and adaptive clutch control to provide superior shift quality over a wide range of operating conditions. The transmission can be programmed to have up to six forward ranges, neutral and one reverse range.

The WT Electronic Control system consists of four major components connected by wiring harnesses: Electronic Control Unit (ECU), three speed sensors, shift selector, and

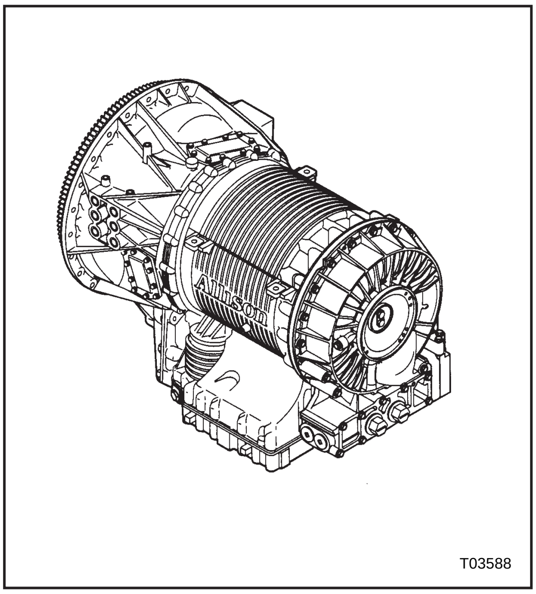
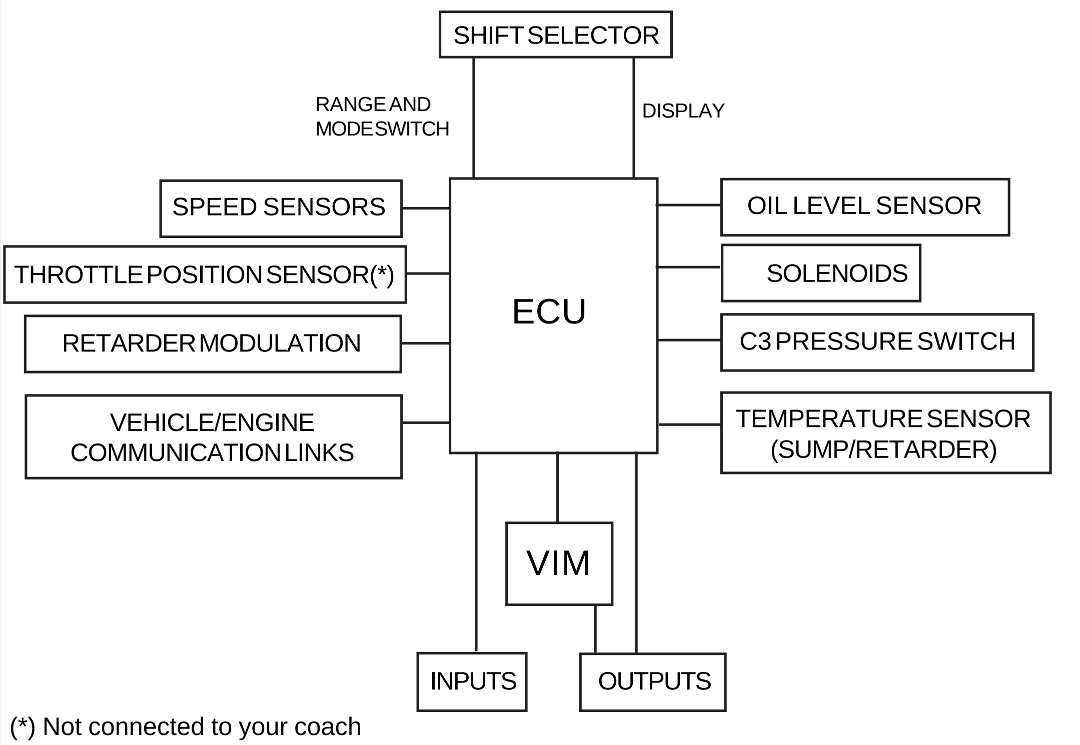


Figure 1: WT B500 automatic transmission



(*) Not connected to your coach

Figure 2: Electronic control unit block diagram

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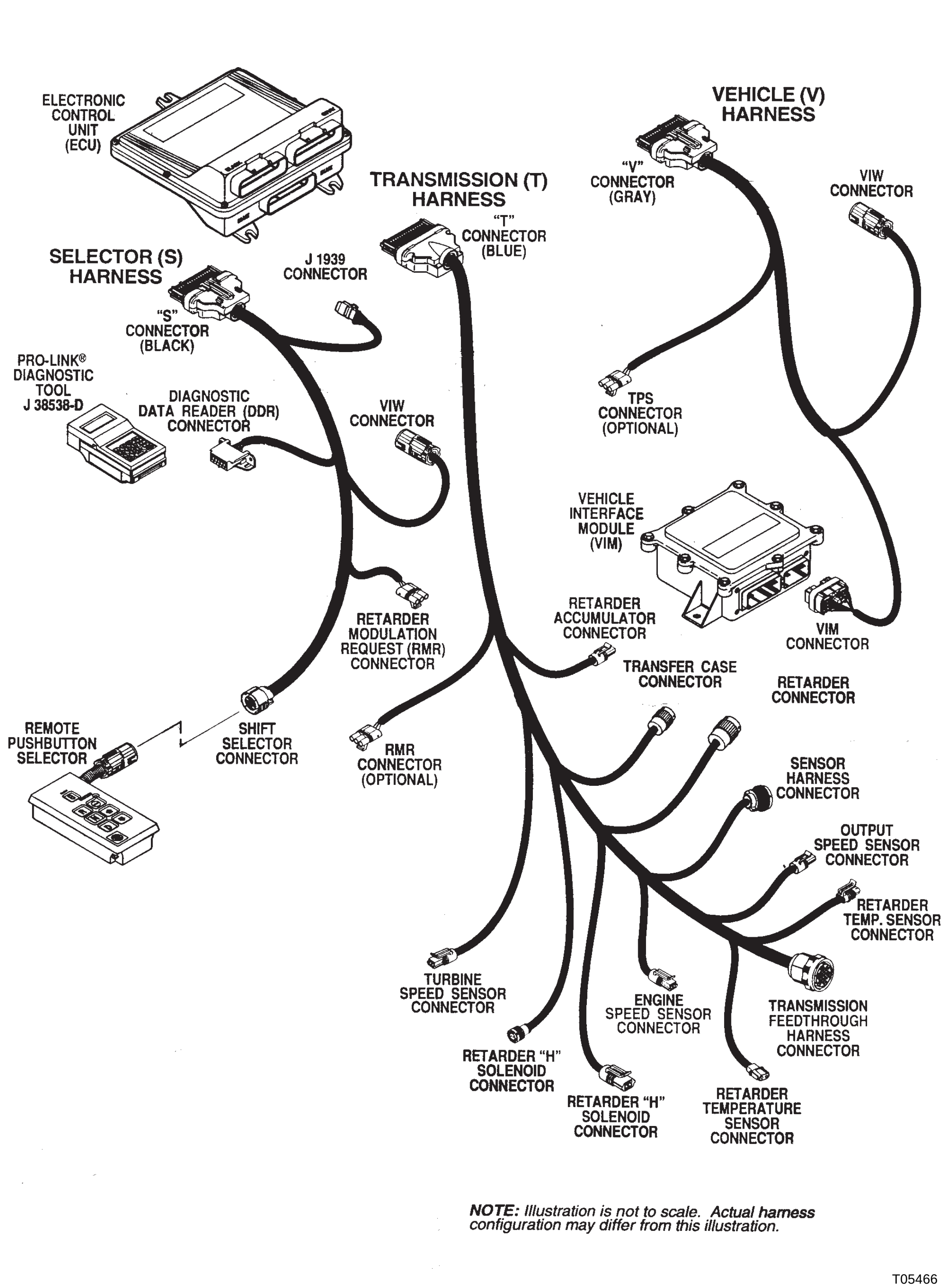

Figure 3: Electronic control unit components

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control module (which contains solenoid valves and a pressure switch). The engine ECM (connected to the transmission ECU by electronic CAN bus), speed sensors, pressure switch and shift selector transmit information to the ECU. The ECU processes this information and then sends signals to actuate specific solenoids located on the control module in the transmission. These solenoids control both oncoming and offgoing clutch pressures to provide closed-loop shift control by matching rpm during a shift to a previously established desired profile that is programmed into the ECU.

In addition to controlling the operation of the transmission, the ECU monitors the system for conditions that could result in damage to the transmission or improper vehicle operation. When one of the conditions is detected, the ECU is programmed to respond automatically in a manner which will ensure safe operation of the vehicle and the transmission.

ELECTRONIC CONTROL UNIT (ECU)

The ECU, located in the main junction box, contains the microcomputer, which is the brain of the control system. The ECU receives information defining: shift selector position, throttle position, engine speed, turbine speed and transmission output speed. Information processed by the ECU controls transmission solenoids and valves, supplies system status and provides diagnostic information. The ECU contains an Electronically Erasable Programmable Read Only Memory (EEPROM), which is programmed with the shift calibration and other data for a specific transmission assembly, engine and coach vocation.

SHIFT SELECTOR

The push button shift selector has six buttons, a mode indicator (LED) and a single digital display. The six buttons are: **R** (Reverse), **N** (Neutral), **D** (Drive), (↑), (↓) and **MODE**. Manual forward range downshifts and upshifts are made by pressing the up (↑) or down (↓) arrow buttons after selecting **D** (Drive). The **N** (Neutral) button has a raised lip to aid in finding it by touch. The digital display on the push button selector indicates the range selected.

During normal transmission operation, illumination of the LED mode indicator indicates that "Power" has been selected by pressing the **MODE** button. In diagnostic display mode,

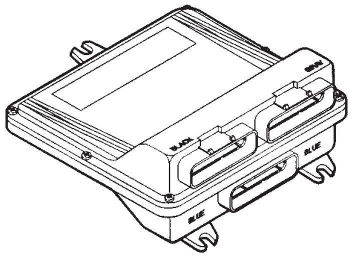

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Figure 4: Electronic control unit (ECU)

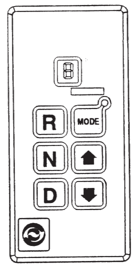

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Figure 5: Push button shift selector

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illumination of the LED indicator indicates the displayed diagnostic code is active.

SPEED SENSORS

Three speed sensors: engine speed, turbine speed, and output speed, provide information to the ECU. The engine speed signal is generated by vane bumps on the shell of the torque converter pump. The turbine speed signal is generated by the rotating-clutch housing spline contours and the output speed signal is generated by a gear on the output shaft. The speed ratios between the various speed sensors allows the ECU to determine if the transmission is in the selected range. Speed sensor information is also used to control the timing of clutch apply and exhaust pressures, resulting in the smoothest shifts possible. Hydraulic problems are detected by comparing the speed sensor information for the current range to that range’s speed sensor information stored in the ECU memory.

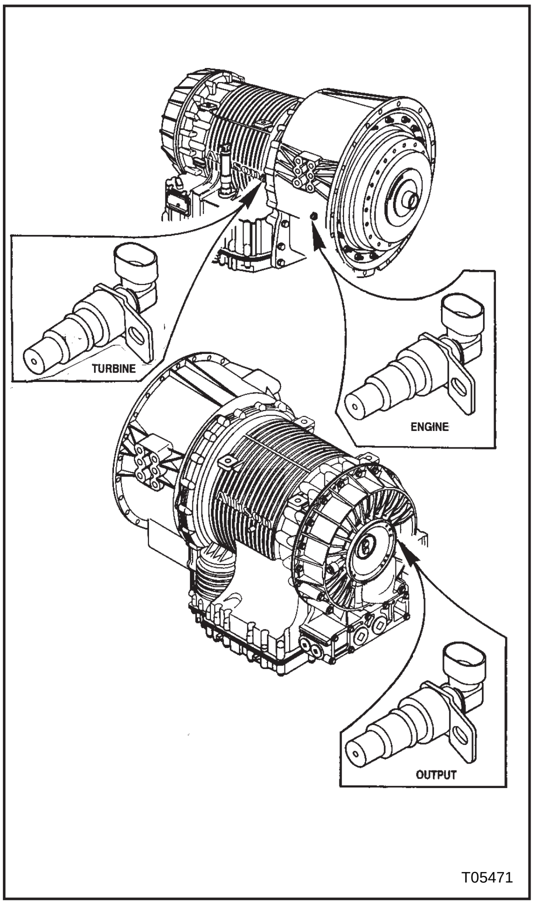

Figure 6: Speed sensors location

CONTROL MODULE

The transmission control module contains a channel plate on which is mounted: the main valve body assembly, the stationary-clutch valve body assembly, and the rotating-clutch valve body assembly. Pulse width modulated solenoids are used in the valve bodies. The rotating-clutch valve body assembly contains A (C1), B (C2) and F (lockup) solenoids, solenoid regulator valves controlled by the solenoids, and the C3 pressure switch. The stationary-clutch valve body assembly contains C (C3), D (C4) and E (C5) solenoids and solenoid regulator valves controlled by the solenoids and the C3 accumulator relay valve. The main valve body assembly contains G solenoid and the C1 and C2 latch valves controlled by the solenoid, the main and lube regulator valves, the control main and converter regulator valves, and the converter flow valve and exhaust backfill valves.

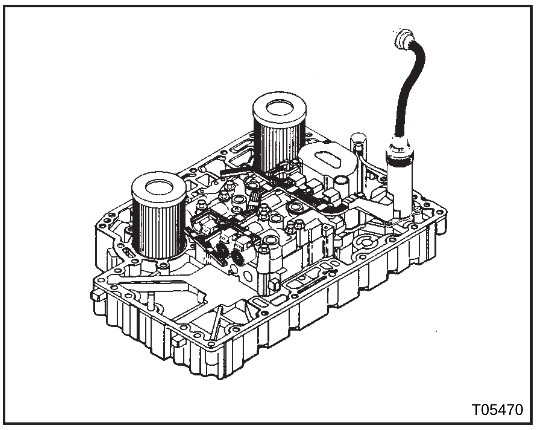

Figure 7: Control module

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A temperature sensor (thermistor) is located in the internal wiring harness. Changes in sump fluid temperature are indicated by changes in sensor resistance which changes the signal sent to the ECU.

The oil level sensor is a float type device, mounted on the control module channel plate, which senses transmission fluid level by electronically measuring the buoyancy forces on the float. The sensor operates on 5VDC supplied by the ECU.

The C3 pressure switch is mounted on the rotating-clutch valve body assembly and indicates when pressure exists in the C3 clutch-apply passage. An accumulator/relay valve is in-line ahead of the C3 pressure switch and prevents high frequency hydraulic pulses generated by the C3 solenoid from cycling the C3 pressure switch.

The turbine speed sensor is located on the outside of the main housing.

VEHICLE INTERFACE MODULE (VIM)

The vehicle interface module (VIM), located in the main junction box, provides the relays, fuses and connection points for interface with the output side of the vehicle electrical system.

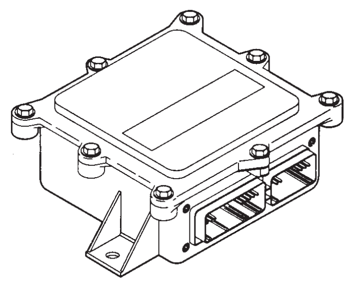

Figure 8: Vehicle interface module

DO NOT SHIFT LIGHT

When the ECU detects a serious transmission fault, the "DO NOT SHIFT" light on the instrument panel illuminates and action is automatically taken to protect operator, vehicle and the transmission. A diagnostic code will nearly always be registered when the "DO NOT SHIFT" light is on; however, not all diagnostic codes will turn on the "DO NOT SHIFT" light. Codes related to the "DO NOT SHIFT" light are detailed further in this Section.

Illumination of the "Do not shift" light indicates that a condition was detected that requires service attention. Operation may or may not be restricted but even when restricted will allow the vehicle to reach a service assistance location. Depending upon the cause for the "DO NOT SHIFT" light illumination, the ECU may or may not respond to shift selector requests. The transmission may be locked in a range. That range will be shown on the shift selector display. Both upshifts and downshifts may be restricted when the "DO NOT SHIFT" light is illuminated. Seek service assistance as soon as possible.

Each time the engine is started, the "DO NOT SHIFT" light illuminates briefly and then goes out. This momentary lighting shows the light circuit is working properly. If the light does not come on during engine start, request service immediately.

DIAGNOSTIC DATA READER (DDR)

The current Diagnostic Data Reader (DDR) is the Pro-Link® 9000 diagnostic tool which is available through Kent-Moore Heavy Duty Division. The Pro-Link® is a portable microcomputer-based receiver/ transmitter/display unit; it transmits and

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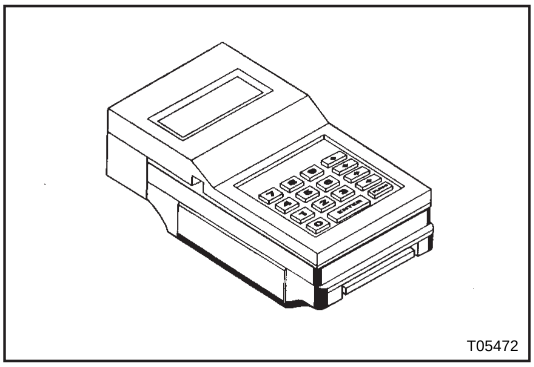

Figure 9: Diagnostic data reader

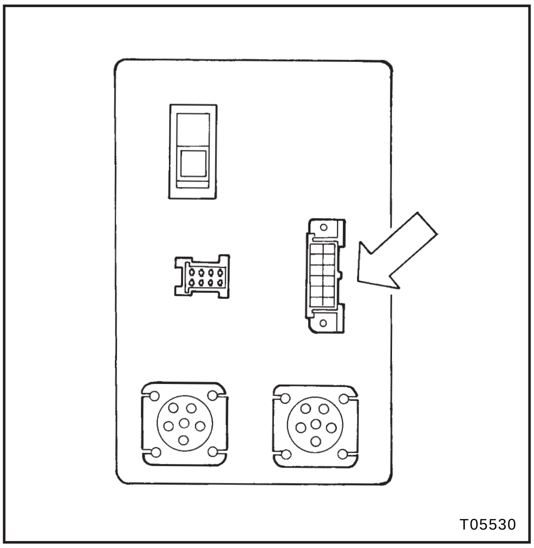

Figure 10: Transmission diagnostic data reader connector mounted behind the door in the R.H. console

receives data to and from the ECU, processes the data and displays appropriate information.

Use the Pro-Link® during installation checkout and troubleshooting. Operation instructions are supplied with each Pro-Link®. There is a new Pro-Link® cartridge needed for use with WTEC III controls. Connect the Pro-Link® to the diagnostic Data Reader Connector mounted in the diagnostic box in the R.H. console.

Tool part numbers for the Pro-Link® are as follows:

- Diagnostic Kit: J 38538E
- Diagnostic Cartridge: J 38500-303
- MPC J 38500-1500C
- PCMCIA (Diagnostic and Reprogramming): J 38500-1700B
- PCMCIA (Diagnostic Only): J 38500-1800A

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MAINTENANCE

PERIODIC INSPECTION AND CARE

Clean and inspect the exterior of the transmission at regular intervals. Severity of service and operating conditions determine the frequency of these inspections. Inspect the transmission for:

- Loose bolts - transmission and mounting components
- Fluid leaks - repair immediately
- Loose, dirty or improperly adjusted throttle sensor linkage
- Damaged or loose hoses
- Worn, frayed or improperly routed electrical harnesses
- Worn or out-of-phase driveline, U-joints and slip fittings

!!! CAUTION !!!
WHEN WELDING ON THE COACH: DO NOT WELD ON THE COACH WITHOUT DISCONNECTING THE CONNECTORS FROM THE ECU NOR WITHOUT DISCONNECTING BATTERY POWER AND GROUND LEADS FROM THE ECU. DO NOT WELD ON ANY CONTROL COMPONENTS EITHER. DO NOT CONNECT WELDING CABLES TO ANY CONTROL COMPONENTS.

TO CHECK FLUID LEVEL

Transmission fluid cools, lubricates and transmits hydraulic power. Always maintain proper fluid level. If fluid level is too low, the torque converter and clutches do not receive an adequate supply of fluid and the transmission overheats. If the level is too high, the fluid aerates causing the transmission to shift erroneously and overheat. Fluid may be expelled through the breather when the fluid level is too high.

To check fluid level with dipstick

!!! CAUTION !!!
WHEN CHECKING THE FLUID LEVEL, MAKE SURE THAT THE TRANSMISSION IS IN NEUTRAL, THAT THE PARKING BRAKE HAS BEEN PROPERLY ENGAGED AND THAT THE WHEELS HAVE BEEN CHOCKED. IGNORING THESE PRECAUTIONS MAY LEAD TO UNEXPECTED SUDDEN COACH MOVEMENT.

Clean the area around the end of the fill tube and the dipstick tube before removing the cap and the dipstick. This will help prevent dirt or foreign matter from entering the fluid system, which may cause valves to stick, bring about undue wear of transmission parts or which may clog passages.

Cold Check

The purpose of the Cold check is to determine whether the transmission contains enough fluid to operate safely until a Hot check can be carried out.

1. If the engine has been shut down for an extended time, park the coach on a level surface and apply the parking brake.

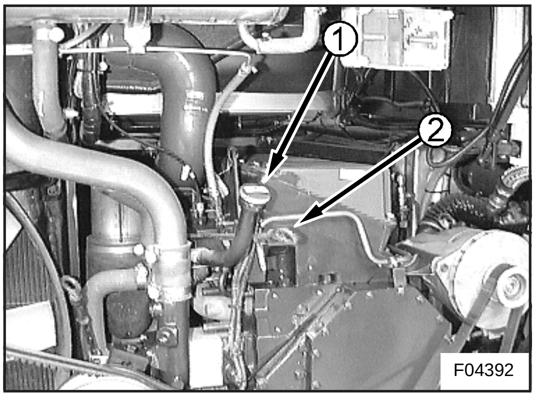

Figure 11: Transmission fill tube and dipstick

1. **Fill tube**
2. **Dipstick**

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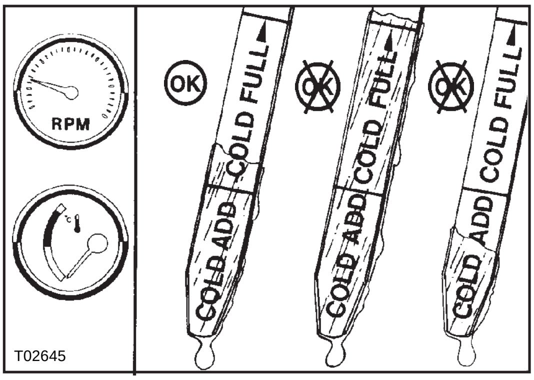

Figure 12: Cold check fluid level

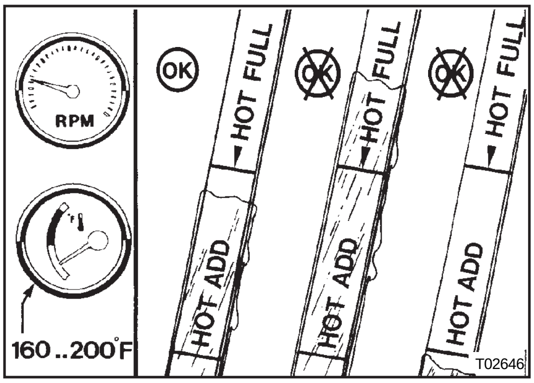

Figure 13: Hot check fluid level

2. Run the engine for at least 1 minute. Shift to Drive and operate the engine for 30 seconds at 1,000 - 1,500 rpm; then shift to Reverse to clear the hydraulic system of air. Then shift to Neutral and allow the engine to idle.

3. Having wiped the dipstick clean, check the fluid level. If the fluid on the dipstick is between the COLD ADD and the COLD FULL marker, the level is satisfactory. If the fluid level is not within this area, add or drain fluid until the right level is reached.

4. Perform a Hot Check at the first opportunity after normal operating temperature (160°F - 200°F) has been reached.

!!! CAUTION !!!
FLUID LEVEL CHECK CANNOT BE ACCURATE UNLESS THE ENGINE IS IDLING IN NEUTRAL, THE TRANSMISSION FLUID IS AT PROPER TEMPERATURE AND THE COACH IS ON A LEVEL SURFACE.

Hot Check

As temperature increase causes the fluid level to rise, the fluid must be hot to guarantee accurate checking.

1. Drive coach until engine is at operating temperature

2. Park the coach on a level surface and shift to Neutral. Apply the parking brake and allow the engine to idle.

3. Having wiped the dipstick clean, check the fluid level. The safe operating level is anywhere within the area ranging from the HOT ADD to the HOT FULL marker on the dipstick.

4. If the level is not within this area, add or drain fluid as necessary until the level is within the right area. DO NOT OVERFILL!

To check fluid level with pushbutton selector

The transmission has an oil level sensor providing the operator with an indication of the fluid level through the shift selector.

NOTE
THE PUSHBUTTON SELECTOR CAN DISPLAY ONE CHARACTER AT A TIME.

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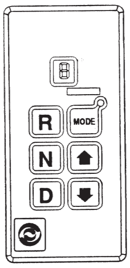

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Figure 14: Push button shift selector

1. Park the coach on a level surface, shift to **N** (Neutral) and apply the parking brake.
2. Press the up and down arrow buttons once simultaneously.
3. The fluid level check may be delayed until the following conditions are met:
   - fluid temperature above 140°F and below 220°F;
   - transmission in neutral;
   - coach stationary for approx. two minutes to allow the fluid to settle;
   - engine at idle;
   - transmission output shaft is stopped.

   The indication of a delayed fluid level check is a "-" in the display window followed by a numerical display.

   Correct Fluid Level: "o,L" is displayed ("o,L" represents "Fluid (Oil) Level Check Mode"), followed by "o,K". The "o,K" display indicates the fluid is within the correct fluid level zone. The sensor display and the transmission dipstick may not agree exactly because the oil level sensor compensates for fluid temperature.

Low Fluid Level: "o,L" is displayed ("o,L" represents "Fluid (Oil) Level Check Mode"), followed by "Lo" ("Lo" represents "Low Oil Level") and the number of quarts the transmission fluid is low. Example: "2" indicates two additional quarts of fluid will bring the fluid level within the middle of the "oK" zone.

High Fluid Level: "o,L" is displayed ("o,L" represents "Fluid (Oil) Level Check Mode"), followed by "HI" ("HI" represents "High Oil Level") and the number of quarts the transmission fluid is overfilled. Example: "1" indicates one quart of fluid above the full transmission level.

Invalid for display: "o,L" is displayed ("o,L" represents "Fluid (Oil) Level Check Mode"), followed by "-" and a numerical display. The numerical display is a fault code and indicates conditions are not proper to receive the fluid level information, or that there is a system malfunction. The fault codes that may be encountered are shown in the table below.

DISPLAY	CAUSE OF CODE
o,L,-,0,X	Settling time too short
o,L,-,5,0	Engine speed (rpm) too low
o,L,-,5,9	Engine speed (rpm) too high
o,L,-,6,5	Neutral must be selected
o,L,-,7,0	Sump fluid temperature too low
o,L,-,7,9	Sump fluid temperature too high
o,L,-,8,9	Output shaft rotation
o,L,-,9,5	Sensor failure

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!!! CAUTION !!!

LOW OR HIGH FLUID LEVEL CAN CAUSE OVERHEATING AND IRREGULAR SHIFT PATTERNS. THESE CONDITIONS CAN DAMAGE THE TRANSMISSION IF NOT CORRECTED.

NOTE

SENSOR FAILURE DISPLAY SHOULD BE REPORTED TO A VAN HOOL OR ALLISON SERVICE CENTER IN YOUR AREA.

5. To exit the fluid level display mode, press any range button on the pushbutton shift selector.

TO CHANGE FLUID AND FILTERS

At each fluid change, examine the drained fluid for evidence of dirt, water and metal particles. A normal amount of condensation will appear in the fluid during operation.

To drain fluid

1. Drain the fluid when the transmission is at operating temperature (160°F - 200°F).

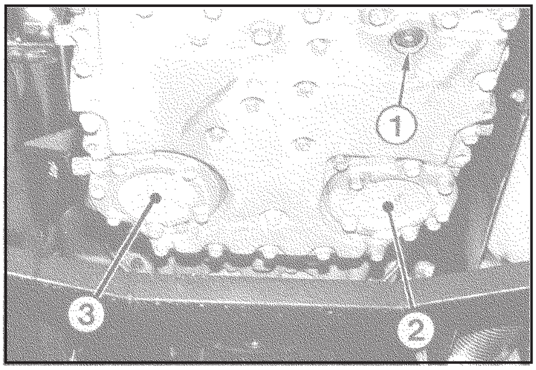

Figure 15: Bottom of transmission

1. Drain plug
2. and 3. Filter covers

2. Remove drain plug (1, Figure 16) and allow the fluid to drain into a suitable container.
3. Examine the fluid.

To replace filters

1. Remove twelve bolts, two filter covers, two O-rings, two square cut seals and two filters from the bottom of the control module.

NOTE

LUBRICATE THE O-RING INSIDE THE FILTER CARTRIDGES ONLY.

2. Pre-lube and install an O-ring on each filter assembly. Install a square cut seal on each cover assembly. Install the filters onto the cover assemblies.

!!! CAUTION !!!

DO NOT USE THE BOLTS TO DRAW FILTER COVERS TO THE SUMP. THIS CAN DAMAGE THE COVERS, SEALS OR SUMP.

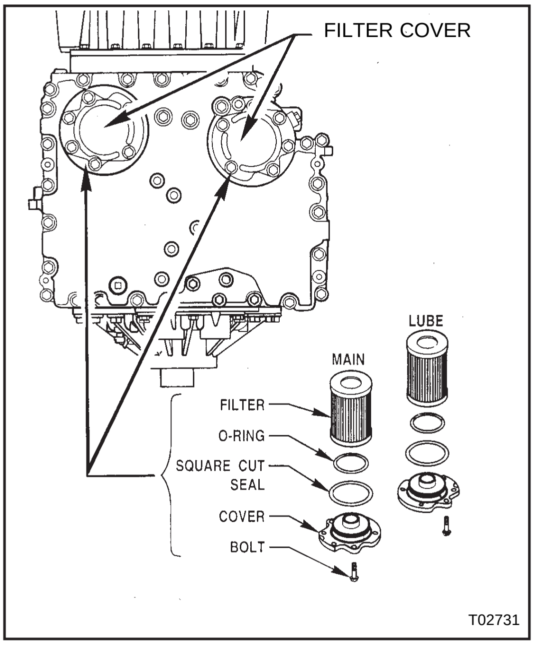

Figure 16: Location of filters

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3. Install filter and cover assemblies into the filter compartment. Align each filter/cover assembly with the holes in the channel plate/sump. Push the cover assemblies in by hand to seat the seals.
4. Install six bolts into each cover and tighten to 38-45 ft.lbf.

5. Inspect the drain plug O-ring and replace if necessary. Install plug and tighten to 18-24 ft.lbf.

6. Refill transmission and check fluid level as described in this section.

TO CLEAN BREATHER

The breather is located on top of the transmission converter housing. The breather prevents air pressure buildup within the transmission and its passage must be kept clean and open. The amount of dust and dirt encountered will determine the frequency of breather cleaning. Use care when cleaning the transmission. Spraying steam, water or cleaning solutions directly at the breather can force the water or cleaning solution into the transmission.

Always use a wrench of the proper size to remove or replace the breather. Pliers or a pipe wrench can crush or damage the stem and produce metal chips which could enter the transmission. Tighten the breather to 9-12 ft.lbf.

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TROUBLESHOOTING

DIAGNOSTIC CODE MEMORY

Diagnostic codes are logged in a list in memory (sometimes referred to as the queue), listing the most recently occurring code first and logging up to five codes. The codes contained in the list have information recorded as shown in the chart below (codes are examples). Access to the code list postion, main code, subcode and active indicator is through either the shift selector display or the Pro-Link® diagnostic tool. Access to the ignition cycle counter and event counter information is through the diagnostic tool only.

The following paragraphs define the different parts of the code list.

a. **Code List Position.** The position which a code occupies in the code list. Positions are displayed as "d1" through "d5" (Code List Position #1 through Code List Position #5).

b. **Main Code.** The general condition or area of fault detected by the ECU.

c. **Subcode.** The specific area or condition related to the main code in which a fault is detected.

d. **Active Indicator.** Indicates when a diagnostic code is active. The MODE indicator LED on the shift selector is illuminated or the diagnostic tool displays **YES**.

e. **Ignition Cycle Counter.** Determines when inactive diagnostic codes are automatically cleared form the code list. The counter is increased by one each time a normal ECU power down occurs (ignition turned off). Inactive codes are cleared from the code list after the counter exceeds 25.

f. **Event counter.** Counts the number of occurrences of a diagnostic code. If a code is already in the code list and the code is again detected, that code is moved to position d1, the active indicator is turned on, the Ignition Cycle Counter is cleared, and 1 is added to the Event Counter.

Code List Position	Main Code	Subcode	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 shift selector and diagnostic tool (d = "diagnostic")			YES = LED indicator illuminated	Not available on shift selector display	

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CODE READING AND CODE CLEARING

Diagnostic codes can be read and cleared by two methods: by using the ProLink® 9000 diagnostic tool or by entering the diagnostic display mode and using the shift selector display. The use of the ProLink® 9000 diagnostic tool is described in the instruction manual furnished with each tool. The method of reading and clearing codes described below refers to entering the diagnostic display mode by the proper button movements on the shift selector. The diagnostic display mode may be entered for viewing of codes at any speed. Active codes can only be cleared when the output speed = 0 and no output speed sensor failure is active.

Reading codes

Diagnostic codes are displayed only in the diagnostic display mode. The first simultaneous depression of the pushbutton selector's **UP** (↑) and **DOWN** (↓) arrow buttons displays the fluid level readout. Enter the diagnostic display mode by again simultaneously pressing the **UP** (↑) and **DOWN** (↓) arrow buttons.
The code list or queue position is the first item displayed, followed by the main code and the subcode. Each item is displayed for about one second. The display cycles continuously until the next code list position is accessed by pressing the **MODE** button. The following list represents the display cycle using code 25 11 as an example:

1. Code list position — **d,1**
2. Main code — **2,5**
3. Subcode — **1,1**
4. Cycle repeats — **d,1**

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To view the second, third, fourth and fifth positions (d2, d3, d4, and d5) momentarily press the **MODE** button as explained above.

Momentaily press the **MODE** button after the fifth position is displayed to restart the sequence of code list positions.

An active code is indicated by the illumination of the LED indicator when a code position is displayed while in the diagnostic display mode. In the normal operating mode, the LED indicator illuminates to show a secondary mode operation.

Any code position which does not have a diagnostic code logged will display "— " for both the main and subcodes. No diagnostic codes are logged after an empty code position.

Clearing active indicators

A diagnostic code's active indicator can be cleared, which allows the code inhibit to be cleared but remains in the queue as inactive.

The active indicator clearing methods are:

1. Power down — All active indicators, except code 69 34 (refer to the "DIAGNOSTIC CODE LIST") are cleared at ECU power down.

2. Self-clearing — Some codes will clear their active indicator when the condition causing the code is no longer detected by the ECU.

3. Manual — Some active indicators can be cleared manually, while in the diagnostic display mode, after the condition causing the code is corrected.

!!! CAUTION !!!

IF AN ACTIVE INDICATOR IS CLEARED WHILE THE TRANSMISSION IS LOCKED IN A FORWARD RANGE OR REVERSE (FAIL-TO-RANGE), THE TRANSMISSION WILL REMAIN IN THE FORWARD RANGE OR REVERSE AFTER THE CLEARING PROCEDURE IS COMPLETED. NEUTRAL MUST BE MANUALLY SELECTED.

Manually clearing codes and active indicators from the code list

To clear all codes or active indicators:

1. Enter the Diagnostic Display Mode.

2. Press and hold the MODE button for approximately three seconds until the LED indicator flashes. All active indicators are cleared. To remove all inactive codes, press and hold the MODE button for about ten seconds until the LED indicator flashes again. All active indicators will be cleared at ECU power down.

3. Codes that cannot be manually cleared will remain.

Exiting the diagnostic display mode

1. Press the **UP** (↑) and **DOWN** (↓) arrow buttons at the same time or press any range button **D**, **N** or **R**. The shift (**D**, **N** or **R**) is commanded if not inhibited by an active code.

2. Wait until time-out (approximately 10 minutes) and the system will automatically return to the normal operating mode.

3. Turn off ignition switch.

DIAGNOSTIC CODE RESPONSE

The following ECU responses to a fault provide for safe transmission operation:

- **D**o **N**ot **S**hift (DNS) Response
  - Release lockup clutch and inhibit lockup operation.
  - Inhibit all shifts.
  - Turn on the "Do not shift" light.
  - Display the range attained.
  - Ignore any range selection inputs from the pushbutton shift selector.

- **SOL**enoid **OFF** (SOL OFF) Response
  - All solenoids are commanded off (turning solenoids "A" and "B" off electrically causes them to be on hydraulically).

- **R**eturn to **P**revious **R**ange (RPR) Response
  - When the speed sensor ratio or C3 pressure switch tests associated with a shift are not successful, the ECU commands the same range as commanded before the shift.

- **N**eutral **N**o **C**lutches (NNC) Response
  - When certain speed sensor ratio or C3 pressure switch tests are not successful, the ECU commands a neutral condition with no clutches applied.

SHIFT SELECTOR DISPLAYS RELATED TO ACTIVE CODES

- "Cateye"- The forward slash segments and the middle horizontal segments (-\-) may be on under the following conditions:
  - RSI link fault is active (code 23 12 or 23 14).

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- When two COP timeouts occur within two seconds of each other (reference code 69 33).
- Shift selector display line fault is active (23 16).
- Display the range attained.
- Ignore any range selection inputs from the pushbutton shift selector.

• All Segments Displayed- All display segments will be illuminated if a severity 1 diagnostic code is present during initialization, or if an electrical code for solenoids A, B, C, D, E, or G is logged before initialization completes.

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DIAGNOSTIC CODE LIST AND DESCRIPTION

Main code	Subcode	Description	"Do not shift" light	Inhibited Operation Description
13	12	ECU input voltage, low	Yes	DNS, DNA,SOL OFF (hydraulic default)
	13	ECU input voltage, medium low	No	DNA
	23	ECU input voltage, high	Yes	DNS, SOL OFF (hydraulic default)
14	12	Oil level sensor, failed low	No	None
	23	Oil level sensor, failed high	No	None
21	12	Throttle position sensor, failed low	No	Use throttle default values, DNA
	23	Throttle position sensor, failed high	No	Use throttle default values, DNA
22	14	Engine speed sensor reasonableness test	No	Use default engine speed, DNA
	15	Turbine speed sensor reasonableness test	Yes	DNS, lock in current range, DNA
	16	Output speed sensor reasonableness test	Yes(1)	DNS, lock in current range, DNA
23	12	Primary shift selector or RSI link fault	No	Hold in last valid direction. May cause "cateye" display.
	13	Primary shift selector mode function fault	No	Mode change not permitted.
	14	Secondary shift selector or RSI link fault	No	Hold in last valid direction. May cause "cateye" display.
	15	Secondary shift selector mode function fault	No	Mode change not permitted.
	16	Shift selector display line fault	No	None. May cause "cateye" display.
24	12	Sump fluid temperature, cold	Yes	DNS, lock in neutral
	23	Sump fluid temperature, hot	No	No upshifts above a calibration range.
25	00	Output speed sensor, detected at 0 output rpm, Low	Yes(1)	DNS, lock in current range (Low), DNA
	11	Output speed sensor, detected at 0 output rpm, 1st	Yes(1)	DNS, lock in current range (1st), DNA
	22	Output speed sensor, detected at 0 output rpm, 2nd	Yes(1)	DNS, lock in current range (2nd), DNA
	33	Output speed sensor, detected at 0 output rpm, 3rd	Yes(1)	DNS, lock in current range (3rd), DNA
	44	Output speed sensor, detected at 0 output rpm, 4th	Yes(1)	DNS, lock in current range (4th), DNA
	55	Output speed sensor, detected at 0 output rpm, 5th	Yes(1)	DNS, lock in current range (5th), DNA
	66	Output speed sensor, detected at 0 output rpm, 6th	Yes(1)	DNS, lock in current range (6th), DNA
	77	Output speed sensor, detected at 0 output rpm, R	Yes(1)	DNS, lock in current range (R), DNA

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Main code	Subcode	Description	"Do not shift" light	Inhibited Operation Description
26	00	Throttle source not detected	No	Use throttle default values, DNA
	11	Engine coolant source not detected	No	Use default value of 0°F
32	00	C3 pressure switch open, low range	Yes	DNS, lock in current range (low), DNA
	33	C3 pressure switch open, 3rd range	Yes	DNS, lock in current range (3rd), DNA
	55	C3 pressure switch open, 5th range	Yes	DNS, lock in current range (5th), DNA
	77	C3 pressure switch open, reverse range	Yes	DNS, lock in current range (R), DNA
33	12	Sump oil temperature sensor, failed low	No	Use default value of 200 °F
	23	Sump oil temperature sensor, failed high	No	Use default value of 200 °F
34	12	Factory calibration compatibility number wrong	Yes[(5)]	DNS, SOL OFF (hydraulic default), DNA
	13	Factory calibration block checksum	Yes[(5)]	DNS, SOL OFF (hydraulic default), DNA
	14	Power off block checksum	No	Use previous location, or factory calibration and reset adaptive, DNA
	15	Diagnostic queue block checksum	No	Use previous location, or clear diagnostic queue, DNA
	16	Real time block checksum	Yes	DNS, SOL OFF (hydraulic default), DNA
	17	Customer modifiable constants checksum	Yes[(5)]	DNS, SOL OFF (hydraulic default), DNA
35	00	Power interruption (code set after power restored)	No	None (hydraulic default during interruption)
	16	Real time write interruption	Yes	DNS, SOL OFF (hydraulic default), DNA
36	00	Hardware/software not compatible	Yes[(2)]	DNS, SOL OFF (hydraulic default), DNA
	01	TID not compatible with hardware/software	No[(2)]	Use TIDCAP cal
	02	Tid did not complete	No	Use TIDCAP cal, code 42 XX or 69 XX may be logged
42	12	Short-to-battery, A solenoid circuit	Yes	DNS, SOL OFF, DNA
	13	Short-to-battery, B solenoid circuit	Yes	DNS, SOL OFF, DNA
	14	Short-to-battery, C solenoid circuit	Yes	DNS, SOL OFF, DNA
	15	Short-to-battery, D solenoid circuit	Yes	DNS, SOL OFF, DNA
	16	Short-to-battery, E solenoid circuit	Yes	DNS, SOL OFF, DNA
	21	Short-to-battery, F solenoid circuit	No	Lockup inhibited, DNA

Main code	Subcode	Description	"Do not shift" light	Inhibited Operation Description
42	22	Short-to-battery, G solenoid circuit	Yes	DNS, SOL OFF, DNA
	23	Short-to-battery, H solenoid circuit	No	Differential lock inhibited (3070 only), retarder inhibited
	24	Short-to-battery, J solenoid circuit	No	Low and 1st inhibited
	26	Short-to-battery, N solenoid circuit	No	Low and 1st inhibited, allow retarder
44	12	Short-to-ground, A solenoid circuit	Yes	DNS, SOL OFF (hydraulic default), DNA
	13	Short-to-ground, B solenoid circuit	Yes	DNS, SOL OFF (hydraulic default), DNA
	14	Short-to-ground, C solenoid circuit	Yes	DNS, SOL OFF (hydraulic default), DNA
	15	Short-to-ground, D solenoid circuit	Yes	DNS, SOL OFF (hydraulic default), DNA
	16	Short-to-ground, E solenoid circuit	Yes	DNS, SOL OFF (hydraulic default), DNA
	21	Short-to-ground, F solenoid circuit	No	Lockup inhibited, DNA
	22	Short-to-ground, G solenoid circuit	Yes	DNS, SOL OFF (hydraulic default), DNA
	23	Short-to-ground, H solenoid circuit	No	Differential lock inhibited (3070 only), retarder operation inhibited
	24	Short-to-ground, J solenoid circuit	No	Low and 1st inhibited
	26	Short-to-ground, N solenoid circuit	No	Low and 1st inhibited, retarder allowed
45	12	Open circuit, A solenoid circuit	Yes	DNS, SOL OFF (hydraulic default), DNA
	13	Open circuit, B solenoid circuit	Yes	DNS, SOL OFF (hydraulic default), DNA
	14	Open circuit, C solenoid circuit	Yes	DNS, SOL OFF (hydraulic default), DNA
	15	Open circuit, D solenoid circuit	Yes	DNS, SOL OFF (hydraulic default), DNA
	16	Open circuit, E solenoid circuit	Yes	DNS, SOL OFF (hydraulic default), DNA
	21	Open circuit, F solenoid circuit	No	Lockup inhibited, DNA
	22	Open circuit, G solenoid circuit	Yes	DNS, SOL OFF (hydraulic default), DNA
	23	Open circuit, H solenoid circuit	No	Differential lock inhibited (3070 only), retarder operation inhibited
	24	Open circuit, J solenoid circuit	No	Low and 1st inhibited
	26	Open circuit, N solenoid circuit	No	Low and 1st inhibited, retarder allowed
46	21	Overcurrent, F solenoid circuit	No	Lockup inhibited, DNA
	26	Overcurrent, N and H solenoid circuit	No	Low and first inhibited or retarder inhibited, DNA
	27	Overcurrent, A-Hi solenoid circuit	Yes	DNS, SOL OFF (hydraulic default), DNA

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Main code	Subcode	Description	"Do not shift" light	Inhibited Operation Description
51	01	Offgoing ratio test (during shift), Low to 1	Yes	DNS, RPR, DNA
	10	Offgoing ratio test (during shift), 1 to low	Yes	DNS, RPR, DNA
	12	Offgoing ratio test (during shift), 1 to 2	Yes	DNS, RPR, DNA
	21	Offgoing ratio test (during shift), 2 to 1	Yes	DNS, RPR, DNA
	23	Offgoing ratio test (during shift), 2 to 3	Yes	DNS, RPR, DNA
	24	Offgoing ratio test (during shift), 2 to 4	Yes	DNS, RPR, DNA
	35	Offgoing ratio test (during shift), 3 to 5	Yes	DNS, RPR, DNA
	42	Offgoing ratio test (during shift), 4 to 2	Yes	DNS, RPR, DNA
	43	Offgoing ratio test (during shift), 4 to 3	Yes[(1)]	DNS, RPR, DNA
	45	Offgoing ratio test (during shift), 4 to 5	Yes[(1)]	DNS, RPR, DNA
	46	Offgoing ratio test (during shift), 4 to 6	Yes	DNS, RPR, DNA
	53	Offgoing ratio test (during shift), 5 to 3	Yes	DNS, RPR, DNA
	64	Offgoing ratio test (during shift), 6 to 4	Yes	DNS, RPR, DNA
	65	Offgoing ratio test (during shift), 6 to 5	Yes	DNS, RPR, DNA
	XY	Offgoing ratio test, X to Y[(3)]		
52	01	Offgoing C3PS test (during shift), Low to 1	Yes	DNS, RPR, DNA
	08	Offgoing C3PS test (during shift), Low to N1	Yes	DNS, NNC, DNA
	32	Offgoing C3PS test (during shift), 3 to 2	Yes	DNS, RPR, DNA
	34	Offgoing C3PS test (during shift), 3 to 4	Yes	DNS, RPR, DNA
	54	Offgoing C3PS test (during shift), 5 to 4	Yes	DNS, RPR, DNA
	56	Offgoing C3PS test (during shift), 5 to 6	Yes	DNS, RPR, DNA
	71	Offgoing C3PS test (during shift), R to 1	Yes	DNS, NNC, DNA
	72	Offgoing C3PS test (during shift), R to 2	Yes	DNS, NNC, DNA
	78	Offgoing C3PS test (during shift), R to N1	Yes	DNS, NNC, DNA
	99	Offgoing C3PS test (during shift), N3 to N2	Yes	DNS, RPR, DNA
	XY	Offgoing C3PS test, X to Y[(3)]		
53	08	Offgoing speed test (during shift), L to N1	Yes[(1)]	DNS, NNC, DNA
	18	Offgoing speed test (during shift), 1 to N1	Yes[(1)]	DNS, NNC, DNA
	28	Offgoing speed test (during shift), 2 to N1	Yes[(1)]	DNS, NNC, DNA
	29	Offgoing speed test (during shift), 2 to N2	Yes[(1)]	DNS, RPR, DNA

Main code	Subcode	Description	"Do not shift" light	Inhibited Operation Description
53	38	Offgoing speed test (during shift), 3 to N1	Yes(1)	DNS, NNC, DNA
	39	Offgoing speed test (during shift), 3 to N3	Yes(1)	DNS, RPR, DNA
	48	Offgoing speed test (during shift), 4 to N1	Yes(1)	DNS, NNC, DNA
	49	Offgoing speed test (during shift), 4 to N3	Yes(1)	DNS, RPR, DNA
	58	Offgoing speed test (during shift), 5 to N1	Yes(1)	DNS, NNC, DNA
	59	Offgoing speed test (during shift), 5 to N3	Yes(1)	DNS, RPR, DNA
	68	Offgoing speed test (during shift), 6 to N1	Yes(1)	DNS, NNC, DNA
	69	Offgoing speed test (during shift), 6 to N4	Yes(1)	DNS, RPR, DNA
	78	Offgoing speed test (during shift), R to N1	Yes	DNS, NNC, DNA
	99	Offgoing speed test (during shift), N2 to N3 or N3 to N2	Yes	DNS, RPR, DNA
	XY	Offgoing speed test (during shift), X to Y(3)		
54	01	Oncoming ratio test (after shift), L to 1	Yes	DNS, RPR, DNA
	07	Oncoming ratio test (after shift), L to R	Yes	DNS, NNC, DNA
	10	Oncoming ratio test (after shift), 1 to L	Yes	DNS, RPR, DNA
	12	Oncoming ratio test (after shift), 1 to 2	Yes	DNS, RPR, DNA
	17	Oncoming ratio test (after shift), 1 to R	Yes	DNS, NNC, DNA
	21	Oncoming ratio test (after shift), 2 to 1	Yes	DNS, RPR, DNA
	23	Oncoming ratio test (after shift), 2 to 3	Yes	DNS, RPR, DNA
	24	Oncoming ratio test (during shift), 2 to 4	Yes	DNS, RPR, DNA
	27	Oncoming ratio test (after shift), 2 to R	Yes	DNS, RPR, DNA
	32	Oncoming ratio test (after shift), 3 to 2	Yes	DNS, RPR, DNA
	34	Oncoming ratio test (after shift), 3 to 4	Yes	DNS, RPR, DNA
	35	Oncoming ratio test (during shift), 3 to 5	Yes	DNS, RPR, DNA
	42	Oncoming ratio test (during shift), 4 to 2	Yes	DNS, RPR, DNA
	43	Oncoming ratio test (after shift), 4 to 3	Yes	DNS, RPR, DNA
	45	Oncoming ratio test (after shift), 4 to 5	Yes	DNS, RPR or SOL OFF (hydraulic default), DNA
	46	Oncoming ratio test (during shift), 4 to 6	Yes	DNS, RPR, DNA
	53	Oncoming ratio test (during shift), 5 to 3	Yes	DNS, RPR, DNA
	54	Oncoming ratio test (after shift), 5 to 4	Yes	DNS, RPR, DNA
	56	Oncoming ratio test (after shift), 5 to 6	Yes	DNS, RPR, DNA
	64	Oncoming ratio test (after shift), 6 to 4	Yes	DNS, RPR, DNA

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Main code	Subcode	Description	"Do not shift" light	Inhibited Operation Description
54	65	Oncoming ratio test (after shift), 6 to 5	Yes	DNS, RPR, DNA
	70	Oncoming ratio test (after shift), R to L	Yes	DNS, NNC, DNA
	71	Oncoming ratio test (after shift), R to 1	Yes	DNS, NNC, DNA
	72	Oncoming ratio test (after shift), R to 2	Yes	DNS, NNC, DNA
	80	Oncoming ratio test (after shift), N1 to L	Yes	DNS, RPR, DNA
	81	Oncoming ratio test (after shift), N1 to 1	Yes	DNS, RPR, DNA
	82	Oncoming ratio test (after shift), N1 to 2	Yes	DNS, RPR, DNA
	83	Oncoming ratio test (after shift), N1 to 3	Yes	DNS, RPR, DNA
	85	Oncoming ratio test (after shift), N1 to 5	Yes	DNS, RPR, DNA
	86	Oncoming ratio test (after shift), N1 to 6	Yes	DNS, RPR, DNA
	92	Oncoming ratio test (after shift), N2 to 2	Yes	DNS, RPR, DNA
	93	Oncoming ratio test (after shift), N3 to 3	Yes	DNS, RPR, DNA
	95	Oncoming ratio test (after shift), N3 to 5	Yes	DNS, RPR, DNA
	96	Oncoming ratio test (after shift), N4 to 6	Yes	DNS, RPR, DNA
	XY	Oncoming ratio test (after shift), X to Y(3)		
55	07	Oncoming C3PS test (after shift), low to R	Yes(1)	DNS, NNC, DNA
	17	Oncoming C3PS test (after shift), 1 to R	Yes(1)	DNS, NNC, DNA
	27	Oncoming C3PS test (after shift), 2 to R	Yes(1)	DNS, NNC, DNA
	87	Oncoming C3PS test (after shift), N1 to R	Yes	DNS, RPR, DNA
	97	Oncoming C3PS test (after shift), NVL to R	Yes(1)	DNS, NNC, DNA
	XY	Oncoming C3PS test (after shift), X to Y(3)		
56	00	Range verification test, L	Yes(1)	DNS, 1st, Low, or SOL OFF (Low), DNA
	11	Range verification ratio test, 1st	Yes	DNS, 6th, DNA
	22	Range verification ratio test, 2nd	Yes(1)	DNS, 6th or 5th, DNA
	33	Range verification ratio test, 3rd	Yes(1)	DNS, 5th or SOL OFF (4th), DNA
	44	Range verification ratio test, 4th	Yes	DNS, 3rd or 5th, DNA
	55	Range verification radio test, 5th	Yes(1)	DNS, SOL OFF (5th) or 3rd, DNA
	66	Range verification ratio test, 6th	Yes	DNS, 5th, 3rd, or SOL OFF (3rd), DNA
	77	Range verification ratio test, R	Yes	DNS, N2 or N3, DNA

Main code	Subcode	Description	"Do not shift" light	Inhibited Operation Description
57	11	Range verification C3PS test, 1st	Yes	DNS, SOL OFF (3rd), DNA
	22	Range verification C3PS test, 2nd	Yes	DNS, 3rd, DNA
	44	Range verification C3PS test, 4th	Yes	DNS, 5th or SOL OFF (3rd), DNA
	66	Range verification C3PS test, 6th	Yes	DNS, SOL OFF (5th), DNA
	88	Range verification C3PS test, N1	Yes	DNS, N3, DNA
	99	Range verification C3PS test, N2 or N4	Yes	DNS, N3, DNA
61	00	Retarder oil temperature, hot	No	None
62	12	Retarder temperature sensor failed low	No	None
	23	Retarder temperature sensor failed high	No	None
	32	Engine coolant sensor failed low	No	Use default value of 0 °F
	33	Engine coolant sensor failed high	No	Use default value of 0 °F
63	00	Input function fault	No	Does not prevent neutral to range shifts for Aux Function Range Inhibit-Special when two signals required are not "on" within 120 seconds of each other.
	26	Kickdown input failed on	No	Kickdown operation inhibited
	40	Service brake status input failed on	No	No auto Neutral to Drive shifts for refuse packer. (I/O package #41). No retarder if a TPS code is also active.
	41	Pump/pack and a neutral general purpose input	No	No auto N-D shifts for refuse packer (I/O package #41)
64	12	Retarder modulation request sensor failed low	No	Retarder operation inhibited
	23	Retarder modulation request sensor failed high	No	Retarder operation inhibited
66	00	Serial communications interface fault	No	Use default throttle values, DNA
	11	SCI engine coolant source fault	No	Use default value of 0 °F
69	27	ECU, inoperative A-Hi switch	Yes	DNS, NNC, DNA
	28	ECU, inoperative F-Hi switch	Yes	Lockup inhibited, DNA
	29	ECU, inoperative N and H-Hi switch	No	Low and first inhibited, retarder inhibited, DNA

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Main code	Subcode	Description	"Do not shift" light	Inhibited Operation Description
69	33	ECU, Computer Operating Properly (COP) timeout	No	Reset ECU, shutdown ECU on 2nd occurrence (power loss; hydraulic defaults). May cause "cateye" display or all segments blank display, DNA(4)
	34	ECU, write timeout	Yes	DNS, SOL OFF (hydraulic defaults), DNA
	35	ECU, checksum test	No	Induce COP timeout (reset ECU), DNA(4)
	36	ECU, RAM self test	No	Induce COP timeout (reset ECU), DNA(4)
	39	Communication chip addressing error	No	Use defaults for J1939 data, DNA
	41	ECU, I/O ASIC adressing test	No	Induce COP timeout (reset ECU), DNA(4)
	42	SPI output failure	Yes	GPO 1-8 and reverse warning inoperable
	43	SPI input failure	Yes	DNS, lock-in-range, DNA
70	12	Software, minor loop overrun	No	Induce COP timeout (reset ECU)
	13	Illegal write to address $0000	No	Induce COP timeout (reset ECU)
	14	Software, major loop overrun	No	Induce COP timeout (reset ECU)

NOTES

(1) This code is logged to real time to protect the transmission in case a loss of power to the ECU (Power Interruption, code 35 00) occurs.

(2) This ECU hardware or software must be changed so that they are compatible.

(3) Additional codes could be logged for other shifts where X indicates range shifted from and Y indicates range shifted to.

(4) The COP reset will clear the active inhibit

(5) The factory calibration must be rewritten to the ECU, or a different factory calibration is required to match the software in the ECU.

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ZF ASTRONIC TRANSMISSION

MAINTENANCE

PERIODIC INSPECTION AND CARE

Clean and inspect the exterior of the transmission at regular intervals. Severity of service and operating conditions determine the frequency of these inspections.

- Inspect for fluid leaks - repair immediately;
- Inspect for worn, frayed or improperly routed electrical harnesses.

TO CHECK TRANSMISSION HOUSING BREATHER - Figure 1

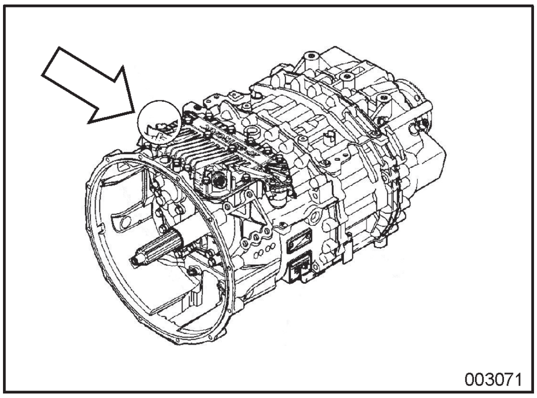

Figure 1: Location of transmission housing breather (illustration shows ZF Astronic without Intarder)

The breather serves to prevent pressure build-up within the transmission. The unit must be kept clean and the passage open at all times.

TO CHECK FLUID LEVEL - Figures 2 and 3

Check the fluid level when the transmission is cold (fluid temperature less than 104 °F). Refer to Section 12.3 for the recommended fluid.

!!! CAUTION !!!
LOW FLUID LEVEL WILL DAMAGE THE TRANSMISSION. RISK OF ACCIDENT.

!!! CAUTION !!!
FOR ZF ASTRONIC WITH INTARDER ONLY: DO NOT OPERATE THE INTARDER JUST BEFORE STOPPING THE ENGINE. OTHERWISE A PART OF THE FLUID WILL RUN TO THE INTARDER AND THE FLUID LEVEL CHECK, WHICH IS PERFORMED IN THE TRANSMISSION HOUSING, WILL BE INACCURATE.

1. Park the vehicle above an inspection pit and shut off the engine.

2. Clean the area around filler plug (2) and remove the plug.
   Fluid should be level with bottom of the filler hole. If necessary, top up with the recommended fluid via the filler hole.

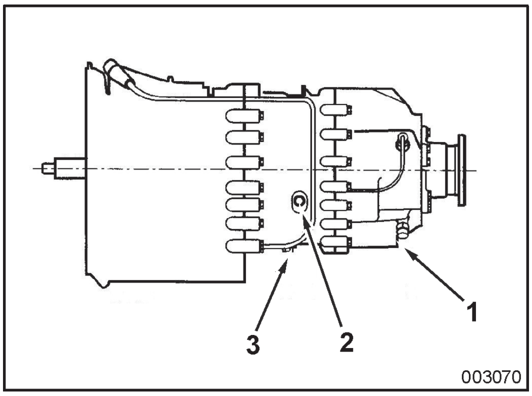

Figure 2: Side view of ZF Astronic without Intarder

1 and 3. Drain plugs
2. Filler plug

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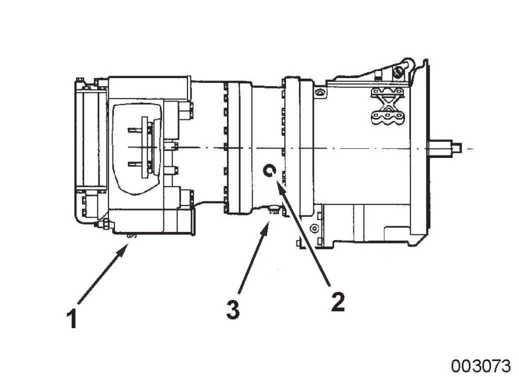

Figure 3: Side view of ZF Astronic with Intarder

1 and 3. Drain plugs
2. Filler plug

TO CHANGE FLUID
- Figures 2 and 3

To drain fluid

Drain the fluid when the transmission is at operating temperature.

!!! CAUTION !!!
HOT FLUID FLOWING OUT THE TRANSMISSION CAN CAUSE SCALDS. AVOID DIRECT CONTACT WITH YOUR SKIN.

!!! CAUTION !!!
FOR ZF ASTRONIC WITH INTARDER ONLY: DO NOT OPERATE THE INTARDER JUST BEFORE STOPPING THE ENGINE. OTHERWISE A PART OF THE FLUID WILL RUN TO THE INTARDER AND NOT ALL FLUID WILL BE DRAINED.

1. Park the vehicle above an inspection pit and shut off the engine.

2. Clean the area around drain plugs (1 and 3) and remove the plugs. Allow the fluid to drain into a suitable container. Always dispose of used fluid in an environmentally resposible manner, according to EPA and state recommendations.

3. Clean magnetic drain plugs.

4. Install drain plugs with a new gasket. Tightening torque: 45 ft.lbf.

5. For ZF Astronic with Intarder only: change the Intarder fluid filter (refer to "To change Intarder fluid filter" further on).

To fill

For ZF Astronic with Intarder only: the filler plug has an tag with fluid change instructions (see Figure 4). Do not forget to re-install it afterwards.

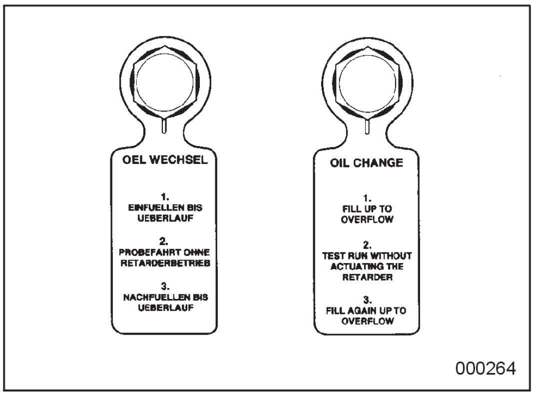

Figure 4: Tag with fluid change instructions

1. Remove filler plug (2).

2. Fill the transmission with the recommended fluid via the filler hole until level with bottom of hole.

3. Install filler plug with new gasket. Tightening torque: 45 ft.lbf.

NOTE
STEPS 4 TO 8 SHOULD ONLY BE PERFORMED WHEN THE ZF ASTRONIC IS EQUIPPED WITH AN INTARDER.

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4. Do not operate the Intarder during the road test! Perform a road test of 2 to 3 miles.

5. Park the vehicle again over an inspection pit. Do not operate the Intarder!

6. Remove filler plug (2).
   Fluid should be level with bottom of the filler hole. If necessary, top up with the recommended fluid via the filler hole.

7. Install filler plug (2) with new gasket. Tightening torque: 45 ft.lbf.

8. Secure the tag with fluid change instructions to the filler plug.

TO CHANGE INTARDER FLUID FILTER

On ZF Astronic with Intarder only.

!!! CAUTION !!!
THERE IS SOME RESIDUAL FLUID IN THE FILTER HOUSING. HOT FLUID CAN CAUSE SCALDS. AVOID DIRECT CONTACT WITH YOUR SKIN.

1. Remove retaining screw (1, Figure 6) of fluid filter cover (2, Figure 6).

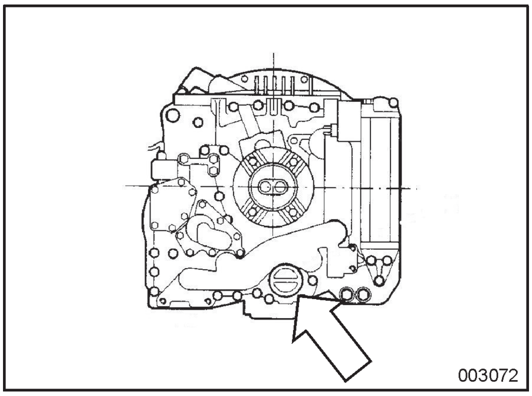

Figure 5: Location of Intarder fluid filter housing

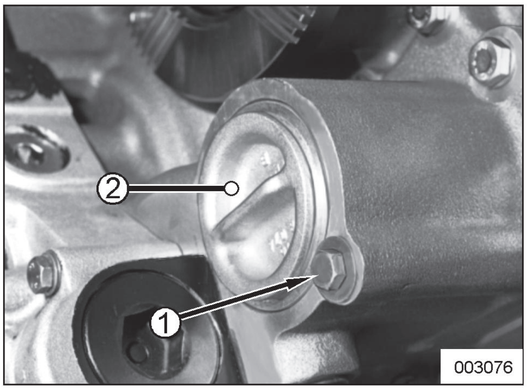

Figure 6: Fluid filter cover fixation

1. **Retaining screw**
2. **Fluid filter cover**

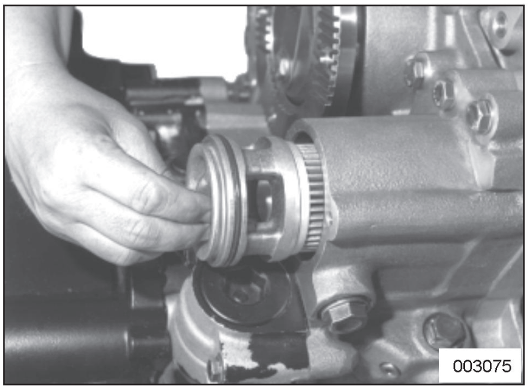

Figure 7: Pull out fluid filter

2. Pull cover together with filter out of the housing (see Figure 7).

3. Separate filter element from cover.

4. Inspect cover O-ring (2, Figure 8) for damage. Change, if necessary.

5. Grease cover O-ring (2, Figure 8).

6. Secure magnet (5, Figure 8) to the new filter element.

7. Grease filter O-ring (3, Figure 8).

8. Push cover (1, Figure 8) onto filter element (4, Figure 8).

9. Install the filter assembly into the housing until stop.

10. Install cover retaining screw (1, Figure 6). Tightening torque: 17 ft.lbf.

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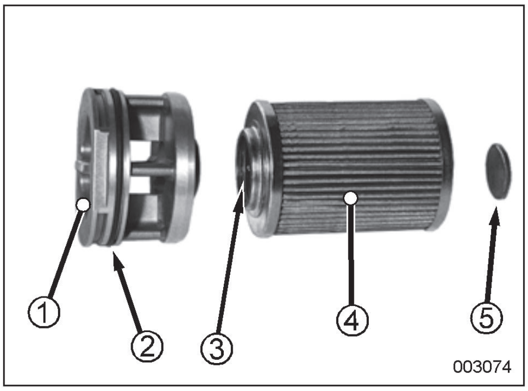


Figure 8: Fluid filter assembly

1. **Fluid filter cover**
2. **Cover O-ring**
3. **Filter O-ring**
4. **Filter element**
5. **Magnet**

OVERHAUL

TO REMOVE/INSTALL CLUTCH SERVO UNIT

The clutch servo unit is mounted on the clutch bell housing of the transmission and is accessible from underneath the vehicle. The air-operated servo unit is activated by the transmission electronics.

!!! CAUTION !!!
NEVER DISCONNECT A LINE CONTAINING PRESSURE. NEVER REMOVE A COMPONENT UNLESS YOU ARE CERTAIN ALL SYSTEM PRESSURE HAS BEEN DEPLETED. ALWAYS WEAR SAFETY GLASSES.

To remove

!!! CAUTION !!!
THE TRANSMISSION ELECTRONICS ACTIVATE THE SERVO UNIT EACH TIME THE IGNITION IS SWITCHED ON (PUSH-ROD MOVES OUTWARDS WITH A FORCE OF 4500 Lbf). FOLLOW THE PROCEDURE BELOW TO PREVENT THIS HAPPENS WHEN THE SERVO UNIT IS REMOVED FROM THE CLUTCH BELL HOUSING (BODY INJURY DANGER!!!).

1. Turn the ignition off and, if applicable, remove the ignition key.

2. Switch off the master switch on the instrument panel.

3. Drain the air pressure from all tanks by means of its drain valves. For the location of the compressed-air tanks, refer to Section 6.4.

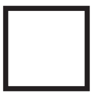
4. Remove the servo unit.

To install

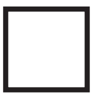
!!! CAUTION !!!
MAKE SURE THAT ALL PRESSURE IS DEPLETED FROM THE COMPRESSED-AIR SYSTEM BEFORE INSTALLING THE SERVO UNIT.

THROUBLESHOOTING

FAULT MESSAGES


ASTRONIC

A **system fault** is present if the "ASTRONIC" red waning light on the dashboard illuminates.


ASTRONIC

A **serious system fault** is present if the "ASTRONIC" red waning light on the dashboard illuminates and the message "SM" appears on the display of the push-button shift selector.

NOTE:
IF "SM" IS DISPLAYED WITHOUT THE ILLUMINATION OF THE "ASTRONIC" RED WARNING LIGHT, THE WARNING LAMP IS DEFECTIVE.

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TO CLEAR FAULT MEMORY

With the vehicle stationary, proceed as follows:

1. Switch off the ignition and wait until the display extinguishes.

   If the display does not extinguish, switch off master switch.

2. Switch ignition back on.

   If the fault message is still present, you have to bring the vehicle to a specialized workshop. Read fault codes before calling for assistance.

TO DISPLAY ACTIVE FAULT CODE

1. Switch on the ignition.
2. Start to push the "N" button.
3. Hold down the "↑" button of the push-button shift selector.

   The fault code appears on the display.

TO DISPLAY FAULT CODES FROM THE FAULT MEMORY

1. Switch on the ignition.
2. Start to push the "N" button of the push-button shift selector and, at the same time, depress the brake pedal.
3. While holding down the brake pedal, push and hold down the "↑" button of the push-button shift selector.

   The faults saved appear on the display of the push-button shift selector, one after another.

DIAGNOSTIC DATA READER (PRO-LINK)

Use the Diagnostic Data Reader (DDR) Pro-Link® 9000 which is available through Kent-Moore Heavy Duty Division. The Pro-Link® is a portable microcomputer-based receiver/ transmitter/display unit; it transmits and receives data to and from the ECU, processes the data and displays appropriate information.

Use the Pro-Link® during installation checkout and troubleshooting. Operation instructions are supplied with each Pro-Link®. Use the appropriate Pro-Link® cartridge. Connect the Pro-Link® to the round 6-pin Astronic diagnostic Data Reader receptable mounted in the diagnostic box in the R.H. console.

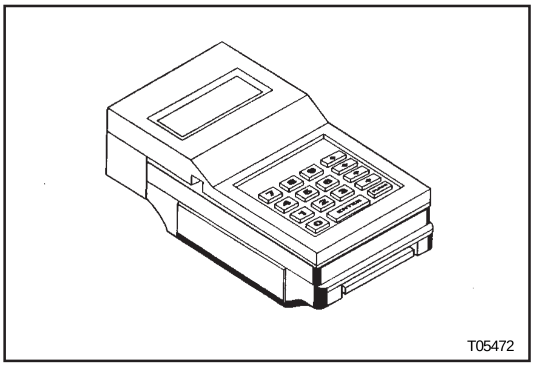

Figure 9: Diagnostic data reader

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PROPELLER SHAFT

MAINTENANCE

!!! CAUTION !!!

NEVER CLEAN THE PROPELLER SHAFT WITH A HIGH-PRESSURE OR STEAM CLEANER. IF IN DOUBT, REGREASE PROPELLER SHAFT UNIVERSAL JOINTS UNTIL NEW GREASE ESCAPES FROM THE BEARING SEALS.

MINOR INSPECTION

For intervals, see Section 12.1 "Maintenance Schedule".
This inspection should be carried out with the propeller shaft mounted in the vehicle.

If the propeller shaft is damaged, parts are missing or excessive wear is found, remove the shaft for repair in an authorized workshop.

To check flange bolts/screws for security

Check security of flange bolts by means of a torque wrench.

For recommended torque, see further in this Section.

To check for wear

Hold the shaft with both hands and try to move it up and down to make sure there is no lash in the sliding joint.

NOTE

Check for looseness in the universal joints BEFORE re-lubricating them.

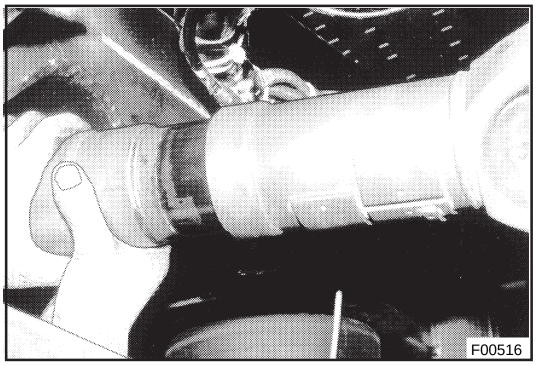

Figure 1: Checking for lash in sliding joint

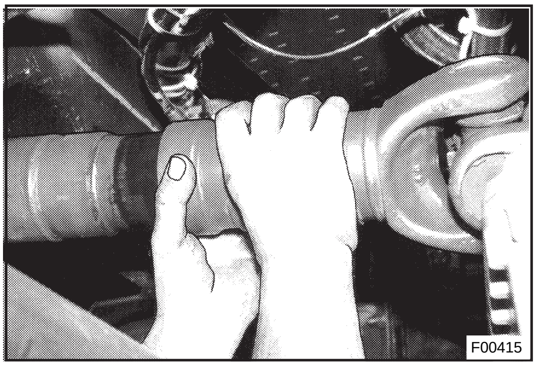

Figure 2: Checking for play in the universal joints

Try to twist the shaft by hand: any movement of the shaft main section in relation to the flange yoke indicates play in the universal joint.

!!! CAUTION !!!

DO NOT ATTEMPT TO TURN THE PROPELLER SHAFT BY MEANS OF A LEVER INSERTED THROUGH A UNIVERSAL JOINT, AS THIS MAY CAUSE DAMAGE TO SEALS AND LUBRICATORS.

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To check balance weights

Check whether all the balance weights are secure. Look for traces of missing balance weights. Remove any build-up of foreign matter, which can cause an out-of-balance condition from the shaft tube.

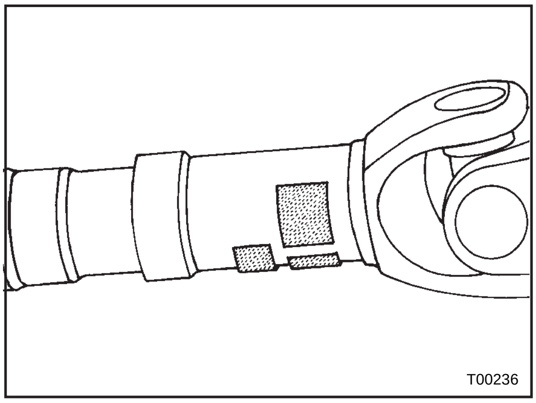

Figure 3: Balance weights

To check universal joint bearings

Check whether all bearings are secured with a snap ring (1, Figure 4). Check bearing cup (2, Figure 4) for signs of overheating (blue discolouration).

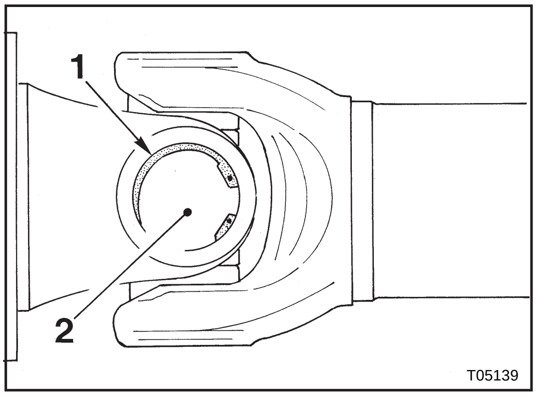

Figure 4: Universal joint

1. **Snap ring**
2. **Universal joint bearing**

To check seals

Visually check the condition of the universal joint bearing seals and the sliding joint seal. A damaged seal will result in excessive grease loss and breakdown of the propeller shaft.

To check synthetic resin-coating

Check the condition of the synthetic resin-coating at the outer diameter of the slip stub shaft (were the protective sleeve seal will slide) for damage or abrasion.

!!! CAUTION !!!
DO NOT APPLY LUBRICANT ON THE RESIN-COATED ZONE.

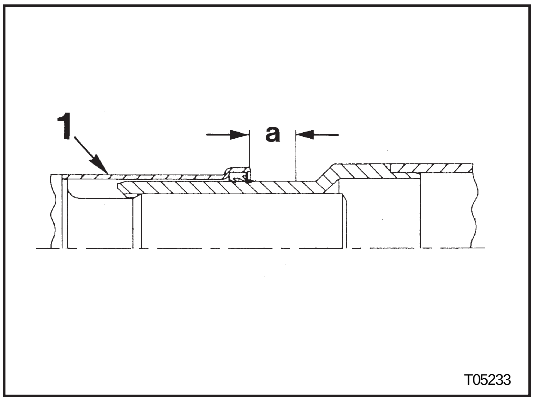

Figure 5: Detail of sliding joint

1. **Protective sleeve**

a. **Synthetic resin-coated zone**

To check shaft for damage

Visually check the shaft tube for flaked paint, cracks and dents. Check the protective sleeve (1, Figure 5) of the sliding joint for eccentricity.

TO LUBRICATE

At the intervals given in the maintenance schedule, use a grease gun to apply

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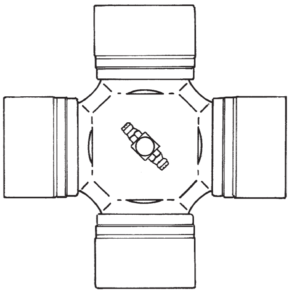

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Figure 6: Tee- grease nipple on universal joint

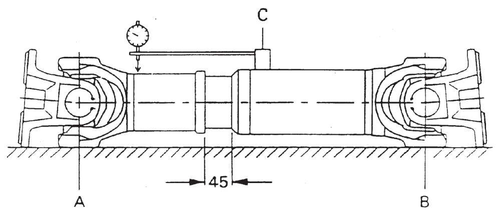

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Figure 7: Set-up for checking lash in sliding joint

lubricant through the Tee-nipple on the trunnion of both universal joints. Check that old grease escapes from all bearing seals. Use only a grease mentioned in Section 12.3.

!!! CAUTION !!!
TO AVOID DAMAGE, DO NOT FORCE IN THE GREASE WITH EXCESSIVE PRESSURE AND AVOID SHARP PRESSURE SURGES. MAXIMUM GREASE GUN PRESSURE: 200 PSI.

MAJOR INSPECTION

To be carried out at the intervals indicated in the maintenance schedule, Section 12.1. The propeller shaft should be removed from the vehicle.

If this inspection reveals damage or excessive wear, bring the shaft to an authorized work-shop for repair.

To check universal joints

Manoeuvre the universal joints in all directions by hand to check they are free from play or "tight spots" (e.g. hooking).

To check lash in sliding joint

1. Lay the complete shaft on a flat surface, the lugs of the inner yokes resting on the surface (points A and B, Figure 7). Extend the sliding joint by approximately 1.77 inch.
2. Mount a dial indicator with a magnetic base next to the weld of the sliding yoke (point C, Figure 7). Position stylus of dial indicator against the protective sleeve, as close as possible to the weld of this latter.
3. Lift the propeller shaft (approximately in its center of gravity) until the inner yokes become free of the flat surface.
4. Read the variation shown by the indicator. The maximum allowable value is 0.0067 inch.

To visually check the dismantled sliding joint

1. Withdraw the slip stub shaft from the sliding yoke.

!!! CAUTION !!!
DO NOT DAMAGE THE SYNTHETIC COATING OF THE SLIDING JOINT. DO NOT USE SOLVENTS; THIS WOULD AFFECT THE SYNTHETIC COATING.

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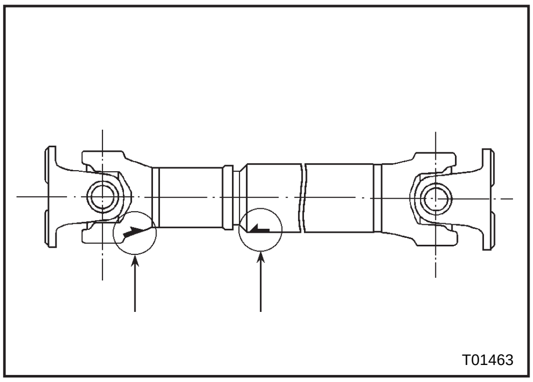

Figure 8: Alignment marks on the shaft members

2. Examine the sliding joint for damage at the inside and outside of the sliding yoke and at the splines of the slip stub shaft.

3. Check the condition of the protective sleeve seal.

4. If the sliding joint is undamaged, regrease the splines and the seal. Grease specifications: see Section 12.3.

5. Push the slip stub shaft into the sliding yoke, making sure the alignment marks (arrows) are in line, see figure 8.

TO INSTALL PROPELLER SHAFT

The following instructions should be observed when installing a propeller shaft:

- Prior to installation, mounting surfaces should be carefully cleaned. Remove any traces of rust-preventer, paint and lubricant with a suitable solvent.
- Prior to installation, check the relative position of the sliding joint members. The arrows on sliding yoke and slip stub shaft should be aligned (see figure 8).
- Pay attention to the correct sense of mounting: if on your vehicle the propeller shaft has been mounted in tilted position, the sliding yoke should be above.
- Bolt threads should be slightly oiled. Do not use lubricants containing molybdenum disulphide (MoS_2).
- The synthetic-resin coated plain section (a, Figure 5) of the sliding yoke, where the protective sleeve seal will slide, must be protected during painting operations.
- Tighten the flange bolts/screws to a torque of 130 to 150 ft.lbf.

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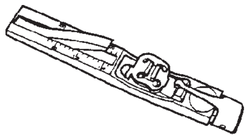
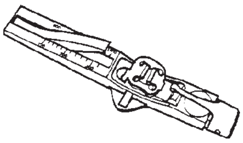
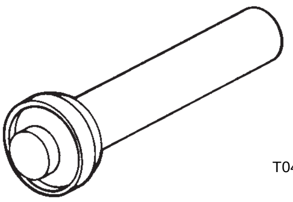
SPECIAL SERVICE TOOLS

TOOL NO. + ILLUSTRATION	DESCRIPTION
Gates 7401-00071  T03693	**Krikit I** To measure V-belt tension.
Gates 7401-00072  T03693	**Krikit II** To measure Powerband tension.
VH 10616471  T04175	**Bearing installation drift** To install idler pulley bearings

TOOL03AC

TOOL03AC

SERVICE BULLETINS

Service Bulletins are issued to supplement or supersede information in the Van Hool manuals. Note below number, date and subject of Bulletins pertaining to this chapter. File Bulletins separately by number for future reference.

Number	Date	Subject

CHAPTER 4

AXLES, WHEELS AND TYRES

MAIN04AG

TAG AXLE WITH LUCAS D-ELSA BRAKES

WHEELS AND TIRES

FRONT AXLE WITH LUCAS D-ELSA BRAKES

TECHNICAL DATA

Make: .... Van Hool

Track: .... approx. 81 inches

ALIGNMENT SPECIFICATIONS - Figure 1

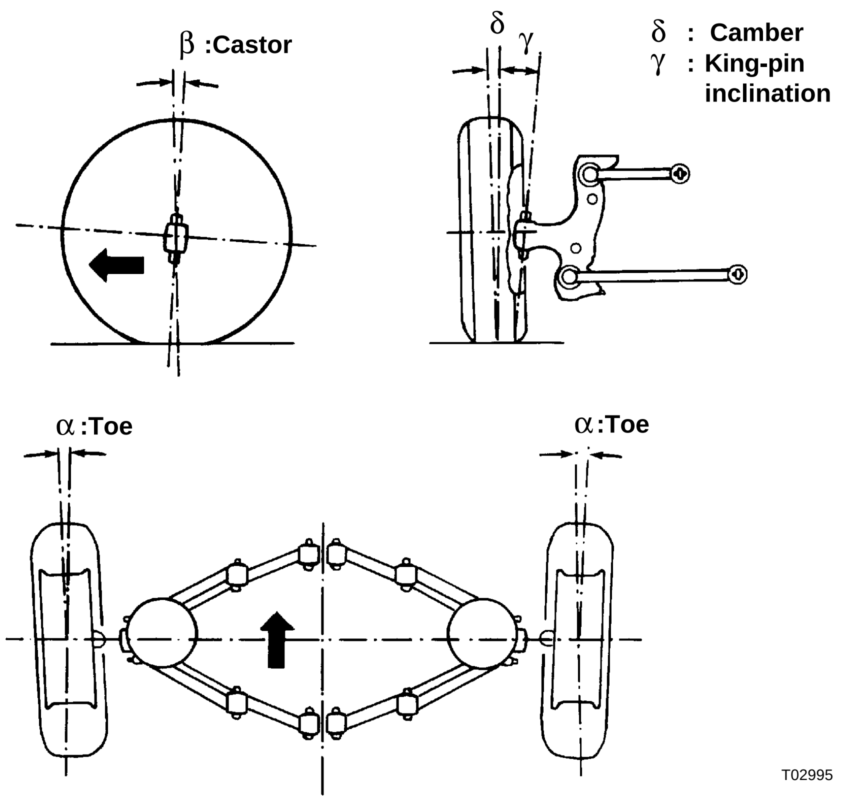


Figure 1: Alignment specifications

Caster: .... $\beta = 3 \pm 1/4°$

Camber:

- axle with non maintenance-free king-pin bearings......... $\delta = 1 + 1/2°$
- axle with maintenance-free king-pin bearings .... $\delta = 0 + 1/2°$

King-pin inclination:

- axle with non maintenance-free king-pin bearings........ $\gamma = 7 \pm 1/4°$
- axle with maintenance-free king-pin bearings .... $\gamma = 8 \pm 1/4°$

Toe: .... $\alpha = 0 \pm 1/8°$

Maximum steering angle:

Inner wheel: .... 50°

Outer wheel: .... 43°

NOTE
ALIGNMENT SHOULD BE PERFORMED ON AN EMPTY VEHICLE AND WITH AIR BELLOWS AT CORRECT HEIGHT.

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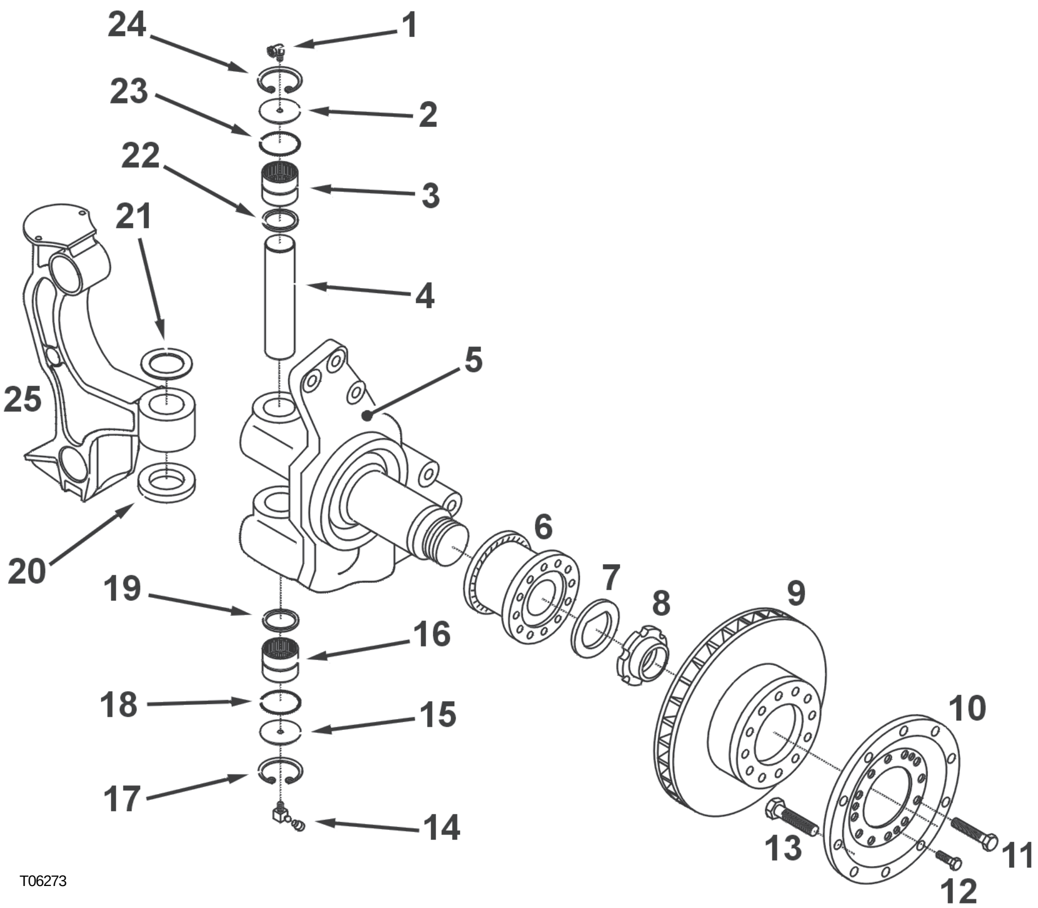

1. Elbow
2. Plug
3. Upper needle roller bearings
4. King-pin
5. Steering knuckle
6. Hub unit
7. Washer
8. Hub nut
9. Brake disc
10. Wheel flange
11 Screw securing brake disc and wheel flange to hub unit
12. Socket screw
13. Wheel stud
14. Grease nipple
15. Plug
16. Lower needle roller bearings
17. Snap ring
18. O-ring
19. Grease seal
20. Thrust roller bearing
21. Shim
22. Grease seal
23. O-ring
24. Snap ring
25. Steering knuckle carrier

Figure 2: Exploded view, front axle end with "non maintenance-free" steering knuckle bearings

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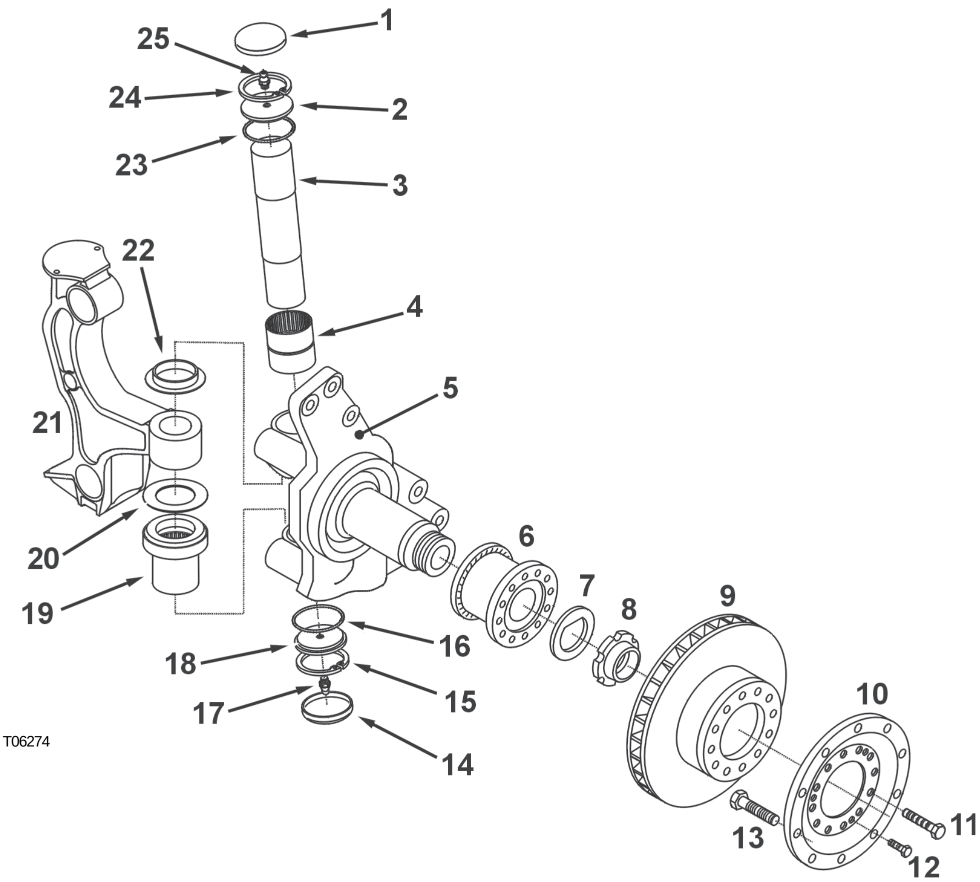

1. End cap
2. Plug
3. King-pin
4. Upper needle roller bearing
5. Steering knuckle
6. Hub unit
7. Washer
8. Hub nut
9. Brake disc
10. Wheel flange
11 Screw securing brake disc and wheel flange to hub unit
12. Socket screw
13. Wheel stud
14. End cap
15. Snap ring
16. O-ring
17. Grease nipple
18. Plug
19. Lower needle roller bearing unit
20. Shim
21. Steering knuckle carrier
22. Grease seal
23. O-ring
24. Snap ring
25. Grease nipple

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Figure 3: Exploded view, front axle end with "maintenance-free" steering knuckle bearings

STEERING KNUCKLE TYPES

INTRODUCTION

Two types can be found on Van Hool vehicles:

- Steering knuckles with **"non maintenance-free"** steering knuckle bearings. These should be lubricated periodically.
- Steering knuckles with "**maintenance-free**" steering knuckle bearings. These should **not** be lubricated periodically. The grease nipples are only used at assembly.

HOW TO RECOGNIZE?

Use figure 4 to appoint which steering knuckle type is used on your vehicle. Pay attention to the steering knuckle carrier center shape and the location of the grease nipples.

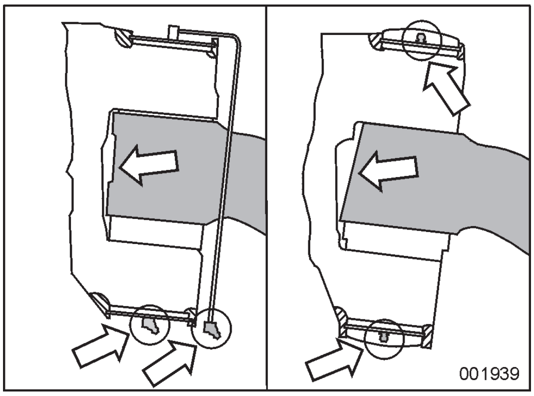

Figure 4: Steering knuckle types

Left: **steering knuckle with "non maintenance-free" steering knuckle bearings**
Right: **steering knuckle with "maintenance-free" steering knuckle bearings**

MAINTENANCE

TO LUBRICATE KING-PINS (only for axles with "non maintenance-free" steering knuckle bearings)

Lubricate the king-pins at the intervals given in Maintenance Schedule. Refer to chapter 12 for recommended lubricant.

Jack up the understructure until the front wheels are clear off the ground. Then press grease through the grease nipples (see arrows) on each steering knuckle until new grease appears at the gaps.

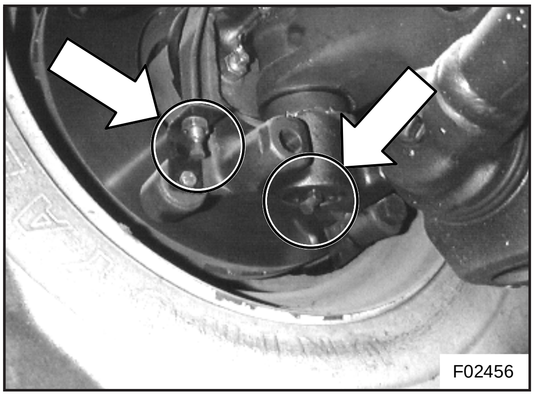

Figure 5: King-pin grease nipples

TO CHECK AXIAL CLEARANCE BETWEEN STEERING KNUCKLE AND CARRIER CENTER

Check the play between the steering knuckle and carrier center at the intervals given in the Maintenance Schedule, see chapter 12.

1. Place the vehicle over an inspection pit.
2. Chock the wheels remaining on the ground.
3. Attach dial indicator to the lower steering knuckle yoke. Position the stylus of the dial indicator to the lower edge of the carrier center. Distance between stylus and dial indicator support should be as short as possible.

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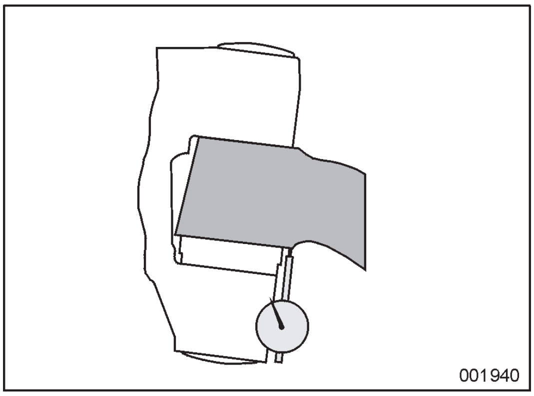

Figure 6: Measurement setup

4. Jack up the steering knuckle carrier until the wheels clear the ground.

5. Set dial indicator to zero.

6. Lower steering knuckle carrier onto ground.

7. Note the variation shown by the dial indicator. If variation is more than 0.4 mm (0.016 inch), then you have to remove the steering knuckle and replace all damaged parts.

TO REPLACE HUB GREASE

The wheel hubs are lubricated for life.

TO CHECK WHEEL BEARING END-PLAY

Check the wheel bearing end-play at the intervals given in the Maintenance Schedule, see chapter 12.

NOTE
BEARING END-PLAY IS NOT ADJUSTABLE. CHANGE THE COMPLETE HUB UNIT IF THE MEASURED VALUE IS OUT-OF-LIMIT.

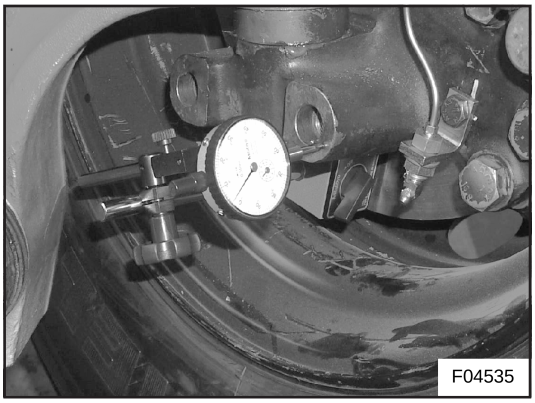

Figure 7: Dial indicator position

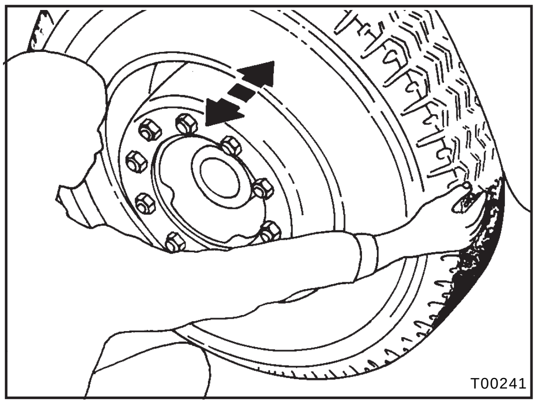

Figure 8: Push and pull the wheel

1. Jack up the steering knuckle carrier until the front wheel clears the ground.

2. Mount a dial indicator with a magnetic base at the bottom against the inside of the brake disc. Position the stylus of the dial indicator at a right angle to the brake disc against the machined face of the lower steering knuckle yoke, near the frontmost threaded hole.

3. Take a firm grip on the wheel and alternately push and pull it forward and backward.

4. Note the total variation shown by the indicator, which should be maximum 0.25 mm (0.01 inch).

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TO CHECK TOE

Check the toe with unladen vehicle and wheels on the ground. To be sure the measurement is correct, check the following points:

- Tire pressure;
- Air bellows height;
- Wheels for out-of-balance;
- Wheels for excessive lateral run-out;
- Steering linkage ball-joints for play.

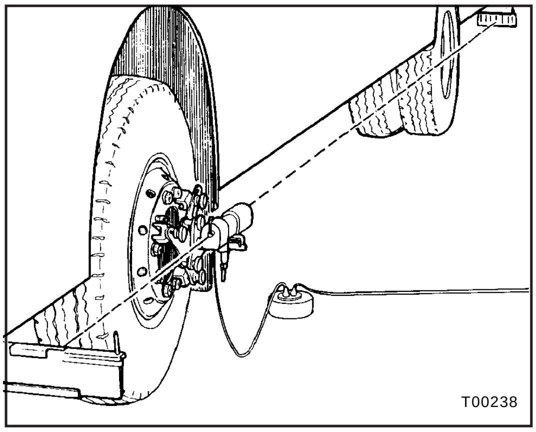

Figure 9

Check the toe for each wheel separately, with optical equipment. Follow the instructions of the manufacturer of the optical equipment.

Correct toe: $\alpha = 0 \pm 1/8°$

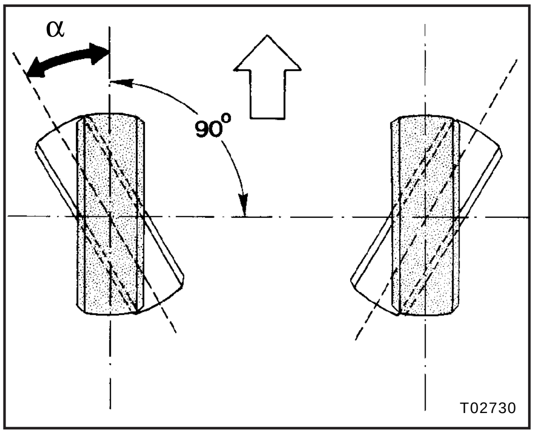

Figure 10

The toe is adjusted by changing the length of the tie-rod of the relevant wheel. This is to be done with the steering gear in the centralized position (see chapter 7). Loosen clamp bolt nut (1) on tie-rod ends and turn the rod tube as required to obtain correct toe measurement. One full turn of tie-rod corresponds with a wheel angle change of 0.118 inch/ft. Retighten clamp nuts (1) to 44 to 60 ft.lbf.

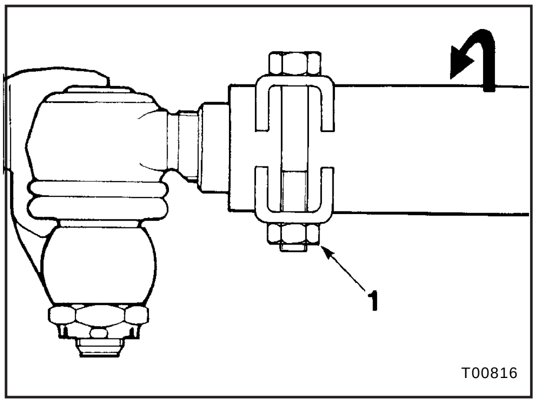

Figure 11

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OVERHAUL

WHEEL HUB

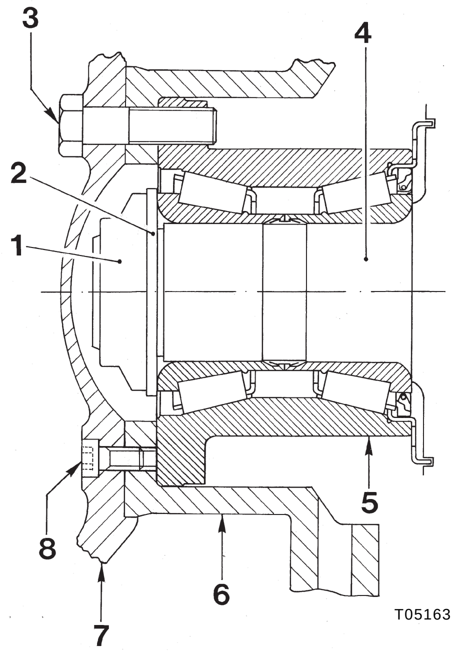
To remove the hub unit- Figure 12

NOTE
THE HUB UNIT COMBINES TWO BEARINGS, A GREASE SEAL AND AN ABS TOOTH WHEEL. IF ONE OF THESE COMPONENTS IS DAMAGED, THE COMPLETE UNIT MUST BE REPLACED BY A NEW ONE.

1. Apply the parking brake and chock the drive wheels. Jack up the vehicle at the front and position safety blocks under the chassis members. Remove the road wheel.
2. Refer to Section 5.1 to remove the brake caliper/brake carrier assembly.

!!!CAUTION!!!
THE WHEEL FLANGE AND THE BRAKE DISC ARE HEAVY. BE SURE THEY ARE WELL SUPPORTED BEFORE UNDOING THE RETAINING SCREWS.

3. Remove socket screw (8).
4. Remove the twelve screws (3) retaining the wheel flange and the brake disc to the hub unit.
5. Remove wheel flange (7).
6. Thread puller screws into the three M12 x 1.5 tapped holes in the brake disc to free it from the hub unit. Remove the brake disc.
7. Unscrew hub nut (1) using the socket of figure 10. Remove washer (2).



1. Hub nut
2. Washer
3. Screws securing brake disc and wheel flange to hub unit
4. Steering knuckle
5. Hub unit
6. Brake disc
7. Wheel flange
8. Socket screw

Figure 12: Section through front wheel hub

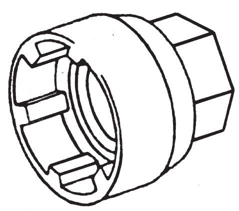


Figure 13: Hub nut socket (Van Hool ordering No. A996030253)

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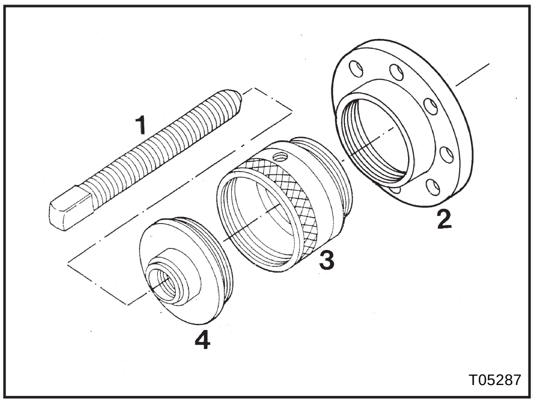


Figure 14: Tool set to remove hub unit

1. **Spindle (Van Hool No. A996060240)**
2. **Flange (Van Hool No. A996060464)**
3. **Threaded bush (Van Hool No. A996060251)**
4. **Cover (Van Hool No. A996060238)**

8. Use the tool set of figure 14 to remove the hub unit.

   Procedure:

   a. Secure flange (2) to the hub unit with three screws.

   b. Screw threaded bush (3) into flange (2).

   c. Screw cover (4) into threaded bush (3).

   d. Screw spindle (1) into cover (4).

   e. Remove the hub unit by turning spindle (1) clockwise.

To install the hub unit - Figure 12

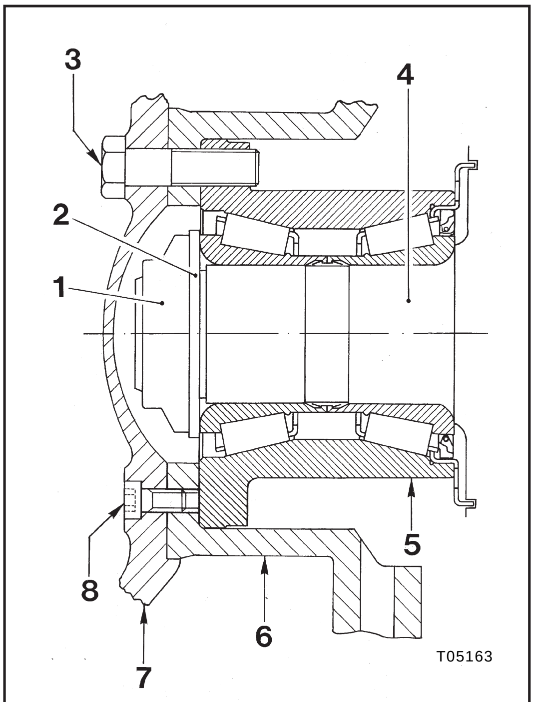
1. Apply a thin film of Never-Seez to steering knuckle spindle (4).

2. Use the tool set of figure 15 to install the hub unit.

   Procedure:

   a. Screw guide bush (1) onto the steering knuckle spindle.

   b. Slide the hub unit on bush (1).



1. Hub nut
2. Washer
3. Screws securing brake disc and wheel flange to hub unit
4. Steering knuckle
5. Hub unit
6. Brake disc
7. Wheel flange
8. Socket screw

Figure 12: Section through front wheel hub

   c. Slide press bush (2) on guide bush (1).

   d. Install washer (3) and nut (4) on the threaded rod of guide bush (1).

   e. Turn nut (4) clockwise to install the hub unit on the steering knuckle spindle.

   f. Remove the tools.

3. Install washer (2). Install hub nut (1). Tighten the hub nut to a torque of 740 ± 40 Nm (545 ± 30 ft. lbf.) and simultaneously rotate the hub in both directions to settle the hub bearings.

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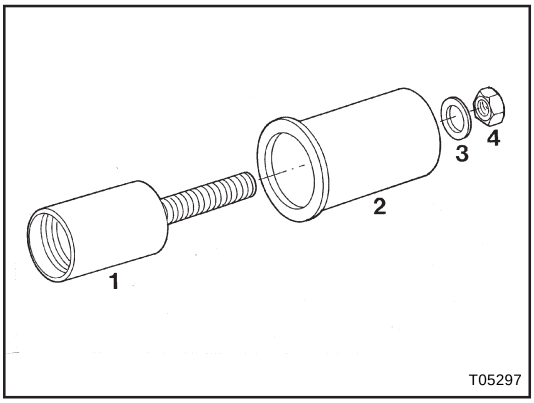

Figure 15: Tool set to install hub unit (Van Hool ordering No. 10678700)

4. Apply a thin film of NLGI No.2 grade high temperature lithium grease to the contact surfaces between brake disc (6) and hub unit (5).

5. Lay brake disc (6) on a flat surface. Position wheel flange (7) on brake disc (6) so that its small hole coincides with the small tapped hole in the brake disc. Secure wheel flange (7) to brake disc (6) with socket screw (8). Tightening torque of socket screw (8): 75 ± 10 Nm (55 ± 7 ft. lbf). Position the wheel flange/brake disc assembly to the hub unit so that there holes coincide with the tapped holes of the hub unit. Install the twelve screws (3) and tighten them crosswise in steps to a torque of 430 ± 30 Nm (320 ± 20 ft.lbf).

6. Refer to Section 5.1 to install the brake caliper/brake carrier.

7. Install the road wheel.

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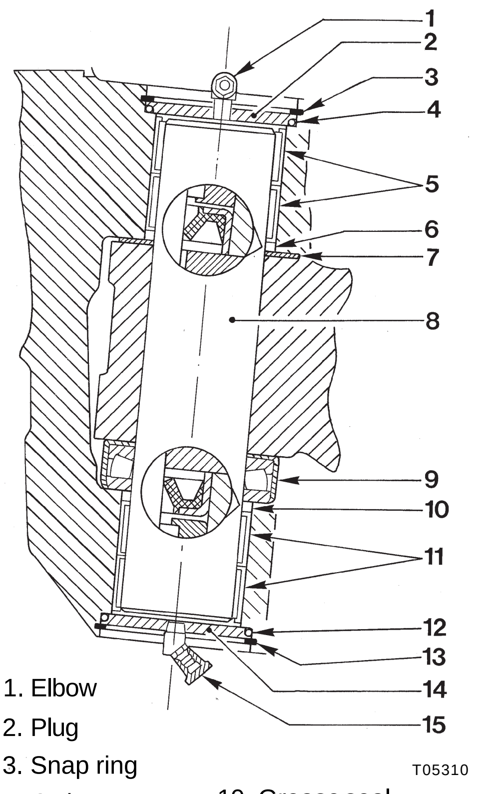
NON MAINTENANCE-FREE KING-PIN

To remove the king-pin- Figure 16

1. Chock the wheels and jack up the vehicle until the front wheels are clear of the ground. Position safety blocks under the chassis members. Remove the road wheel.
2. Refer to Section 5.1 to remove the brake caliper/brake carrier assembly.
3. Refer to "Wheel hub" to remove the hub unit.



1. Elbow
2. Plug
3. Snap ring
4. O-ring
5. Upper needle roller bearing
6. Grease seal
7. Shim washer
8. King-pin
9. Thrust roller bearing
10. Grease seal
11. Lower needle roller bearing
12. O-ring
13. Snap ring
14. Plug
15. Grease nipple (with dust cap)

Figure 16: Steering knuckle assembly (non maintenance-free king-pin)

!!! CAUTION !!!
IN CASE A TIE-ROD ARM SHOULD BE REMOVED: TO PREVENT DAMAGE TO THE ABS SENSOR AND THE ABS TOOTH WHEEL, REMOVE THE ABS SENSOR BEFORE REMOVING A TIE-ROD ARM. OTHERWISE THE ABS SENSOR WILL BE KNOCKED AGAINST THE STEERING KNUCKLE CARRIER WHEN THE STEERING KNUCKLE IS FULLY TURNED. THIS MAY RESULT IN DAMAGE TO THE ABS SENSOR AND ABS TOOTH WHEEL. NOTE THAT IF THE ABS TOOTH WHEEL IS DAMAGED THE WHOLE HUB UNIT MUST BE CHANGED.

4. Disconnect the tie-rod by removing the ball-pillar nut and drawing the ball-pillar out of the tie-rod arm.
5. Disconnect the grease line on elbow (1).
6. Remove snap rings (3) and (13).
7. Remove plugs (2) and (14).
8. Remove O-rings (4) and (12).

!!! CAUTION !!!
THE KING-PIN CAN ONLY BE REMOVED THROUGH THE TOP OF THE STEERING KNUCKLE.

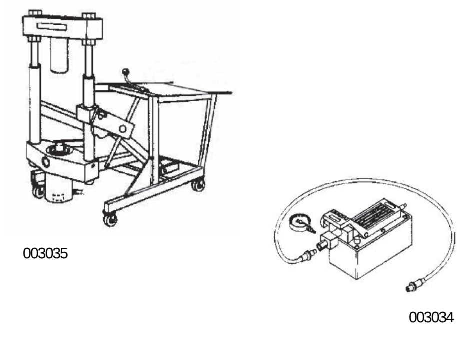


Figure 17: Press tool

1. **Press (Van Hool No. A996066079)**
2. **Pump (Van Hool No. A996206008)**

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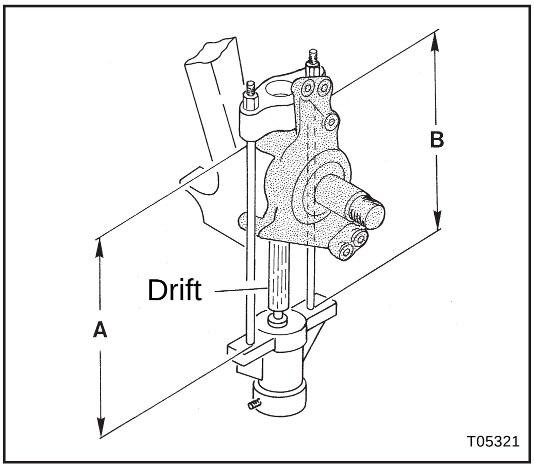

Figure 18: To remove the king-pin

Van Hool No. drift: A996170083

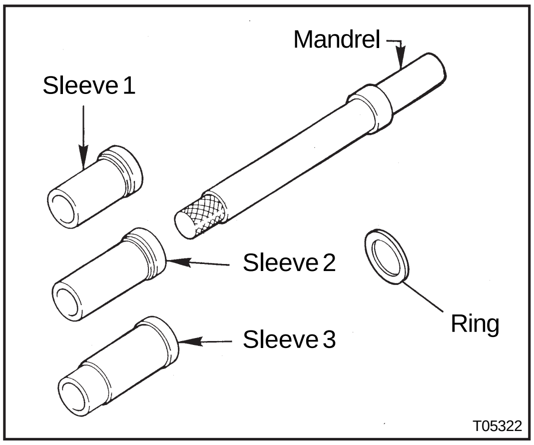

Figure 19: Tool set to remove and install the needle roller bearings and the grease seals

Van Hool No. sleeve 1: A996160096

Van Hool No. sleeve 2: A996160097

Van Hool No. sleeve 3: A996160098

Van Hool No. ring: A996160080

Van Hool No. set
(sleeves 1,2,3 and ring): A996166003

Van Hool No. mandrel: A996170025

9. Use the portable press of Figure 17 to free king-pin (8) from its fit in the steering knuckle carrier. Attach the press tool as indicated in figure 18. Position the drift (see figure 18) on top of the press. Tighten the nuts of the press tool so that the dimension A is equal to B. Press out the king-pin.

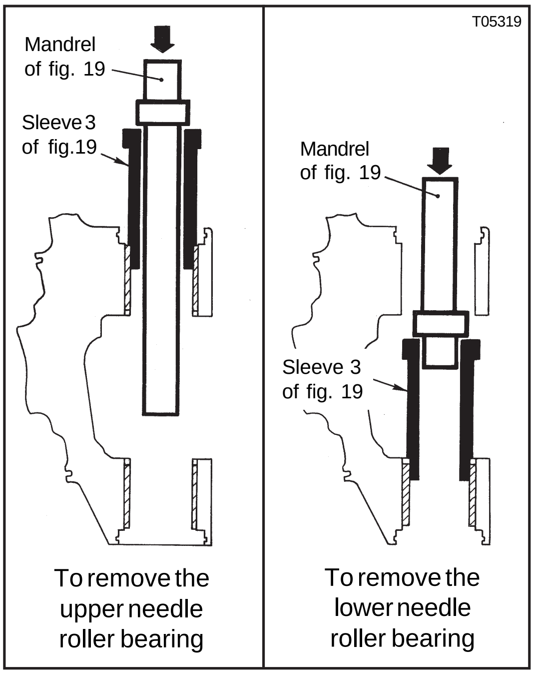

Figure 20: To remove the needle roller bearings

10. Remove steering knuckle assembly from steering knuckle carrier.

11. If needle roller bearings (5) and (11) are to be removed, press or tab the bearings (together with the grease seals) out of the steering knuckle, employing sleeve 3 and the mandrel of figure 19. Refer to figure 20 for the procedure. Discard the bearings and the grease seals.

To install the king-pin

1. Check the axial clearance, to select the appropriate shim washer thickness, as follows (see figure 21):

   a. Gauge the internal dimension between the steering knuckle yokes (measure "a").

   b. Gauge between the machined upper and lower faces of the carrier center (measure "b").

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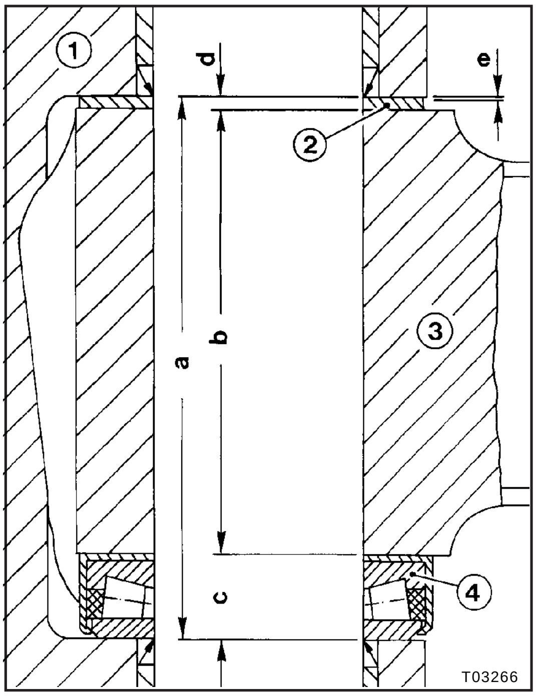

Figure 21: To check axial clearance

1. Steering knuckle
2. Shim washer
3. Steering knuckle carrier
4. Thrust roller bearing

Van Hool No. shim washers:

Thickness 1.8 mm (0.071 inch): N907130918
Thickness 1.9 mm (0.075 inch): N907130919
Thickness 2.0 mm (0.079 inch): N907130920
Thickness 2.1 mm (0.083 inch): N907130921
Thickness 2.2 mm (0.087 inch): N907130922
Thickness 2.3 mm (0.091 inch): N907130923

Set shim washers: N907130927

c. Gauge the thickness of the thrust roller bearing (measure "c").

d. Gauge the thickness of the shim washer (measure "d").

e. Axial clearance e:

$$\boxed{e = a - (b + c + d)}$$

Maximum allowable axial clearance is 0.2 mm (0.008 inch). If necessary, use a thicker shim washer.

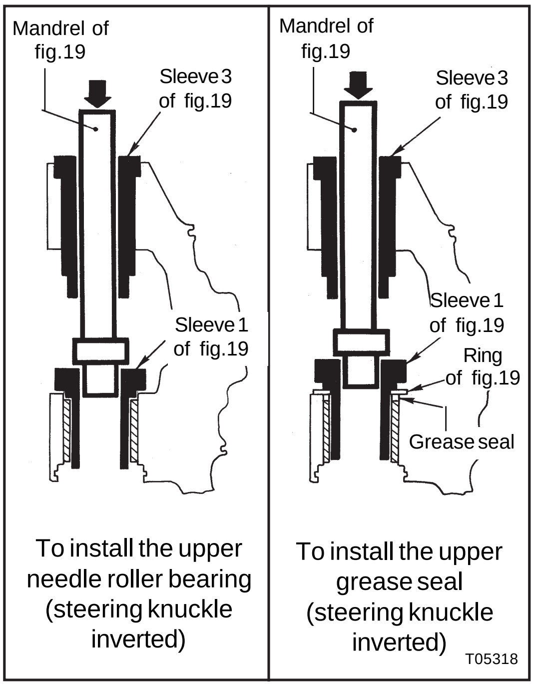

Figure 22: To install the upper needle roller bearing and the grease seal

2. Install the upper needle roller bearing and the grease seal as follows (see figure 22):

   a. Invert the steering knuckle.

   b. Locate sleeve 3 in the lower yoke of the steering knuckle to act as a guide for the mandrel.

   c. Press in the upper roller bearing using the mandrel and sleeve 1.

   d. Fit the grease seal in the upper yoke of the steering knuckle by using the mandrel, sleeve 1 and ring.

NOTE
THE SEAL IS TO BE ORIENTATED AS SHOWN IN FIGURE 16.

3. Install the lower needle roller bearing and the grease seal as follows (see figure 23):

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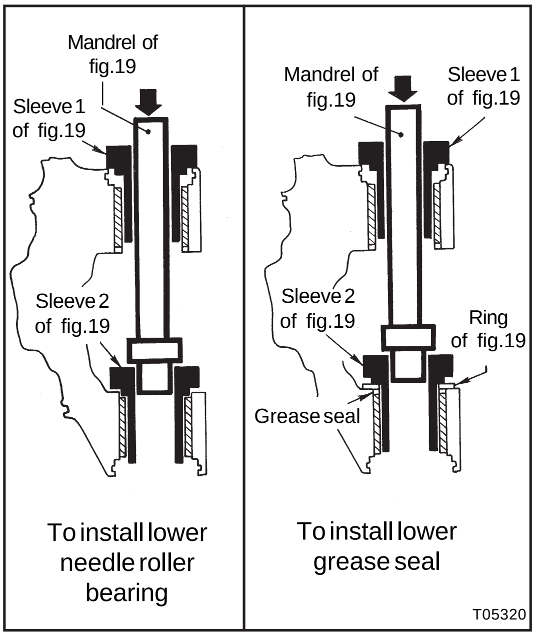

Figure 23: To install the lower needle roller bearing and the grease seal

a. Invert the stub axle so that its upper yoke is at the top.

b. Locate sleeve 1 in the upper yoke of the steering knuckle to act as a guide for the mandrel.

c. Press in the lower needle roller bearing using the mandrel and sleeve 2.

d. Fit the grease seal into the lower yoke of the steering knuckle using the mandrel, sleeve 2 and ring.

NOTE
THE SEAL IS TO BE ORIENTATED AS SHOWN IN FIGURE 16.

4. Position and support the steering knuckle assembly on the carrier center.

5. Slide the thrust roller bearing between the lower face of the carrier center and the upper face of the lower steering knuckle yoke.

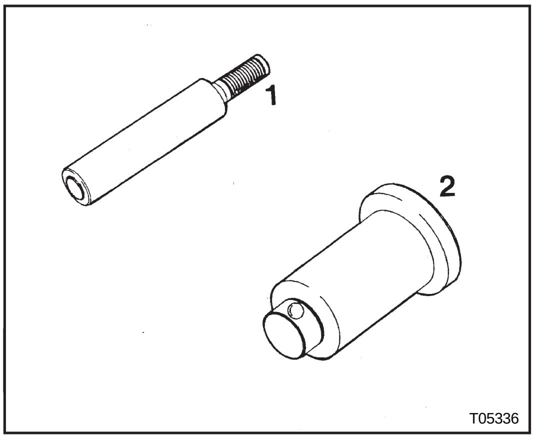

Figure 24: Special tools

1. **Guide pin (Van Hool No. A996170175)**
2. **King-pin drift (Van Hool No. A996170179)**

6. Lift the steering knuckle in position and slide the proper shim washer between the upper face of the carrier center and the lower face of the upper steering knuckle yoke.

7. Shift the steering knuckle with one hand and insert guide pin (1, Figure 24) from the top into the king-pin bore with the other hand. Carefully align the steering knuckle, the shim washer and the thrust bearing with the carrier center.

!!!CAUTION!!!
THE KING-PIN CAN ONLY BE INSTALLED THROUGH THE TOP OF THE STEERING KNUCKLE. THE KING-PIN MUST BE DRY, FREE OF GREASE AND CLEAN.

8. Attach the press tool as indicated in figure 25. Position the king-pin, with the smaller diameter at the bottom, on the guide pin.
Position drift (2, Figure 24) on top of the king-pin. Tighten the nuts of the press tool equally so that the measurement A is equal to B.
Press in the king-pin until stop.

9. Remove the press tool.

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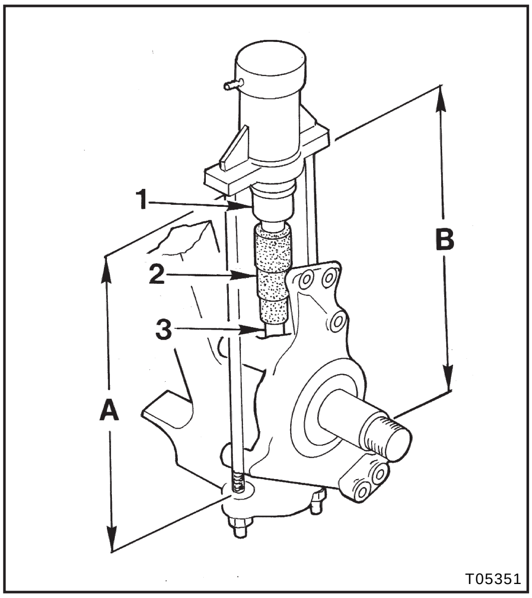

Figure 25: To install the king-pin

1. **King-pin drift of figure 21**
2. **King-pin**
3. **Guide pin of figure 21**

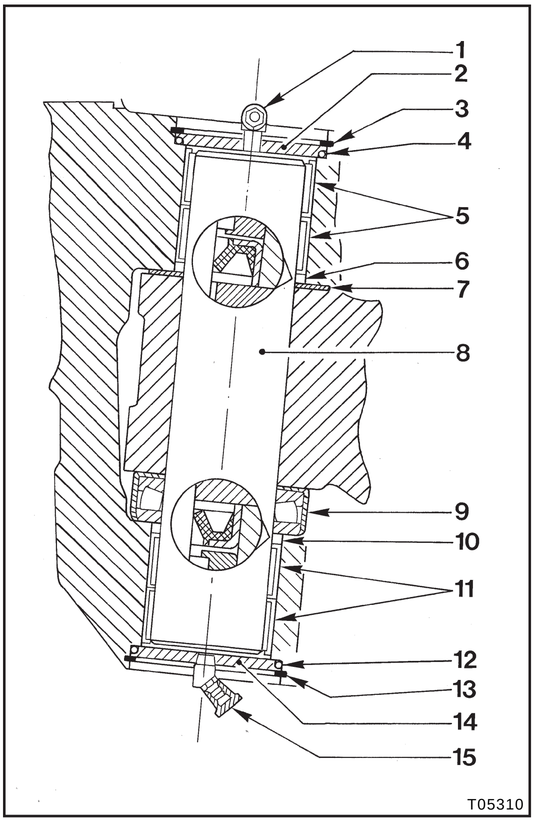

Figure 16: Steering knuckle assembly (non maintenance-free king-pin)

10. Install plug (14, Figure 16) with O-ring (12, Figure 16) and snap ring (13, Figure 16).
11. Install plug (2, Figure 16) with O-ring (4, Figure 16) and snap ring (3, Figure 16).
12. Thread grease nipple (15, Figure 16) in plug (14, Figure 16), elbow (1, Figure 16) in plug (2, Figure 16). Connect the grease line to elbow (1, Figure 16).
13. Lubricate the king-pin.
14. Refer to "Wheel hub" to install the hub assembly.
15. Refer to Section 5.1 to install the brake caliper/brake carrier assembly.
16. Connect the tie-rod.
17. Install the road wheel.

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MAINTENANCE-FREE KING-PIN

To remove the king-pin- Figure 26

1. Chock the wheels and jack up the vehicle until the front wheels are clear of the ground. Position safety blocks under the chassis members. Remove the road wheel.

2. Refer to Section 5.1 to remove the brake caliper/brake carrier assembly.

3. Refer to "Wheel hub" to remove the hub unit.

!!! CAUTION !!!
IN CASE A TIE-ROD ARM SHOULD BE REMOVED: TO PREVENT DAMAGE TO THE ABS SENSOR AND THE ABS TOOTH WHEEL, REMOVE THE ABS SENSOR BEFORE REMOVING A TIE-ROD ARM. OTHERWISE THE ABS SENSOR WILL BE KNOCKED AGAINST THE STEERING KNUCKLE CARRIER WHEN THE STEERING KNUCKLE IS FULLY TURNED. THIS MAY RESULT IN DAMAGE TO THE ABS SENSOR AND ABS TOOTH WHEEL. NOTE THAT IF THE ABS TOOTH WHEEL IS DAMAGED THE WHOLE HUB UNIT MUST BE CHANGED.

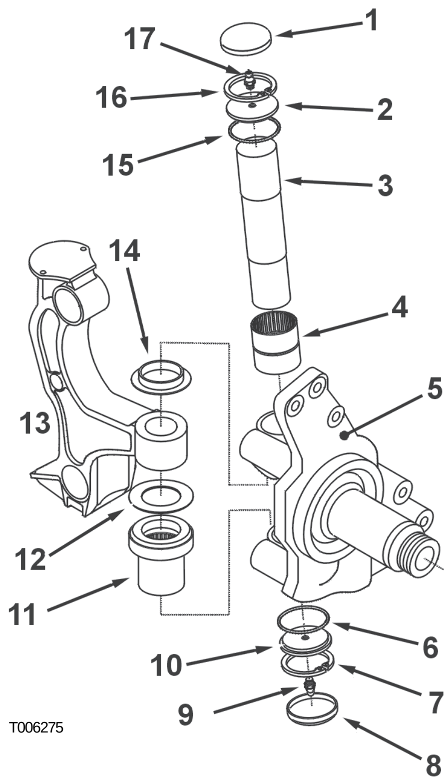
4. Disconnect the tie-rod by removing the ball-pillar nut and drawing the ball-pillar out of the tie-rod arm.

5. Lever off king-pin end caps (1) and (8).

6. Remove snap rings (7) and (16).

7. Remove plugs (2) and (10).

8. Remove O-rings (6) and (15).



1. End cap
2. Plug
3. King-pin
4. Upper needle roller bearings
5. Steering knuckle
6. O-ring
7. Snap ring
8. End cap
9. Grease nipple
10. Plug
11. Lower needle roller bearing unit
12. Shim
13. Steering knuckle carrier
14. Grease seal
15. O-ring
16. Snap ring
17. Grease nipple

Figure 26: Steering knuckle assembly (maintenance-free king-pin)

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9. Roll the portable press (1) of Figure 17, with the ram at the bottom, under the steering knuckle. Align the ram with the king-pin. Secure steering knuckle (2) with tension belt (3). Connect the hydraulic pump to the press.

Van Hool No. press: A996066079
Van Hool No. pump: A996206008

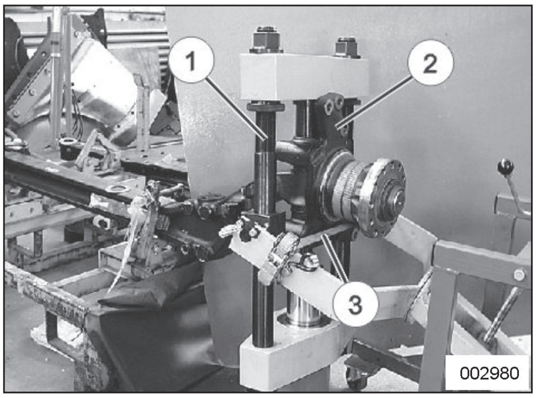

Figure 27

10. Push down lip (1) of lower needle bearing unit dust shield .

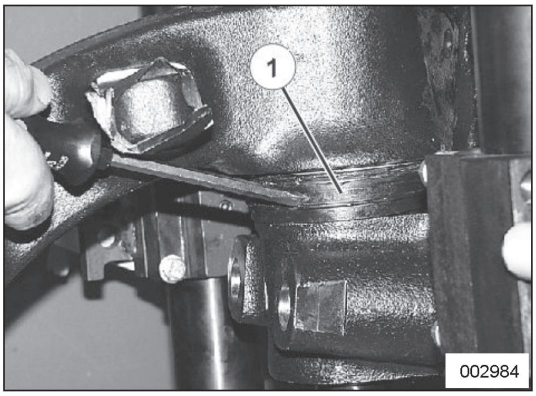

Figure 28

11. Position drift (1) on top of the ram and distance sleeve (2) on top of the steering knuckle. Press out the king-pin from the bottom.

Van Hool No. drift: A996170183
Van Hool No. distance sleeve: A996040228

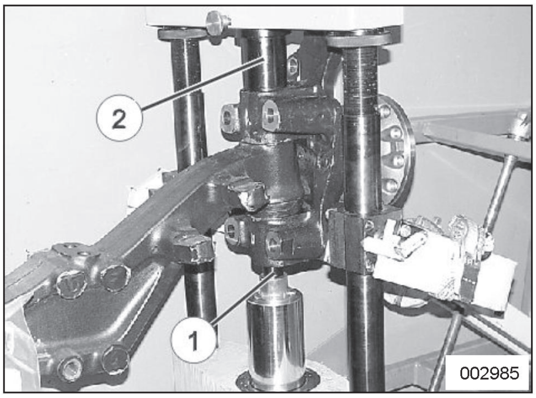

Figure 29

12. Withdraw the king-pin by using a magnet.

13. Pump down the press. Remove the drift and replace it by drift A996170179 (1). Apply pressure and center steering knuckle (2) between distance sleeve (3) and drift (1). Remove steering knuckle assembly from steering knuckle carrier.

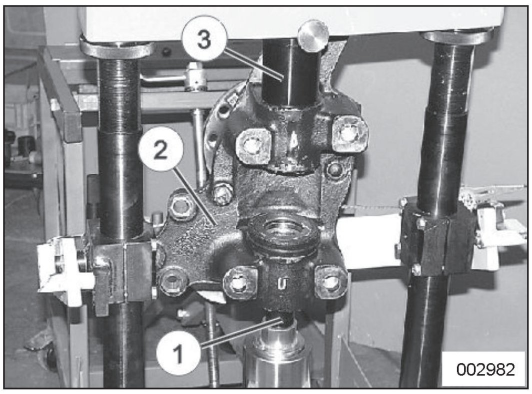

Figure 30

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14. Proceed as follows if lower needle bearing unit should be removed:

    a. Install steering knuckle (2) upside down onto distance sleeve (1). Install the steering knuckle assembly into the press with the ram on top. Secure the steering knuckle with a tension belt.

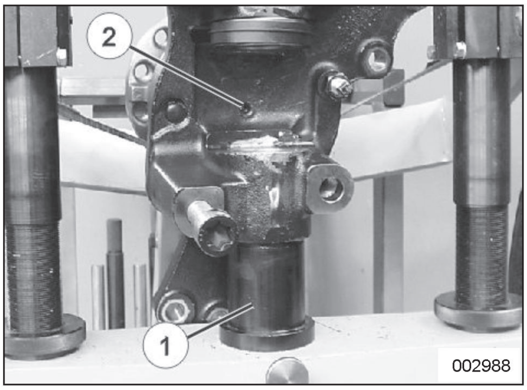

Figure 31

Van Hool No. distance sleeve: A996040228

    b. Press out lower needle bearing unit (2) by using sleeve (1).

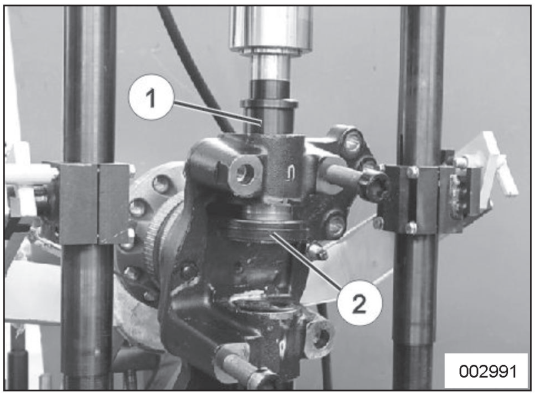

Figure 32

Van Hool No. sleeve: A996350051

15. Proceed as follows if upper needle bearings should be removed:

    a. With the steering knuckle in the same position as for the removal of the lower needle bearing unit, remove grease seal (1).

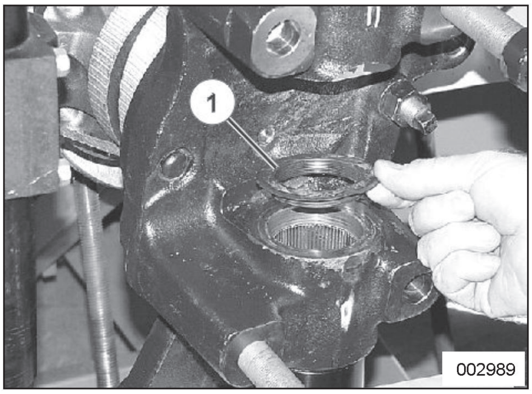

Figure 33

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b. Press out the upper needle bearings using mandrel (2) and sleeve (1).

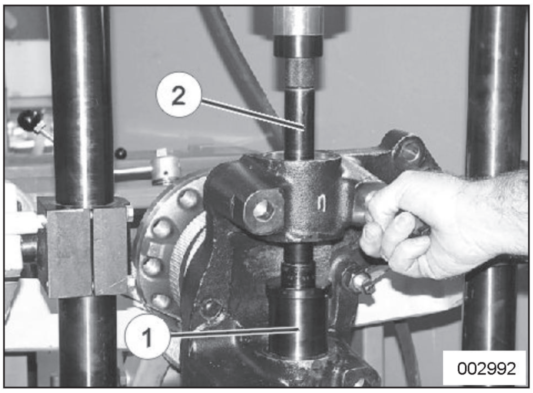

Figure 34

Van Hool No. mandrel: A996170190
Van Hool No. sleeve: A996350051

To install the king-pin

!!! CAUTION !!!
BEFORE HANDLING THE STEERING KNUCKLE, ALWAYS INSTALL THE PACKING INSERTS INTO THE NEEDLE BEARINGS TO PREVENT THE ROLLERS FROM FALLING OUT.

1. Install the upper needle bearings as follows (see Figure 35):

   a. Invert the steering knuckle.

   b. Remove the packing insert from the upper needle bearings.

   c. Slide the upper needle bearings onto sleeve (2).

   d. Locate sleeve (2) together with the upper needle bearings above the steering knuckle bore.

   e. Install mandrel (4).

   f. Locate sleeve (3) in the lower yoke of the steering knuckle to act as a pilot for the mandrel.

   g. By applying pressure to mandrel (4), press the upper needle bearings into the bore until stop.

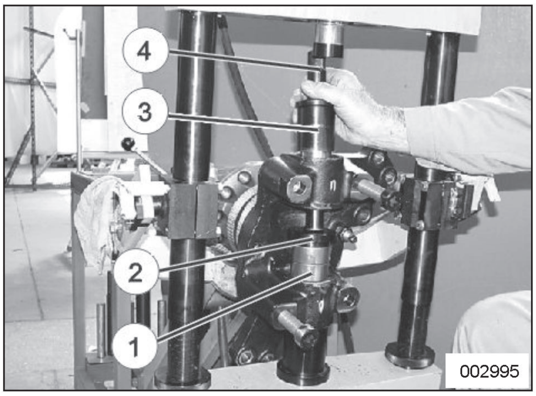

Figure 35

Van Hool No. sleeve (2): A996350050
Van Hool No. sleeve (3): A996350051
Van Hool No. mandrel: A996170190

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2. Install the lower needle bearing unit as follows (see Figure 36):

   a. Invert the steering knuckle so that its upper yoke is at the top.

   b. Slide the lower needle bearing unit (1) onto sleeve (2). Leave the packing insert in place.

   c. Locate sleeve (2) together with the bearing unit above the steering knuckle bore.

   d. Install mandrel (4).

   e. Locate sleeve (3) in the upper yoke of the steering knuckle to act as a pilot for the mandrel.

   f. By applying pressure to mandrel (4), press the bearing unit into the bore until stop.

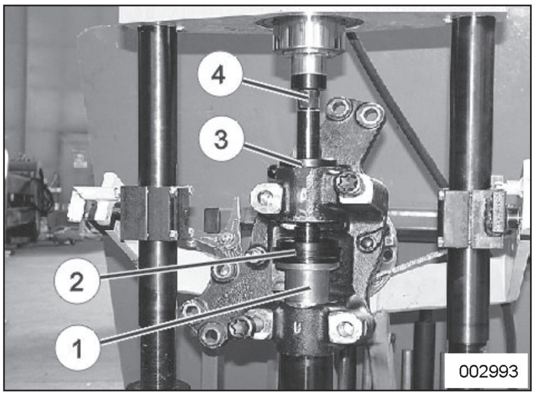

Figure 36

Van Hool No. sleeve (2): A996350049
Van Hool No. sleeve (3): A996350050
Van Hool No. mandrel: A996170190

3. Install the grease seal.

4. Check the axial clearance, to select the appropriate shim washer thickness, as follows (see figure 37):

   a. Gauge the internal dimension between the lower needle bearing unit and the upper steering knuckle yoke (measure "a").

   b. Gauge between the machined upper and lower faces of the carrier center (measure "b").

   c. Gauge the thickness of the shim washer (measure "c").

   d. Axial clearance e:

   $\boxed{e = a - (b + c)}$

   Maximum allowable axial clearance is 0.2 mm (0.008 inch). If necessary, use a thicker shim washer.

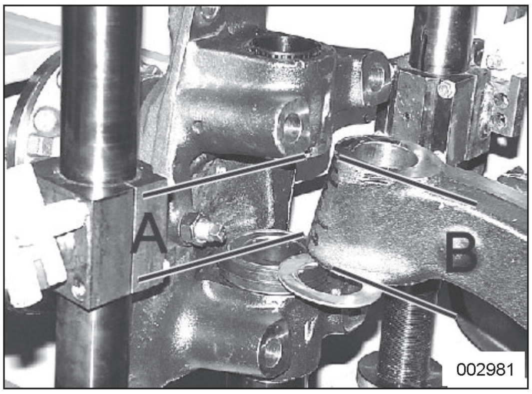

Figure 37

Van Hool No. shim washers:

Thickness 1.8 mm (0.071 inch): N907140340
Thickness 1.9 mm (0.075 inch): N907140341
Thickness 2.0 mm (0.079 inch): N907140342
Thickness 2.1 mm (0.083 inch): N907140343
Thickness 2.2 mm (0.087 inch): N907140344
Thickness 2.3 mm (0.091 inch): N907140345
Thickness 2.4 mm (0.095 inch): N907140346
Thickness 2.5 mm (0.098 inch): N907140347
Thickness 2.6 mm (0.1 inch): N907140348

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5. With the ram of the press on top, center steering knuckle (1) between drift (2) and distance sleeve (3). Position the steering knuckle assembly on the carrier center while you slide the proper shim washer between the lower face of the carrier center and the lower needle bearing unit.

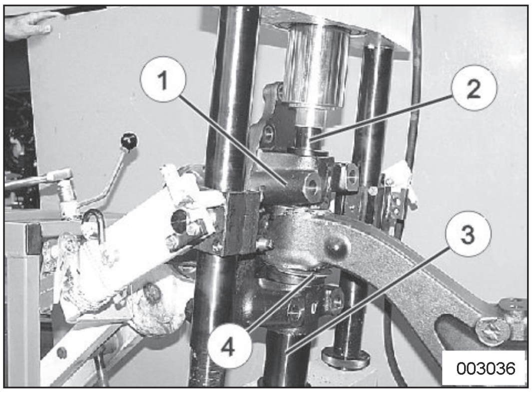

Figure 38

Van Hool No. drift: A996170179
Van Hool No. distance sleeve: A996040228

6. Carefully remove the portable press. Secure the steering knuckle with a sling (1) and hoist against falling down. Shift the steering knuckle with one hand and insert guide pin (2) from the top into the king-pin bore with the other hand. Carefully align the steering knuckle and shim washer with the carrier center.

!!! CAUTION !!!
THE KING-PIN CAN ONLY BE INSTALLED THROUGH THE TOP OF THE STEERING KNUCKLE. THE KING-PIN MUST BE DRY, FREE OF GREASE AND CLEAN.

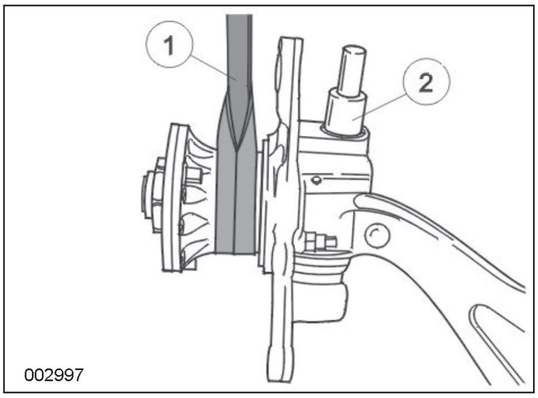

Figure 39

Van Hool No. guide pin: A996170196

7. Position king-pin (1), with the smaller diameter at the bottom, together with magnetic guide (2) into the steering knuckle.

8. Remove the sling and hoist. Roll the press, with the ram on the top, under the steering knuckle.

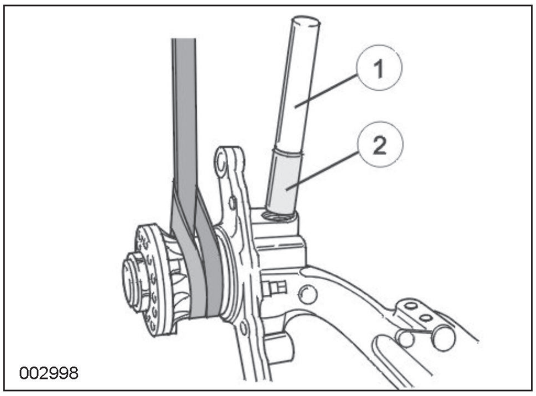

Figure 40

Van Hool No. magnetic guide: A996170197

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9. Position drift (2) on top of king-pin (1). Press in the king-pin until stop.

10. Remove the press tool.

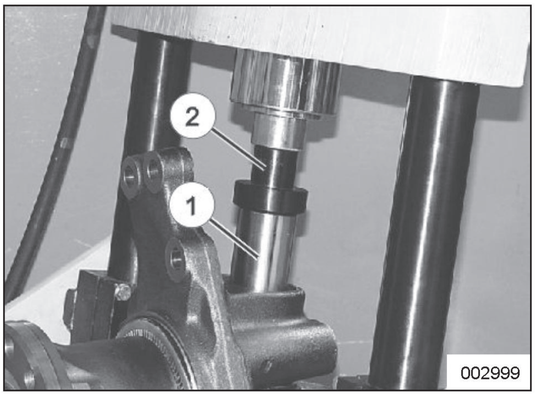

Figure 41

Van Hool No. drift: A996170179

11. Using special pliers (1), lift the needle bearing dust shield lip until it locks into position.

Van Hool No. pliers: A9962560015

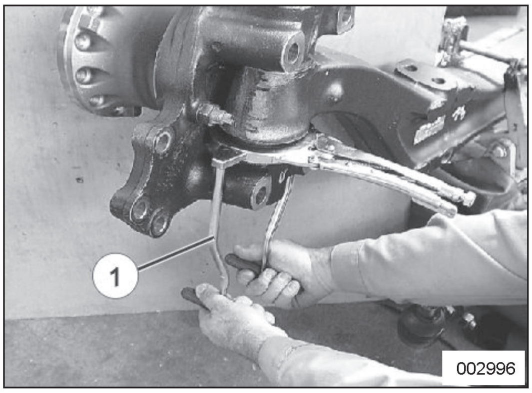

Figure 42

12. Install plug (2) with O-ring (15) and snap ring (16).

13. Install plug (10) with O-ring (6) and snap ring (7).

14. Using a high-pressure grease gun, lubricate the king-pin from both sides (top and bottom). Use DEA Renolit OTP2 grease.

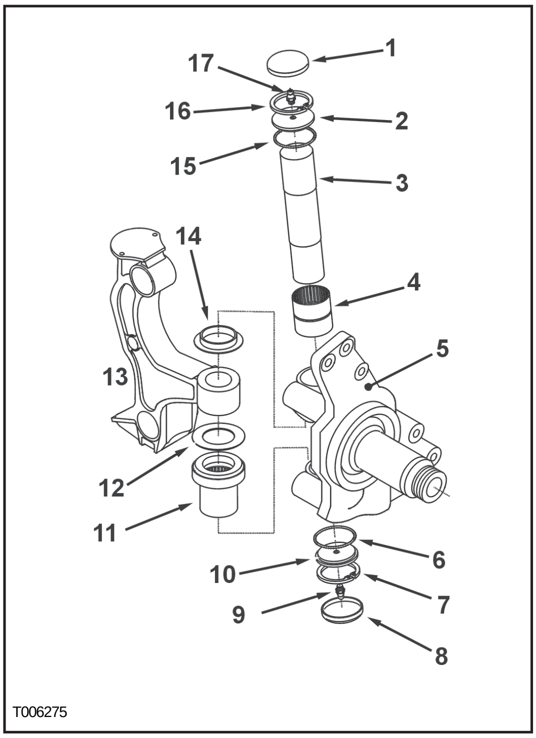

Figure 26

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15. Install both top and bottom end caps by using drift (1).

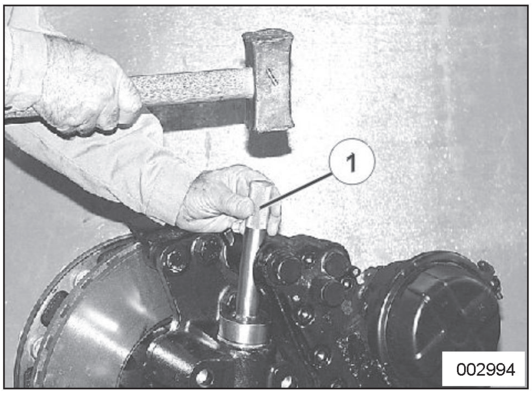

Figure 43

Van Hool No. drift : A996170195

16. Refer to "Wheel hub" to install the hub assembly.
17. Refer to Section 5.1 to install the brake caliper/brake carrier assembly.
18. Connect the tie-rod.
19. Install the road wheel.

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TO REPLACE THE SUSPENSION ARM

!!! CAUTION !!!

SUSPENSION ARMS ARE NOT INTERCHANGEABLE.

The criterions to determine whether the suspension arm is located at the correct position are:

• the snap ring of the flexible ball-joint must be orientated to the front of the vehicle and the cast rib with the hole to receive the tie-rod must be at the top on the upper suspension arms;

• the snap ring of the flexible ball-joint must be orientated to the rear of the vehicle on the lower suspension arms.

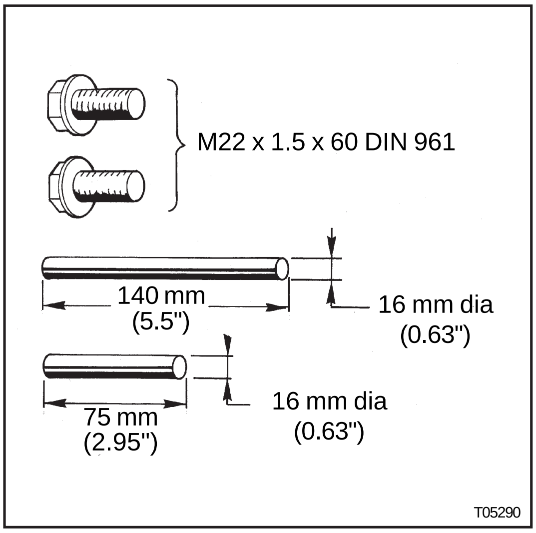

Figure 44: Tool set to free the suspension arms from the steering knuckle carrier

Van Hool No. 10695670

TO REPLACE RUBBER BUSHINGS OF SUSPENSION ARMS, STEERING KNUCKLE CARRIER SIDE

To remove the articulation bushings - Figure 45

Use the tool set Van Hool No. 10695670.

Procedure:

1. Loosen bolts (1) securing both suspension arms to the chassis.

2. Dependent of the articulation that is to be dismantled, remove screw (2) or nut (3) from the tie-rod of the corresponding suspension triangle.

3. Remove articulation assembly bolt (4).

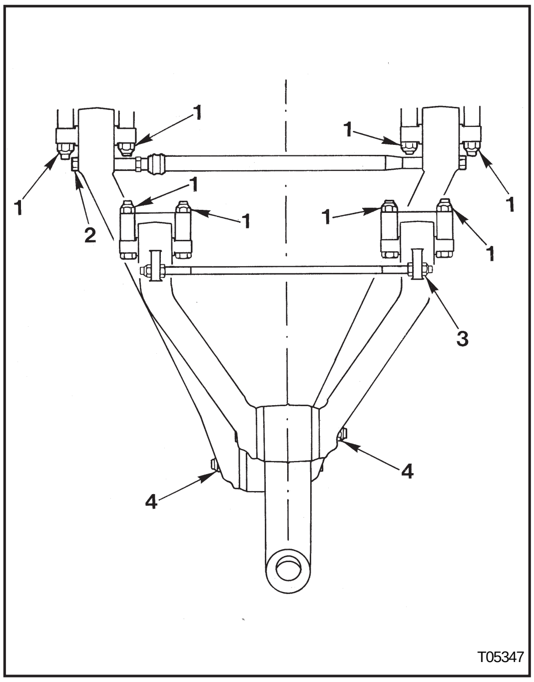

Figure 45: View from above on the LHS suspension assembly half

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4. Use the two M22 puller screws and the long 16 mm dia pin to separate the first suspension arm (see figure 46); use the two M22 puller screws and the short 16 mm dia pin to separate the second suspension arm (see figure 47).

5. Drift the articulation shaft out of the steering knuckle carrier bore and remove the two rubber bushings.

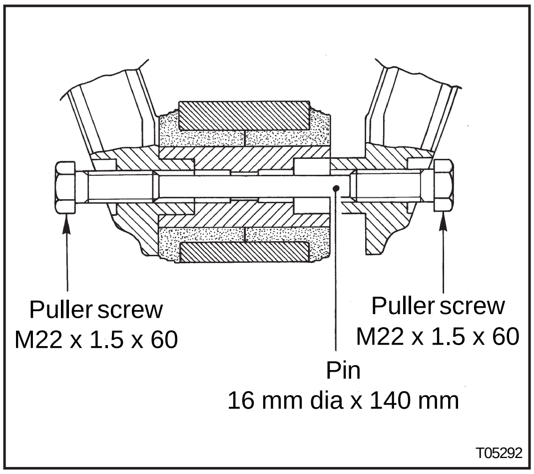

Figure 46: To free the first suspension arm from the steering knuckle carrier

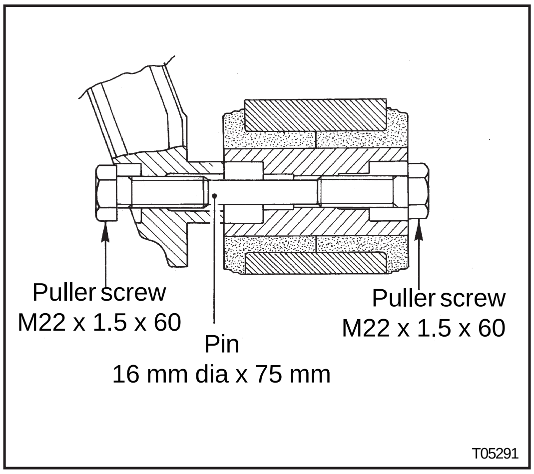

Figure 47: To free the second suspension arm from the steering knuckle carrier

To install the articulation bushings - Figure 48

1. Degrease steering knuckle carrier (4) bore with a brush and detergent. Wipe dry with a clean cloth.

2. To ease the mounting of rubber bushings (5), apply water (no soap water) to the bushings and to the steering knuckle carrier bore.

3. Insert both rubber bushings (5) and articulation assembly shaft (3) into the steering knuckle carrier bore.

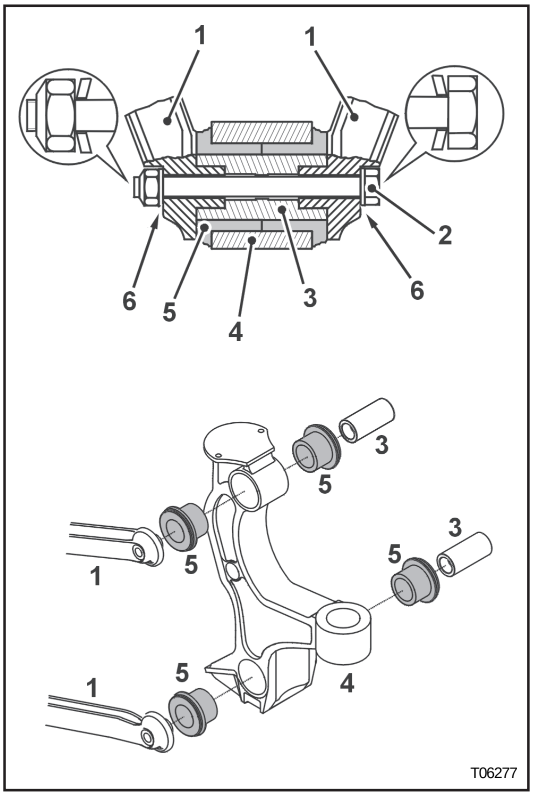

Figure 48: Articulation joint, steering knuckle carrier side

1. **Suspension arm**
2. **Articulation assembly bolt (with self-locking nut)**
3. **Articulation assembly shaft**
4. **Steering knuckle carrier**
5. **Rubber bushing**
6. **Special spring washer**

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4. With bolts (1, Figure 45) loose, fit suspension arms (1) in articulation assembly shaft (3) ends. If necessary, use a soft headed mallet.

5. Install articulation assembly bolt (2) with special spring washers (6) and a new nut. Spring washers (6) must only be fitted with the dished side towards the suspension arm. Handtighten the nut of articulation assembly bolt (2).

6. Secure the tie-rod. Refer to "To adjust the tie-rod length" if the suspension arm bolt holes do not coincide with the chassis holes.

7. Tighten the bolts securing the suspension arms to the chassis. Tightening torques:
   - 280 + 30 Nm (205 + 20 ft.lbf) for the upper suspension arms;
   - 390 ± 58 Nm (285 ± 40 ft.lbf) for the lower suspension arms.

8. Tighten articulation assembly bolt (2) to a torque of 300 + 50 Nm (220 + 35 ft.lbf). To make sure there is equal strain on the rubber bushings when the wheel moves up or down, it is essential to tighten the bolt with the suspension arms parallel to the ground. To do this, jack up the steering knuckle carrier.

TO REPLACE THE FLEXIBLE BALL-JOINT OF THE SUSPENSION ARM, CHASSIS SIDE - Figure 49

To remove the flexible ball-joint of the suspension arm, first remove the suspension arm. Removal can be done with a press and a sleeve slightly smaller than the outside diameter of the ball-joint.

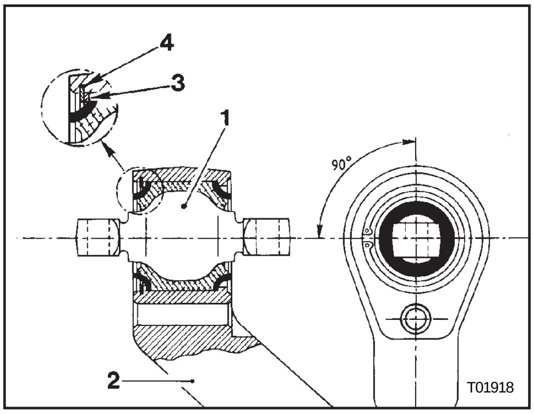

Figure 49: Suspension arm ball-joint, chassis side

1. Ball-joint
2. Suspension arm
3. Washer
4. Snap ring

To remove the flexible ball-joint

1. Remove snap ring (4) and washer (3). This is only possible when there is a slight press load on the ball-joint at the snap ring side. Press ball-joint (1) out.

2. Thoroughly clean the ball-joint housing in the suspension arm, especially the groove receiving snap ring (4).

To install the flexible ball-joint

1. Place the ball-joint on the suspension arm hole and position it so that the ball-joint shaft holes are orientated as shown in figure 49. Press the ball-joint into the suspension arm.

NOTE
DO NOT USE LUBRICANT TO INSTALL THE BALL-JOINT.

2. Install washer (3) and snap ring (4) when the ball-joint is still under pressure. Position washer (3) so that its opening is at the top when

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the suspension arm is installed onto the chassis. The snap ring is to be positioned so that its opening is opposite to the opening of the washer (= at the bottom when the suspension arm is installed onto chassis).

TO ADJUST THE TIE-ROD LENGTH - Figure 50

Adjust the length of tie-rods (A) and (B) so that the bolt holes of the suspension arms ball-joints coincide with the chassis holes, before finally tightening the bolts that secure the suspension arms to the chassis. This is to avoid preload on the ball-joints when tightening the bolts that secure the suspension arms to the chassis.

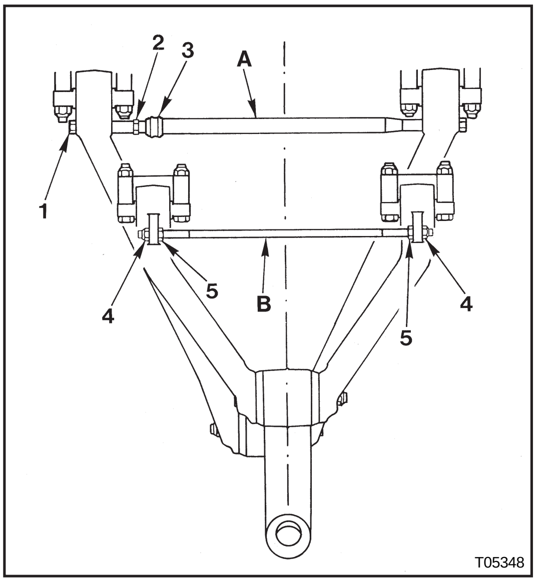

Figure 50: View from above on the LHS suspension assembly half

1. **Fixation screw**
2. **Hexagon for length adjustment**
3. **Clamp**
4. **Self-locking nut**
5. **Nut for length adjustment**

A. Lower tie-rod
B. Upper tie-rod

Procedure:

- For tie-rod (A) of the lower suspension triangle : loosen screw (1) and the nut of clamp bolt (3), and turn hexagon (2) to adjust the length.
- For tie-rod (B) of the upper suspension triangle: loosen nuts (4) and turn nuts (5) to adjust the length.

TO REMOVE / INSTALL COMPLETE WHEEL SUSPENSION ASSEMBLY HALF

To remove the wheel suspension assembly half

1. Apply the parking brake and chock the drive wheels to prevent the vehicle from rolling.
2. Discharge all the air from the suspension system by opening the drain valve of the auxiliary tank.
3. At the side of the assembly which should be removed, slacken all the road wheel nuts half a turn.
4. Using two jacks, jack up the vehicle under the chassis until the front wheels are clear of the ground. Position safety blocks under the chassis members.
5. Mark the position of the wheel with respect to the hub (these parts are balanced together). Remove the road wheel.
6. Disconnect the levelling valve control rod from its lower attachment at the left road wheel side. Pull down the control rod to deflate the air bellows.

!!! CAUTION !!!
MAKE SURE THAT THE WHEEL SUSPENSION ASSEMBLY HALF IS WELL SUPPORTED.

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7. Roll a trolley lift under the wheel suspension assembly half.

8. Discharge all the air from the brake system. Disconnect the brake chamber air line.

9. Disconnect the shock absorber from the steering knuckle carrier.

10. Remove the screws securing the air bellows piston to the steering knuckle carrier.

!!! CAUTION !!!
IN CASE A TIE-ROD ARM SHOULD BE REMOVED: TO PREVENT DAMAGE TO THE ABS SENSOR AND THE ABS TOOTH WHEEL, REMOVE THE ABS SENSOR BEFORE REMOVING A TIE-ROD STEERING ARM. OTHERWISE THE ABS SENSOR WILL BE KNOCKED AGAINST THE STEERING KNUCKLE CARRIER WHEN THE STEERING KNUCKLE IS FULLY TURNED. THIS MAY RESULT IN DAMAGE TO THE ABS SENSOR AND ABS TOOTH WHEEL. NOTE THAT IF THE ABS TOOTH WHEEL IS DAMAGED THE WHOLE HUB UNIT MUST BE CHANGED.

11. Disconnect the tie-rod from the tie-rod arm.

NOTE
TIE THE "CAMBER" ADJUSTMENT SPACERS TOGETHER AND IDENTIFY THEM FOR RE-USE DURING ASSEMBLY.

12. Starting with the upper suspension arms, remove the eight bolts securing the suspension arms to the chassis. To hold the opposite wheel suspension assembly half into position, temporarily re-install the boltnuts of the lower suspension arms.

13. Withdraw the wheel suspension assembly half from the vehicle.

To install the wheel suspension assembly half

1. Using a trolley lift, offer the complete wheel suspension assembly half into position under the vehicle.

2. Starting with the upper arms, secure the suspension arms to the chassis. Hand-tighten the suspension arms boltnuts. Install the camber adjustment spacers as found during the removal. See figure 51 for the correct spacer orientation.

!!! CAUTION !!!
IF THE FIXATION BOLTS CAN NOT BE INSERTED FREELY IN THE SUSPENSION ARMS BOLT HOLES, THE TIE-ROD LENGTH MUST BE ADJUSTED UNTIL THE BOLT HOLES COINCIDE WITH THE HOLES IN THE CHASSIS. THIS IS TO AVOID PRELOAD ON THE BALL-JOINTS WHEN TIGHTENING THE BOLTS THAT SECURE THE SUSPENSION ARMS TO THE CHASSIS.

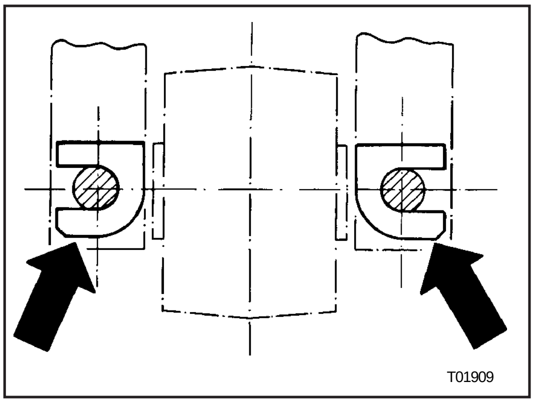

Figure 51: Camber adjustment spacers must be orientated so that the openings are horizontal and to the outside

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3. Finally tighten the four bolts of the lower suspension arms to a torque of 390 ± 58 Nm (285 ± 40 ft.lbf.), the four bolts of the upper suspension arms to a torque of 280 + 30 Nm (205 + 20 ft. lbf.).

NOTE
IF THE ARTICULATION BUSHINGS AT THE STEERING KNUCKLE CARRIER SIDE ARE REMOVED, TIGHTEN THE ARTICULATION ASSEMBLY BOLT ONLY WHEN THE SUSPENSION ARMS ARE PARALLEL TO THE GROUND (SEE "TO REPLACE THE RUBBER BUSHINGS OF THE SUSPENSION ARMS, STEERING KNUCKLE CARRIER SIDE").

4. Connect the tie-rod.
   Refer to Chapter 7 for the tightening torques.

5. Secure the air bellows piston to the steering knuckle carrier. Tighten the screws to a torque of 70 ± 10 Nm (52 ± 7 ft.lbf.).

6. Secure the shock absorber to the steering knuckle carrier. Tighten the self-locking nut to a torque of 100 Nm (70 ft.lbf.).

7. Refit the brake chamber air line.

8. Reconnect the levelling valve control rod to its lower attachment.

9. Install the road wheel and lower the vehicle.

10. Fill the air system and adjust the air bellows height as explained in chapter 8.

11. Check the toe, see earlier in this Section.

12. Road-test the vehicle and recheck the toe.

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DANA 11.36 HYPOID DRIVE AXLE WITH DISC BRAKES

TECHNICAL DATA

Make .... DANA
Model....................................... 11.36
Type....... Single reduction hypoid axle
Ratio .... varies acc. to drive train

IDENTIFICATION

AXLE AND DIFFERENTIAL CARRIER IDENTIFICATION

Axle and differential carrier identification is shown on a metal tag affixed to the carrier.

Example:

11.36

where

11 = Gross axle weight in tonnes
36 = Gross combination weight in tonnes

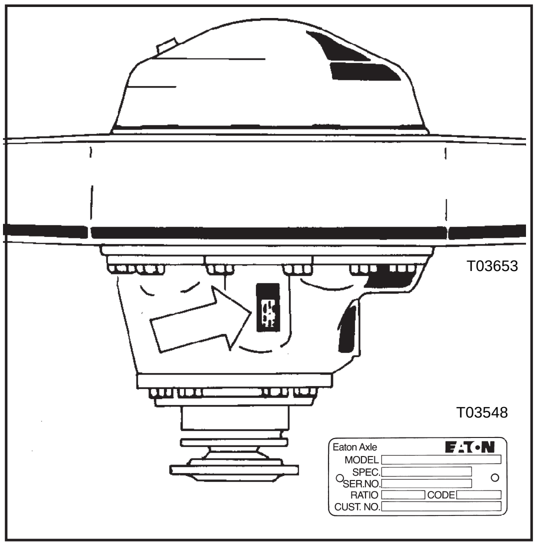

Figure 1: Location of metal tag on differential carrier

AXLE SPECIFICATION NUMBER

All axle housings include a metal identification tag which only identifies the housing. It does not identify the differential carrier assembly components.

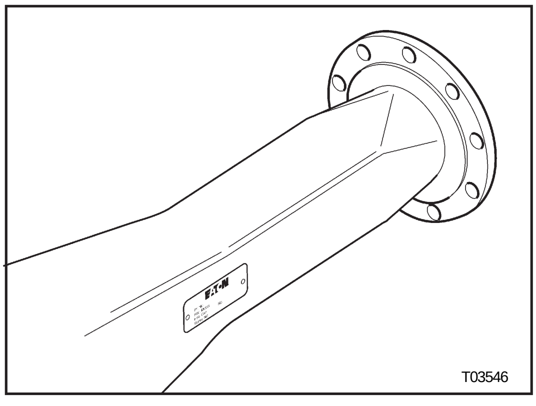

Figure 2: Metal identification tag

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RING GEAR AND PINION IDENTIFICATION

Ring gear and pinion are matched parts and must be replaced in sets. Check VH parts manual for part numbers and ordering instructions.
To help identify gear sets, parts are stamped with such information as number of pinion and ring gear teeth, individual part number and matched part number.

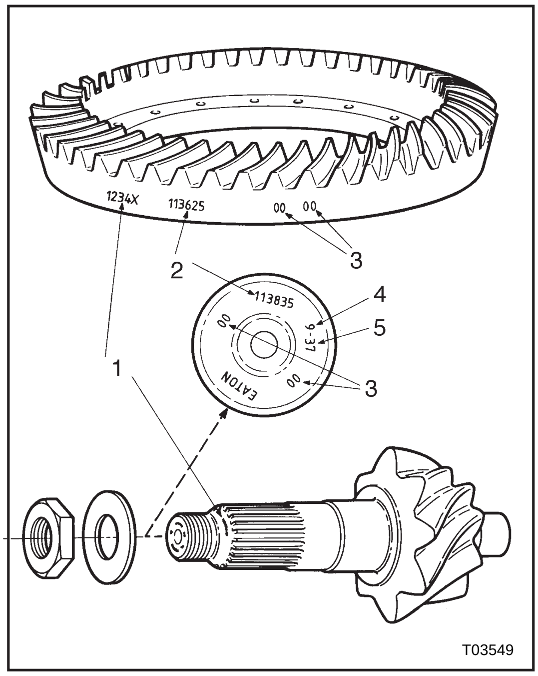

Figure 3: Ring gear and pinion identification

1. **Matched gear set number**
2. **Parts number**
3. **Manufacturing numbers**
4. **Number of pinion teeth**
5. **Number of ring gear teeth**

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MAINTENANCE

TO CHECK LUBE LEVEL

Remove filler hole plug (1, Figure 4). Lube should be level with bottom of this hole. Top up, if necessary, via filler hole.

!!! CAUTION !!!
LUBE LEVEL CLOSE ENOUGH TO HOLE TO BE TOUCHED IS NOT SUFFICIENT. IT MUST BE LEVEL WITH HOLE.

NOTE
WHEN CHECKING LUBE LEVEL, ALSO CHECK AND CLEAN HOUSING BREATHER.

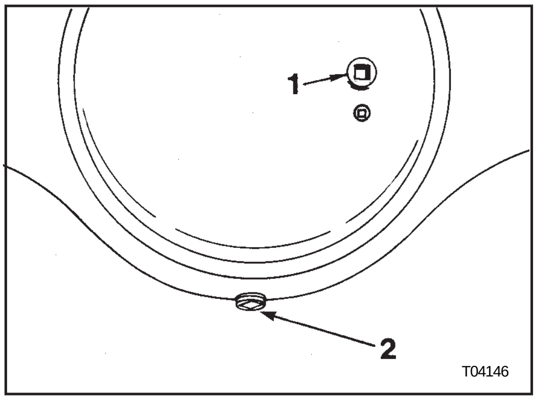

Figure 4: Plugs in axle housing

1. **Filler plug**
2. **Drain plug**

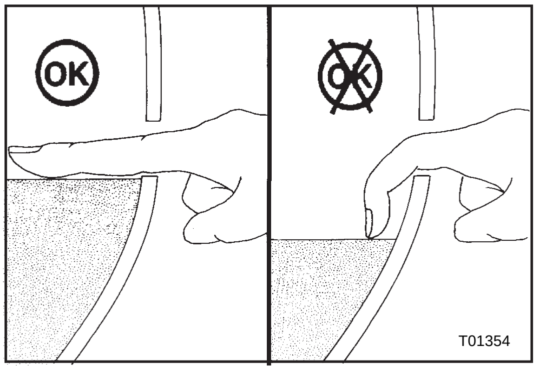

Figure 5: Lube level with bottom of filler hole

TO CHANGE LUBE

To drain

Drain when lube is at normal operating temperature. It will run freely and minimize the time necessary to fully drain axle.

Unscrew magnetic drain plug (2, Figure 4) on underside of axle housing bowl section and allow lube to drain into a suitable container. Inspect drain plug for large quantities of metal particles. These particles are signs of damage or extreme wear in axle. Inspection of entire unit may be warranted. Clean drain plug and reinstall it after lube has drained completely.

To fill

!!! CAUTION !!!
DO NOT USE LITTLE HOLE UNDER FILLER PLUG (1, FIGURE 4) AS LEVEL INDICATOR.

Remove filler plug (1, Figure 4) and fill axle with approved lubricant until level with bottom of filler hole.

NOTE
OIL ADDITIVES AND FRICTION MODIFIERS ARE NOT APPROVED FOR USE IN DANA AXLES.

To fill after hub removal

NOTE
DANA AXLES OF CURRENT PRODUCTION ARE FITTED WITH "UNIFIED" WHEEL BEARINGS INSTEAD OF ORDINARY BEARING DESIGN. BECAUSE "UNIFIED" BEARINGS ARE FACTORY LUBRICATED FOR LIFE, THE PROCEDURE BELOW IS NOT APPLICABLE FOR AXLES WITH THESE "UNIFIED" WHEEL BEARINGS. REFER TO FIGURES 6 AND 7 TO VISUALLY IDENTIFY THE WHEEL BEARING TYPE USED ON YOUR AXLE.

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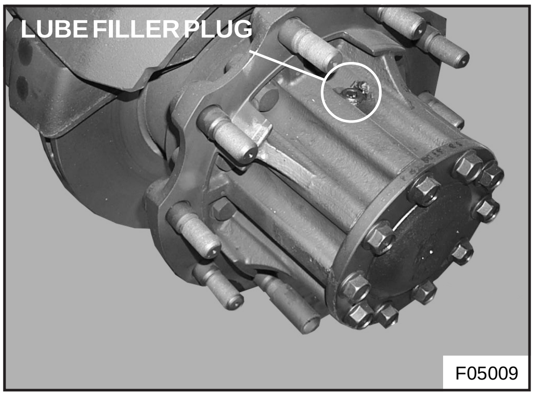

Figure 6: Wheel end of an axle with ordinary wheel bearings

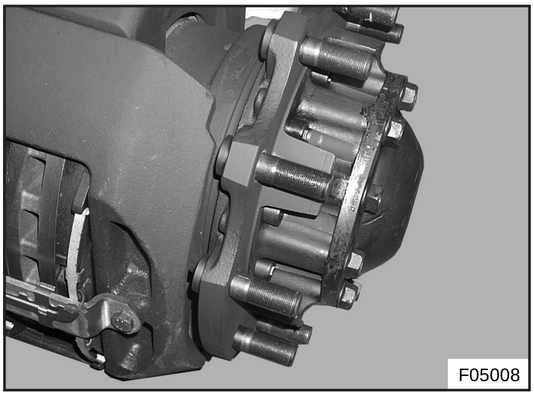

Figure 7: Wheel end of an axle with "unified" wheel bearings

Under normal operating conditions, axle wheel bearings and hub seals are protected by lube carried into wheel ends by motion of axle shafts and differential gearing. Lube becomes trapped in cavities of wheel and remains there, ensuring that lube is instantly available when vehicle is placed in motion.

To avoid risk of premature damage to wheel bearings and hub seals-as it takes some time before the lube has reached all cavities-, they must be "pre-lubed" any time wheel equipment is being installed.

1. Rotate the wheel end hub until the lube filler plug is up. Refer to Figure 6 for location of lube filler plug.

2. Remove the oil filler plug.

3. Pour 1 pint oil into each hub through the wheel end oil filler hole.

4. Install lube filler plug applying "Loctite 572" and tighten to 40 to 60 ft.lbf.

5. Once the axle is leveled, add lube through the differential housing filler hole until level with bottom of hole.

WHEEL END

NOTE
DANA AXLES OF CURRENT PRODUCTION ARE FITTED WITH "UNIFIED" WHEEL BEARINGS INSTEAD OF ORDINARY BEARING DESIGN. REFER TO FIGURES 6 AND 7 TO VISUALLY IDENTIFY THE WHEEL BEARING TYPE ON YOUR AXLE. THE BEARING END-PLAY OF THE "UNIFIED" WHEEL BEARINGS IS NOT ADJUSTABLE. CHANGE THE COMPLETE BEARING UNIT IF THE END-PLAY IS OUT-OF-LIMIT.

TO REMOVE/INSTALL WHEEL END ON AXLES WITH ORDINARY WHEEL BEARINGS

Refer to Dana "Service manual single axle" (Dana reference No.613501).

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TO REMOVE/INSTALL WHEEL END ON AXLES WITH "UNIFIED" WHEEL BEARINGS

!!! CAUTION !!!

NEVER WORK UNDER A VEHICLE SUPPORTED ONLY BY A JACK. ENSURE THAT VEHICLE WILL NOT ROLL BEFORE RELEASING BRAKES.

NOTE

DANA HAVE INTRODUCED A NEW TYPE "UNIFIED" BEARING. THE SEPARATE O-RING, WHICH FITS IN THE SPINDLE GROOVE AND SHOULD BE USED WITH THE PREVIOUS TYPE BEARING, IS NOW INCORPORATED IN THE BEARING.

OLD AND NEW TYPE "UNIFIED" BEARINGS ARE INTERCHANGEABLE, BUT DO NOT USE A SEPARATE O-RING IN COMBINATION WITH A NEW TYPE BEARING.

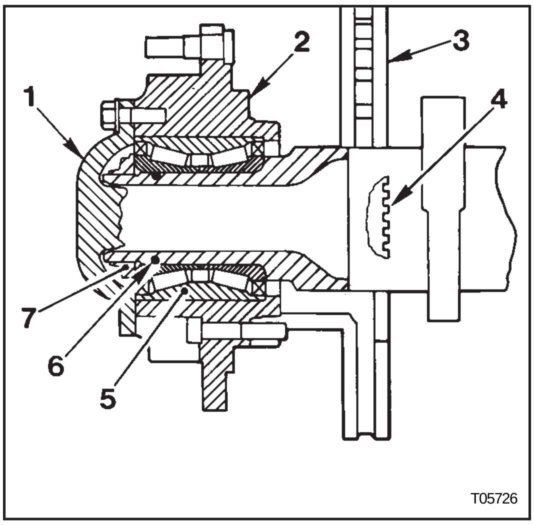

Figure 8: Section through wheel end of an axle with previous type "unified" bearing

1. Axle shaft
2. Hub
3. Brake disc
4. ABS tooth wheel
5. "Unified" bearing
6. O-ring
7. Hub nut

To remove wheel end - Figure 8

1. Mechanically release the spring brake chamber as follows:

   a. Remove the dust cap of the release bolt at the back of the drive wheel brake chamber.

   b. Turn the release bolt of the brake chamber counterclockwise as far as it will go.

2. Discharge all air from the brake system. Disconnect the brake chamber air lines.
3. Remove the brake pads as explained in Section 5.3.

!!! CAUTION !!!

THE BRAKE CALIPER/BRAKE CARRIER/ BRAKE CHAMBER ASSEMBLY IS VERY HEAVY. BE SURE IT IS WELL SUPPORTED BEFORE UNDOING THE RETAINING SCREWS.

4. Remove the brake caliper/brake carrier/brake chamber assembly as explained in Section 5.3.
5. Remove axle shaft (1).
6. Remove hub nut (7) using the socket of figure 9.

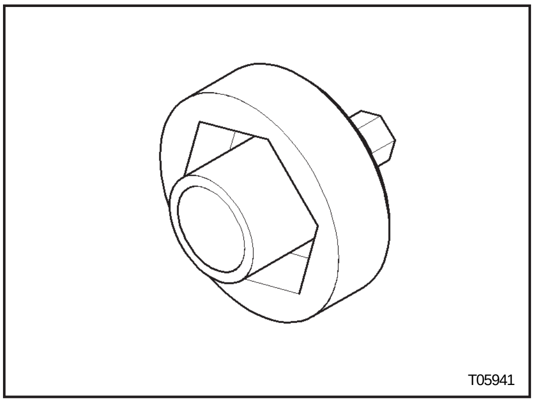

Figure 9: Hub nut socket (Van Hool ordering No. 10732280)

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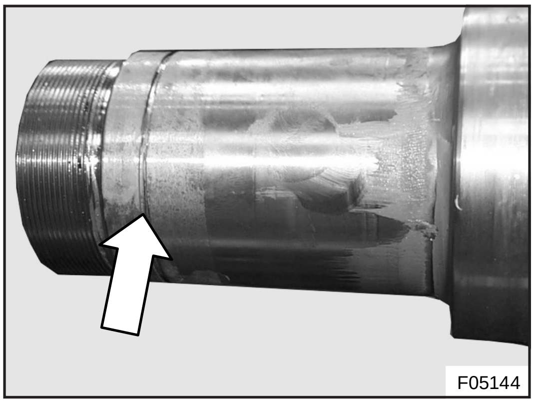

Figure 10: O-ring groove in axle spindle. This O-ring groove is without function when a new type "unitied" bearing is used.

7. Remove hub/brake disc assembly.
8. Free brake disc (3) from hub (2).
9. Remove "unified" bearing (5) from hub (2) by using a press.
10. Remove O-ring (6) from the spindle (see Figure 10).

To install wheel end - Figure 8

NOTE
AS OPPOSED TO THE PREVIOUS TYPE "UNIFIED" BEARING, THE NEW TYPE IS DIRECTIONAL. MAKE SURE THAT THE INCORPORATED O-RING IS INSTALLED TOWARDS THE DIFFERENTIAL HOUSING. INCORRECT ORIENTATION WILL CAUSE LEAKAGE.

1. Press "unified" bearing (5) into hub (2) by using a proper drift. Refer to Dana "Service manual single axle" for the proper dimensions of the drift.
2. Secure brake disc (3) to hub (2). Tightening torque: 275 to 305 Nm (205 to 225 ft.lbf).

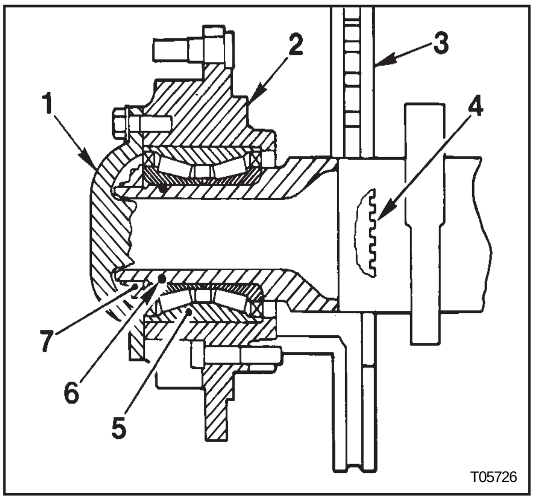

Figure 8: Section through wheel end of an axle with previous type "unified" bearing

1. Axle shaft
2. Hub
3. Brake disc
4. ABS tooth wheel
5. "Unified" bearing
6. O-ring
7. Hub nut

3. Thoroughly clean the axle spindle. Only when installing a previous type "unified" bearing: fit a new O-ring (6)
4. Apply a thin film of Never-Seez to the axle spindle.
5. Install the hub/brake disc assembly on the axle spindle.
6. Install hub nut (7) and tighten to a torque of 360 to 400 Nm (265 to 295 ft.lbf) using the socket of figure 9.
7. Rotate the hub ten revolutions to settle the bearing.
8. Rotate the hub nut 202 to 222 degrees further.
9. Check that hub nut (7) tightening torque is between 1300 and 1470 Nm (980 and 1085 ft.lbf).
10. Apply Loctite 518 on the mating surfaces of axle shaft (1) and hub (2). Install axle shaft (1). Tighten the axle shaft retaining screws to a torque of 350 to 390 Nm (260 to 290 ft.lbf).

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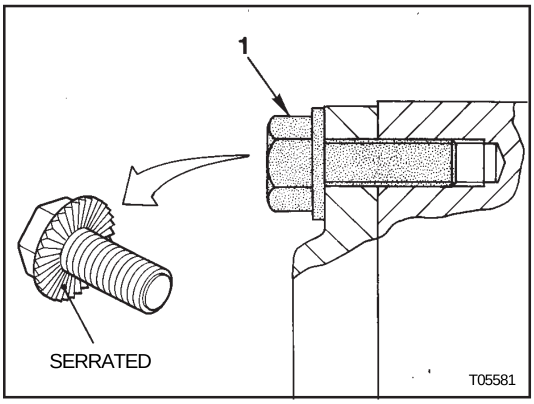

Figure 11: Axle shaft flange mounting

1. Serrated flange head screw (tightening torque: 260 to 290 ft.lbf)

11. Secure the brake carrier to the axle. Tighten the screws to a torque of 430 to 475 Nm (320 to 350 ft.lbf). Install the brake caliper as explained in Section 5.3.

12. Remount the brake chamber onto the vehicle. Install the mounting stud nuts and tighten them to a torque of 210 - 30 Nm (155 - 20 ft.lbf).

13. Reconnect air pressure lines.

14. screw release bolt completely counterclockwise to a torque of 30 to 36 Nm (23 to 26 ft.lbf). Reinstall the release bolt cap.

DIFFERENTIALOVERHAUL

Refer to "Dana Service manual" annexed at the end of this Chapter.

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TAG AXLE WITH LUCAS D-ELSA BRAKES

TECHNICAL DATA

Make: .... Van Hool
Type: ....
Track: .... approx. 81 inches

ALIGNMENT SPECIFICATIONS - Figure 1

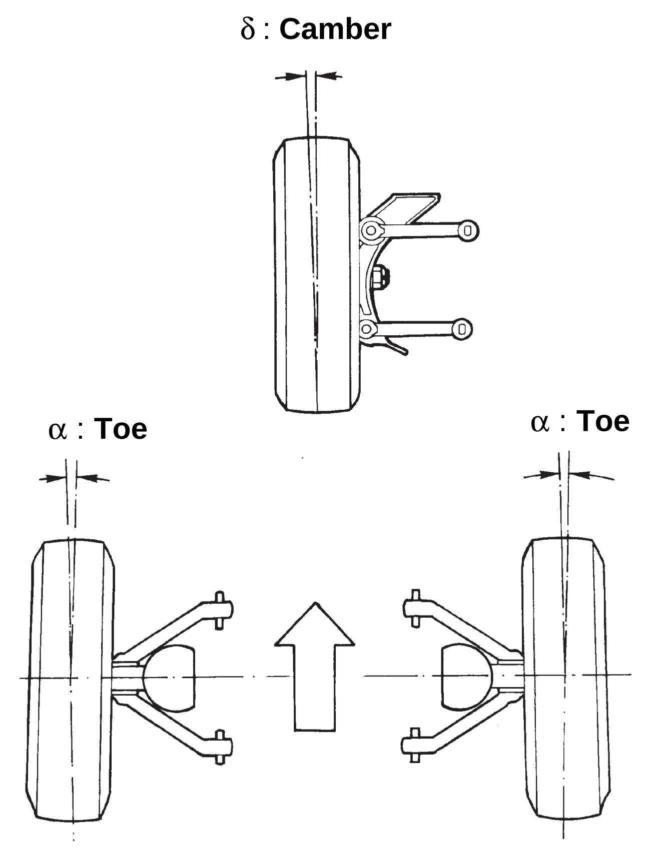

Figure 1: Alignment specifications

Camber: .... $\delta = 1° - 30'$
Toe: .... $\alpha = 0° + 12'$

NOTE
Alignment should be performed on an empty vehicle and with air bellows at correct height.

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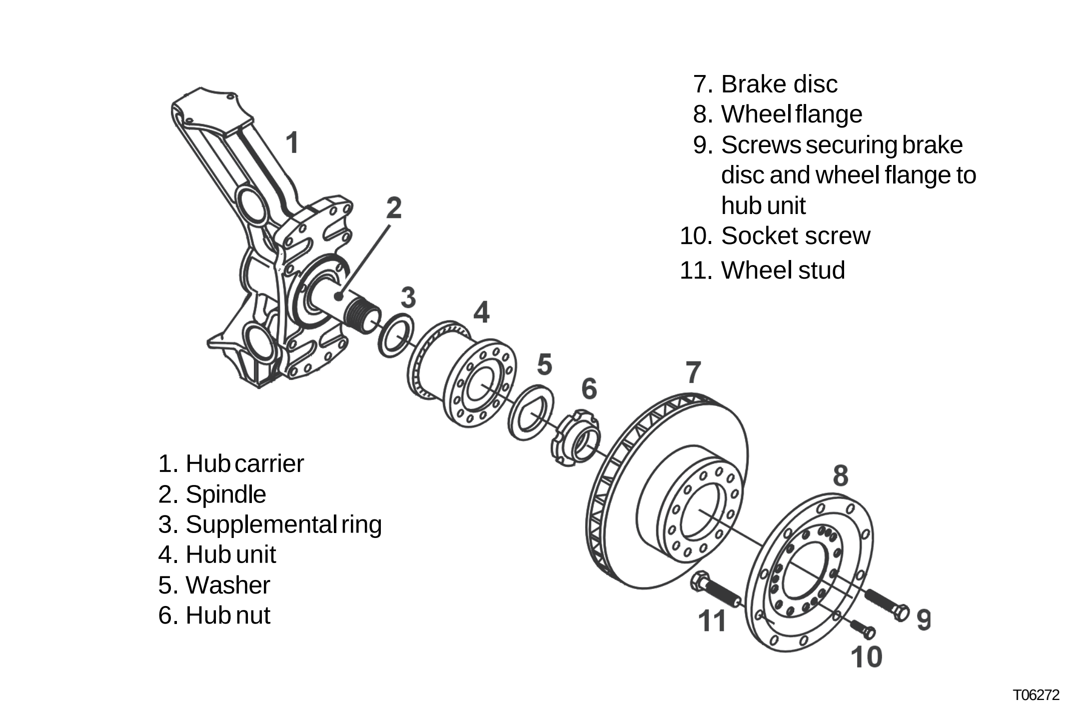

Figure 2: Exploded view, tag axle end

MAINTENANCE

TO REPLACE HUB GREASE

The wheel hubs are lubricated for life.

TO CHECK WHEEL BEARING END-PLAY

Check the wheel bearing end-play at the intervals given in the Maintenance Schedule, see chapter 12.

NOTE
Bearing end-play is not adjustable. Change the complete hub unit if the measured value is out-of-limit.

1. Jack up the hub carrier until the tag wheel clears the ground.
2. Mount a dial indicator with a magnetic base against the inside of the brake disc. Position the stylus of the dial indicator at a right angle to the brake disc against the hub carrier.
3. Take a firm grip on the wheel and alternately push and pull it forward and backward.
4. Note the total variation shown by the indicator, which should be maximum 0.25 mm (0.01 inch).

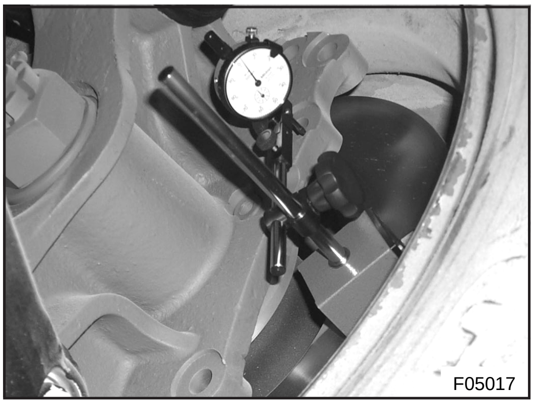

Figure 3: Dial indicator position

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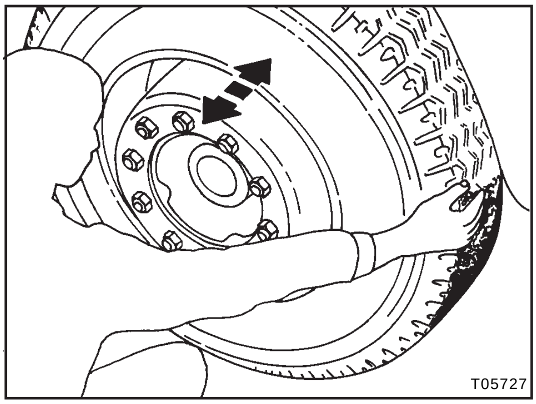


Figure 4: Push and pull the wheel

TO CHECK TOE

Check toe with unladen vehicle and wheels on the ground. To make sure that measurement is correct, check following points:

- Tire pressure;
- Air bellows height;
- Wheels for out-of-balance;
- Wheels for excessive lateral run-out.

Check toe for each wheel separately, with optical equipment. Follow instructions of optical equipment manufacturer.

Correct toe: $\alpha = 0° + 12'$

Toe is adjusted by installing more or less spacers between the suspension arm ball-joints and the chassis (see Figure 5). Note that toe adjustment will influence camber adjustment. So after toe adjustment, check camber adjustment. Refer to "To remove/install complete wheel suspension assembly half" for correct spacer orientation.

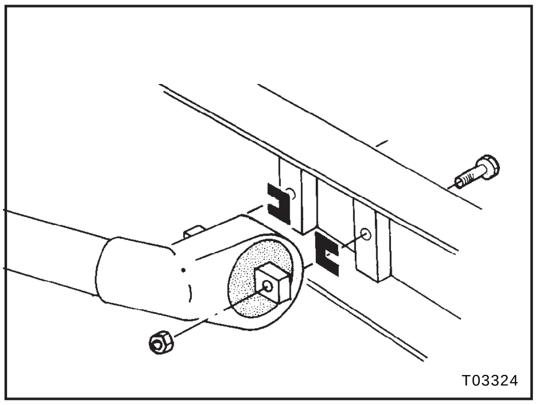


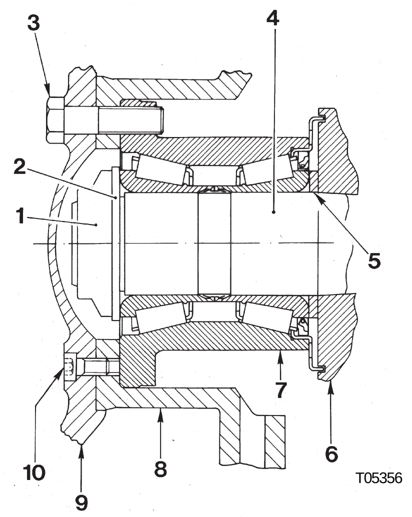
Figure 5: Spacers between suspension arms and chassis to adjust toe and camber

OVERHAUL

TO REMOVE/INSTALL THE HUB UNIT

!!! CAUTION !!!

THE ONLY DIFFERENCE BETWEEN THE FRONT AND TAG AXLE HUB ASSEMBLY IS RING (5, FIGURE 6) ON THE TAG AXLE WHICH IS NOT FITTED ON THE FRONT AXLE. DO NOT FORGET TO INSTALL THIS SUPPLEMENTAL RING DURING TAG AXLE HUB INSTALLATION.



1. Hub nut
2. Washer
3. Screws securing brake disc and wheel flange to hub unit
4. Spindle
5. Supplemental ring
6. Hub carrier
7. Hub unit
8. Brake disc
9. Wheel flange
10. Socket screw

Figure 6: Section through tag wheel hub

Refer to Section "Front Axle with D-ELSA brakes" for procedure.

TO REPLACE SUSPENSION ARM

!!! CAUTION !!!
SUSPENSION ARMS ARE NOT INTERCHANGEABLE.

The criterion to determine whether the suspension arm is located correct is the position of the cast rib with the hole to receive the tie-rod.

Hold the suspension arm in the position as it should be installed on the chassis.

- The cast rib with the hole to receive the tie-rod should be at the top on the upper suspension arms;
- The cast rib with the hole to receive the tie-rod should be at the bottom on the lower suspension arms.

TO REPLACE RUBBER BUSHING OF SUSPENSION ARMS, HUB CARRIER SIDE

!!! CAUTION !!!
BOLTS SECURING SUSPENSION ARMS TO CHASSIS ARE ON THE TAG WHEEL SUSPENSION ALL OF THE M16 X 1.5 TYPE. SO TIGHTENING TORQUE IS 280 + 30 NM (205 + 20 FT.LBF) FOR ALL THESE BOLTS.

Refer to Section "Front Axle with D-ELSA brakes" for procedure.

TO REPLACE FLEXIBLE BALL-JOINT OF SUSPENSION ARM, CHASSIS SIDE

!!! CAUTION !!!
BOLTS SECURING SUSPENSION ARMS TO CHASSIS ARE ON THE TAG WHEEL SUSPENSION ALL OF THE M16 X 1.5 TYPE. SO TIGHTENING TORQUE IS 280 + 30 NM (205 + 20 FT.LBF) FOR ALL THESE BOLTS.

Refer to Section "Front Axle with D-ELSA brakes" for procedure.

TO ADJUST THE TIE-ROD LENGTH - Figure 7

Adjust the length of tie-rods (A) and (B) so that the bolt holes of the suspension arms ball-joints coincide with the chassis holes, before finally tightening the bolts that secure the suspension arms to the chassis. This is to avoid preload on the ball-joints when

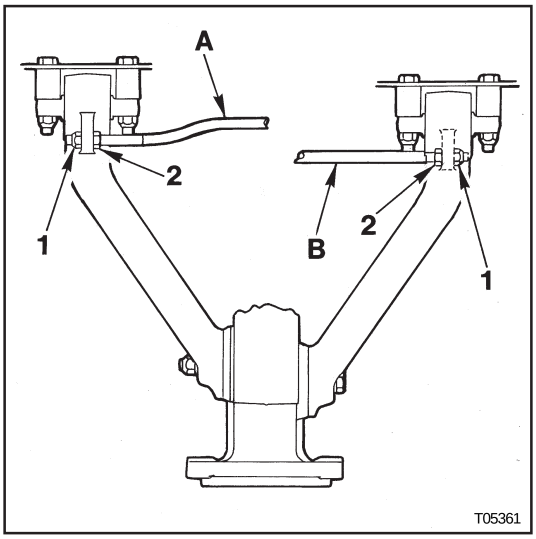


Figure 7: View from above on the LHS suspension assembly half

1. Self-locking nut
2. Nut for length adjustment

A. Upper tie-rod
B. Lower tie-rod

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tightening the bolts that secure the suspension arms to the chassis.

Procedure: Loosen screws (1) and turn nuts (2) to adjust the length.

TO REMOVE / INSTALL COMPLETE WHEEL SUSPENSION ASSEMBLY HALF

To remove suspension assembly half

1. Chock front wheels to prevent coach from rolling.

2. Discharge all the air from the suspension system by opening the drain valve of the auxiliary tank.

3. At the side of the assembly which should be removed, slacken all road wheel nuts half a turn.

4. Using two jacks, jack up coach until the tag wheels are clear of the ground. Position safety blocks under chassis members.

5. Mark the position of the wheel with respect to the hub (these parts are balanced together). Remove the road wheel.

6. Disconnect both tag axle levelling valve control rods from their lower attachment. Pull down control rods to deflate air bellows.

!!! CAUTION !!!
MAKE SURE THAT THE WHEEL SUSPENSION ASSEMBLY HALF IS WELL SUPPORTED.

7. Roll a trolley lift under the wheel suspension assembly half.

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8. Discharge all air from the brake system. Disconnect the brake chamber air line.

8. Disconnect shock absorber from hub carrier.

9. Remove the screws securing the air bellow piston to the hub carrier.

NOTE
Tie "toe-in/camber" adjustment spacers together and identify for re-use during assembly.

10. Starting with the upper suspension arms, remove the eight bolts securing the suspension arms to the chassis.

11. Withdraw wheel suspension assembly half from coach.

To install suspension assembly half

1. Using a trolley lift, offer the complete wheel suspension assembly half into position under the coach.

2. Starting with the upper arms, secure the suspension arms to the chassis. Handtighten the suspension arms boltnuts. Install "toe/camber" adjustment spacers as found during the removal. See Figure 8 for correct spacer orientation.

!!! CAUTION !!!
IF FIXATION BOLTS CANNOT BE INSERTED FREELY IN THE SUSPENSION ARMS BOLT HOLES, TIE-ROD LENGTH MUST BE ADJUSTED UNTIL BOLT HOLES COINCIDE WITH THE HOLES THE CHASSIS. THIS IS TO AVOID PRELOAD ON THE BALL-JOINTS WHEN TIGHTENING THE BOLTS THAT SECURE THE SUSPENSION ARMS TO THE CHASSIS.

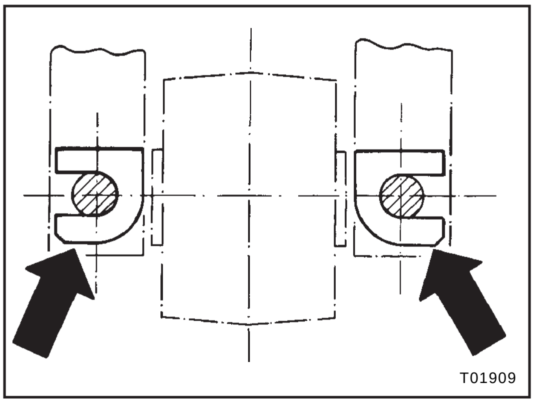

Figure 8: "Toe/camber" adjustment spacers must be orientated so that the openings are horizontal and to the outside

3. Finally tighten the eight bolts of the suspension arms to a torque of 280 + 30 Nm (205 + 20 ft.lbf).

NOTE
If articulation bushings at hub carrier side are removed, tighten articulation assembly bolt only when the lower suspension arms are parallel to the ground (see "To replace rubber bushings of suspension arms, hub carrier side").

4. Secure air bellow piston to hub carrier. Tighten screws to a torque of 70 ± 10 Nm (52 ± 7 ft.lbf).

5. Secure shock absorber to hub carrier. Tighten self-locking nut to a torque of 100 Nm (70 ft.lbf).

6. Refit brake chamber air line.

7. Reconnect levelling valves control rods to their lower attachment.

8. Install road wheel and lower coach.

9. Fill air system and adjust air bellow height as explained in chapter 8.

10. Check toe.

11. Road-test the vehicle and recheck toe.

TO INSTALL THE SPINDLE IN THE HUB CARRIER

Tighten the spindle nut to a torque of 500 Nm (370 ft.lbf).

Check the spindle installation dimension with the tool of Figure 9.

Procedure:

1. Slide the tool with the "moet raken" (should touch) side over the spindle. The tool should touch the hub carrier (see top of Figure 10).

2. Turn the tool and slide it with the "mag niet raken" (may not touch) side over the spindle. The tool may not touch the hub carrier (see bottom of Figure 10).

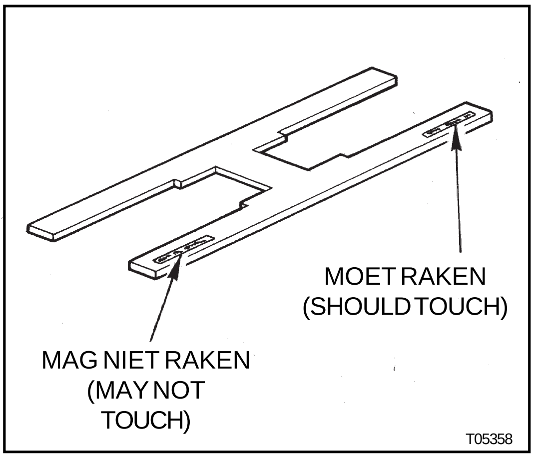

Figure 9: Tool

Van Hool ordering number 10679038

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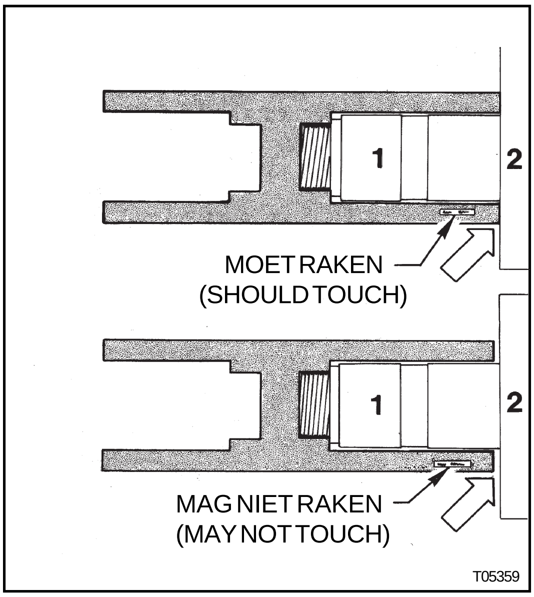

Figure 10: To check the spindle installation dimension by using the tool of Figure 9.

1. **Spindle**
2. **Hub carrier**

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WHEELS AND TIRES

WHEELS

WHEEL MOUNTING SYSTEMS

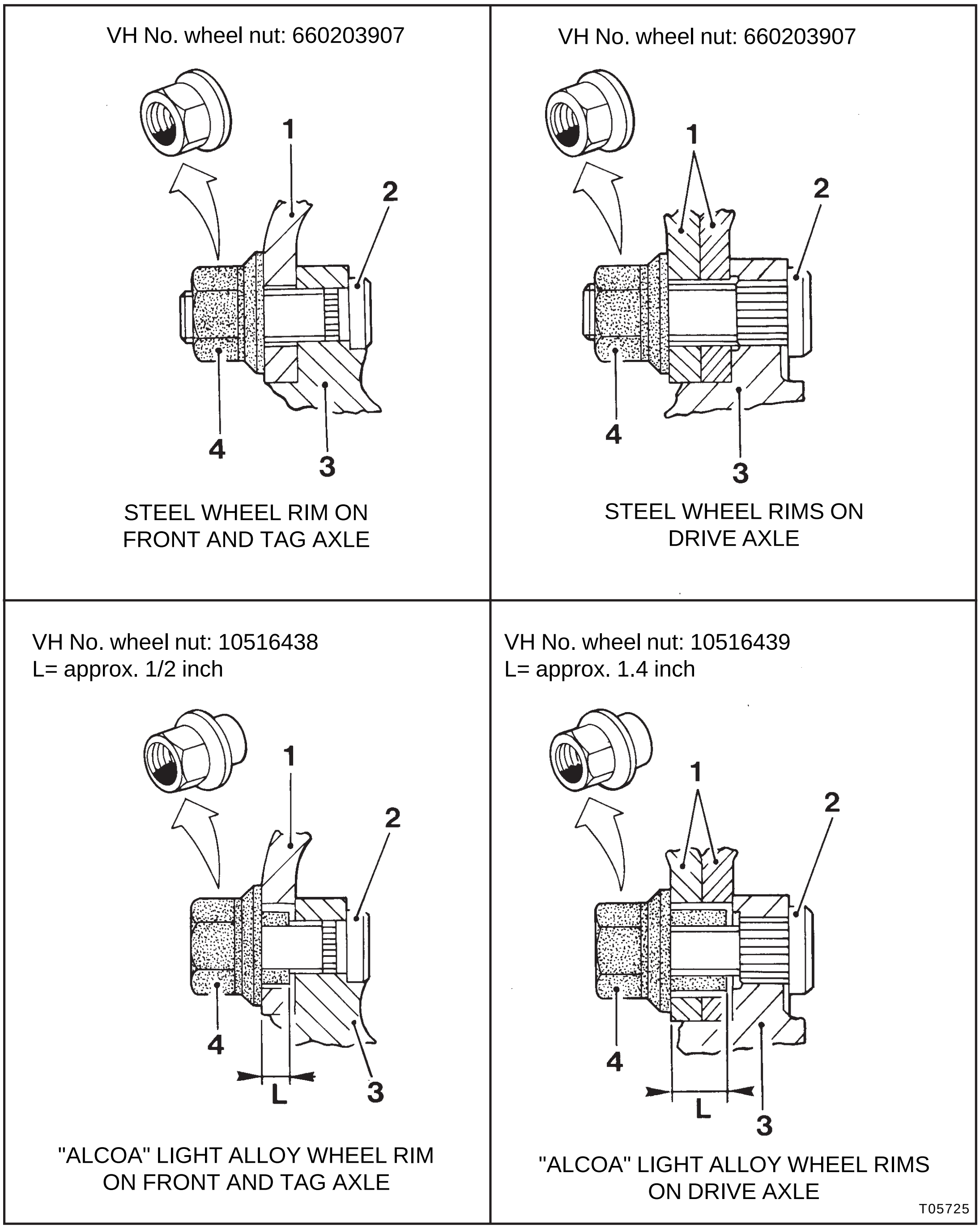

Figure 1: Wheel mounting systems (section view)

1. Wheel rim
2. Wheel stud
3. Hub
4. Wheel nut

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Van Hool coaches are equipped with a hub-piloted wheel system which uses the hub to center the rim. The center hole of the wheel rim precisely fits the machined pilot (or a number of pads) on the hub. The wheel nuts have a non-removable rotary flat washer.

!!! CAUTION !!!
ONLY USE WHEELS AND WHEEL NUTS SUITABLE FOR HUB CENTERING. REFER TO FIGURE 1 FOR CORRECT WHEEL NUT TYPE.

MAINTENANCE

1. Before mounting a wheel, remove burrs, rust, dirt and paint runs from contact surfaces; that is, the wheel disc areas that touch the hub as well as the wheel nut contact areas.
2. Apply only a very thin coat of paint to contact surfaces. The total coat thickness may not exceed 0.002 inch in any place. Wait until paint has fully hardened before mounting a wheel. Too thick a coat of paint or wheel mounting when paint is not yet entirely hard can cause wheel nut slackening.
3. Before mounting a wheel, always clean entire width of rim base. Only steel wheel rim: apply a thin coat of quick-drying metal primer on bald spots.
4. Before mounting a wheel, always check wheel studs for damage. Also check that studs are well secured in stud holes of hub.
5. After fitting a new tire, the wheel must be balanced again.
6. At regular intervals, check the wheels for any damage that can disturb wheel balance.

TO CHANGE A WHEEL

1. With a socket wrench: remove the "Radolid" wheel nut caps by turning them to the left until they can be removed.
2. Clean wheel stud ends with a stiff brush.
3. Slacken all wheel nuts half a turn.
4. Jack up vehicle.
5. Remove wheel nuts and wheel.
6. Clean hub pilot and inner wheel edge. Smear pilot lightly with "Never-Seez".
7. Clean wheel studs with a steel brush and apply a drop of oil to stud end

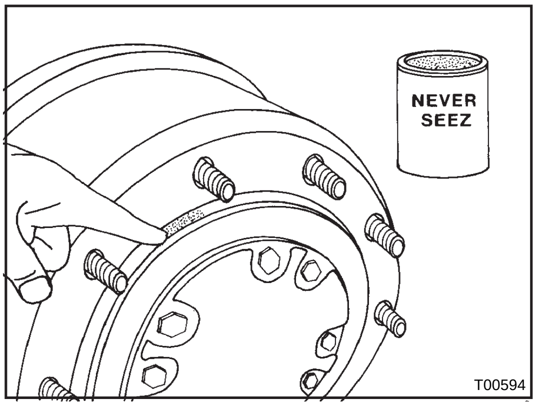

Figure 2: Smearing pilot or pads on hub (typical) lightly with "Never-Seez" makes wheel removal easier at a later stage

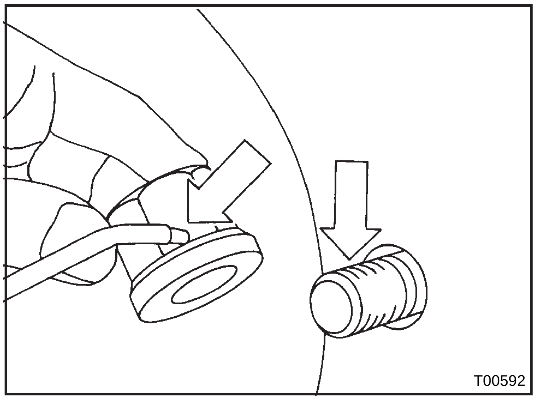

Figure 3: Apply a drop of oil between wheel nut and washer and on stub end threads

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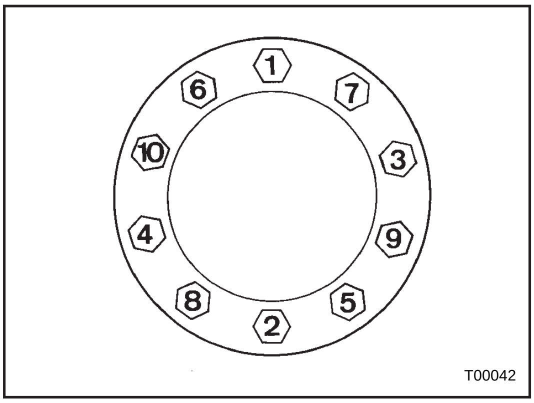

Figure 4: Wheel nut tightening sequence

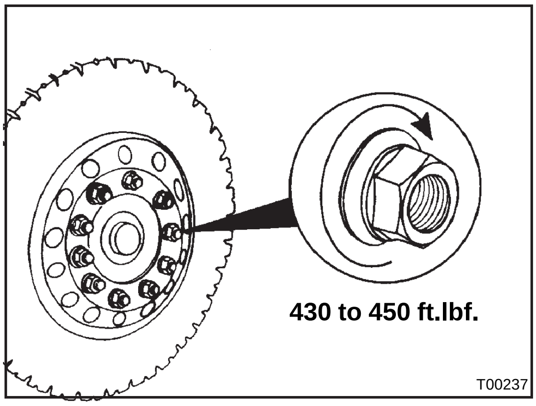

Figure 5: Wheel nut tightening torque

threads. For wheel nut 660203907 only: also apply a drop of oil between washer and wheel nut.

8. Install wheel on hub.

9. Screw wheel nuts on and tighten them according to the sequence given in Figure 4. Tighten wheel nuts evenly by alternately turning every nut just a bit further each time until the specified torque is reached (see Figure 5).

10. Install the "Radolid" wheel nut caps as follows:

    a. Place wheel nut cap loosely over wheel nut.

!!! CAUTION !!!
USE ONLY A SOCKET WRENCH IN NEXT STEP. NO OTHER TYPES OF WRENCHES ARE ALLOWED.

    b. Using a socket wrench, turn wheel nut cap to the right until a light snap-effect is felt.

TO RETIGHTEN WHEEL NUTS

When a wheel has been changed, retighten wheel nuts with a torque wrench after 25 miles and again after the next 50 miles. Then check torque daily until nuts are finally tight. Wheel nut slackening is explained by the fact that the fastening elements set, so that part of the original torque is lost.

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TIRES

SPECIFICATIONS

!!! CAUTION !!!
DO NOT FIT TIRES OF OTHER SIZE OR CONSTRUCTION THAN THE ORIGINAL ONES WITHOUT PRIOR CONSENT OF VAN HOOL. NEVER FIT TIRES WITH LOWER LOAD OR SPEED RATINGS.

TO CHECK TIRE INFLATION PRESSURES

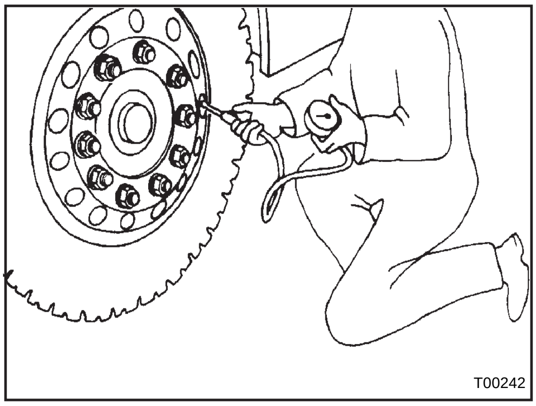

Figure 6: To check tire inflation pressure

Check inflation pressure of each tire every day and adjust, if necessary.

Correct pressure will prolong the tire durability. Underinflation will cause increased fuel consumption and tire overheating (risk of bursting). If tire pressure is too high, the ride and road-holding qualities of the vehicle will be impaired.

Use an accurate pressure gauge. The inflation pressures for the standard tires (Goodyear 315/80 R22.5 and Firestone 315/80 R22.5) are mentioned on the vehicle identification plate in the stepwell of the entrance door. Pressure values apply to cold tires; that is, after at least one hour standing still. If pressure has dropped more than normal, remove and inspect tire to determine the cause.

If your coach is equipped with other tires than the standard ones, follow the instructions of the tyre manufacturer in relation to the maximum speed, maximum load and inflation pressures.

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TO INSPECT TIRES

Tire damage

Remove sharp stones and other foreign bodies from tire thread. They may cause damage in the long run.

Replace tire if you encounter one of the following signs of damage:

- Bumps, bulges or knots;
- Thread cuts, snags or side wall cracks deep enough to expose cords;
- Visible body cords.

Also pay attention to tread wear pattern.

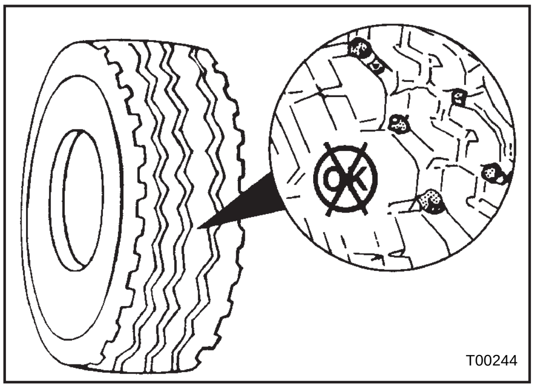

Figure 7: Remove sharp stones and other foreign bodies from tire thread

ABNORMAL TREAD WEAR

1. **Shoulder wear at both sides.** Cause: "Concave" tread due to underinflation.

2. **Center wear.** Cause: "Convex" tread due to overinflation.

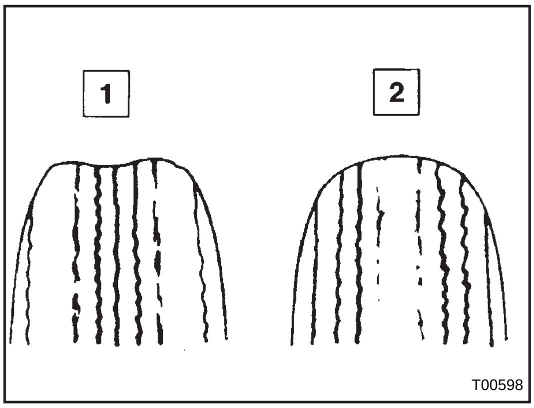

Figure 8

3. **Shoulder wear at one side.** Cause: Major cause is camber maladjustment, or, in some cases, incorrect toe.

4. **Feather edging.** This is identified by sliding the hand across tire tread. Sharp edges will be felt in one direction and smoothness in the other. Cause: incorrect toe.

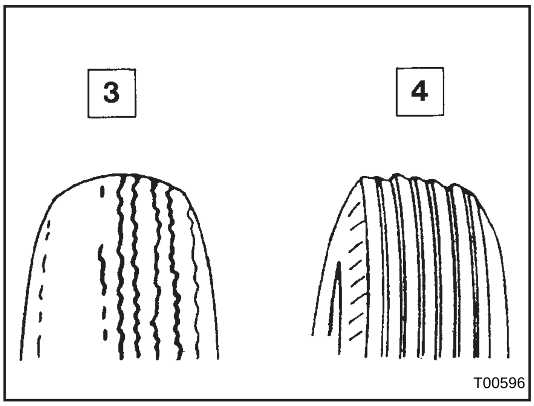

Figure 9

US0440AH

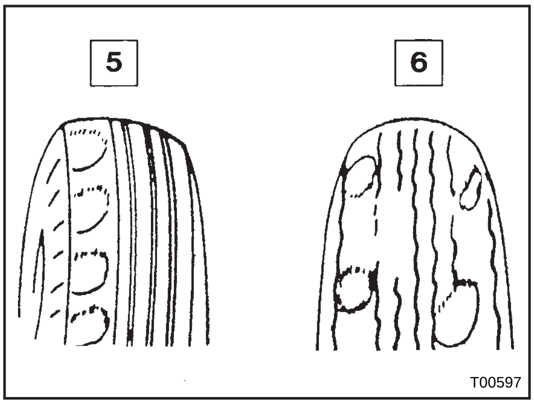

Figure 10

5. **Cupping.** Causes: in most cases bad shock absorbers or, in some cases, wheel imbalance. In rare cases, the cause is incorrect toe.

6. **Bald spots.** Causes: wheel imbalance, wheel run-out, excessive wheel bearing play, incorrect toe combined with worn steering joints or braking problems.

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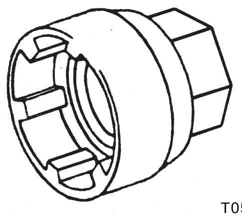
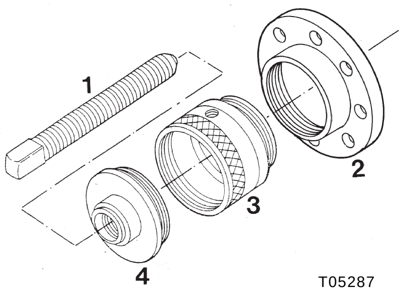
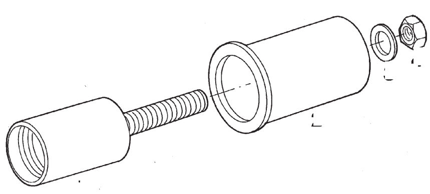
SPECIAL SERVICE TOOLS

TOOL No. + ILLUSTRATION	DESCRIPTION
Van Hool A996030253  T05288	**Hub nut socket** To remove and install hub nut. (front and tag axle with D-Elsa brakes)
1. Van Hool A996060240 2. Van Hool A996060464 3. Van Hool A996060251 4. Van Hool A996060238  T05287	**Tool set** To remove hub unit. (front and tag axle with D-Elsa brakes)
Van Hool 10678700  T05297	**Tool set** To install hub unit. (front and tag axle with D-Elsa brakes)

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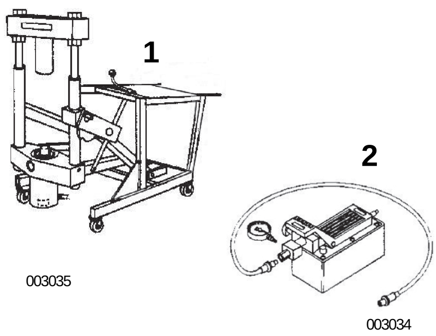
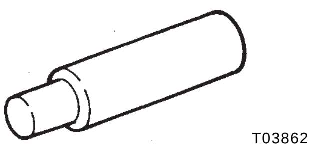
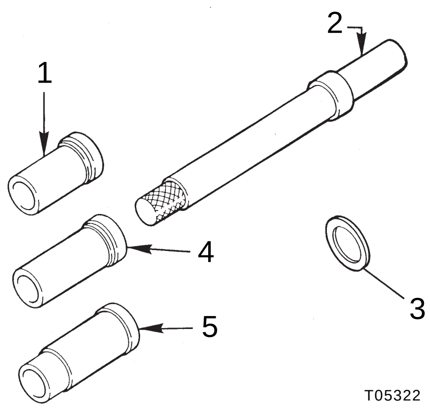
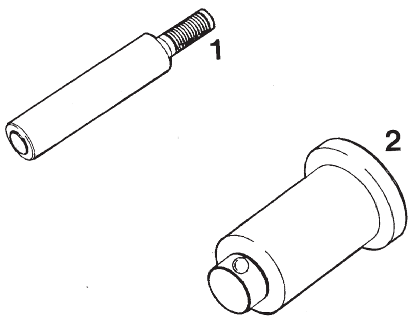
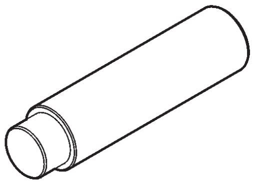
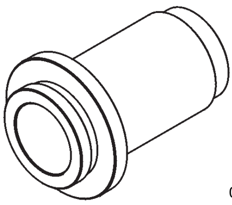
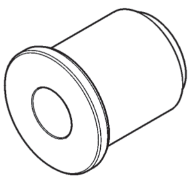
TOOL No. + ILLUSTRATION	DESCRIPTION
1. Van Hool A996066079 2. Van Hool A996206008  	**Tool set** To remove/install king-pin. (front axle)
Van Hool A996170083  	**Drift** To remove king-pin. (front axle with D-Elsa brakes and non maintenance-free king-pin bearings)
1. Van Hool A996160096 2. Van Hool A996170025 3. Van Hool A996160080 4. Van Hool A996160097 5. Van Hool A996160098 Set of 1,3,4,5 Van Hool A996166003  	**Tool set** To remove/install needle roller bearings and grease seals. (front axle with D-Elsa brakes and non maintenance-free king-pin bearings)

TOOL04AE

TOOL No. + ILLUSTRATION	DESCRIPTION
1. Van Hool A996170175 2. Van Hool A996170179  T05336	**Tool set** To install king-pin. (front axle with D-Elsa brakes and non maintenance-free king-pin bearings)
Van Hool A996170183  003023	**Drift** To remove king-pin. (front axle with D-Elsa brakes and maintenance-free king-pin bearings)
Van Hool A996040228  003024	**Distance sleeve** To remove king-pin and lower needle bearing unit. (front axle with D-Elsa brakes and maintenance-free king-pin bearings)
Van Hool A996350051  003032	**Sleeve** To remove lower needle bearing unit and upper bearings (front axle with D-Elsa brakes and maintenance-free king-pin bearings)

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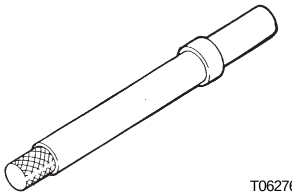
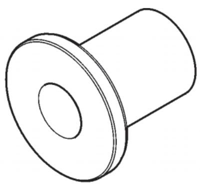
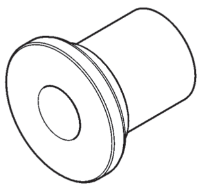
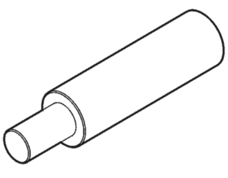
TOOL No. + ILLUSTRATION	DESCRIPTION
Van Hool A996170190  T06276	**Mandrel** To remove/install upper needle bearings and lower needle bearing unit. (front axle with D-Elsa brakes and maintenance-free king-pin bearings)
Van Hool A996350049  003030	**Sleeve** To install lower needle bearing unit. (front axle with D-Elsa brakes and maintenance-free king-pin bearings)
Van Hool A996350050  003031	**Sleeve** To install upper needle bearings. (front axle with D-Elsa brakes and maintenance-free king-pin bearings)
Van Hool A996170196  003027	**Guide pin** To install king-pin (front axle with D-Elsa brakes and maintenance-free king-pin bearings)

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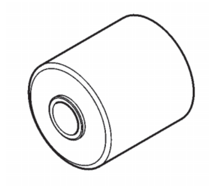
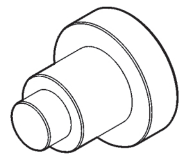
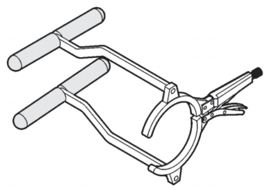
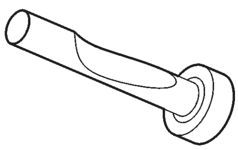
TOOL No. + ILLUSTRATION	DESCRIPTION
Van Hool A996170197  003028	**Magnetic guide** To install king-pin (front axle with D-Elsa brakes and maintenance-free king-pin bearings)
Van Hool A996170179  003025	**Drift** To install king-pin (front axle with D-Elsa brakes and maintenance-free king-pin bearings)
Van Hool A9962560015  003029	**Pliers** To lift lip of lower needle bearing unit dust shield. (front axle with D-Elsa brakes and maintenance-free king-pin bearings)
Van Hool A996170195  003026	**Drift** To install king-pin end caps. (front axle with D-Elsa brakes and maintenance-free king-pin bearings)

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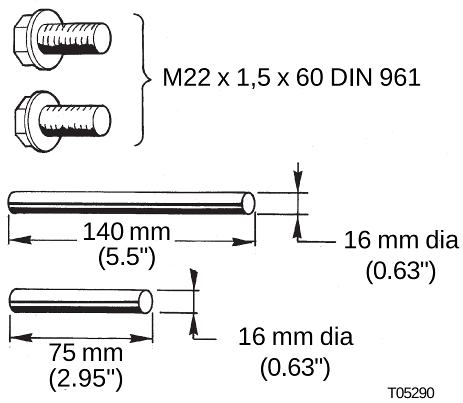
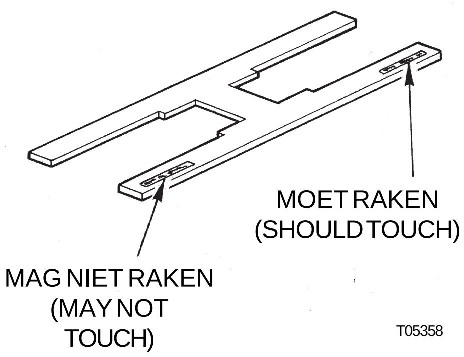
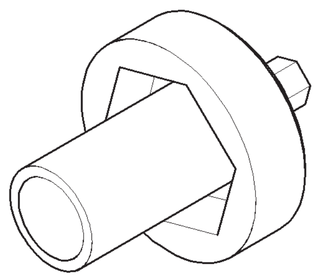
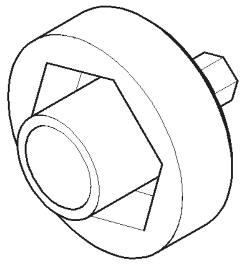
TOOL No. + ILLUSTRATION	DESCRIPTION
Van Hool 10695670 	**Tool set** To free suspension arms from carrier. (front and tag axle with D-Elsa brakes)
Van Hool 10679038 	**Measuring tool** To check spindle installation dimension (tag axle with D-Elsa brakes)
Van Hool 10610064 	**Hub nut tool** To remove and install hub nut (Dana drive axle with ordinary wheel bearings)

TOOL04AE

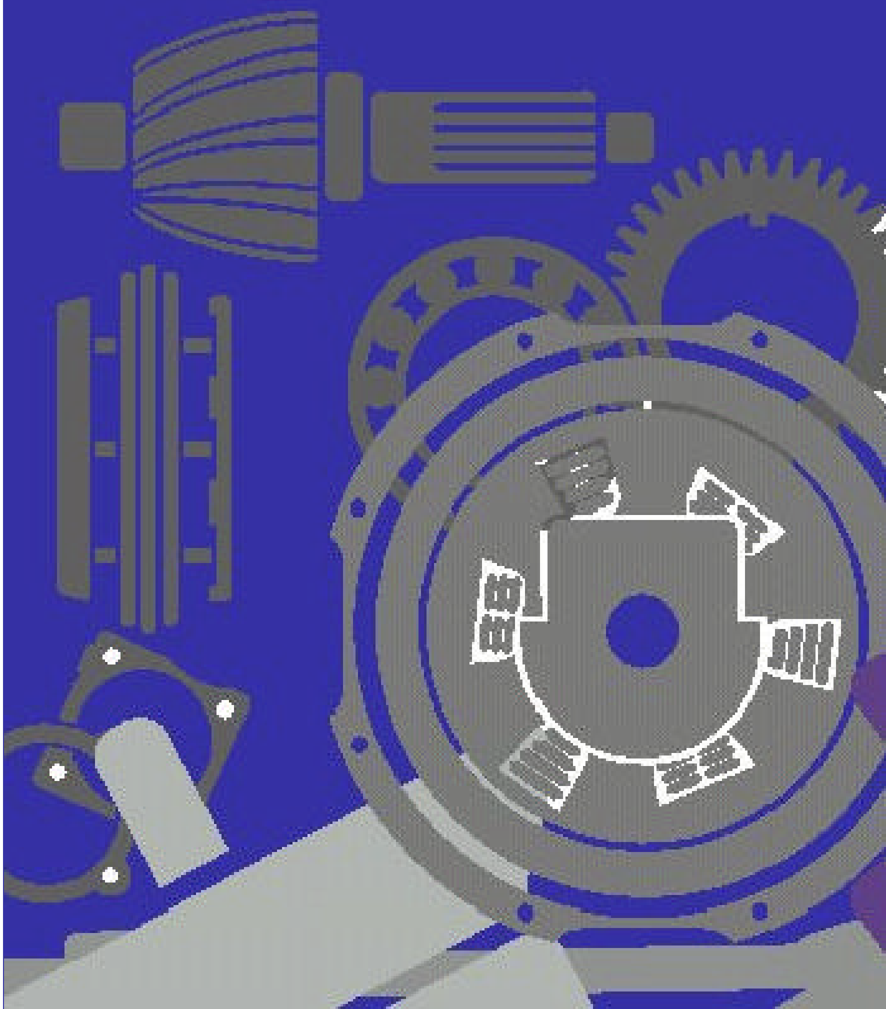
TOOL No. + ILLUSTRATION	DESCRIPTION
Van Hool 10732280  T05941	**Hub nut tool** To remove and install hub nut (Dana drive axle with "unified" wheel bearing)

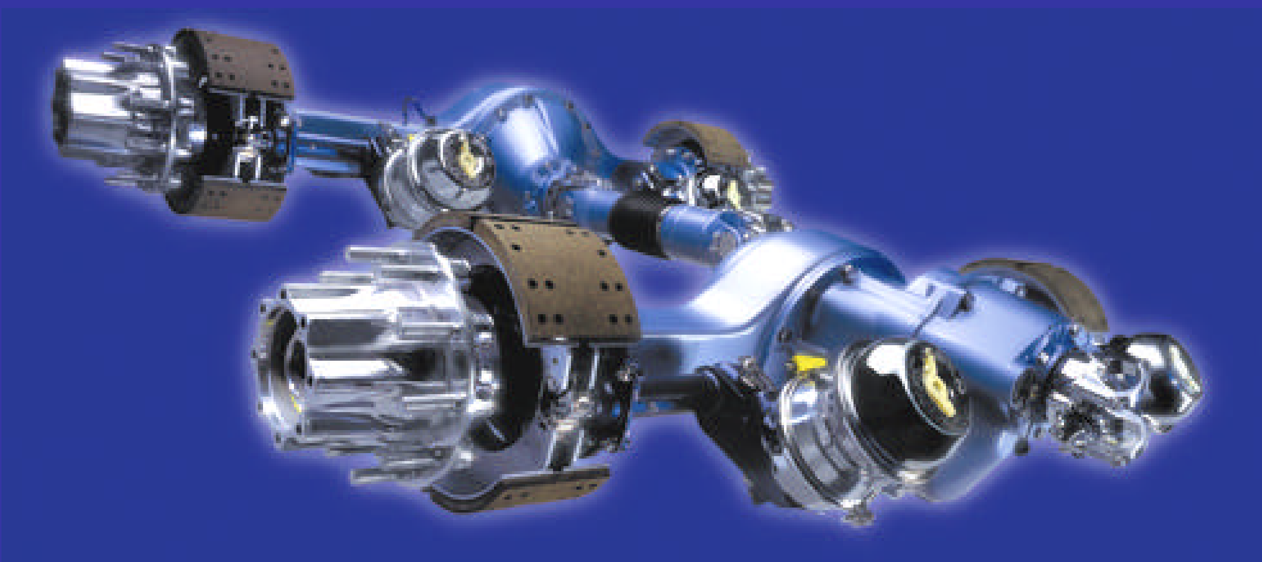
TOOL04AE

TOOL04AE

Service Manual

Dana® Spicer®



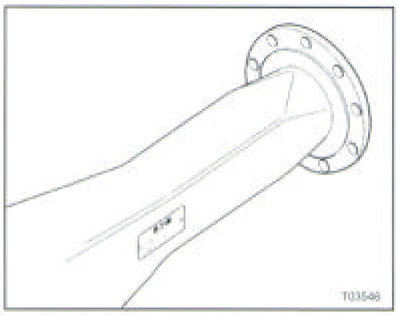


Last Modification	Date	Approved by	Date	Level	Reference	Eng. Change
E. Aznar	01/01/00	R. Yoldi	01/01/00	A	613501	-
A. Fernández	4/12/02	R. Yoldi	4/12/02	B	613501	02796
A. Fernández	03/02/03	R. Yoldi	03/02/03	C	613501	03622

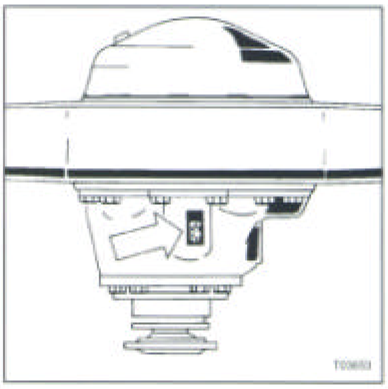
Contents

Axle Housing Identification

All axle housings include a metal identification tag which only identifies the housing. It does not identify the differential carrier assembly components.



Axle Identification

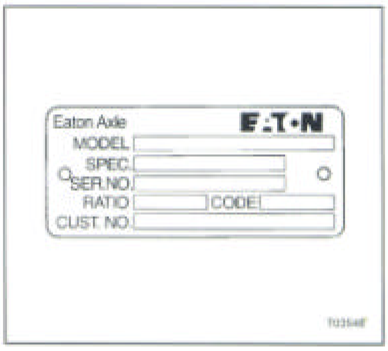


Axle identification is stamped on a metal tag affixed to the housing and differential carrier identification is stamped on a metal tag affixed to the carrier. Location on the carrier is the same.

Single axle models are 08.18(D), 09.24(D),10.24(D), 11.26(D), 11.28(D) & 11.36(D).

Where

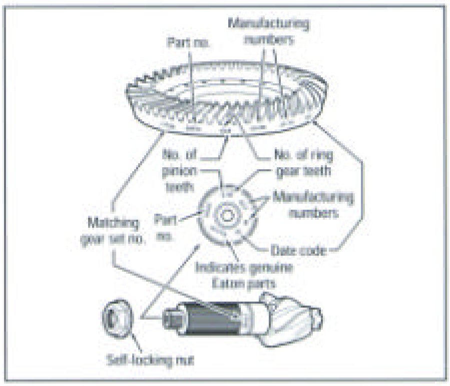
08/09/10/11 = Gross axle weight in tonnes:
18/24/26/28/36 = Gross combination weight in tonnes
D = Diff. Lock version.



Ring Gear and Pinion Identification

Ring Gear and Drive Pinion are matched parts and must be replaced in sets.

To aid in identifying gear sets, parts are stamped with such information as number of pinion and ring gear teeth, individual part number and matched set number (refer to drawing).



Last Modification	Date	Approved by	Date	Level	Reference	Eng. Change
A. Fernández	03/02/03	R. Yoldi	03/02/03	C	613501	03622

Lubrication

The ability of a drive axle to deliver quiet, trouble-free operation over a period of years is largely dependent upon the use of good quality gear lubrication in the correct quantity. The most satisfactory results can be obtained by following the directions contained in this manual.

The following lubrication instructions represent the most current recommendations from the Axle & Brake Division of DANA Corporation.

Approved Lubricants

General - Gear lubrications acceptable under military specification (MILSPEC) MIL-L-2105D (Lubricating Oils, Gear, Multipurpose) are approved for use in Eaton Drive Axles. The MIL-L-2105D specification defines performance and viscosity requirements for multigrade oils. It supersedes both MIL-L-2105B, MIL-L-2105C and cold weather specification MIL-L-10324A. This specification applies to both petroleum-based and synthetic-based gear lubricants if they appear on the most current “Qualified Products List” (QPL-2105) for MIL-L-2105D.

NOTE: The use of separate oil additives and/or friction modifiers are not approved in DANA Drive Axles.

Synthetic-based - Synthetic-based gear lubricants exhibit superior thermal and oxidation stability and generally degrade at a lower rate when compared to petroleum-based lubricants. The performance characteristics of these lubricants include extended change intervals, improved fuel economy, better extreme temperature operation, reduced wear and cleaner component appearance. The family of Eaton Roadranger™ gear lubricants represents a premium quality synthetic lube which fully meets or exceeds the requirements of MIL-L-2105D. These products, available in both 75W-90 and 80/W-140, have demonstrated superior performance in comparison to others qualified under the MILSPEC, as demonstrated by extensive laboratory and field testing. For a complete list of Roadranger® approved synthetic lubricants contact your local Eaton representative.

Makeup Lube - Maximum amount of non-synthetic makeup lube is 10%.

Viscosity/Ambient Temperature Recommendations

The following chart lists the various SAE Grades covered by
MIL-L-2105D and the associated ambient temperature range from each. Those SAE grades shown with an asterisk (*) are available in the Roadranger family of synthetic gear lubricants.

The lowest ambient temperatures covered by this chart are -40°F and -40°C. Lubrication recommendations for those applications which consistently operate below this temperature range, must be obtained through Eaton Corporation by contacting your local Eaton representative.

Grade	Ambient Temperature Range
75W	-40°F to -15°F (-40°C to -26°C)
75W-80	-40° F to 80°F (-40°C to 21°C)
75W-90*	-40°F to 100°F (-40°C to 38°C)
75W-140	-40° F and above (-40°C and above)
80W-90	-15°F to 100°F (-26°C to 38°C)
80W-140*	-15°F and above (-26°C and above)
85W-140	10° F and above (-12°C and above)

SERVICE MANUAL SINGLE AXLE

Lube Change Intervals

This product combines the latest manufacturing and part washing technology. When filled with an Eaton approved synthetic lubricant at the factory, the initial drain is not required.

Change the lubricant within the first 5,000 miles of operation when not using a Roadranger approved synthetic lubricant in either a new axle or after a carrier head replacement. Base subsequent lubricant changes on a combination of the following chart and user assessment of the application and operating environment.

Severe Service Lubrication Change Intervals - Severe service applications are those where the vehicle consistently operates at or near its maximum GCW or GVW ratings, dusty or wet environments, or consistent operation on grades greater than 8%. For these applications, the ON/OFF HIGHWAY portion of the chart should be used. Typical applications are construction, logging, mining and refuse removal.

NOTE: Clean metallic particles from the magnetic filler plug and drain plugs. Clean or replace the breather yearly to avoid lube contamination due to water ingestion.

Guidelines-Lube Change Intervals for Drive Axles				
Lubricant Type	On-Highway Miles	Maximum Change Interval	On/Off Highway Severe Service Miles	Maximum Change Interval
Mineral Based	100,000	Yearly	40,000	Yearly
Eaton Approved Synthetic	250,000	3 Years	100,000	Yearly

Changing Lube

Draining: Drain into suitable container with lube at normal operating temperature. Inspect drain plug for excessive metal particle accumu-lation symptomatic of extreme wear. Clean and replace plug after draining.

NOTE: After initial lube change, the entire unit should be inspected if excessive particle accumulation is observed.

Filling: Remove filler hole plug and fill housing with approved lubri-cant until level with bottom of filler hole.

Lube Capacities- DO NOT OVERFILL AXLES		
Late Axle Model	Pints	Litres
08.18	21.0	10.0
09.24 / 10.24	25.0	12.0
11.26	28.0	13.0
11.36	40.0	19.0
13.44	54.0	25.5

Axles installed at angles exceeding 6° or operated regularly on grades exceeding 12% may require stand-pipes to allow proper fill levels.

Wheel End Lubrication

To prevent failure, lubricate the wheel hub cavities and bearings following any wheel end servicing.

CAUTION: Make sure the wheel ends are well lubricated with the same axle lubricant used in the axle sump. Do not pack the bearings with grease before installation as grease will prevent the proper circulation of axle lubricant and may cause wheel seal failure.

Eaton axles may be equipped with either of two wheel end designs:

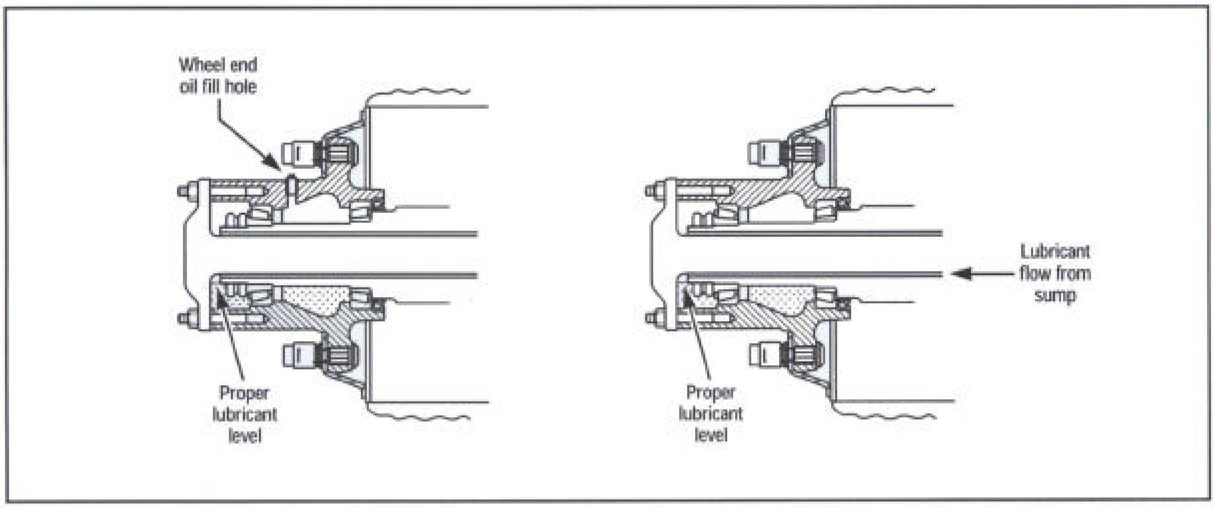
- Wheel ends **with** an oil fill hole
- Wheel ends **without** an oil fill hole

See illustration for cutaway views of the two different designs.

Wheel ends with an oil fill hole

1. Rotate the wheel end hub until the oil fill hole is up.
2. Remove the oil fill plug.
3. Pour axle sump lubricant into each hub through the wheel end fill hole as per below chart.
4. Install oil fill plug and tighten to 54-81 N.m (40-60 lbf.ft).

AXLE	*Litres*
08.18	0.35*2
09.24	0.60*2
10.24 / 11.26 11.36 / 13.44	0,85*2



Cutaway Views of Typical Wheel End Assemblies

Inspection

As the drive axle is disassembled, set all parts aside for thorough cleaning and inspection. Careful inspection will help determine whether parts should be reused. In many cases, the causes of pre-mature wear or drive axle failure will also be revealed.

Cleaning

The differential carrier assembly may be steam-cleaned while mounted in the housing as long as all openings are tightly plugged. Once removed from its housing, do not steam clean differential carrier or any components. Steam cleaning at this time could allow water to be trapped in cored passages, leading to rust, lubricant contamination, and premature component wear. The only proper way to clean the assembly is to disassemble it completely. Other methods will not be effective except as preparatory steps in the process. Wash steel parts with ground or polished surfaces in solvent. There are many suitable commercial solvents available. Kerosene and diesel fuel are acceptable.

WARNING: Gasoline is not an acceptable solvent because of its extreme combustibility. It is unsafe in he workshop environment.

Wash castings or other rough parts in solvent or clean in hot solution tanks using mild alkali solutions. If a hot solution tank is used, make sure parts are heated thoroughly before rinsing.

Rinse thoroughly to remove all traces of the cleaning solution. Dry parts immediately with clean rags.

Lightly oil parts if they are to be reused immediately. Otherwise, coat with oil and wrap in corrosion-resistant paper. Store parts in a clean, dry place.

Inspection

Inspect steel parts for notches, visible steps or grooves created by wear. Look for pitting or cracking along gear contact lines. Scuffing, deformation or discoloration are signs of excessive heat in the axle, usually related to low lubricant levels or improper lubrication practices.

Before reusing a gear set, inspect teeth for signs of excessive wear. Check tooth contact pattern for evidence of incorrect adjustment. (see Adjustment Section for correct pattern).

Inspect machined surfaces of cast or malleable parts. They must be free of cracks, scoring and wear. Look for elongation of drilled holes, wear on surfaces machined for bearing fits and nicks or burrs in mating surfaces.

Inspect fasteners for rounded heads, bends, cracks or damaged threads.

The axle housing should be examined for cracks or leaks. Also look for loose studs or cross-threaded holes.

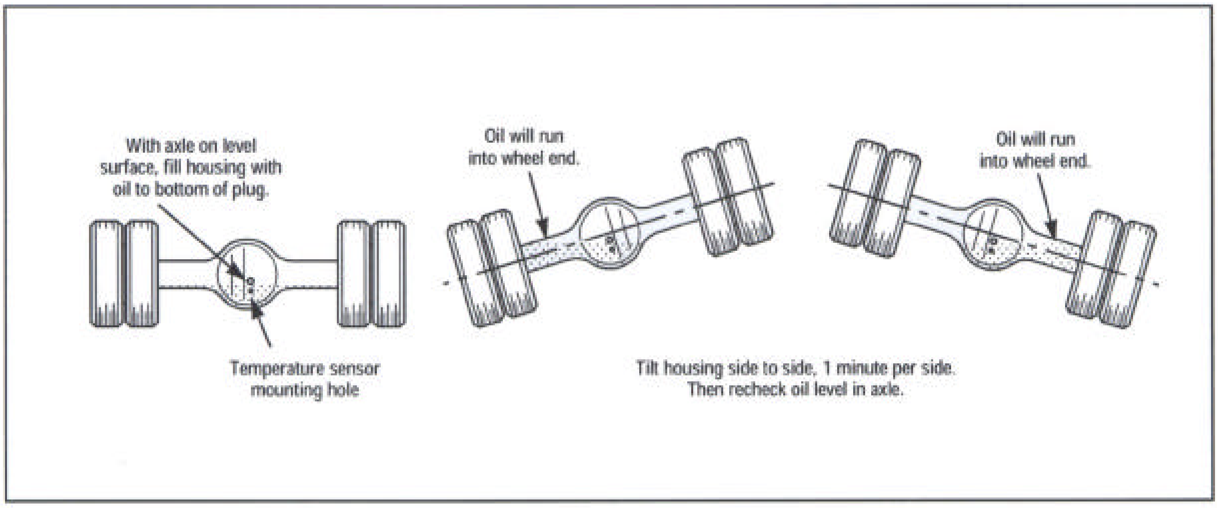
Inspect machined surfaces for nicks and burrs.

Wheel ends without an oil fill hole

1. With axle level and wheel ends assembled, add lubricantthrough the filler hole in axle housing cover until fluid islevel with the bottom of filler hole.
2. Raise the left side of the axle 6 inches or more. Hold axle in this position for one minute.
3. Lower the left side.
4. Raise the right side of the axle 6 inches or more. Hold axle in this position for one minute.
5. Lower the right side.
6. With axle on a level surface, add additional lubricant through the housing cover oil filler hole to raise lube to required level.

NOTE: Axles without wheel end fill holes will require approximately 2.5 additional pints of lubricant to bring the lube level even with the bottom of the fill hole.

TIP: The use of ramps or making a full lock figure eight turning maneuver at low speed will guarantee the wheel end is charged with lube. Refill axle to proper lube level. (Follow procedure).



Repair and Replacement

IMPORTANT: To achieve maximum value from an axle rebuild, replace lower-cost parts, such as thrust washers seals, etc. These items protect the axle from premature wear or loss of lubricants. Replacing these parts will not increase rebuild cost significantly.

It is important to replace other parts which display signs of heavy wear even though not cracked or broken. A significant portion of such a part's useful life has been expended and the damage caused, should the part fail, is far in excess of its cost.

Steel Parts - Gear sets, differential parts and bearings are not repairable. Worn or damaged parts should be discarded without hesi-tation. Also discard mating parts in some cases. Gear sets for example, must be replaced in sets.

Miscellaneous Parts - Seals and washers are routinely replaced. None of these parts can be reused if damaged. Fasteners using self-locking nylon "patches" may be reused if damaged, but should be secured by a few drops of Loctite #518 on the threaded surface of the hole during installation and carefully torqued during installation.

Axle Housings - Repairs are limited to removal of nicks or burrs on machined surfaces and the replacement of loose or broken studs.

CAUTION: Any damage which affects the alignment or structural integrity of the housing requires housing replacement. Do not repair by welding or straightening. This process can affect the housing heat treatment and cause it to fail completely when under load.

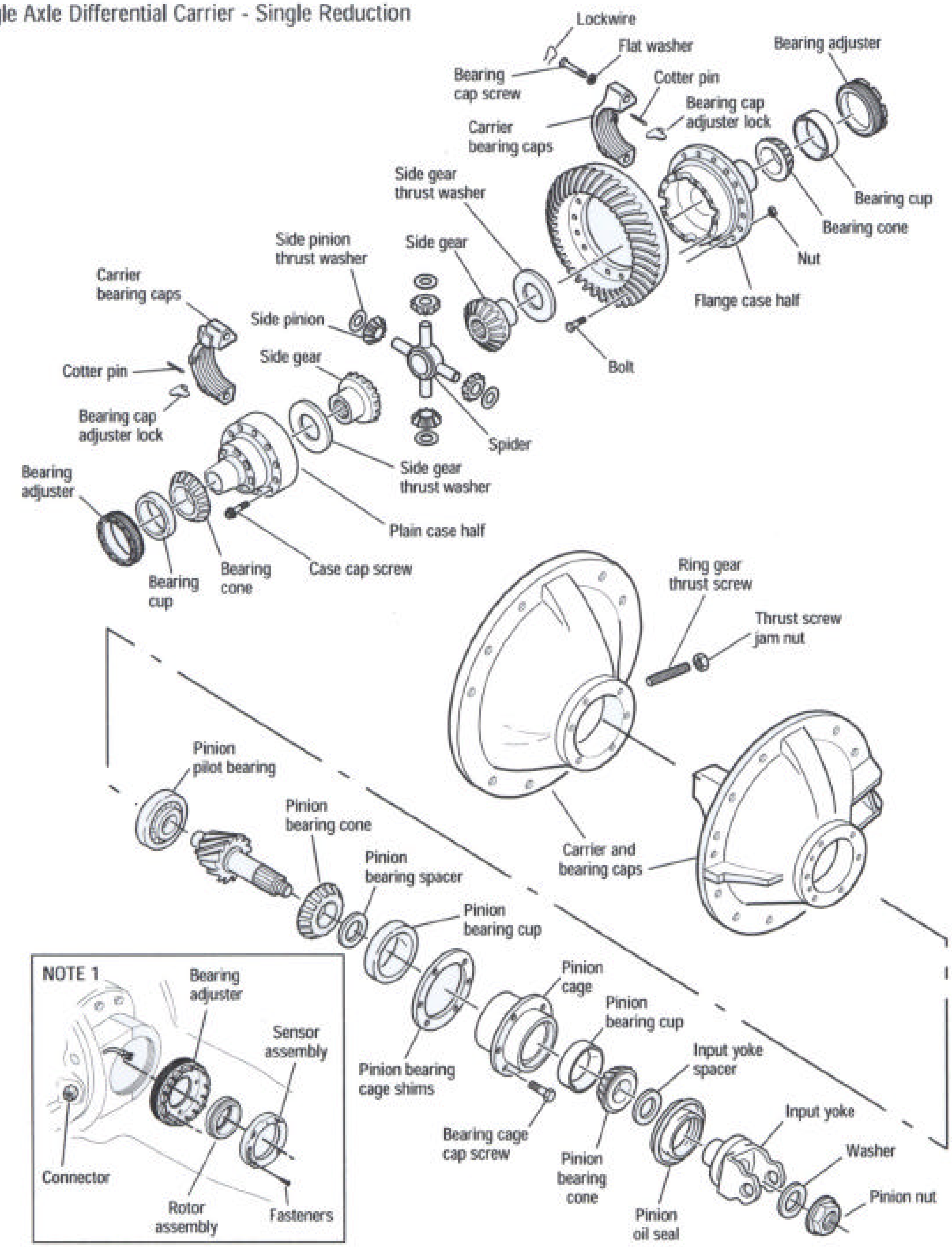
Silicone Rubber Gasket Compound - For more effective sealing, Eaton uses silicone rubber gasket compound to seal the majority of metal-to-metal mating surfaces.

Eaton includes gasket compound and application instructions in many repair parts kits.

It is recommended that this compound be used in place of conven-tional gaskets. The compound will provide a more effective seal against lube seepage and is easier to remove from mating surfaces when replacing parts.

Differential Carrier Assembly Exploded View

Single Axle Differential Carrier - Single Reduction



NOTE 1: For service information on axles that are equipped with IASS (In Axle Speed Sensors) reference the Antilock Brake System service manual BRIP-0100.

Last Modification	Date	Approved by	Date	Level	Reference	Eng. Change
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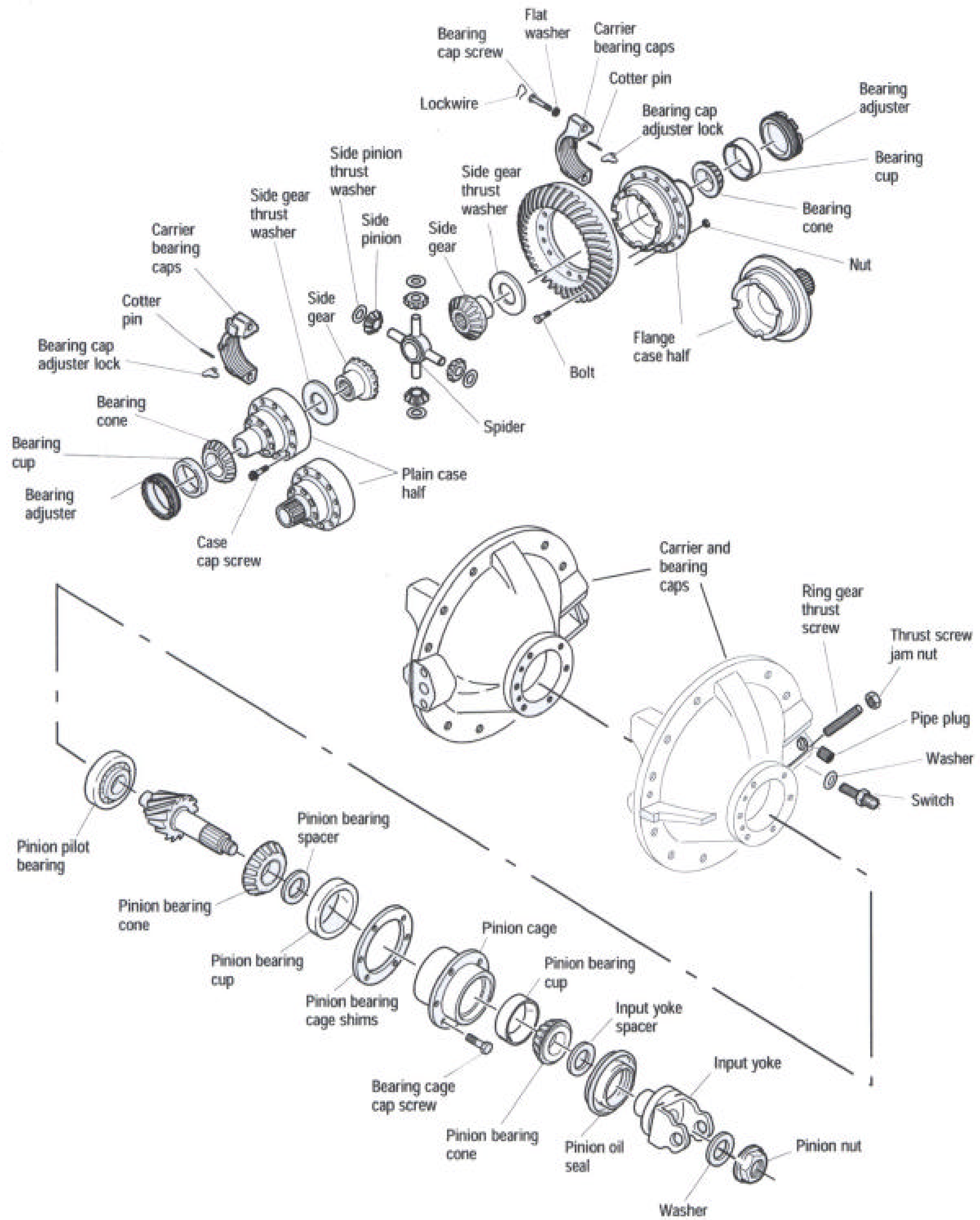
Single Axle Differential Carrier w/Differential Lock - Single Reduction



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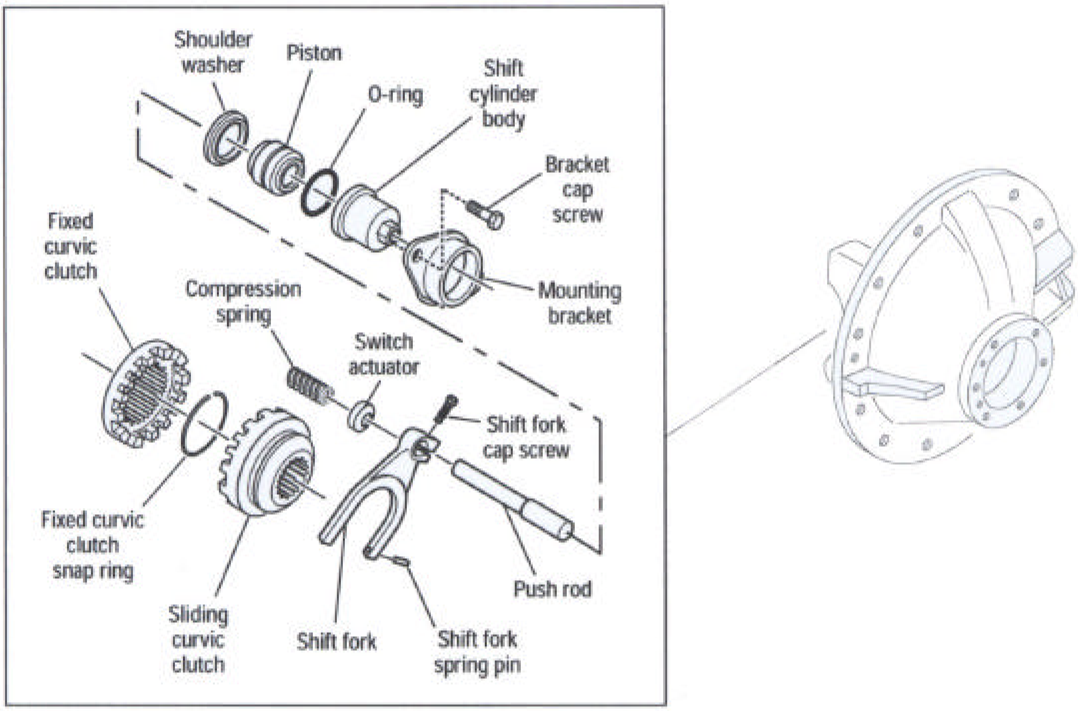
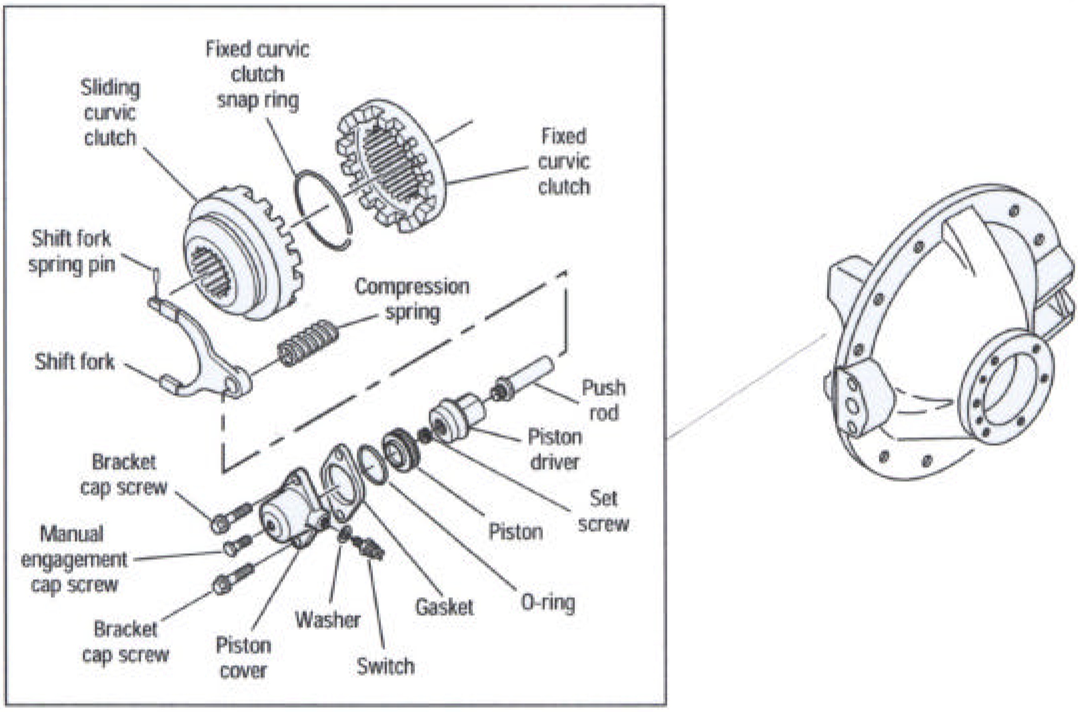
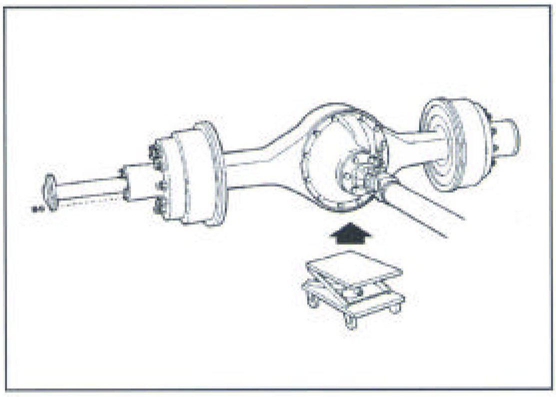

Shoulder washer
Piston
O-ring
Shift cylinder body
Bracket cap screw
Fixed curvic clutch
Compression spring
Mounting bracket
Switch actuator
Shift fork cap screw
Fixed curvic clutch snap ring
Push rod
Sliding curvic clutch
Shift fork
Shift fork spring pin


Fixed curvic clutch snap ring
Sliding curvic clutch
Fixed curvic clutch
Shift fork spring pin
Compression spring
Shift fork
Push rod
Piston driver
Bracket cap screw
Set screw
Manual engagement cap screw
Piston
Gasket
O-ring
Washer
Bracket cap screw
Piston cover
Switch

Differential Carrier Assembly

Removal of Differential Carrier Assembly



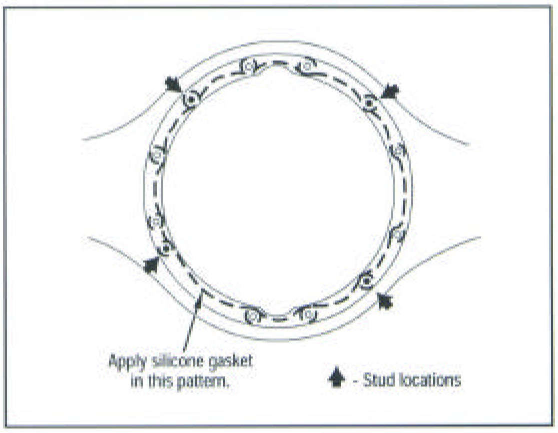
WARNING: Do not strike the axle shaft flange with a hammer. Do not use chisels or wedges to loosen shaft or dowels.

WARNING: Do not lie under carrier while removing fasteners or after fasteners are removed. Use transmission jack to support and remove differential carrier assembly.

Installation of Differential Carrier Assembly

NOTE: Before installing carrier assembly, inspect and thoroughly clean interior of axle housing.

NOTE: Use silicone rubber gasket compound on axle housing mating surface as shown in the illustration. Gasket compound will set in 20 minutes. Install carrier before compound sets or reapply.



1. Install differential carrier assembly in axle housing. Install cap screws and lockwashers. Tighten to correct torque (see torque chart).

NOTE: Fasteners using self-locking thread “patches” may be
reused if not damaged, but should be secured by a few drops of Loctite#518 on threaded surface of differential carrier.

Reused fasteners should be wiped clean of excess oil, but do not require special cleaning.

2. Install axle shafts, silicone gasket compound, and stud nuts. Connect driveline.

3. Fill axle with correct lube.

NOTE: When axle has been disassembled or housing, gears, axle shafts or wheel equipment replaced, check axle assembly for proper differential action before operating vehicle. Wheels must rotate freely and independently.

Differential Carrier Overhaul

NOTE: If gear set is to be reused, check tooth contact pattern and ring gear backlash before disassembling differential carrier. Best results are obtained when established wear patterns are maintained in used gearing. Omit this step if the gear set is to be replaced.

1. Mount differential carrier assembly in repair stand. Loosen but do not remove pinion nut.

2. Loosen jam nut on ring gear thrust screw (if so equipped).Remove thrust screw.

3. Punch mark differential bearing caps. If reusing gear set, also punch mark bearing adjusters for reference during reassembly.

4. Cut lockwires (when used). Remove cap screws, flat washers and bearing caps.

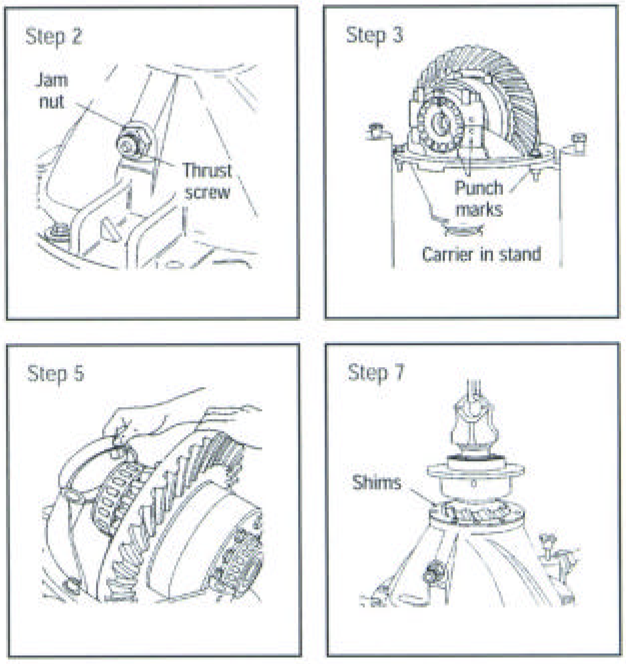
5. Remove bearing adjuster and bearing cups. Using a chain hoist, lift ring gear and differential assembly out of carrier.

6. Invert carrier in stand for drive pinion assembly removal.

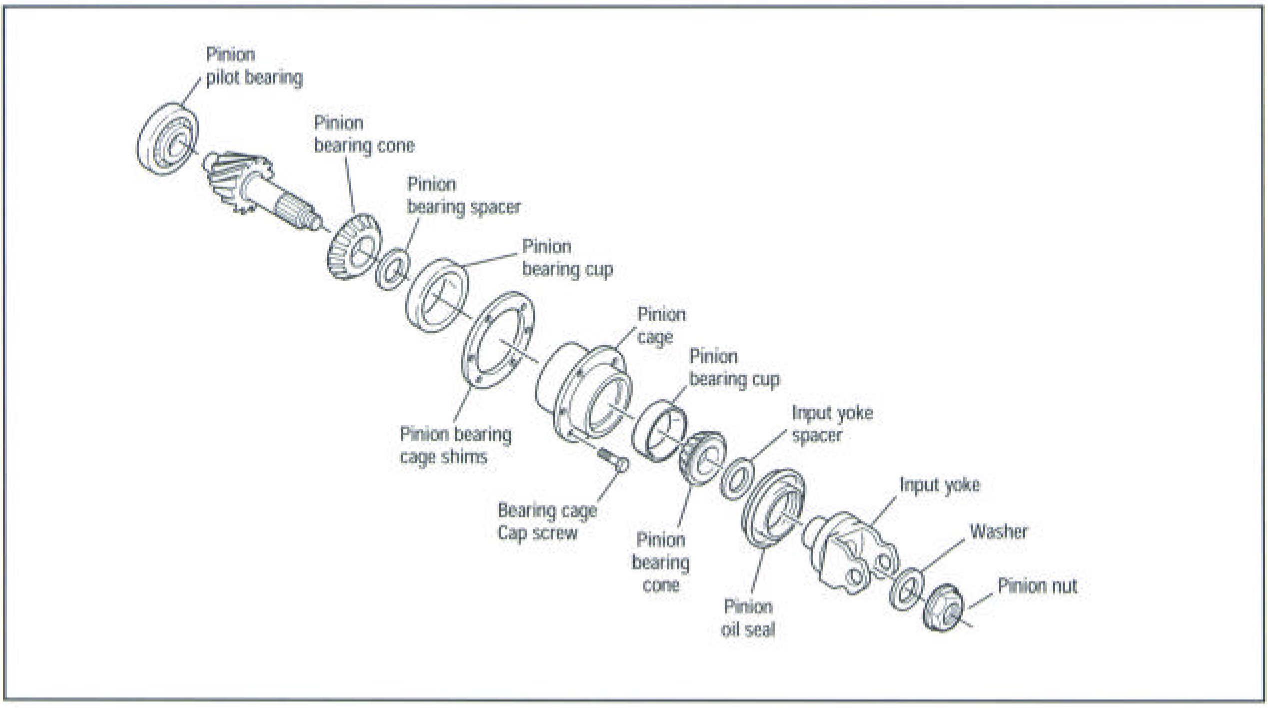
7. Remove pinion bearing cage cap screws. Using a chain hoist, lift drive pinion, cage and yoke assembly out of carrier.

NOTE: If gear set is to be reused, keep pinion bearing cage shim pack intact for use in reassembly. If the original shims cannot be reused, record the number and size of shims in the pack.

Disassembly of Differential Carrier

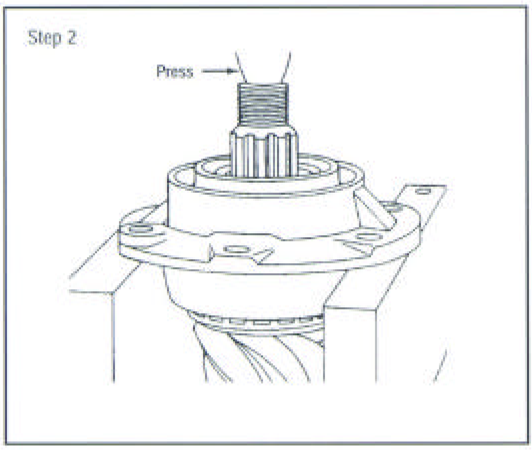


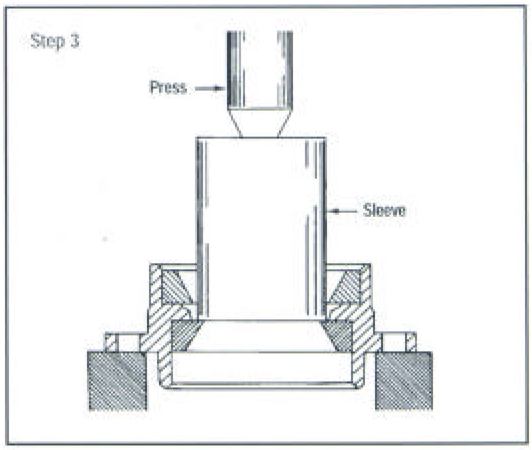
Disassembly Drive Pinion



CAUTION: During the following yoke removal procedure, do not allow pinion to drop on hard surface.

1. If pinion nut was not loosened during earlier disassembly, clamp yoke in vise jaws. Use brass pads to prevent damage. Loosen and remove pinion nut. To remove yoke, use suitable puller or press pinion out of yoke.
2. Support cage and press pinion out of bearing cage.
3. Press oil seal and outer bearing cup out of cage.





Disassemble Drive Pinion (continued)

4. Remove bearing spacer from pinion.

5. Using a suitable bearing cup remover, remove inner bearing cup.

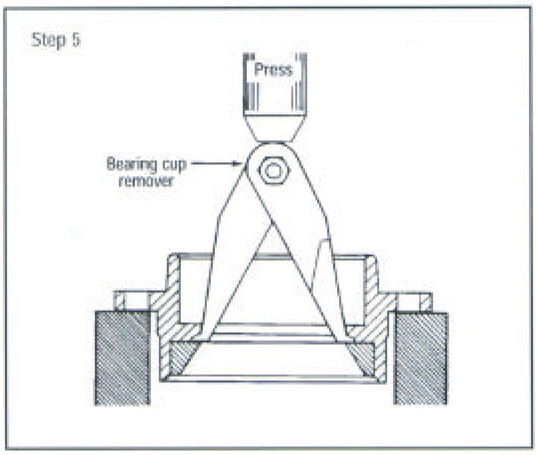
NOTE: Bearing cup remover, or equivalent can be used to remove inner bearing cup.

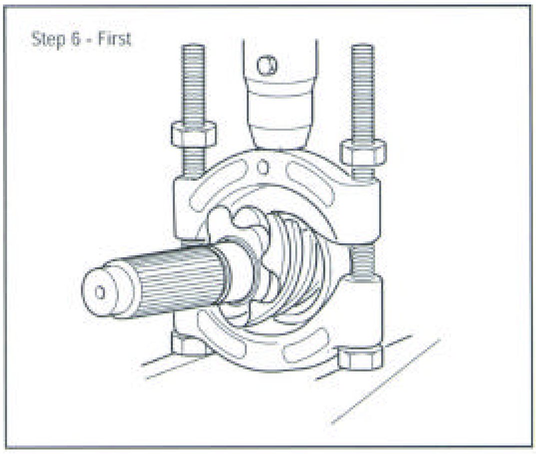
6. Remove pilot bearing and inner bearing cone from pinion, using a split-type puller. Use two procedure steps to remove each bearing (see illustrations).

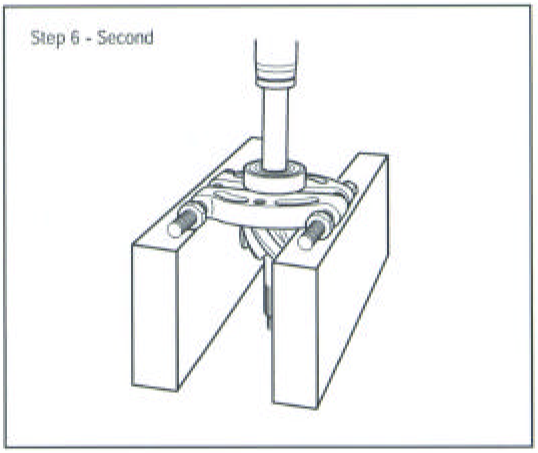
First, mount puller vertically to split the bearing.

Second, mount puller horizontally to press pinion out of bearing. This action will force puller halves under bearing and start moving bearing off pinion.

The same procedure can be used to remove both pilot bearing and pinion inner bearing cone.







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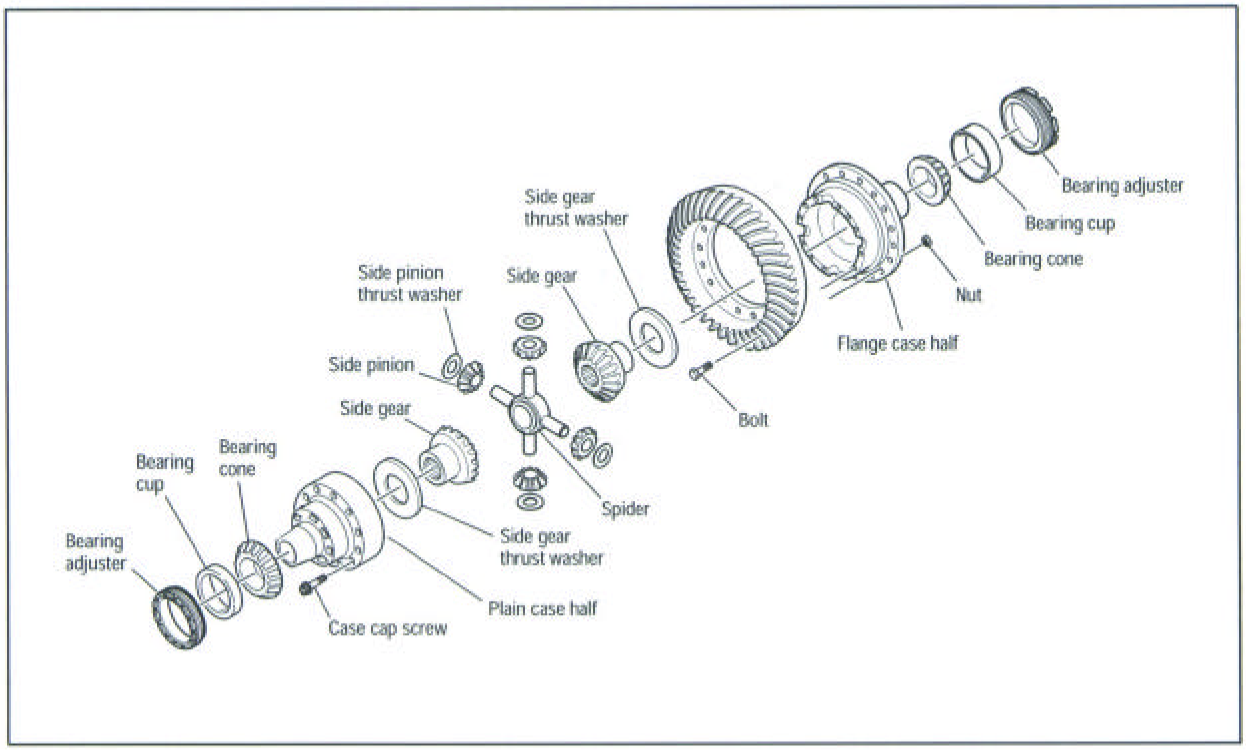
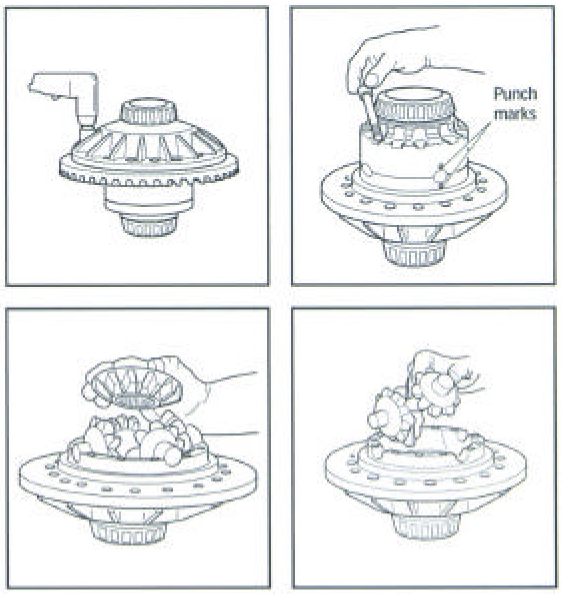
A. Fernández	03/02/03	R. Yoldi	03/02/03	C	613501	03622

Disassemble Wheel Differential



IMPORTANT: During following procedure, place differential assembly on malleable surface to prevent damage when ring gear falls off its mounting position.



1. Remove nuts and bolts fastening ring gear to differential cases, allowing gear to fall free. If gear does not fall, tap outer diameter with soft mallet to loosen.

2. Punch mark differential cases for correct location during assembly. Remove cap screws and lift off plain differential case half.

3. Lift out side gear and thrust washer.

4. Lift out spider, side pinions and thrust washers.

5. Remove side gear and thrust washer.

Disassemble Wheel Differential (continued)

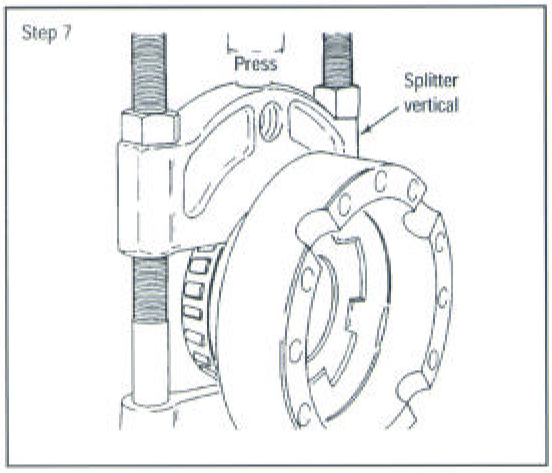
6. Remove bearing cones from case halves using suitable puller.

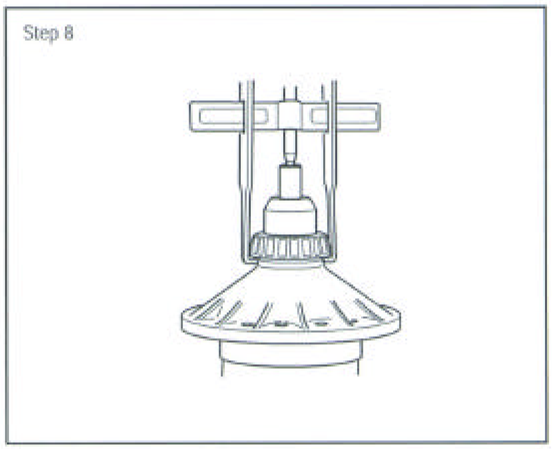
7. Remove bearing cone from plain case half in two steps:

First, mount puller vertically to split bearing.

Second, mount puller horizontally to remove cone.

8. Remove bearing cone from flanged case half using suitable puller.





Assemble Wheel Differential

NOTE: Lubricate differential parts with gear lube during assembly.

1. Press bearing cones on differential case halves.

IMPORTANT: To prevent bearing damage, use suitable sleeve that only contacts the inner race of the cone. A used bearing race would be a suitable tool. This tool should have a slit cut if the ID is the same as the flange OD.

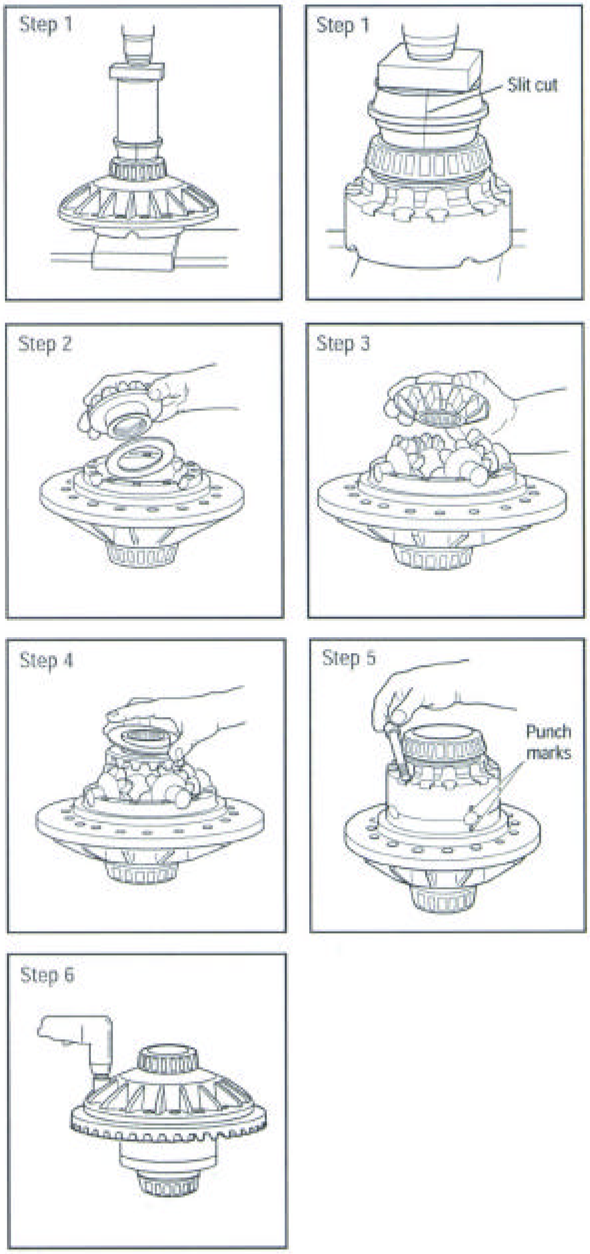
2. Place thrust washer and side gear in flanged differential case.

3. Assemble side pinion and thrust washers on spider. Place this assembly in flanged differential case. Rotate gears and check for proper mesh.

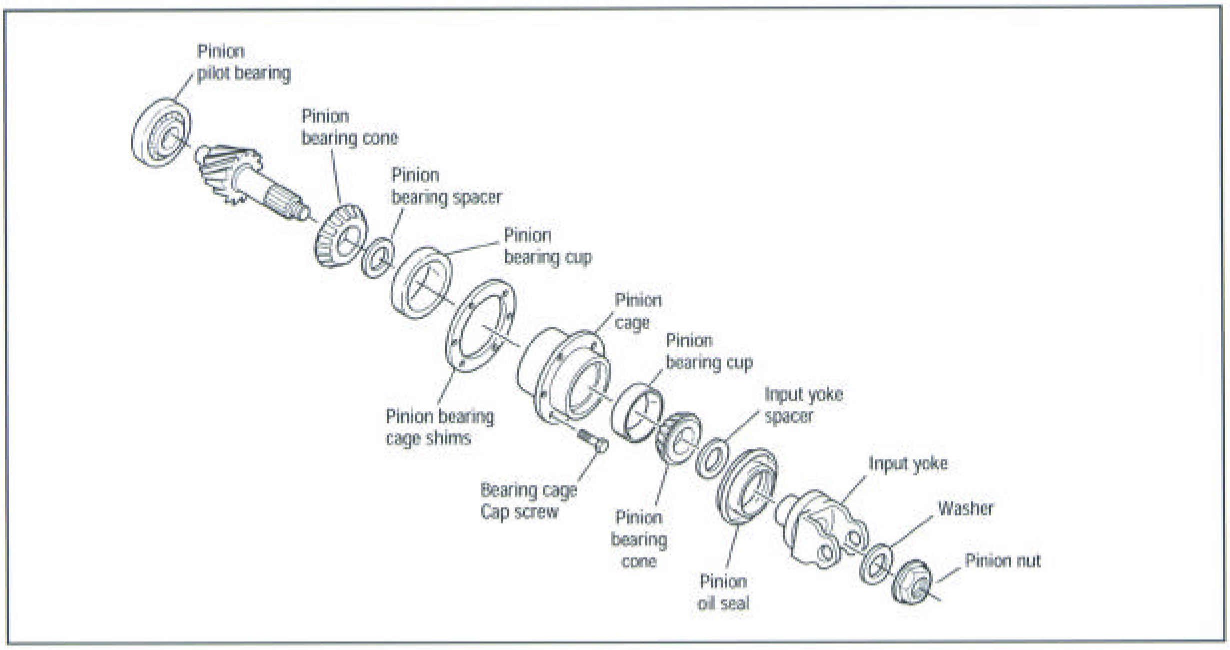
4. Place side gear and thrust washer on side pinions.

5. Align punch marks and install plain case half. Install cap screws and tighten to correct torque. Check differential for free rotation by turning side gear hub.

6. Install ring gear, applying Loctite #510 between ring gear and differential case faces. Secure with bolts and nuts. Torque nuts to correct specification, see torque chart.



Assemble Drive Pinion

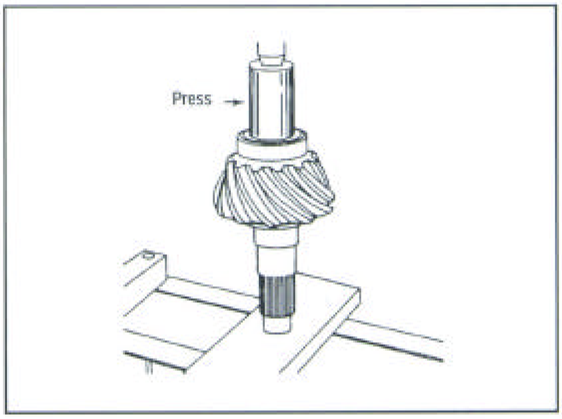


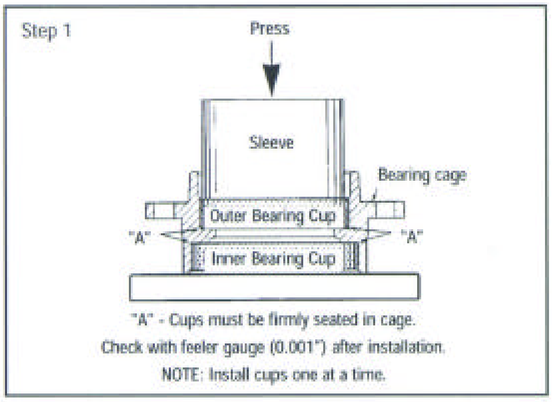
NOTE: Lubricate parts with gear lube during reassembly. When installing bearing cones and pilot bearing, use properly-sized sleeves that only contact the inner bearing race.

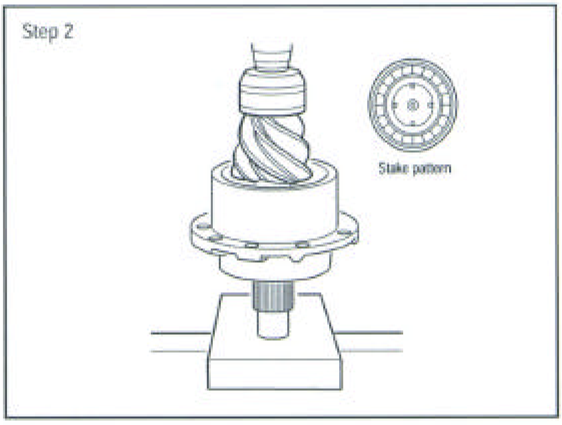
1. Before installing cups, check for burrs on bearing surfaces and remove if present. Press bearing cups in cage.

2. Press pilot bearing on pinion. Stake bearing using staking tool. See illustration for stake pattern.

3. Adjust pinion bearing preload by performing "Trial Build-Up Test."







Last Modification	Date	Approved by	Date	Level	Reference	Eng. Change
A. Fernández	03/02/03	R. Yoldi	03/02/03	C	613501	03622

Adjust Pinion Bearing Preload

Trial Build-up

1. Assemble pinion bearing cage, bearings, spacer and spacer washer (without drive pinion or oil seal). Center bearing spacer between two bearing cones.

NOTE: When new gear set or pinion bearings are used, select nominal size spacer from the specification chart below. If original parts are used, use spacer removed during disassembly.

2. With the bearings well lubricated, place the assembly in the press. Position sleeve so that load is applied directly to the back-face of the outer bearing cone.

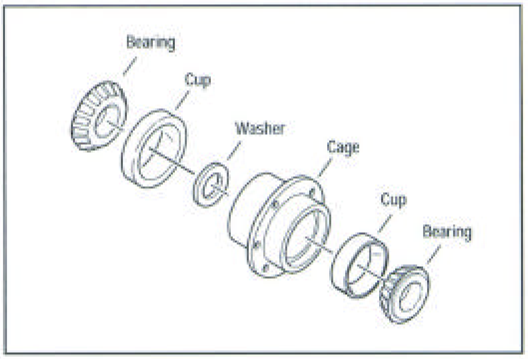
3. Apply press load (see chart below) to the assembly and check rolling torque. Wrap soft wire around the bearing cage, attach spring scale and pull. Preload is correct when torque required to rotate the pinion bearing cage is from 10-20 Lbs-in. (1.1-2.3 N•m). This specification is translated into spring scale readings in the chart below.

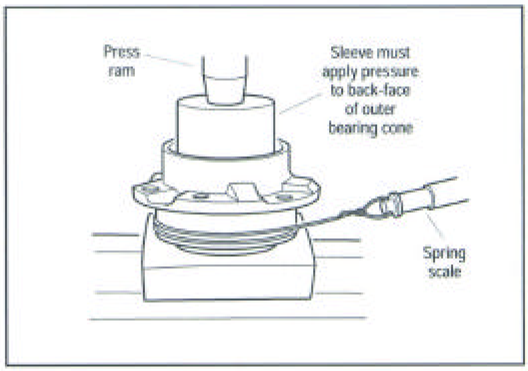
CAUTION: Read only the torque value after the bearing cage starts to rotate.

4. If necessary, adjust pinion bearing preload by changing the pinion bearing spacer. A thicker spacer will decrease pre-load. A thinner spacer will increase preload.

IMPORTANT: Do not assume that all assemblies will retain roper preload once bearings are pressed on pinion shank. FINAL PRELOAD TEST MUST BE MADE IN EVERY CASE.

IMPORTANT: Once correct bearing preload has been established, note the spacer size used. Select a spacer 0.001" larger for use in the final pinion bearing cage assembly. The larger spacer compensates for slight "growth" in the bearings which occurs when they are pressed on the pinion shank. The trial build-up will result in proper pinion bearing preload in three or four cases.





Spring Scale Reading (w/o pinion seal) Torque to rotate bearing cage 10 - 20 in-lbs. (1.1 - 2.3 N•m)						
Axle Model	Nominal Bearing Spacer Thickness		Press Loads		Spring Scale Adjustment	
	In.	mm	Tons	Metric Tons	Lbs.	N•m
08.18	.703	17.86	12-13	11-12	4-7	17-33
09.24 / 10.24	.703	17.86	12-13	11-12	4-7	17-33
11.26	.638	16.21	14-15	13-14	4-8	17-35
11.36	.672	17.07	18-19	16-17	3-6	12-24
13.44	.527	13.40	18-19	16-17	3-6	12-24

Final Pinion Bearing Preload Test

1. Assemble the complete pinion bearing cage unit as recommended in this manual.

NOTE: Forward axle pinion is equipped with helical gear. For easier disassembly during bearing adjustment procedure, use a dummy yoke (if available) in place of helical gear.

2. Apply clamp load to the pinion bearing cage assembly. Either install the yoke (or helical gear) and torque the pinion nut to specifications or use the press to simulate nut torque (see chart below).

Vise Method - If the yoke and nut are used, mount the assembly in a vise, clamping yoke firmly.

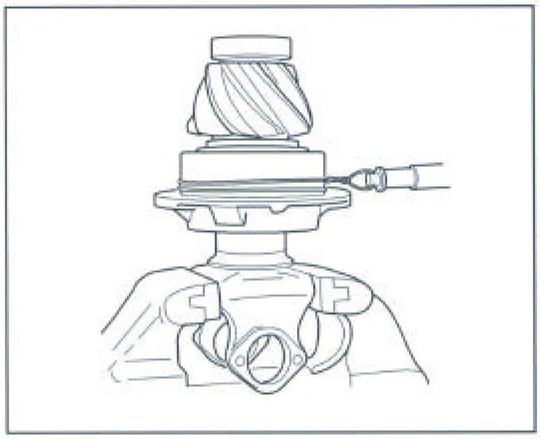
Press Method - If a press is used, position a sleeve or spacer so that load is applied directly to the back-face of the outer bearing cone.

3. **Measure Pinion Bearing Preload** - Use a spring scale to test the assembly rolling torque. To use the spring scale, wrap soft wire around the bearing cage, attach the scale and pull. Preload is correct when torque required to rotate the pinion bearing cage is from 15-35 Lbs-in. (1.7-4.0 N•m). This specification is translated into spring scale readings in the chart below.

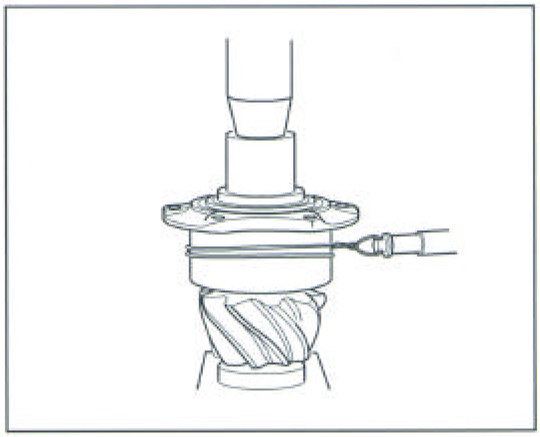
CAUTION: Read only the torque value after the bearing cagestarts to rotate.

4. **Adjust Pinion Bearing Preload** - If necessary, adjust pinion bearing preload. Disassemble the pinion bearing cage as recommended in this manual and change the pinion bearing spacer. A thicker spacer will decrease preload. A thinner spacer will increase preload.

IMPORTANT: Use the correctly sized spacer: At the middle of the pinion nut torque tolerance, the rolling torque of the final assembly, must be within the specification: 15-35 in lbs. Do not exceed pinion nut torque to achieve rolling torque specification, in that case it should be necessary to change the spacer. Do not use shim stock or grind spacers. These practices can lead to loss of bearing preload and gear or bearing failure.



Measuring Bearing Preload with Pinion in Vise



Measuring Bearing Preload with Pinion in Press

Specifications for final Pinion Bearing Preload Test Torque to rotate bearing cage 15 - 35 in-lbs. (1.7 - 4.0 N•m)						
Axle Model	Pinion Nut Torque		Press Loads		Spring Scale Adjustment	
	Lbs-ft	N•m	Tons	Metric Tons	Lbs.	N•m
08.18	376-461	510-625	12-13	11-12	6-13	25-58
09.24 / 10.24	376-461	510-625	12-13	11-12	6-13	25-58
11.26	575-703	759-949	14-15	13-14	6-14	25-60
11.36	789-966	1070-1310	18-19	16-17	4-10	18-43
13.44	840-1020	1140-1383	18-19	16-17	4-10	18-43

Install Drive Pinion

1. Place shim pack on carrier.

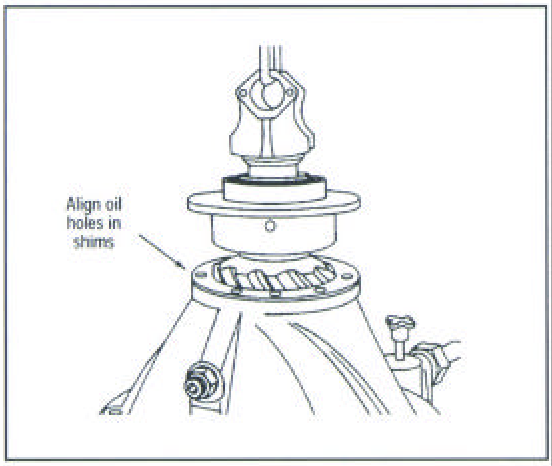
NOTE: If gear is to be reused, install same quantity and size of shims removed during disassembly. When installing a new gear set, use nominal shim pack (see chart below).

2. Install pinion assembly. Install bearing cage cap screws. Torque cap screws. (see torque chart).

NOTE: Fasteners using self-locking thread "patches" may be reused if not damaged, but should be secured by a few drops of Loctite #518 on threaded surface of differential carrier.

Reused fasteners should be wiped clean of excess oil, but do not require special cleaning.

Nominal Shim Pack	
08.18 / 09.24 10.24 / 11.36	.024 in (.61 mm)
11.26 / 11.28	.023 in (.58 mm)
13.44	.021 in (.53 mm)



Install Differential Ring Gear Assembly

NOTE: Drive Axle with Wheel Differential Lock. Do not install Differential Lock until the differential carrier is completely assembled and adjusted.

NOTE: Lubricate bearings during the following assembly procedures.

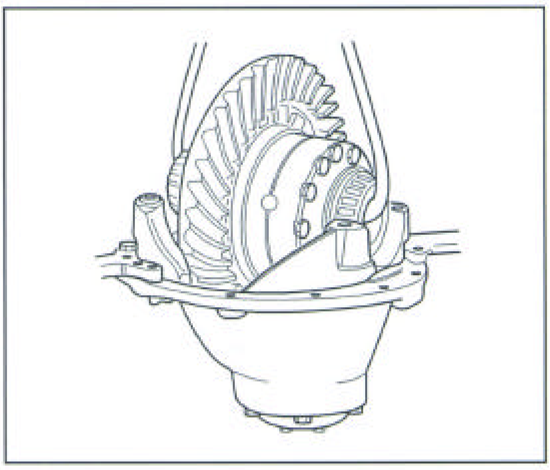
1. Place ring gear and differential assembly in carrier. Carefully lower the assembly until bearing cones rest on carrier.

2. Install bearing cups at both sides of differential case. Install bearing adjusters and caps. Install cap screws and flat washers.

3. Tighten bearing cap screws finger-tight. If this is difficult, se hand wrench.

CAUTION: When installing bearing caps and adjusters, exercise care not to cross threads. Make sure threads are well lubricated.

NOTE: The assembly is now ready for adjustment of differential bearing preload, ring gear backlash and gear tooth contact.



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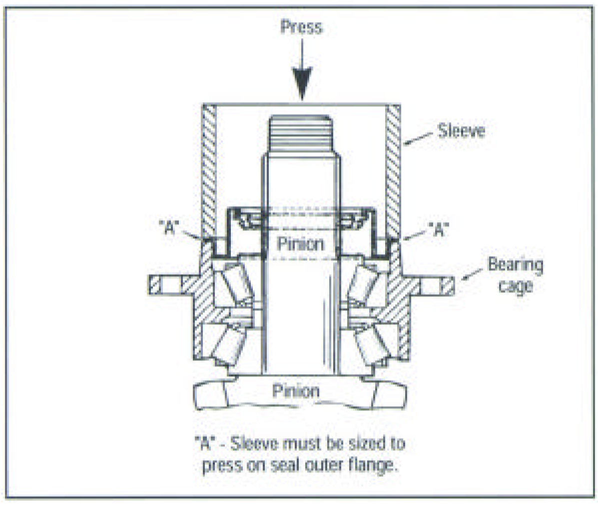
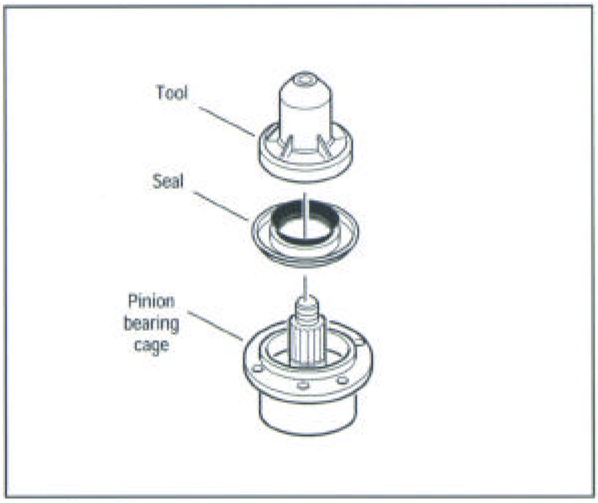
Install Pinion Oil Seal and Yoke

1. With pinion bearing preload adjustment complete, install oil seal. If available, use a properly sized installation tool to install the oil seal. Otherwise, use a press and properly sized sleeve to prevent distortion or contact with seal lips during installation (see illustration).

2. Make sure yoke is clean and dry. Install yoke and nut (or nut washer on some models). Tighten nut to correct torque (see torque chart).

NOTE: After tightening nut, recheck pinion bearing rolling torque, then proceed with pinion installation in carrier.





Tool Driver P/N: 126917

Yoke Reuse Guidelines

CAUTION: Do not use the yoke if it has any damage on the seal surface (nicks or scratches).

The surface of the yoke and the lips of the seal form a critical interface which retains the axle's lubricant while sealing the axle from outside contaminants. The condition of the yoke hub's surface is a very important factor in determining seal life.

Carefully inspect the seal surface area of the yoke hub for signs of wear and damage. Do not reuse the yoke if there is noticeable wear such as heavy grooving, beyond normal polishing from the seal lips.

NOTE: Do not rework the yoke with abrasives such as emery paper or crocus cloth. Clean the surface of the yoke as necessary using chemical cleaners. Remove all trace of the chemicals from the yoke after cleaning.

Do not use wear sleeves. Wear sleeves increase the yoke hub surface diameter and cause premature seal wear and repeat seal failure.

Seal Replacement

Eaton strongly recommends using seal drivers when installing new seals. Use the proper driver to ensure that the seal is square and installed to the proper depth.

CAUTION: Oil seals can be easily damaged prior to installation. Use care when handling the new seal to prevent damage or contamination. Leave the seal in its package until installation. On new yokes, leave the protector on the yoke until it is installed on the shaft to prevent damage or contamination.

Adjust Differential Bearing Preload

Correct differential bearing preload insures proper location of these bearings under load and helps position the ring gear for proper gear tooth contact.

NOTE: Before performing the following adjustments, make sure there is adequate clearance between the ring gear and thrust screw, if still installed. Adjust thrust screw only after all carrier adjustments are completed.

1. At teeth-side of ring gear, position bearing adjuster until its first thread is visible.

2. At the back-face side of ring gear, tighten adjuster until there is no backlash.

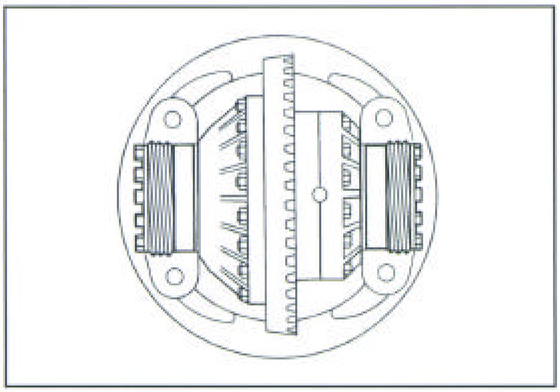
3. At the teeth-side of ring gear, tighten adjuster until it contacts the bearing cup. Continue tightening adjuster two or three notches. This will preload bearings and provide backlash.

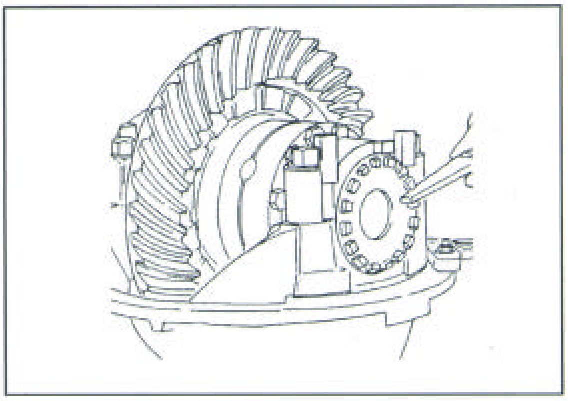
4. Check Ring Gear Backlash. Measure backlash with a dial indicator, specifications are listed below. Refer to detailed instructions on adjusting backlash.

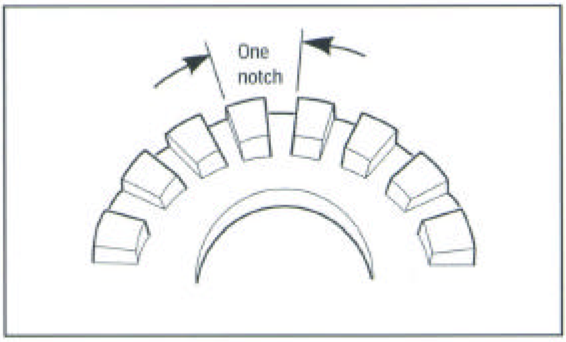
Ring Gear Backlash Specifications:

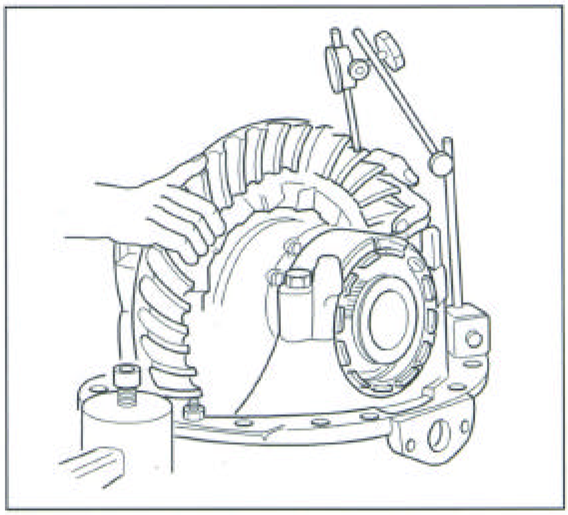
Used Gearing - Reset to backlash recorded before disassembly

New Gearing - See chart on next page.









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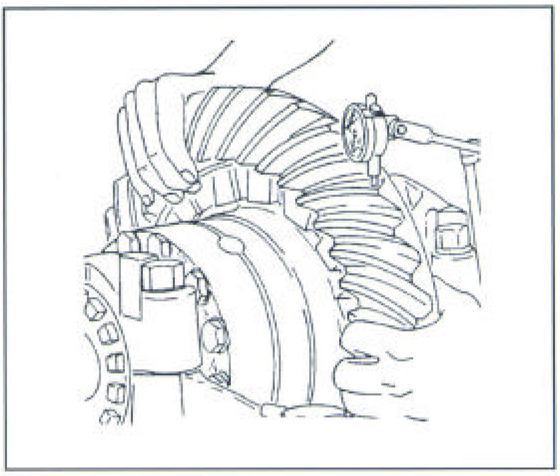
A. Fernández	03/02/03	R. Yoldi	03/02/03	C	613501	03622

Adjust Ring Gear Backlash

IMPORTANT: Check backlash as described below and adjust if necessary.



1. Measure backlash with a dial indicator. The indicator should be positioned on a ring gear tooth, at the extreme heel end, perpendicular to the tooth surface.

Backlash Specifications (Normal)	
08.18 / 09.24 / 10.24 11.26 / 11.28	.006" - .016" (.15 - .41 mm)
11.36 / 13.44	008" - .018" (.20 - .46 mm)
New Gearing Ring Gear Backface Runout: .010" **NOTE:** For new gearing, check ring gear backlash after each shim change and adjust if necessary.	
Used Gearing: Reset to normal backlash recorded before disassembly.	

To remove backlash: Loosen the adjuster on the teeth side of the ring gear several notches. Tighten the opposite adjuster one notch.

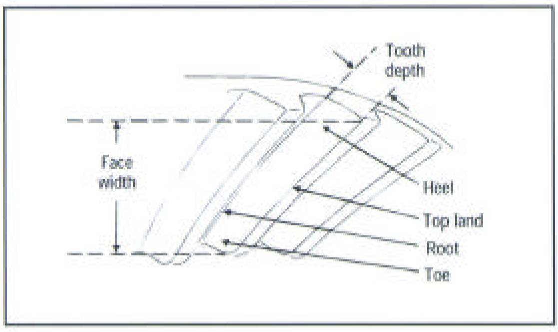
Return to adjuster on teeth side of ring gear and tighten adjuster until it contacts the bearing cup. Continue tightening the same adjuster 2 or 3 notches. Recheck backlash.

To add backlash: Loosen the adjuster on the teeth side of the ring gear several notches. Loosen the opposite adjuster one notch.

Return to adjuster on teeth side of ring gear and tighten adjuster until contacts the bearing cup. Continue tightening the same adjuster 2 or 3 notches. Recheck backlash.

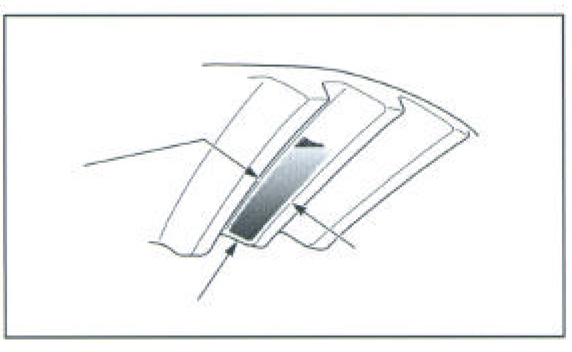
Adjust Ring Gear Tooth Contact
(All models excepting 13.44)

After differential bearing preload and gear backlash adjustment is complete, check gear tooth contact pattern and adjust if necessary.



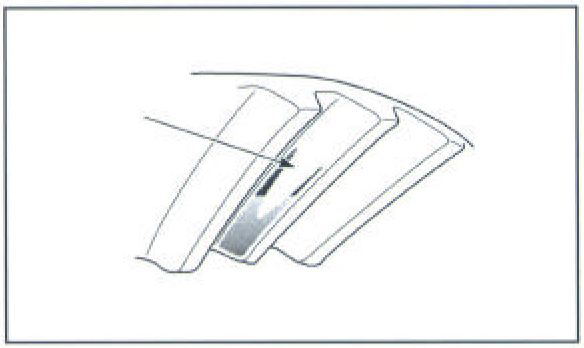
Correct Tooth Contact Pattern (New Gearing)

Paint ring gear teeth with marking compound and roll the gear to obtain a contact pattern as shown in the drawings. The length of the pattern in an unloaded condition is approximately one half to two-thirds of the ring gear tooth in most models and ratios.



Correct Tooth Contact Pattern (Used Gearing)

Used gearing may not display the square, even contact pattern found in new gear sets. The gear may have a “pocket” at heel end of con-tact pattern. The more use a gear has had, the more the pocket becomes the dominant characteristic of the pattern.



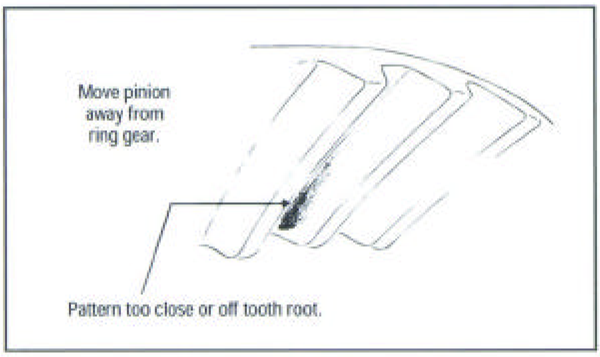
Adjust used gear sets to display the same contact pattern observed before disassembly. A correct pattern is up slightly off the toe and centers evenly along the face width between the top land and root. Otherwise, the length and shape of the pattern are highly variable and are considered acceptable as long as there is some pattern on toe end of the tooth.

NOTE: Tooth contact patterns are a function of the relative positions of the ring gear and pinion. An improper pattern will require relocation of either or both. Always adjust pinion position first, then if necessary, adjust ring gear position. Recheck backlash when done.

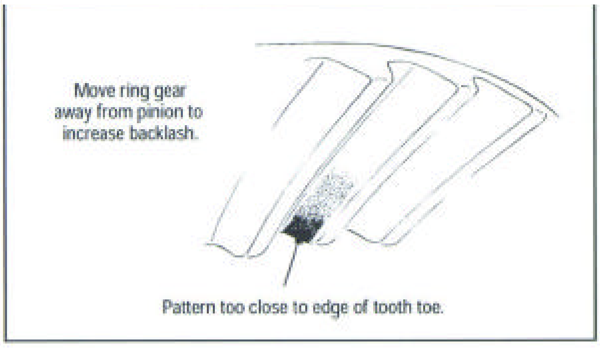
Adjust Pinion Position

NOTE: Before adjusting ring gear position in the following proce-dures, loosen thrust screw locknut and back off thrust screw (if so equipped). This procedure is necessary to provide adequate clear-anceand allow ring gear movement.

If the contact pattern shows incorrect tooth depth contact, change drive pinion position by altering the shim pack under the cage and cup assembly. Used gears should achieve proper contact with the same shims removed from the axle at disassembly.



If the pattern is too close to the root of the gear tooth, add pinion shims.

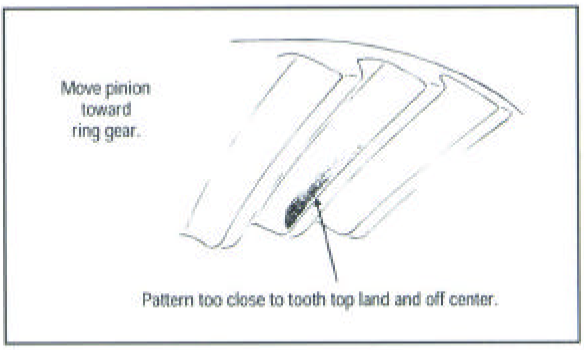


If the pattern is too close to the top land of the gear tooth, remove pinion shims.

and adjust if necessary to maintain correct backlash (see backlash specifications). Always recheck tooth contact pattern after making shim pack changes.

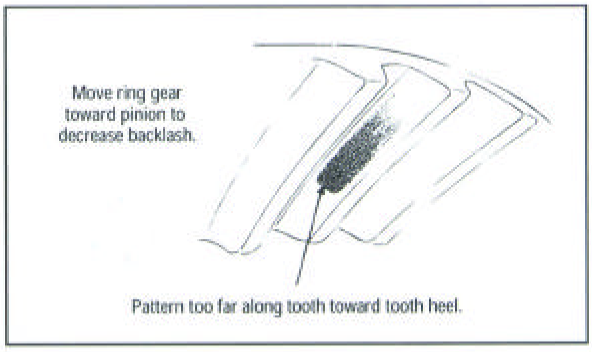
Adjust Backlash

If the contact pattern shows incorrect face width contact, change backlash and recheck the contact pattern.



With the pattern concentrated at the toe (too far down the tooth), **add backlash** by loosening the bearing adjuster on the teeth side of ring gear several notches. Loosen the opposite adjuster one notch.

Return to adjuster on teeth side of ring gear and tighten adjuster until it contacts the bearing cup. Continue tightening the same adjuster 2 or 3 notches. Recheck backlash.

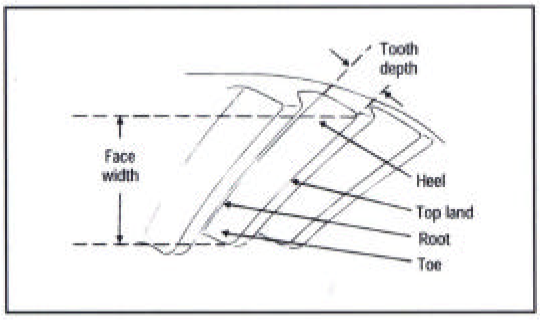


If the pattern is concentrated at the heel (too far up the tooth), **remove backlash** by loosening the bearing adjuster on the teeth side of ring gear several notches. Tighten the opposite adjuster one notch.

Return to adjuster on teeth side of ring gear and tighten adjuster until it contacts the bearing cup. Continue tightening the same adjuster 2 or 3 notches. Recheck backlash.

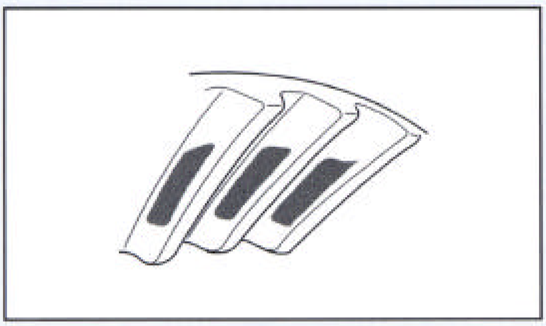
Adjust Ring Gear Tooth Contact
(Axle Model 13.44)

After differential bearing preload and gear backlash adjustment is omplete, check gear tooth contact pattern and adjust if necessary.



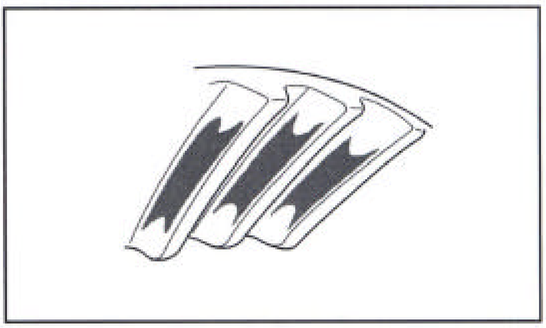
Correct Tooth Contact Pattern (New Gearing)

Paint ring gear teeth with marking compound and roll the gear to obtain a contact pattern. The correct pattern is well-centered on the ring gear tooth with lengthwise contact up off the toe. The length of the pattern in an unloaded condition is approximately one-half to two-thirds of the ring gear tooth in most models and ratios.



Correct Tooth Contact Pattern (Used Gearing)

Used gearing may not display the square, even contact pattern found in new gear sets. The gear will normally have a “pocket” at the end of the gear tooth. The more use a gear has had, the more the pocket becomes the dominant characteristic of the pattern.



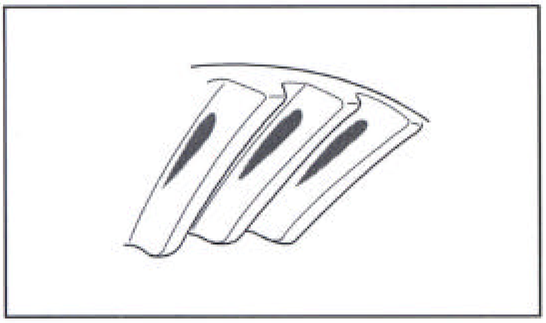
Adjust used gear sets to display the same contact pattern observed before disassembly. A correct pattern observed before disassembly. A correct pattern is up off the toe and centers evenly along the face width between the top land and root. Otherwise, the length and shape of the pattern are highly variable and are considered acceptable as long as they do not run off the tooth at any point.

NOTE: Tooth contact patterns are a function of the relative positions of the ring gear and pinion. An improper pattern will require relocation of either or both. Always adjust pinion position first, then if necessary, adjust ring gear position. Recheck backlash when done.

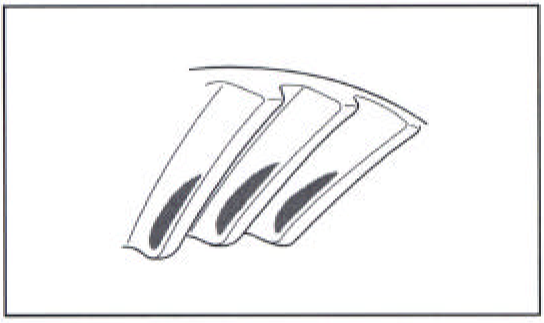
Adjust Pinion Position

NOTE: Before adjusting ring gear position in the following proce-dures, loosen thrust screw locknut and back off thrust screw. This procedure is necessary to provide adequate clearance and allow ring gear movement.

If the contact pattern shows incorrect tooth depth contact, change drive pinion position by altering the shim pack under the cage and cup assembly. Used gears should achieve proper contact with the same shims removed from the axle at disassembly.



If the pattern is too close to the root of the gear tooth, add pinion shims.

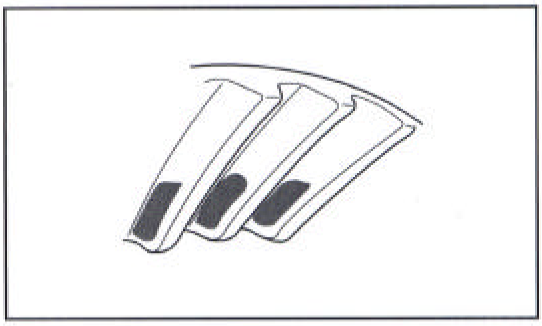


If the pattern is too close to the top land of the gear tooth, remove pinion shims.

NOTE: Check ring gear backlash after each shim change and adjust if necessary to maintain correct backlash (see backlash specs). Always recheck tooth contact pattern after making shim pack changes.

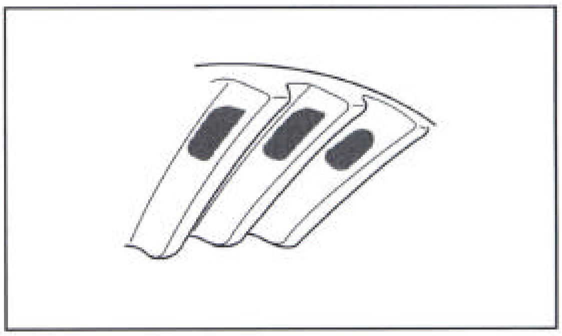
Adjust Backlash

If the contact pattern shows incorrect face width contact, change backlash and recheck the contact pattern.



With the pattern concentrated at the toe (too far down the tooth), **add backlash** by loosening the bearing adjuster on the teeth side of ring gear several notches. Loosen the opposite adjuster one notch.

Return to adjuster on teeth side of ring gear and tighten adjuster until it contacts the bearing cup. Continue tightening the same adjuster 2 or 3 notches. Recheck backlash.



If the pattern is concentrated at the heel (too far up the tooth), **remove backlash** by loosening the bearing adjuster on the teeth side of ring gear several notches. Tighten the opposite adjuster one notch.

Return to adjuster on teeth side of ring gear and tighten adjuster until it contacts the bearing cup. Continue tightening the same adjuster 2 or 3 notches. Recheck backlash.

When preload, backlash, and tooth contact are correct, align differential bearing adjusters with cotter pin holes (or locks), then tighten differential bearing cap screws to correct torque (see chart). Install cot-ter pins (or locks). On 13.44 axles, lockwire differential bearing cap screws.

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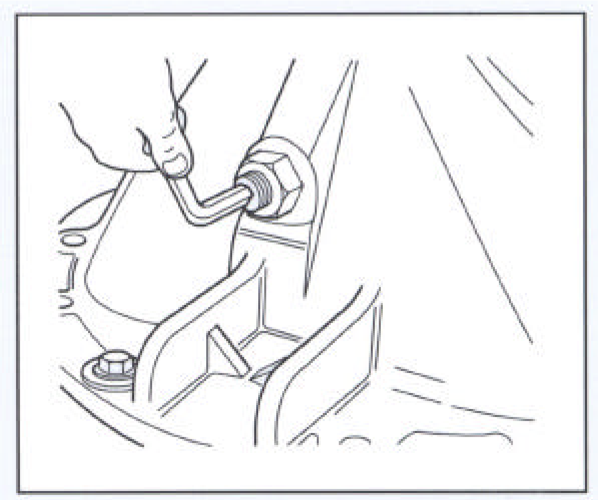
A. Fernández	03/02/03	R. Yoldi	03/02/03	C	613501	03622

Install & Adjust Ring Gear Thrust Screw (if so equipped)



1. Thread thrust screw into the carrier until firm contact with the back-face of the ring gear is made.

2. Loosen the thrust screw 1/4 turn to obtain the correct adjustment of 0.020" (0.50 mm) clearance between gear face and screw. Torque jam nut to correct specification (see torque chart, page 53).

TIP: Hold thrust screw stationary with a wrench while tightening nut.

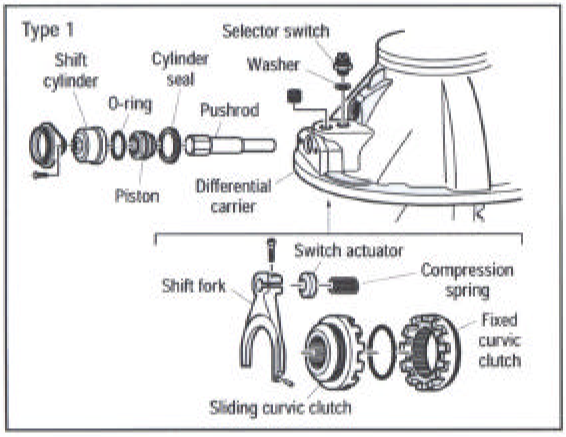
3. Recheck to assure minimum clearance during full rotation of ring gear.

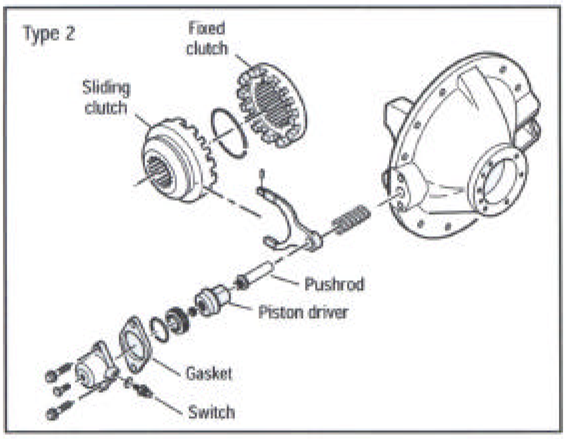
Wheel Differential Locking Axles

Comparison Information on Eaton Wheel Differential Locking Axles

This section covers Eaton “Wheel Differential Locking” axles. The basic concept of Eaton’s Wheel Differential Locking axles are the same, but the designs vary model to model. When servicing your Diff Lock axle, pay close attention to all NOTES, TIPS and WARNING signs that will assist you while you work on your axle. The Diff Lock axles listed below are grouped together by design type. In this section they will be referred to as Type 1 and Type 2.

NOTE: Information for Type 3 Diff Lock Axles are **not** covered in this manual.





Type 1 Style Diff Lock Axles Feature:

• A sliding curvic clutch

• A fixed curvic clutch

• The flange half Diff Case is externally splined

• Uses double spline or extended spline axle shaft (11" spline length) on flange half side of axle

• Uses standard spline axle shaft (4" spline length) on plain half side of axle

• The Diff Lock selector switch is located on the carrier/ cap assembly

Type 2 Style Diff Lock Axles Feature:

• A sliding curvic clutch

• A fixed curvic clutch

• The plain half Diff Case is externally splined

• Uses extended spline axle shaft (11" spline length) on plain half side of axle

• Uses standard spline axle shaft (4" spline length) on flange half side of axle

• The Diff Lock selector switch is located on the Diff Lock shift cylinder

Type 1	Type 2
08.18D 09.24D 10.24D 11.36D 13.44D	11.26D 11.28D

Towing of Axles Equipped with Wheel Differential Lock

Follow these listed procedures for vehicle towing when the drive axles are equipped with wheel differential lock. The purpose is to maintain proper alignment of the sliding clutch for axle shaft removal and installation. Removing the axle shafts prevents gear rotation with the drive wheels and possibly lubrication damage.

1. Engage the wheel diff lock until the indicator light is on (move vehicle to verify engagement).
2. Shift transmission into neutral.
3. With vehicle stationary, release the air pressure on the wheel diff. lock shift system and apply the parking brake.
4. Disconnect the air supply and fitting at the shift cylinder.
5. Install the shipping cap screw or 128274 (M12 X 1.5 screw), usually in Europe or 128642 (.250 X 18 NPSM screw), usually in US. Manually engage the wheel diff. lock until the indicator light is on and the main differential lock is completely engaged.
6. Remove the axle shafts.

NOTE: Axle shafts are location specific. Remember the double-splined or extended splined axle shafts are located on the "shift cylinder" side of the axle.

7. Install temporary cover on hub to prevent contamination entering and also to prevent the loss of lubricant.

Description

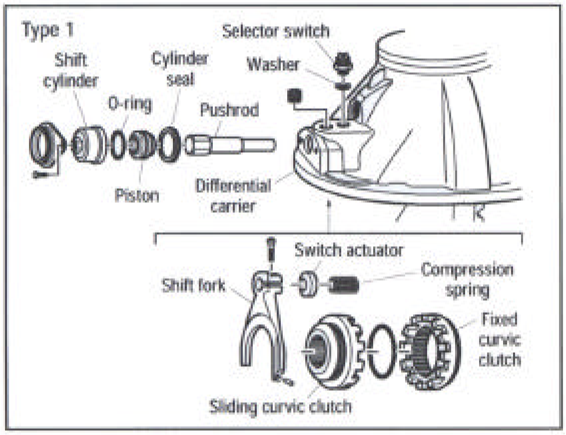
The Eaton Wheel Differential Lock is an optional feature for Eaton Axles. In operation, it positively locks the wheel differential to provide improved traction under adverse road conditions.

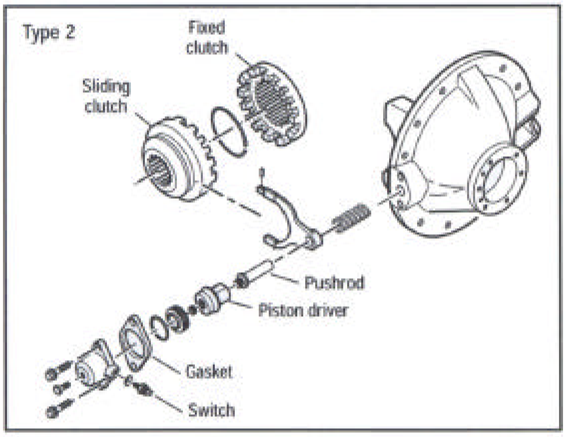
The differential lock is driver-controlled through an electric switch or air valve mounted in the cab. The locking mechanism is air-operated to engage a mechanical clutch and lock the wheel differential. It is spring-operated to disengage the lock and permit the wheel differential to function normally.

The Wheel Differential Lock consists of three major assemblies (see illustrations).

- A shift cylinder assembly which operates a shift fork and push rod assembly.
- A shift fork and push rod assembly which engages and disengages the differential lock curvic clutch assembly.
- A curvic clutch assembly which consists of a sliding clutch splined to a axle shaft and a fixed clutch which is splined to the differential case hub.

The Differential Lock also includes a selector switch (electric) which senses clutch engagement and sends an electrical signal to a cab-mounted indicator light (or an audible signal device).





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Differential Lock Engaged. Air pressure applied to the shift cylinder moves the piston, pushrod, shift fork and sliding curvic clutch as an assembly. The sliding curvic clutch engages the fixed curvic clutch.

The sliding clutch is splined to the axle shaft. The fixed clutch is
splined to the differential case hub. Engaging the two clutches locks the wheel differential thus preventing wheel differential action.

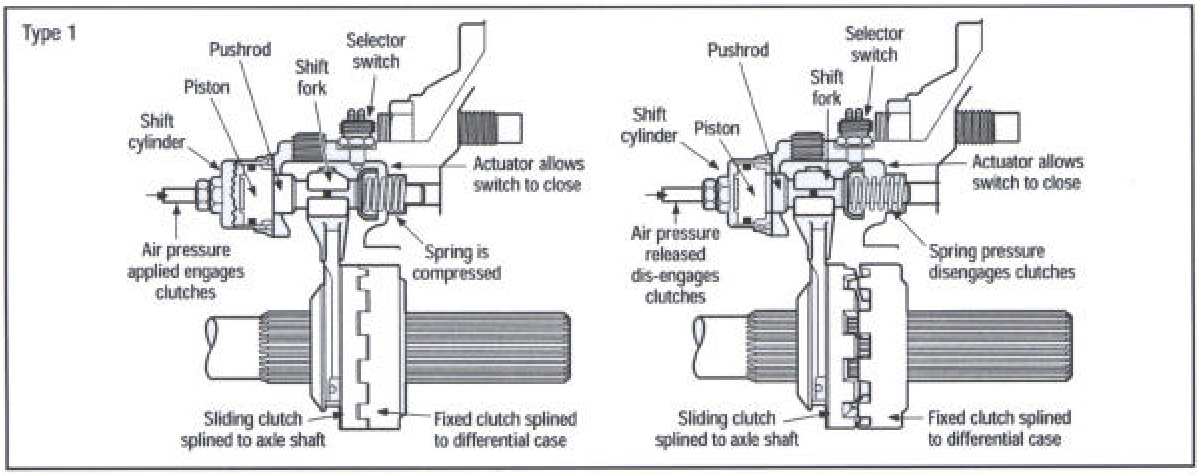
Differential Lock Disengaged. When air pressure at the shift cylinder is released, a compression spring (mounted on the pushrod) moves the pushrod, shift fork and sliding clutch as an assembly. The sliding clutch moves out of engagement with the fixed clutch. The wheel differential is unlocked and operates normally.

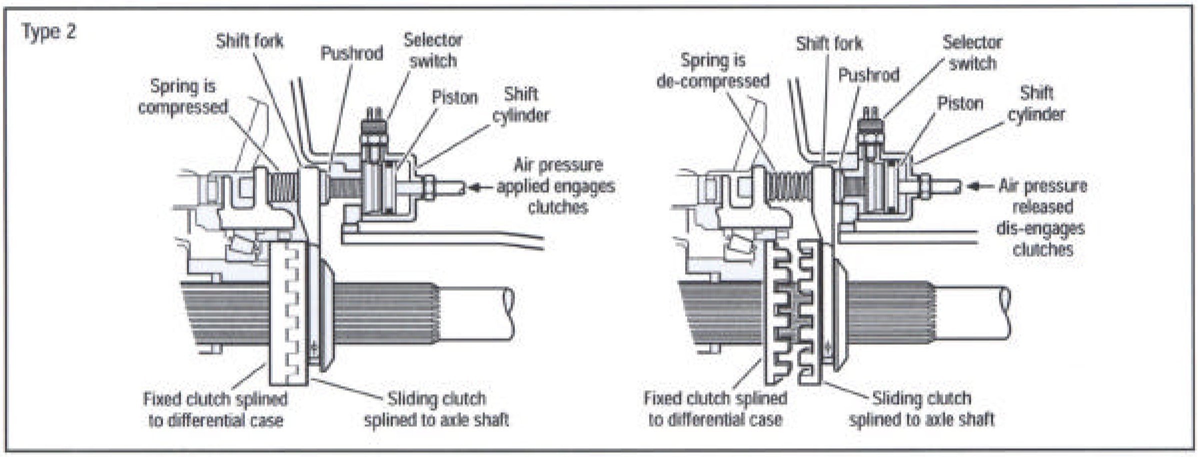
Differential Lock Engagement Indicator. Differential Lock engagement is detected by a switch (electric) mounted on the differential carrier (Type 1) or shift cylinder (Type 2).

NOTE: In Type 1 axles, the switch actuator is a separate part. In Type 2 axles, the switch actuator is part of the piston driver.

When the shift fork moves to engage the Differential Lock, the switch actuator moves away from the switch, allows the switch to close and sends an electrical signal to turn on a cab-mounted indicator light (or an audible signal).

When the shift fork moves to disengage the Differential Lock, the compression spring also moves the switch actuator to contact the switch. The switch is opened and turns off the cab-mounted indicator light (or the audible signal).





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Control Systems

Two types of systems may be used to control the Differential Lock operation.

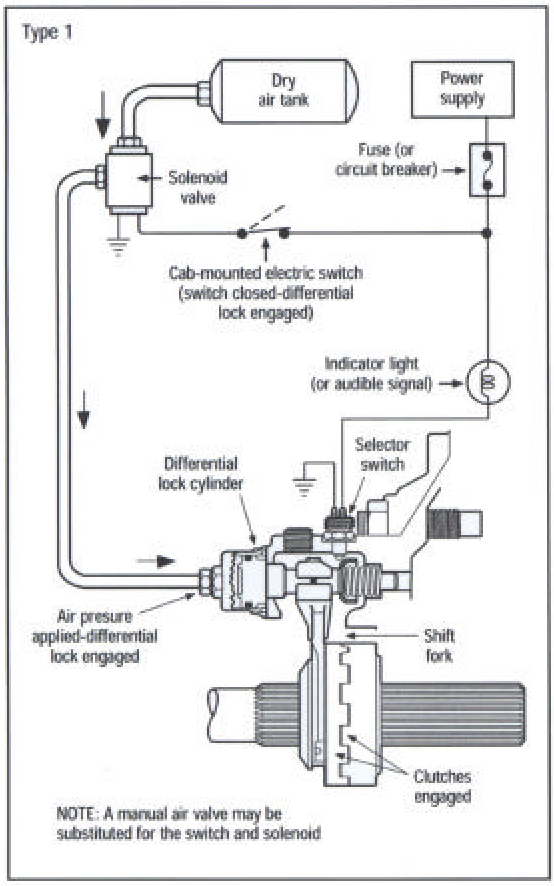
Transmission Low-Range Interlock Control System. The wheel differential is locked manually with the transmission in Low-Range. It is unlocked by the driver or unlocked when the transmission is shifted out of Low-Range. For full description of the system operation.

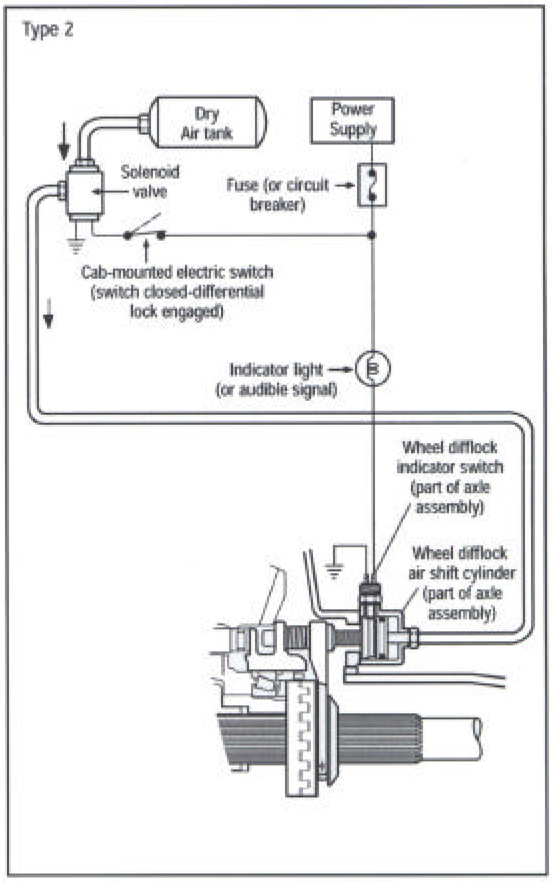
NOTE: The Interlock System is preferred for vehicles equipped with an air-shifted, Low-Range transmission. It is designed to insure the Differential Lock is not left engaged (and to prevent accidental engagement) when transmission is in high range.

Direct Driver-Controlled System. The driver manually locks and unlocks the wheel differential using a cab-mounted electric switch (or air valve). The following description assumes the system includes a cab-mounted electric switch and a solenoid valve as shown in the illustration. An air valve may be substituted for these components.

Operation is as follows:

1. With control switch in the "unlock" position, the wheel differential functions normally.
2. When the control switch is placed in the "lock" position, the air supply solenoid valve opens and air pressure activates the shift cylinder. The shift fork is moved to engage the curvic clutches, which lock the wheel differential.
3. When the control switch is placed in the "unlock" position, air pressure supply to the shift cylinder is shut off and air pressure is released from the cylinder. A compression spring moves the shift fork to disengage the curvic clutch and unlock the wheel differential.





Transmission Low-Range Interlock Control System
(Preferred System).

With this system, the Wheel Differential Lock can only be engaged when transmission is in Low-Range. Operation as follows:

1. When the transmission is in a range above low speed, the transmission Low-Range control valve is closed, shutting off air supply to the cab-mounted control valve and differential lock shift cylinder. The Differential Lock is disengaged and the wheel differential functions normally.

2. With the transmission in Low-Range, the transmission control valve opens and supplies pressure to the cab-mounted control valve.

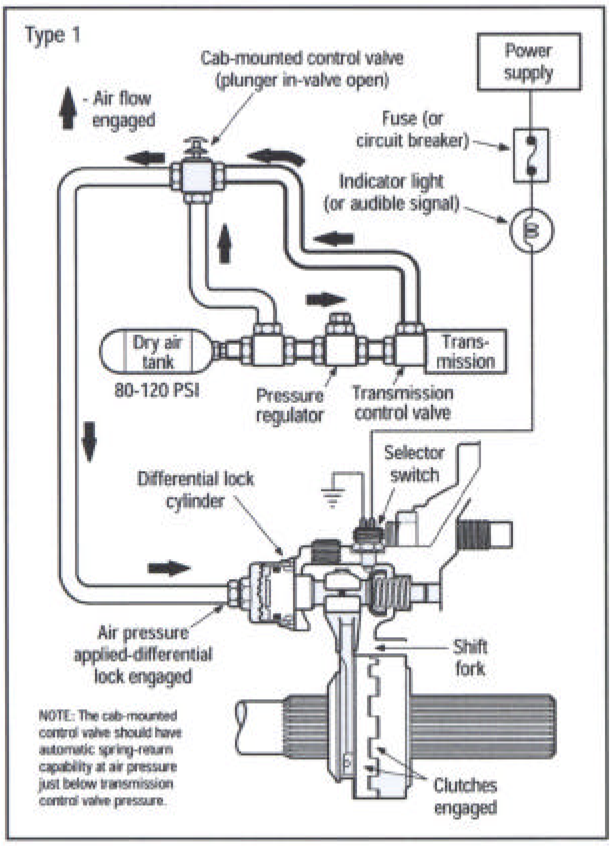
3. When the driver places the cab-mounted control valve in the "lock" position, air pressure from the transmission control valve and tank air pressure is supplied to the Differential Lock shift cylinder through the cab-mounted control valve. The shift fork is moved to engage the curvic clutches, which lock the wheel differential.

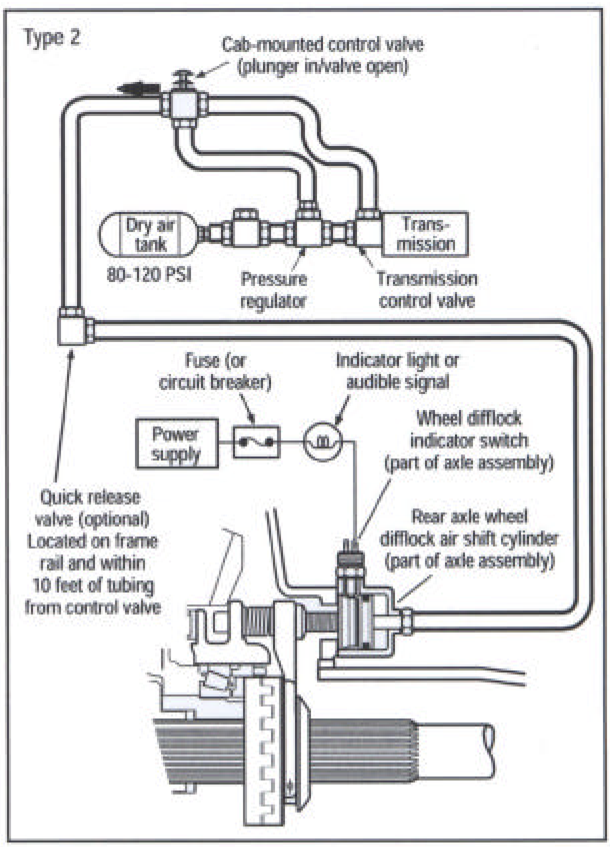
4. When the driver places the cab-mounted control valve in the "unlock" position, air supply from tank to the differential lock shift cylinder is shut-off. Air is released from the cylinder and a compression spring moves the shift fork to disengage the curvic clutches and unlock the wheel differential.

NOTE: If the transmission is shifted out of Low-Range, (with cab-mounted control valve in the "lock" position), the air pressure to the differential lock shift cylinder is shut off automatically. The transmission Low-Range control valve closes, shuts off air assist supply to the cab-mounted control valve, which releases the tank air pressure from the Differential Lock shift cylinder.

If the driver subsequently shifts back into Low-Range, the differential lock will not re-engage automatically.

NOTE: With either control system, torque on the wheel differential must be relieved to allow the differential to fully lock or unlock. Relieve this torque by depressing the clutch.





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Removal of Diff Lock Carrier Assembly from Axle Housing - Type 1 and 2 Axles

NOTE: The illustrations on this page are showing the Type 2 axles. The removal service procedures are the same for the Type 1 axles.

1. Block the vehicle.

2. Drain axle lubricant and disconnect driveline, following instructions for your specific axle.

3. Disconnect lead wires to the selector switch and air line at shift cylinder.

4. For removal of the differential carrier assembly, the Differential Lock must be engaged and held in the engaged position. This can be accomplished by one of two methods:

Air Pressure Engagement. Using and auxiliary air line, apply 80-120 psi air pressure to shift cylinder air port to engage clutch.

Manual Engagement. Install an M12x1.5 bolt, over 38mm (1.5") long, in the cylinder air port to manually engage the clutches. GM models require a .250 X 18NPSM bolt.

NOTE: Hand-tighten the bolt. Over-torquing may cause damage to the shift unit. To facilitate hand-tightening, coat bolt threads with axle lube.

NOTE: With either method, the axle shaft may have to be rotated to permit the clutch to become engaged.

5. Remove axle shaft stud nuts, lockwashers or taper dowels (if used).

TIP: If necessary, loosen dowels by holding a brass drift in the centre of the shaft head and striking drift a sharp blow with a hammer.

IMPORTANT: When removing axle shafts, identify left and right axle shaft location for reference during reassembly. Axle shafts are location specific.

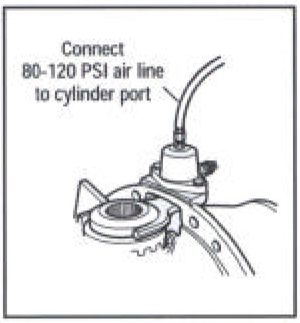
6. Remove axle shafts.

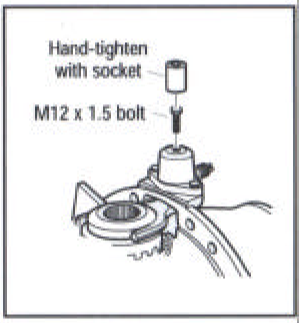
CAUTION: Do not strike the shaft head with a steel hammer. Do not use chisels or wedges to loosen shaft or dowels.

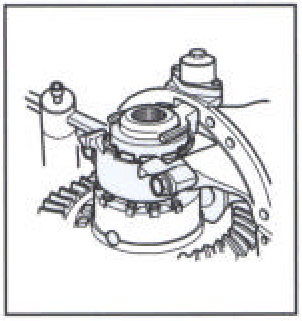
WARNING: Do not lie under carrier after fasteners are removed. Use transmission jack to support differential carrier assembly prior to loosening fasteners.

7. Remove carrier capscrews, nuts, and lockwashers.

8. Remove differential carrier assembly.







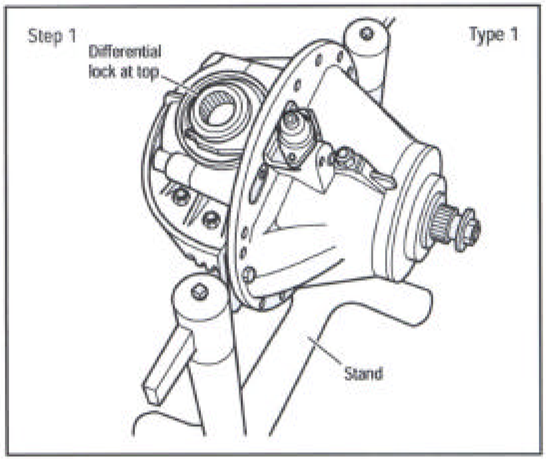
Differential Lock Shift Assembly Removal
- Type 1 Axles

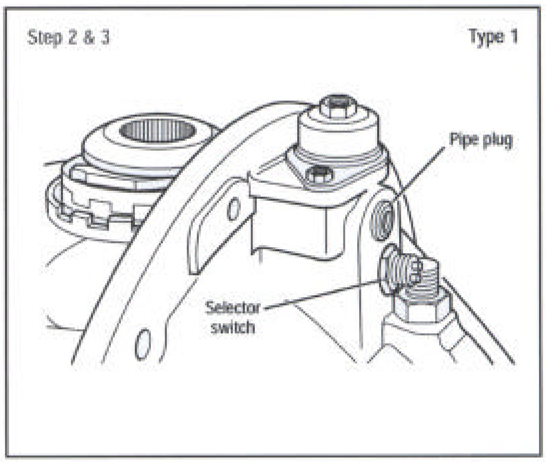
1. For ease of servicing, mount differential carrier in stand with differential lock facing up.

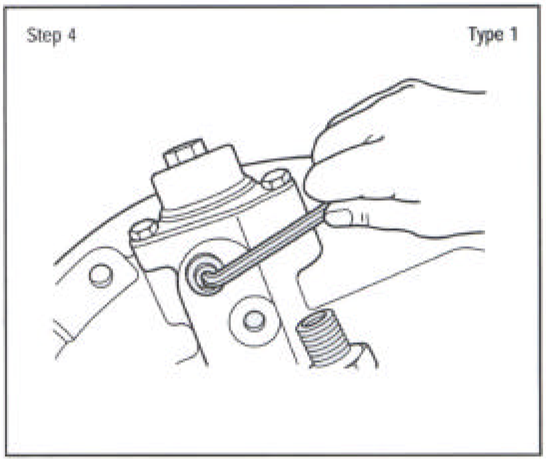
2. Remove pipe plug from differential carrier shift box.

3. Remove selector switch and plastic washer from carrier.

4. Working through the pipe plug opening, loosen shift fork cap screw, using a hex-socket wrench.







Differential Lock Assembly Removal - Type 1 Axles (continued)

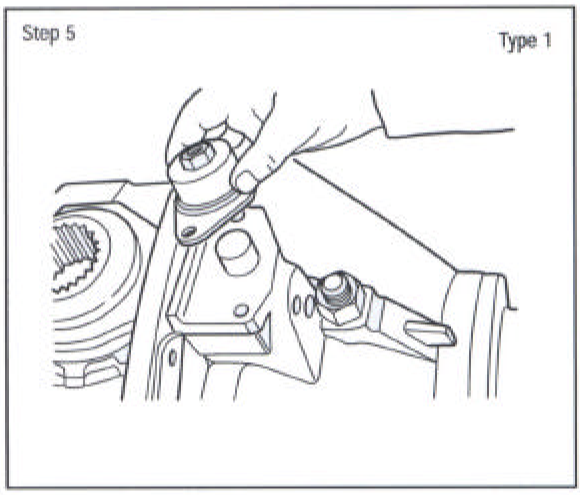
5. Remove cylinder mounting bracket screws, then lift shift cylinder, bracket, seal, piston and O-ring assembly off carrier and end of push rod.

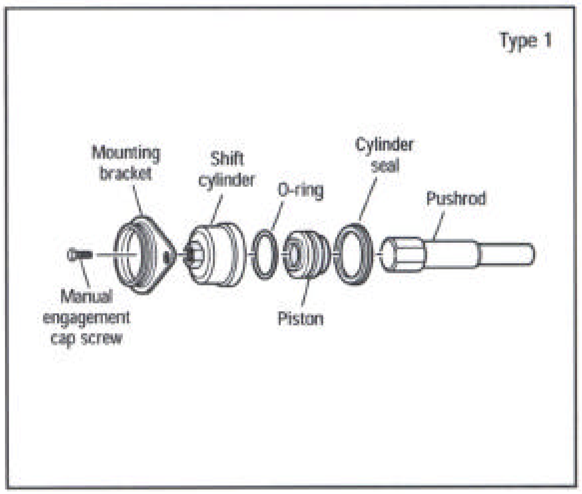
6. To disassemble shift cylinder for inspection, remove seal and slide mounting bracket off cylinder. The piston and O-ring assembly can be removed by inserting a pencil-shaped tool through the cylinder air port.

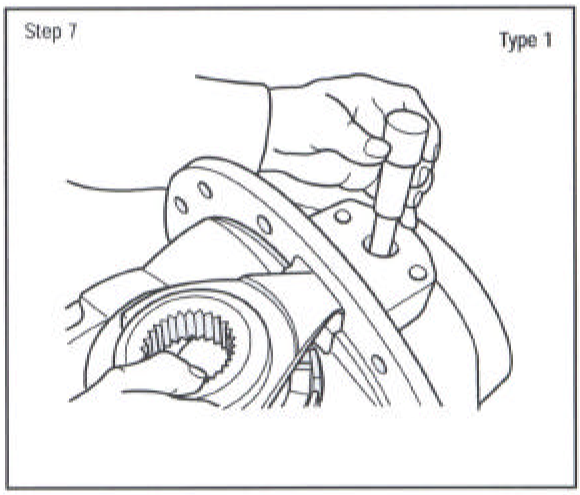
7. Grasp pushrod end and pull it out of the shift fork and carrier.

NOTE: When pushrod is disengaged from the shift fork, the fork and sliding curvic clutch assembly can be removed from carrier.

NOTE: Do not disassemble shift fork from the sliding curvic clutch unless parts replacement is necessary. To disassemble, use pin punch to remove spring pin from long leg of fork. The fork can now be disengaged from the clutch.







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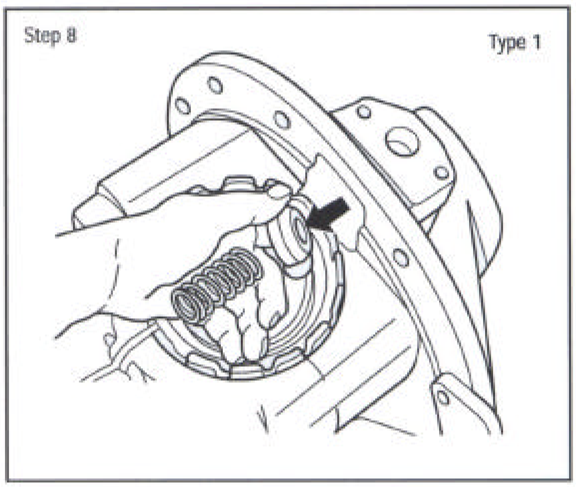
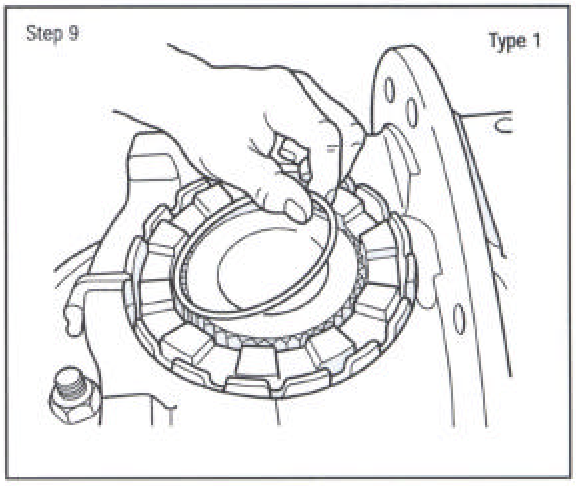
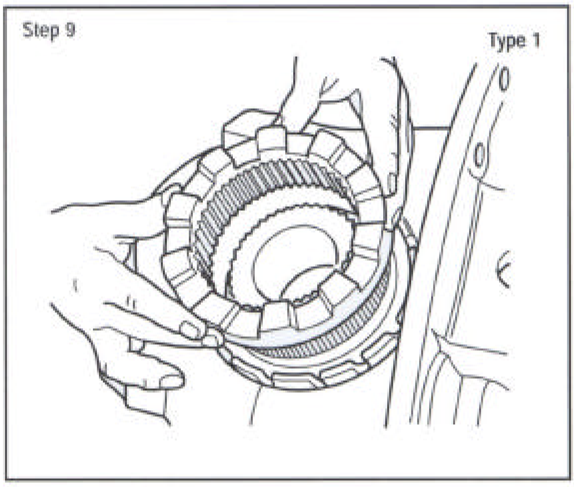
Differential Lock Assembly Removal - Type 1 Axles (continued)

8. With shift fork removed, the switch actuator and compression spring are accessible for removal from the shift box opening.

9. Remove snap ring, then lift fixed curvic clutch off differential case hub spline.







Install and Adjust Differential Lock - Type 1 Axles

NOTE: With differential carrier completely assembled and adjusted, install differential lock assembly for Type 1 axles as follows:

1. Install fixed curvic clutch on splined hub of flanged differential case, then install snap ring.

2. If shift fork and sliding curvic clutch are disassembled, engage fork with clutch hub and install spring pin in end of fork long leg to hold components together. See illustration for fork mounting position on clutch. Install clamp screw in fork and tighten finger-tight.

3. Place compression spring and switch actuator in shift box.

4. Position shift fork and clutch assembly on carrier, inserting fork head in shift box on top of actuator. Install pushrod, engaging fork head, switch actuator, compression spring and pilot hole in carrier.

NOTE: The shift cylinder is serviced only as an assembly. However, if the cylinder was disassembled and parts are serviceable, assemble as described in steps 5 thru 8.

5. Install new O-ring on piston.

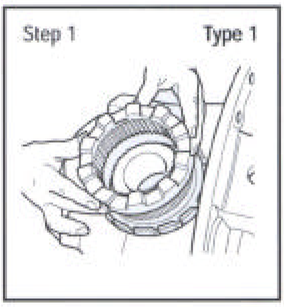
6. Lubricate piston and O-ring with silicone grease and install piston with small diameter hub toward closed end of cylinder.

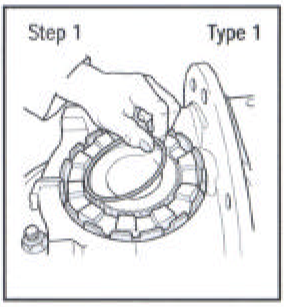
7. Install seal on cylinder, piloting seal shoulder inside cylinder.

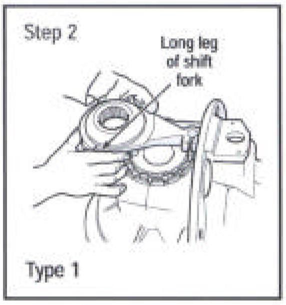
8. Install mounting bracket on cylinder.

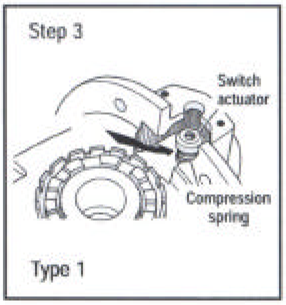
9. Place shift cylinder assembly on end of pushrod. Compress cylinder assembly by hand to keep pushrod piloted in carrier, and install mounting bracket cap screws. Torque to 28-35 lbs. -ft. (38-47 N.m).

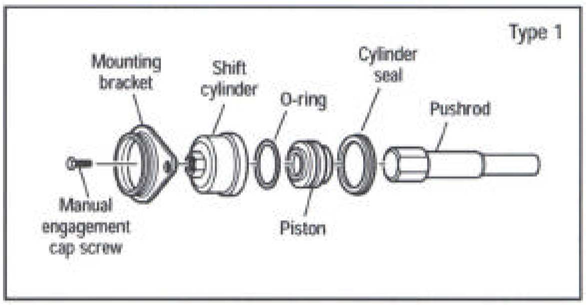
NOTE: At this stage of assembly, adjust shift fork position.

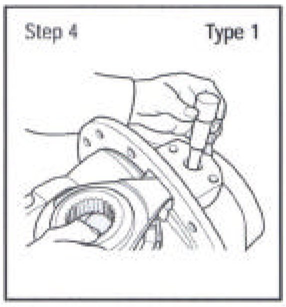


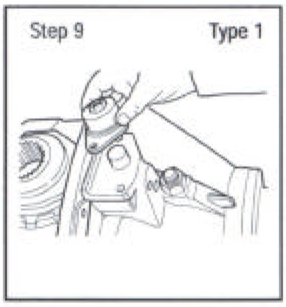












Shift Fork Adjustment - Type 1 Axles

1. With clutches disengaged, adjust position of shift fork on pushrod to set a clearance of 0.120" (3.05mm) between the clutch teeth.

2. Adjust as follows: Place two 0.120" (3.05mm) feeler gauges (one on each side of the clutches) between the tips of the clutch teeth. Slide shift fork on pushrod to set clutch clearance. Working through carrier pipe plug opening, tighten shift fork cap screw to 12-15 lbs.-ft. (16-20 N•m) torque.

3. Check differential lock clutch engagement by one of two methods:

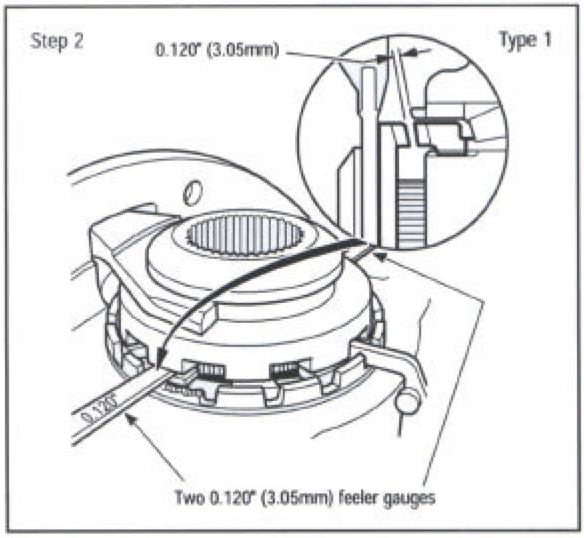
Air Pressure Engagement. Apply air pressure (80-120 psi) to shift cylinder port to engage clutches.

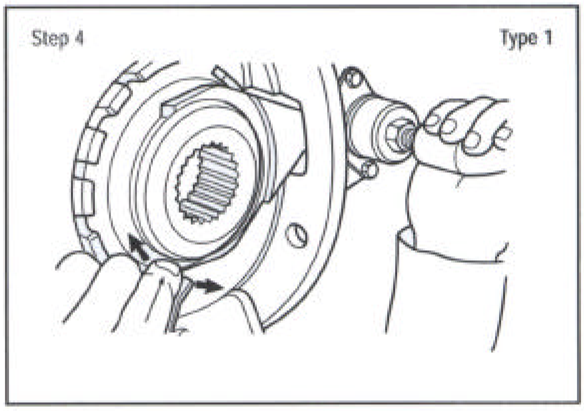
Manual Engagement. Install an M12x1.5 bolt, over 38mm (1.5") long, in the cylinder air port to manually engage clutches.

NOTE: Hand-tighten the bolt. Over-torquing may cause damage to the shift unit. To facilitate hand-tightening, lubricate bolt threads with axle lube.

4. Correct Fork Adjustment. Fork adjustment is correct when clutch curvic teeth are fully engaged with the fork free when moved by hand (see illustration). When air pressure is released or manual bolt is removed, the shift assembly should disengage freely.

5. Recheck the 0.120" (3.05mm) clutch teeth clearance with shift cylinder fully disengaged. If not correct, readjust fork position (see Steps 1 and 2).





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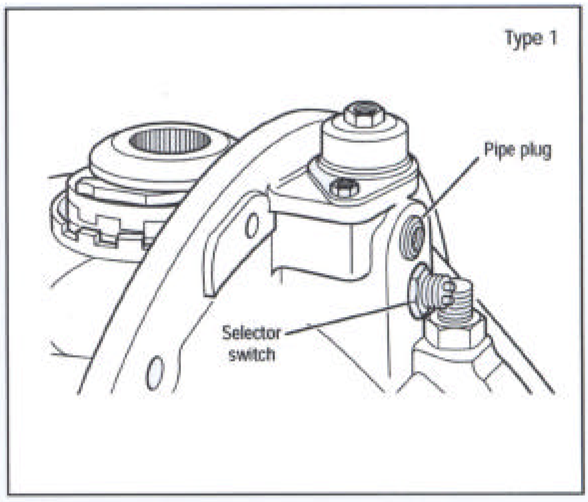
Continue Assembly of Differential Lock - Type 1 Axles

1. With differential lock correctly adjusted, coat pipe plug with sealant and install plug in carrier shift box.

2. Install selector switch and plastic washer in carrier shift box. Torque switch to 10-12 lbs.-ft. (14-16 N.m).

NOTE Effective July 1, 1996, Eaton will standardise on the selector switch and wiring harness. Types 1 and 2 switches with 12 mm threads will be discontinued. The selector switch and wiring harnesses are not interchangeable with each other.

3. Check Selector Switch Operation. Check switch electrically with an ohmmeter or continuity tester. Switch should close (show continuity) when clutches are engaged and should open (no continuity) when clutches are disengaged.



Install Differential Carrier Assembly in Axle Housing

1. The differential lock must be engaged and held in the engaged position to facilitate installation of carrier assembly in axle housing. This can be accomplished by one of two methods:

Air pressure Engagement. Using an auxiliary air line, apply 80-120 psi air pressure to shift cylinder air port to engage clutch.

Manual Engagement. Install an M12x1.5 bolt, over 38mm (1.5") long, in the cylinder air port to manually engage the clutches.

NOTE: Hand-tighten the bolt. Over-torquing may cause damage to the shift unit. To facilitate hand tightening, lubricate bolt threads with axle lube.

2. Complete the installation of the carrier following instructions of this manual.

IMPORTANT: When installing axle shafts, make sure the double-splined or extended splined axle shaft is installed in the shift unit side of differential carrier.

3. After carrier installation, disconnect auxiliary air line or remove bolt from cylinder air port. Connect vehicle air supply to shift cylinder and electrical lead wires to selector switch.

4. Check differential lock operation from driver's cab before releasing vehicle for service.

Diff Lock Shift Assembly Removal - Type 2 Axles

1. For ease of servicing, mount differential carrier in stand with differential lock facing up.

2. Remove actuator switch from cylinder cover.

3. Remove cylinder mounting screws, then lift shift cylinder, piston and O-ring assembly off carrier and end of push rod.

NOTE: Do not disassemble shift cylinder unless it is suspected of requiring service. The shift cylinder is serviced only as an assembly. For disassembly instructions, see next step.

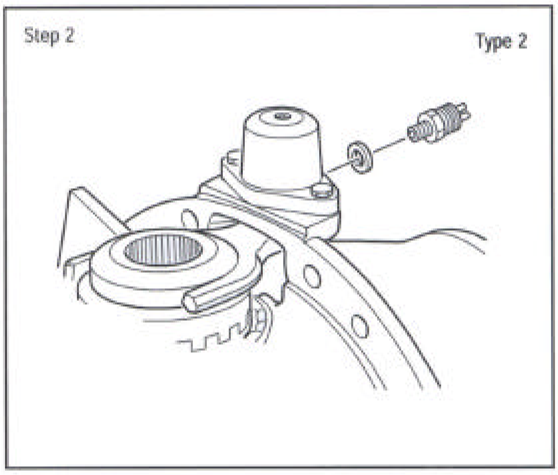
4. After removal of the shift cylinder cover, remove the pisto and O-ring assembly by inserting a pencil-size tool through the cylinder air port.

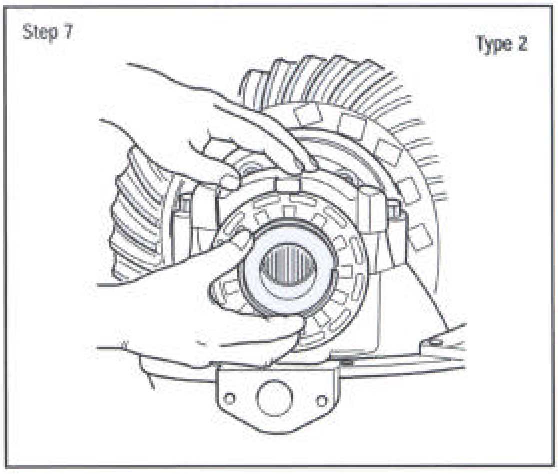
5. Grasp piston driver and pushrod assembly, and pull it away from the shift fork, spring and carrier.

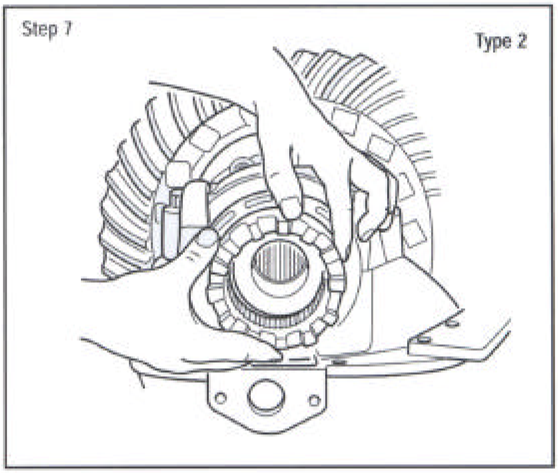
6. When the pushrod is removed from the shift fork, the fork and sliding curvic clutch assembly can be removed from carrier.

NOTE: Do not disassemble shift fork from the siding curvic clutch unless parts replacement is necessary. To disassemble, use pin punch to remove spring pin from long leg of fork. The fork can now be disengaged from the curvic clutch.

7. Remove the snap ring, then lift fixed curvic clutch off differential case hub spline. Further disassembly of carrier is the same for axles without differential lock.







Install and Adjust Differential Lock - Type 2 Axles

NOTE: With differential carrier completely assembled and adjusted, install differential lock as follows:

1. Install fixed curvic clutch on splined hub of flanged differential case, then install snap ring.

2. If shift fork and sliding curvic clutch are disassembled, engage fork with clutch hub, and install spring pin in the long leg of the fork. See illustration for fork mounting position on clutch.

3. Position compression spring, shift fork and clutch assembly in shift opening of the carrier. Align pilot hole of shift fork with pilot hole of carrier. Install pushrod, engaging shift fork head and compression spring in carrier.

NOTE: The shift cylinder is serviced only as an assembly. However, if the cylinder was disassembled and parts are serviceable, assemble as described in steps 4 and 5.

4. Install new O-ring on piston.

5. Lubricate piston and O-ring with silicone grease and install piston assembly in cylinder. Position piston with small diameter hub toward closed end of cylinder.

6. Screw piston driver on pushrod.

7. Tighten piston driver until shift fork clutch is approximately .030 of an inch from the fixed clutch.

8. Push down by hand on the piston driver, both clutches must be completely engaged.

9. Install set screw in piston driver and torque to 12-15 lbs-ft. (16-20 N•m).

10. Trial fit, install piston cover assembly. Hand tighten cap screws.

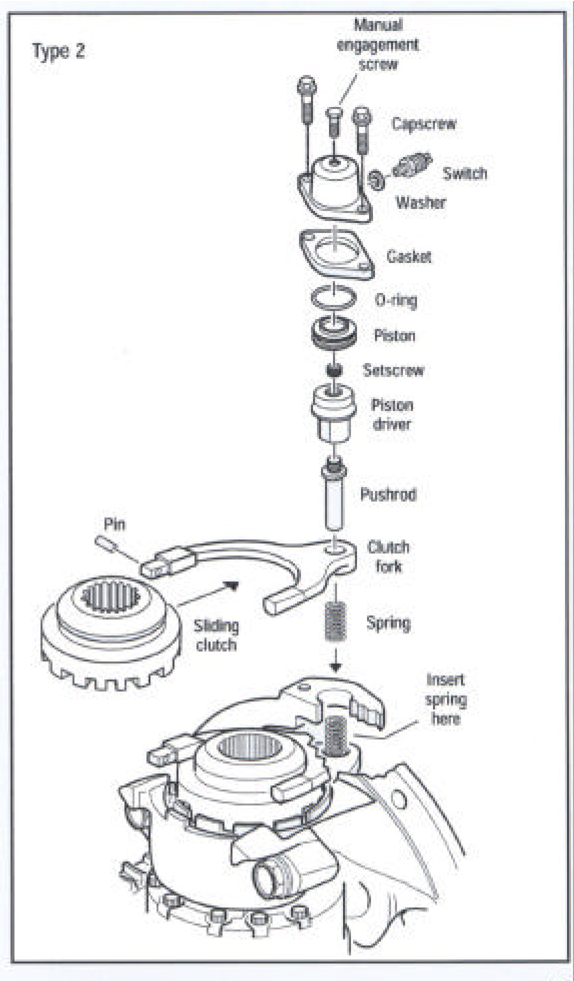
11. Screw in manual engagement screw by hand approximately 1 inch or until snug fit (light resistance pressure is felt). Both clutches must be completely engaged.

12. Remove manual engagement screw clutches until completely disengaged.

Repeat above procedure if clutches are not completely disengaged.

NOTE: Fork adjustment is correct when curvic clutch teeth are fully engaged with the fork free when moved by hand. When air pressure is released or the manual bolt is removed, the shift assembly should disengage freely.

13. When adjustment is complete, torque fasteners to 28-35 lbs.-ft. (38-47 N•m).



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A. Fernández	03/02/03	R. Yoldi	03/02/03	C	613501	03622

Install and Adjust Differential Lock - Type 2 Axles (continued)

Continue Assembly of Differential Lock

1. Install selector switch in cylinder cover. Torque switch to 10-12 lbs.-ft. (14-16 N•m).

NOTE: Effective July 1, 1996, Eaton will standardise on the selector switch and wiring harness. Types 1 and 2 switches with 12 mm threads will be discontinued. The selector switch and wiring harnesses are not interchangeable with each other

2. Check Selector Switch Operation. Check switch electrically with an ohmmeter or continuity tester. Switch should close (show continuity) when clutches are engaged and should open (no continuity) when clutches are disengaged.

Install Differential Carrier Assembly in Axle Housing

1. The differential lock must be engaged and held in the engaged position for installation of carrier assembly in axle housing. This can be accomplished by one of two methods:

Air Pressure Engagement. Using an auxiliary air line, apply 80-120 psi air pressure to shift cylinder air port to engage clutch.

Manual Engagement. Install an M12x1.5 bolt, over 38mm (1.5") long, in the cylinder air port to manually engage the clutches.

With clutches engaged, grasp fork long leg between thumb and forefinger. Move fork back and forth to check for free movement.

Some GM models use a .250 x 18 NPSM (128642), manual engagement bolt.

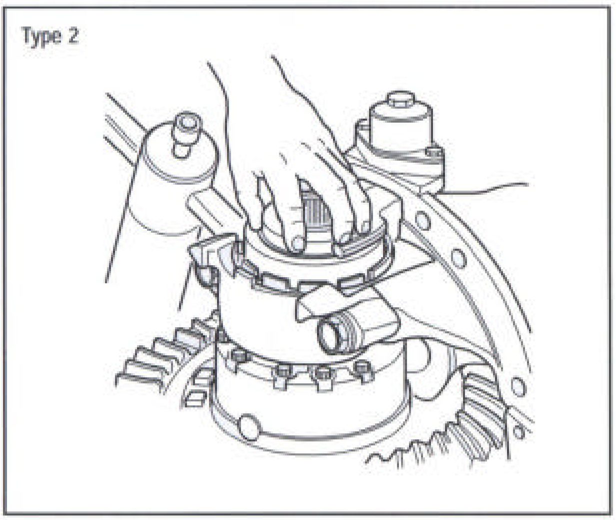
NOTE: Hand-tighten the bolt, over-torquing may cause damage to the shift unit. To facilitate hand tightening, lubricate bolt threads with axle lube.

2. Complete the installation of the carrier following instructions for your specific axle.

IMPORTANT: When installing axle shafts, make sure the long/splined shaft is installed in the shift unit side of differential carrier.

3. After carrier and axle shaft installation, disconnect auxiliary air line or remove bolt from cylinder air port. Connect vehicle air supply to shift cylinder and electrical lead wires to selector switch.

4. Check differential lock operation from driver's cab before releasing vehicle for service. 5. Verify that the driver caution label is in the vehicle cab and that it is easily visible by the driver.



Warning Label 128045

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Wheel Bearing Adjustment

1. Identify the wheel nut system being installed. Three systems are available:

• Three piece Dowel-type wheel nut system - Fig. 1

• Three piece Tang-type wheel nut system - Fig. 2

• Four piece Tang/Dowel-type wheel nut system - Fig. 3

WARNING: Do not mix spindle nuts and lock washers from different systems. Mixing spindle nuts and lock washers can cause wheel separation.

NOTE: The lock washer for a four piece tang/dowel-type wheel nut system is thinner than the lock washer for a three piece tang-type wheel nut system and is not designed to bear against the inner nut.

2. Inspect the spindle and nut threads for corrosion and clean thoroughly or replace as required.

NOTE: Proper assembly and adjustment is not possible if the spindle or nut threads are corroded.

• Inspect the tang-type washer (if used). Replace the washer if the tangs are broken, cracked, or damaged.

3. Install the hub and drum on the spindle with care to prevent damage or distortion to the wheel seal.

CAUTION: A wheel dolly is recommended during installation to make sure that the wheel seal is not damaged by the weight of the hub and drum. Never support the hub on the spindle with just the inner bearing and seal. This can damage the seal and cause premature failure.

• Completely fill the hub cavity between the inner and outer bearing races with the same lubricant used in the axle sump.

NOTE: Lubricate only with **clean** axle lubricant of the same type used in the axle sump. Do not pack the bearings with grease before installation. Grease will prevent the proper circulation of axle lubricant and may cause wheel seal failure.

4. Install the outer bearing on the spindle.

• Install the inner nut on the spindle.

• Tighten the inner nut to 200 lbs-ft. (271 N•m) while rotating the wheel hub.

CAUTION: Never use an impact wrench to adjust wheel bearings. A torque wrench is required to assure that the nuts are properly tightened.

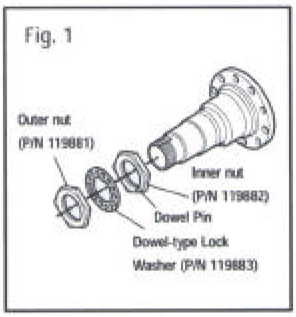
5. Back-off the inner nut one full turn. Rotate the wheel hub.

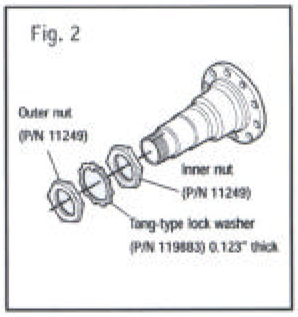
6. Re-tighten the inner nut to 100 lbs-ft. (135 N•m) while rotating the wheel hub.

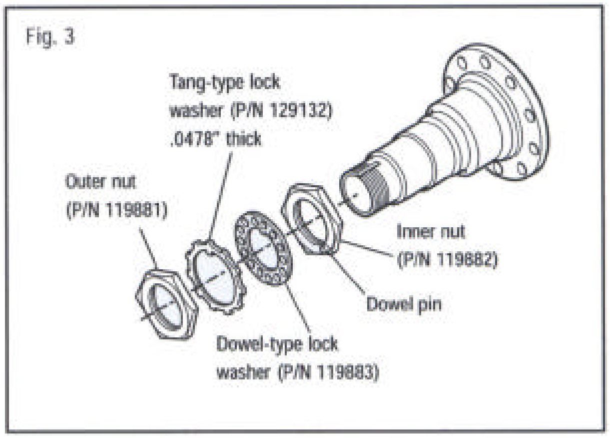
7. Back-off the inner nut **45°** to **60°** of a full turn.

NOTE: This adjustment procedure allows the wheel to rotate freely with 0.001" - 0.005" (0.025 mm - 0.127 mm) end play.

8. Install the correct lock washer for the wheel nut system being used.







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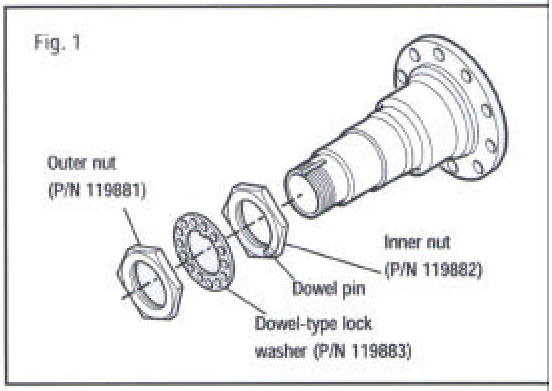
Three Piece Dowel-Type Lock Washer System (Fig. 1)



• Install the dowel-type lock washer on the spindle.

NOTE: If the dowel pin and washer are not aligned, remove washer, turn it over and reinstall. If required, **loosen** the inner nut just enough for alignment.

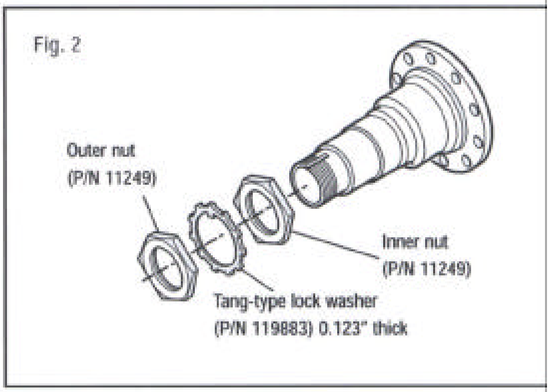
IMPORTANT: Never tighten the inner nut for alignment. This can preload the bearing and cause premature failure.

• Install the outer nut on the spindle and tighten to 350 lbs-ft. (475 N•m).

• Verify end-play (see End Play Verification Procedure).

• Go to Step 9.

Three Piece Tang-Type Lock Washer System (Fig. 2 and 4)



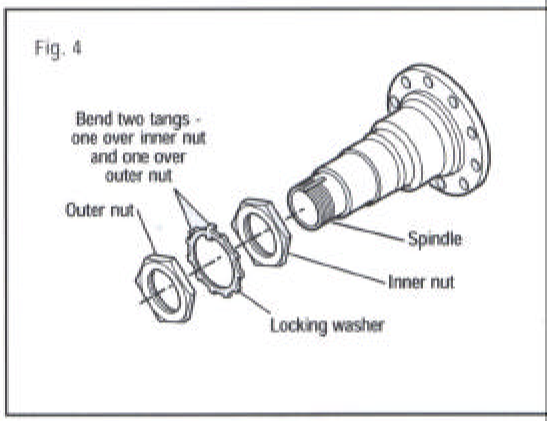
• Install the tang-type lock washer on the spindle.

IMPORTANT: Never tighten the inner nut for alignment. This can preload the bearing and cause premature failure.

• Install the outer nut on the spindle and tighten to 250 lbs-ft. (339 N•m).

• Verify end-play (see End Play Verification Procedure).

• After verifying end play, secure wheel nuts by bending one of the locking washer tangs over the outer wheel nut and another tang over the inner wheel nut as shown in Fig. 4.



• Go to Step 9.

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Four Piece Tang/Dowel-Type Lock Washer System (Fig. 3 and 5)

• First, install the dowel-type lock washer on the spindle.

NOTE: If the dowel pin and washer are not aligned, remove washer, turn it over and reinstall. If required, **loosen** the inner nut just enough for alignment.

IMPORTANT: Never tighten the inner nut for alignment. This can preload the bearing and cause premature failure.

• Install the Tang-type lock washer on the spindle.

• Install the outer nut on the spindle and tighten to 250 lbs-ft. (339 N•m).

• Verify end-play (see End Play Verification Procedure).

• After verifying end play, secure wheel nuts by bending two opposing (180° apart) tangs of the locking washer over the outer nut as shown in Fig. 5.

9. Install:

• New gasket at axle shaft flange

• Axle shaft

• Axle flange nuts and tighten to specified torque. See fastener torque specifications on Torque Chart.

10. Lubricate axle wheel ends (see Wheel End Lubrication Procedure).

Fig. 3

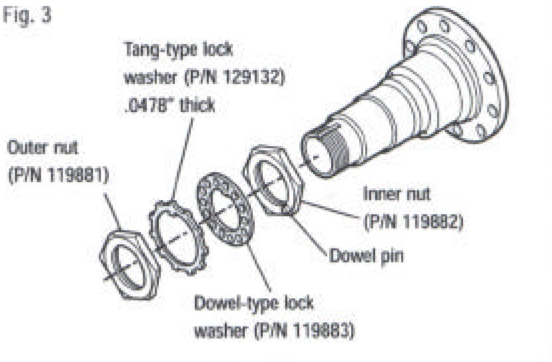
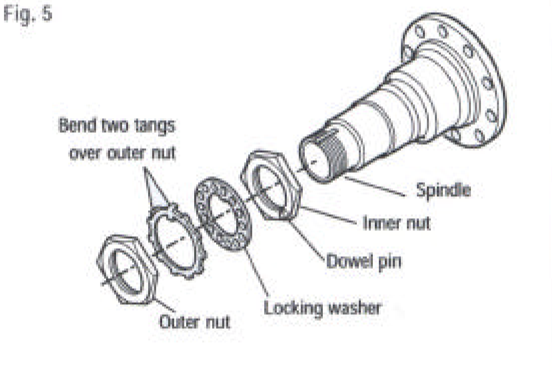


Fig. 5



End Play Verification Procedure

Verify that end-play meets specification using a dial indicator. An indication with 0.001" (0.03 mm) resolution is required. Wheel end play is the free movement of the tire and wheel assembly along the spindle axis.

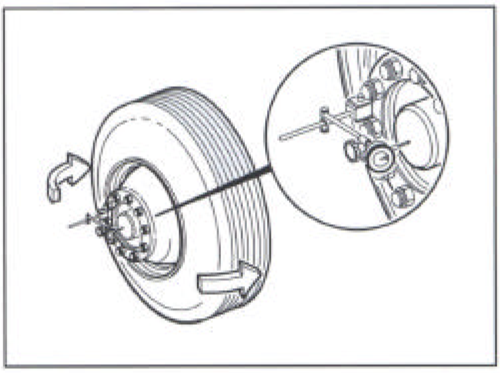
Correct end play is 0.001" - 0.005" (0.025 mm - 0.125 mm).

a. Attach a dial indicator with its magnetic base to the hub or brake drum (see illustrations).

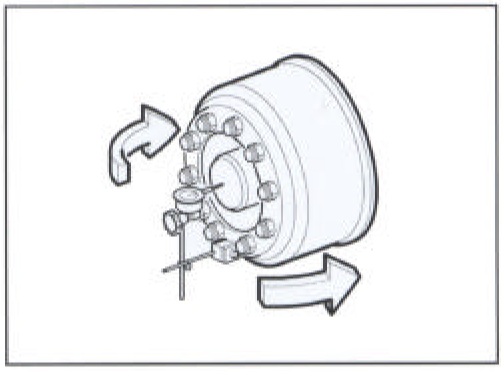
b. Adjust the dial indicator so that its plunger or pointer is against the end of the spindle with its line of action approximately parallel to the axis of the spindle.

c. Grasp the wheel assembly at the 3 o'clock and 9 o'clock positions. Push the wheel assembly in and out while oscillating it to seat the bearings. Read bearing end play as the total indicator movement.

CAUTION: If end play is not within specification, readjustment is required. End Play Adjustment with Tire and Wheel Assembly



End Play Adjustment with Tire and Wheel Assembly



End Play Adjustment with Wheel Hub

End Play Re-adjustment Procedure

Excessive End Play - If end play is greater than .005" (.127 mm), remove the outer nut and pull the lock washer away from the inner nut, but not off the spindle. Tighten the inner nut to the next alignment hole of the dowel-type washer (if used). Reassemble the washer, and torque the outer nut. Verify end play with the dial indicator.

Insufficient End Play - If end play is not present, remove the outer nut, and pull the lock washer away from the inner nut but not off the spindle. Loosen the inner nut to the next adjustment hole of the dowel-type washer (if used). Reassemble the washer and retorque the outer nut. Verify end play with a dial indicator.

Fine Tuning the End Play - If after performing the readjustment procedures end play is still not within the .001" - .005" (.025 mm - .127 mm) range, disassemble and inspect the components. If parts are found to be defective, replace the defective parts, reassemble and repeat wheel bearing adjustment procedure. Verify end play with a dial indicator.

Wheel End Seal

WARNING: Never work under a vehicle supported by only a jack. Always support vehicle with stands. Block the wheels and make sure the vehicle will not roll before releasing the brakes.

IMPORTANT: Wheel end seals can be easily damaged during handling. Leave the seal in its package until installation to prevent damage or contamination.

1. Remove:

• The outer bearing and wheel.

• The oil seal or grease retainer and discard.

• The inner bearing.

• The oil seal or grease retainer and discard.

• The inner bearing.

• The old wear sleeve (2-piece design only) with a ball peen hammer and discard.

CAUTION: Do not cut through the old wear sleeve. Damage to the housing may result.

2. Inspect:

• The spindle journal and hub bore for scratches or burrs. Recondition with an emery cloth as required.

NOTE: Deep gouges can be repaired by filling gouge with hardening gasket cement and smoothing with emery cloth.

3. Clean:

• The hub cavity and bearing bores before reassembly. Be sure to remove contaminants from all recesses and corners.

• The bearings thoroughly with solvent and examine for damage. Replace damaged or worn bearings.

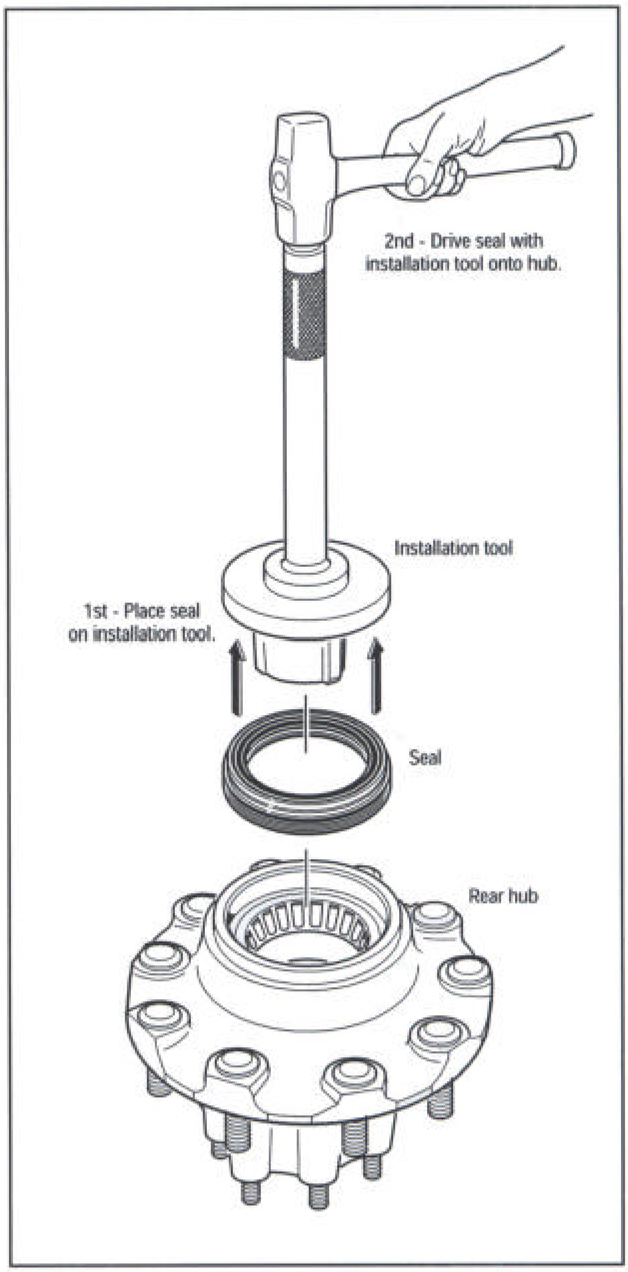
4. Before installation, lubricate with the same lubricant used in the axle sump:

5.

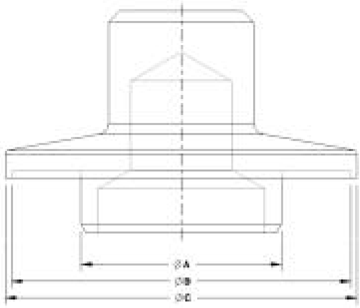
• The inner bearing.

• The wheel seal following the directions provided by the seal supplier.

IMPORTANT: Always use the seal installation tool specified by the seal manufacturer. Using an improper tool can distort or damage the seal and cause premature seal failure.



HUB UNIT & DISC BRAKE FITTING PROCEDURE



1. Fit Unitised Bearing into the hub by using a press, (necessary force is between 29 and 43 kN), until bearing faces hub inner diameter top. Keep pressing until reaching 80 kN of axial force. For assembly or dissasembly, press only the outer cone using the proper tool. (See picture).

CAUTION: Never press the inner cone, could cause damage on the bearing.

2. Fit the Rotor to the Hub (see below Chart).

Bolt	Max. Torque (Nm)	Min. Torque (Nm)
M12 x 1.5	125	110
M14 x 1.5	205	185
M16 x 1.5	305	275

Tool	Dia A	Dia B	Dia C
78 Bearing	77,9 - 77,7	122.5	128
82 Bearing	81,9 - 81,7	131,5	138
90 Bearing	89,9 - 89,7	152,5	158

NOTE: Allen bolts, DIN 912, 10.9, 6g, phosphated.

3. Fit "O-ring" on spindle.

4. Apply anticorrosive grease on the Spindle seat.

- Molycote TP 42 (Dow Corning)
- Altemp Q NB 50 (Klüber)
- Nomynol VI 1200 BF (Reiner/Fuchs)

5. Fit the Rotor & Hub Set on the Spindle.

6. Tighten the Spindle Nut (6g, phosphated) as follows:

NUT SIZE	MAX. TORQUE (Nm)	MIN. TORQUE (Nm)
M75 x 1.5	300	270
M86 x 2.0	400	360

7. Spin the Rotor & Hub set 10 rev.

8. Turn Spindle nut as per below Chart.

NUT SIZE	DEGREES (^{O})
M75 x 1.5	155±8
M86 x 2.0	212±10

9. Check that final Spindle Nut Torque value is between ± 5% of final torque shown in Cart below.

NUT SIZE	FINAL TORQUE (Nm)	AXIAL FORCE (kN)
M75 x 1.5	860 - 950	70 - 80
M86 x 2.0	1330 – 1470	95 - 105

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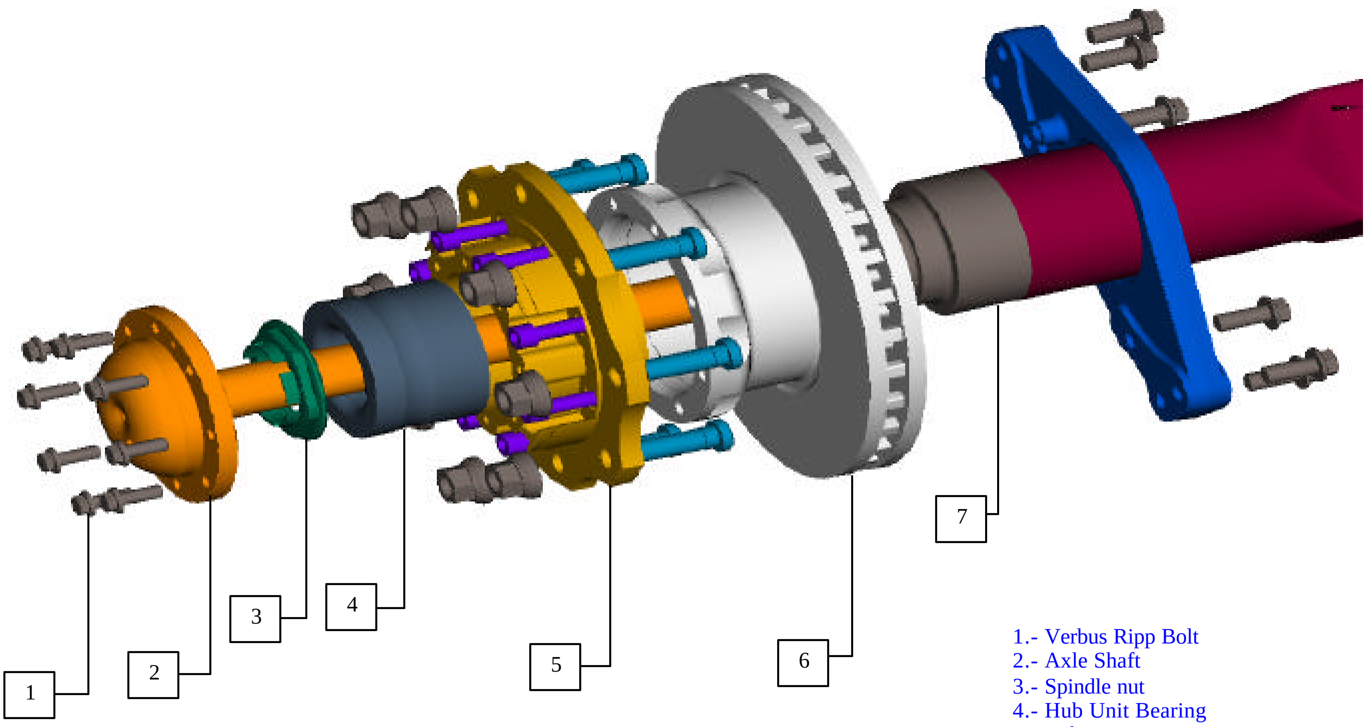
10. Apply loctite 518 between the axle shafts and the Hubs. Fit the axle shafts, (see Torque Chart below)

BOLT	MAX. TORQUE (Nm)	MIN. TORQUE (Nm)
M12	155	140
M16	390	350

NOTE: Verbus Ripp, 10.9, 6g, phosphated.

11. Fit the Brake Caliper to the Axle, (see Torque Chart below)

BOLT	MAX. TORQUE (Nm)	MIN. TORQUE (Nm)
M14 x 1.5	220	200
M16 x 1.5	330	300
M18 x 1.5	475	430

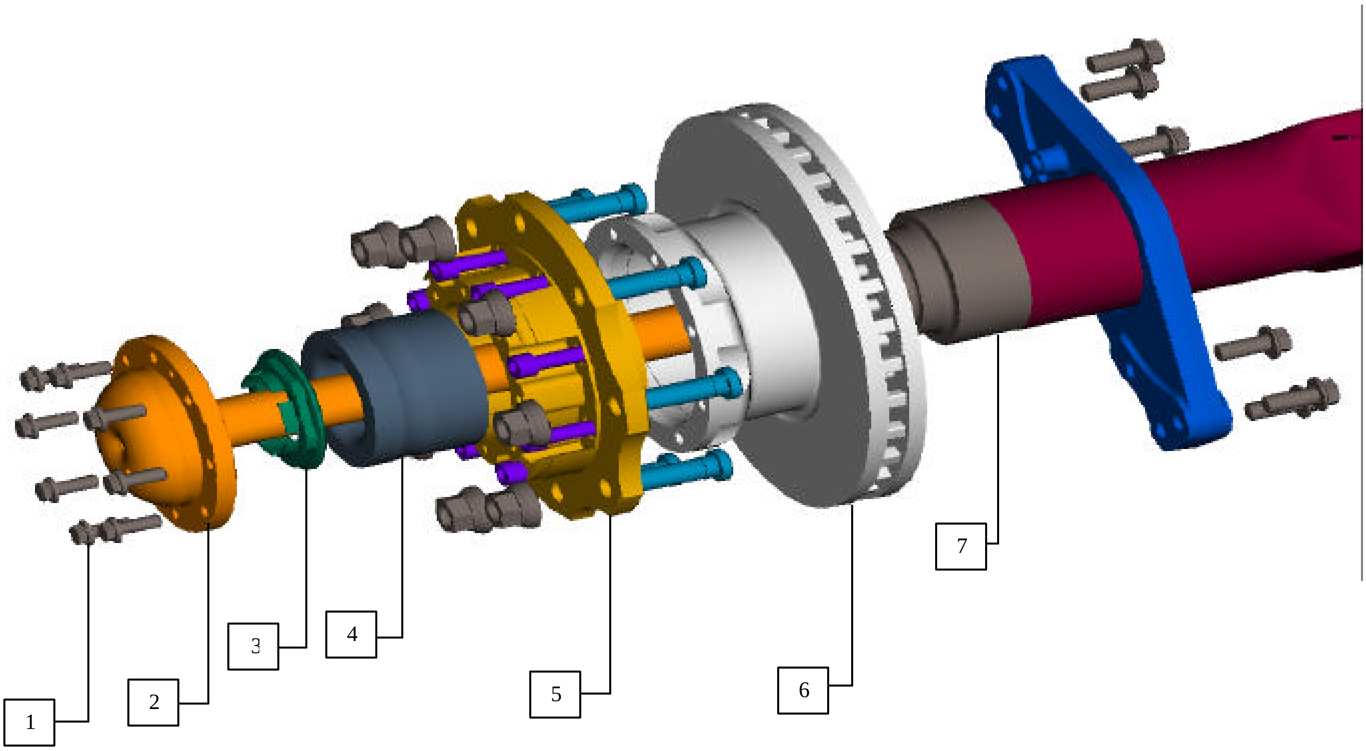


1.- Verbus Ripp Bolt
2.- Axle Shaft
3.- Spindle nut
4.- Hub Unit Bearing
5.- Hub
6.- Rotor
7.- Spindle

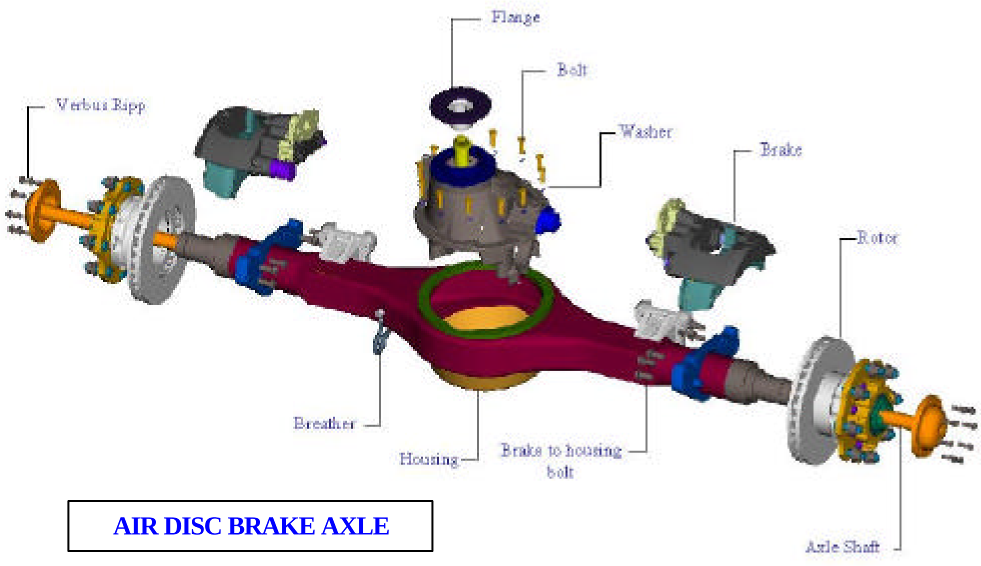
SERVICE MANUAL SINGLE AXLE

HUB UNIT & DISC BRAKE REMOVAL PROCEDURE

1. Remove brake caliper by loosening Caliper to Brake Flange Bolts.
2. Loosen axle sahft bolts and remove axle shafts.
3. Loosen Spindle Nut and remove Hub & Rotor Set.
4. Disassembly Rotor and Hub by loosening Rotor to Hub Bolts.
5. Remove Unitised Bearing from Hub by usin a press.

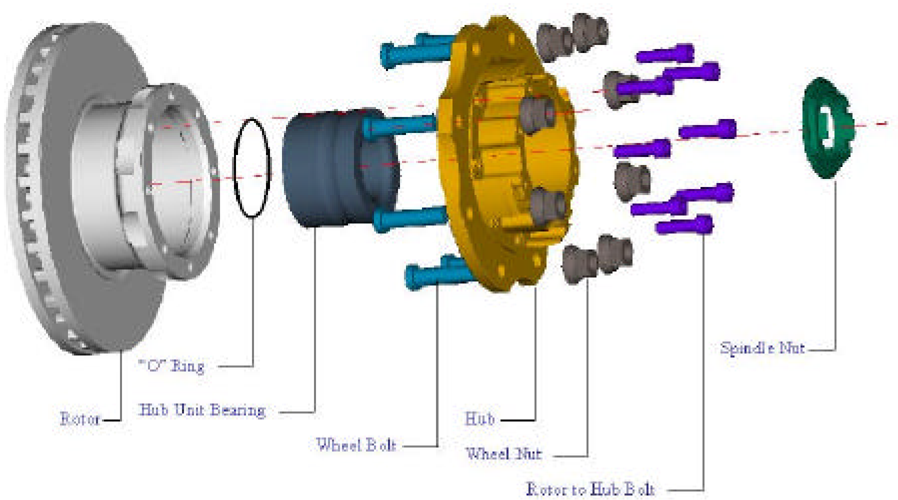


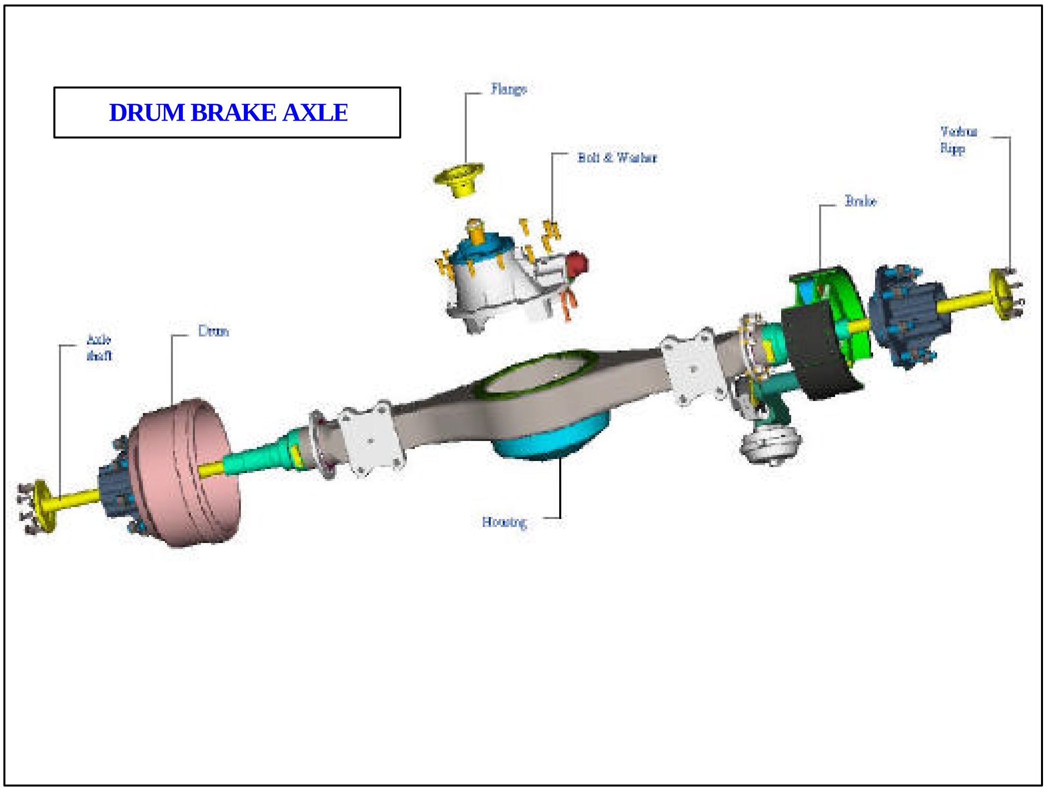
1.- Verbus Ripp Bolt
2.- Axle Shaft
3.- Spindle nut
4.- Hub Unit Bearing
5.- Hub
6.- Rotor
7.- Spindle

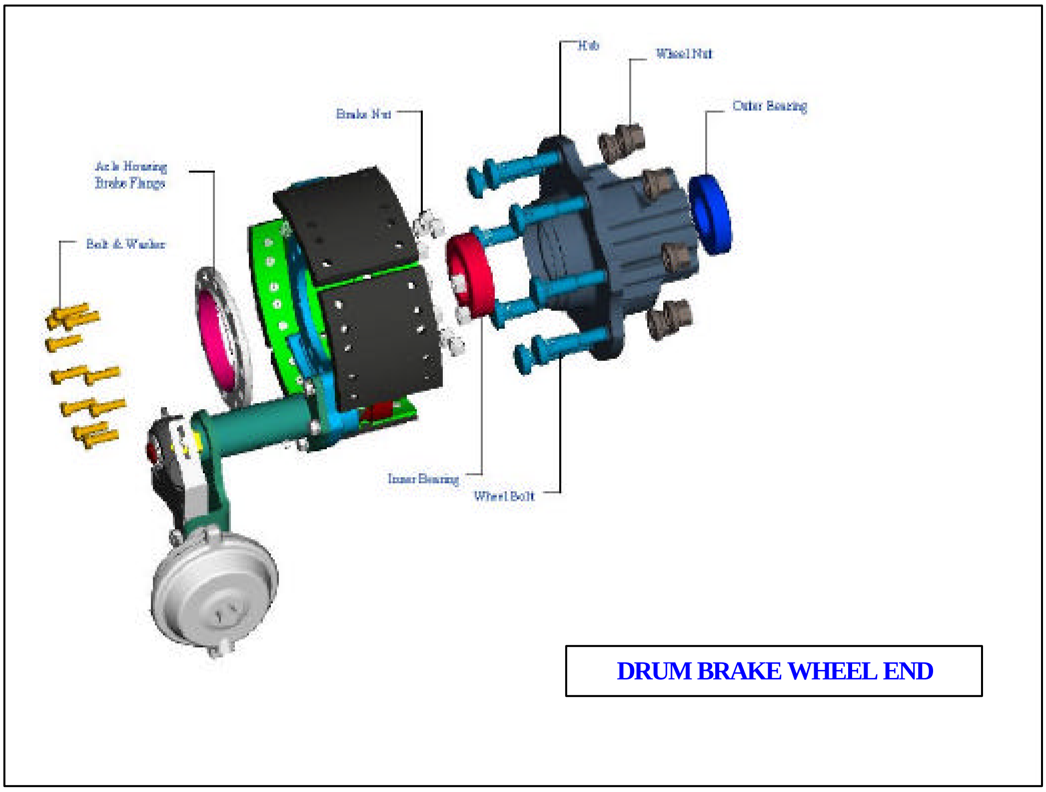


AIR DISC BRAKE AXLE

DISC BRAKE WHEEL END







TORQUE CHART

Last Modification	Date	Approved by	Date	Level	Reference	Eng. Change
A. Fernández	03/02/03	R. Yoldi	03/02/03	C	613501	03622

Fastener Torque Specifications					
Fastener	**Axle Model**	**Class**	**Size**	**Lbs·ft**	**N·m**
Diferentital Case Capscrew	08.18	10.9	M12x1.75	100-110	136-149
	09.24 / 10.24	10.9	M12x1.75	100-110	136-149
	11.26 / 11.28	10.9	M14x2.0	114-140	155-190
	11.36	10.9	M16x2.0	177-218	240-296
	13.44	10.9	M14x1.5	214-244	290-330
Ring Gear Nut	08.18	12	M14x1.5	170-190	230-258
	09.24 / 10.24	12	M16x1.5	260-290	352-393
	11.26 / 11.28	12	M16x1.5	215-255	292-346
	11.36	12	M18x1.5	325-395	441-596
	13.44	12.9	M18x1.5	441-536	620-680
Pinion Bearing Cage Capscrew	08.18	10.9	M14x2.0	114-140	155-190
	09.24 / 10.24	10.9	M14x2.0	114-140	155-190
	11.26 / 11.28	10.9	M16x2.0	175-220	237-298
	11.36	10.9	M16x2.0	177-218	240-296
	13.44	100	M16x1.5	258-288	350-390
Bearing Cap Capscrew	08.18	12.9	M16x2.0	177-218	240-296
	09.24 / 10.24	12.9	M20x2.5	350-428	475-580
	11.26 / 11.28	12.9	M20x2.5	350-428	475-580
	11.36	12.9	M20x2.5	350-428	475-580
	13.44	12.9	M20x2.0	369-413	500-560
Carrier to housing Capscrew	08.18	12.9	M12x1.75	85-105	115-142
	09.24 / 10.24	10.9	M12x1.75	85-105	115-142
	11.26 / 11.28	12.9	M16x1.5	200-245	271-332
	11.36	12.9	M16x2.0	200-245	271-332
	13.44	100	M16x1.5	258-288	350-390
Pinion Nut	08.18	-	M30x1.5	376-461	510-625
	09.24 / 10.24	-	M30x1.5	376-461	510-625
	11.26 / 11.28	-	M36x1.5	542-664	735-900
	11.36	-	M42x1.5	840-1020	1139-1383
	13.44	-	M55x1.5	840-1020	1139-1383
Brake Drum Retaining Screw	08.18	8.8	M10 x 1.5	35 - 45	48 - 61
	09.24 / 10.24	8.8	M10 x 1.5	35 - 45	48 - 61
	11.26 / 11.28	8.8	M10 x 1.5	35 - 45	48 - 61
	11.36	8.8	M10 x 1.5	35 - 45	48 - 61
	13.44	8.8	M10 x 1.5	35 - 45	48 - 61
Brake to Axle Nut (Drum Brake)	08.18	12	M16 x 1.5	175 - 200	237 - 271
	09.24 / 10.24	12	M16 x 1.5	175 - 200	237 - 271
	11.26 / 11.28	12	M16 x 1.5	175 - 200	237 - 271
	11.36	12	M16 x 1.5	175 - 200	237 - 271
	13.44	12	M16 x 1.5	175 - 200	237 - 271
Oil drain plug	08.18	-	¾" - 14	40 - 60	54 - 81
	09.24 / 10.24	-	¾" - 14	40 - 60	54 - 81
	11.26 / 11.28	-	¾" - 14	40 - 60	54 - 81
	11.36	-	¾" - 14	40 - 60	54 - 81
	13.44	-	¾" - 14	40 - 60	54 - 81
Magnetic plug (Filler)	08.18	-	1" – 11 1/2	40 - 60	54 - 81
	09.24 / 10.24	-	1" – 11 1/2	40 - 60	54 - 81
	11.26 / 11.28	-	1" – 11 1/2	40 - 60	54 - 81
	11.36	-	1" – 11 1/2	40 - 60	54 - 81
	13.44	-	1" – 11 1/2	40 - 60	54 - 81

SERVICE BULLETINS

Service Bulletins are issued to supplement or supersede information in the Van Hool manuals. Note below number, date and subject of Bulletins pertaining to this chapter. File Bulletins separately by number for future reference.

Number	Date	Subject

CHAPTER 5

BRAKES

PAGE

GENERAL

"D-ELSA" FRONT WHEEL BRAKES - MECHANICAL SYSTEM

"D-ELSA" FRONT WHEEL BRAKES - AIR SYSTEM

"D-ELSA" DRIVE WHEEL BRAKES - MECHANICAL SYSTEM

"D-ELSA" DRIVE WHEEL BRAKES - AIR SYSTEM

MAIN05AH

"D-ELSA" TAG WHEEL BRAKES - MECHANICAL SYSTEM

"D-ELSA" TAG WHEEL BRAKES - AIR SYSTEM

JAKE BRAKE

ABS AND ASR

GENERAL

NON-ASBESTOS WARNING

The brake linings used on your vehicle 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. Medical experts do not agree about the potential long-term risks from working with and inhaling non-asbestos fibers. Therefore, we recommend that workers use caution to avoid creating and breathing dust when working on brakes that contain non-asbestos fibers.

The following procedures for servicing brakes are recommended to reduce exposure to brake dust.

Abbreviations used further on:

- **OSHA**: Occupational Safety and Health Administration
- **NIOSH**: National Institute of Occupational Safety and health
- **MSHA**: Mine Safety and Health Administration
- **HEPA**: Health and Environmental Protection Agency
- **EPA**: Environmental Protection Agency

RECOMMENDED WORK PRACTICES

1. **Separate work area**. Whenever possible, work on brakes in a separate area away from other operations to reduce risks to unprotected persons.
2. **Respiratory protection**. Wear a respirator approved by NIOSH or MSHA at all times when servicing brakes, beginning with the removal of the wheels.
3. **Procedures for servicing brakes**.

   a. Never use compressed air or dry brushing to clean brake parts or assemblies. OSHA recommends that you use a negative pressure enclosure to enclose the brake. The enclosure should be equipped with a HEPA vacuum and worker arm sleeves. But, if such equipment is not available, carefully clean parts and assemblies in the open air.

   b. 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 parts. After using the vacuum, remove any remaining dust with a rag soaked in water and wrung until nearly dry.
4. **Cleaning work areas**. Clean work areas with a vacuum equipped with a HEPA filter or by wet wiping. NEVER use compressed air or dry sweeping to clean work areas. When you empty vacuum cleaners and handle used rags, wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA. When you replace a HEPA filter, wet the filter with a fine mist of water and dispose of the used filter with care.

US0500AD

5. **Worker clean-up**. After servicing brakes, wash your hands before you eat, drink or smoke. Shower after work. Do not wear work clothes home. Use a vacuum equipped with a HEPA filter to vacuum work clothes after they are worn. Launder them separately. Do not shake or use compressed air to remove dust from work clothes.

6. **Waste disposal**. Dispose of discarded linings, used rags, cloths and HEPA filters with care, such as in sealed plastic bags. Consult applicable EPA, state and local regulations on waste disposal.

REGULATORY GUIDANCE

References to OSHA, NIOSH, MSHA, and EPA, which are regulatory agencies in the United States, are made to provide further guidance to employers and workers employed within the United States. Employers and workers employed outside of the United States should consult the regulations that apply to them for further guidance.

US0500AD

BRAKE HOSES

INSPECTION

Maintenance of brake hoses is an important step to ensure safe operation of the vehicle.

Check brake hoses daily as part of the pre-starting checks. Examine brake hoses 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 hazardous areas. Since all machinery vibrates and moves to a certain extent, clamps and ties can loosen and wear with age. To ensure continued proper support, inspect fasteners frequently and tighten or replace them as necessary.

Investigate leaks immediately to determine if fittings have loosened or cracked and also if hoses have ruptured or worn through. Take corrective action immediately.

SERVICE LIFE

A brake hose has a limited service life, determined by the temperature and pressure of the air within it, time in service, mounting, ambient temperatures, amount of flexing, and the vibration it is subject to. The service life of a brake hose may also be reduced by exposure to road salt.

Van Hool recommends that all brake hoses be thoroughly inspected at least every 24,000 miles and/or annualy. Look for cover damage or indications of damaged, twisted, worn crimped, brittle, cracked or leaking lines. Hoses having the outer cover worn through should be considered unfit for service. Van Hool further recommends that all brake hoses be replaced after a maximum of five years service. Use only brake hoses mentioned in the Van Hool Spare Parts manual.

US0500AD

AIR BRAKE SYSTEM FUNCTIONAL CHECK

These tests are designed to identify the cause(s) of a sluggish performance and/ or leaks in the system.
The tests give you a general idea of the system condition.

PRELIMINARY

1. Park vehicle above an inspection pit and chock the wheels.

2. Prior to performing any test, check condition of all air lines. Check for kinks or dents, and hoses for signs of wear, drying out or overheating.

TEST 1: PRESSURE BUILD-UP/ LOW PRESSURE WARNING CUT OFF POINT/ GOVERNOR CUT-OUT AND CUT-IN

1. Completely drain the entire air system by using the drain cocks on the air tanks.

2. Close the air tank cocks if air system is drained.

3. Connect an accurate pressure gauge to the test fitting (identified by two red adhesive tapes) behind the front bumper.

4. Turn ignition on.

   Result: low air warning light on dashboard should illuminate and low air buzzer should sound. If not so, check wiring or replace low pressure switch and/or buzzer.

5. Start engine and run at 1,600 rpm.

   Result: low air warning light should go out and buzzer should stop when pressure reaches approx. 66 psi. If not so, check wiring or replace low pressure switch and/or buzzer.

6. Start timing as system pressure reaches 85 psi and stop at 100 psi.

   Result: air build-up time should be 45 seconds or less. If the build-up time is excessive, check:

   • for excessive air system leakage;
   • for restrictions in the air compressor inlet or discharge lines (carbon build-up);
   • air compressor condition (excessive wear on piston rings and/ or cylinders);
   • operation of air compressor inlet and discharge valves.

7. Idle the engine. Observe reading on air pressure gauge when governor cuts out compressor. This reading should be between 125 to 135 psi.

8. With the engine still running, slowly reduce air pressure in the system by applying and releasing the brakes. Observe reading on pressure gauge when governor cuts in the compressor. This reading should be between 105 to 110 psi. If not so, check operation of governor and unloading mechanisme on compressor.

US0500AD

TEST 2: LEAKAGE IN TANK SUPPLY CIRCUIT

1. Connect an accurate pressure gauge to the test fitting (identified by two red adhesive tapes) behind the front bumper.

2. Fully charge the air system and stop the engine.

3. Allow pressure to stabilize for at least 1 minute.

4. Observe pressure gauge for 2 minutes, and note any pressure drop.

   Result: pressure drop should not be more than 3 psi per minute. If not so, 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.

TEST 3: LEAKAGE IN SERVICE AIR DELIVERY CIRCUITS

1. Connect an accurate pressure gauge to the test fitting (identified by two red adhesive tapes) behind the front bumper.

2. Fully charge the air system and stop the engine.

3. Apply foot brake, allow pressure to stabilize for at least 1 minute.

4. Hold down foot brake for 2 minutes while observing the pressure gauge. Pressure drop should not be more than 4 psi per minute. If not so, coat all brake 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.

TEST 4: PARKING BRAKE OPERATION

1. Connect an accurate pressure gauge to the test fitting in the air line leading to the spring brake part of the brake cylinder of the left-hand drive wheel.

2. Fully charge the air system and stop the engine.

3. Pull the parking brake button to apply the parking brake. The pressure gauge should indicate no pressure.

4. Push and hold the emergency parking brake release button to release the parking brake. The pressure gauge should indicate pressure.

5. Release the emergency parking brake release button.

6. Push the parking brake button to release the parking brake. The pressure gauge should indicate pressure.

7. Reduce air pressure in the system by applying and releasing the foot brake.

   Result: low air warning light on dashboard should illuminate and low air buzzer should sound when pressure drops to approx. 66 psi. Drive axle spring brakes should dynamite when pressure drops to approx. 60 psi.

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8. Make sure that the transmission is in neutral en remove the wheel chocks.

9. Start the engine and fully charge the air system.

10. Check the parking brake holding ability as follows:

    a. Put the transmission in forward drive.

    b. **Lightly** depress the throttle pedal. The vehicle should remain stationary.

11. Put transmission back in neutral.

12. Stop the engine and chock the wheels to prevent vehicle movement.

TEST 5: OPERATION OF ONE WAY CHECK VALVES

1. Fully charge the air system and stop the engine.

2. Drain the buffer supply tank. The air pressure gauges on the dashboard should not indicate a loss of pressure.

TEST 6: OPERATION OF DUAL AIR SYSTEM

1. Connect accurate pressure gauges to:

   • the test fitting in the air line leading to the brake cylinder of a front wheel

   • the test fitting in the air line leading to the service part of a brake cylinder of a drive wheel

   • the test fitting in the air line leading to the brake cylinder of a tag wheel

2. Fully charge the air system and stop the engine.

3. Drain the drive axle service brakes tank.

4. Make a service brake application and check whether pressure gauges connected to the front and tag axle brakes indicate pressure.

5. Close the drain valve of the drive axle service brakes tank.

6. Start the engine and fully charge the air system again.

7. Stop the engine.

8. Drain the front axle brakes tank.

9. Make a service brake application and check whether pressure gauges connected to the drive and tag axle brakes indicate pressure.

10. Close the drain valve of the front axle brakes tank.

11. Start the engine and fully charge the air system again.

12. Stop the engine.

13. Drain the tag axle brakes tank.

14. Make a service brake application and check whether pressure gauges connected to the front and drive axle brakes indicate pressure.

15. Close the drain valve of the tag axle brakes tank.

16. Start the engine and fully charge the air system again.

17. Stop the engine.

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FOOT BRAKE VALVE

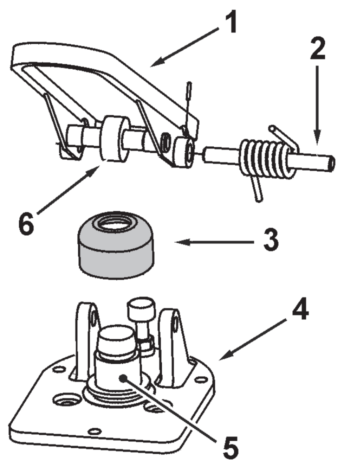

Figure 1: Foot brake valve operating mechanism

1. **Treadle**
2. **Hinge pin with return spring**
3. **Plunger boot**
4. **Mounting plate**
5. **Plunger**
6. **Treadle roller**

TO CHECK AND LUBRICATE OPERATING MECHANISM - Figure 1

Interval: see "Maintenance Schedule", Section 12.1.

1. Remove any accumulated dirt, dust, gravel and grease from the heel of treadle (1), plunger (5), plunger boot (3) and mounting plate (4).

2. Check rubber plunger boot (3) for damage. Replace if necessary.

3. Check treadle (1) and mounting plate (4) for damage, wear and corrosion. Replace if necessary.

4. Apply 2 to 4 drops of oil between plunger (5) and mounting plate (4). Do not over oil!

5. Lubricate treadle roller (6), the treadle roller pin and hinge pin (2) with light oil.

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"D-ELSA" FRONT WHEEL BRAKES - MECHANICAL SYSTEM

SPECIFICATIONS

MAKE AND TYPE .... Lucas D-ELSA
Ventilated disc, reaction beam caliper, air actuated

BRAKE DISC

- Diameter .... 432 mm (17 inches)
- Maximum permissible run-out
  when installed .... 0.15 mm (0.006 inch)
- Thickness, new .... 45 mm (1.77 inches)
- Oversize brake pads needed
  at disc thickness of .... 41 mm (1.61 inches)
- Maximum remachining thickness .... 38 mm (1.50 inches)
- Minimum disc thickness .... 35 mm (1.38 inches)

BRAKE PADS

- Brake area per pad .... 229 cm² (35.5 in²)
- Lining
  Thickness, new .... 20 mm (0.79 inch)
  Min. permissible thickness .... 2 mm (0.08 inch)
  Material .... Textar T3010.3AX (asbestos free) or Ferodo 4568 (asbestos free)
- Backplate
  Thickness, standard pad .... 8 mm (0.31 inch)
  Thickness, oversize pad .... 10 mm (0.39 inch)

ALLOWABLE
LINING-TO-DISC CLEARANCE .... 0.6 to 0.9 mm (0.024 to 0.035 inch)

TIGHTENING TORQUES

- Brake carrier mounting screws .... 430 ± 30 Nm (320 ± 20 ft.lbf.)
- Brake chamber to caliper .... 165 ± 15 Nm (120 ± 10 ft.lbf.)
- Guide sleeve mounting screws .... 540 ± 45 Nm (400 ± 30 ft.lbf.)
- Pad retaining plate screw .... 37.5 ± 2.5 Nm (30 ± 2 ft.lbf.)
- Screws to mount brake disc
  and wheel flange to
  wheel hub .... 430 ± 30 Nm (320 ± 20 ft.lbf.)

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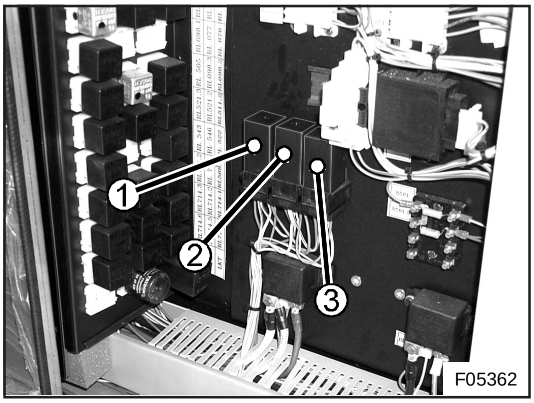

Figure 1: Control units of brake wear indicator system (not on multiplexed vehicles)

1. **Control unit of the front axle brakes**
2. **Control unit of the drive axle brakes**
3. **Control unit of the tag axle brakes**

MAINTENANCE

TO CHECK BRAKE PAD WEAR

NOTE

THE VEHICLE IS FITTED WITH ELECTRIC BRAKE WEAR INDICATORS. IF THE BRAKE PAD LINING IS ALMOST WORN TO THE LIMIT, A WARNING LIGHT ON THE INSTRUMENT PANEL WILL ILLUMINATE EACH TIME THE BRAKE PEDAL IS DEPRESSED. IF THE BRAKE PADS ARE WORN TO THE LIMIT, THE LIGHT WILL ILLUMINATE CONTINUOUSLY. TO DETERMINE WHICH AXLE IS AFFECTED, GO TO THE "BASIC ELECTRICS" SECTION OF THE MAIN JUNCTION BOX. THERE YOU FIND THE THREE CONTROL UNITS OF THE BRAKE WEAR INDICATOR SYSTEM. THE RED LED ON THE CONTROL UNIT OF THE AFFECTED AXLE WILL ILLUMINATE. CONTROL UNIT RSC1 REFERS TO THE FRONT AXLE, RSC2 TO THE DRIVE AXLE AND RSC3 TELLS WHETHER THE TAG AXLE IS AFFECTED (SEE FIGURE 1) .

Regardless of the presence of electric wear indicators, it is recommended to visually check the brake lining wear through the hand-holes of the rim at regular intervals. The brake pads should be changed at the latest when worn down to the minimum permissible thickness given in the specifications.

TO CHECK THE STATE OF THE BRAKE DISC- Figure 2

Check the brake disc for cracks and grooves. The guidelines to evaluate the brake disc are:

A: small cracks on the disc surface showing a network are *allowed*;

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B: cracks in the direction of the centre of the hub are *allowed* if they are less than 0.5 mm (0.02 inch) wide and deep, and not longer than 3/4 (=0,75) of the height of the brake pad lining contact surface;

C: grooves or scores on the brake lining contact surface of the disc are *allowed* to a dept of 1.5 mm (0.06 inch);

D: cracks running over the full height of the brake pad lining contact surface are *not allowed*.

Measure also the thickness of the brake disc. The brake disc must not be re-used if the wear limit from the specifications has been reached.

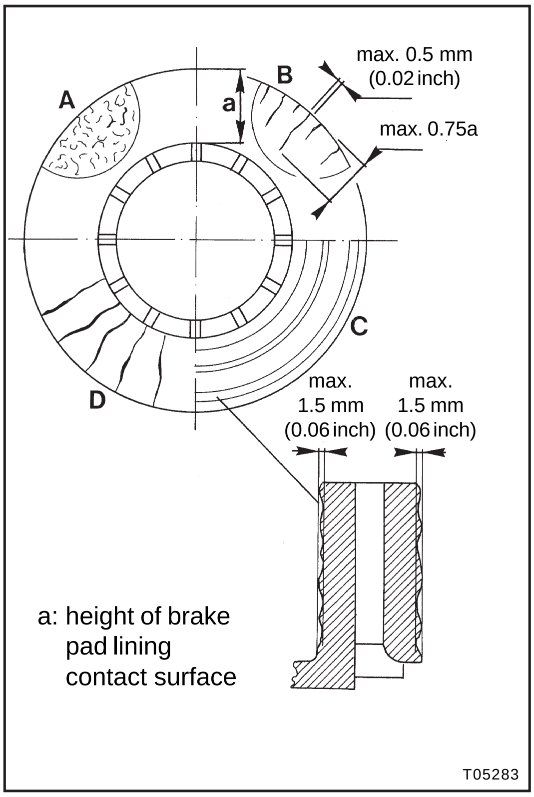

Figure 2: To check brake disc condition

TO CHECK RUN-OUT OF BRAKE DISC

Attach a dial indicator to the brake carrier. Position the stylus of the dial indicator at a right angle to the brake disc, 35 mm (1.38 inches) from the disc edge. Set the dial indicator to zero. Turn the wheel hub and read the total variation on the dial indicator. Maximum permissible run-out: 0.15 mm (0.006 inch). If a run-out of more than 0.15 mm (0.006 inch) is measured, the brake disc should be remachined or changed.

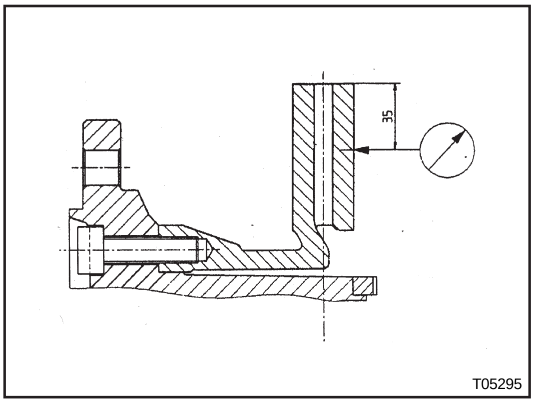

Figure 3: To check run-out of brake disc

!!!CAUTION!!!
ALWAYS CHANGE BRAKE DISCS ON BOTH SIDES OF THE AXLE AT THE SAME TIME.

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TO CHECK THE ADJUSTING MECHANISM OPERATION

1. Remove the adjuster stem cover.

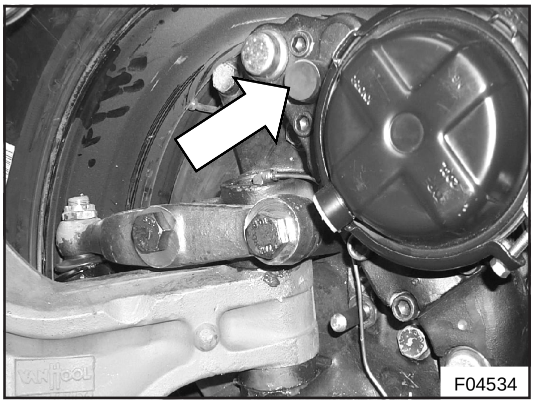

Figure 4: Adjuster stem cover

2. Using a 10 mm-box wrench, turn the adjuster stem:

   • of a right-hand brake to the left;
   • of a left-hand brake to the right;

   until a lining-to-disc clearance of 2 to 3 mm (0.08 to 0.12 inch) is achieved.

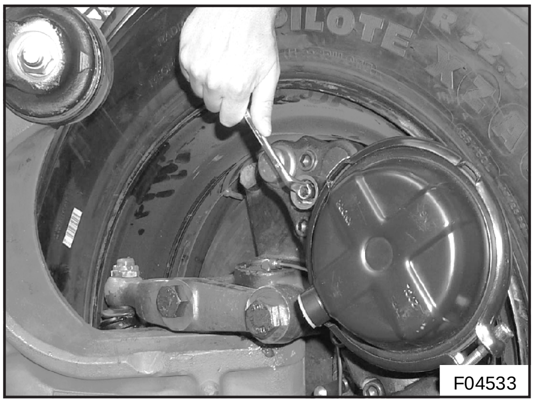

Figure 5: To turn the adjuster stem with a box wrench

3. Leave the box wrench engaged on the adjuster stem.

4. While an assistant makes a series of foot brake applications, check whether the wrench turns slightly (some degrees):

   • clockwise on a right-hand brake;
   • counterclockwise on a left-hand brake.

   If it does so, this is an indication that the adjusting mechanism operates properly. After a successful check, set the running clearance between the brake disc and pad. To do this, turn the adjuster stem in the appropriate direction until both pads touch the disc. Then turn the adjuster back 1/4 turn thus guaranteeing the

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running clearance. Remove the box wrench and re-install the adjuster stem cover.

TO CHECK CALIPER SLIDING SYSTEM

1. Remove the brake pads (see further in this Section).
2. Move the caliper backwards and forwards in the direction of the arrows and check whether the caliper slides easily on the guide sleeves.
3. If in doubt, check the force required to slide the caliper. The force must be less than 150 N (34 lbf).

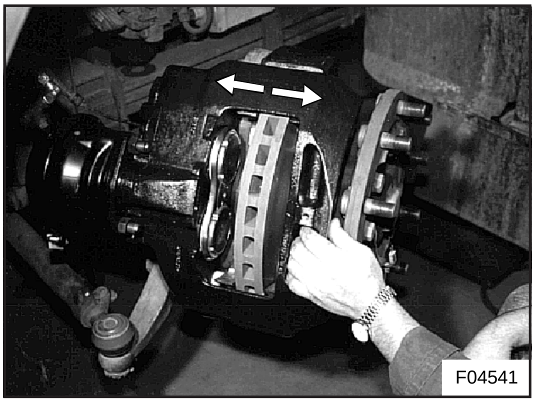

Figure 6: To slide the caliper

4. Check the sliding system for wear.

   Procedure:

   a. Pull caliper fully to the wheelside.

   b. Attach dial indicator (2). Position stylus of dial indicator at a right angle to the caliper and in line with centre line (3) of short guide pin (4). Set dial indicator to zero.

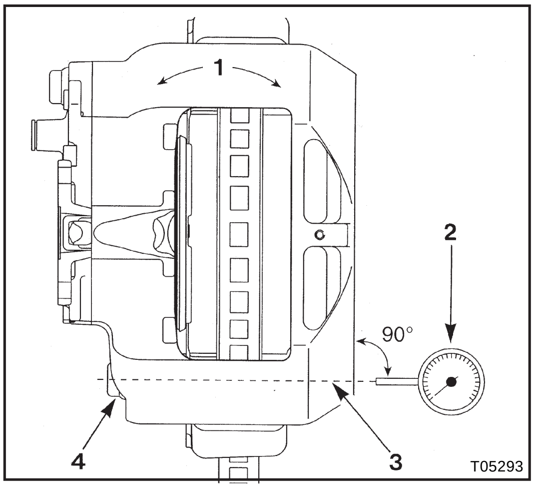

Figure 7

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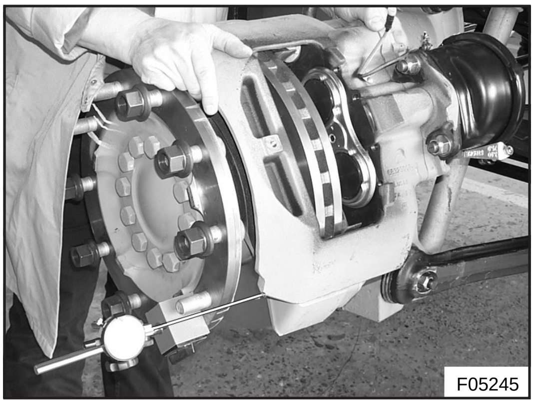

Figure 8

c. Grab the caliper with both hands at the long guide sleeve side and move it in the direction of the arrows (1) indicated in previous drawing (Do not slide the caliper!).

d. Note the total variation shown by the dial indicator. Maximum permissible variation: 3 mm (0.118 inch).

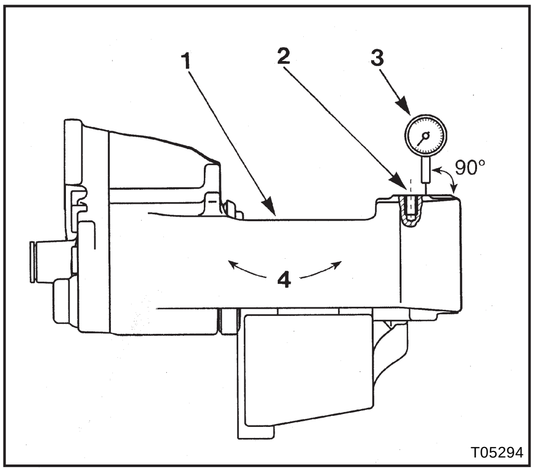

Figure 9

e. Attach dial indicator (3) as indicated in the drawing aside. The drawing shows a view from above of caliper (1), in which (2) is the tapped hole to receive the screw of the pad retaining plate.

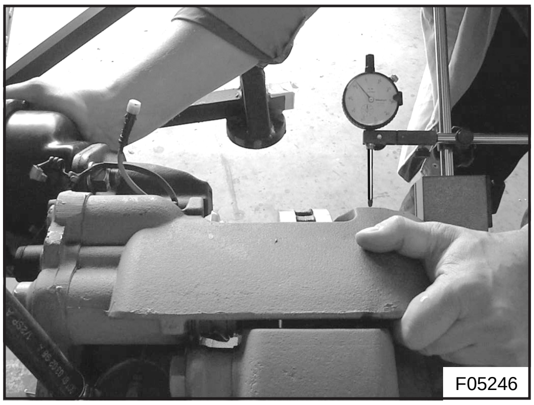

Figure 10

f. Hold the caliper at the side of the outer pad. Swivel the caliper by hand in the direction of the arrows (4) indicated in previous drawing (Do not slide the caliper!).

g. Note the total variation shown by the dial indicator. Maximum permissible variation: 2 mm (0.079 inch).

5. The guide sleeves and bushes must be replaced if one of the these values is exceeded.

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OVERHAUL

TO REMOVE AND INSTALL THE BRAKE PADS

To remove the brake pads

1. Chock and jack the vehicle. Remove the road wheel.

2. Remove the electrical pad wear indicator cable holder.

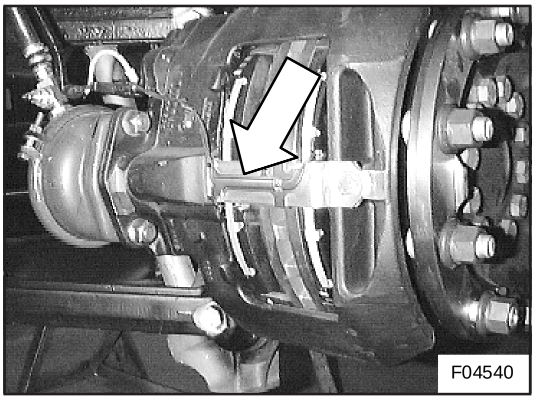

Figure 11A: Pad wear indicator cable holder (early type)

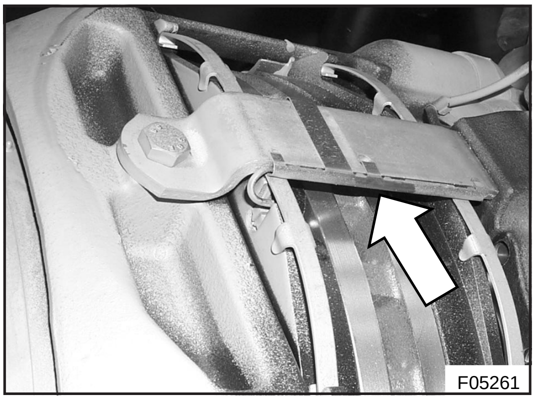

Figure 11B: Pad wear indicator cable holder (current type)

3. Remove the screw (2) of the pad retaining plate (1).

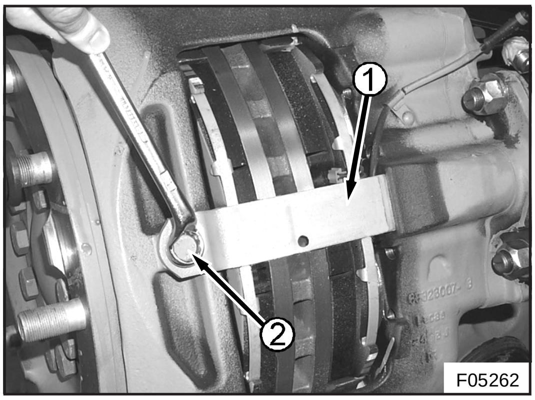

Figure 12

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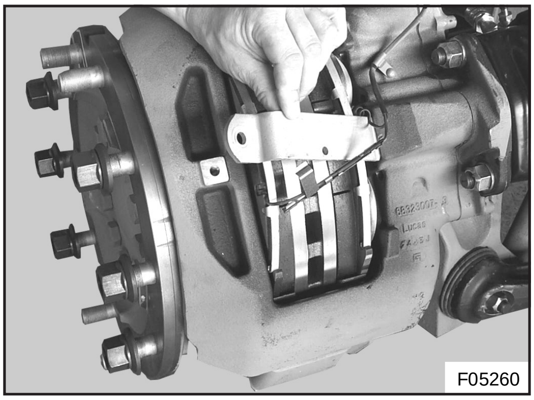

Figure 13

4. Remove the pad retaining plate.

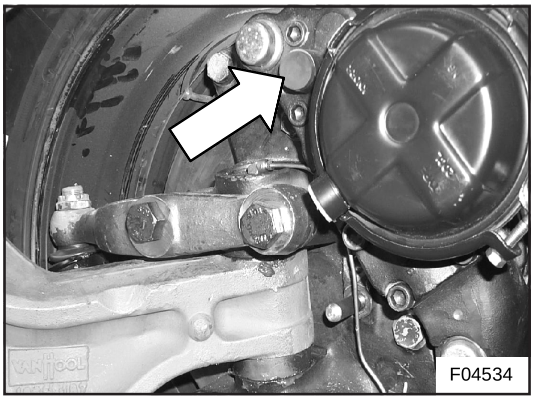

Figure 14

5. Remove the adjuster stem cover.

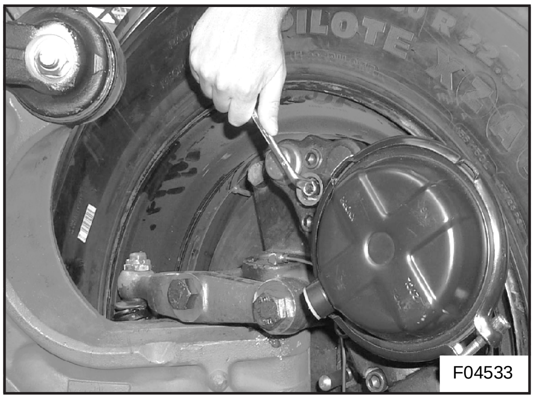

Figure 15

6. Using a 10 mm-box spanner, turn the adjuster stem:

   • of a right-hand brake to the left;
   • of a left-hand brake to the right,

   to allow sufficient space to remove the pads.

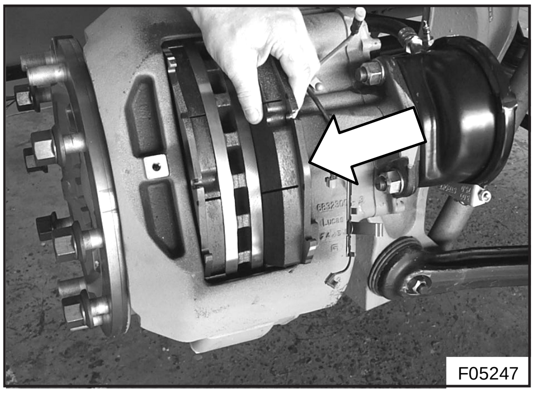

Figure 16

7. Remove and discard the old wear indicators. Remove the inner brake pad out of the caliper.

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8. Slide the caliper and remove the outer brake pad out of the caliper.

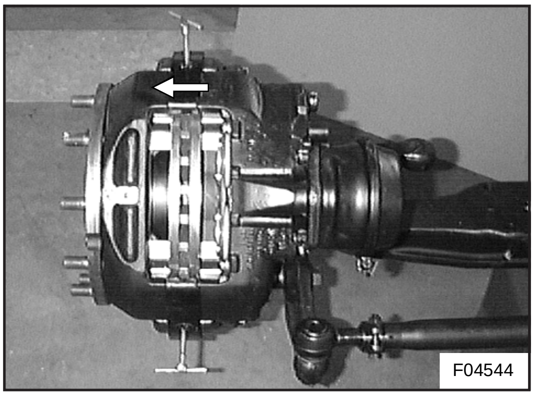

Figure 17

9. Clean the pad slide faces of the brake carrier with a wire brush or a flat scraper.

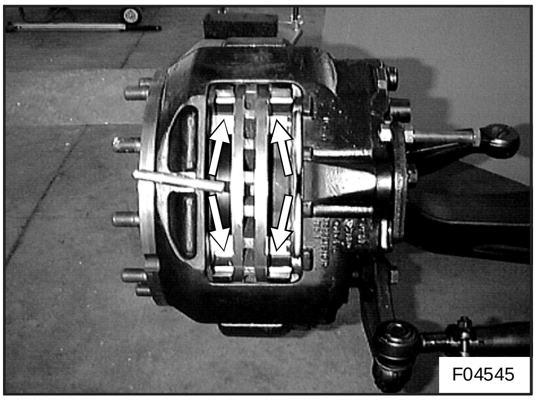

Figure 18

10. Turn the adjuster stem of a right-hand brake to the right and of a left-hand brake to the left until the rubber boots of the tappets are visible. Check the rubber boots (2 and 3) of the tappets and the rubber boots (1 and 4) of the guide sleeves for damage. Change them if necessary.

11. Check the caliper sliding system and the brake disc as explained earlier in this Section.

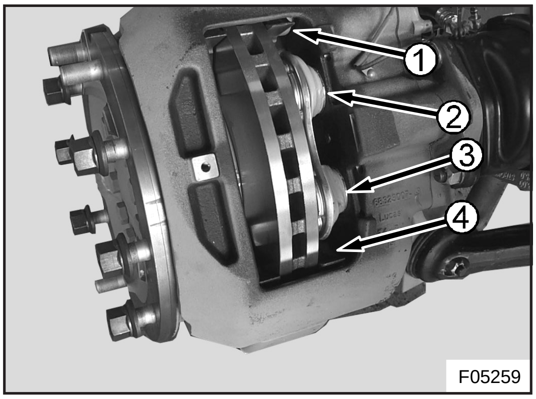

Figure 19

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To install the brake pads

!!!CAUTION!!!
DO NOT USE PADS WITH LINING MATERIAL OTHER THAN THE ONE MENTIONED IN THE SPECIFICATIONS. ALWAYS CHANGE PADS ON BOTH SIDES OF THE AXLE AT THE SAME TIME. ALWAYS USE NEW PAD HOLD-DOWN SPRINGS AND ELECTRICAL PAD WEAR INDICATORS WHEN CHANGING PADS.

1. Using a 10 mm-box spanner, turn the adjuster stem of a right-hand brake to the left and of a left-hand brake to the right. By this the tappets, which are secured by a plate to prevent them rotating, will move in.

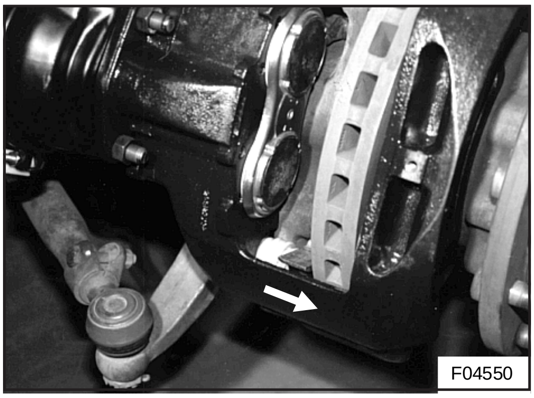

Figure 20

2. Pull the caliper to the wheelside with your hands until the outer brake pad can be fitted.

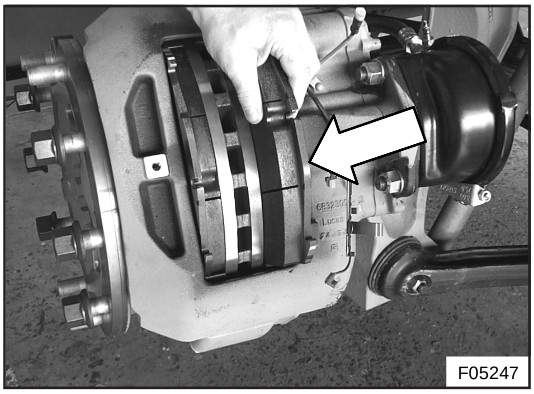

Figure 21

3. Fit the outer pad into the caliper and slide the caliper so that the outer pad makes full contact with the brake disc. Fit the inner pad into the caliper.

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4. Turn the adjuster stem of a right-hand brake to the right and of a left-hand brake to the left until both pads are in contact with the disc. Turn the adjuster stem back 1/4 of a revolution to achieve the necessary lining-to-disc clearance. Using a feeler gauge, measure lining-to-disc clearance. The correct clearance is 0.6 to 0.9 mm (0.024 to 0.035 inch). Adjust by turning the adjuster stem in the appropriate direction. Check that brake disc runs free.

5. Fit the hold-down springs to the pad back-plates.

6. Re-install the adjuster stem cover.

7. Install new electrical pad wear indicator cables on the brake pads.

8. Refit the brake pad retaining plate. Tighten the pad retaining plate screw to a torque of 37.5 ± 2.5 Nm (30 ± 2 ft.lbf.).

9. Route the electrical pad wear indicator cables in the cable holder as indicated in the Figures 22A and 22B. Push the cable holder on the brake pad retaining plate. Plug in the connector.

10. With the air system charged, apply the brake pedal several times. Check for correct lining-to-disc clearance. Check that hub runs free. Refit the road wheel and perform a brake operation road test.

NOTE
AVOID SEVERE OR LONG BRAKING, IF POSSIBLE, DURING THE FIRST 200 KM (120 MILES).

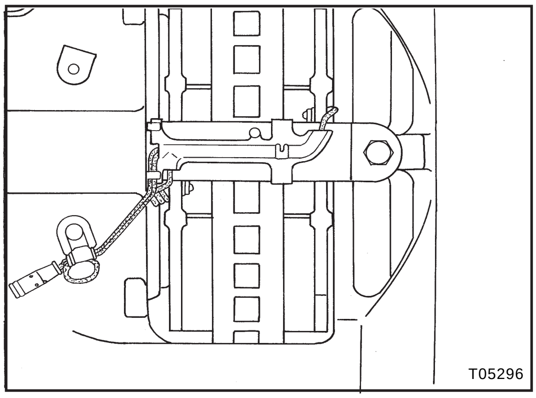

Figure 22A: Pad wear indicator cable installation (early type of cable holder)

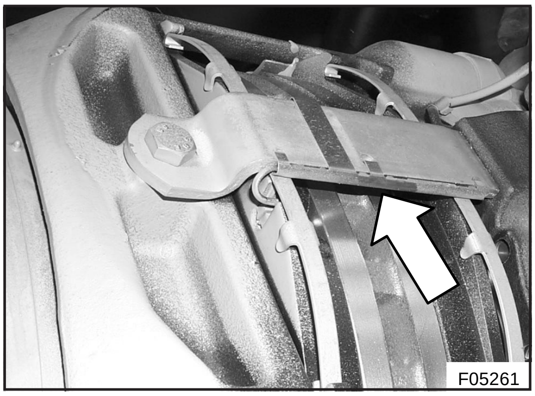

Figure 22B: Pad wear indicator cable installation (current type of cable holder)

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TO REMOVE AND INSTALL THE BRAKE CALIPER

To remove the brake caliper

1. Remove the brake pads as explained earlier in this Section.

2. Discharge all air from the brake system. Disconnect the brake chamber air line.

3. Remove the nuts and washers securing the brake chamber to the brake caliper. Remove the brake chamber.

Figure 23

4. Remove the end caps of the guide sleeves by using a hammer and a screwdriver.

5. Support the brake caliper.

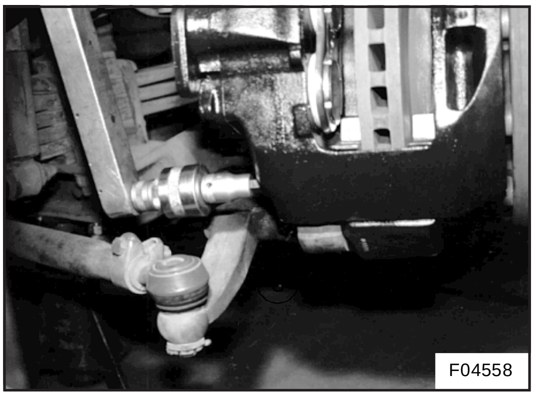

Figure 24

6. Remove the two guide sleeve screws by using a 14 mm-socket wrench.

7. Remove the brake caliper.

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To install the brake caliper

1. Position the brake caliper on the brake carrier.

2. Fit the brake caliper to the brake carrier with new guide sleeve screws. Refer to "Specifications" earlier in this Section for tightening torque.

3. Check the caliper for easy sliding by pushing and pulling it.

4. Fit new guide sleeve screw end caps into the caliper.

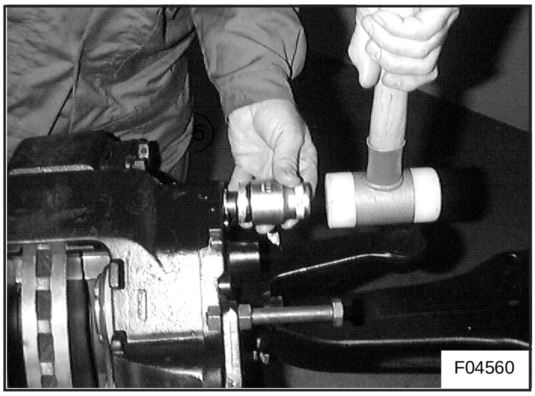

Figure 25

5. Check the seal at the bottom of the brake chamber for damage. Change it if necessary.

6. Secure the brake chamber to the brake caliper with two washers and two new nuts. Refer to "Specifications" earlier in this Section for tightening torque.

7. Install the brake pads as explained earlier in this Section.

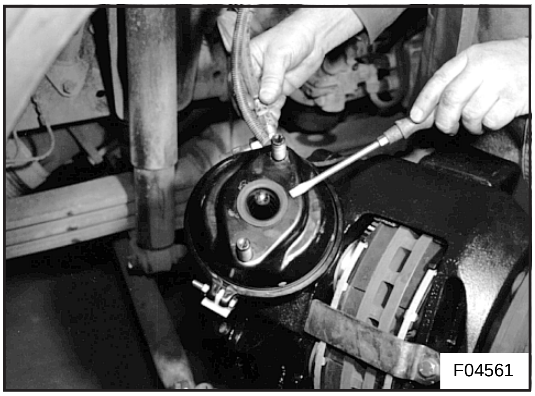

Figure 26

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TO REMOVE AND INSTALL THE GUIDE SLEEVE BUSHES

NOTE
THE SPECIAL TOOLS MENTIONED BELOW SHOULD BE LOCALLY FABRICATED. FOR MORE INFORMATION, REFER TO "SPECIAL TOOLS" AT THE END OF THIS CHAPTER.

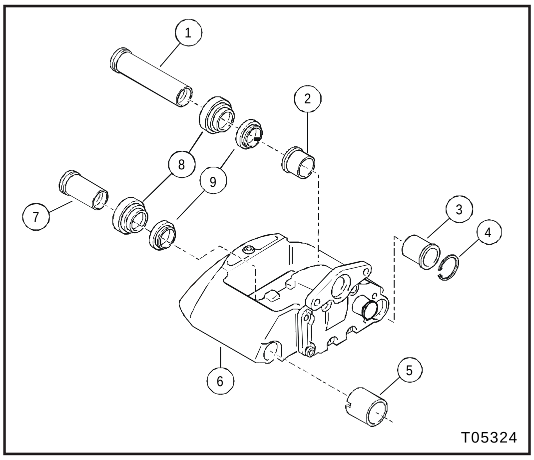

Figure 27: To remove and install guide sleeve bushes

1. Long guide sleeve
2. Coated guide bush
3. Coated guide bush
4. Snap ring
5. Brass guide bush
6. Brake caliper
7. Short guide sleeve
8. Rubber boot of guide sleeve
9. Rubber boot retaining ring

To remove the brass bush of the short guide sleeve

1. Remove the short guide sleeve together with the rubber boot from the brake caliper.

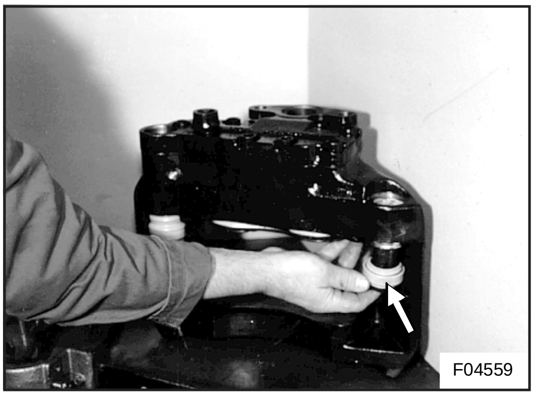

Figure 28

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2. Knock the rubber boot retaining ring out of the brake caliper by using a hammer and a screwdriver.

3. Press the brash bush out of the brake caliper with mandrel A.

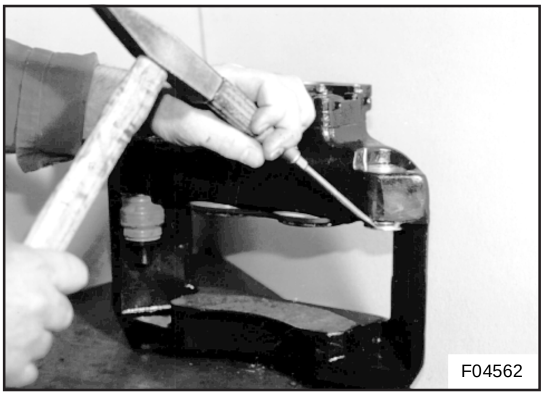
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Figure 29

To install the brass bush of the short guide sleeve

1. Position the new brass bush on the caliper bore so that the two notches of the bush are aligned with the marks on the caliper.

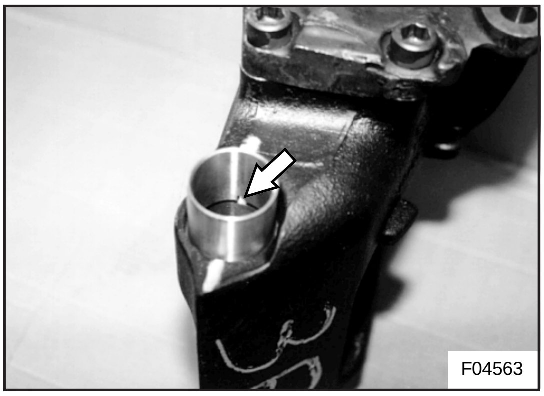
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Figure 30

2. Pull the bush into the caliper until stop by using the tools indicated in the drawing aside.

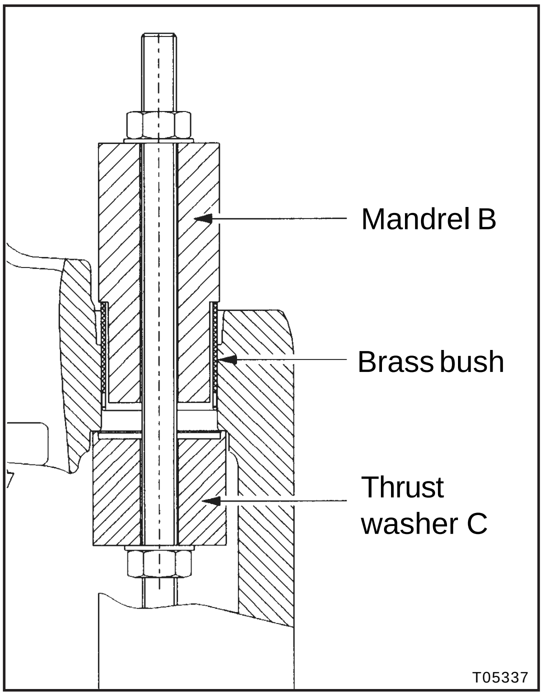

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Figure 31

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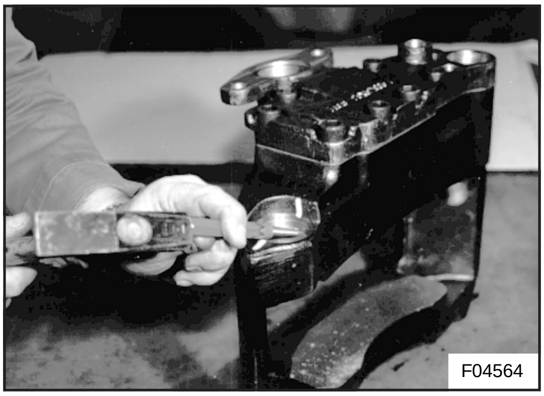

Figure 32

3. Secure the bush in the brake caliper by peening the edge over all around.

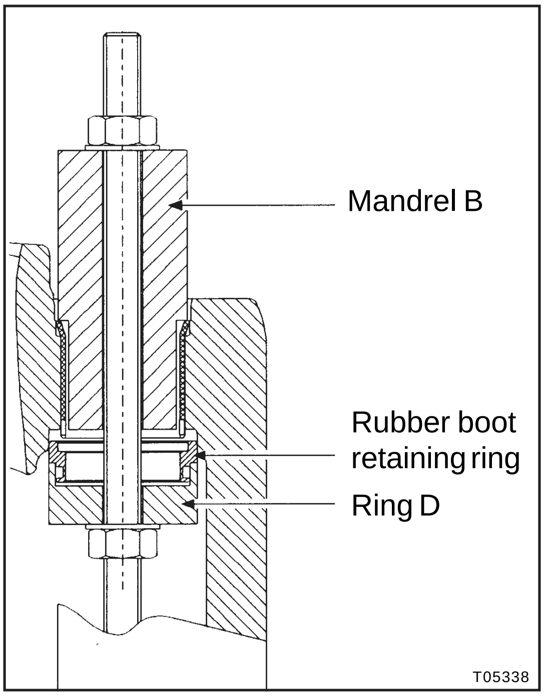

Figure 33

4. Pull the rubber boot retaining ring into the brake caliper by using the tools indicated in the drawing aside.

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To install the coated bushes of the long guide sleeve

1. Remove the long guide sleeve together with the rubber boot from the brake caliper.

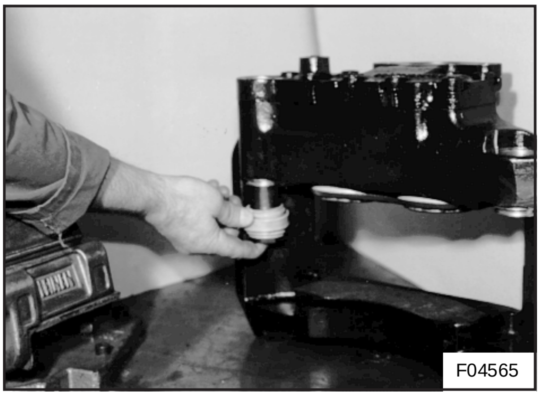

Figure 34

2. Remove the snap ring.

Figure 35

3. Knock the rubber boot retaining ring out of the brake caliper by using a hammer and a screwdriver.

4. Remove the coated bush at the brake chamber side by using a puller. Press out the coated bush at the brake disc side by using mandrel E. Ensure that the caliper bore is not damaged.

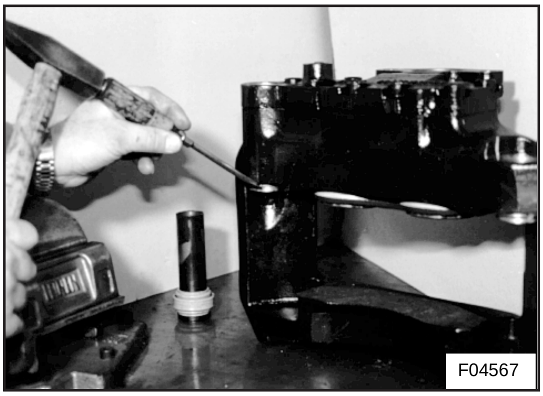

Figure 36

US0510AH

To install the coated bushes of the long guide sleeve

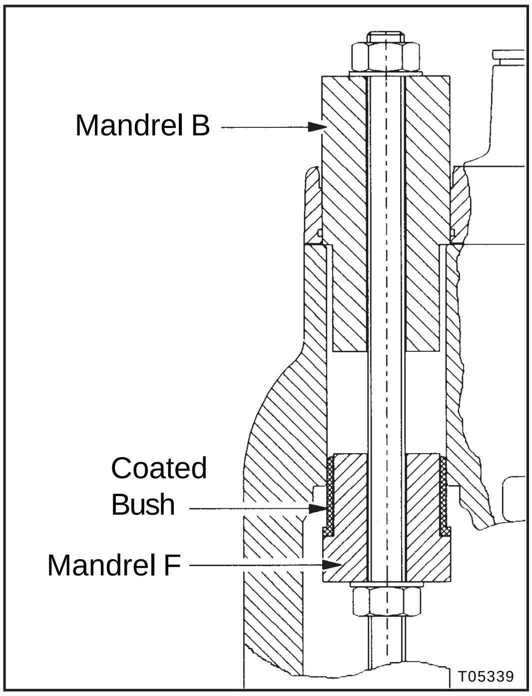

Figure 37

1. Install the coated bush at the brake disc side first. To do this use the tools indicated in the drawing aside.

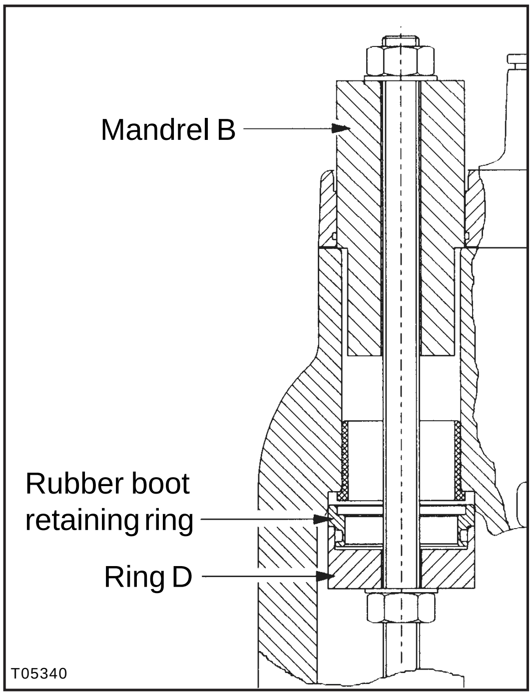

Figure 38

2. Pull the rubber boot retaining ring into the caliper using the tools indicated in the drawing aside.

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3. Pull the other coated bush into the brake caliper by using the tools indicated in the drawing aside.

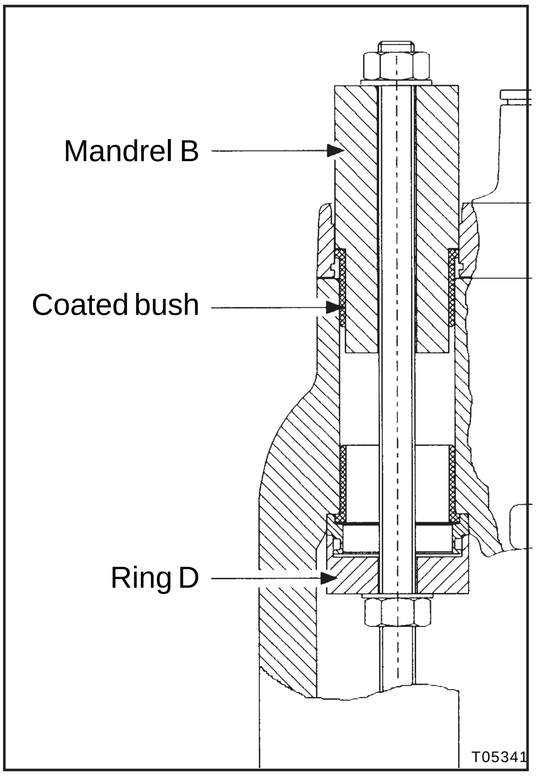

Figure 39

4. Insert a new snap ring in the slot of the brake caliper.

Figure 40

5. Lubricate the two bores with FUCHS Renolith Unitemp 2 grease. Fill the gap (1) between the two coated bushes with the same grease.

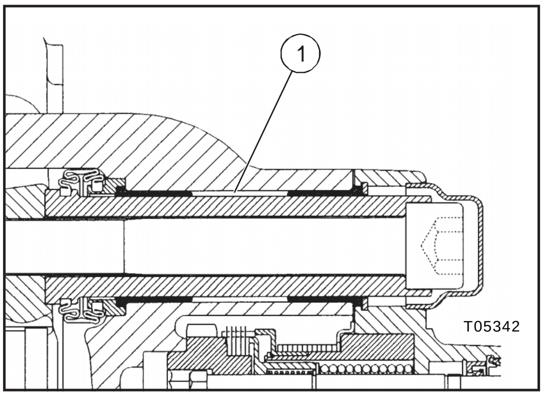

Figure 41

US0510AH

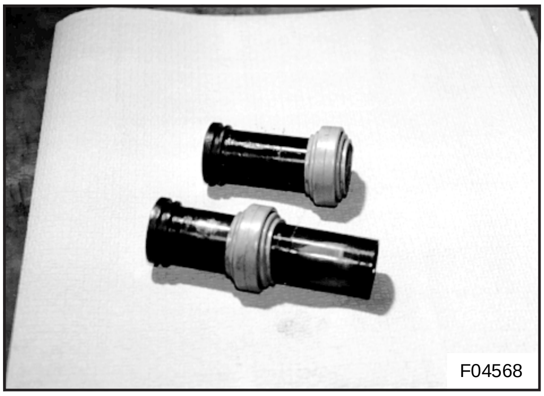

Figure 42

6. Lubricate the guide sleeves with FUCHS Renolith Unitemp 2 grease. Pull the rubber boots onto the guide sleeves until sealing lip snaps into the groove in the guide sleeve.

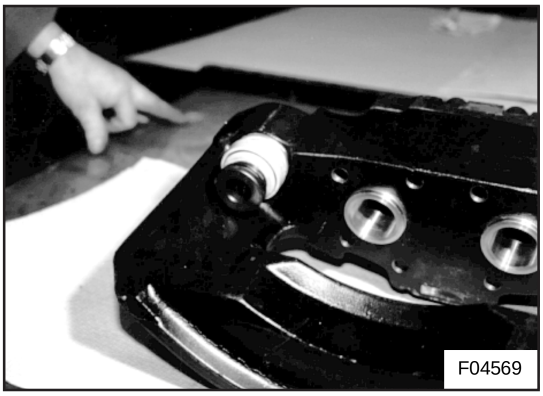

Figure 43

7. Slide the short guide sleeve in the brake caliper and secure the rubber boot to the retaining ring in the brake caliper.

Figure 44

8. Slide the long guide sleeve in the brake caliper and secure the rubber boot to the retaining ring in the brake caliper.

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TO REMOVE AND INSTALL THE RUBBER BOOTS OF THE TAPPETS

NOTE
THE SPECIAL TOOLS MENTIONED BELOW SHOULD BE LOCALLY FABRICATED. FOR MORE INFORMATION, REFER TO "SPECIAL TOOLS" AT THE END OF THIS CHAPTER.

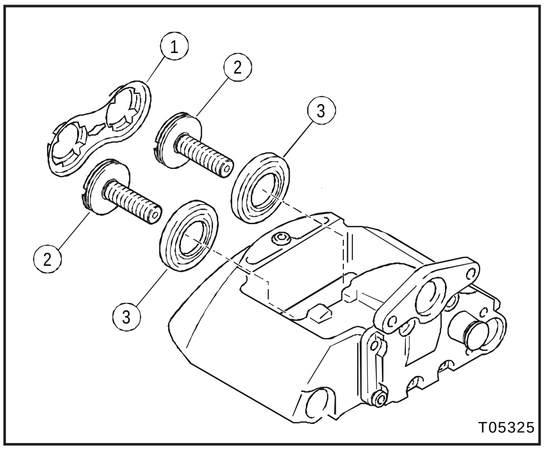

Figure 45

1. retaining plate
2. tappet
3. Rubber boot

1. Unlock and remove the retaining plate.

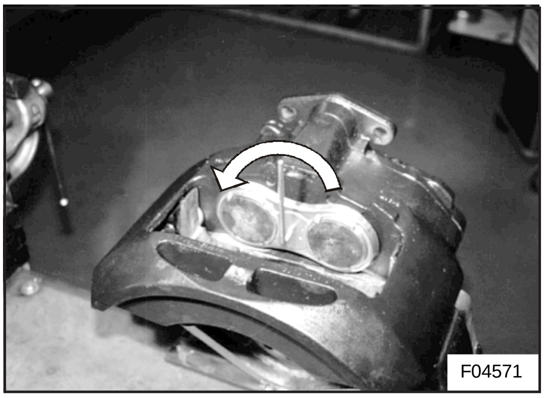

Figure 46

2. Fully unscrew one tappet and remove the old dust cover.

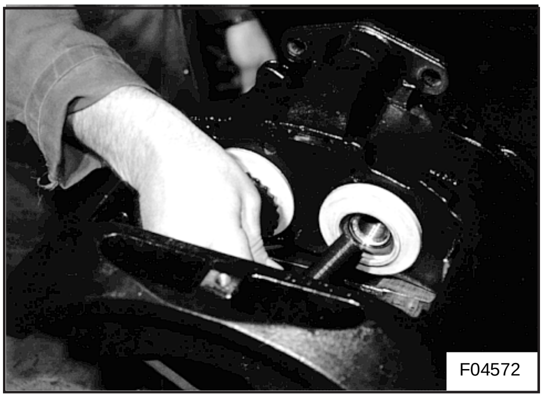

Figure 47

US0510AH

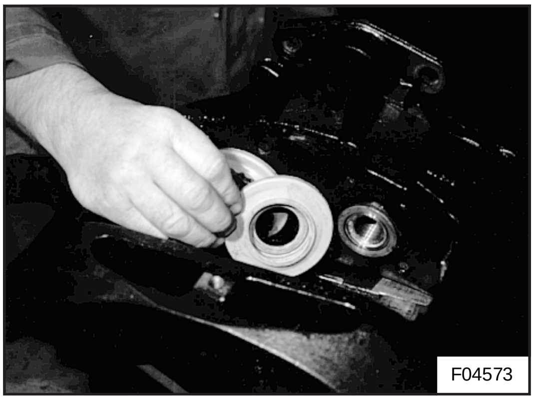

Figure 48

3. Push a new rubber cover on its seat.

Figure 49

4. Clean de tappet thread and check the thread for damage.

Figure 50

5. Lubricate the tappet thread with FUCHS Renolith Unitemp 2 grease.

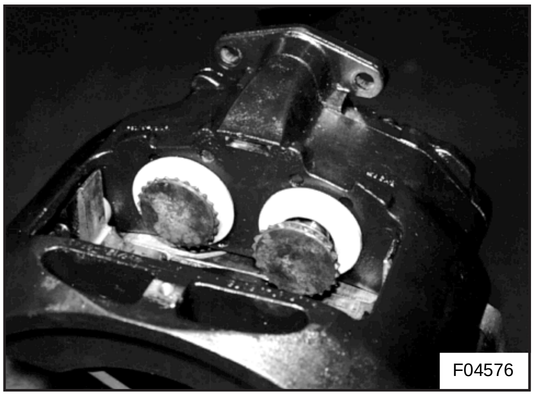

Figure 51

6. Screw the tappet back in.
7. Secure the dust cover to the tappet.
8. Repeat this procedure for the second tappet.

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9. Position the spacer between the tappet head and the brake caliper. Hold the spacer against the brake caliper and screw out the tappet until it touches the spacer.

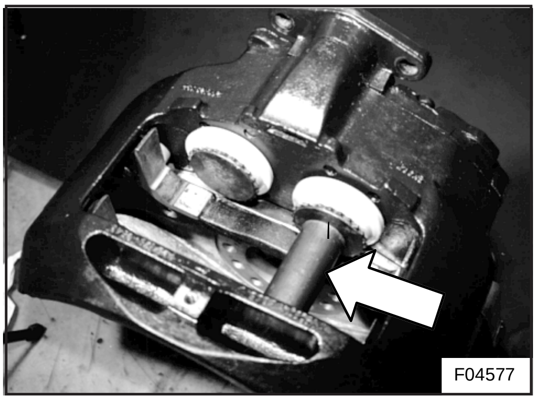

Figure 52

10. Repeat this for the other tappet.

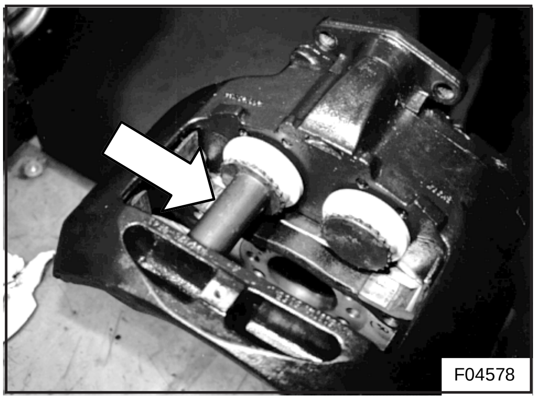

Figure 53

11. Fit the retaining plate onto the tappets and allow it to engage with the teeth of the tappets.

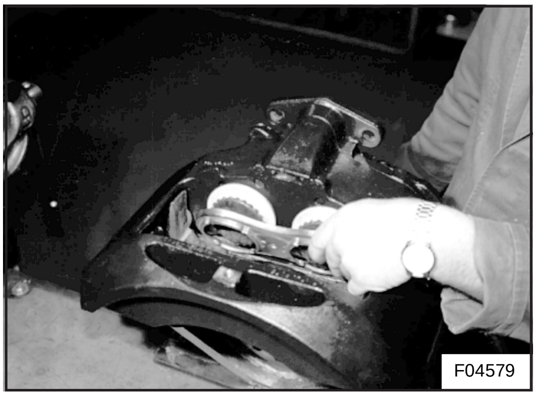

Figure 54

12. Lock the retaining plate.

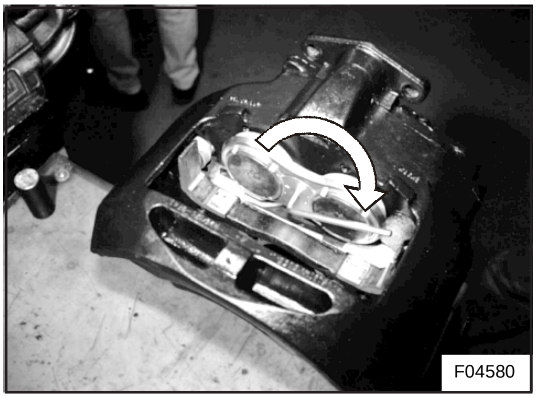

Figure 55

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TO REMOVE AND INSTALL THE BRAKE CARRIER

To remove the brake carrier

1. Remove the brake caliper as explained earlier in this Section.

2. Remove the six screws retaining the brake carrier to the steering knuckle.

To install the brake carrier

1. Clean the seats for guide sleeves and bores for guide sleeves screws in the brake carrier. Check the brake carrier for wear. If there are signs of wear, replace brake carrier.

2. Fit the brake carrier to the steering knuckle with the six screws. Refer to "Specifications" earlier in this Section for tightening torque.

TO REMOVE AND INSTALL THE BRAKE DISC

To remove the brake disc

1. Remove the brake pads, brake chamber, brake caliper and brake carrier as explained earlier in this Section.

2. Refer to "To remove the hub unit" in Chapter 4, to remove the wheel flange and the brake disc from the hub unit.

To install the brake disc

1. Refer to "To install the hub unit" in Chapter 4, to install the wheel flange and the brake disc to the hub unit.

2. Install the brake carrier, brake caliper, brake chamber and brake pads as explained earlier in this Section.

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"D-ELSA" FRONT WHEEL BRAKES - AIR SYSTEM

BRAKE CHAMBERS

!!! CAUTION !!!

THIS IS A LONG STROKE BRAKE CHAMBER. MAXIMUM ALLOWABLE PUSH ROD STROKE IS 3.00 INCHES.

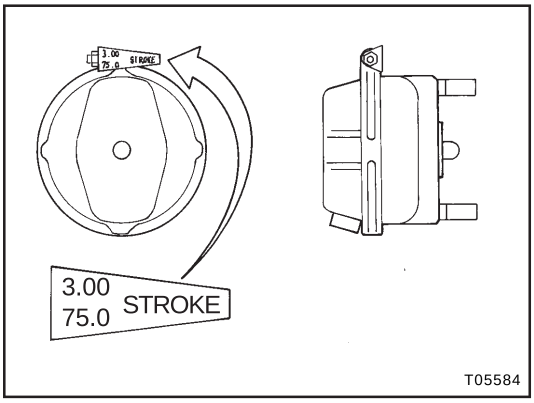

Figure 1: Long stroke brake chamber identification (20" brake chamber)

THEORY OF OPERATION

If brake pedal is depressed, compressed air enters the chamber behind the pressure side of diaphragm (3). Diaphragm (3) is forced outward together with push rod (2), overcoming the force of spring (1). As a result, the brake pads are forced against the brake disc. The air on the other side of the diaphragm is exhausted through a vent hole. When the brakes are released, the force of the release spring (1) returns the push rod assembly (2) and diaphragm (3) to its fully OFF position.

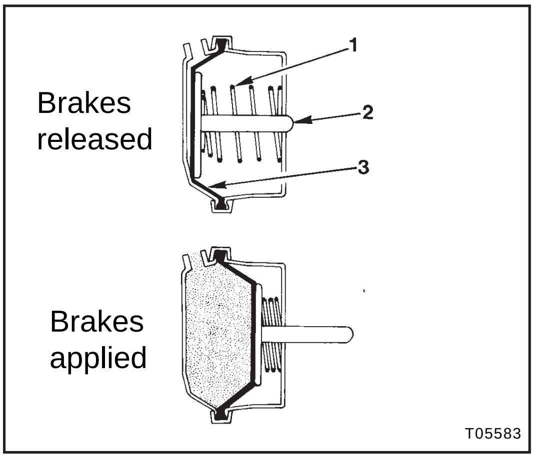

Figure 2: Brake chamber

MAINTENANCE

At service intervals, clean exterior of brake chamber. Inspect for damage and air leaks from clamp ring and vent holes in non-pressure plate.

1. Chock wheels so that vehicle cannot move.
2. Apply liquid soap to clamp ring and vent holes.
3. Apply full pressure to chamber. Watch for leaks. There should be no leakage at vent hole. (Leakage indicates a defective brake diaphragm). Only slight frothing is allowed at clamp ring.

OVERHAUL

To remove brake chamber

1. Block wheels so that coach cannot move.
2. Use drain valve to remove all air from air supply system.
3. Disconnect air line from brake chamber. Plug end of line.

5. Remove nuts and lock washers from the mounting studs, then remove brake chamber assembly from caliper.

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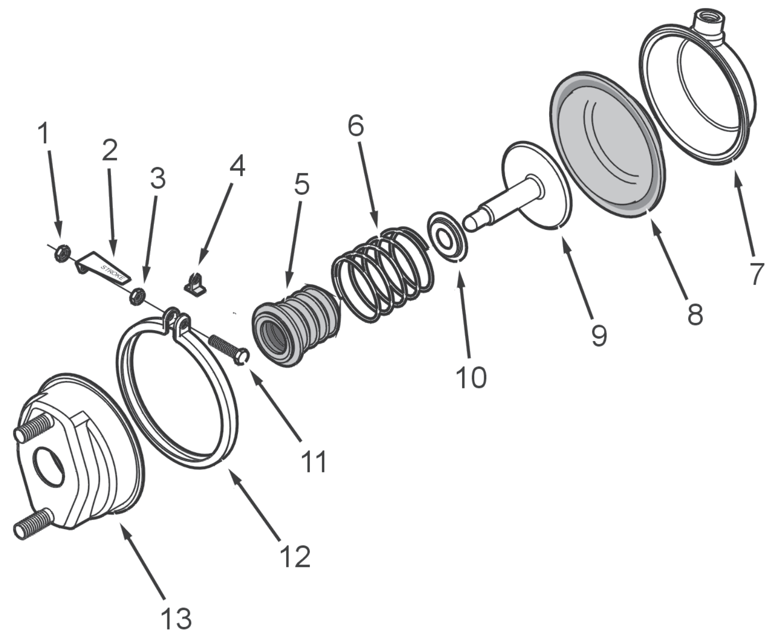

Figure 3: Exploded view of brake chamber

1. **Nut**
2. **Stroke tag**
3. **Nut**
4. **Packing piece**
5. **Rubber boot**
6. **Return spring**
7. **Pressure plate**
8. **Diaphragm**
9. **Push-rod**
10. **Spring seat**
11. **Clamp ring bolt**
12. **Clamp ring**
13. **Non-pressure plate**

To install brake chamber

1. Position brake chamber at caliper with air line connection at the top and with mounting studs through holes in caliper. Install lock washer and nut on each stud and tighten to a torque of 135 to 155 ft.lbf. Reconnect air pressure line.

2. Be sure that the lowest vent hole in the non-pressure plate is open and the other ones plugged with plastic plugs.

3. Check for leaks at all connections. Use a soap and water solution to check for leaks.

To change brake chamber diaphragm -Figure 2

1. Mark non-pressure plate (13), pressure plate (7) and clamp ring (12). Parts may then be reassembled in the same position as before disassembly.

!!! CAUTION !!!
USE CAUTION WHEN REMOVING THE CLAMP RING BECAUSE OF TENSION OF RETURN SPRING.

2. Remove nut (1) from clamp ring bolt (11) and remove "3.00/75.0 Stroke" tag (2). Remove nut (3) and bolt

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(11). Spread clamp ring (12) and remove from plates, then remove pressure plate (7) and diaphragm (8).

3. Remove push rod (9) and spring (6) from non-pressure plate (13).
4. Clean all metal parts thoroughly, using a suitable cleaning solvent.
5. Examine push rod and spring. Replace with new parts if not in first class condition.
6. Inspect pressure plate and non-pressure plate. Clamping flanges on plates should not be bent or otherwise damaged. Replace damaged parts.
7. Open Van Hool repair kit 10904812. The kit contains a diaphragm, a spring seat, a rubber boot and a packing piece.
8. Slide new spring seat (10) on push-rod (9).
9. Slide new rubber boot (5) on push-rod (9).
10. Install spring (6) on push-rod (9).
11. Position the push-rod assembly in non-pressure plate (13). Pull the sealing lip of rubber boot (5) over the edge of the non-pressure plate hole.
12. Fit new diaphragm (8) onto pressure plate (7).

!!! CAUTION !!!
DO NOT TWIST RUBBER BOOT (5) DURING ASSEMBLY AS THIS WILL CAUSE PREMATURE FAILURE OF THE CALIPER DUE TO CORROSION.

13. With the marks previously inscribed aligned, fit non-pressure plate (13) onto pressure plate (7).
14. Place clamp ring (12) and align marks.
15. Draw clamp ring (12) together, with new packing piece (4) inserted between clamp ring ears. Install bolt (11) and nut (3). Tighten nut (3) to a torque of 10 to 14 Nm (8 to 10 ft.lbf).
16. Install "3.00/75.0 Stroke" tag (2) and nut (1). Tighten nut (1) to a torque of 10 to 17 Nm (8 to 12 ft.lbf).

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QUICK RELEASE VALVE

GENERAL

Quick release valves are installed in air brake system adjacent to brake chambers to fasten exhaust of air from brake chambers when applied pressure is released.

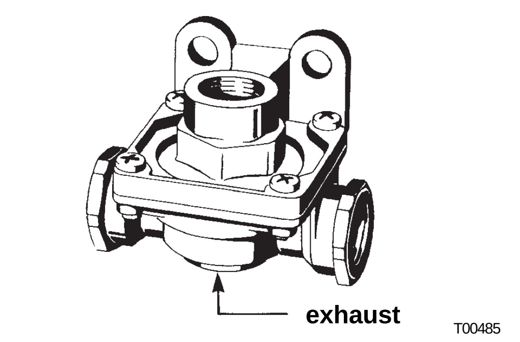

Figure 4: Quick release valve

OPERATION

When air is supplied to supply port at A, diaphragm (D) is pushed away from seat (B) and against exhaust seat (F), sealing exit to port E. Air now flows around edge of circular flexible diaphragm and passes out of delivery ports (C and G), and then to brake chambers.
As applied pressure at A is reduced, pressure present in brake chambers and therefore under diaphragm will be

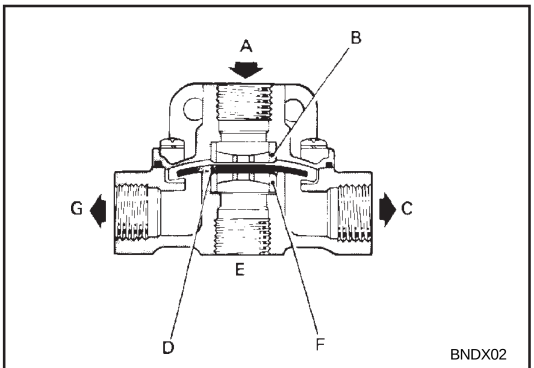

Figure 5: 'Air Supply' position

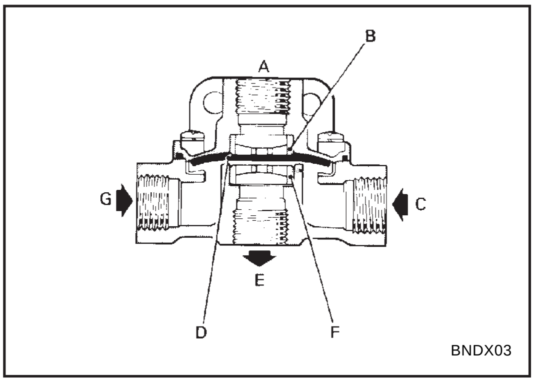

Figure 6: 'Exhaust' position

greater. Diaphragm will lift away from seat (F) allowing air in chambers to exhaust completely and quickly to atmosphere through port E.

MAINTENANCE

At intervals given in maintenance schedule, check valve as follows:

1. Apply brakes and make sure that, when they are released, air pressure is quickly exhausted through valve exhaust ports.

2. With brakes applied, use soap solution to detect any air leaks from valve body or exhaust port. Any leakage at exhaust port must not exceed a 1 inch diameter soap bubble in 1 second. No other leakage is allowable.

3. Remove quick release valve, if it is found to be faulty in operation or is leaking.

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"D-ELSA" DRIVE WHEEL BRAKES - MECHANICAL SYSTEM

SPECIFICATIONS

MAKE AND TYPE .... Lucas D-ELSA
Ventilated disc, reaction beam caliper, air actuated

BRAKE DISC

- Diameter .... 432 mm (17 inches)
- Maximum permissible run-out when installed .... 0.15 mm (0.006 inch)
- Thickness, new .... 45 mm (1.77 inches)
- Oversize brake pads needed at disc thickness of .... 41 mm (1.61 inches)
- Maximum remachining thickness .... 38 mm (1.50 inches)
- Minimum disc thickness .... 35 mm (1.38 inches)

BRAKE PADS

- Brake area per pad .... 229 cm² (35.5 in²)
- Lining
  Thickness, new .... 20 mm (0.79 inch)
  Min. permissible thickness .... 2 mm (0.08 inch)
  Material .... Textar T3010.3AX (asbestos free) or Ferodo 4568 (asbestos free)
- Backplate
  Thickness, standard pad .... 8 mm (0.31 inch)
  Thickness, oversize pad .... 10 mm (0.39 inch)

ALLOWABLE LINING-TO-DISC CLEARANCE .... 0.6 to 0.9 mm (0.024 to 0.035 inch)

TIGHTENING TORQUES

- Brake carrier mounting screws .... 430 to 475 Nm (320 to 350 ft.lbf.)
- Brake chamber to caliper .... 210 - 30 Nm (155 - 20 ft.lbf.)
- Guide sleeve mounting screws .... 540 ± 45 Nm (400 ± 30 ft.lbf.)
- Pad retaining plate screw .... 37.5 ± 2.5 Nm (30 ± 2 ft.lbf.)
- Brake disc mounting screws .... 290 ± 15 Nm (215 ± 10 ft.lbf.)

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MAINTENANCE

!!! CAUTION !!!

BEFORE ANY MAINTENANCE, BLOCK WHEELS TO PREVENT VEHICLE MOVEMENT.

TO CHECK BRAKE PAD WEAR

Refer to Section 5.1 "D-ELSA front wheel brakes - Mechanical System".

You have to remove the wheels to visually check the brake pads wear.

TO CHECK THE STATE OF THE BRAKE DISC

Refer to Section 5.1 "D-ELSA front wheel brakes - Mechanical System".

TO CHECK RUN-OUT OF BRAKE DISC

Refer to Section 5.1 "D-ELSA front wheel brakes - Mechanical System".

TO CHECK THE ADJUSTING MECHANISM OPERATION

!!! CAUTION !!!

PRIOR TO PERFORM THIS CHECK MECHANICALLY RELEASE THE BRAKE CHAMBER.

To mechanically release the brake chamber:

1. Remove the release bolt dust cap at the rear of the brake chamber.
2. Turn the release bolt counterclockwise as far as it will go.

Refer to Section 5.1 "D-ELSA front wheel brakes - Mechanical System".

!!! CAUTION !!!

DO NOT FORGET TO REWIND THE RELEASE BOLT OF THE BRAKE CHAMBER AFTER ALL WORK IS DONE.

TO CHECK THE CALIPER SLIDING SYSTEM

!!! CAUTION !!!

PRIOR TO PERFORM THIS CHECK MECHANICALLY RELEASE THE BRAKE CHAMBER.

To mechanically release the brake chamber:

1. Remove the release bolt dust cap at the rear of the brake chamber.
2. Turn the release bolt counterclockwise as far as it will go.

Refer to Section 5.1 "D-ELSA front wheel brakes - Mechanical System".

!!! CAUTION !!!

DO NOT FORGET TO REWIND THE RELEASE BOLT OF THE BRAKE CHAMBER AFTER ALL WORK IS DONE.

OVERHAUL

!! CAUTION !!!

PRIOR TO PERFORM ANY OVERHAUL BLOCK WHEELS TO PREVENT VEHICLE MOVEMENT AND MECHANICALLY RELEASE THE BRAKE CHAMBER.

DO NOT FORGET TO REWIND THE RELEASE BOLT OF THE BRAKE CHAMBER AFTER ALL WORK IS DONE.

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To mechanically release the brake chamber:

1. Remove the release bolt dust cap at the rear of the brake chamber.

2. Turn the release bolt counterclockwise as far as it will go.

TO REMOVE AND INSTALL THE BRAKE PADS

Refer to Section 5.1 "D-ELSA front wheel brakes - Mechanical System".

TO REMOVE AND INSTALL THE BRAKE CALIPER

Refer to Section 5.1 "D-ELSA front wheel brakes - Mechanical System".

TO REMOVE AND INSTALL THE GUIDE SLEEVE BUSHES

Refer to Section 5.1 "D-ELSA front wheel brakes - Mechanical System".

TO REMOVE AND INSTALL THE RUBBER BOOTS OF THE TAPPETS

Refer to Section 5.1 "D-ELSA front wheel brakes - Mechanical System".

TO REMOVE AND INSTALL THE BRAKE CARRIER

To remove the brake carrier

1. Remove the brake caliper as explained earlier in this Section.

2. Remove the six screws retaining the brake carrier to the axle.

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To install the brake carrier

1. Clean the seats for guide sleeves and bores for guide sleeves screws in the brake carrier. Check the brake carrier for wear. If there are signs of wear, replace brake carrier.

2. Fit the brake carrier to the axle with the six screws. Refer to "Specifications" earlier in this Section for tightening torque.

TO REMOVE AND INSTALL THE BRAKE DISC

To remove the brake disc

1. Remove the brake pads, brake chamber, brake caliper and brake carrier as explained earlier in this Section.

2. Refer to "To remove/install the wheel end" in Chapter 4, to remove the hub/brake disc assembly.

3. Free the brake disc from the hub.

To install the brake disc

1. Secure the brake disc to the hub. Refer to "Specifications" earlier in this Section for tightening torque.

2. Refer to "To remove/install the wheel end" in Chapter 4, to install the hub/brake disc assembly onto the axle.

3. Install the brake carrier, brake caliper, brake chamber and brake pads as explained earlier in this Section.

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"D-ELSA" DRIVE WHEEL BRAKES - AIR SYSTEM

"WABCO TRISTOP" BRAKE CHAMBER

SPECIFICATIONS

Make .... Wabco

Type.................... Tristop 20/24 (8000)

where:

20 = effective area of the service brake diaphragm in square inches

24 = effective area of the parking brake piston in square inches

8000 = output of the power spring portion in Newtons at 50 mm stroke (1mm = 0.04 inch and 1N = 0.225 lbf)

!!! CAUTION !!!
THIS IS A LONG STROKE BRAKE CHAMBER, MAXIMUM ALLOWABLE PUSH ROD STROKE IS 3.00 INCHES. THIS IS INDICATED BY THE "3.00/75.0 STROKE" TAG AT THE CLAMP RING BOLT.

MAINTENANCE

At regular service intervals, clean the brake chamber exterior. Inspect it for damage and leaks.

Apply a soap solution to the service chamber vent opening and the clamp ring.

1. Chock the vehicle wheels.
2. Apply a soap solution to the service chamber vent opening, the clamp ring and the area around the emergency release bolt.
3. Apply full air pressure to service and spring brake chambers, in sequence.
4. Watch for soap bubbles. No leakage is allowed at the service chamber vent hole. Just a slight amount of leakage may occur at the clamp ring and around the emergency release bolt (slight frothing).
5. If a brake chamber is damaged or leaking, it must be removed for servicing and testing.

OVERHAUL

To remove brake chamber

!!! CAUTION !!!
RELEASE ALL AIR FROM THE SYSTEM.

1. With the coach standing on level ground and the wheels chocked, pull parking brake control knob up. This will release air from the spring brake chamber.

NOTE
MARK AIR LINES FOR REINSTALLATION REFERENCE.

Disconnect the air lines from spring and service ports of the brake chamber.

- Spring brake port: 12
- Service brake port: 11

2. Fully unscrew the release bolt (at the end of the brake chamber) to release spring brakes.

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3. Unscrew the nuts from the mounting studs and remove the brake chamber from the coach.

To install brake chamber

NOTE
BE SURE THE SPRING BRAKE IS MANUALLY RELEASED.

1. Before installation, the power spring should always be wound up by means of the release bolt (Turn the release bolt completely counterclockwise).

NOTE
THE BRAKE CHAMBER SHOULD ALWAYS BE INSTALLED WITH THE BREATHER TUBE ABOVE THE HORIZONTAL CENTERLINE OF THE BRAKE CHAMBER.

2. Remount the brake chamber onto the vehicle. Install mounting stud nuts to a torque of 210 -30 Nm (155 - 20 ft.lbf).

3. Screw release bolt completely clockwise to a torque of 30 to 36 Nm (11 to 25 ft.lbf).

4. Reconnect air pressure lines and charge system to governor cut-out pressure.

5. Carry out operating and leakage tests.

To change service brake chamber diaphragm

1. Remove the brake chamber from the vehicle.

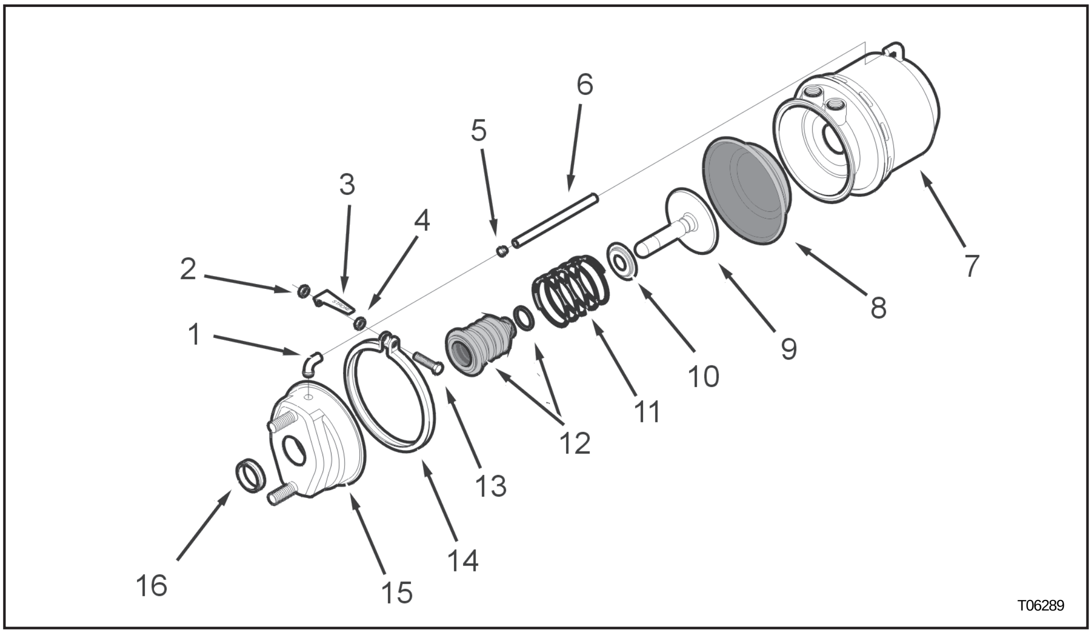

Figure 1: Drive axle brake chamber

1. **Breather tube elbow**
2. **Nut**
3. **Stroke tag**
4. **Nut**
5. **Porous-metal filter**
6. **Breather tube**
7. **Spring brake chamber**
8. **Diaphragm**
9. **Push-rod**
10. **Spring seat**
11. **Return spring**
12. **Rubber boot (+ retaining ring)**
13. **Clamp ring bolt**
14. **Clamp ring**
15. **Non-pressure plate**
16. **Ring**

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2. Thoroughly clean the exterior of the brake chamber and scribe a line across the chamber to ensure correct assembly alignment.

3. Remove breather tube (6) connected between the two rubber elbows at the front and rear of the brake chamber.

!!! CAUTION !!!
USE CAUTION WHEN REMOVING THE CLAMP RING BECAUSE OF TENSION OF RETURN SPRING.

4. Remove clamp ring (14).
5. Remove non-pressure plate (15) from spring brake chamber (7).
6. Discard diaphragm (8), ring (16), rubber boot (12), porous-metal filter (5) and elbow (1).
7. Clean all other parts.
8. Open Van Hool repair kit 10904813. The kit contains a diaphragm, a ring to secure rubber boot, a rubber boot, a porous-metal filter and an elbow.
9. Slide spring seat (10) onto push-rod (9).
10. Install spring (11) on push-rod (9).
11. Slide new rubber boot (12) with its retaining ring on push-rod (9) until it snaps in the push-rod groove.
12. Position the push-rod assembly in the non-pressure plate. Pull the sealing lip of rubber boot (12) over the edge of the non-pressure plate hole. Install ring (16) to secure rubber boot (12). For the position of ring (16), refer to figure 2.

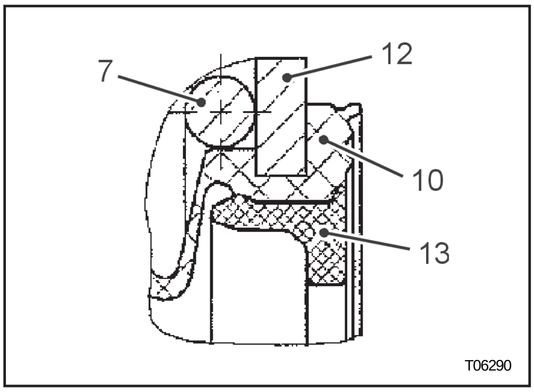

Figure 2: Position of ring (16) to secure rubber boot (12) to non-pressure plate (15)

13. Fit the new diaphragm onto the spring brake chamber.

!!! CAUTION !!!
DO NOT TWIST RUBBER BOOT (12) DURING ASSEMBLY AS THIS WILL CAUSE PREMATURE FAILURE OF THE CALIPER DUE TO CORROSION.

14. With the marks previously inscribed aligned, fit the non-pressure plate onto the spring brake chamber.
15. Refit the clamp ring. Install bolt (13) and nut (4). Tighten nut (4) to a torque of 10 to 12 Nm (8 to 9 ft.lbf).
16. Install "3.00/75.0 Stroke" tag (3) and nut (2). Tighten nut (2) to a torque of 10 to 12 Nm (8 to 9 ft.lbf).
17. Install new porous-metal filter (5) and elbow (1). Reinstall the breather tube between the rubber elbows at front and rear.
18. Remount the brake chamber on the vehicle.
19. Carry out the tests indicated under MAINTENANCE earlier in this section.

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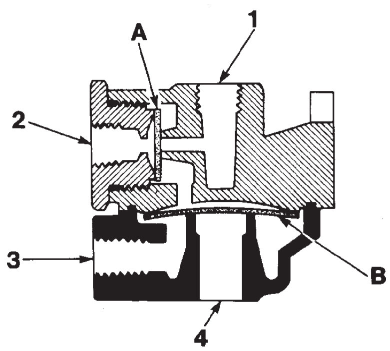
To repair / overhaul spring brake chamber

!!! CAUTION !!!

SPRING BRAKE CHAMBER IS NOT REPAIRABLE. IN CASE OF FAILURE, COMPLETE SPRING BRAKE CHAMBER MUST BE REPLACED BY A NEW UNIT.

SPRING BRAKE CHAMBER CONTAINS A SPRING WITH HIGH FORCE. DO NOT TRY TO OPEN SPRING BRAKE CHAMBER.



1. Balance port
2. Supply port
3. Delivery port
4. Exhaust

A. Double check diaphragm
B. Quick release diaphragm

Figure 3: Quick release double check valve

QUICK RELEASE DOUBLE CHECK VALVE

GENERAL

This valve has a dual function. The primary function is to serve the emergency side of a spring brake actuator as a quick release valve. In addition, it functions as an anti-compound device. The double check valve prevents a service and emergency brake application from occurring simultaneously.

The air connections are as follows:

1. Delivery port (3) connected to emergency part of the spring brake.
2. Balance port (1) connected to delivery port of relay valve.
3. Supply port (2) connected to delivery of park control valve.

OPERATION

Spring brake released

When the spring brakes are released, air from the park control valve flows through the valve, causing the double check diaphragm (A) and quick release diaphragm (B) to flex and seal the balance and exhaust ports (4). Air flows into the emergency port of the spring brakes from the valve delivery ports.

Spring brake applied

When the spring brakes are applied, supply line air pressure to the valve is exhausted through the park control valve. As air pressure is removed from one side of the double check and quick release diaphragms, they flex in the opposite direction, opening the balance and exhaust port. Spring brake emergency pressure is released at the exhaust port of the valve while the small amount of air trapped between the two diaphragms is released through the balance port.

Anti-compounding

When a service brake application is made with the spring brake applied, service air enters the balance port and

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flows through the valve into the emergency ports of the spring brakes. This prevents the compounding of a service and spring brake application. Service air passing through the valve flexes the double check and quick release diaphragms, sealing the supply and exhaust ports. When the service application is released, air is exhausted from the spring brakes.

MAINTENANCE

Before performing these tests, park the vehicle on a level surface and hold the vehicle by means other than the brakes.

1. With the park control valve in the released position, note that the spring brakes are released.

2. Remove the air line connected to the balance port and apply a soap solution to the exhaust and balance port. A 1 inch bubble in five seconds is permissible at either location.

3. Reconnect the balance in line and, using the park control valve, park the vehicle.

NOTE
A PROMPT APPLICATION OF THE SPRING BRAKES WILL EXHAUST AIR AT THE EXHAUST PORT.

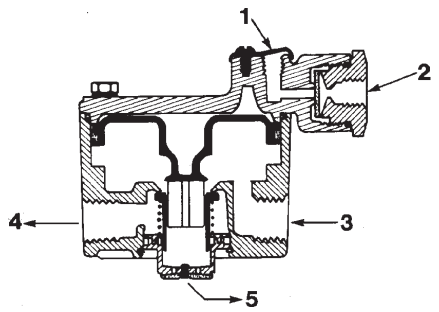
4. Remove the air line connected to the supply port of the valve. With a service brake application hold applied, apply a soap solution to the supply port and around the seam between the body and cover. A 1 inch bubble in 5 seconds is permissible at the supply port. No leakage is permitted between the body and the cover.

5. Reconnect the supply port air line. 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.

RELAY VALVE

GENERAL

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 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.



1. Balance port
2. Service port
3. Supply
4. Delivery
5. Exhaust

T02873

Figure 4: Relay valve

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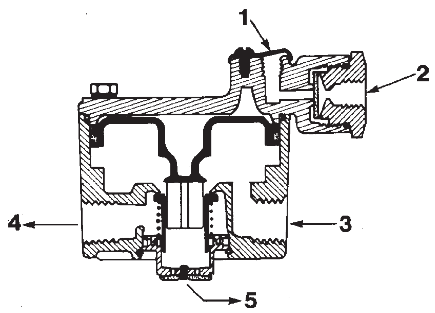

1. Balance port
2. Service port
3. Supply
4. Delivery
5. Exhaust

T02873

Figure 4: Relay valve

OPERATION

Application

Air pressure delivered to the service port (2) 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 of the 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 retuns 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 pasage (5). With the exhaust passage open, the air pressure in the brake chambers is then permitted to exhaust through the exhaust port, releasing the brakes.

MAINTENANCE

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 valve is used to control the service brakes.

   b. Make the check with the spring brake applied (PARK) when the valve is used to control the spring brakes.

   Coat the exhaust port and area around the retaining ring with a soap solution. A 1 inch bubble in 3 seconds leakage is permitted.

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4. Check for exhaust valve leakage.

   a. Make this check with the service brakes fully applied if the valve controls the service brakes.

   b. Make this check with the spring brakes fully released if the valve 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 covers joins the body to check for seal ring leakage. No leakage is permitted.

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"D-ELSA" TAG WHEEL BRAKES - MECHANICAL SYSTEM

SPECIFICATIONS

Refer to section 5.1 "D-ELSA front wheel brakes - Mechanical system".

MAINTENANCE

Refer to section 5.1 "D-ELSA front wheel brakes - Mechanical system".

OVERHAUL

Refer to section 5.1 "D-ELSA front wheel brakes - Mechanical system".

US0550AG

"D-ELSA" TAG WHEEL BRAKES - AIR SYSTEM

BRAKE CHAMBERS

!!! CAUTION !!!
THIS IS A LONG STROKE BRAKE CHAMBER. MAXIMUM ALLOWABLE PUSH ROD STROKE IS 3.00 INCHES.

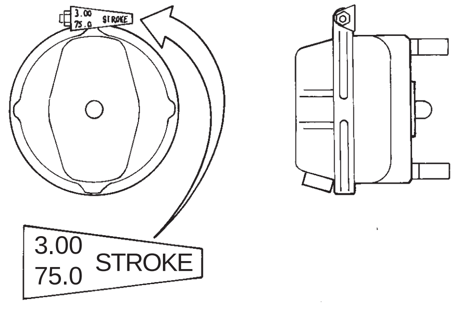

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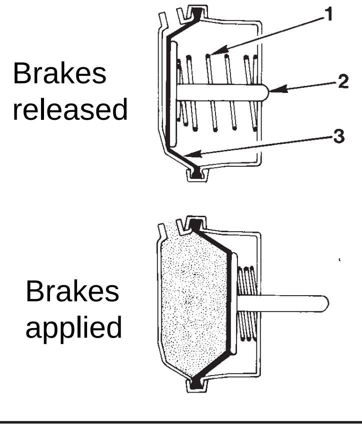
Figure 1: Long stroke brake chamber identification (16" brake chamber)

THEORY OF OPERATION

If brake pedal is depressed, compressed air enters the chamber behind the pressure side of diaphragm (3). Diaphragm (3) is forced outward together with push rod (2), overcoming the force of spring (1). As a result, the brake pads are forced against the brake disc. The air on the other side of the diaphragm is exhausted through a vent hole. When the brakes are released, the force of the release spring (1) returns the push rod assembly (2) and diaphragm (3) to its fully OFF position.



T05583

Figure 2: Brake chamber

MAINTENANCE

At service intervals, clean exterior of brake chamber. Inspect for damage and air leaks from clamp ring and vent holes in non-pressure plate.

1. Chock wheels so that vehicle cannot move.
2. Apply liquid soap to clamp ring and vent holes.
3. Apply full pressure to chamber. Watch for leaks. There should be no leakage at vent hole (leakage indicates a defective brake diaphragm). Only slight frothing is allowed at clamp ring.

OVERHAUL

To remove brake chamber

1. Block wheels so that coach cannot move.
2. Use drain valve to remove all air from air supply system.
3. Disconnect air line from brake chamber. Plug end of line.

5. Remove nuts and lock washers from the mounting studs, then remove brake chamber assembly from caliper.

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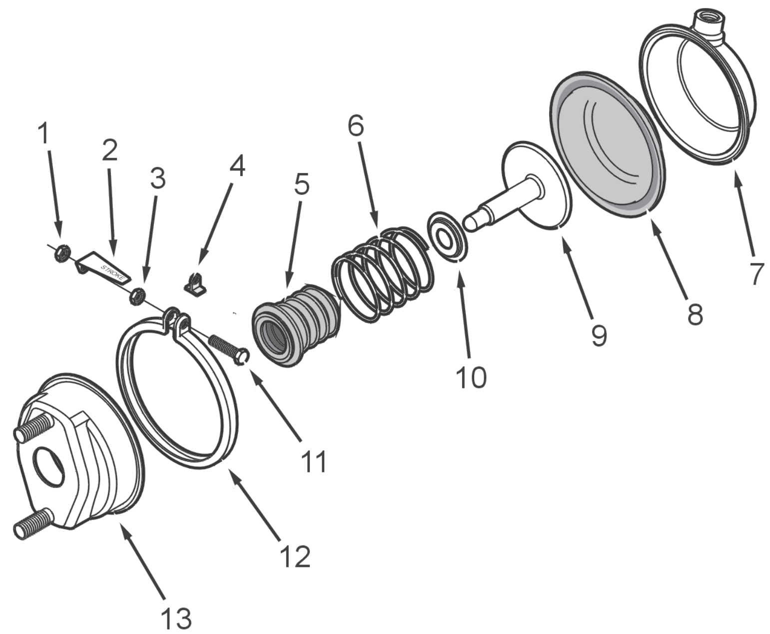

Figure 3: Exploded view of brake chamber

1. **Nut**
2. **Stroke tag**
3. **Nut**
4. **Packing piece**
5. **Rubber boot**
6. **Return spring**
7. **Pressure plate**
8. **Diaphragm**
9. **Push-rod**
10. **Spring seat**
11. **Clamp ring bolt**
12. **Clamp ring**
13. **Non-pressure plate**

To install brake chamber

1. Position brake chamber at caliper with air line connection at the top and with mounting studs through holes in caliper. Install lock washer and nut on each stud and tighten to a torque of 135 to 155 ft.lbf. Reconnect air pressure line.

2. Be sure that the lowest vent hole in the non-pressure plate is open and the other ones plugged with plastic plugs.

3. Check for leaks at all connections. Use a soap and water solution to check for leaks.

To change brake chamber diaphragm -Figure 2

1. Mark non-pressure plate (13), pressure plate (7) and clamp ring (12). Parts may then be reassembled in the same position as before disassembly.

!!! CAUTION !!!
USE CAUTION WHEN REMOVING THE CLAMP RING BECAUSE OF TENSION OF RETURN SPRING.

2. Remove nut (1) from clamp ring bolt (11) and remove "3.00/75.0 Stroke" tag (2). Remove nut (3) and bolt

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(11). Spread clamp ring (12) and remove from plates, then remove pressure plate (7) and diaphragm (8).

3. Remove push rod (9) and spring (6) from non-pressure plate (13).
4. Clean all metal parts thoroughly, using a suitable cleaning solvent.
5. Examine push rod and spring. Replace with new parts if not in first class condition.
6. Inspect pressure plate and non-pressure plate. Clamping flanges on plates should not be bent or otherwise damaged. Replace damaged parts.
7. Open Van Hool repair kit 10904810. The kit contains a diaphragm, a spring seat, a rubber boot and a packing piece.
8. Slide new spring seat (10) on push-rod (9).
9. Slide new rubber boot (5) on push-rod (9).
10. Install spring (6) on push-rod (9).
11. Position the push-rod assembly in non-pressure plate (13). Pull the sealing lip of rubber boot (5) over the edge of the non-pressure plate hole.
12. Fit new diaphragm (8) onto pressure plate (7).

!!! CAUTION !!!
DO NOT TWIST RUBBER BOOT (5) DURING ASSEMBLY AS THIS WILL CAUSE PREMATURE FAILURE OF THE CALIPER DUE TO CORROSION.

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13. With the marks previously inscribed aligned, fit non-pressure plate (13) onto pressure plate (7).
14. Place clamp ring (12) and align marks.
15. Draw clamp ring (12) together, with new packing piece (4) inserted between clamp ring ears. Install bolt (11) and nut (3). Tighten nut (3) to a torque of 10 to 14 Nm (8 to 10 ft.lbf).
16. Install "3.00/75.0 Stroke" tag (2) and nut (1). Tighten nut (1) to a torque of 10 to 17 Nm (8 to 12 ft.lbf).

RELAY VALVE

Refer to "D-ELSA Drive wheel brakes - Air system".

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JAKE BRAKE

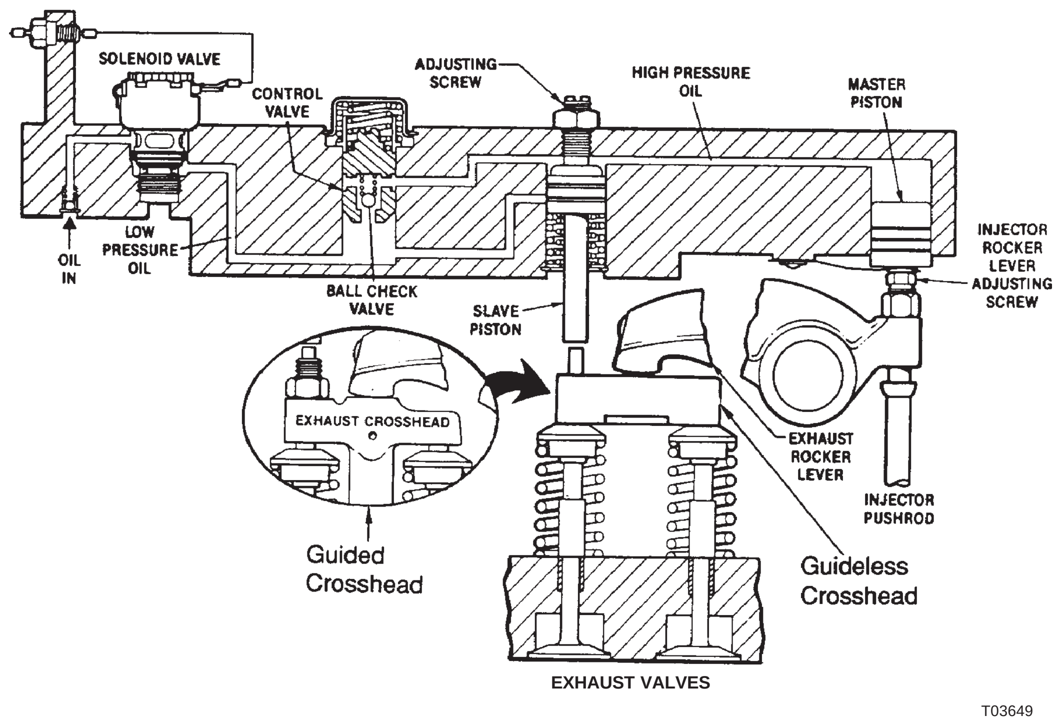

Figure 1: Schematic diagram of engine brake operation

THEORY OF OPERATION

Simply stated, 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.

EXHAUST BLOWDOWN

Referring to the schematic drawing, exhaust blowdown occurs as follows:

1. Energizing the solenoid valve permits engine lube oil to flow under pressure through the control valve to both the master piston and the slave piston.

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

3. The injector rocker arm adjusting screw begins upward travel (as in normal injection cycle) forcing the master piston upward and directing high-pressure oil to the slave piston.

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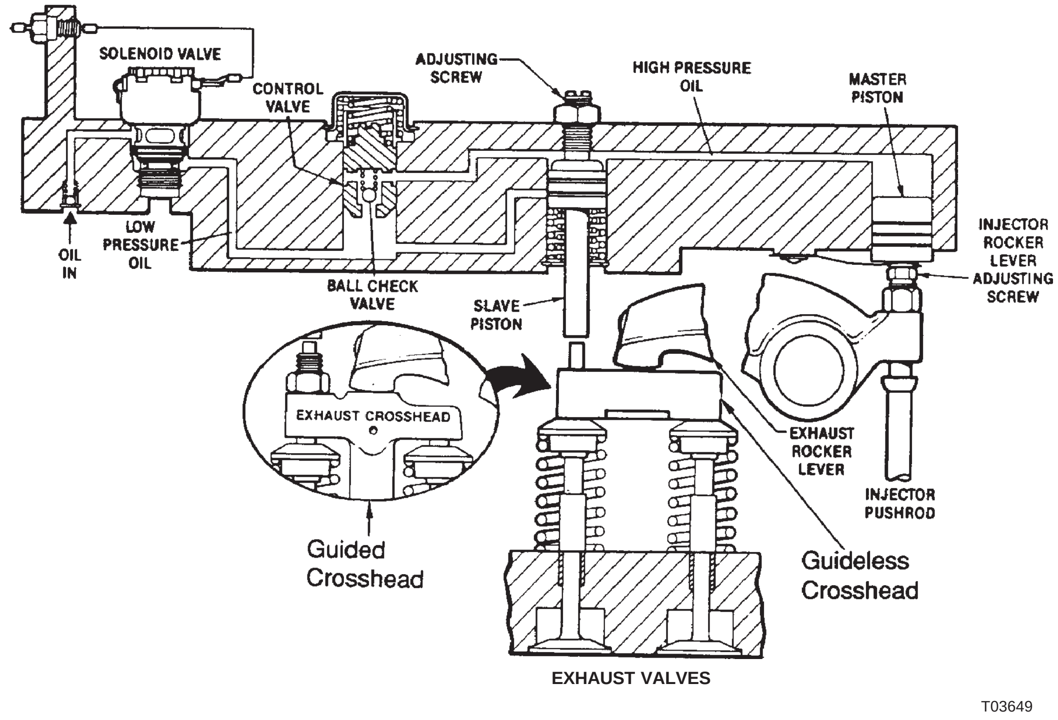

Figure 1: Schematic diagram of engine brake operation

The ball check valve in the control valve imprisons high-pressure oil in the master-slave piston system.

4. The slave piston under the influence of the high-pressure oil moves down, momentarily opening the exhaust valve, while the engine piston is near its top dead center position, releasing compressed cylinder air to the exhaust manifold.

5. Compressed air escapes to the atmosphere, completing a compression brake cycle.

US0570AI

ABS AND ASR

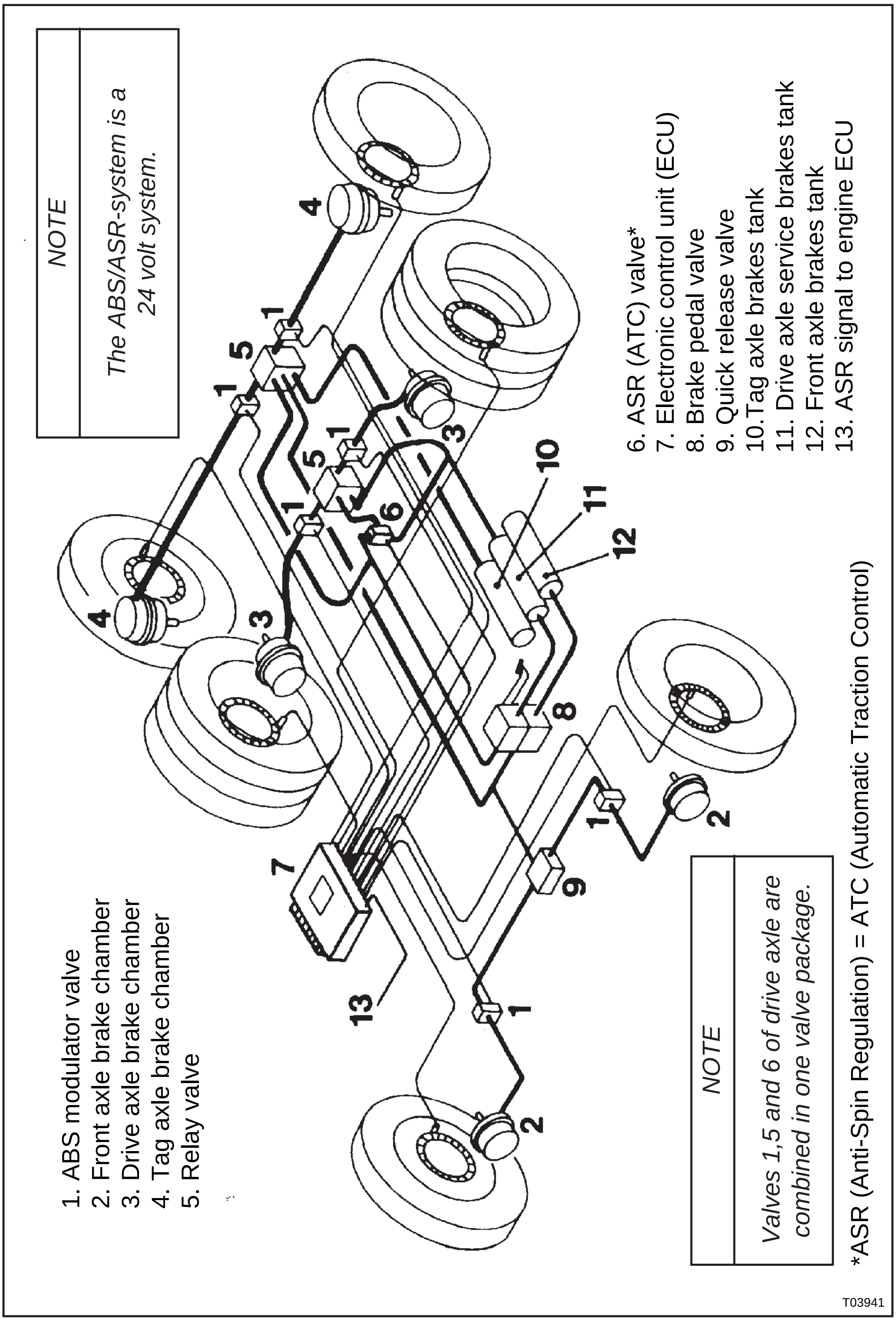

Figure 1: 6S/6M ABS/ASR configuration

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ANTI-LOCK BRAKING SYSTEM (ABS)

Meritor WABCO ABS is an electronic system that prevents wheel lock-up in conventional air brake systems during severe braking. ABS monitors wheel speeds at all times. As wheel speed decreases and approaches lock-up, brake pressure is modulated to allow wheels to continue rotating at just above the lock-up point. Since the tires are not allowed to skid, vehicle stability and control are greatly improved.

In the event of a malfunction in the system, the ABS of the affected wheel(s) is disabled, while retaining the normal brake functions. The other wheels keep the ABS function.

The ABS warning lamp on the dashboard lets drivers know the status of the system. This symbol is also used to display blink code diagnostics.

ABS works fully automatic, drivers do not have to select this feature.

ABS CONFIGURATION

The ABS configuration on your coach is the 6S/6M. This means the system has 6 wheel sensors(6S) and 6 modulator valves(6M).

ABS COMPONENTS

Electronic control unit (ECU)

The ECU is the brain of the system. It receives information from the sensors and sends signals to the ABS modulator valves.
The ECU is mounted in the main junction box (in luggage compartment).

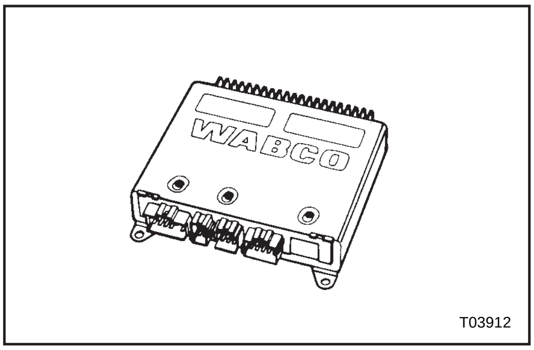

Figure 2: Electronic control unit

Tooth wheel and sensor

A tooth wheel(A) is mounted on the hub of each wheel, with a sensor(B) installed so that its end is close against the tooth wheel. A sensor clip(C) holds the sensor in place at the tooth wheel.

The sensor and clip must be greased with special high temperature grease (VH No.10610096).

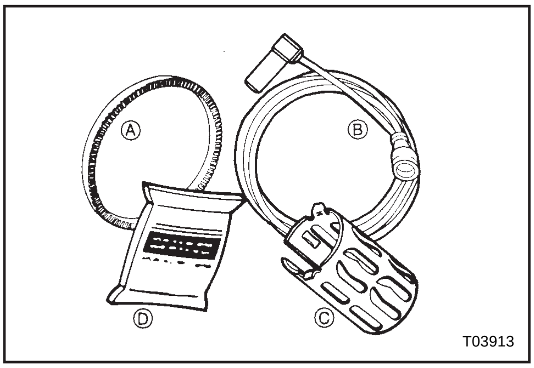

Figure 3: Tooth wheel and sensor

ABS modulator valve

An ABS modulator valve controls air pressure to each affected brake during an ABS event.

The ABS valves are located between:

- the quick release valve and the brake chambers at the front axle;
- the relay valve and the brake chambers at the tag axle.

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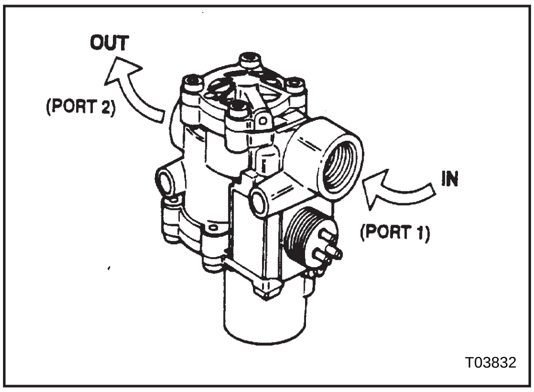


Figure 4: ABS modulator valve

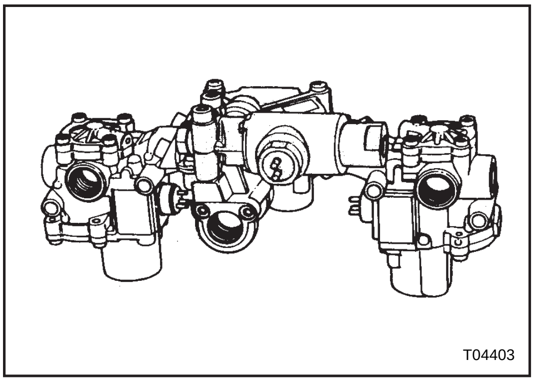
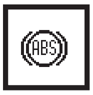


Figure 5: ABS/ASR valve package

At the drive axle an ABS/ASR valve package is used. It combines two ABS modulator valves, one relay valve and one ASR-valve.

ABS warning lamp



The ABS warning lamp is located in the lamp cluster on the central dashboard.

The ABS warning lamp comes on as follows with ignition on:

ABS lamp comes on momentarily for a bulb check, then goes out.	System is O.K.
ABS lamp does not go out at ignition.	•When coach is driven at speeds above 4mph, lamp goes out. System O.K. •If lamp does not go out at speeds above 4mph, the ECU senses a fault in the ABS system.

If the ECU senses a fault during normal coach operation, the ABS warning lamp will come on and stay on.

Optional test equipment

The MPSI Pro-Link® 9000 with the Meritor WABCO cartridge, available from Kent-Moore, lets you test ABS components.

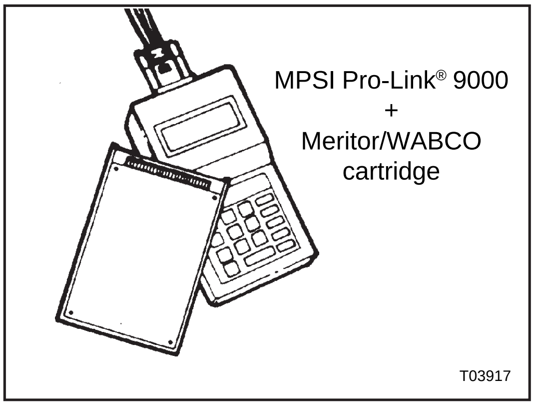


Figure 6: Optional test equipment

ANTI-SPIN REGULATION (ASR)

ASR helps improve traction when coach is on slippery surfaces by reducing drive wheel overspin. ASR works automatically in two different ways:

1. If a drive wheel starts to spin, ASR applies air pressure to brake the wheel.This transfers engine torque to the wheels with better traction.
2. If all drive wheels spin, ASR reduces engine torque to provide improved traction.

ASR turns itself on and off, drivers do not have to select this feature.

ASR

If drive wheels spin during acceleration, the ASR indicator lamp on the lamp cluster comes on, indicating ASR is active. It goes out when the drive wheels stop spinning.

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DEEP SNOW AND MUD SWITCH

This function increases available traction on extra soft surfaces like slush or mud, or on snow-covered upgrades, by slightly increasing the permissible wheel spin.

When this feature is selected, the ASR indicator lamp blinks continuously.

Here's how the deep snow and mud feature works:

Driver action	System response	Function	
		Active	Not active
Press deep snow and mud switch.	ASR lamp blinks continuously.	X	
Press switch again.	ASR lamp stops blinking.		X

NOTE
TURNING OFF THE IGNITION WILL ALSO DEACTIVATE THE DEEP SNOW AND MUD FEATURE.

ASR VALVE

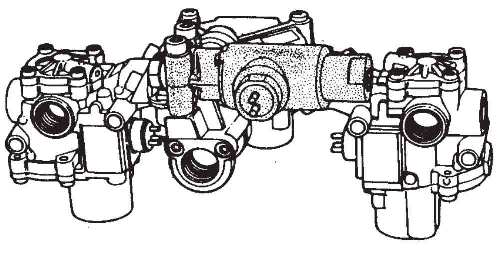

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Figure 7: ABS/ASR valve package (Dotted:ASR valve)

MAINTENANCE

There is no regular maintenance required for the Meritor WABCO ABS/ ASR. However, ABS does not change current vehicle maintenance requirements.

WARNING LAMP CHECK

To make sure the ABS lamp is operating, you should check the lamp every time the coach is started. When the coach is started, the ABS lamp should come on momentarily. If it does not come on, it could mean a burned-out bulb.

TROUBLESHOOTING

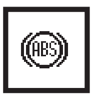
SUGGESTED DIAGNOSTIC TOOLS

Standard: Blink Code Diagnostics

Optional:
- Pro-Link® 9000
- TOOLBOX software. Is a PC-based diagnostics program. Runs in Windows 95, 98 and NT. An RS232 to J1708 convertor box is required. Refer to TOOLBOX software manual for operating instructions.

BLINK CODE DIAGNOSTICS

Before using blink code diagnostics, you should be familiar with a few basic terms.



ABS warning lamp: This lamp serves two purposes: it alerts drivers to an ABS fault and it is used during diagnostics to display the blink code.

Blink code: A series of blinks or flashes that describe a particular ABS system fault or condition.

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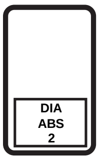
Blink code cycle: Two sets of flashes with each set separated by a one-and-one-half second pause. Blink codes are defined in tables 3 and 4.



Diagnostic switch: This switch activates blink code diagnostic capabilities. This switch is located in the diagnostic box in the R.H. console of the dashboard.

Clear: The process of erasing faults from the ECU.

Diagnostics: The process of using blink codes to determine ABS system faults.

Fault: An ABS malfunction detected and stored in memory by the Meritor WABCO ECU. System faults may be **Active** or **Stored**.

Active fault: A condition that currently exists in the ABS system; for example, a sensor circuit malfunction on the left front wheel. An active fault must be repaired before it can be cleared from memory - and before you can display additional faults.

Stored fault: There are two types of stored faults:

a) A repaired active fault that has not been cleared from the ECU.

b) A fault that occurred but no longer exists. For example, a loose wire that makes intermittent contact. Because stored faults are not currently active they do not have to be repaired before they can be cleared from memory.

Meritor WABCO recommends you keep a record of these faults for future reference.

System configuration code: One digit code displayed during the clear mode (6S/6M = 1 flash of ABS lamp).

DIAGNOSTIC MODE

To enter the diagnostic mode, press and hold the diagnostic switch for one second, then release.

CLEAR MODE

To erase faults from the ECU, you must be in the clear mode. To enter the clear mode, press and hold the diagnostic switch for at least three seconds, then release.

If the system displays eight quick flashes followed by a system configuration code, the clear was successful. The ABS fault has been cleared from memory.

If you do not receive eight flashes, there are still active faults that must be repaired before they can be cleared.

NOTE
IF YOU HAVE ANY QUESTIONS CONCERNING DIAGNOSIS ISSUES YOU ARE INVITED TO CONTACT THE MERITOR/WABCO ORGANIZATION.

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BLINK CODE DIAGNOSTIC PROCEDURE (TABLE 1)

Follow these steps to use the blink code:

MODE	PROCEDURE	SYSTEM RESPONSE	ACTION
DIAGNOSTIC	**Step I** Turn ignition key **ON**.	Three responses possible: 1. ABS warning lamp comes on momentarily then goes out, indicating system is O.K.	No recognizable active faults in the ABS. No action required.
		2. ABS warning lamp does not light, indicating possible wiring fault or burned-out bulb.	Inspect wiring. Inspect bulb. Make necessary repairs.
		3. ABS warning lamp stays on, indicating there is a fault, or faults, in the system.	Continue with blink code diagnostics.**(Go to Step II)** Determine if fault is active or stored:
	Step II Press and hold diagnostic switch for one second, then release.	ABS warning lamp begins flashing two-digit blink code(s).	**Active fault:** Lamp will repeatedly display one code. **Stored fault:** Lamp will display code for each stored fault then stop blinking. Faults will be displayed **one time only**. Turn ignition OFF.
	Step III Count the flashes to determine the blink code.	First digit: 1 - 8 flashes, pause(1-1/2 seconds). Second digit: 1 - 6 flashes, pause(4 seconds)	Find definition for blink code in tables 3 and 4. Make the necessary repairs.
	Step IV Repair and record faults.	Active fault.	Repeat steps I, II and III until system O.K. code (1 - 1) received.
		Stored faults.	Record for future reference. *NOTE* *Last fault stored is first fault displayed.*
CLEAR	**Step V** Clear faults from memory: Press and hold diagnostic switch for at least three seconds, then release.	ABS warning lamp flashes eight times.	All faults successfully cleared. Turn ignition off.
		Eight flashes not received.	Active faults still exist, repeat steps I through V.

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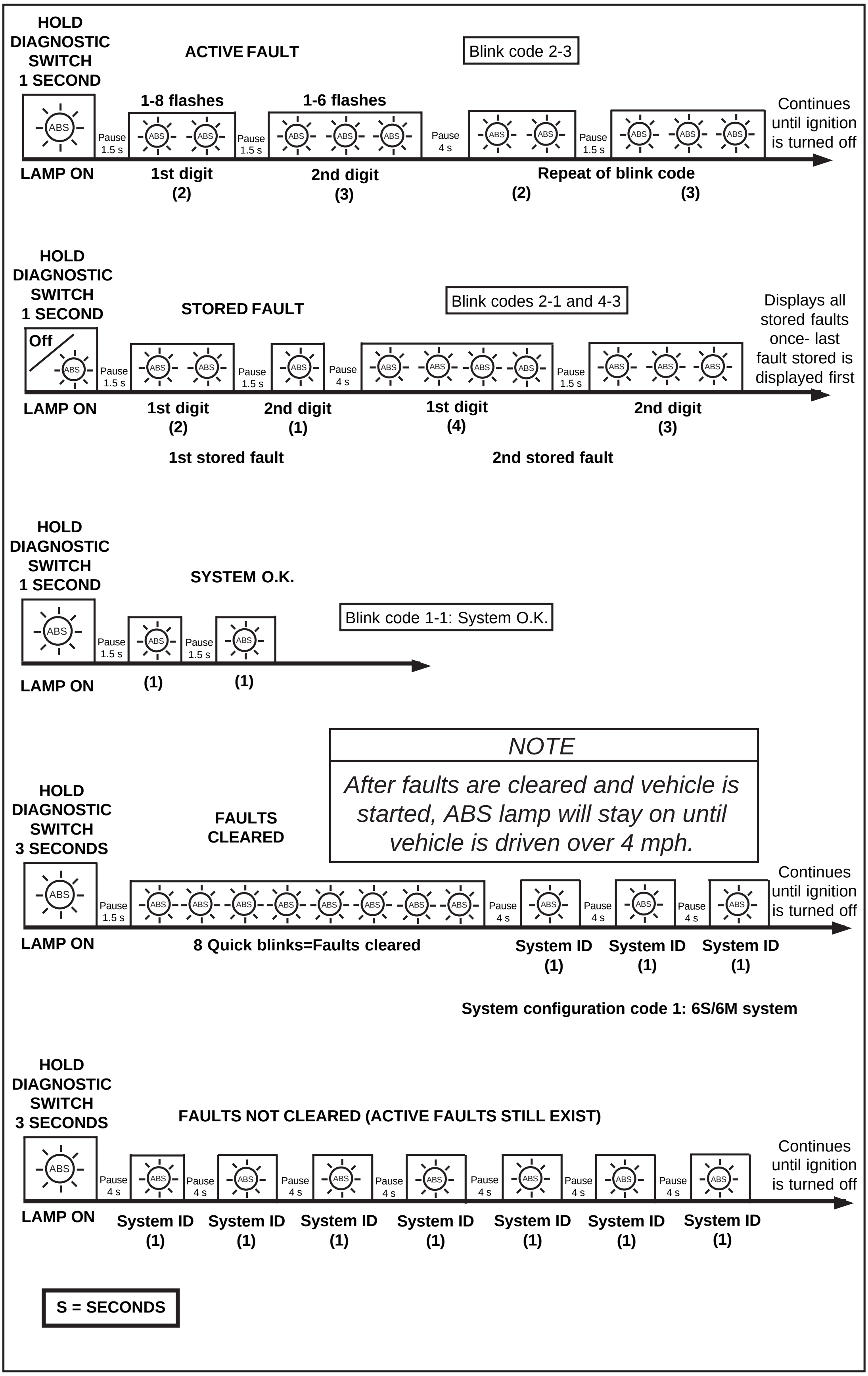

Figure 8: Blink code illustrated

WORKING WITH BLINK CODES (TABLE 2)

When using blink code diagnostics, the following conditions could occur:

CONDITION	REASON	ACTION
ABS warning lamp does not come on at ignition.	Loose or burned-out bulb.	Check connections. Check bulb. Make necessary repairs.
	Voltage not within acceptable range (18-30 volts).	Check connections. Measure voltage. Make necessary repairs.
Can't use blink code diagnostics; ABS lamp will not go off when blink code is activated.	Switch not held for proper length of time: 1 second - Diagnostics mode 3 seconds - Clear all mode	Repeat procedure, hold switch for proper length of time.
	Improper or faulty wiring.	Inspect and repair wiring.
Eight flashes not received after diagnostic switch pressed for **at least** three seconds, then released.	Active faults still exist.	Identify active faults, then make necessary repairs. Turn ignition off, then repeat blink code diagnostics.

BLINK CODE IDENTIFICATION *(TABLE 3)*

FIRST DIGIT(Type of fault)	SECOND DIGIT(Specific location of fault)
1 No faults	**1** No faults
2 ABS modulator valve **3** Too much sensor gap **4** Sensor short or open **5** Sensor signal erratic **6** Tooth wheel	**1** Right front wheel **2** Left front wheel **3** Right drive wheel **4** Left drive wheel **5** Right tag wheel **6** Left tag wheel
7 System function	**1** J1922 or J1939 datalink **2** ASR valve **3** Retarder relay(auxiliary brake) **4** ABS warning light **5** ASR configuration **6** Reserved for future use
8 ECU	**1** Low power supply **2** High power supply **3** Internal fault **4** System configuration error **5** Ground

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BLINK CODE TROUBLESHOOTING AND REPAIR*(TABLE 4)*

BLINK CODE	ACTION REQUIRED	REFERENCE
2-1 2-4 2-2 2-5 2-3 2-6	Check ABS modulator valve, valve cable, and connectors. Verify ABS modulator valve resistance.	Resistance check,page 11
3-1 3-2 3-3 3-4 3-5 3-6	Adjust wheel sensor to touch tooth wheel. Check sensor gap. Check for loose wheel bearings or excessive hub runout. Verify sensor output voltage.	Sensor adjustment,page 11 Sensor voltage check,page 11 Prolink component test,page 10
4-1 4-2 4-3 4-4 4-5 4-6	Check sensor, sensor cable, and connectors. Verify resistance.	
5-1 5-2 5-3 5-4 5-5 5-6	Check for tire size mismatch or tooth wheel difference. Check sensor, sensor cable, and connector for intermittent contact.	Tire size range
6-1 6-2 6-3 6-4 6-5 6-6	Check for damaged tooth wheel.	
7-1	Check for proper data link connection(J1922 and J1939). Verify wheelspin on each axle.	Wiring diagram
7-2	Check ASR valve, valve cables, and connectors.	Resistance check,page 13
7-3	Check retarder (auxiliary relay) connections.	Wiring diagram
7-4	Check ABS warning lamp connections.	
7-5	Verify proper ASR set-up.	
7-6	Verify accuracy of blink code and clear from ECU memory.	Blink code diagnostics,page 4
8-1	Check coach voltage and supply to ECU.	Wiring diagram Voltage check,page 11
8-2	Check vehicle voltage. Verify accuracy of blink code and clear from ECU memory.	Voltage check,page 11 Blink code diagnostics,page 4
8-3	Verify accuracy of blink code and clear from ECU memory.	Blink code diagnostics,page 4
8-4	Verify all ECU connectors are in place. Verify accuracy of blink code and clear from ECU. If code does not clear, it may be necessary to replace the ECU.	Contact Van Hool Service Center.
8-5	Check ABS ground connections.	Wiring diagram.

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MSPI PRO-LINK® 9000

NOTE
YOU MUST USE THE D VERSION CARTRIDGE, 4.0 OR HIGHER.

Use the Pro-Link® 9000 to:

- Diagnose system faults on ABS and ABS/ASR systems.
- Perform component measurement and function tests.

NOTE
THE PRO-LINK® MAY BE USED IN PLACE OF BLINK CODE DIAGNOSTIC PROCEDURES.

COMPONENT TESTS

Components that may be tested with the Pro-Link 9000 are:

- Vehicle voltage
- ABS modulator valves
- ASR valves
- ABS/ASR lamps
- Sensors
- Engine datalink
- Retarder relay
- Retarder datalink
- ABS/ASR switches

DIAGNOSTIC AND TESTING PROCEDURE

1. Slide the Meritor WABCO D version cartridge into the Pro-Link keypad until the connection is tight (see figure 9).

2. Chock the wheels, apply the parking brake, and make sure ignition is off.

3. Insert the 6-pin connector from the Pro-Link into the 6-pin diagnostic receptacle(see figure 10).

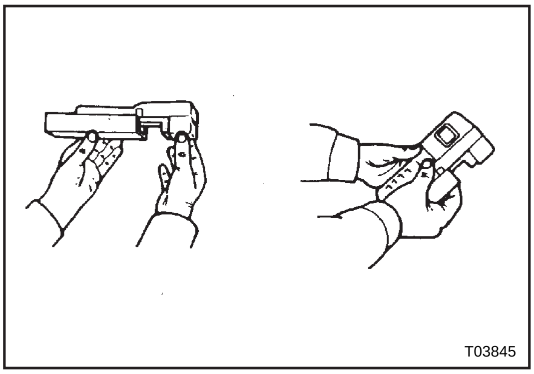

Figure 9: To slide cartridge into Pro-Link keypad

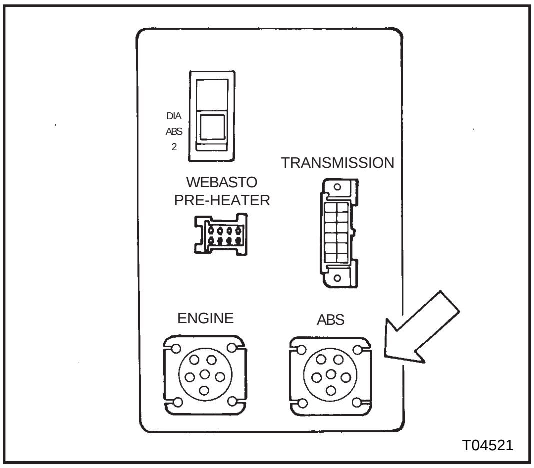

Figure 10: 6-pin diagnostic receptacle (located in diagnostic box in R.H. console of dashboard)

4. Turn the ignition ON.

5. The Pro-Link screen should power up. If the Pro-Link does not power up, or if the screen indicates NO DATA RECEIVED:
   - Check connections.
   - Make sure the cartridge is properly connected to the Pro-Link keypad.
   - Verify 24 volts DC power and ground at the connector and ABS ECU.
   - Check the fuse panel for a blown fuse.
   - Check for proper wiring in the diagnostic connector.

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6. Refer to the Pro-Link manual for complete diagnostic and testing instructions.

TIRE SIZE RANGE

For proper ABS/ASR operation with the standard ECU, front and rear tire sizes must be within ± 14 % of each other. When this tire size range is exceeded without electronically modifying the ECU, the system performance can be affected and the warning lamp can illuminate.

Calculate the tire size range with the following equation:

$$\% \text{ Difference} = \left\{ \frac{\text{RPM Front}}{\text{RPM Drive}} - 1 \right\} \times 100$$

(RPM: tire revolutions per mile)

TESTING COMPONENTS

!!! CAUTION !!!

WHEN TROUBLESHOOTING AND TESTING THE ABS SYSTEM, DO NOT DAMAGE THE CONNECTOR TERMINALS.

VOLTAGE CHECK

Voltage must be between 18 and 30 volts. The ignition must be turned ON for this test.
Measure voltage between pin 7 and pin 10, pin 8 and pin 11, and pin 9 and pin 12 of the 18 pin ECU connector. For numbering and location of pins, see Figure 16.

SENSOR ADJUSTMENT

- Push the sensor in until it contacts the tooth wheel.
- Do not pry or push sensors with sharp objects.
- Sensors will self-adjust after wheel rotation.

SENSOR OUTPUT VOLTAGE TEST

Voltage must be at least 0.2 volts AC at 30 rpm. To check sensor voltage:

1. Turn ignition OFF.
2. Rotate wheel by hand at 30 rpm (1 revolution every 2 seconds).
3. Measure voltage at the following pins:

Sensor	ECU-connector	Pins
Left front	6-pin	4 and 5
Right front	9-pin	4 and 5
Left drive	15-pin	5 and 6
Right drive	15-pin	8 and 9
Left tag	12-pin	5 and 6
Right tag	12-pin	8 and 9

SENSOR RESISTANCE

The sensor circuit resistance must be 900-2000 ohms. Resistance can be measured at the sensor connector, or at the pins on the ECU connector. To measure resistance:

1. Turn ignition OFF.
2. To measure resistance at the ECU connector, disconnect the ECU connector from the ECU. Measure resistance at the pins indicated in table under "Sensor output voltage test".
3. To measure resistance at the sensor connector, disconnect the sensor from the sensor extension cable.

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ABS MODULATOR VALVE

Measure resistance across each valve solenoid coil terminal and ground on the ABS valve to ensure 11 to 21 ohms.

• If the resistance is greater than 21 ohms, clean the electrical contacts of the solenoid. Check the resistance again.

- To check the cable and ABS valve as a unit, measure resistance across the pins:
  - 1 and 3, and 2 and 3 on the ECU 6 pin-connector of the harness for the ABS valve of the left front wheel.
  - 7 and 9, and 8 and 9 on the ECU 9 pin-connector of the harness for the ABS valve of the right front wheel.
  - 1 and 3, and 2 and 3 on the ECU 15 pin-connector of the harness for the ABS valve of the left drive wheel.
  - 10 and 12, and 11 and 12 on the ECU 15 pin-connector of the harness for the ABS valve of the right drive wheel.
  - 1 and 3, and 2 and 3 on the ECU 12 pin-connector of the harness for the ABS valve of the left tag wheel.
  - 10 and 12, and 11 and 12 on the ECU 12 pin-connector of the harness for the ABS valve of the right tag wheel.

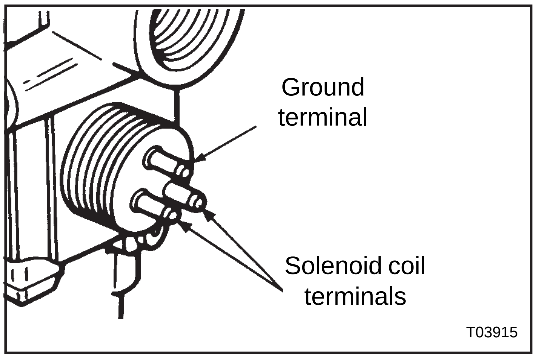

Figure 11: ABS modulator valve terminals

MERITOR WABCO ABS VALVE PACKAGE TROUBLESHOOTING

This troubleshooting guide is a reference tool to help identify possible malfunctions of the ABS modulator or relay valves. It does not take the place of diagnostic tests or other service instructions.

TABLE 5

CONDITION	POSSIBLE CAUSE	RECOMMENDED ACTION
Air constantly leaks from exhaust port of relay valve.	Internal relay valve problem.	• Replace the relay valve.
Air leaks from exhaust port of ABS modulator valve or relay valve when parking brake is released.	Parking brake problem. or Anti-compound 2-way check valve problem.	• Service appropriate component.
Drive wheel service brakes releasing slowly(brakes dragging).	Kinked air line. Dirt build-up inside relay valve.	•Inspect/repair lines, brakes. ***If condition is not corrected:*** •Replace relay valve.

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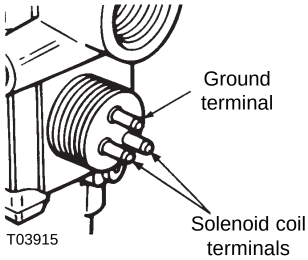
TABLE 5 (CONTINUED)

CONDITION	POSSIBLE CAUSE	RECOMMENDED ACTION
Valves don't cycle at power-up. or Warning lamp comes on (blink code or diagnostic tool indicates electrical problem with ABS valve).	Broken wire. or Loose or broken terminal connection. Corroded connector pins or Problem with solenoid. 	•Check wires and connections. -Make repairs as needed. ***If condition is not corrected:*** • Measure resistance across each valve solenoid coil terminal and ground on the ABS modulator valve to ensure 11 to 21 ohms. - If greater than 21 ohms, clean terminals in the solenoid coils - If cleaning does not solve problem, replace the ABS modulator valve. - If less than 11 ohms, replace ABS modulator valve.
ABS valve package damaged.	Road hazards or Vehicle damage.	Replace complete ABS valve package or individual component as required.

ASR VALVE

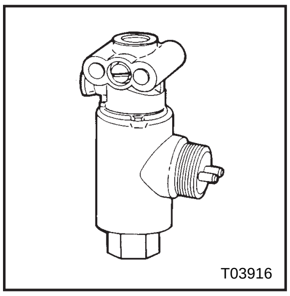


Figure 12: ASR valve

Measure resistance across the two electrical terminals on the ASR valve to ensure 26.3 to 49 ohms.

• If the resistance is greater than 49 ohms, clean the electrical contacts on the solenoid. Check the resistance again.

• To check the cable and ASR valve as a unit, measure resistance across the pins 4 and 7 on the ECU 15 pin-connector of the harness.

DYNAMOMETER TESTING VEHICLES WITH ASR

!!! CAUTION !!!

FAILURE TO DISABLE THE ASR BEFORE DYNAMOMETER TESTING COULD RESULT IN SERIOUS PERSONAL INJURY AND DAMAGE TO THE VEHICLE.

Vehicles with ASR must have the ASR disabled to test the vehicle on a dynamometer. To disable the ASR, press and hold the diagnostic switch for at least three seconds. Once the system configuration code begins, ASR has been disabled. The ASR lamp comes on and stays on while disabled.

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NOTE

REMOVING THE ABS CIRCUIT BREAKER OR REMOVING THE ECU POWER CONNECTOR WILL ALSO DISABLE ABS AND ASR.

COMPONENT REMOVAL AND INSTALLATION

!!! CAUTION !!!

TO PREVENT SERIOUS EYE INJURY, ALWAYS WEAR SAFE EYE PROTECTION WHEN PERFORMING MAINTENANCE OR SERVICE.

RELEASE ALL AIR FROM THE AIR SYSTEMS BEFORE YOU REMOVE ANY COMPONENTS. PRESSURIZED AIR CAN CAUSE SERIOUS PERSONAL INJURY.

CHOCK THE WHEELS REMAINING ON THE GROUND TO PREVENT THE VEHICLE FROM MOVING. APPLY THE PARKING BRAKE.

DO NOT WORK UNDER A VEHICLE SUPPORTED ONLY BY JACKS. JACKS CAN SLIP OR FALL OVER AND CAUSE SERIOUS PERSONAL INJURY. ALWAYS USE SAFETY STANDS.

MOISTURE CAN AFFECT THE PERFORMANCE OF ALL ABS/ASR SYSTEMS, AS WELL AS THE STANDARD BRAKING SYSTEM. MOISTURE IN AIR LINES CAN CAUSE AIR LINES TO FREEZE IN COLD WEATHER.

WHEN WELDING ON THE VEHICLE IS NECESSARY, DISCONNECT POWER AND GROUND LEADS FROM THE ECU.

SENSORS

To remove

1. If necessary, raise the tires off the ground. Install safety stands.

NOTE

ON THE FRONT (AND TAG) AXLE THE SENSOR IS ACCESSIBLE ON THE IN-BOARD SIDE OF THE STEERING KNUCKLE(HUB CARRIER).
ON THE DRIVE AXLE THE WHEEL AND DRUM ASSEMBLY MUST BE PULLED TO GAIN ACCESS TO THE SENSOR.

2. Remove the sensor from the sensor holder. Use a twisting motion if necessary. **Do not pull on the cable!**

3. Disconnect the fasteners that hold the sensor cable to other components.

4. Disconnect the sensor cable from the chassis harness.

To install

NOTE

IN ORDER TO PREVENT WATER INTRUSION, FILL THE CONNECTOR BETWEEN THE SENSOR AND THE CHASSIS HARNESS WITH "BLUE SEAL" VASELINE.

1. Connect the sensor cable to the chassis harness.

2. Install the fasteners used to hold the sensor cable in place.

3. Apply special high temperature grease (VH No. 10610096) to the sensor spring clip and to the body of the sensor.

4. Install the sensor spring clip. Make sure the flange stops are on the inboard side of the vehicle.

5. Push the sensor spring clip into place until the clip stops.

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6. Push the sensor completely into the sensor spring clip until it contacts the tooth wheel.

7. Reinstall wheel and brake drum on drive axle.

8. Remove the blocks and safety stands.

ABS MODULATOR VALVE

To remove

1. Turn ignition switch to the OFF position, apply parking brake.

2. Chock the wheels remaining on the ground.

3. Disconnect the wiring connector from the ABS modulator valve.

4. Disconnect the air lines from Ports 1 and 2 of the ABS modulator valve.

5. Remove the two mounting capscrews and nuts.

6. Remove the ABS modulator valve.

To install

1. Install the ABS modulator valve with two mounting capscrews and nuts. Tighten the capscrews.

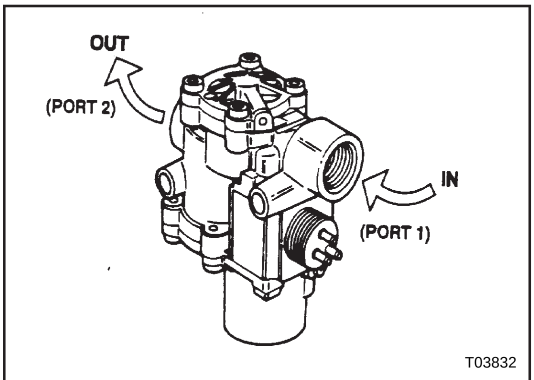

Figure 13: ABS modulator valve

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2. Connect the brake chamber air line to Port 2 of the ABS modulator valve. Connect the air supply line to Port 1 of the ABS modulator valve.

3. Connect the wiring connector to the ABS modulator valve. Handtighten only.

4. Remove the blocks and stands.

5. To check the installation:

   a. Apply the brakes. Listen for leaks at the modulator valve.

   b. Turn the ignition on and listen to the modulator valve cycle. If the valve fails to cycle:
      - Check the electrical cable connection.
      - Use table 5 to diagnose and solve the problem.

   c. Drive the vehicle. Verify that the ABS warning lamp operates properly.

REMOVING AND REPLACING THE ABS/ASR VALVE PACKAGE

1. Chock the wheels remaining on the ground.

2. Drain air from all system air tanks.

3. Remove all air lines and wiring from ABS/ASR valve package.

4. Remove mounting bolts from the valve package - remove the valve package from vehicle.

5. When replacing the ABS/ASR valve package:
   Tighten bolts and reconnect air lines and wiring. Remove blocks and safety stands.

6. Test the installation(see table 5)

REPLACING THE RELAY AND ABS MODULATOR VALVES

1. Remove ABS valve package from vehicle.
2. Use a 6 mm Allen wrench to loosen and remove the Allen head bolts.
3. Carefully separate ABS modulator valve(s) from the relay valve.
4. Remove and discard old O-rings. Lubricate replacement O-rings with grease provided.
5. Plug any unused ports on the replacement valve(s).
6. Attach the ABS modulator valve(s) to the relay valve. Torque the Allen head bolts to 13-15 ft.lbf.
7. Reinstall ABS/ASR valve package. Reconnect air lines and wiring. Check valves for leaks.

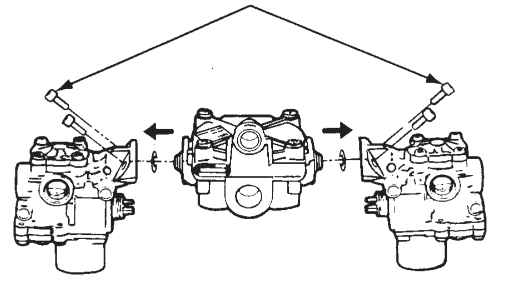

Figure 14: ABS valve package

REPLACING THE ASR VALVE ON THE ABS VALVE PACKAGE

To remove

1. Remove ABS/ASR valve package from vehicle.
2. Use a 6 mm Allen wrench to remove the two mounting bolts that hold the ASR valve to the adapter piece.

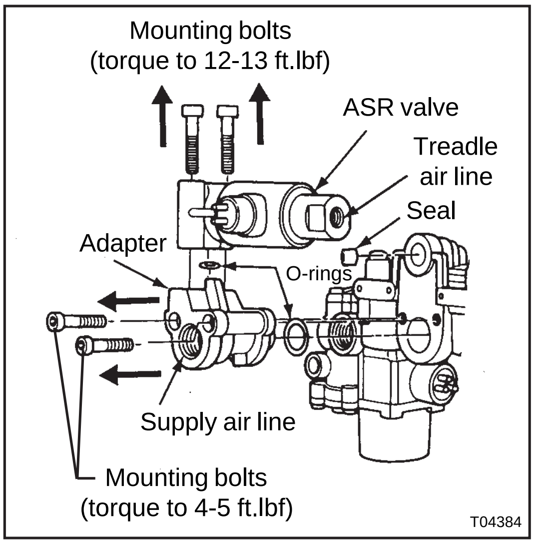

Figure 15: ASR valve on ABS valve package

3. Use a 5 mm Allen wrench to remove the two screws that hold the adapter piece to the relay valve portion of the valve package.
4. Remove the adapter piece,ASR valve, seal and O-ring from the valve package.
5. Remove the ASR valve and O-ring from the adapter piece.

To install

1. Clean and lubricate the small adapter piece O-ring. Install O-ring on adapter piece.
2. Use two new M8 Allen head bolts to attach the ASR valve to the adapter piece. Use a 6 mm Allen head tool to tighten to 12-13 ft.lbf.
3. Lubricate the replacement seal and install it in port 2 of the ASR valve.
4. Lubricate the large replacement O-ring and install it in the groove of the relay valve supply port.
5. Use the two M6 Allen head bolts to attach the adapter to the relay valve.

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Use a 5 mm Allen head tool to tighten to 4-5 ft.lbf.

6. Install ABS/ASR valve package on vehicle. Reconnect ABS air lines and wiring.
7. Connect the supply air line to the supply port on the adapter. Connect the treadle air line to the control port on the ASR valve.
8. Attach the wiring connector to the ASR valve. Hand tighten only.
9. Remove blocks and stands.
10. Test the installation (see below).

TO CHECK THE INSTALLATION

To test the ASR valve:

1. Start vehicle.
2. Fully charge air tanks. Shut off vehicle.
3. Apply brakes.
4. Listen for air leaks at ASR valve.
5. Drive the vehicle. Verify that the ABS warning symbol operates properly.

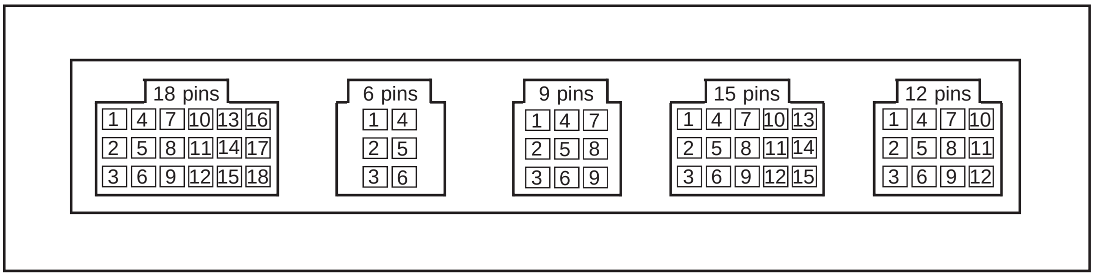

Figure 16: View into ECU-connector pins

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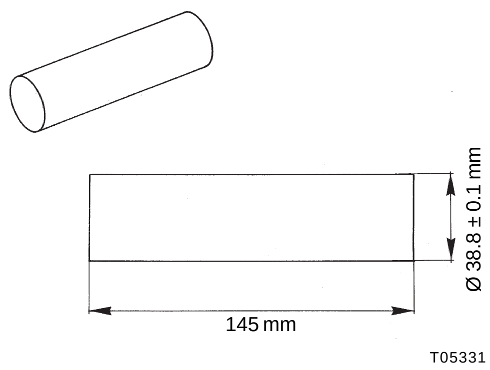
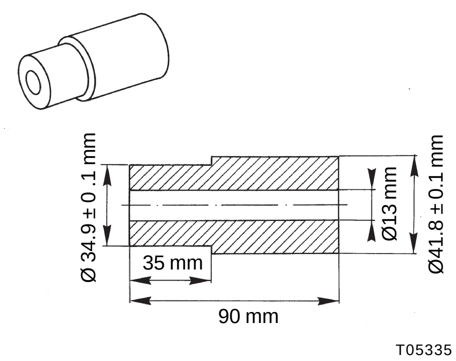
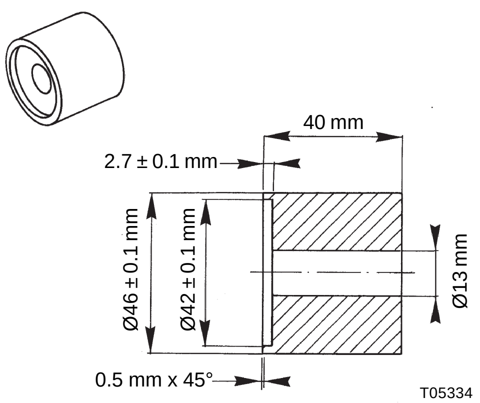
SPECIAL SERVICE TOOLS

TOOL No. + ILLUSTRATION	DESCRIPTION
To fabricate locally 	**Mandrel A** To press out the brass bush. (Lucas "D-Elsa" brakes)
To fabricate locally 	**Mandrel B** For various processes (Lucas "D-Elsa" brakes)
To fabricate locally 	**Thrust washer C** To install the brass bush. (Lucas "D-Elsa" brakes)

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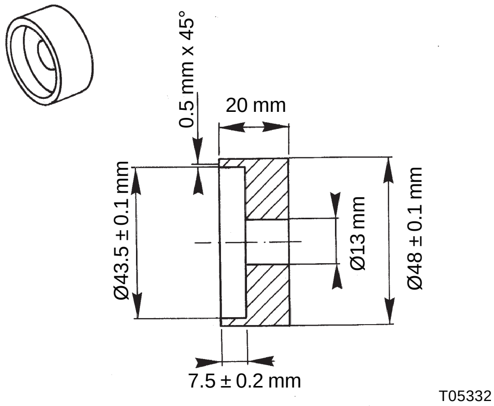
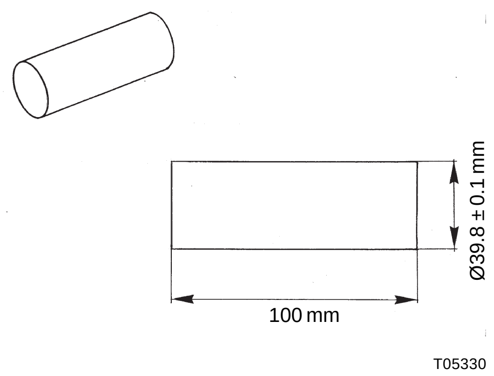
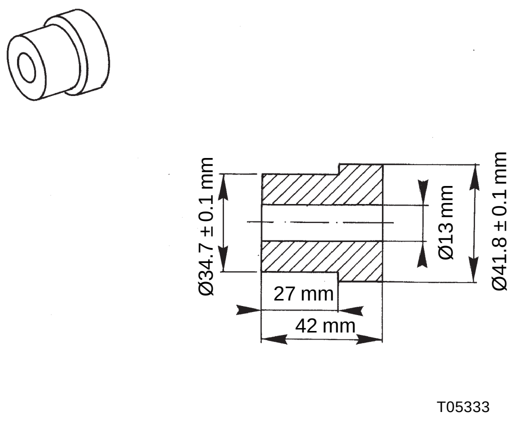
TOOL No. + ILLUSTRATION	DESCRIPTION
To fabricate locally 	**Disc D** To install the rubber boot retaining rings. (Lucas "D-Elsa" brakes)
To fabricate locally 	**Mandrel E** To press out the second coated bush. (Lucas "D-Elsa" brakes)
To fabricate locally 	**Mandrel F** To install the coated bush at the brake disc side. (Lucas "D-Elsa" brakes)

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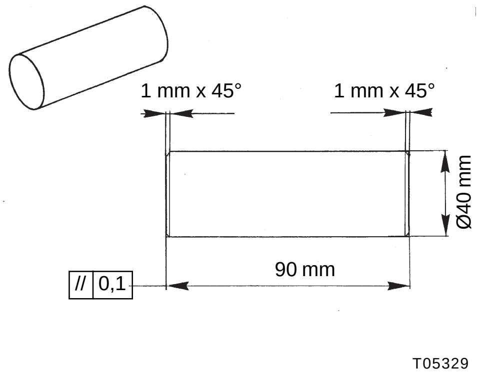
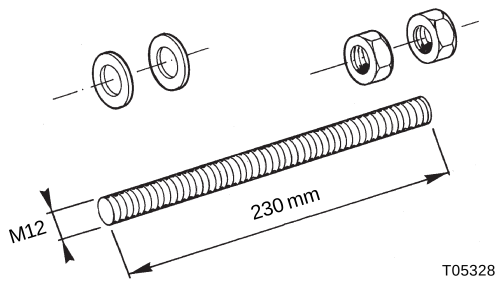
TOOL No. + ILLUSTRATION	DESCRIPTION
To fabricate locally 	**Spacer** To adjust tappet position. (Lucas "D-Elsa" brakes)
To fabricate locally 	**Thread rod M12 x 230, two washers and two M12-nuts** (Lucas "D-Elsa" brakes)

TOOL05AE

TOOL05AE

SERVICE BULLETINS

Service Bulletins are issued to supplement or supersede information in the Van Hool manuals. Note below number, date and subject of Bulletins pertaining to this chapter. File Bulletins separately by number for future reference.

Number	Date	Subject

CHAPTER 6

AIR SYSTEM

PAGE

MAIN06AG

"CR BRAKEMASTER" AIR DRYER

"HALDEX" AIR DRYER

AIR TANKS

PRESSURE SWITCHES

LOW PRESSURE INDICATOR

VALVES

AIR LINE DIAGRAM

MAIN06AG

AIR SUPPLY

!!! CAUTION !!!
WHEN WORKING ON OR AROUND AIR SYSTEMS, OBSERVE THESE PRECAUTIONS: ALWAYS BLOCK THE VEHICLE WHEELS. STOP ENGINE WHEN WORKING UNDER A VEHICLE. DEPLETING THE VEHICLE AIR SYSTEM PRESSURE MAY CAUSE THE VEHICLE TO ROLL. KEEP HANDS AWAY FROM CHAMBER PUSH RODS AND SLACK ADJUSTERS; THEY MAY ACTIVATE AS SYSTEM PRESSURE DROPS. NEVER CONNECT OR DISCONNECT A HOSE OR LINE CONTAINING AIR PRESSURE. NEVER REMOVE A COMPONENT OR PIPE PLUG UNLESS YOU ARE CERTAIN ALL SYSTEM PRESSURE HAS BEEN REMOVED. NEVER EXCEED RECOMMENDED AIR PRESSURE. ALWAYS WEAR SAFETY GLASSES WHEN WORKING WITH AIR PRESSURE. NEVER LOOK INTO AIR JETS OR POINT THEM AT ANYONE. NEVER ATTEMPT TO DISASSEMBLE A COMPONENT UNIT UNTIL YOU HAVE READ AND UNDERSTOOD RECOMMENDED PROCEDURES. SOME COMPONENTS CONTAIN POWERFUL SPRINGS AND INJURY CAN RESULT IF NOT PROPERLY DISASSEMBLED. USE ONLY PROPER TOOLS AND OBSERVE ALL PRECAUTIONS RELATING TO THE USE OF THOSE TOOLS.

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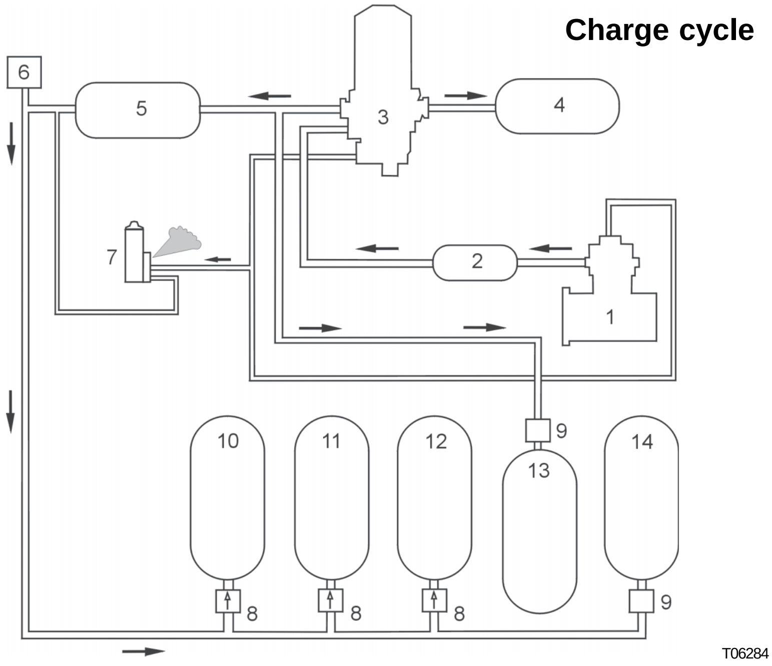

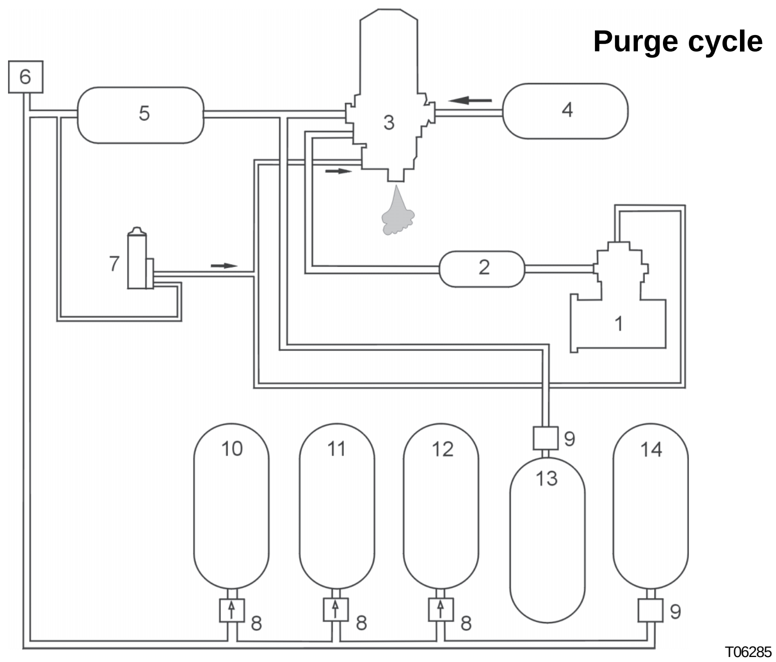

Figure 1: Air supply circuit (CR Brakemaster air dryer)

1. Compressor
2. Ping tank
3. Air dryer
4. Purge tank
5. Buffer tank
6. Safety valve (150 psi)
7. Governor
8. Check valve
9. Pressure protection valve (70 psi)
10. Tag axle brakes tank
11. Drive axle service brakes tank
12. Front axle brakes tank
13. Auxiliaries tank
14. Parking brake emergency release tank

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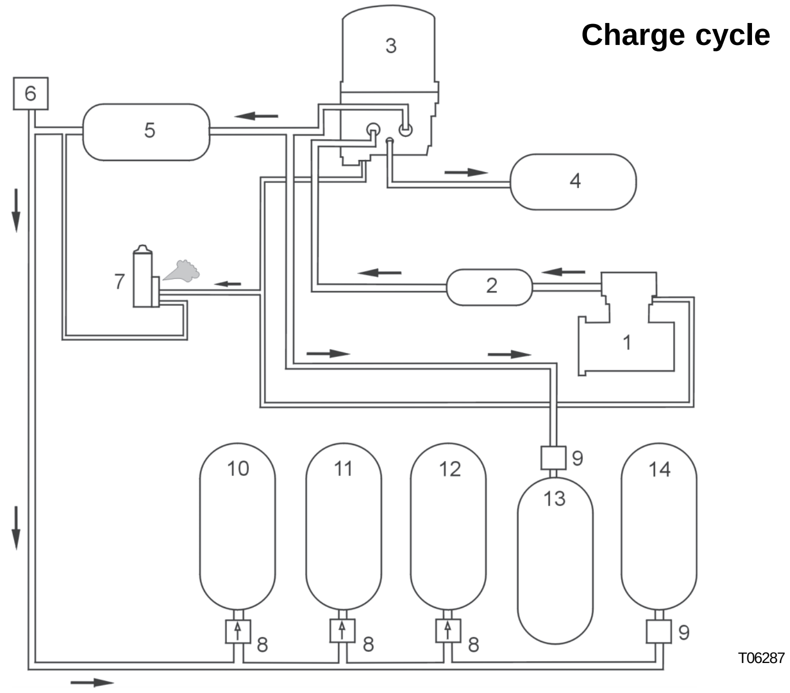

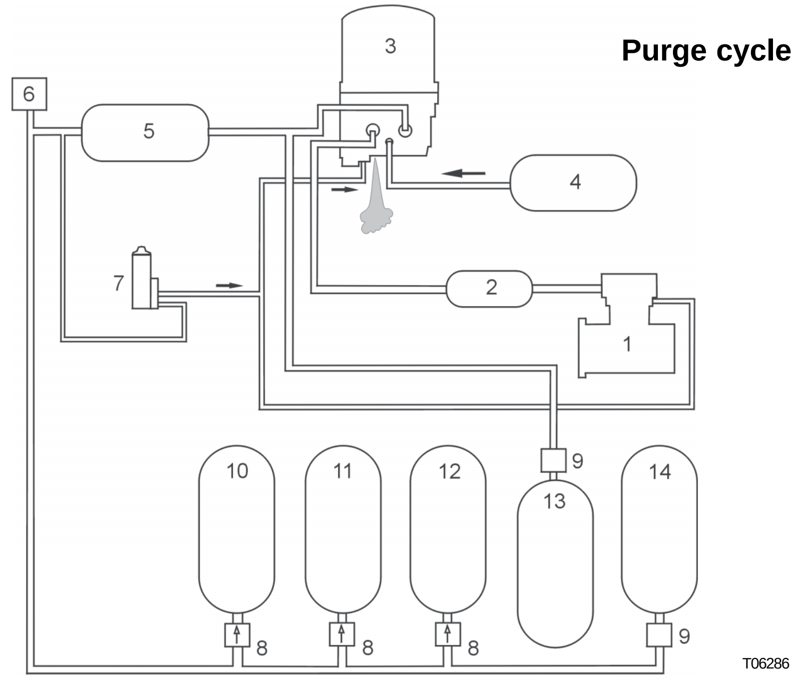

Figure 2: Air supply circuit (Haldex air dryer)

1. Compressor
2. Ping tank
3. Air dryer
4. Purge tank
5. Buffer tank
6. Safety valve (150 psi)
7. Governor
8. Check valve
9. Pressure protection valve (70 psi)
10. Tag axle brakes tank
11. Drive axle service brakes tank
12. Front axle brakes tank
13. Auxiliaries tank
14. Parking brake emergency release tank

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AIR COMPRESSOR

GENERAL

The function of the air compressor is to build up and maintain the air pressure required to operate air powered devices.

The compressor runs continuously while the engine is running but actual compression of air is controlled by a governor which stops and starts the compression of air by loading or unloading the compressor in conjunction with its unloading mechanism. This is done when the air pressure in the system reaches the desired maximum or minimum pressures.

FACTS ABOUT AIR COMPRESSORS

OIL DEPOSITS

All air compressors have a small amount of oil carryover, which lubricates the piston rings and moving parts. When the oil is exposed to normal air compressor operating temperatures over a period of time, it will form varnish or carbon deposits. If not inspected regularly, the air compresor piston rings will be affected by high operating temperatures and pressures, and will not seal properly. The result will be a lesser compressor performance and more oil blow-by, which further increases carbon build-up.

DUTY CYCLE AND COMPRESSOR RELIABILITY

The key factor which determines the reliability and durability of an air compressor in an application is the amount of time the air compressor is supplying air during vehicle operation, known as the duty cycle of the compressor. Compressors are not designed to pump continuously. They have best durability when pumping 25% or less of the engine running time. When pumping, a compressor generates a lot of heat, which is dissipated during the time the compressor is not pumping.

If the compressor duty cycle exceeds 25% of the vehicle running time, the compressor will begin to overheat. Thus the sealing of the piston rings is reduced and more oil will be allowed to pass into the compressed air discharge. This oil carryover fouls the air compressor head, downstream plumbing, the air dryer and the vehicle air system.

DUTY CYCLE AND AIR DRYER PERFORMANCE

The air dryer receives air from the air compressor, traps moisture and oil in a filtration and dessicant system, then purges the contaminants from the air system. High air compressor duty cycles also raise the temperaure of the air supplied to the air dryer, which reduces the effectiveness of the dessicant in the dryer.

SOLUTIONS FOR HIGH DUTY CYCLES

If the duty cycle is found to exceed 25%, there are several options to improve the situation:

a. Find and stop all leaks in the air system. All system leaks can double or triple operating duty cycles. Close

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attention to correcting air system leaks is critical in high duty cycle applications.

b. If stopping the leaks does not reduce compressor duty cycle to below 35%, be prepared to provide increased compressed air system maintenance, including some, or all of the following:

- de-carbonizing the compressor;
- cleaning and replacing restricted discharge plumbing;
- replacing air dryer dissicant more frequently than normal schedules;
- generally cleaning the compressed air system, including downstream components controlling or using compressed air.

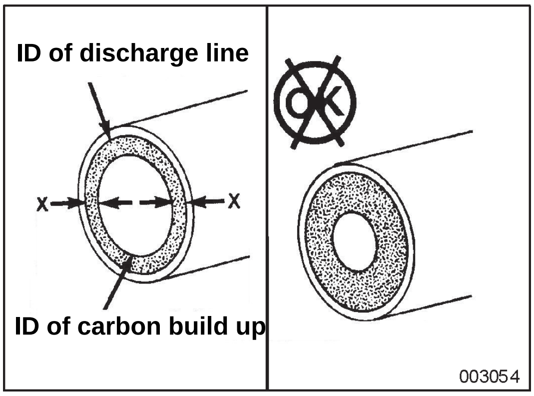

Figure 1: Carbon buildup in discharge line

4. If the total carbon deposit exceeds specifications, continue inspecting the discharge line connections up to the governor and air dryer. Clean or replace any lines or connections that exceed specifications.

MAINTENANCE

TO CHECK AIR COMPRESSOR AND DISCHARGE LINE PERFORMANCE

Refer to "Air brake system functional check" in chapter 5.0.

TO INSPECT AIR COMPRESSOR DISCHARGE

1. Drain the air system.

2. Remove the air discharge line from the air compressor.

3. Measure the total carbon deposit thickness inside the air discharge line. If the total carbon deposit (x + x) exceeds 1/16 inch, clean and inspect the cylinder head, valve assembly and discharge line. Replace, if necessary.

REPAIR INFORMATION

CUMMINS

Refer to Cummins literature.

DETROIT DIESEL

The Detroit Diesel engine can be fitted with:

- a two cylinder Bendix Tu-Flo 750 air compressor. Refer to **Bendix Service Data SD-01-344** for maintenance and repair information.
- or a single cylinder Bendix BA-921 air compressor. Refer to **Bendix Service Data SD-01-676** for maintenance and repair information.

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GOVERNOR

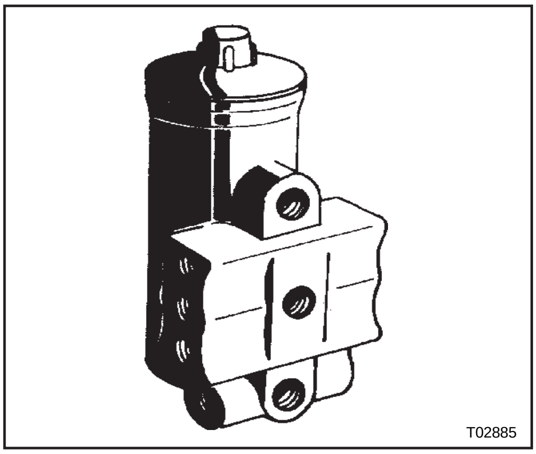

Figure 1: Bendix D-2 governor

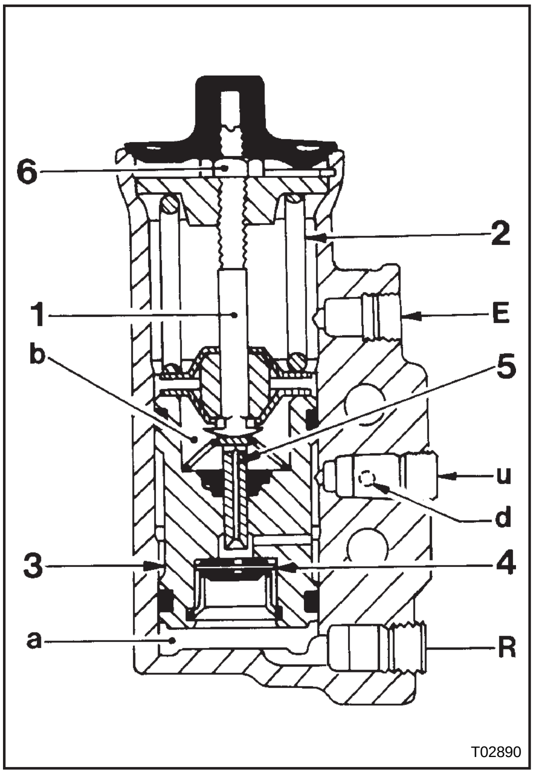

Figure 2: Governor cross section (in cut-out position)

DESCRIPTION

The governor, operating in conjunction with the compressor unloading mechanism, automatically controls the air pressure between a maximum (cut-out) pressure and a minimum (cut-in) pressure. The compressor runs continually while the engine runs, but the actual compression of air is controlled by the governor. The governor actuates the compressor unloading mechanism, which stops or starts the compression of air when the maximum or minimum reservoir pressures are reached.

OPERATION - Figure 2

Tank air pressure enters governor at port "R" and acts on piston (3) and inlet/exhaust valve (4). As air pressure builds up, piston (3) and valve (4) move together against resistance of pressure setting spring (2). When tank air pressure reaches cut-out setting of governor, exhaust stem (5) seats on inlet/exhaust passage and then opens inlet passage. Tank air pressure then flows around inlet/exhaust valve (4), through passage in piston (3) and out unloader port (u) to compressor unloading mechanism.

As the system tank air pressure drops to cut-in setting of governor, force exerted by air pressure on piston (3) will be reduced so that pressure setting spring (2) will move piston (3) down. The inlet/exhaust valve (4) will close and exhaust will open. With exhaust open, air in unloader line will escape back through piston, through exhaust stem (5) and out exhaust port (E).

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MAINTENANCE

SERVICE TESTS

Operating tests

1. Start engine and build up air pressure in the system.

2. Check pressure registered by the dash service brakes air pressure gauge at the time the governor cuts-out (listen for a sound of air exhausting from the air dryer). The cut-out pressure should be between 120 and 130 psi.

3. With engine still running, make a series of brake applications to reduce air pressure and observe at what pressure the governor cuts-in (tank charging begins).

If pressure settings of governor are inaccurate, the adjustment procedure is as follows:

a. Remove top cover from governor.

b. Loosen adjusting screw locknut.

c. To raise pressure settings: turn adjusting screw counterclockwise. To lower pressure setings, turn adjusting screw clockwise.

NOTE
Be careful not to overadjust. Each 1/4 turn of the adjusting screw raises or lowers the pressure setting approximately 4psi.

d. When proper adjustment is obtained, tighten adjusting screw locknut and replace cover.

NOTE
The pressure range between cut-in and cut-out is not adjustable.

Leakage test

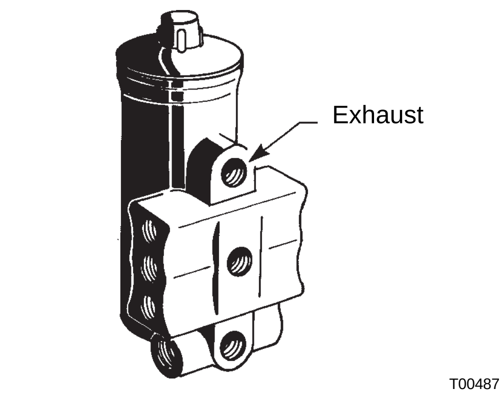

Figure 3: Governor exhaust port

1. Make leakage check at governor exhaust port (see Figure 3).

2. In cut-in position, check exhaust port for inlet valve leakage with a soap solution at exhaust port.

3. In cut-out position, check exhaust port to determine if exhaust valve seat or stem grommets are leaking.

OVERHAUL - Figure 4

TO DISMANTLE

1. Remove cover (1) and O-ring (10) and slightly depress upper spring seat (A) before detaching circlip (2). Lift out control spring assembly (B).

2. Remove exhaust stem (11) and conical spring (8).

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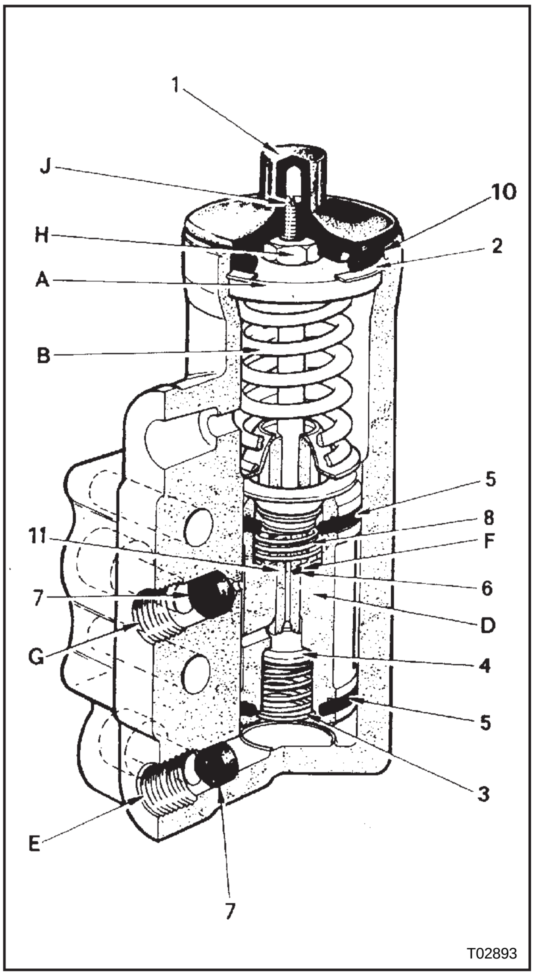

Figure 4: Governor

3. If piston (D) cannot be dislodged by tapping governor on a soft surface, take great care in ejecting it by using only MODERATE air line pressure at port (E).

4. From piston (D), remove valve spring (3), inlet/exhaust valve (4) and O-rings (5). Detach over retaining washer (F) and remove O-ring (6).

5. Remove the two wire mesh filters (7) from governor body ports (E) and (G).

TO CLEAN, INSPECT AND REPAIR

1. Thoroughly clean all parts in a proprietary cleaning fluid before inspecting them for wear and damage.

2. Always renew all the items 1 to 11 as supplied in the kit.

TO REASSEMBLE

1. Use the grease enclosed in the Bendix Service Kit to lubricate O-rings (5 and 6) and the piston bore in the governor body.

2. Take care not to damage the wire mesh filters (7) when fitting them into ports (E and G).

3. After inserting new O-ring (6) into piston (D), reinstall retaining washer (F) and secure it by peening over the surrounding metal on three spots.

4. Insert inlet/exhaust valve (4) into piston and insert valve spring (3), small end first, until the large end coil enters the groove in the spring chamber wall.

5. Fit the two O-rings (5) to piston and grease O-ring (6) before inserting the exhaust stem. The larger end of the conical spring (8) is to be sealed into piston (D).

6. Grease O-rings (5) before inserting piston into bore of governor body. Take care not to damage O-rings (5). Check that stem (11) and spring (8) have not been displaced.

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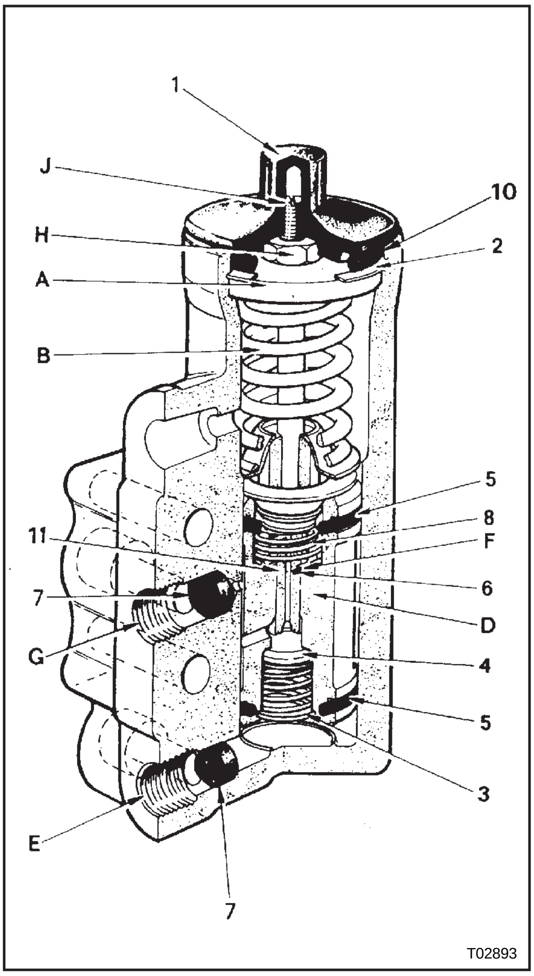

Figure 4: Governor

7. Reinstall control spring assembly (B) and press it down in order to fit circlip (2).

8. Prior to fitting waterproof cover, test governor for correct operation and setting as described under "Operating Tests" earlier in this section.

9. Finally, fit O-ring (10) and screw waterproof cover (1) securely over threaded stem (The stem will cut its own thread in the cover).

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CR BRAKEMASTER AIR DRYER

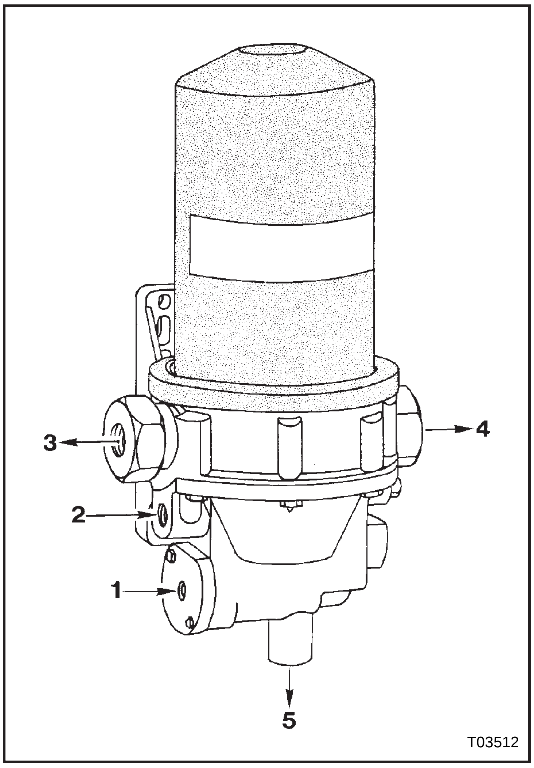

Figure 1: CR brakemaster air dryer

1. **Unloader port**
2. **Inlet port**
3. **Outlet port**
4. **Purge port**
5. **Exhaust port**

GENERAL DESCRIPTION

The air dryer is a desiccant style air dryer, mounted vertically between the air compressor and the supply tanks. The air dryer receives hot compressed air, which it cools, dries and filters before sending it to the supply tanks, reducing the build up of dirt and moisture in the vehicle air system.

The air dryer consists of a light weight aluminum and steel construction housing a spin-off cartridge. Below the cartridge are five ports:

- the inlet port receives air from the compressor
- the outlet port directs clean/dry air to the vehicle air system
- the purge port contains a bleed valve directing air to and from the isolated purge tank
- the unloader port contains the unloader valve that receives a signal from the governor
- the exhaust port expels accumulated moisture and contaminants

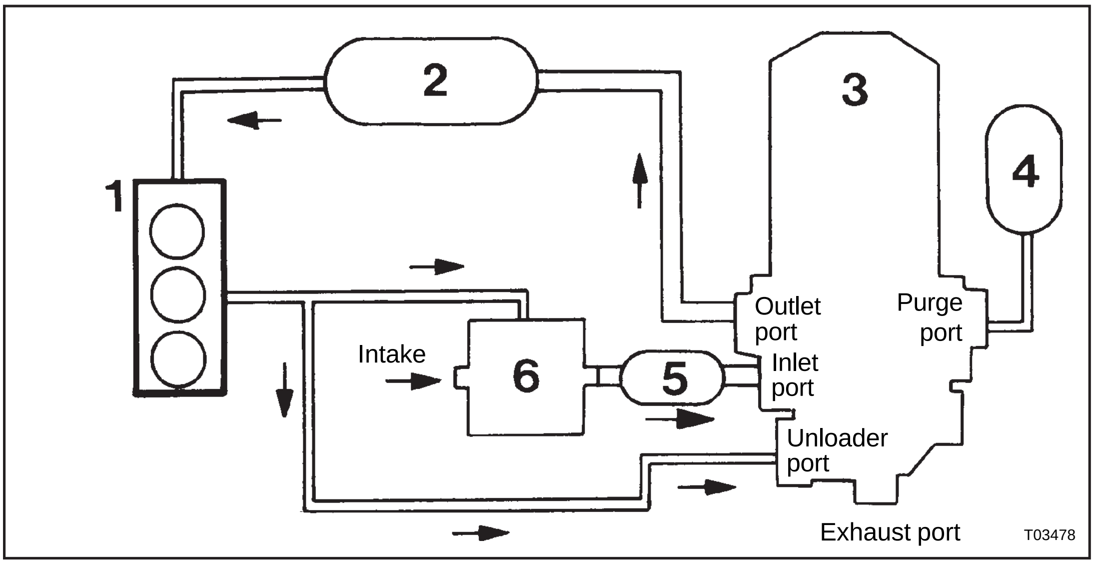

Figure 2: Air dryer installation in air system

1. Governor
2. Buffer tank
3. Air dryer
4. Purge tank
5. Ping tank
6. Compressor

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THEORY OF OPERATION

Hot, compressed air enters the air dryer through the inlet port. As the hot air enters the dryer, the air expands, oil and water vapor condense and accumulate in the sump. The air passes through 3 filters and a cloth bag that removes carbon and other contaminants. Air vapor continues to condense as air travels to the desiccant bed housed in the cartridge. The clean dry air is then directed to the vehicle air system through the outlet port and simultaneously to the purge tank through the purge port.

When the air system reaches the governor regulated cut-out pressure, the air dryer unloader valve opens via an air signal received from the air system governor. The governor will also simultaneously signal the compressor to stop compressing air. The air dryer check valve is closed via back pressure from the wet tank. This rapid action causes a sudden discharge of air through the exhaust port of the dryer. The filtered, dried purge air, which has accumulated in the isolated purge tank, slowly bleeds back through the air dryer. This action regenerates desiccant, cleans filters and expels the contaminants out the exhaust port. This completes the regeneration cycle.

Additionally, the air dryer incorporates an ECON valve and a pressure differential check valve. The ECON valve ensures engine boost pressure cannot escape out the air dryer's exhaust port during the stand-by mode of the compressor. The differential check valve maintains system air pressure within the air compressor discharge line. These two valves ensure full turbo boost pressure is checked and available at all times during the operation of the vehicle.

When the air system drops to the governor regulated cut-in pressure, the air dryer unloader valve closes as the unloader line pressure evacuates through the exhaust port of the governor. The compressor is signalled to proceed pumping.

MAINTENANCE

!!! CAUTION !!!
READ SAFETY PRECAUTIONS FOUND IN SECTION 6.0.

TO INSPECT

Check efficiency of air dryer by draining the compressed air tanks. If there is a lot of water and/or dirt, this means the desiccant has lost adequate absorption capacity through contamination. Replace desiccant cartridge.

TO PRESSURE CHECK AIR DRYER ASSEMBLY

1. With engine off, bleed entire air system.

2. Start engine and build up air pressure as close to cut-out pressure as possible (approx. 100 psi). Do not allow air dryer to exhaust. Stop engine. With engine stopped, check air dryer cartridge and base plate for leakage. If air leaks at base plate, cartridge requires replacement.

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TO CHECK BLEED VALVE

1. Inspect purge tank, hose connections and hose assembly for any damage or loose connections. These conditions will effect the purge cycle.

2. Start engine and build up air system to cut-out pressure allowing air dryer to exhaust. Stop engine. After initial exhaust, air will continue to bleed 45 to 60 seconds completing the purge cycle. With engine off, listen for air exhausting. If no purge cycle, bleed valve requires replacement.

TO CHECK CHECK-VALVE

Start engine and build up air system to cut-out pressure allowing air dryer to exhaust. Stop engine. With engine off, listen for air leaking from the air dryer's exhaust port. If air continues to leak after the completion of the purge cycle (approx. 45 to 60 seconds) from the exhaust port, check valve requires replacement. Replace check valve.

TO CHECK UNLOADER VALVE

1. To check unloader valve during unload (compressor off) cycle, start engine and build up air system to cut-out pressure allowing air dryer to exhaust. Cycle dryer to load and unload several times. if dryer fails to unload or valve sticks, replace unloader valve.

2. To check unloader valve during charge (compressor on) cycle, start engine and build up air pressure as close to cut-out pressure as possible (approx. 100 psi).
   Do not allow air dryer to exhaust. Stop engine. With engine off, listen for air leaking from exhaust port. If air is leaking, remove air line from unloader valve nut. If air leak stops, replacement of the governor is required; if leak still continues, replacement of the unloader valve is required.

TO CHECK HEATER

NOTE
Thermostat must be cooled to at least 35°F to perform the following test procedures.

With thermostat 'closed', connect an ohmmeter across the heater electrical terminals. Ohmmeter should read complete circuit; if circuit is open, heater assembly should be replaced. Replace heater assembly.

TO CHECK SAFETY VALVE

Check for excessive leakage at safety valve by coating exhaust opening.

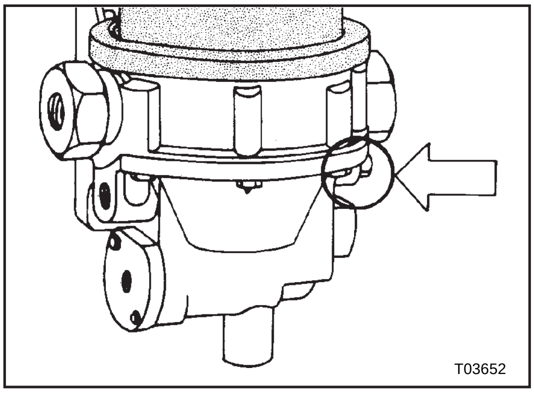

Figure 3: Safety valve location

TO CHANGE DESICCANT CARTRIDGE

1. Drain the air system.
2. Using a strap wrench, turn the desiccant cartridge counterclockwise and remove it. Discard.
3. Remove and discard O-ring from adapter plate stud.

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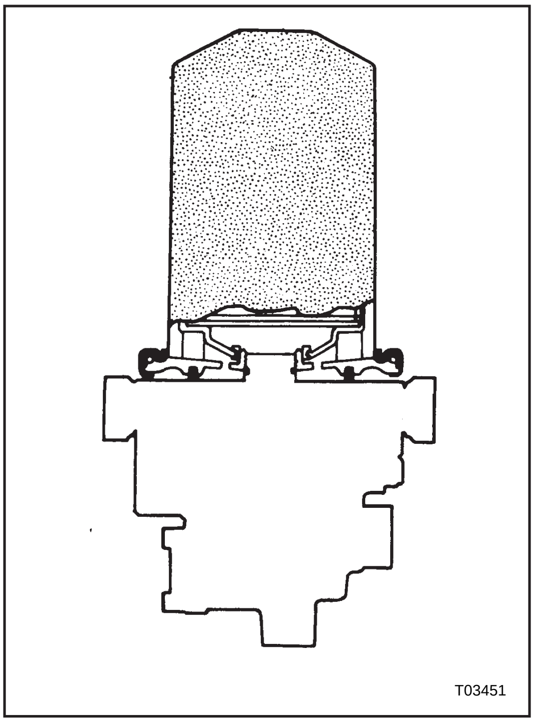

Figure 4: Cartridge installation

NOTE
If there is excessive oil in the check valve port, compressor may require servicing.

4. Clean top surface of adapter plate and threaded stud.

5. Using grease supplied, apply a light coating on O-ring. Install O-ring on adapter stud.

6. Apply a generous coat of grease on the new desiccant cartridge gasket surface.

7. Thread new cartridge onto adapter stud turning clockwise. When gasket contacts adapter plate, tighten cartridge 1/2 turn. Do not overtighten!

OVERHAUL

TO REPLACE BLEED VALVE

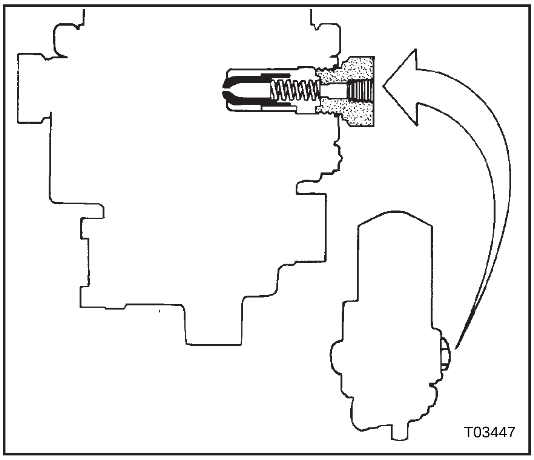

Figure 5: Section through bleed valve

1. Drain the air system.

2. Disconnect the air line at the air dryer purge port.

3. Remove bleed valve nut.

4. Remove and discard O-ring, spring and spindle.

5. Clean bleed valve nut and cavity area.

6. Position new spindle in the cavity with spring pocket side out. Install spring.

7. Using grease supplied, apply a light coating to O-ring. Install O-ring on nut.

8. Apply a light coating of grease to nut threads. Install nut and tighten to 60 ft.lbf.

9. Reconnect air line to air dryer purge port.

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TO REPLACE CHECK VALVE

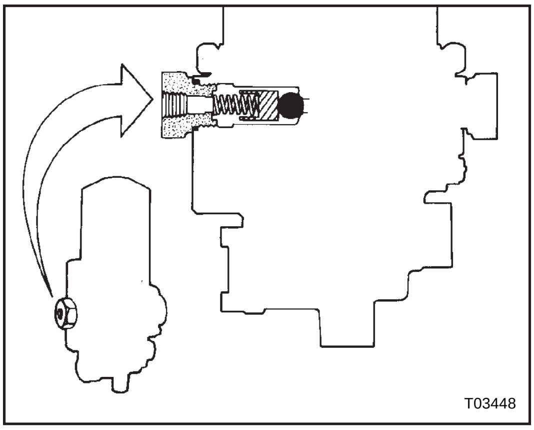

Figure 6: Section through check valve

1. Drain the air system.
2. Disconnect the air line from outlet port.
3. Remove check valve nut.
4. Remove and discard O-ring, spring, spindle and ball.

NOTE
If there is excessive oil in the check valve port, compressor may require servicing.

5. Clean nut and cavity area.
6. Install new ball in cavity. Next, position spindle with spring pocket facing out. Install spring.
7. Using grease supplied, apply a light coating to O-ring. Install O-ring on nut.
8. Apply a light coating of grease to threads of nut. Install nut and tighten to 60 ft.lbf.
9. Reconnect air line to air dryer outlet port.

TO REPLACE UNLOADER VALVE

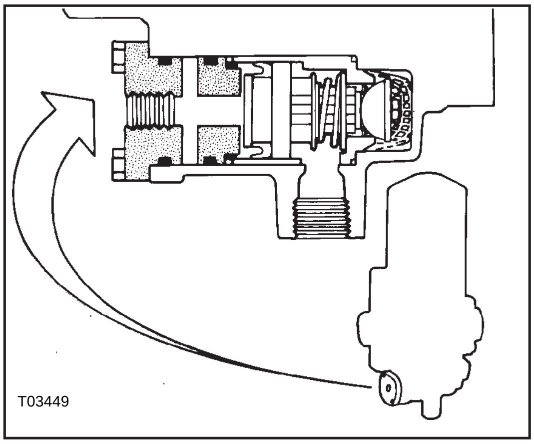

Figure 7: Section through unloader valve

1. Disconnect the unloader air line.
2. Remove the two fasteners that attach the unloader valve retainer. Remove the retainer.
3. Remove the unloader valve assembly from the unloader port and discard.

NOTE
If there is excessive oil in the unloader port, the compressor may require servicing.

4. Clean the unloader port thoroughly.
5. Remove the three O-rings from the retainer and discard.
6. Using grease supplied, lightly grease the new O-rings.
7. Install the two thickest O-rings on the retainer and then install the third, thin O-ring.
8. Install the new filter screen into the unloader cavity open end out.
9. Apply a light coat of grease to the O-ring seat on the valve assembly. Install the thin O-ring on the unloader valve seat.

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10. Aligning the valve exhaust port with the air dryer exhaust port, install the unloader valve assembly. Use care not to dislodge the O-ring from its seat.

!!! CAUTION !!!
IF THE AIR DRYER EXHAUST PORT AND UNLOADER EXHAUST PORT DO NOT ALIGN, THE AIR DRYER WILL NOT UNLOAD.

11. Install retainer.
12. Apply a light coating of grease on the threads of the two retainer bolts.
13. Install the two retainer bolts and tighten to 10 to 15 ft.lbf.
14. Reconnect the unloader air line to air dryer unloader port.

TO REPLACE HEATER ASSEMBLY

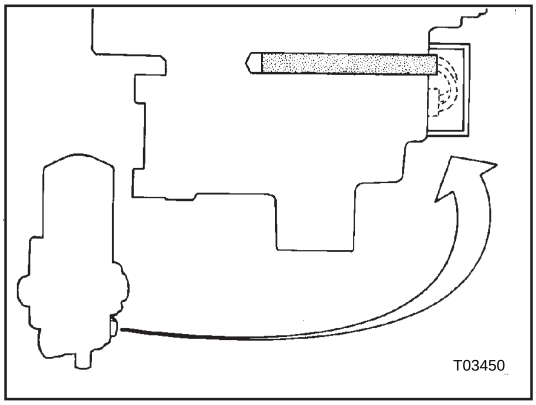

Figure 8: Section through heater assembly

1. Disconnect heater leads.
2. Remove the screws from heater cover.
3. Remove the set screw.

NOTE
Late model air dryers do not incorporate or require a set screw.

4. Remove heater/thermostat assembly and discard.
5. Thoroughly clean the entire area.
6. Apply a light coating of anti-seize to the heater element and to the thermostat cavity only. Do not apply this compound to screws.
7. Install new heater. Twist slightly to spread anti-seize. Install new set screw until snug. Set screw will protrude from bottom cap about 1/8". Do not over-tighten!
8. Install new thermostat. Coil wires around heater cover posts allowing wires to protrude through slots. Place the two 6-32 x 1-1/8 screws in heater cover and attach the thermostat.
9. Fill heater cover with non-corrosive RTV.
10. Connect blue heater wire to a good chassis ground.
11. Connect orange wire to ignition switch.
12. Seal and route heater wires carefully.

TO REPLACE ECON VALVE

NOTE
Recent air dryers do not incorporate an "ECON" valve.

1. Drain the air system.
2. Disconnect the heater wiring. Disconnect the inlet and unloader lines from their respective ports. Mark lines for later assembly.

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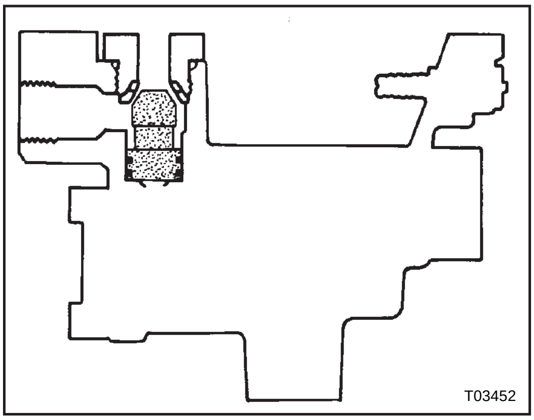

Figure 9: Section through ECON valve

3. Remove 8 bolts from bottom cap and set aside. Discard gasket.

4. Remove ECON nut, valve stop and valve and discard.

5. Clean cavity area thoroughly.

6. Lightly coat the 2 (small) O-ring surfaces and install on piston. Carefully install valve in cavity with tapered side up.

7. Place valve stop on top of valve concave side down.

8. Lightly lube (large) O-ring and place on nut. Install flat seal into nut.

9. Install nut and tighten to 50 ft.lbf.

10. Place gasket on bottom cap aligning small hole with small check valve. Locate bottom cap so that inlet port is directly below outlet port. Install the 8 bolts set aside during assembly. Tighten bolts to 15 to 20 ft.lbf.

11. Reconnect inlet and unloader lines as previously marked to the air dryer.

12. Reconnect heater wiring.

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TROUBLESHOOTING

Problem	Probable Cause	Remedy
1. Air continually exhausts from the exhaust port when the compressor is in the standby mode	1. Air dryer check valve is worn.	1. Replace check valve assembly.
	2. ECON valve is damaged or worn.	2. Replace ECON valve assembly.
	3. Air dryer unloader valve seal is worn.	3. Replace unloader valve assembly.
2. System air pressure drops rapidly.	1. Fittings are loose or damaged.	1. Tighten and/or replace as necessary.
	2. Air tank, tubing, or hoses are damaged.	2. Repair or replace as necessary.
	3. Air dryer check valve is worn.	3. Replace check valve assembly.
	4. ECON valve is leaking.	4. Replace ECON valve assembly.
	5. Air dryer unloader valve seal is worn.	5. Replace unloader valve assembly.
3. The air compressor goes into the standby mode but cycles rapidly.	1. Fittings are loose or damaged.	1. Tighten and/or replace as necessary.
	2. Air tank, tubing, or hoses are damaged.	2. Repair or replace as necessary.
	3. Air dryer check valve is worn.	3. Replace check valve assembly.
	4. ECON valve is worn.	4. Replace ECON valve assembly.
	5. D2 governor malfunctioning.	5. Replace governor.
	6. Air dryer unloader valve seal is worn.	6. Replace unloader valve assembly.

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Problem	Probable Cause	Remedy
4. Air flows from the exhaust port when the air compressor is trying to build up pressure	1. Unloader valve is worn. 2. Dirt/foreign material is stuck in unloader valve. 3. D2 governor malfunctioning. 4. Heater assembly malfunctioning.	1. Replace unloader valve assembly. 2. Replace unloader valve assembly. 3. Replace governor. 4. Replace heater assembly.
5. Air compressor runs continuously (system pressure will not build)	1. Fittings are loose or damaged. 2. Air tank, tubing, or hoses are damaged. 3. Air compressor needs to be serviced or replaced. 4. Air dryer unloader valve is worn. 5. Line between governor and air compressor is blocked. 6. Governor malfunctioning.	1. Tighten or replace loose or damaged fittings. 2. Repair or replace damaged items. 3. Rebuild or replace air compressor. 4. Replace unloader valve assembly. 5. Replace the line or remove the blockage. 6. Replace governor.
6. The air dryer does not unload when the air compressor goes into standby mode	1. Line between air governor and air dryer unloader port is missing, leaking or damaged. 2. Unloader valve is worn. 3. Ice has formed in uloader valve. 4. Heater malfunctioning. 5. Unloader valve sleeve is misaligned.	1. Install or replace air line or tighten the fittings. 2. Replace unloader valve assembly. 3. Check heater assembly; replace with heater kit. 4. Check heater assembly; replace with heater kit. 5. Align unloader valve sleeve.

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Problem	Probable Cause	Remedy
7. Safety valve opens	1. Air dryer check valve is blocked. 2. Air brake system is blocked down stream from the air dryer. 3. D2 governor is malfunctioning. 4. Safety valve is malfunctioning.	1. Replace check valve assembly. 2. Remove blockage or replace the necessary components. 3. Replace D2 governor. 4. Replace safety valve.
8. Water accumulation in air system (tanks)	1. Desiccant is contaminated. 2. Bleed valve is malfunctioning. 3. Line between purge tank and air dryer purge port is missing, leaking or damaged.	1. Replace desiccant cartridge. 2. Replace bleed valve assembly. 3. Install or replace air line or tighten fittings.

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HALDEX AIR DRYER

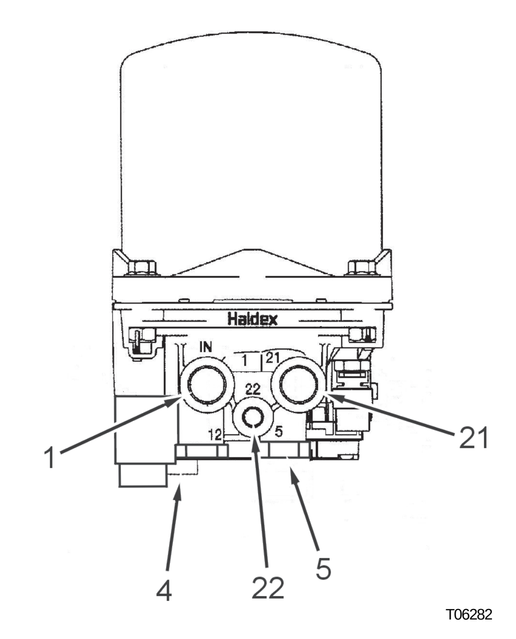

Figure 1: Haldex air dryer

1: **Inlet port (receives air from the compressor)**
4: **Unloader port (receives air from the governor)**
5: **Plugged**
21: **Outlet port (directs clean/dry air to the vehicle air system)**
22: **Purge port (directs air to and from the purge tank)**

MAINTENANCE

!!! CAUTION !!!
READ SAFETY PRECAUTIONS FOUND IN SECTION 6.0.

TO INSPECT

Check efficiency of air dryer by draining the compressed air tanks. If there is a lot of water and/or dirt, this means the desiccant has lost adequate absorption capacity through contamination. In that case, change the desiccant cartridge.

TO CHANGE DESICCANT CARTRIDGE

Refer to the Haldex instruction sheet at the end of this Chapter.

TO CHANGE SAFETY VALVE

!!! CAUTION !!!
DRAIN THE AIR TANKS BEFORE REMOVING THE SAFETY VALVE.

The valve is set to open at 160 + 15 psi. Tighten the valve to 10 ft.lbf.

TO CHANGE VALVE PACK

!!! CAUTION !!!
DRAIN THE AIR TANKS BEFORE REMOVING THE VALVE PACK.

The valve pack is not rebuildable. If valve pack fails, remove and replace by loosening the six screws with a 5 mm Allen key. Clean the mounting surface. Mount the new valve and "O" rings, tighten the six screws to 5 ft.lbf, starting with the two middle screws.

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TROUBLESHOOTING

Problem	Cause	Remedy
Water in air system.	1. Contaminants in desiccant. 2. Leaks in air system	1. Change desiccant cartridge. Check air compressor for excessive oil passage. 2. Tighten air connections, soap connections and recheck for leaks.
Constant exhaust of air at air dryer.	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	1. Tighten air connections, soap connections and recheck for leaks. 2. Clean valve seat and replace check valve.
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.

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AIR TANKS

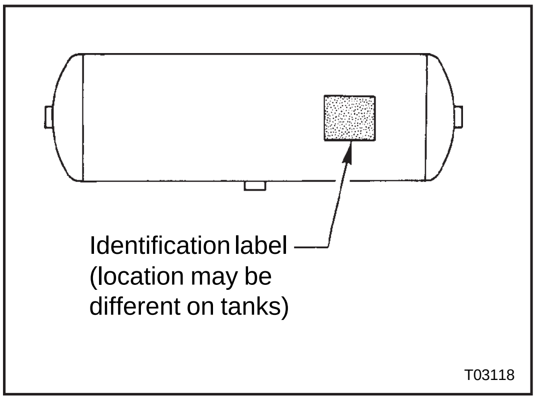

Figure 1: Identification label on air tank

Air tanks store compressed air so there will be ample supply for immediate use. Nine air tanks are used on this coach: one in the front axle brake system, one in the drive axle service brake system, one in the tag axle brake system, one in the auxiliary system, one in the front kneeling system, one in the rear raise system and one in the parking brake emergency release system.

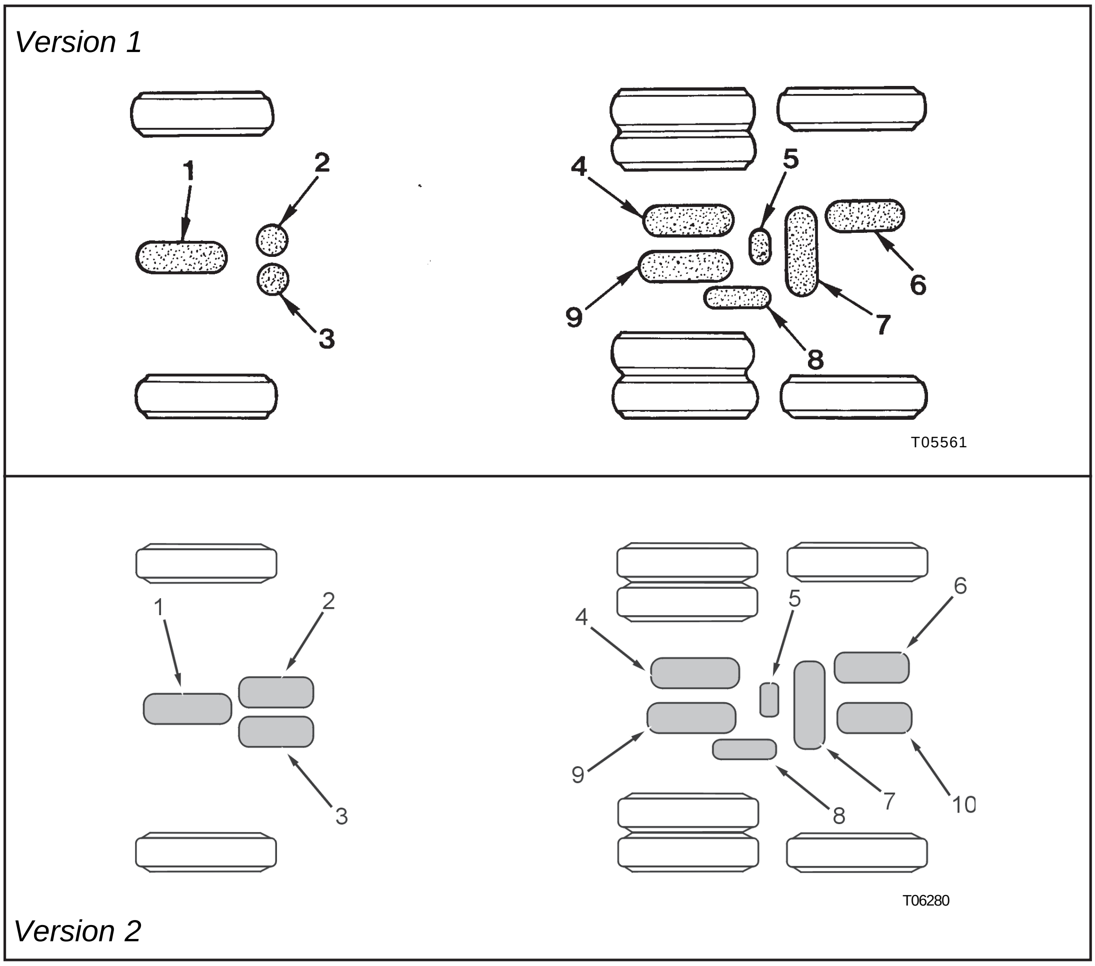

Figure 2: Location of air tanks

1. Front axle brakes
2. Front kneeling system
3. Parking brake emergency release
4. Auxiliaries
5. Buffer tank
6. Tag axle brakes
7. Rear raise system
8. Purge tank
9. Drive axle service brakes
10. Astronic (only on vehicles with Astronic transmission)

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MAINTENANCE

TO DRAIN AIR TANKS

Drain the air tanks at the intervals given in the Maintenance Schedule.
If there is a lot of water and /or dirt, this means that the air dryer desiccant has lost adequate absorption capacity through contamination. Replace desiccant cartridge.

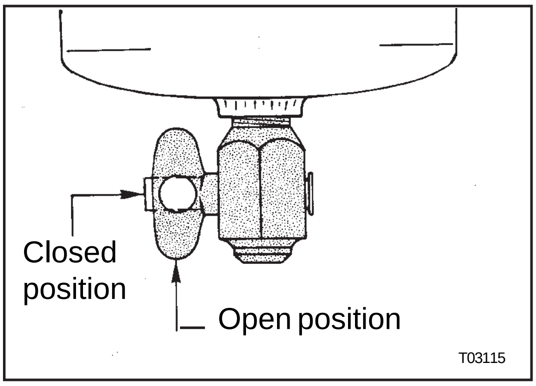

Figure 3: Drain cock in air tank

TO CHECK AIR TANKS

The tanks should be checked for security, for outer surface corrosion and damaged lines and fittings.

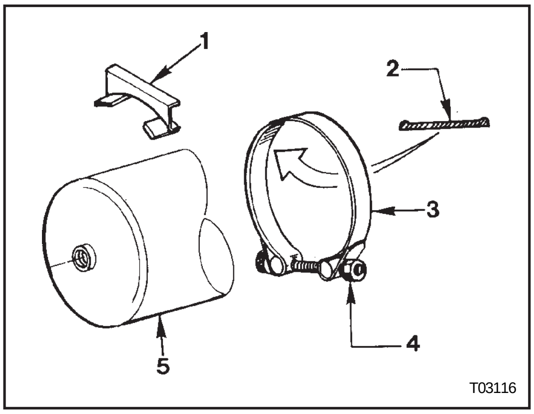

Figure 4: Air tank security

1. Bracket
2. Clamp ring rubber
3. Clamp ring
4. Security bolt
5. Air tank

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PRESSURE SWITCHES

STOPLIGHT SWITCHES

Two stoplight switches are used on this coach: one in the front axle service brake system and one in the drive axle service brake system. The stoplight switches are located in the pressure switch box in the rear wall of the luggage compartment.

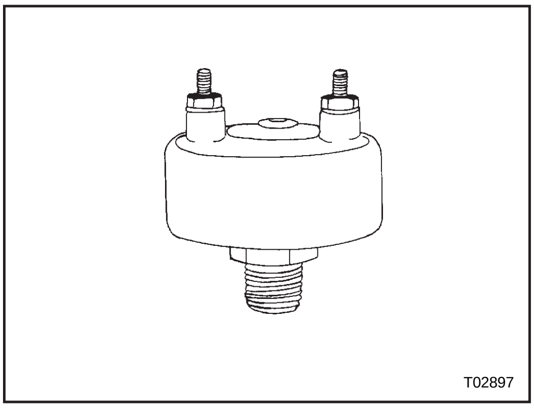

Figure 1: Bendix SL-5 stop light switch

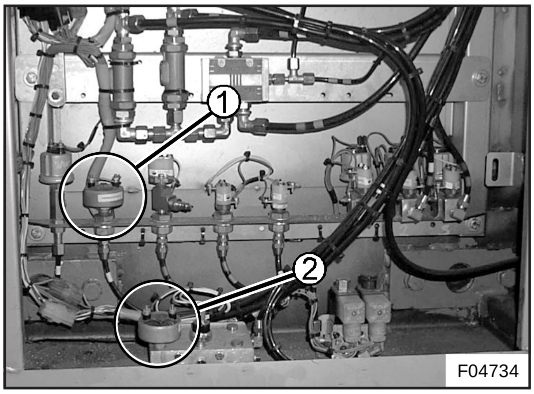

Figure 2: Pressure switch box in rear wall of luggage compartment

1. **Stoplight switch in the drive axle service brake circuit (DK36.2)**
2. **Stoplight switch in the front axle brake circuit (DK36.1)**

DESCRIPTION

The switch is an electropneumatic 5 psi (contacts must be closed at 4 psi nominal) non-grounded switch that operates in conjuction with the brake valve and stop lights by completing the electrical circuit and lighting the stop lights when a brake application is made.

The stop light switch is not a serviceable item; and if found defective, the complete unit must be replaced.

OPERATION -Figure 3

When a brake application is made, air pressure from the brake valve enters the cavity below the diaphragm. The air pressure below the diaphragm moves the piston until it contacts the leaf spring. The leaf spring travels past a fulcrum at which point the leaf spring snaps ashorting bar which mates with the contact strips. The stop light electrical circuit is completed, lighting the stop lights before the brake application pressure reaches 6psi.

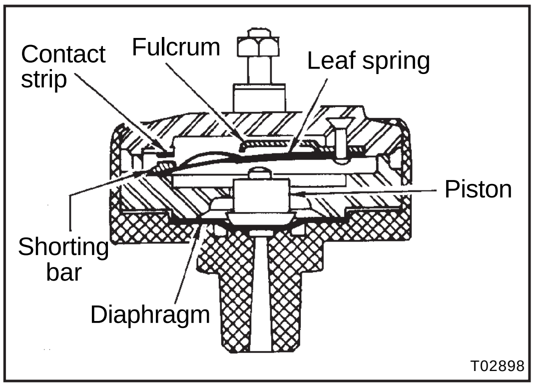

Figure 3: Cross section SL-5 stop light switch

MAINTENANCE

Preventive maintenance

Check electrical connections and determine that stop lamps operate properly.

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Operating and leakage test

1. Install an accurate air gauge in the service line. Apply brake valve gradually. Stop lamps should light at 6 psi or less and go out after the brake application is released. This checks the electrical function of the stop light switch.

2. When pressurized, no leakage is permitted from the body of the switch.

If the stop light switch does not function as described above or if leakage is excessive, the switch should be replaced with a new one.

PRESSURE SWITCHES

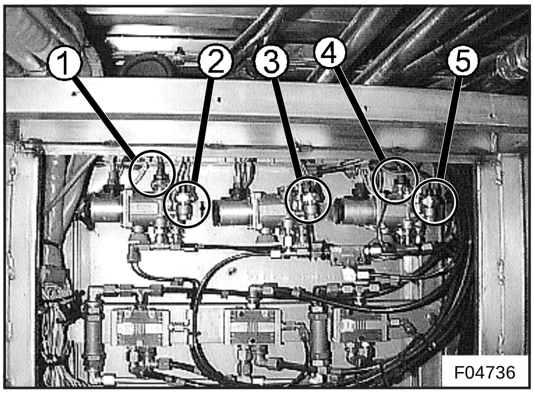

Figure 4: Pressure switches (N.O. 7.2 psi) of suspension system, in pressure switch box in rear wall of luggage compartment

1. **Will prevent the activation of the raise system when the lower system is on (DK48.1)**
2. **Will close an electrical circuit to illluminate the "lower" indicator light when the "lower" system is on (DK48.2)**
3. **Will close an electrical circuit to illluminate the "raise" indicator light when the "rear raise" system is on (DK60.3)**
4. **Will prevent the activation of the lower system when the raise system is on (DK60.1)**
5. **Will close an electrical circuit to illluminate the "raise" indicator light when the "raise" system is on (DK60.2)**

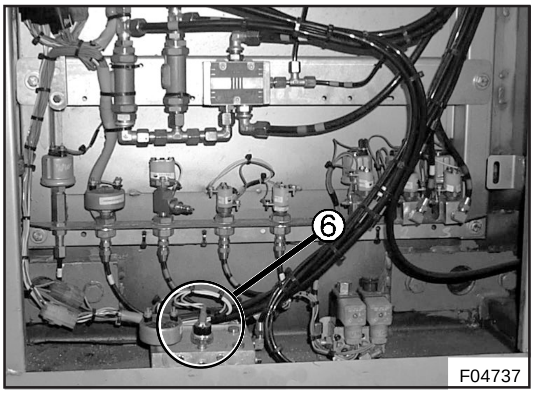

Figure 5: N.C. 4 psi "Cruise control disable" pressure switch (6) (DK036), in pressure switch box in rear wall of luggage compartment. The switch will open when the service brake is applied.

The pressure switches are located in the pressure switch box in the rear wall of the luggage compartment.

NORMALLY OPEN (N.O.) PRESSURE SWITCH

Operation -Figure 6

As pressure is applied, diaphragm (1) and contact plate (2) are raised and poles (3) and (4) are connected.

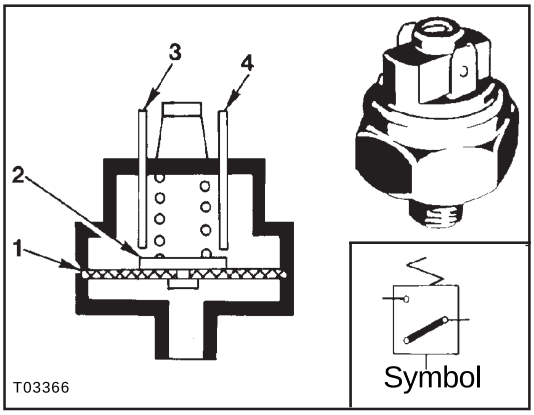

Figure 6: Normally open pressure switch

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NORMALLY CLOSED (N.C.) PRESSURE SWITCH

Operation- Figure 7

As pressure is applied, diaphragm (1) and plunger (5) are raised, lifting contact plate (2) from poles (3) and (4).

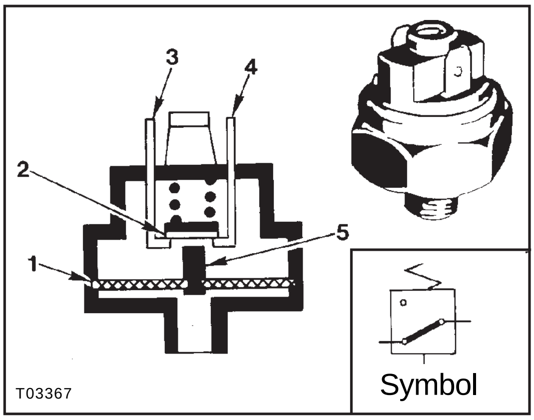

Figure 7: Normally closed pressure switch

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LOW PRESSURE INDICATOR

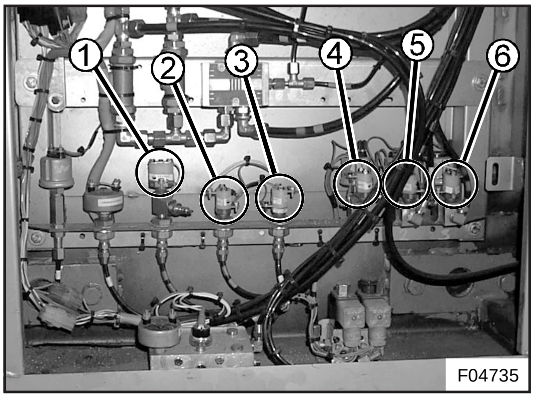

Figure 1: Low pressure indicators (in pressure switch box in rear wall of luggage compartment)

1. **Parking brake emergency release tank, 66 psi (DK038)**
2. **Auxiliaries tank, 66 psi (DK015)**
3. **Parking brake indicator light, 70 psi (DK018)**
4. **Front axle brakes tank, 66 psi (DK012)**
5. **Drive axle service brakes tank, 66 psi (DK013)**
6. **Tag axle brakes tank, 66 psi (DK020)**

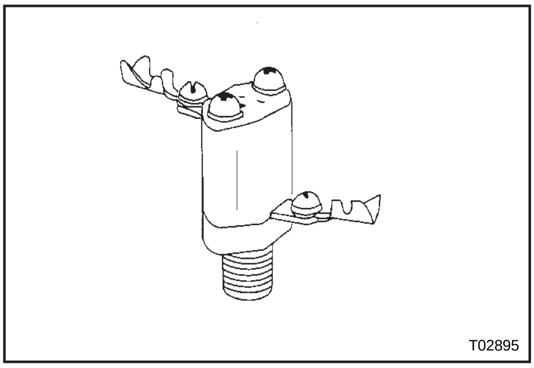

Figure 2: LP-3 low pressure indicator

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.

The electrical contacts provided in the indicator remain closed by spring force until the air pressure below the diaphragm is above 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.

OPERATION

To describe the operation, we shall assume that the low pressure indicator is set for 66 psi. When air pressure at the supply port and under the diaphragm is above 66 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 66 psi, the spring exerts a force which is greater than the force exerted by the air pressure below the diaphragm. This

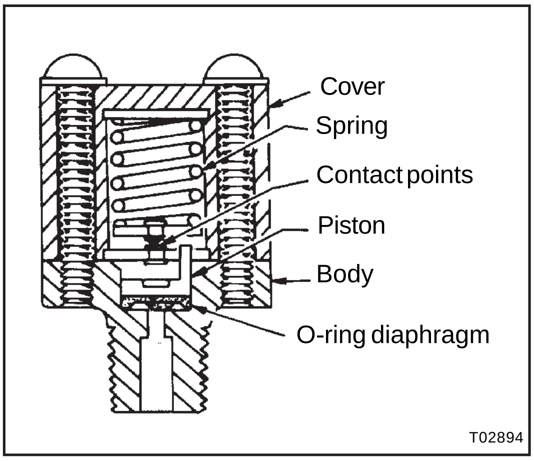

Figure 3: Cross section LP-3 low pressure indicator

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causes the diaphragm and the piston 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.

MAINTENANCE

PREVENTIVE MAINTENANCE

Check electrical connections.

OPERATING AND LEAKAGE TEST

1. Determine the setting of the low pressure indicator by referring to the label on the valve.
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.
3. With air pressure present at the supply port, coat the indicator with a soap solution. No leakage is permitted.

NOTE
Low pressure indicator should be replaced if found defective.

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VALVES

SAFETY VALVE

DESCRIPTION

The safety valve protects the air system against excessive air pressure build-up. The valve consists of a spring loaded ball valve subjected to tank pressure which will permit air to exhaust tank pressure to the atmosphere if tank pressure rises above the valve pressure setting, which is determined by the force of the spring.

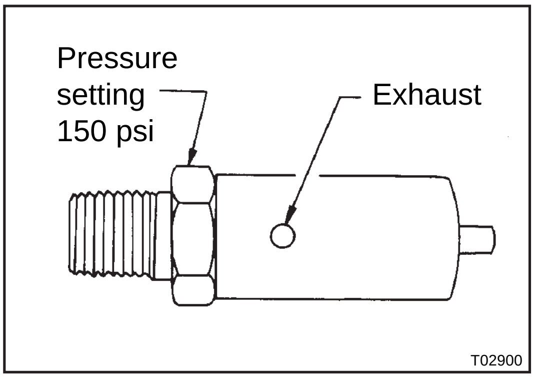

Figure 1: ST-3 safety valve

OPERATION

Should system pressure rise to approximately 150 psi, air pressure would force the ball valve off its seat and allow tank pressure to vent to atmosphere through the exhaust port in the spring cage.

When tank pressure decreases sufficiently, the spring force will seat the ball check valve, sealing off tank pressure. This would occur at approximately 135 psi. The pressure setting is stamped on the wrench flat of the valve.

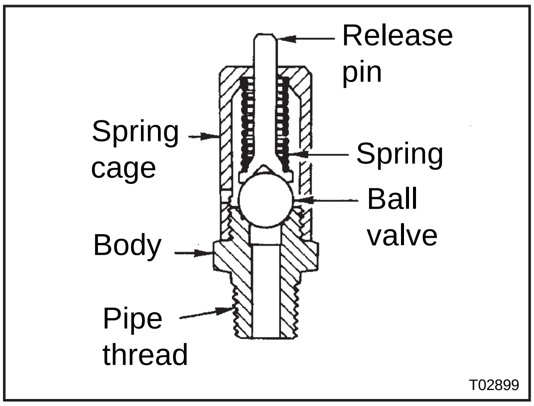

Figure 2: Cross section ST-3 safety valve

Normally, the safety valve remains inoperative and only functions if for any reason tank pressure rises above the setting of the valve. Constant "popping off " or exhausting of the safety valve can be caused by a faulty safety valve, a faulty governor, a faulty compressor unloading mechanism or a combination of the preceding.

MAINTENANCE

Operating test

With air pressure in the system, pull the exposed end of the valve stem removing the spring load from the ball check valve. Air should exhaust from the valve exhaust port. Release the stem, the air flow should stop. Failure of valve to pass operating test would indicate the valve should be disassembled, cleaned and rebuilt.

Leakage check

Coat the exhaust port with soap solution. A leakage of a one (1) inch bubble in 5 seconds is permitted. Excessive leakage indicates dirt in

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valve, faulty ball valve or seat. Valve should be disassembled, cleaned and rebuilt .

PRESSURE PROTECTION VALVE

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 an air system:

- to protect one tank or tank system from another, by closing automatically at a preset pressure should a tank system failure occur.
- to delay filling of auxiliary tank to insure a quick build-up of brake system pressure.

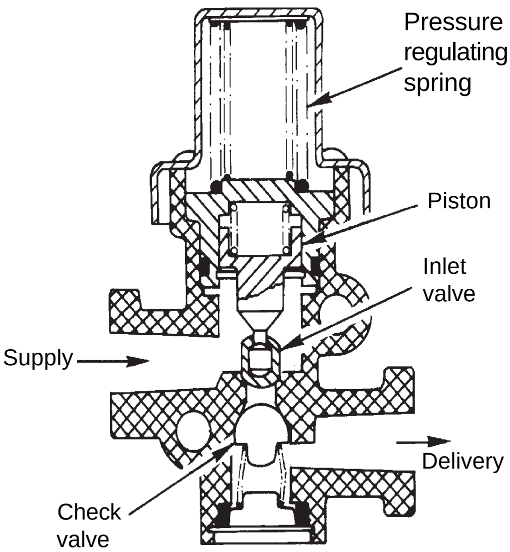

Figure 3: PR-3 pressure protection valve

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 to 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
Opening pressure of the valve is approx. 10 psi higher than closing pressure.

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 either at the supply or delivery side (depending upon where the pressure drop has occurred) will be retained.

OPERATING AND LEAKAGE CHECKS

Operating check

1. Provide a pressure gauge and drain valve at supply side and delivery side of pressure protection valve being checked.
2. Build up air system to full pressure and shut off engine.
3. While watching the gauge on the supply side of the valve, slowy begin to exhaust pressure from the

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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 ±5 psi of the pressure indicated on the valve label. 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. Build pressure up again and shut off engine. Slowly exhaust air from supply side. The gauge on the delivery side of the valve should remain at the highest pressure previously attained.

Leakage check

1. Build up air system to full pressure and shut off engine.

2. Apply a soap solution around cap of pressure protection valve. A one inch-bubble in three seconds is acceptable. No leakage is permitted at bottom of valve.

3. Drain air pressure from delivery side of pressure protection valve and disconnect air line to it.

4. Apply a soap solution to delivery port. A one inch-bubble is acceptable.

NOTE
If pressure protection valve does not operate as described or leakage is excessive, it is recommended to replace the valve.

SINGLE CHECK VALVE

GENERAL

The single check valve is placed in the air line to allow air flow in one direction only and to prevent flow of air in the reverse direction.

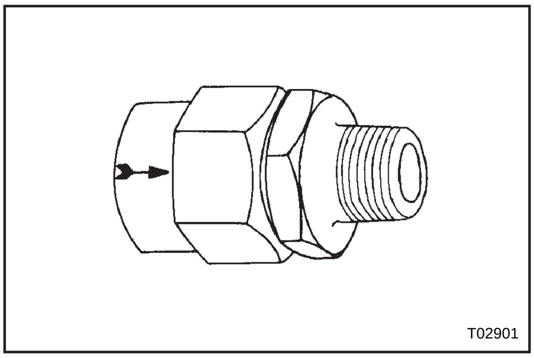

Figure 4: Single check valve

OPERATION

Air flow in the normal direction moves the disc from its seat, and the flow is unobstructed.

Flow in the reverse direction is prevented by the seating of the disc, which is caused by a drop in upstream air pressure. Reverse flow is also prevented by the action of a spring.

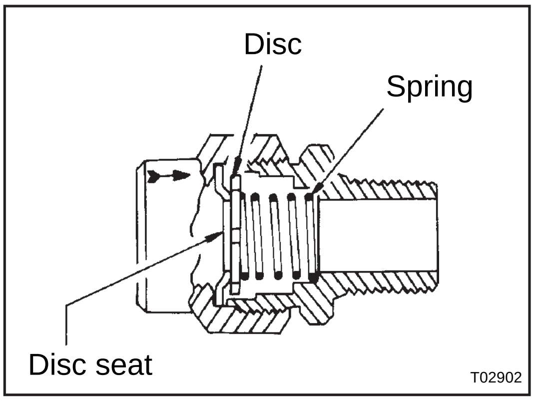

Figure 5: Single check valve

DOUBLE CHECK VALVE

DESCRIPTION

These valves are used to direct a flow of air into a common line from either of two sources, whichever is at the higher pressure.

OPERATION

As air under pressure enters either end of the double check valve (inlet port), the moving shuttle 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 will reverse if the pressure levels are reversed. Double check valves are designed so that the shuttle can never impede the backflow of air in the exhaust mode.

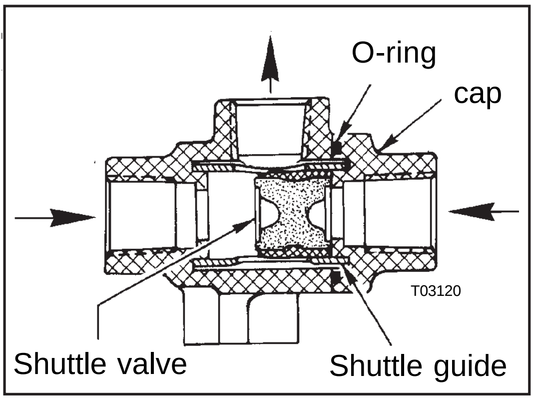

Figure 6: DC-4 double check valve

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AIR LINE DIAGRAM

TO READ DIAGRAM

GENERAL

To describe the operation of air system components, an international standard system of schematic symbols has been adopted. These symbols are easy to understand and add considerable detail so that if a technician examines the diagram carefully, he will be able to describe what the pressurized air stream will do in any given set of conditions.

DIRECTIONAL CONTROL VALVES

Directional control valves change the direction of air flow by moving one or more internal parts within the valve body. The position of the internal part determines which of the valve's external ports are connected or disconnected. In air system directional control valves, the flow paths may connect a supply port to an outlet port, or may allow a pressurized port to exhaust to the atmosphere, or a flow path through the valve may be blocked. Directional control valve outlet ports are usually connected to actuators.

Valve position

Valve position does not refer to the valve's location in the coach or its mounted orientation, but rather to the position of the valve's internal movable part. If a valve offers two usable flow positions, it is called a 2-position valve. The basic symbol for a 2-position valve is two squares side-by-side, with a common edge (see Figure 1). This symbol is called an "envelope".

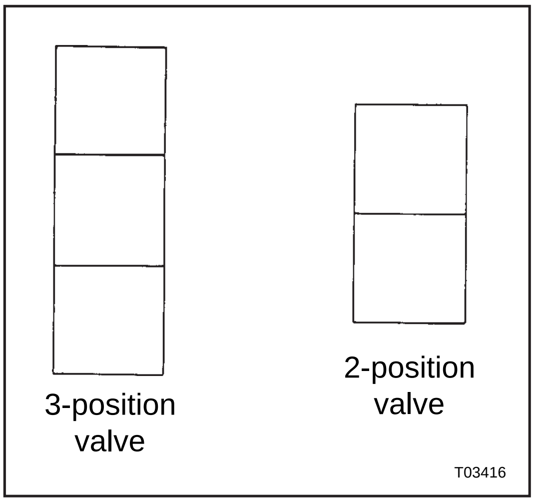

Figure 1: Valve position

Each box, when completed by the addition of other symbols to be described later, represents one position of the valve.

A valve with three usable and different flow positions is called, logically, a 3-position valve and is represented by an envelope of three squares (see Figure 1). The central position of the valve (represented by the center square of the envelope) is called the neutral position. To understand the valves accurately, the center flow position must be noted as well as the two conditions at the ends of the valve. Three-position valves are the most complex type of valve used. The only 3-position valves used in the air system are the suspension levelling valves.

Valve actuators

Actuators are the valve parts through which force is applied to move or position the internal flow-directing elements, thus shifting the valve to another position. This action may be

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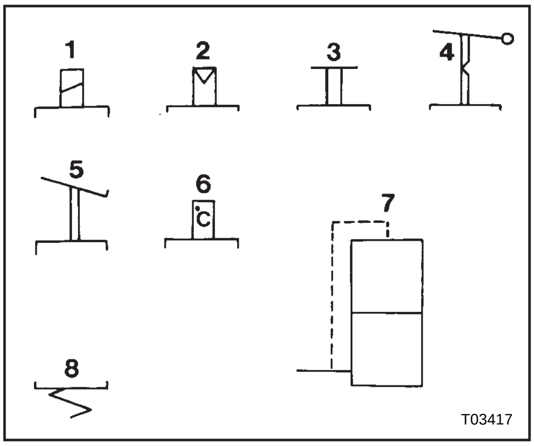

Figure 2: Valve actuators

1. **Electrically actuated valve**
2. **Pneumatically actuated valve**
3. **Push button-actuated valve**
4. **Lever-actuated valve**
5. **Pedal-actuated valve**
6. **(Coolant) temperature-actuated valve**
7. **Actuated by a pilot pressure line (dashed line) formed internally in the valve**
8. **Spring-returned valve**

initiated manually through levers, push buttons or pedals; or mechanically through springs, cams, rollers, levers or stems. In other cases the actuator may accept signals in some other form and translate them into a force.

The two common signals in the latter case are the electrical and pneumatic. Direct solenoid-actuated valves transform an electrical signal into the mechanical motion of the solenoid plunger, which shifts the valve. Air-pilot-operated valves use pneumatic pilot pressure to shift the valve directly.

Many valves have an internal spring at the opposite end of the internal element. A signal or force to the actuator shifts the valve while compressing the spring. When the signal or force is removed, the spring extends to shift the valve back to its original position. This type of valve is called a spring-returned valve.

Valve action

Valve action describes the internal flow paths between ports. The terms which identify the three most common configurations are: 2-port, 3-port, 4-port and 5-port.

A 2-port valve has two ports or connections. In one position it is closed to stop flow; in the alternate position it is open to allow flow. These are the only possible flow conditions, so a 2-port valve is always a 2-position valve.
The terms NORMALLY OPEN (NO) and NORMALLY CLOSED (NC) describe a 2-port valve with a spring actuator controlling one position. The spring always returns the valve to the NORMAL position when the other actuator is not energized or subject to a force. If the spring always selects the closed flow path, the valve is called a normally closed (NC) 2-port. If the spring always selects the open flow path, the valve is called a normally open (NO) 2-port.

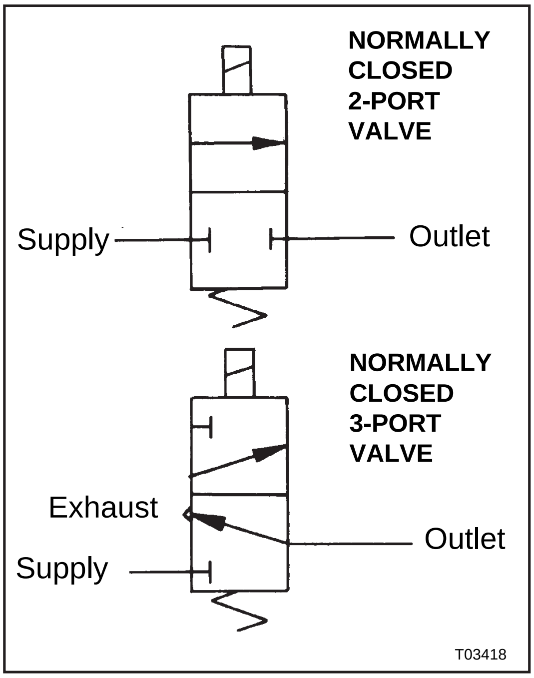

Figure 3: Valve action

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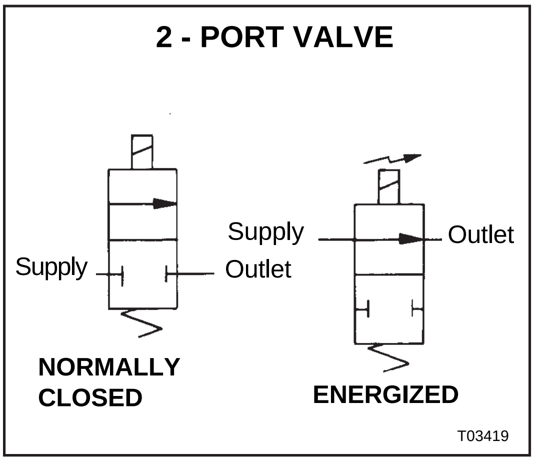

Figure 4: Move envelope in direction of applied force

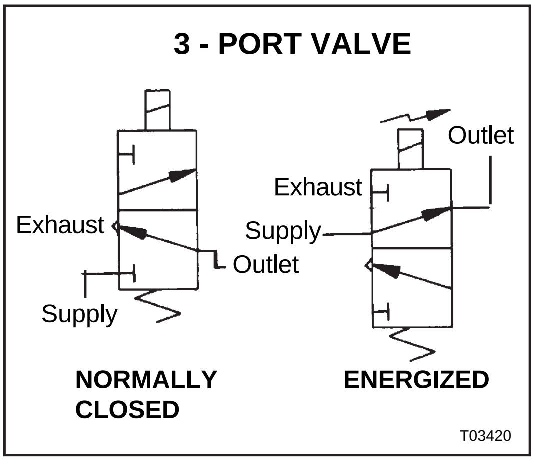

Figure 5: Move envelope in direction of applied force

The T-shaped symbols in the envelope represent closed or blocked-off passages. The arrows indicate the direction of air flow. The triangle symbols represent the exhaust port. When valve solenoid is energized, valve position will shift and will overcome the spring pressure represented by the jagged line at the bottom of the envelope. The NC-valve opens, and air pressure flows from the supply to the outlet. This is represented by moving the envelope of the valve symbol in the direction of the applied force.

This example indicates, in simplified form, the method to use in examining the air system schematic. To determine what functions a valve can perform, move its envelope as a unit, aligning the supply and outlet lines with the internal symbols of the different squares. It will then become apparent how the direction of the air streams can change with the positioning of the valve. This method works well when considering the more complicated 3-port valves, discussed next.

A 3-port valve has three ports: supply, outlet and exhaust. Most 3-port valves have two positions and ordinarily are connected with supply pressure to the supply port, the outlet port to the device being controlled and the exhaust port open to atmosphere. In one position air pressure enters the valve and exhaust is blocked. In the other position, supply is blocked and air pressure from the device can exhaust to the atmosphere.

When the terms OPEN and CLOSED are used with reference to 3-port valves, they refer to the flow condition between the supply port and the outlet port. When a 3-port valve is open, supply is open to the outlet port and the path between outlet and the exhaust port is blocked. If a 3-port valve is spring returned, the same terminology of a "normally open" and "normally closed" applies as for 2-port valves.

Another type of valve design is called the 4-port valve and is found in the door control system and air suspension control system.

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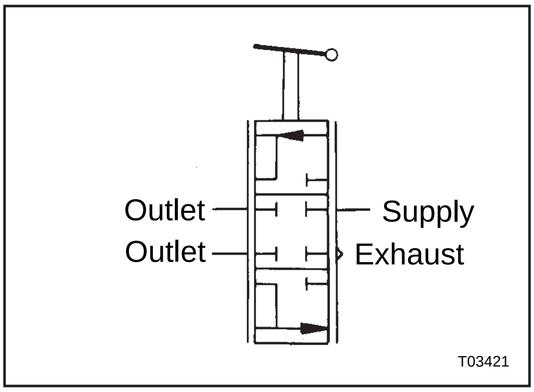

Figure 6: Suspension levelling 4-port valve

The four ports of this valve are:
- supply
- exhaust
- outlet (2)

The suspension levelling 4-port valves are configured to provide three distinct flow paths.

In the first position, supply is blocked and the air bellows are open to exhaust.

In the second position, supply and exhaust are blocked off.

In the third position, the supply air pressure is open to the air bellows and exhaust is blocked.

Some valves have a modulating feature.This means that outlet pressure depends on valve actuator position. These valves can be recognized by the double vertical envelope sides(see figure 6). Example: As brake pedal is depressed further, brake line pressure will increase.

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PNEUMATICAL SYMBOLS

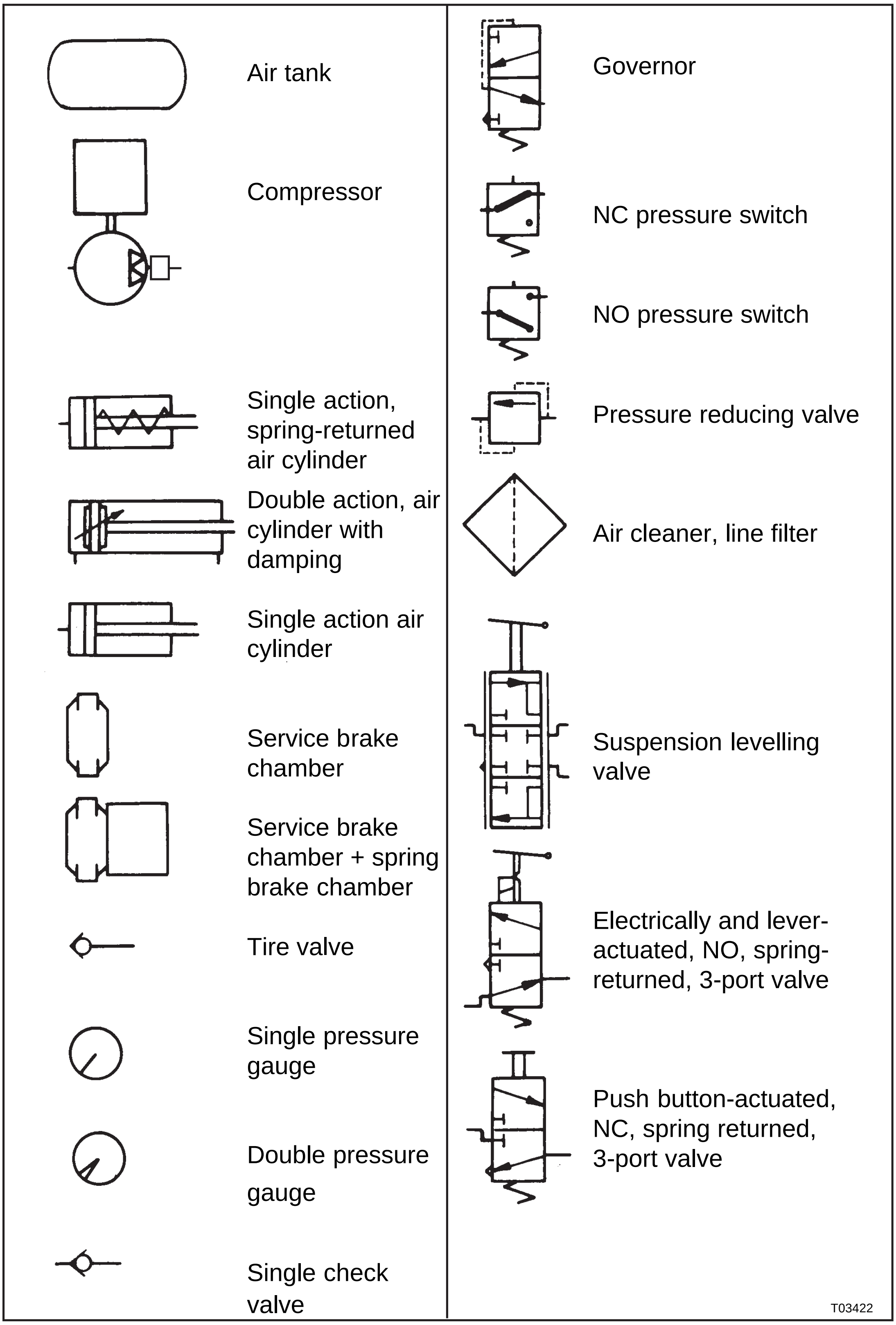

Figure 7: Pneumatical symbols

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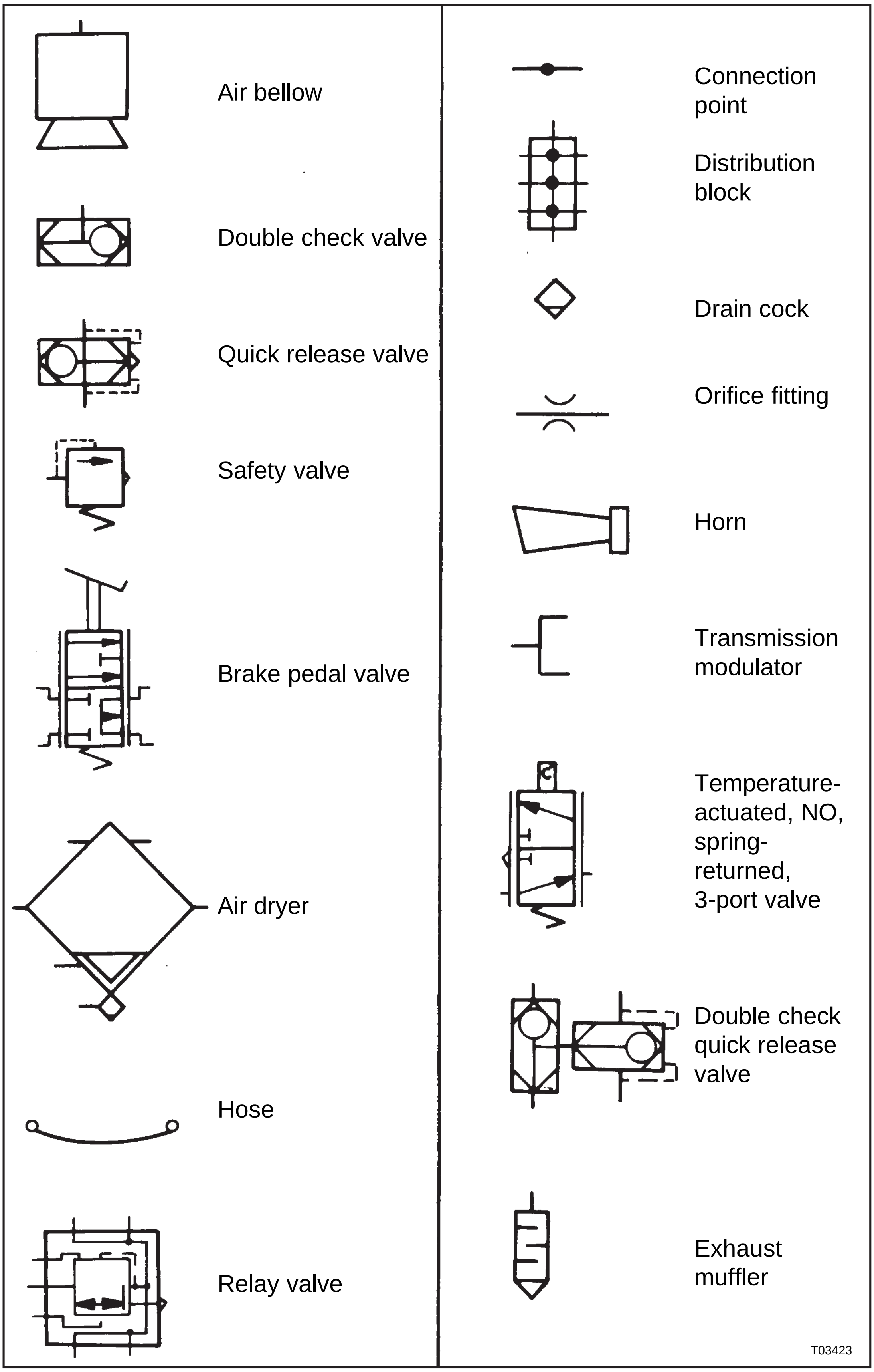

Figure 8: Pneumatic symbols

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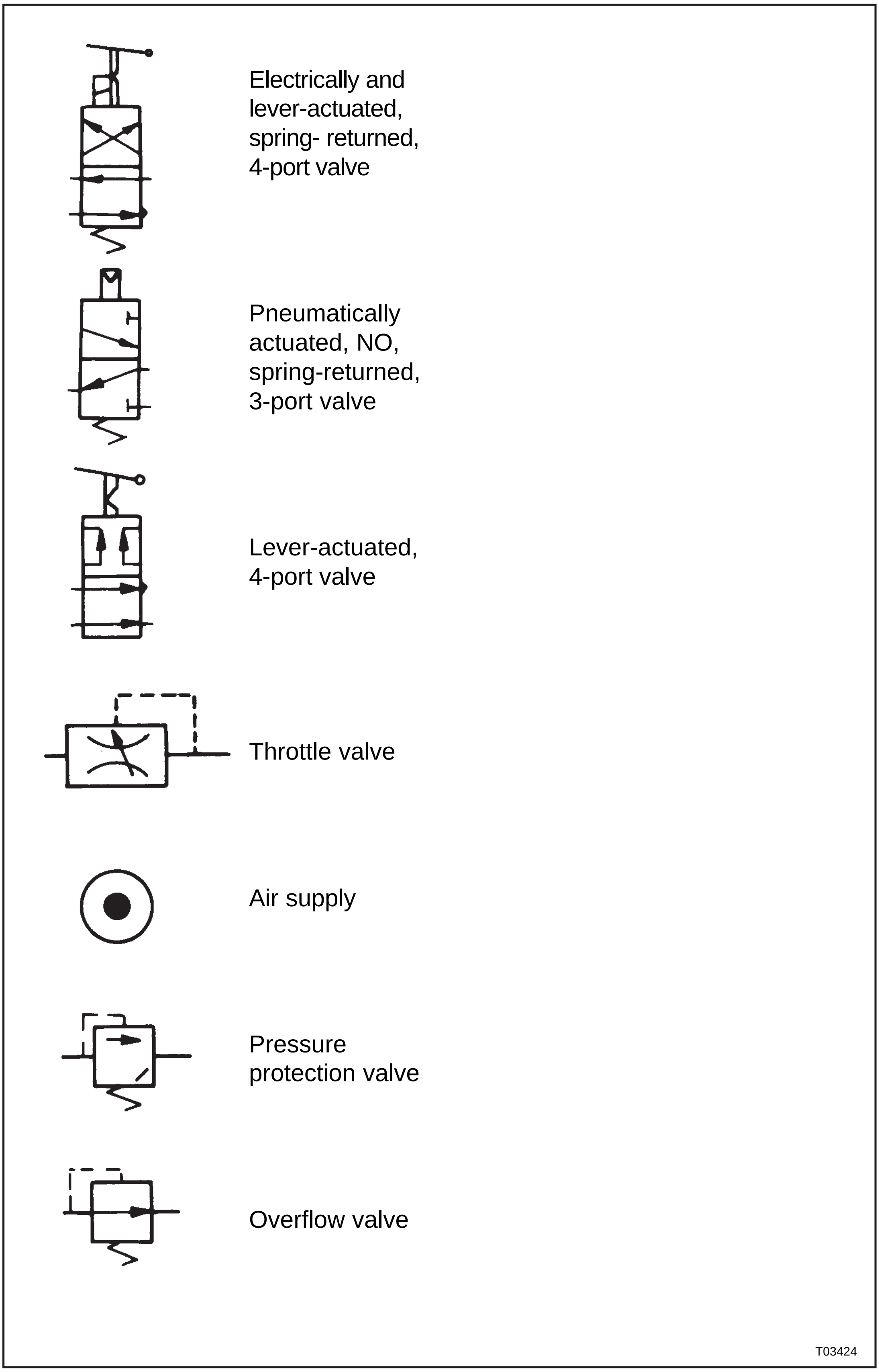

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Figure 9: Pneumatic symbols

AIR LINE COLOR CODE

To assist in tracing circuits and making proper connections, colored adhesive tape bands are provided near the ends of each air line. Abbreviated band color designations are used in air line diagram.

NOTE
Abbreviations are based on Dutch words, not English. "GE", for instance, stands for yellow.

The color code key reads as follows:

Air line marking band colors	Color code letters in air system diagram	Circuit
2 x red	R - R	Main air supply (compressor to tanks)
1 x red, 1 x green	R - GN	Front axle service brakes: tank pressure
1 x green	GN	Front axle service brakes: braking pressure
1 x red, 1 x yellow	R - GE	Drive axle service brakes: tank pressure
1 x yellow	GE	Drive axle service brakes: braking pressure
1 x red, 1 x violet	R - V	Tag axle service brakes: tank pressure
1 x violet	V	Tag axle service brakes: braking pressure
1 x red, 1 x white	R - W	Parking brake: tank pressure
1 x white	W	Parking brake hold-off pressure
1 x brown	BR	Door interlock control line
1 x red, 1 x grey	R - GS	Auxiliaries tank pressure
1 x grey	GS	Air suspension Door operation
1 x red, 1 x blue	R - B	Parking brake emergency release tank pressure
1 x blue	B	Parking brake emergency feed line

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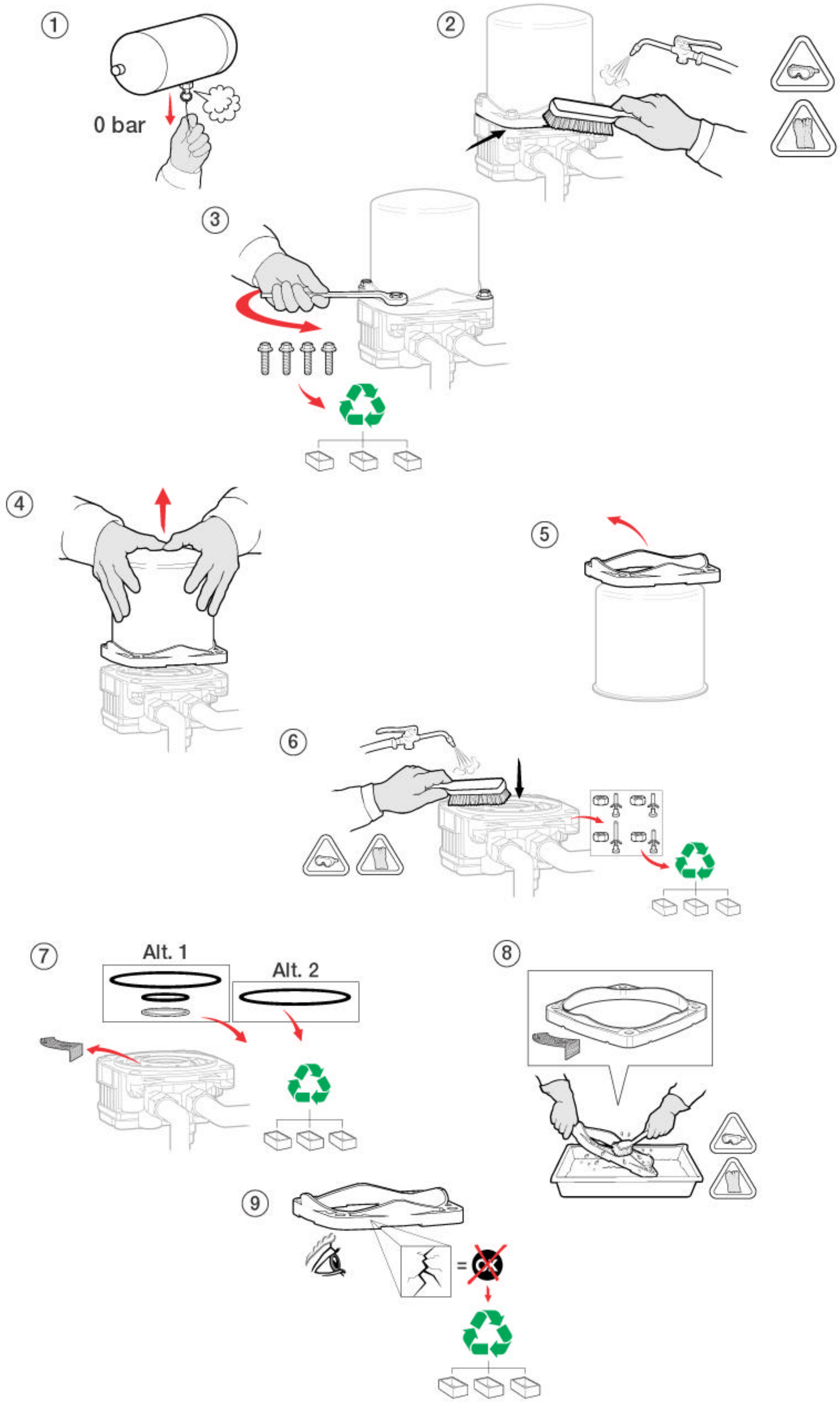
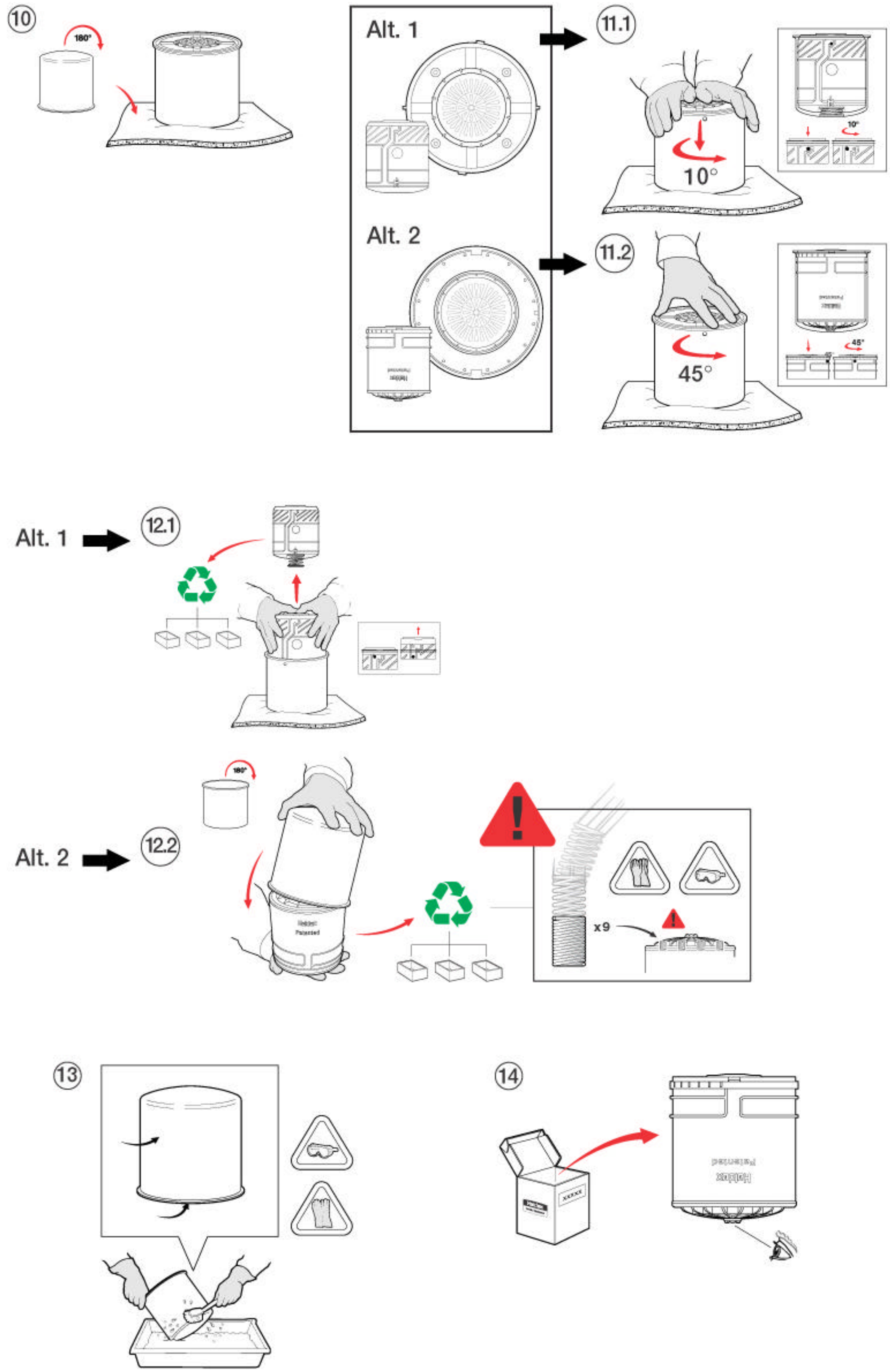
SPECIAL SERVICE TOOLS

TOOL06AC

TOOL06AC

Haldex air dryer: to change cartridge

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180°
Alt. 1
11.1
10°
10°
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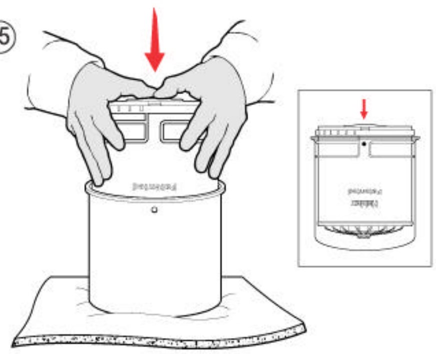

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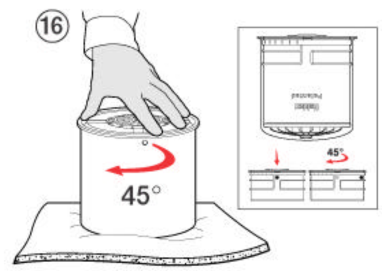

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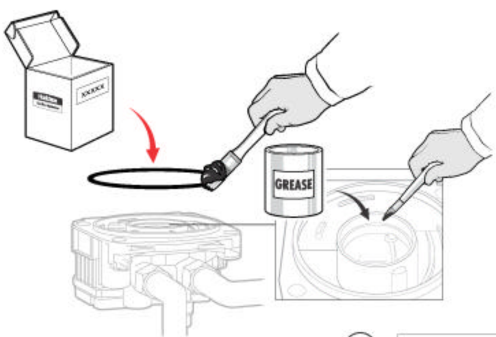

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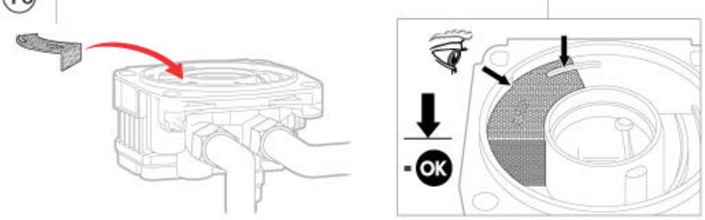

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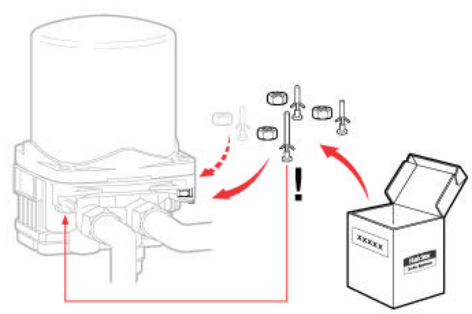

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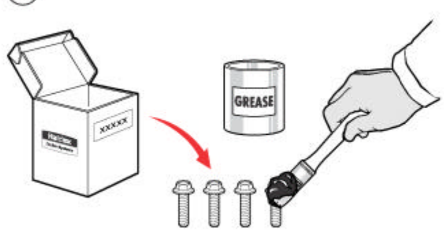

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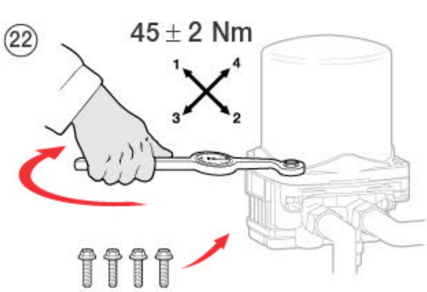

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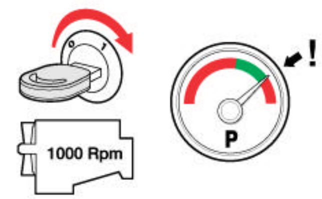

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SERVICE BULLETINS

Service Bulletins are issued to supplement or supersede information in the Van Hool manuals. Note below number, date and subject of Bulletins pertaining to this chapter. File Bulletins separately by number for future reference.

Number	Date	Subject

CHAPTER 7

STEERING

PAGE

STEERING - HYDRAULIC SYSTEM

STEERING - LINKAGE

MAIN07AC

STEERING - HYDRAULIC SYSTEM

PURPOSE

The input torque from the steering wheel is multiplied by the hydraulic power system so that - even under the most severe road conditions - the steering effort is substantially reduced.

SPECIFICATIONS

Make .... ZF
Type 8098
Steering ratio .... variable

MAINTENANCE

!!! CAUTION !!!
WHEN SERVICING THE POWER STEERING HYDRAULIC SYSTEM, CLEANLINESS IS IMPORTANT. BE SURE NOTHING ENTERS THE FLUID RESERVOIR AND CLEAN OFF ALL DIRT BEFORE OPENING THE RESERVOIR OR REMOVING ANY LINE.

TO CHECK FLUID LEVEL

1. Check fluid level when engine is still warm, at idle speed.

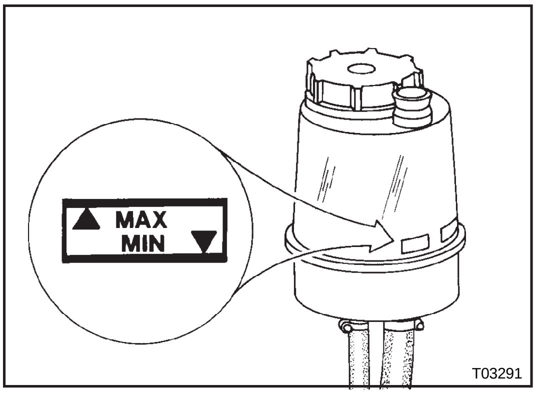

Figure 1: Fluid level marks on reservoir housing

2. The level is correct when fluid reaches the "MAX" mark on reservoir housing.

NOTE
The fluid must not rise more than 0.4 inch to 0.8 inch when engine is shut off. If fluid rises above that level, this indicates that fluid contains surplus air.

TO CHANGE FLUID FILTER- Figure 2

1. Unscrew cap (1).
2. Twist T-shaped filter retainer (3) approximately 1/4 turn to release filter (4).
3. Lift the filter together with the retainer out of the reservoir. Pull retainer (3) from filter (4). Discard filter.
4. Push retainer (3) on new filter (4) and reseat the filter assembly in the reservoir.

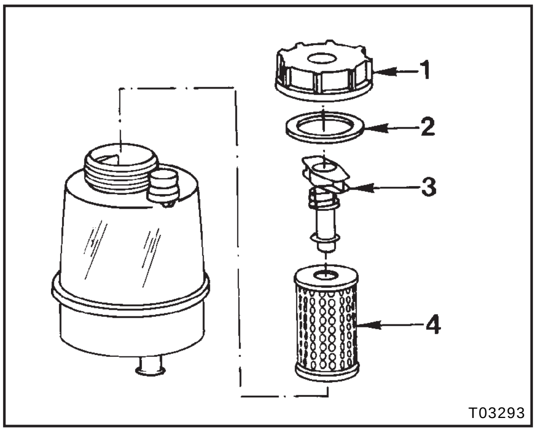

Figure 2: Exploded view of reservoir

1. Filler cap
2. Gasket
3. Filter retainer
4. Filter

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5. Press and twist at the same time to hold filter in place.

6. Check gasket condition. Renew if necessary.

7. Refit cap (1).

TO CHANGE FLUID

ZF recommends to change the fluid when the steering gear or pump is overhauled, or when a replacement one is fitted. At the same time, change fluid filter in reservoir and clean system lines.

!!! CAUTION !!!
NEVER RE-USE FLUID WHICH HAS BEEN DRAINED FROM THE SYSTEM.

To drain the system

1. Park coach over an inspection pit.

2. Apply parking brake and chock drive wheels. Jack up coach so that front wheels are clear off the ground.

3. Place a container of at least 3 gallons capacity beneath steering gear. Disconnect hydraulic pressure and return lines from steering gear.

!!! CAUTION !!!
DURING NEXT STEP, DO NOT RUN ENGINE FOR MORE THAN TEN SECONDS, OTHERWISE DAMAGE TO STEERING PUMP MAY RESULT.

4. Start engine and allow to idle in order to discharge fluid from pump, reservoir and lines.

5. Stop engine, then cycle steering wheel in both directions until no more fluid flows out.

6. Reconnect pressure and return lines to steering gear.

NOTE
A substantial amount of fluid will remain trapped inside the steering gear. If fluid drainage is heavily contaminated (e.g. by metal particles generated by a defective pump), steering gear is to be checked by a Van Hool service center.

To fill the system

!!! CAUTION !!!
DURING THE FILLING PROCEDURE, THE ENGINE IS NOT TO EXCEED IDLING SPEED AT ANY TIME.

1. Unscrew fluid reservoir cap and fill reservoir to the top with recommended hydraulic fluid (see chapter 12 for specifications).

2. Be ready to top up fluid while an assistant starts the engine. With engine running, fluid level in reservoir will rapidly drop: add new fluid at the same rate to avoid the reservoir emptying and air being drawn into the system.

To bleed air from system

Start bleeding procedure no sooner than when fluid in reservoir remains at "MAX" mark while engine is running. DO NOT run engine above idle speed to avoid fluid foaming. Fluid foaming delays bleeding unnecessarily long.

Bleeding should be done with front road wheels off the ground.

1. With engine idling, turn steering wheel slowly all the way to the right

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and to the left (but DO NOT apply effort at steering knuckle carrier stop positions) while an assistant keeps the reservoir topped-up by continuously adding new fluid. Continue this procedure until level remains constant and reservoir is free from air bubbles.

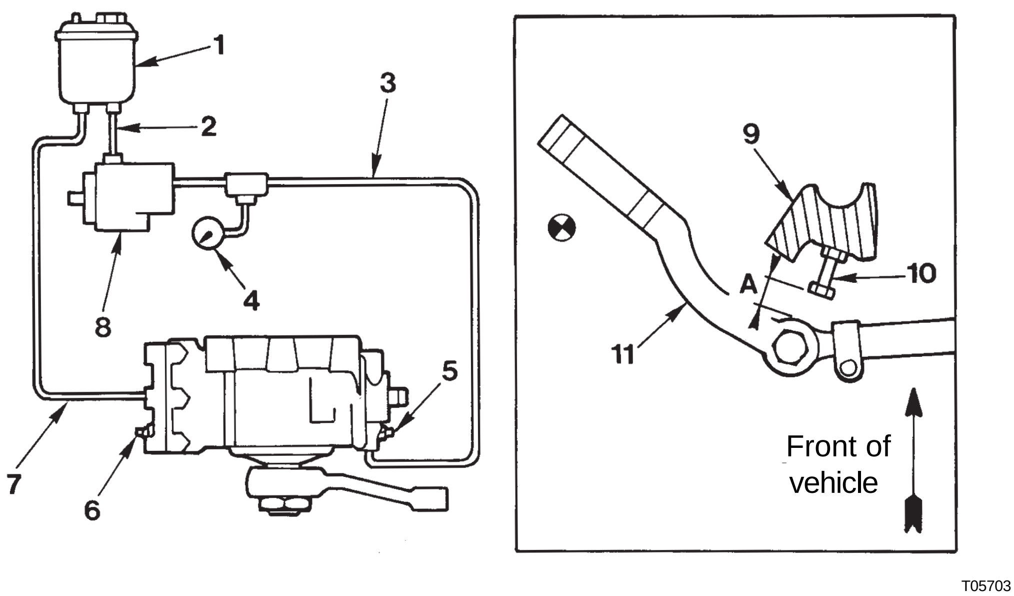
2. Stop engine. System is properly bled if fluid rises no more than 0.4 inch to 0.8 inch above "MAX" mark on reservoir housing.

3. Refit fluid reservoir cap and lower wheels to the ground.

TESTS AND ADJUSTMENTS

TO CHECK/SET HYDRAULIC LIMITER VALVES

When steering a front wheel with full hydraulic pressure against steering knuckle carrier stops (10, Figure 5), overload damage may be caused to power pump and steering mechanism. Therefore, a limiter valve has been incorporated in the steering gear which will cause pressure to drop automatically just before the maximum turning angle is reached. The valve opening time can be set through screws (5 and 6, Figure 5).



1. Hydraulic fluid reservoir	5. Limiter valve adjuster	9. Steering knuckle carrier
2. Suction line	6. Limiter valve adjuster	10. Maximum turning angle adjusting screw (with locknut)
3. High-pressure line	7. Return line	11. Steering arm
4. Pressure checking gauge	8. Power pump	A. Clearance

Figure 5: Steering limiter valve setting diagram

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To check limiter valve relief pressure

The check must be performed while the hydraulic fluid temperature is between 40°C (104°F) and 60°C (140 °F). The fluid can be warmed up by turning steering wheel from stop to stop a number of times while the engine is running. Measure temperature in hydraulic fluid reservoir.

NOTE
When using the special ZF power steering tester, the fluid temperature can rapidly be increased with the "Pressure loading valve" on tester (see "To check hydraulic system operation" further in this section). Fluid temperature can be read from the thermometer on the tester.

Procedure:

1. Check maximum wheel steering angles as follows:
   a. Place front wheels on graduated turntables, with wheels in straight ahead position and turntable scales at zero.
   b. Turn steering wheel until steering arm contacts stop screw on left hand steering knuckle carrier (see Figure 6). Read angular movement on turntable scale and compare with "Maximum Steering Angle/Inner Wheel Data" value (see chapter 4).
   c. Do the same for the right hand road wheel.

   Adjustment, if necessary, is done by loosen the locknut of the steering knuckle carrier stop screw and turning the screw in the appropriate direction. Retighten the locknut.

2. Pull parking brake and chock the drive wheels. Place front wheels on graduated turntables.

3. Pry out steering wheel hub cover using a screwdriver. Unscrew the steering wheel retaining nut and scribe a mark on the top of the steering column and wheel hub for ease of alignment at reassembly. Remove steering wheel. Place a torque tester with special adapter (VH part No. 10575651) on serrations of upper steering column.

4. Underneath the coach, near steering gear, there is a test connection. Remove plug clamp from the T-piece, then remove plug. Connect a 3000 psi pressure checking gauge to hose VH No. 639901590 and connect hose to test connection.

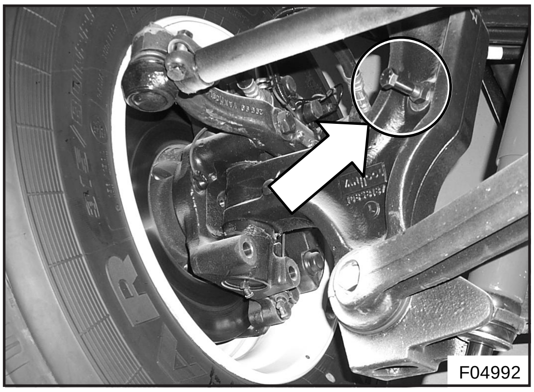

Figure 6: Stop screw on left hand steering knuckle carrier (rear view of front axle)

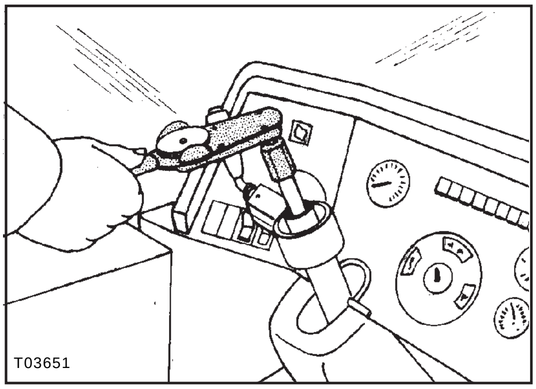

Figure 7: Torque tester with special adapter on serrations of upper steering column

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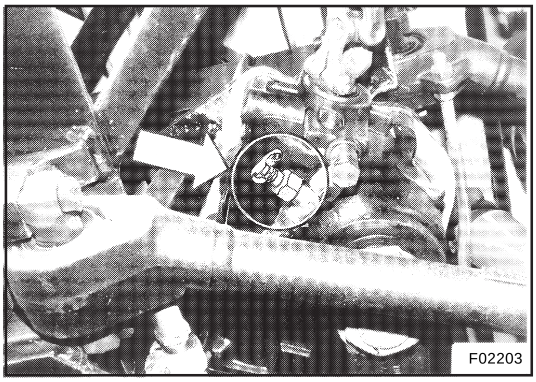

Figure 8: Test connection near steering gear,underneath the coach

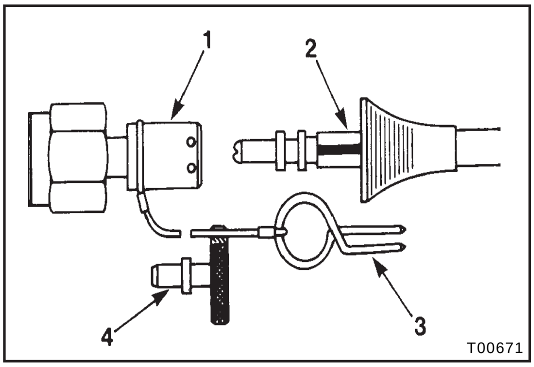

Figure 9: Test connection and hose

1. Test connection
2. Hose (VH 639901590)
3. Clamp
4. Plug

5. Start engine and allow to idle during the remaining part of the test.

!!! CAUTION !!!
THE SPACER MAY BE SQUEEZED OUT FROM BETWEEN STOPS DURING THE NEXT STEP; MIND YOUR HEAD.

6. Have an assistant insert the spacer tool (ZF part No. 7418798452) with the 0.118 inch disc between the right hand steering knuckle carrier stop screw and the steering arm, and turn upper steering column to the right until spacer tool is trapped in place. Once this condition is met, do not exert any additional effort on steering column.

!!! CAUTION !!!
DO NOT HOLD WHEEL AGAINST STOP FOR MORE THAN 5 SECONDS.

7. Pull steering column against the right hand stop with a torque of 20 to 35 ft.lbf. Note the pressure gauge reading.

8. Repeat this procedure for the left road wheel.

9. Pressure gauge reading should be between 50 to 60 bar (725 to 870 psi).

   If the reading does not fall within this range, the limiter valve relief pressure must be adjusted.

To adjust limiter valve relief pressure

!!! CAUTION !!!
DO NOT ADJUST LIMITER VALVES WHILE STEERING GEAR IS AT SYSTEM OPERATING PRESSURE. THIS WILL DAMAGE THE VALVE O-RING SEALS

1. Release the steering column to allow system pressure to drop to no-load level.

2. Loosen locknut of appropriate limiter valve adjuster (see Figure 10).

3. Turn adjuster counterclockwise to raise pressure or clockwise to reduce pressure.

!!! CAUTION !!!
IF PRESSURE DOES NOT CHANGE DURING ADJUSTMENT, BE CAREFUL NOT TO SCREW LIMITER VALVE TOO FAR OUT OF STEERING GEAR. IF THERE IS ANY DOUBT ABOUT THE VALVE, REPLACE IT.

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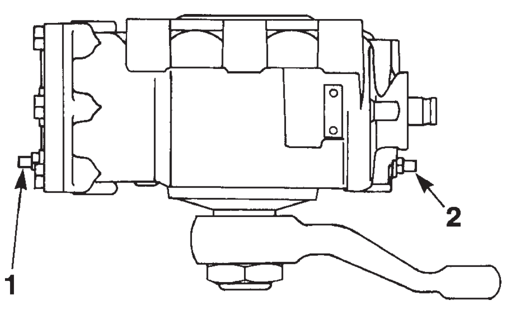

Figure 10: Adjusting screws of hydraulic steering limiter valves

1. **Limiter valve relief pressure left hand front wheel**
2. **Limiter valve relief pressure right hand front wheel**

4. Re-test to see if relief pressure has changed.

5. Repeat the previous steps until the correct relief pressure is reached.

6. Tighten adjuster locknut to a torque of 22 ft.lbf while holding the adjuster stationary.

7. Fit the steering wheel and be sure that marks on column and steering wheel hub are aligned. Refit steering wheel retaining nut and tighten to a torque of 30 to 35 ft.lbf. Refit steering wheel hub cover.

8. Put front wheels back on the ground and, with normally laden vehicle, check the adjustment as follows:

   Drive coach slowly forward, turning steering wheel to the right until hydraulic assistance falls out. At that moment, there should be some clearance between steering knuckle carrier stop screw and steering arm. Repeat this test turning the steering wheel to the left.

9. Stop engine. Remove pressure checking gauge and refit test connection plug.

TO CHECK HYDRAULIC SYSTEM OPERATION

To easy hydraulic system checks, a special power steering tester is available from ZF.

• Previous model "Servotest 550": This tester is without flow control vave. The flow control valve (ZF No. 7418798539) which is necessary when testing the steering gear for internal leakage should be ordered separetely.

• Current model: "Servotest 570": The flow control valve is already fitted on the tester.

To follow the instructions below you should have one at your disposal.

Prior to carrying out any tests, make sure that steering system is topped up with fluid to the correct level, that it has been properly bled, and that the engine is at operating temperature.
The tester is supplied with an instruction manual explaining how to connect the tool into the steering system and how to operate its controls.
Connect power steering tester in system as follows (see Figure 12):

1. Connect pump high pressure line to "INLET" of tester.

2. Connect steering gear pressure line to "OUTLET".

3. Connect a supplemental fluid line to "TANK" and hang the other end in fluid reservoir.

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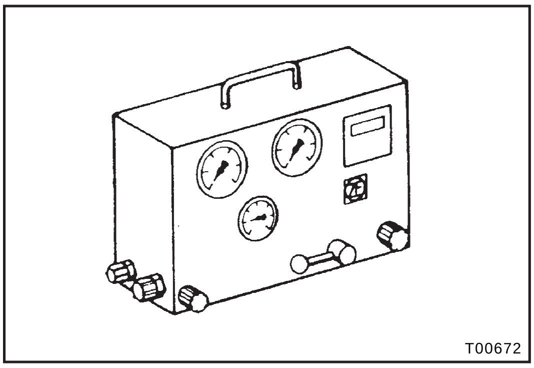

Figure 11: Power steering tester
- **Servotest 550: ZF part No. 7418798550**
- **Servotest 570: ZF part No.7418798574**

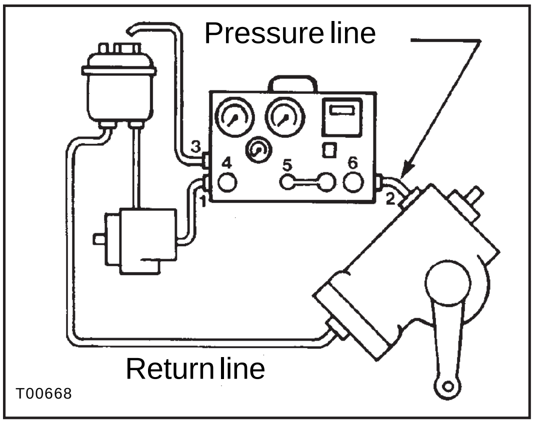

Figure 12: Power steering tester installation diagram

1. Inlet	**5. Pressure relief valve**
2. Outlet	**6. Pressure loading valve**
3. Tank	
4. Needle valve	

With the tester connected, set tester controls as follows:

1. "PRESSURE RELIEF VALVE" lever (knob on Servotest 570) to 150 bar (2170 psi).
2. "NEEDLE VALVE" knob to fully closed position.
3. "PRESSURE LOADING VALVE" knob to fully open position.

Follow procedure below to bring hydraulic fluid to test temperature:

1. Run engine at idle speed.
2. Set pressure to 50 bar (720 psi) with "PRESSURE LOADING VALVE" knob (6, Figure 12).
3. Wait until thermometer on tester indicates the specified test temperature, then return "PRESSURE LOADING VALVE" knob to fully open position.

To check pump pressure

!!! CAUTION !!!

NEVER RUN THE ENGINE ABOVE IDLE DURING FOLLOWING PROCEDURE. SHARP PRESSURE RISES MAY CAUSE THE PRESSURE LINE TO BURST OR DAMAGE THE PUMP

1. Run the engine at idle speed.
2. Slowly close "PRESSURE LOADING VALVE" knob on the tester until pressure gauge indicates 150 bar (2170 psi) pressure (maximum operating pressure). Do not close valve any further and re-open within 5 seconds.

!!! CAUTION !!!

DO NOT MAINTAIN MAXIMUM PRESSURE MORE THAN 5 SECONDS, AS THIS WOULD CAUSE AN ENORMOUS HEAT BUILD-UP WHICH MIGHT BURN THE PUMP.

If maximum operating pressure (with a margin of ± 10%) is not reached, this means that the power pump (or the flow control valve built into the power pump) is faulty.

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To check pump flow

Instructions for this check are included in the "Servotest" manual.

Run engine at idle speed. Set the test pressure, specified in the manual, using "PRESSURE LOADING VALVE" knob on the tester. Read flow rate on tester.

To check steering limiter valve relief pressure

This is the same procedure as described under "TO CHECK / SET HYDRAULIC LIMITER VALVES" earlier in this section.

If using the ZF power steering tester to measure limiter valve relief pressure, make sure that "PRESSURE LOADING VALVE" knob on tester is in the *fully* open position.

To check steering gear pressure

First make sure that "PRESSURE LOADING VALVE" knob on tester is in fully open position.

Procedure:

1. Apply parking brake and chock drive wheels.
2. Pry out steering wheel hub cover using a screwdriver. Unscrew the steering wheel retaining nut and scribe a mark on the top of the steering column and wheel hub for ease of alignment at reassembly. Remove steering wheel. Place a torque tester with special adapter (VH part No. 10575651) on serrations of upper steering column.
3. Start engine and allow to idle during the remaining part of the test.
4. Insert spacer tool (ZF part No. 7418798452) with 0.6 inch disc between right hand steering knuckle carrier stop screw and steering arm. Turn steering column to the right just enough to trap the spacer in place.

!!! CAUTION !!!
THE SPACER MAY BE SQUEEZED OUT FROM BETWEEN STOPS DURING THE NEXT STEP; MIND YOUR HEAD.

5. For not more than 5 seconds, pull steering column against right hand stop with a torque of 20 to 35 ft.lbf. Note the pressure gauge reading.
6. Repeat this procedure for the left road wheel.

If the pressures (or just one of them) are less than the previously measured maximum pump pressure, this indicates a faulty pressure relief valve in the steering gear housing or excessive steering gear internal leakage (due to worn parts).

To check steering gear for internal leakage

1. Carry out steps 1 to 3 of "TO CHECK STEERING GEAR PRESSURE".
2. Turn the "PRESSURE LOADING VALVE" knob to the fully closed position. Close the "NEEDLE VALVE" knob just far enough to build up a pressure that is 30 bar below the previously measured maximum pump pressure. Turn the "PRESSURE LOADING VALVE" knob back to the fully open position.
3. Carry out step 4 of "TO CHECK STEERING GEAR PRESSURE".

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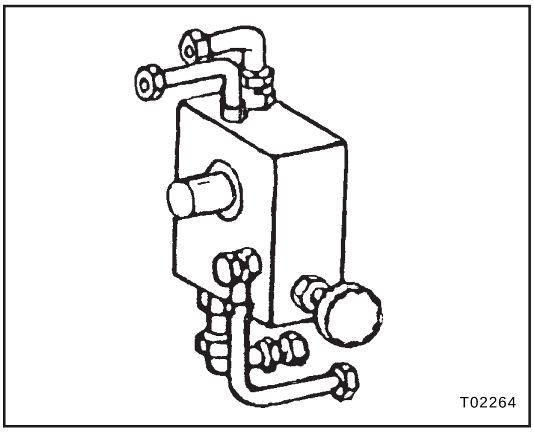

Figure 13: Flow control valve (ZF tool, part No. 7418798539) to connect upstream of "Servotest 550" tester

!!! CAUTION !!!
DO NOT HOLD STEERING COLUMN AGAINST STOP FOR MORE THAN 5 SECONDS.

4. Turn steering column against right hand stop with a torque of 20 to 35 ft.lbf. Note the leak flow rate and release the steering column.

5. Repeat this procedure for the left road wheel.

Leak flow rate must not exceed 2.5 dm^3/min.
Additionally, check high pressure seals in steering gear for properly sealing at low pump flow. Only for Servotest 550: connect flow control valve (see Figure 13) upstream of "Servotest 550". Set flow rate to 3 dm^3/min. Repeat previous leakage test. The recorded flow rate is not to exceed the rate observed at normal pump flow.

Excessive internal leakage may be caused by:

- Faulty pressure relief valve in steering gear. Have a new valve fitted by a VAN HOOL service center.
- Faulty steering limiter valve which opens too soon. Adjust limiter valves as explained in "TO CHECK/SET HYDRAULIC LIMITER VALVES" earlier in this section.
- Leaking seals in steering gear. Remove steering gear for reparation at a VAN HOOL service center.

6. Carry out step 7 of "TO CHECK STEERING GEAR PRESSURE".

To check return time of power steering valve

Lock pitman arm in the mid position. Turn steering wheel to close power steering valve in the steering gear, i.e. until maximum pump pressure is read on the pressure gauge. Slowly release steering wheel. Turn steering wheel until a pressure of 10 bar (145 psi) above no-load is read. After this the power steering valve has to return to neutral position within 1 second. This means that the pressure must drop to a value that exceeds no-load pressure no more than 0.5 bar (7 psi).

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STEERING - LINKAGE

MAINTENANCE

TO GREASE STEERING SYSTEM INTERMEDIATE LEVER

The intermediate lever is equipped with one grease nipple. For grease specifications: see Section 01.03.00. Interval: see Section 01.04.00.

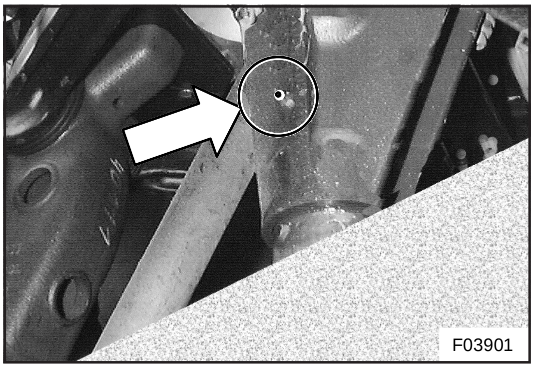

Figure 1: Grease nipple on intermediate lever

TO CHECK STEERING BALL-JOINTS

Clean the exterior of the joint to be checked with a dry cloth or with cotton waste.

!!! CAUTION !!!

DO NOT DAMAGE BALL-JOINT DUST COVER! DO NOT USE DETERGENTS OR SOLVENTS.

To check ball-joint exterior for corrosion - Figure 2

The joint should not present corrosion marks of more than 1 mm deep. Check whether the edge of casing (1) around cover (3) is free of corrosion.
When the joint is corroded to a greater extent than permitted, replace it completely by a new one.

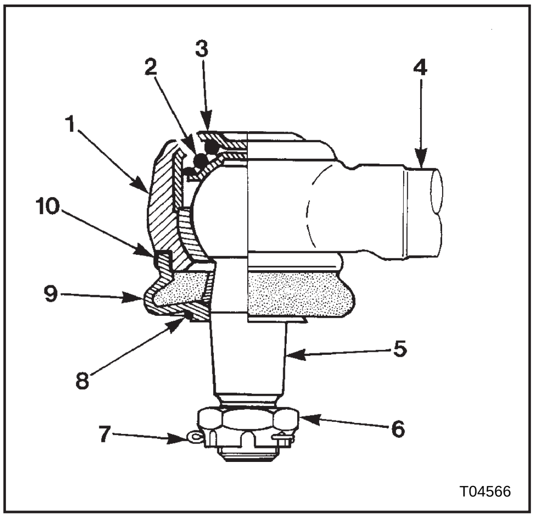

Figure 2 Cross section of typical ball-joint assembly

1. **Casing**
2. **Compression spring**
3. **Cover**
4. **Shank**
5. **Ball-joint pillar**
6. **Castellated nut**
7. **Cotter pin**
8. **Dust cover retaining ring (small)**
9. **Dust cover**
10. **Dust cover retaining ring (large)**

Change cotter pin (7), if any pitting marks are found.

To check dust cover of steering linkage ball-joints - Figure 2

Check dust cover (9) for punctures, cracks or tears. Work the flexible cover between your fingers. No grease should escape through the dust cover walls (only through the opening in the middle).

!!! CAUTION !!!

WATER ENTERING THE BALL-JOINT THROUGH AN UNTIGHT DUST COVER WILL CAUSE IRREPARABLE DAMAGE TO THE BALL-JOINT IN NO TIME.

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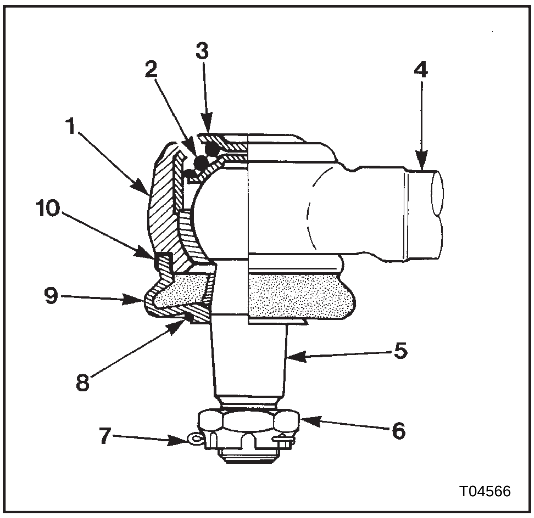

Figure 2 Cross section of typical ball-joint assembly

When in doubt over the perfect tightness of the cover, replace the complete ball-joint.

To check dust cover retaining rings - Figure 2

First check whether rings (8) and (10) have been correctly installed. Also it must be impossible to rotate cover (9) by hand in relation to casing (1) (grab cover with the fingers, near the large ring, and try to turn it. Do not use any tools!).
If the rings are not up to standard: replace entire ball-joint.

To check ball-joint for play

Normal wear is compensated by an internal compression spring, which pushes the ball-joint pillar against the joint liners. Play due to wear can only be detected by pressing the ball-joint pillar inward against spring pressure.

1. Set the front wheels in the dead straight ahead position.

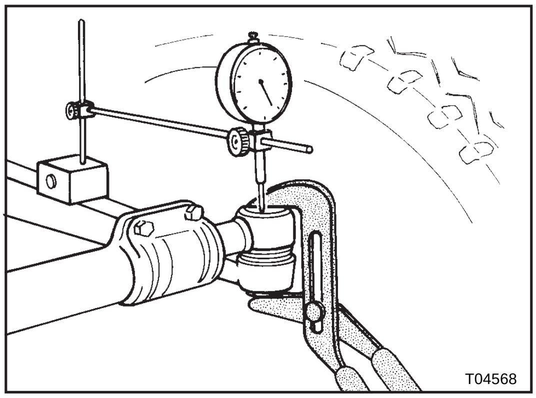

Figure 3 The set-up for measuring ball-joint play

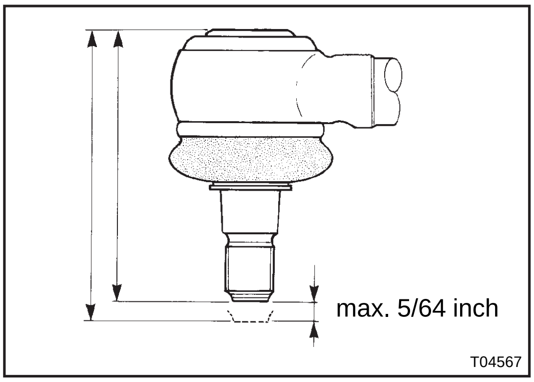

Figure 4 Maximum permissible ball-joint play

2. Mount a dial indicator with a magnetic base on the arm to which the ball-joint is secured, refer to figure 3. Position stylus of dial indicator with a slight pre-pressure against ball-joint cover (3,Figure 2).
3. Compress the joint with adjustable joint pliers and read the travel of ball-joint pillar (5,Figure 2) on the indicator.

If a play of more than 5/64 inch is measured, the complete ball-joint should be replaced.

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TO CHECK TIE-ROD CLAMPS

Clean the exterior of the clamp to be checked with a dry cloth or cotton waste.

- Check that the clamping collar, clamping bolts and clamping nuts are free of corrosion pitting marks to a depth of more than 1/64 inch. If not: replace affected parts.

- Replace clamping bolts if bent on sight.

- Check the inside thread of the rod tube for play. Procedure: with the axle loaded by the weight of the vehicle (wheels to the ground), turn the steering wheel alternately in both directions over a short distance while an assistant feels (finger against the edge of the tube) if there is any play between shank of ball-joint and tube. No play whatsoever is allowed (thread damage). Otherwise, the complete rod/ ball-joint assembly should be replaced.

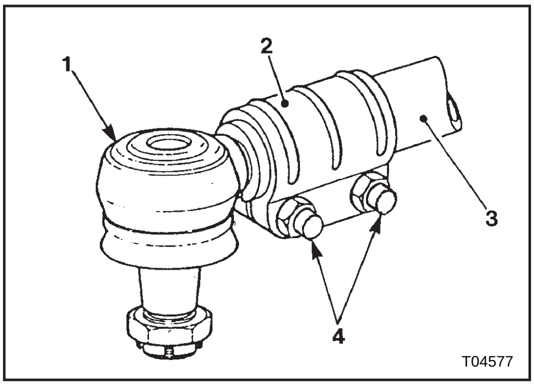

Figure 5 Typical tie-rod end

1. Ball-joint	**3. Tube**
2. Clamp	**4. Clamp bolts**

TO CHECK TIE-ROD TUBES

Visually check the tube for deformation and damage. If necessary, replace the tube.

!!! CAUTION !!!

IT IS NOT PERMITTED TO RESTRAIGHTEN A BENT TIE-ROD.

TO CHECK SPLASH PROTECTION ON STEERING GEAR OUTPUT SHAFT

Sector shaft rusting is prevented by a cap filled with grease, fitted between the pitman arm and the steering gear housing. Rust in sector shaft oil seal area could damage the oil seal, which would cause the steering gear to leak. This inspection involves the removal of the pitman arm by means of a special puller tool. Change the cap if it is damaged or worn. The space inside the cap should be filled with TEXANDO FO 20 grease (by Texaco).

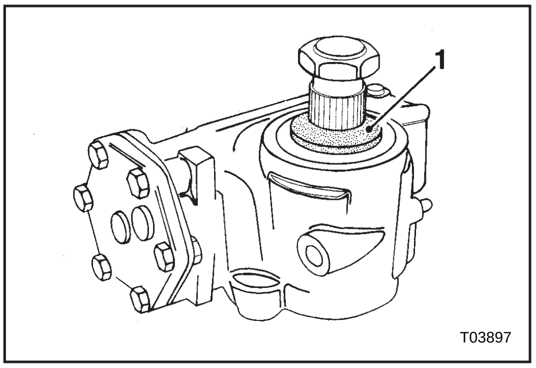

Figure 6: Splash protection (1) on steering gear output shaft

TO MEASURE PLAY ON STEERING WHEEL

1. Connect "Servotest" tester as explained in "To check hydraulic system operation".
2. Lock the left hand front wheel in the straight ahead position by installing two expanding struts (1, Figure 7) between wheel rim (2, Figure 7) (front and rear) and chassis frame (3, Figure 7) at wheel center height.

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3. Place special scale on steering wheel and attach special needle to windshield. (see Figure 8).
4. Start engine and bring fluid temperature up to 50°C (122°F).
5. Let the engine run at approx. 1,000 rpm. Turn steering wheel slowly to the left while watching the left pressure gauge on the "Servotest" tester. When a pressure increase of 1 bar (15 psi) has been attained, as opposed to no-load pressure, hold steering wheel and note scale value.
6. Turn steering wheel to the right until a pressure increase of 1 bar (15 psi) has been achieved once again. Note scale value. The difference between the two values may not exceed 45 mm (1.77 inches), otherwise there is too much play in the steering system.

If play exceeds 45 mm (1.77 inches), repeat the whole procedure with locked pitman arm (struts removed), so that you can see whether there is play in the front or at the rear of the pitman arm (maybe at the ball-joints). If play still exceeds 45 mm (1.77 inches), steering gear has too much play. Remove steering gear and bring it to a VAN HOOL service center for repair.

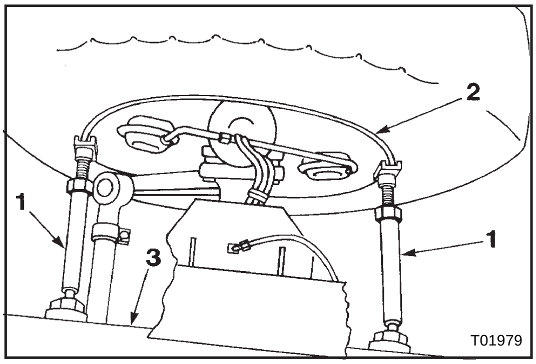

Figure 7: To lock a front wheel in straight ahead position by means of adjustable struts (typical arrangement shown)

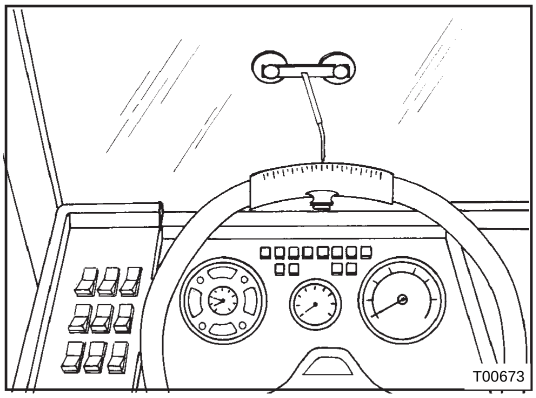

Figure 8: Measuring equipment (ZF tool, part No. 7418798452)

NOTE
REMEMBER THAT PLAY ON STEERING WHEEL IS A LOT HIGHER WHEN IT IS TURNED WITHOUT POWER STEERING. THIS CAN BE NOTICED WHEN STEERING WHEEL IS TURNED WITH STOPPED ENGINE.

TO MEASURE STEERING GEAR MESH LOAD

1. Jack up coach until front wheels are clear off the ground.
2. Disconnect left wheel tie rod and intermediate tie rod from pitman arm.
3. Pry out steering wheel hub cover using a screwdriver.
4. Use torque meter (ZF No. 7418798703) to turn steering wheel through its full travel. Measure the amount of torque at approx. 1/2 turn from the end.
5. Center steering wheel. Rotate steering wheel a half turn to the left and to the right. Read the torque when crossing the mid-point.
6. Torque at the mid-point should be 20 to 160 Ncm more than reading found in point 3.

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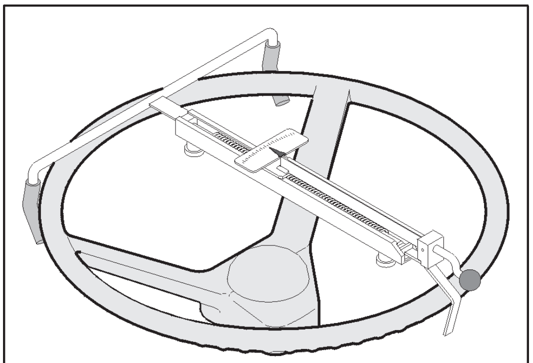

Figure 9: To measure steering gear mesh load in straight ahead position. Torque meter: ZF No. 7418798703

NOTE
IF THE STEERING SYSTEM HAS BEEN WORN IN, THE TORQUE CAN ALSO BE LESS THAN 20 Ncm.

If steering gear mesh load is out of limit, remove steering gear and bring it to a VAN HOOL service center for repair.

TO CHECK STEERING COLUMN BEARINGS

When there is play in the steering column bearings, the column must be replaced.

TO CHECK UNIVERSAL JOINTS AND FLEX COUPLINGS

Turn steering wheel to the left and the right while watching universal joints and flex couplings. No lag or binding should be evident.

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STEERING LINKAGE TIGHTENING TORQUES

Visually check screws and nuts that are locked by means of a cotter pin, liquid locking (LOCTITE), nut metal deformation or "micro-encapsulating". Check all the other screws and nuts mechanically and if necessary retighten. Refer to figure below and on next page.

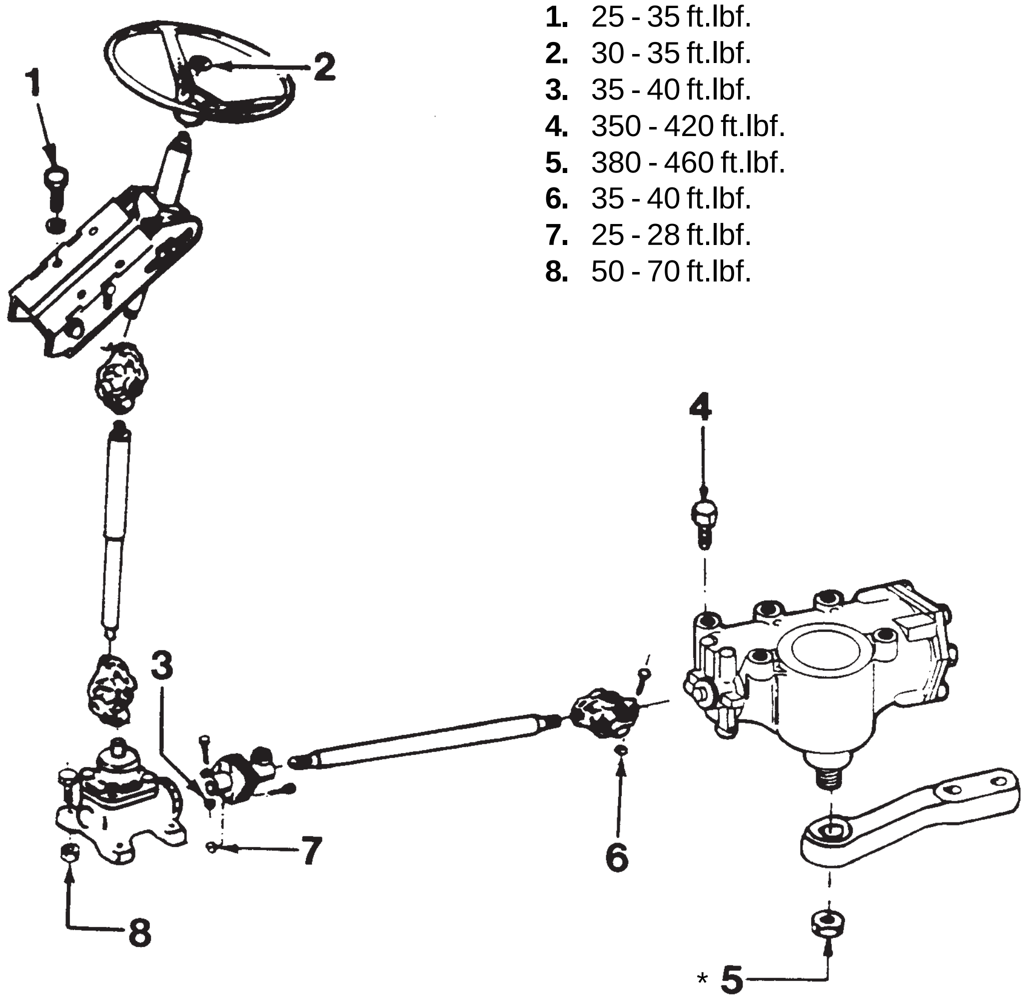

Figure 10: Steering gear and linkage tightening torques

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!!! CAUTION !!!
NEVER RETIGHTEN "LIQUID LOCKED" SCREWS (INDICATED IN FIGURE 12), OTHERWISE THE LOCKING QUALITY WILL BE LOST. NEVER RETIGHTEN "MICRO-ENCAPSULATED" SCREWS (INDICATED IN FIGURE 12), OTHERWISE THE LOCKING QUALITY WILL BE LOST. NEVER RE-USE THESE SCREWS.

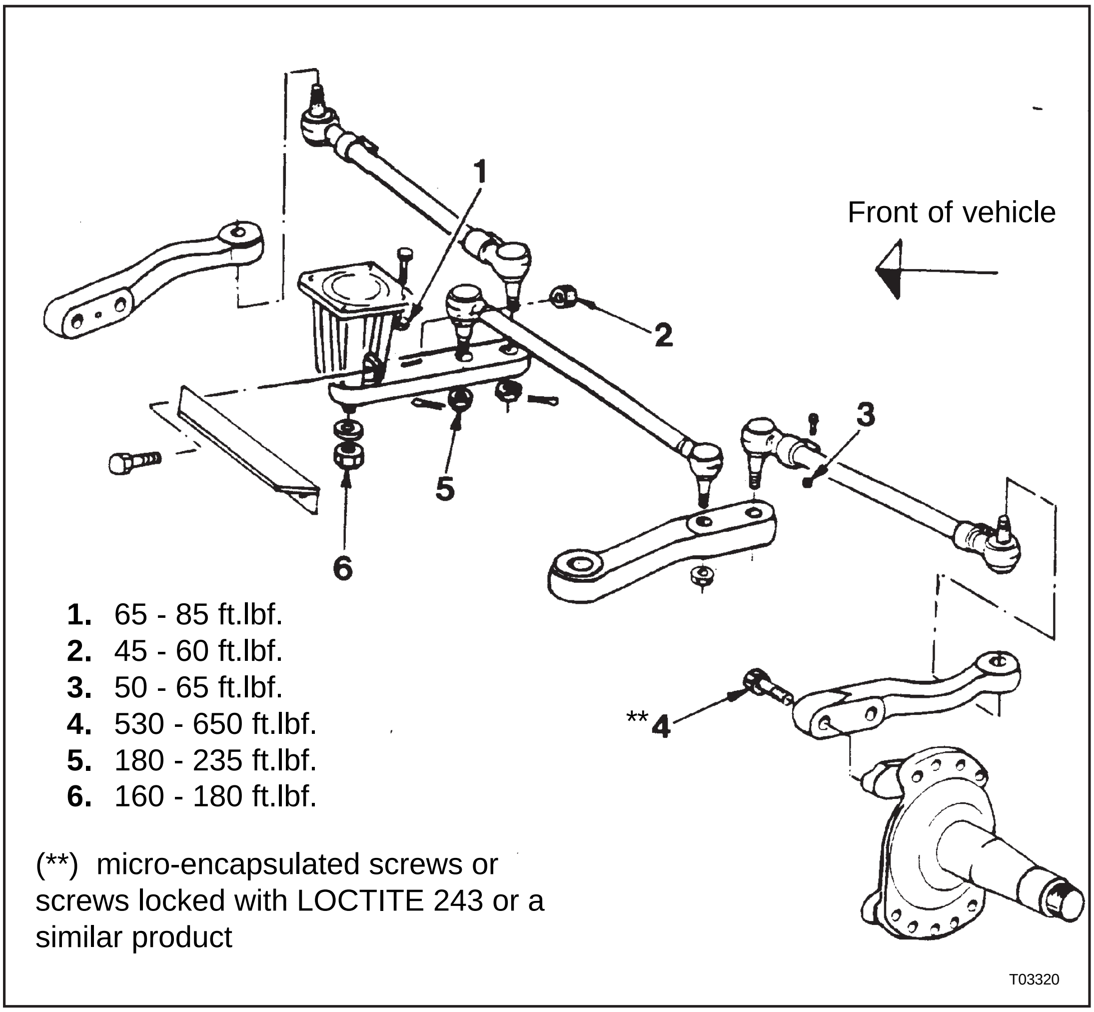

Figure 11: Steering linkage tightening torques

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TO REMOVE AND INSTALL STEERING ASSEMBLY

TO REMOVE STEERING ASSEMBLY

The removal of the steering components is a rather straightforward operation, needing little explanation. There are, however, a few points to be watched.

- To remove the steering wheel center trim, simply pry it out with a screwdriver.
- The steering wheel and the pitman arm must be removed with special service tools available from Van Hool:
  Steering wheel puller: VH ordering number 619900910

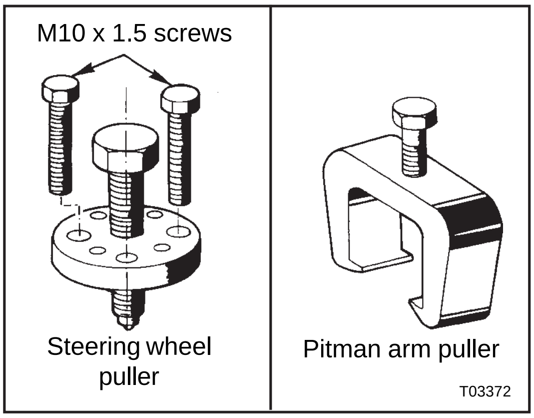
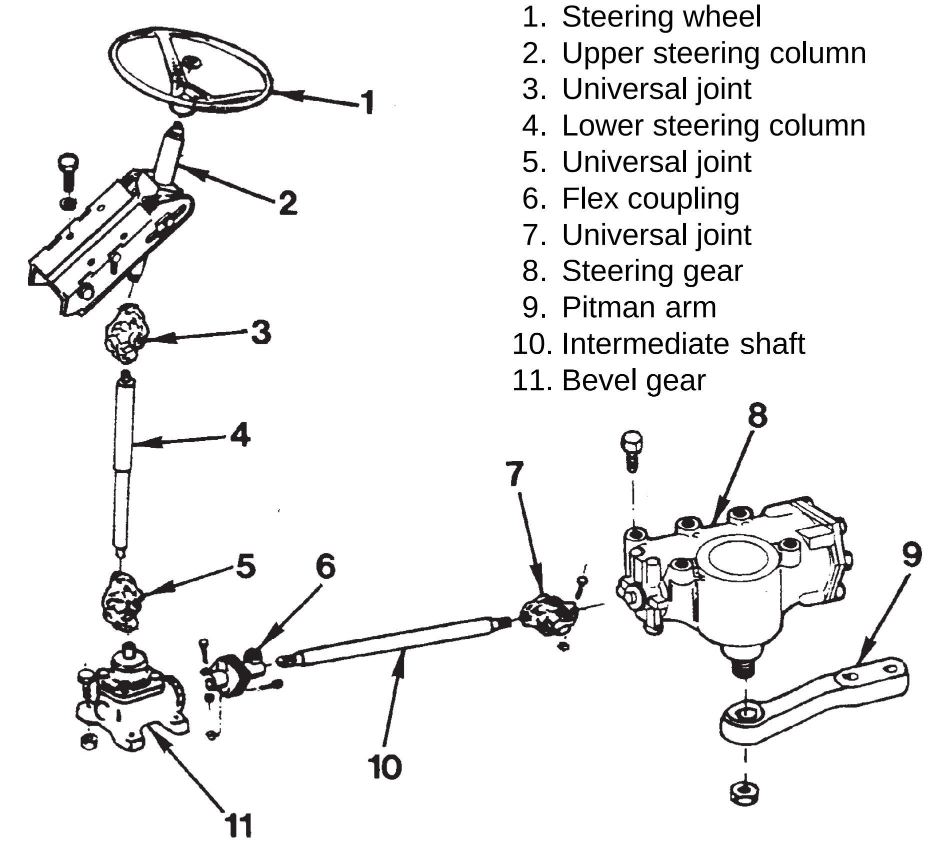


Figure 13: Steering wheel puller and pitman arm puller

Pitman arm puller: VH ordering number 619900920

Ball-joint pillars can be extracted from their mating taper by means of a universal ball-joint separator.



1. Steering wheel
2. Upper steering column
3. Universal joint
4. Lower steering column
5. Universal joint
6. Flex coupling
7. Universal joint
8. Steering gear
9. Pitman arm
10. Intermediate shaft
11. Bevel gear

Figure 12: Exploded view of steering gear and linkage

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!!! CAUTION !!!

BEFORE UNDOING PIPE OR HOSE CONNECTIONS, CLEAN OFF ALL ROAD DIRT FROM THE CONNECTION AND ITS IMMEDIATE SURROUNDINGS. CAP OR PLUG ALL OPENINGS TO PREVENT EXCESSIVE WASTAGE OF HYDRAULIC FLUID AND TO KEEP OUT DIRT. DO NOT RE-USE FLUID DRAINED FROM THE SYSTEM. ALWAYS DISPOSE OF USED HYDRAULIC FLUID IN AN ENVIRONMENTALLY RESPONSIBLE MANNER, ACCORDING TO EPA AND STATE RECOMMENDATIONS.

DO NOT UNDER ANY CIRCUMSTANCES DRIVE A WEDGE BETWEEN PITMAN ARM AND STEERING GEAR HOUSING, NOR HAMMER THE PITMAN ARM TO BREAK IT LOOSE FROM ITS SHAFT. TO DO SO WOULD CAUSE SERIOUS INTERNAL DAMAGE TO THE STEERING GEAR. NEVER ATTEMPT TO FREE THE PITMAN ARM BY HEATING IT WITH A BLOW TORCH. THE HEAT AFFECTS THE METAL STRUCTURE OF THE PITMAN ARM, THUS CREATING A RISK OF POTENTIALLY CATASTROPHIC FAILURE.

THE STEERING GEAR WEIGHS APPROX. 140LB. SO BE SURE IT IS WELL SUPPORTED BEFORE UNDOING ITS ATTACHING SCREWS.

TO INSTALL STEERING ASSEMBLY

1. To install steering assembly, first place coach over inspection pit, with parking brake applied, drive wheels chocked and front wheels on turntables.
2. Remove all paint and dirt from mating surfaces of steering gear and chassis frame.
3. Position steering gear to chassis frame member and install attaching screws and conical spring washers listed in the Van Hool Spare Parts Manual.

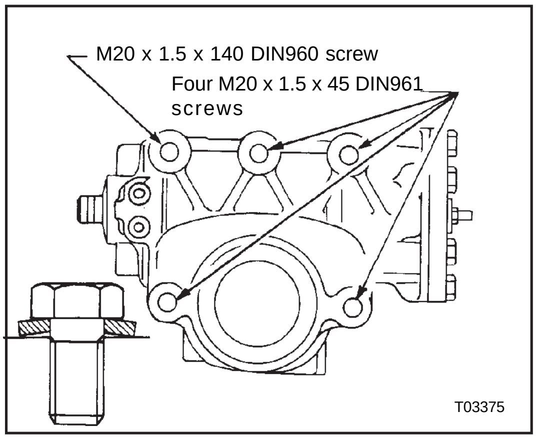

Figure 14: Steering gear attaching screws

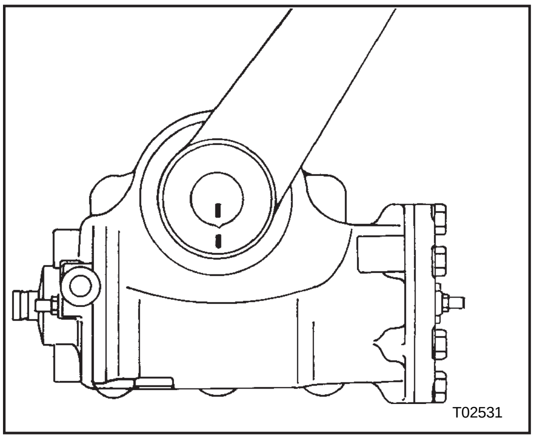

Figure 15: Marks on pitman arm and sector shaft must be in line

NOTE

THE DISHED SIDE OF THE SPRING WASHERS MUST FACE THE STEERING GEAR (SEE FIGURE 14).

Tighten all screws to a torque of 350 to 420 ft.lbf.

4. Connect fluid pressure and return lines to steering gear.
5. Check condition and grease reserve of plastic seal cap on sector shaft (see earlier in this section). Prior to installation, pack the space inside the new cap with TEXANDO F020 grease (manufacturer TEXACO).

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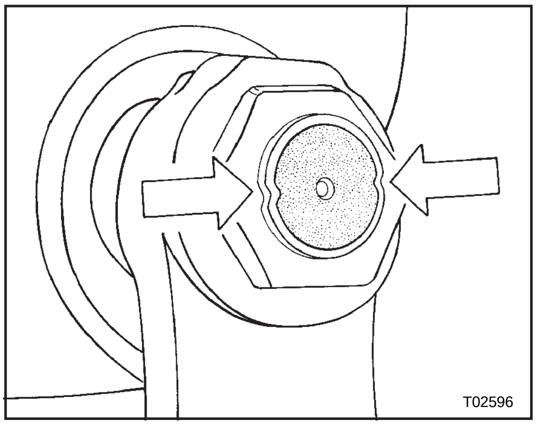

Figure 16: Punch nut collar into slots on end of shaft to lock pitman arm retaining nut

6. Position pitman arm on sector shaft serrations so that the marks are aligned as shown in Figure 15. Install a new pitman arm retaining nut.

NOTE
BECAUSE THE RESULT OF AN ATTEMPT TO LOCK A REINSTALLED PITMAN ARM RETAINING NUT IS UNCERTAIN, NEVER REFIT AN OLD NUT AFTER REMOVAL. ALWAYS FIT A NEW ONE.

Tighten the nut to a torque of 380 to 460 ft.lbf, then punch nut collar into the two slots on end of shaft to lock the nut in place (see figure 16).

!!! CAUTION !!!
IF A RETAINING NUT WITHOUT A "DEFORMATION COLLAR" IS USED, IT MUST BE SECURED WITH A NEW LOCK TAB BETWEEN STEERING GEAR AND NUT. THIS TAB MUST BE PEENED OVER TO LOCK THE NUT, AFTER THE NUT IS TIGHTENED TO THE PROPER TORQUE.

7. Assemble flex coupling and U-joint onto intermediate shaft. Do not tighten the U-joint and flex coupling clamp bolts yet. Then slide U-joint of intermediate shaft assembly on

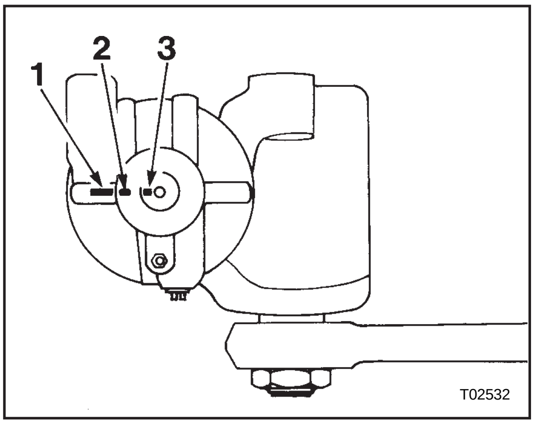

Figure 17: Centralizing marks at steering gear input side

1. Mark on housing
2. Mark on dust cap
3. Mark on input shaft

serrations of steering gear input shaft.Install U-joint clamp bolt on steering gear side.Recommended tightening torque for clamp bolt is 35 to 40 ft.lbf.

8. Centralise steering gear:

   a. Turn intermediate shaft from lock to lock and count number of revolutions.

   b.Turn back half the number of revolutions and exactly align mark (1, Figure 17) with mark (2, Figure 17).

9. Install tie-rods (2,3,6, Figure 18). Refer to Figure 11 for tightening torques. If necessary, tighten ball-joint nuts further until next slot of castellated nut lines up with cotter pin hole in ball pillar. Lock the nuts with a new cotter pin.

!!! CAUTION !!!
THE COTTER PIN LEGS OF THE INNER BALL-JOINTS OF THE OUTER TIE-RODS MUST BE PEENED HORIZONTALLY.

10. Adjust length of outer tie-rods so that wheels are in the

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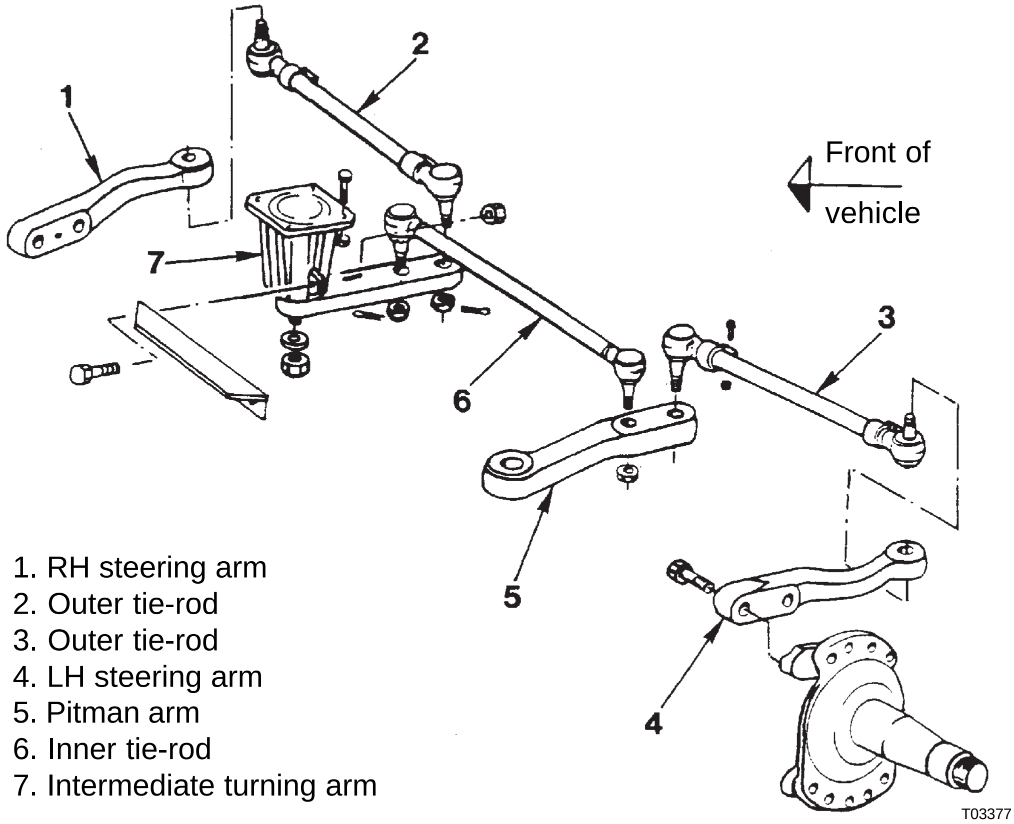

Figure 18: Steering linkage

straightforward position and parallel to each other (maximum permissable toe-out: see section 4.1). To do so, turn the rod in the appropriate direction after loosening the clamp nuts without changing pitman arm position. Tighten self-locking clamp nuts of outer tie-rods. Tightening torque: 50 to 65 ft.lbf.

NOTE
THE SLOTS OF THE CLAMPS OF THE OUTER TIE-RODS MUST BE ORIENTATED HORIZONTALLY AND TO THE REAR OF THE COACH.

11. Rotate input shaft of bevel gear to align mark on bevel gear dust cap with ridge on bevel gear housing, as in Figure 19. This is the "zero backlash" position of the bevel gear.

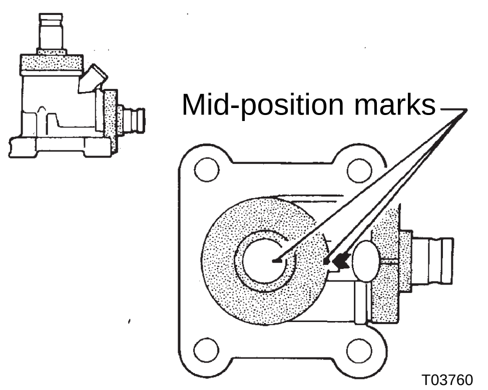

Figure 19: "Mid-position" marks at input side of bevel gear

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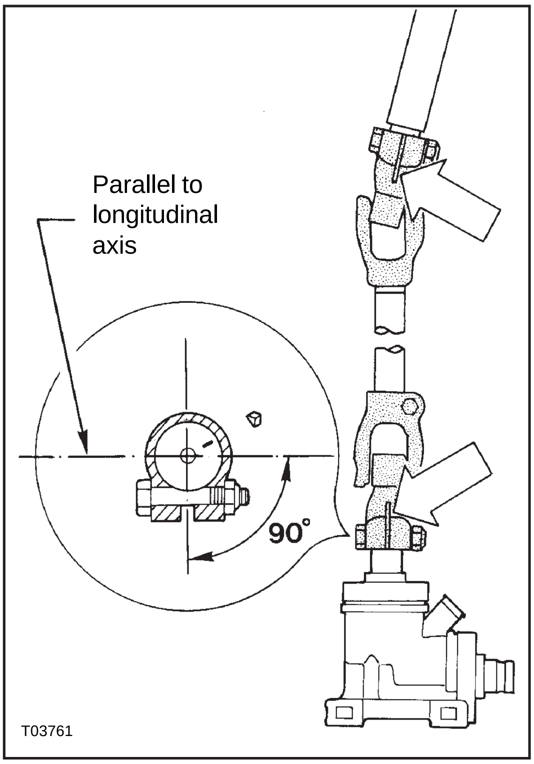

Figure 20: Steering column in centralised position

NOTE
STEP 13 IS TO BE CARRIED OUT WITH THE STEERING GEAR CENTRALISED.

12. Slide the bevel gear output shaft into the flex coupling of the intermediate shaft assembly.

13. Position bevel gear on chassis frame support. Install the four M12 attaching bolts and torque-tighten to 50 to 70 ft.lbf. Tighten U-joint and flex coupling clamp bolts of intermediate shaft assembly to a torque of 30 to 40 ft.lbf.

14. Assemble steering wheel column with U-joints aligned as illustrated in Figure 20. Slot of lower U-joint must be perpendicular to longitudinal axis of coach. Recommended tightening torque for steering column U-joint clamp bolts is 30 to 40 ft.lbf.

15. Install steering wheel so that the spokes are in the 8 and 4 o'clock positions. Fit steering wheel retaining nut and tighten to a torque of 30 to 35 ft.lbf. Fit steering wheel center trim (press into position by hand).

16. Fill power steering system with the recommended grade of hydraulic fluid and bleed the system following the procedure given in the previous section.

17. Set steering limiter valves, see previous section.

18. Take the vehicle for a road test and check whether the steering wheel is indeed in the straight-ahead position when driving a straight course. If not, adjust length of outer tie-rods.

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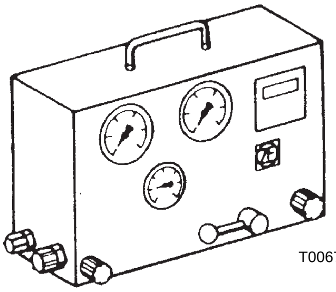
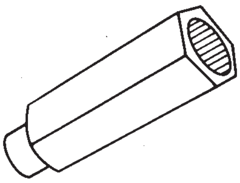
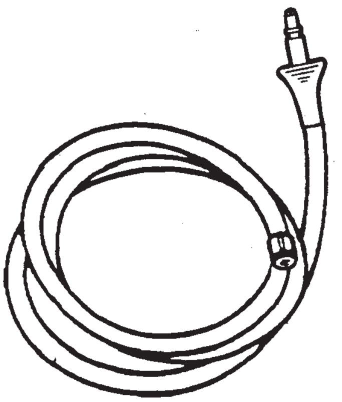
SPECIAL SERVICE TOOLS

TOOL NUMBER	DESCRIPTION
Servotest 550: ZF 7418798550 Servotest 570: ZF 7418798574  T00672	**Servotest** To check hydraulic steering system.
Van Hool 10575651  T03860	**Adapter** To turn steering column.
Van Hool 639901590  T03863	**Hose** To connect at test connection near steering gear.

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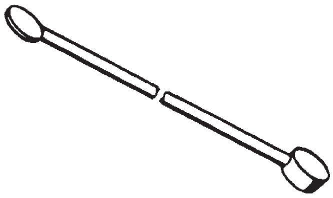
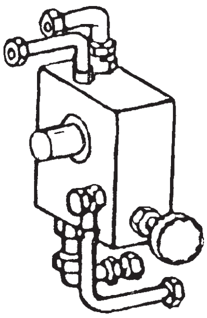
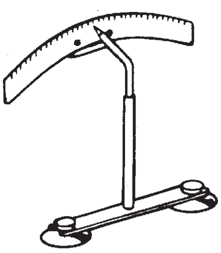
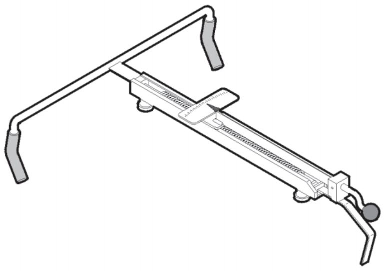
TOOL No. + ILLUSTRATION	DESCRIPTION
Van Hool 10572469  T03858	**Spacer tool** To test hydraulic steering system.
Van Hool 10675796  T02264	**Flow control valve** To check steering gear for internal leakage (only with Servotest 550)
Van Hool 10675798  T03859	**Scale and needle** To measure play on steering wheel.
Van Hool 7418798703  001809	**Torque meter** To measure steering gear mesh load.

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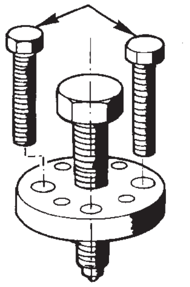
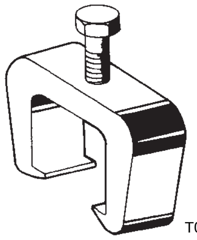
TOOL No. + ILLUSTRATION	DESCRIPTION
Van Hool 619900910  T03372	**Steering wheel puller** To remove steering wheel.
Van Hool 619900920  T03372	**Pitman arm puller** To remove pitman arm.

TOOL07AC

TOOL07AC

SERVICE BULLETINS

Service Bulletins are issued to supplement or supersede information in the Van Hool manuals. Note below number, date and subject of Bulletins pertaining to this chapter. File Bulletins separately by number for future reference.

Number	Date	Subject

CHAPTER 8

SUSPENSION

PAGE

SUSPENSION - AIR SYSTEM

SUSPENSION - MECHANICAL SYSTEM

SUSPENSION - AIR SYSTEM

GENERAL

The air suspension system main components are: the air tanks, the air bellows, the levelling valves, the air lines and the control valves. The main purpose of the air suspension system is to maintain a constant vehicle height regardless of the load. Several different types of suspension control systems can be installed on your vehicle :

- front kneeling system;
- raising/lowering system;
- tag axle unloading system;
- rear raise system.

The air suspension system is fed by the auxiliary air tank.

MAINTENANCE

DAILY OPERATION CHECK

Before commencing daily service, with vehicle stationary and normal air pressure in system, visually check that normal body ground clearance is maintained at both sides of coach.

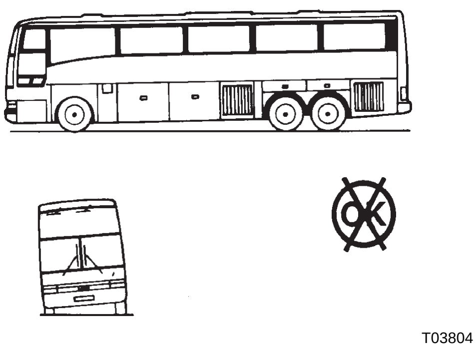
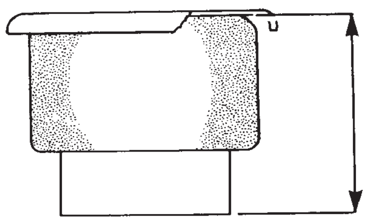


Figure 1: Vehicle ground clearance check

TO CHECK AIR BELLOWS HEIGHT

The correct vehicle ride height is checked by measuring the height of the left air bellows of the front axle and the left and right rear air bellows of the drive axle. This height should be 11 to 11.4 inches at the most. Refer to Figure 2 to identify the correct location where the measurement has to be taken.



Air bellow height

Figure 2: Correct location of height measurement

When measuring air bellows height, make sure that:

- the vehicle is parked on a flat level surface;
- the suspension system is in the normal driving position, after having been cycled from normal ride height to low ride height and back to normal ride height again;
- there are no air leaks in the system;
- the air system is charged to normal operating pressure.

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TO ADJUST AIR BELLOWS HEIGHT

When adjustment is required, control lever (1, Figure 3) should be moved up to raise the height of the body, and down to lower it. This is done by adjusting anchor bracket (3, Figure 3) of retaining rod (2, Figure 3) up or down.

NOTE
ADJUSTMENTS MUST BE MADE ON FILL CYCLE. THIS MEANS THAT AIR MUST BE RELEASED FROM BELLOWS FIRST, THEN BELLOWS MUST BE INFLATED AGAIN. IF IT IS NECESSARY TO LOWER VEHICLE HEIGHT, RELEASE SUFFICIENT AIR TO WELL BELOW REQUIRED HEIGHT AND ADJUST TO REQUIRED HEIGHT ON FILL CYCLE.

Procedure

1. With the vehicle at normal operating pressure, disconnect rubber coupling (2, Figure 4) of retaining rod (1, Figure 4)

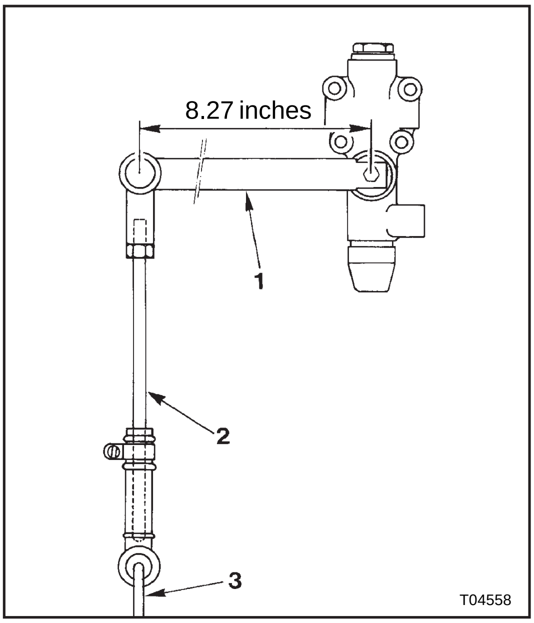

Figure 3: Levelling valve link connection

1. Control lever
2. Retaining rod
3. Anchor bracket

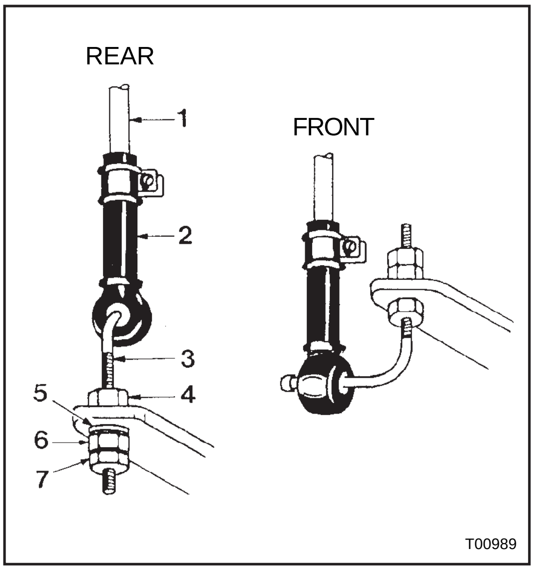

Figure 4: Lower attachment of levelling valve retaining rod

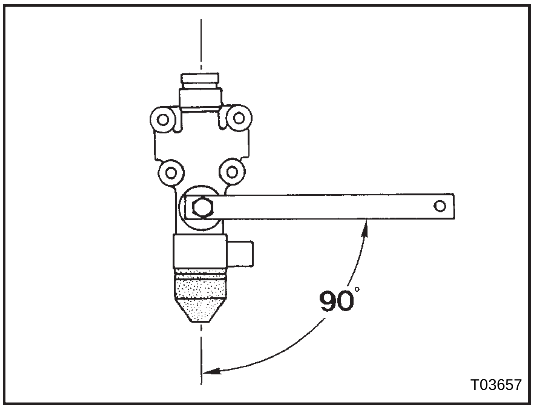

Figure 5: Levelling valve in neutral position

from anchor bracket (3, Figure 4). Undo and remove retaining nuts (6 and 7, Figure 4) and screw adjusting nut (4, Figure 4) upwards as far as it will go.

2. Lower coach body by pulling retaining rod downwards, releasing air from bellows.

3. Inflate air bellows again by raising the control lever until desired height is reached; then instantly return levelling valve control lever to its neutral position (see figure 5) to stop inflation.

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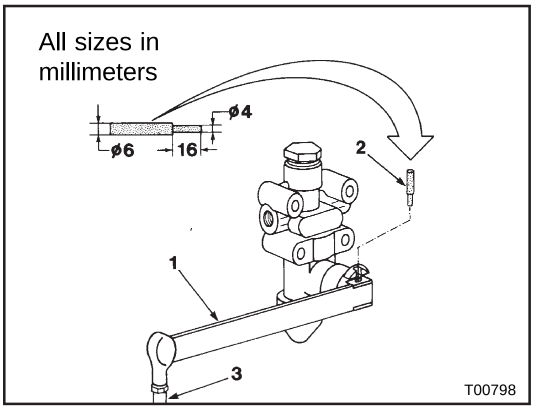

Figure 6: Locking levelling valve in neutral with dowel pin

1. Control lever
2. Dowel pin
3. Retaining rod

4. Lock control lever with dowel pin (see Figure 6).

5. With the dowel pin keeping the control lever in the neutral position, refit the rubber coupling of the retaining rod to the anchor bracket, and adjust anchor bracket to fit. Secure adjusting nuts and remove dowel pin.

6. If there is not enough play on the adjusting nuts, it is possible to make further adjustments by loosening the clamps on the rubber coupling and bringing the retaining rod up or down.

NOTE
ALLOW SUSPENSION TO STABILIZE BEFORE TAKING READING.

Sequence of adjustment

Since changing the height of one bellows has an influence on the height of the others, following sequence of adjustment should be followed:

1. On the left hand side of the coach, adjust height of both drive axle bellows with the control lever of the levelling valve above the tag axle. Adjust height of drive axle bellows to read between 11 and 11.4 inches. Do not attempt to adjust the height of the tag axle bellows. Tag axle bellows will selfadjust automatically.

2. Repeat the procedure of item 1 on the right hand side of the coach.

3. Adjust height of air bellows of front axle to read between 11 and 11.4 inches.

4. Recheck height of drive axle bellows left and right. Leave height of tag axle bellows as it is. Readjust if necessary.

5. Make a short test drive on a winding road and readjust drive axle bellows height, if necessary.

TO CHECK AIR BAG CONDITION

Air bag should be changed if:

- Torque cracks on "down-rolling" part to casing fabric;
- Cutting damage down to casing fabric;
- Chafings down to casing fabric;
- Blisters.

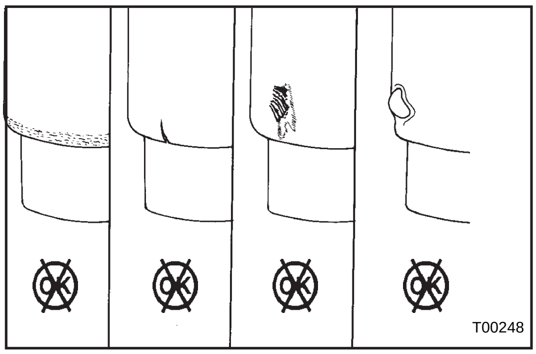

Figure 7: Air bag condition

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TO CHECK AIR BELLOWS FOR LEAKS

Check air bellows for leakage with a soap solution at upper and lower seats. If an air leakage is found, remove air bag for further inspection.

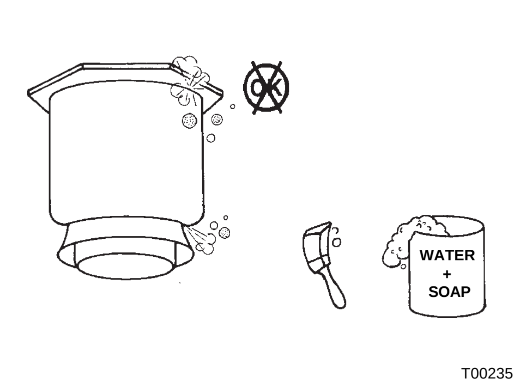

Figure 8: Checking air bellows for leaks

TO CLEAN LINE FILTER

!!! CAUTION !!!
BEFORE REMOVING FILTER, RELEASE PRESSURE OF AIR SYSTEM BY MEANS OF DRAIN VALVE ON AUXILIARY AIR TANK.

Remove filter (1) and clean it by blowing air pressure in opposite direction of normal air flow. Lubricate grommet with BW-204-M at assembly.

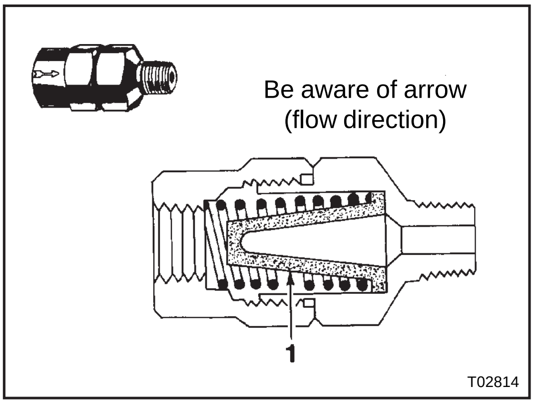

Figure 9: Line filter

AIR TANK MAINTENANCE

Refer to Section 6.4 for complete instructions on air tank maintenance.

COMPONENTS

AIR LINE FILTER-Figure 9

The two air line filters are mounted in the air line between the auxiliary tank and the levelling valves. They prevent the entrance of dirt into the air suspension system.

LEVELLING VALVE - Figure 10

Purpose

The three levelling valves charge and exhaust air bellows in proportion to the load being carried. This maintains a constant ride height.

Operation

Since the levelling valve is linked to the suspension, and the valve is mounted onto the coach body, the valve moves downwards with the body during loading. As lever (7) and cam follower (6) turn, plunger (5) pushes inlet / exhaust valve (2) of its seat and air flows through orifice (4) into the air bellows. As the air pressure in the air bellows increases, the air bellows expand and raise the coach body. Check-valve (8) allows air to travel in one direction only.

The increased air pressure expands the air bellows lifting the coach body and the levelling valves. Lever (7) returns to "Neutral" as the coach body approaches normal ride height. The inlet / exhaust valve (2) seats and plunger (5) seals off exhaust passage.

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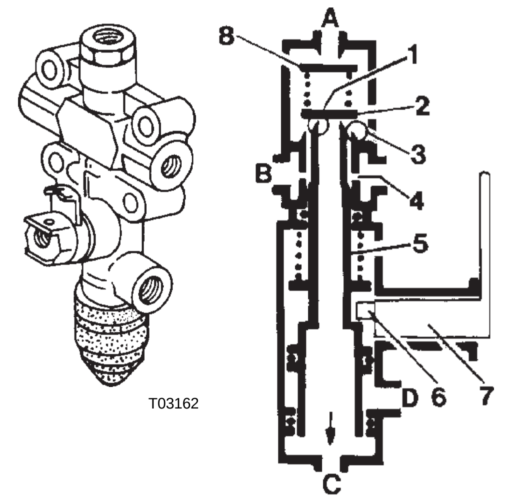

Section through shows levelling valve in raised position

A: Inlet
B: To bellows
C: Exhaust

1. Exhaust seat
2. Inlet/exhaust valve
3. Inlet seat
4. Orifice
5. Plunger
6. Cam follower
7. Lever
8. Check-valve

Figure 10: KNORR levelling valve

This condition remains static until the coach load is altered.

When the load decreases, pressure in the air bellows raises the coach body. Lever (7) is pulled downwards from "Neutral", and plunger (5) lowers and opens the exhaust passage. The inlet / exhaust valve remains seated to prevent direct air flow from the auxiliary tank to the atmosphere.
As the air is exhausted from the air bellows, the coach body is lowered until lever (7) returns to "Neutral".

The neutral position of the valve can be changed by connecting air pressure (approx. 115 psi) to port "D" of the levelling valve. This is used to place the coach body in raised position.

PRESSURE PROTECTION VALVE - Figure 11

Description

The purpose of the pressure protection valve is to leave a residual air pressure in the air line when this air line is exhausted.

Operation

Air passes through the valve in the direction of the arrow. Air passes through hole (4) to act on diaphragm (3). Diaphragm (3) lifts off its seat allowing air to flow through bore (5). Air flows out of the delivery port. When the air pressure drops below setting pressure, spring (1) pressure overcomes the air pressure and the diaphragm comes on its seat to prevent further air flow out of the delivery port.

The setting pressure can be adjusted by turning the screw at the top of the valve:

- Clockwise: increases the pressure
- Counterclockwise: decreases the pressure

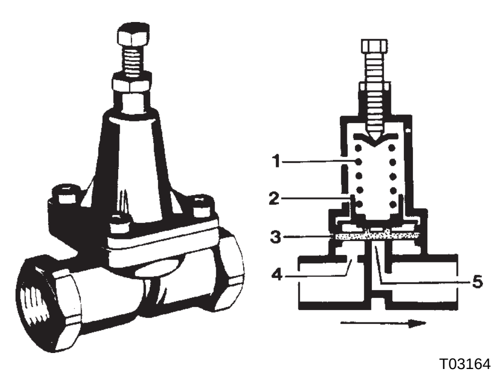

Figure 11: Pressure protection valve

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EXHAUST MUFFLER

Mufflers are used to deaden the noise produced by escaping air.

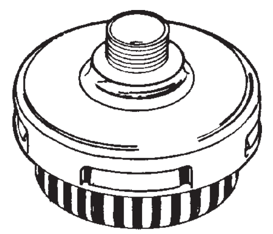

Figure 12: Exhaust muffler

WABCO 3/2 SOLENOID VALVE - Figure 13

Description

It will exhaust or charge an air line with an electrical signal.

Operation

The air tank line is connected to port "P". Spring (3) holds the inlet valve (4) on its seat.
When solenoid coil (1) is energized, core (5) moves upwards, closing the exhaust valve (2) and opening the inlet valve (4). Air from port "P" flows through port "A" into the delivery line.

When solenoid coil (1) is de-energized, the spring (3) pushes the core (5) downwards, the inlet valve (4) closes and the exhaust valve (2) opens. The air in the delivery line escapes to the atmosphere via "R".
Each solenoid valve has a small lever fitted on its base. This lever can be used in emergency when no electrical current is available. To switch the valve, press yellow lever and

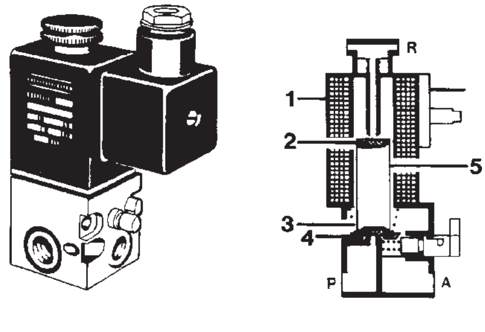

Figure 13: Normally closed WABCO 3/2 solenoid valve

simultaneously turn it to position marked "1".

- Position "1": manual override
- Position "0": automatic operation

3/2 PNEUMATIC VALVE

Description

It will exhaust or charge an air line with a pneumatic signal.

Operation

The air line is connected between port "A" and port "R1/P2". Another air line is connected to port "Z". As long as there is no air pressure at port "Z", air pressure flows to air bellows. When

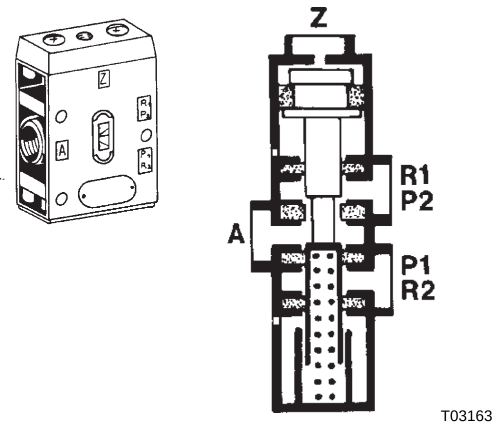

Figure 14: WABCO 3/2 pneumatic valve

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there is air pressure at port "Z", air bellows are exhausted to atmosphere via port "P1/R2". These valves control the lower system.

NORMALLY OPEN (N.O.) PRESSURE SWITCH

The pressure switches are screwed in a port of the BOSCH 4/2 solenoid valve. Switching pressure: 7.2 ± 1.4 psi.

Operation - Figure 15

As pressure is applied, diaphragm (1) and contact plate (2) are raised and poles (3) and (4) are connected.

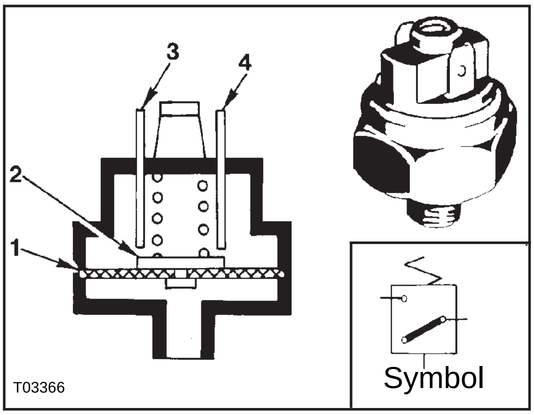

Figure 15: Normally open pressure switch

DOUBLE CHECK VALVE

Description

This valve is used to direct a flow of air into a common line from either of two sources, whichever is at the higher pressure.

Operation

As air under pressure enters either end of the double check valve (IN port), the moving shuttle 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 (CYL) of the double

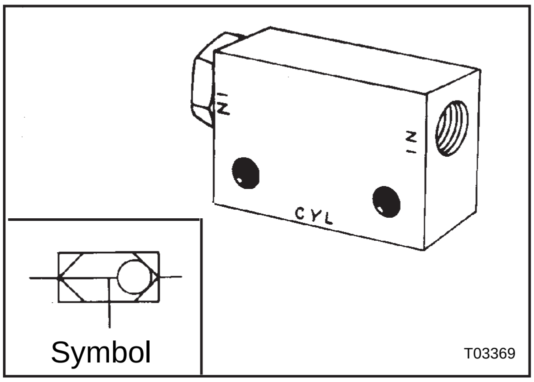

Figure 16: Double check valve

check valve. The position of the shuttle will reverse if the pressure levels are reversed. Double check valve is designed so that the shuttle can never impede the backflow of air in the exhaust mode.

SCHRADER 3/2 SOLENOID VALVE

This valve is ideal for applications where extremely rapid response is mandatory. It gives full flow just milliseconds after actuation.

NOTE
ON CURRENT VEHICLES "SCHRADER VALVE" (ITEM 7 IN THE AIR SUSPENSION PNEUMATIC DIAGRAMS) IS REPLACED BY A "3/2 SOLENOID VALVE " AND A "3/2 PNEUMATIC VALVE". FOLLOWING DIAGRAMS SHOW SCHRADER VALVE ONLY.

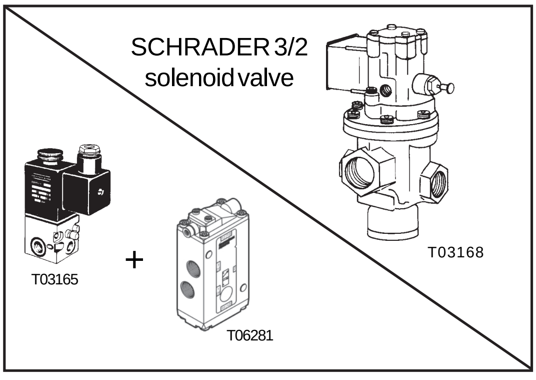

Figure 17: SCHRADER 3/2 solenoid valve and its replacement

BOSCH 4/2 SOLENOID VALVE

These are located in the pressure switch box in the rear wall of the luggage compartment.

NOTE
THE SOLENOID VALVE IS DESIGNED FOR MOMENTARY SWITCHING ONLY. A CONSTANTLY CLOSED ELECTRICAL CIRCUIT CAN DAMAGE THE SOLENOID.

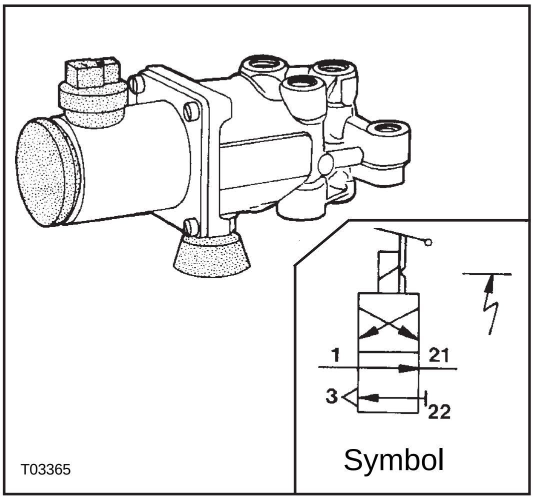

Figure 18: Bosch solenoid valve

Operation - Figure 19

System off

Compressed air flows from the supply room (12) through open inlet valve (11) to port "22". Because port "22" is plugged, no further air flow is possible. The system is switched off in this valve position.

System on

When current is supplied to solenoid (3), armature (2) moves downward and pushes plunger (4) against rocker (5). Rocker (5) tilts onto tappet (6) which causes inlet valve (8) to open. Supply air flows through port "21" to the system. Interruption of the current supply to solenoid (3) causes a spring to push armature (2) upwards back to its neutral position.

To switch off the system, current is supplied back to solenoid (3). This causes armature (2) to move downward and plunger (4) pushes rocker (5) into its original position. A spring under tappet (6) pushes it upward. This causes inlet valve (8) to close and exhaust valve (7) to open. Air is exhausted through opened exhaust valve (7) and exhaust port (3) into the atmosphere.

If the current supply is interrupted, the solenoid valve can also be hand operated by pressing down on armature (2).

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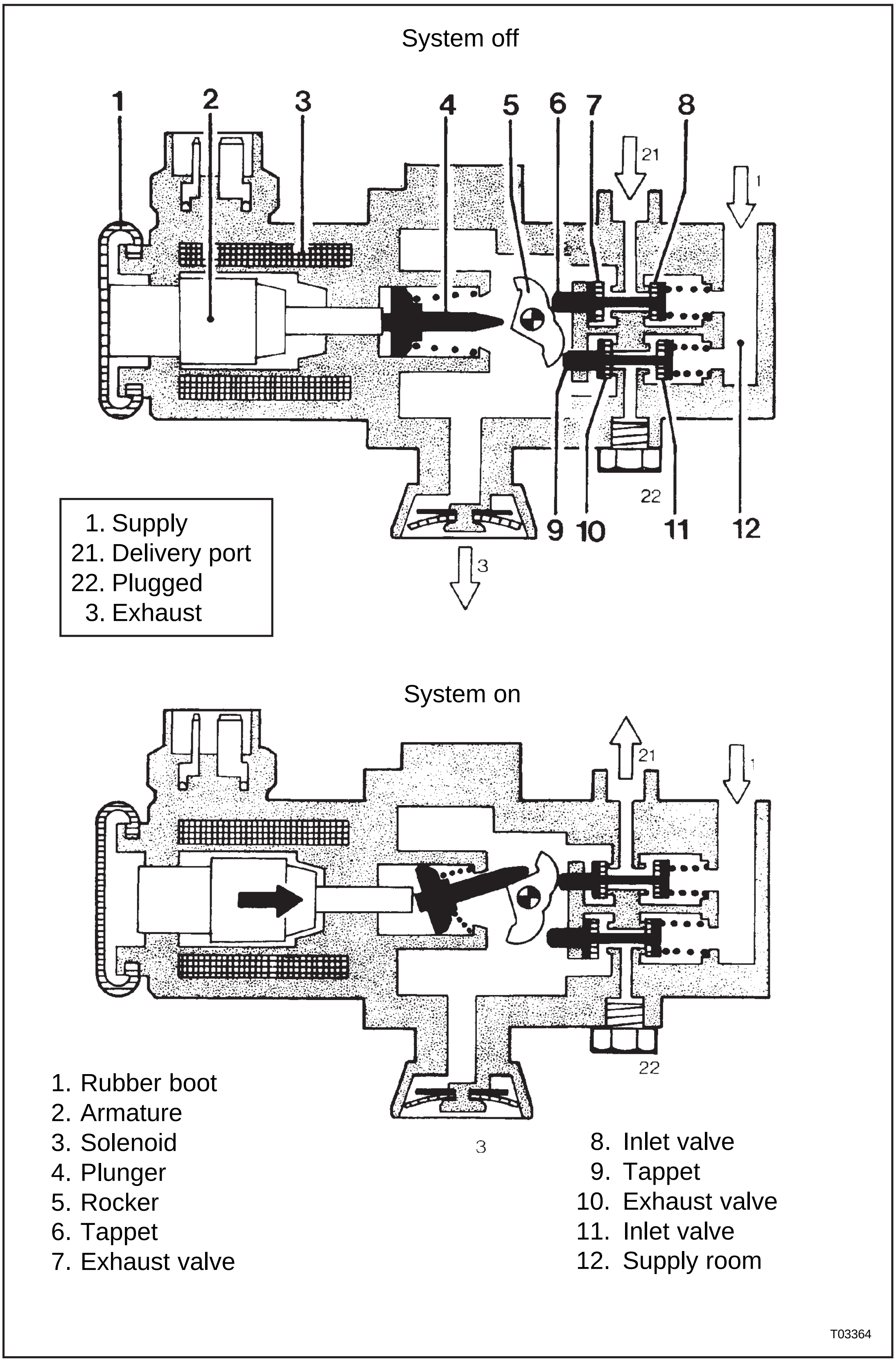

Figure 19: Section through Bosch solenoid valve

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AIR SUSPENSION PNEUMATIC DIAGRAMS

For the sake of clarity the air suspension pneumatic diagram is divided in several separate subdiagrams. On the next pages you find the following pneumatic diagrams:

- basic system;
- basic system + tag axle unloading;
- basic system + tag axle unloading + raising;
- basic system + tag axle unloading + raising + lowering;
- basic system + tag axle unloading + raising + lowering + front kneeling;
- basic system + tag axle unloading + raising + lowering + front kneeling + rear raising.

BASIC AIR SUSPENSION SYSTEM - Figure 21

The three levelling valves (2) automatically charge or exhaust air bellows (1,3,4) to maintain a constant ride height regardless of load, or load distribution.

Loading position

As the load increases and lowers the vehicle body, the control lever commands the levelling valve to add air to the air bellows.

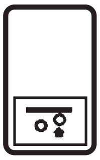
Neutral position

When vehicle body reaches the normal ride height, the control lever of the levelling valve 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 control lever commands the levelling valve to release air from the air bellows.

TAG AXLE UNLOADING SYSTEM - Figure 22



The two normally open solenoid valves (7) cycle when the tag axle unloading system is activated by the switch located on the instrument panel. This allows air from the tag axle bellows (4) to exhaust via the solenoid valves (7) and the pressure protection valve (8). Muffler (9) reduces the noise produced by the escaping air. Pressure protection valve (8) closes as air pressure in the tag axle bellows (4) drops below the setting (11.6 psi) of valve (8). This means that a residual pressure is maintained in the tag axle bellows. This will reduce the time necessary to bring the vehicle from "tag axle unloading" position to normal position.

When the tag axle unloading system is switched off, the two normally open solenoid valves (7) are de-energized. Port "IN" is open to port "CYL". This allows air from the rear levelling valve circuit to flow through the solenoid valve into the tag axle bellows.

The tag axle unloading system is automatically disabled when the vehicle speed reaches or exceeds 10 mph.

RAISING SYSTEM - Figure 23

The neutral position of the levelling valves used on your vehicle can be changed by connecting air pressure to port "4" of the levelling valves. This

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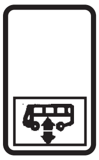
feature is used to place the vehicle in the raised position.

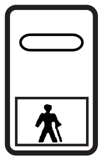


Momentarily pushing the upper part of "raise/lower" switch located on the instrument panel will activate the raising system. Solenoid valve (11) is energized and air from the auxiliary tank flows out of port "21" to port "4" of the levelling valves.
Pressure switch (12) will close an electrical circuit to illuminate the "raise" indicator light on the instrument panel.
Pressure switch (10) makes it impossible to switch on the lowering system when the raising system is on.
To switch off the raising system: push the upper part of the switch again. Air in the pilot line to port "4" of the levelling valves will be exhausted to the atmosphere via port "3" of solenoid valve (11).

LOWERING SYSTEM - Figure 24

Momentarily pushing the lower part of the "raise/lower" switch located on the instrument panel will activate the lowering system. Solenoid valve (13) is energized and air from the auxiliary tank flows out of port "21" to port "Z" of pneumatic valves (16,17,18,19). These valves will cycle and air from the front axle bellows exhaust via pressure protection valve (22); air from the drive and tag axle bellows via pressure protection valve (20). Mufflers (21,23) reduce the noise produced by the escaping air. Valves (20,22) will close as air pressure in air bellows drops below the valve setting (11.6 psi). This means that a residual pressure is maintained in the air bellows.
Pressure switch (15) will close an electrical circuit to illuminate the "lower" indicator light on the instrument panel.
Pressure switch (14) makes it impossible to switch on the raising system when the lowering system is on.
To switch off the lowering system: push the lower part of the switch again. Air in the pilot line to port "Z" of the pneumatic valves will be exhausted to the atmosphere via port "3" of solenoid valve (13). Pneumatic valves (16,17,18,19) will cycle: port "P2" open to port "A". This allows air delivered by the levelling valve to flow through the pneumatic valves into the air bellows.

FRONT KNEELING SYSTEM - Figure 25



The normally closed solenoid valve (26) opens when the front kneeling system is activated by the switch located on the instrument panel. Air from the auxiliary tank flows to port "Z" of pneumatic valves (18,19). These valves will cycle and air from the front axle bellows exhausts via pressure protection valve (22). Muffler (23) reduces the noise produced by the escaping air. Valve (22) will close as air pressure in air bellows drops below the valve setting (11.6 psi). This means that a residual pressure is maintained in the front axle air bellows.

The front kneeling action will be stopped by a proximity switch. Current vehicles have a magnetic proximity switch instead of an inductive one (see Figure 20). Refer to Figures 20A and 20B for adjustment. The proximity switch is located between the upper suspension arms of the front right wheel suspension assembly. When the switch closes, it will energize the normally closed solenoid valve (30): port "P" open to port "A". Air flows to port "Z" of pneumatic valve (31). Exhausting will be stopped.

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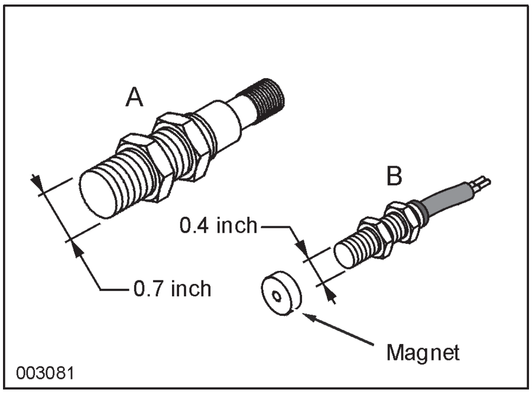


Figure 20: Inductive proximity switch (A) and magnetic proximity switch (B)

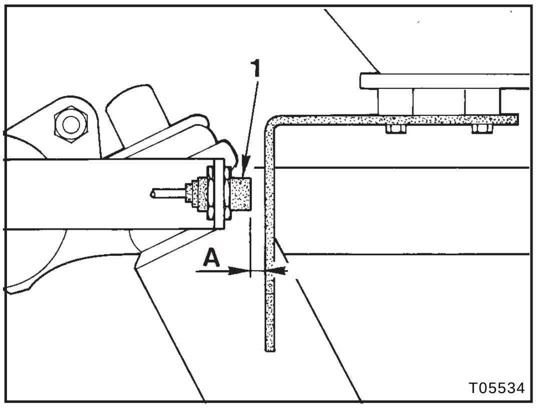


Figure 20A: Inductive proximity switch (1) of front kneeling system

A= 0.12 to 0.19 inch

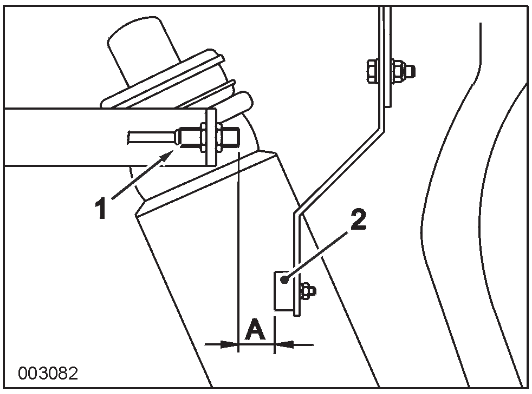
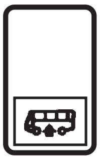


Figure 20B: Magnetic proximity switch (1) of front kneeling system with magnet (2)

A= 0.3 to 0.4 inch

A supplemental air tank (25) is provided to bring the vehicle body fast from "front kneeling" to "normal ride" position. Air tank (25) is filled with air during the front kneeling cycle and the air in this tank will flow via check valves (28,29) directly to the front axle bellows (1) when the front kneeling system is switched off.

REAR RAISING SYSTEM
- Figure 26



Momentarily pushing the "Rear raise" switch located on the instrument panel will activate the rear raising system. Solenoid valve (32) is energized and air from the auxiliary tank flows out of port "21" to port "4" of the rear levelling valves.
Pressure switch (33) will close an electrical circuit to illuminate the "raise" indicator light on the instrument panel.
A supplemental air tank (34) is provided to bring the vehicle body fast from "normal ride" to "rear raise" position. Air tank (34) is filled with air when the rear raise system is switched off. The air in this tank will flow via check valves (35,37) directly to the bellows of the drive and tag axle when the rear raise system is switched on.
To switch off the rear raising system: push the switch again. Air in the pilot line to port "4" of the levelling valves will be exhausted to the atmosphere via port "3" of solenoid valve (32).

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LEGEND FOR AIR SUSPENSION PNEUMATIC DIAGRAMS

1. **Front axle suspension bellows**
2. **Levelling valve**
3. **Drive axle suspension bellows**
4. **Tag axle suspension bellows**
5. **Air line filter**
6. **Auxiliary air tank**
7. **Normally open (N.O.) Schrader 3/2 solenoid valve *(V532.1 on electrical drawing)***
8. **Pressure protection valve (0.8 bar = 11.6 psi)**
9. **Exhaust muffler**
10. **Normally open (N.O.) pressure switch (7.2 psi) *(DK60.1 on electrical drawing)***
11. **Bosch 4/2 solenoid valve *(V025 on electrical drawing)***
12. **Normally open (N.O.) pressure switch (7.2 psi) *(DK60.2 on electrical drawing)***
13. **Bosch 4/2 solenoid valve *(V049 on electrical drawing)***
14. **Normally open (N.O.) pressure switch (7.2 psi) *(DK48.1 on electrical drawing)***
15. **Normally open (N.O.) pressure switch (7.2 psi) *(DK48.2 on electrical drawing)***
16. **Wabco 3/2 pneumatic valve**
17. **Wabco 3/2 pneumatic valve**
18. **Wabco 3/2 pneumatic valve**
19. **Wabco 3/2 pneumatic valve**
20. **Pressure protection valve (0.8 bar = 11.6 psi)**
21. **Exhaust muffler**
22. **Pressure protection valve (0.8 bar = 11.6 psi)**
23. **Exhaust muffler**
24. **Wabco 3/2 pneumatic valve**
25. **Air tank (1,224 cu.in.)**
26. **Normally closed (N.C.) Wabco 3/2 solenoid valve *(V024 on electrical drawing)***
27. **Double check valve**
28. **Check valve**
29. **Check valve**
30. **Normally closed (N.C.) Wabco 3/2 solenoid valve *(V036 on electrical drawing)***
31. **Wabco 3/2 pneumatic valve**
32. **Bosch 4/2 solenoid valve *(V025.2 on electrical drawing)***
33. **Normally open (N.O.) pressure switch (7.2 psi) *(DK60.3 on electrical drawing)***
34. **Air tank (1,791 cu.in.)**
35. **Check valve**
36. **Wabco 3/2 pneumatic valve**
37. **Check valve**
38. **Double check valve**

——— AIR TANK PRESSURE

· · · · · · LEVELLING VALVE PRESSURE

- - - - - - EXHAUST

▬▬▬ PNEUMATIC PILOT LINE

═══ ATMOSPHERE

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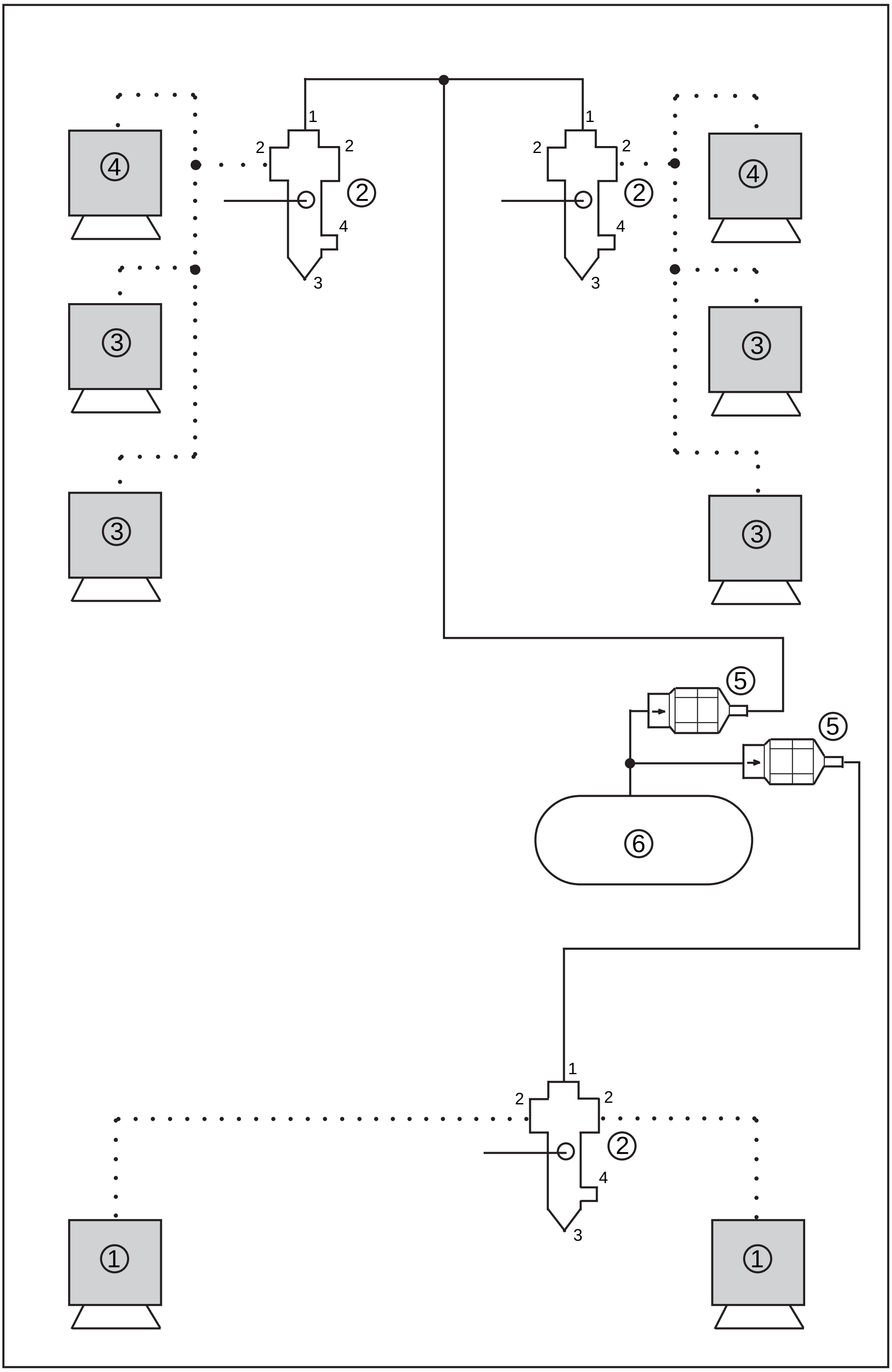

Figure 21: Basic air suspension pneumatic diagram

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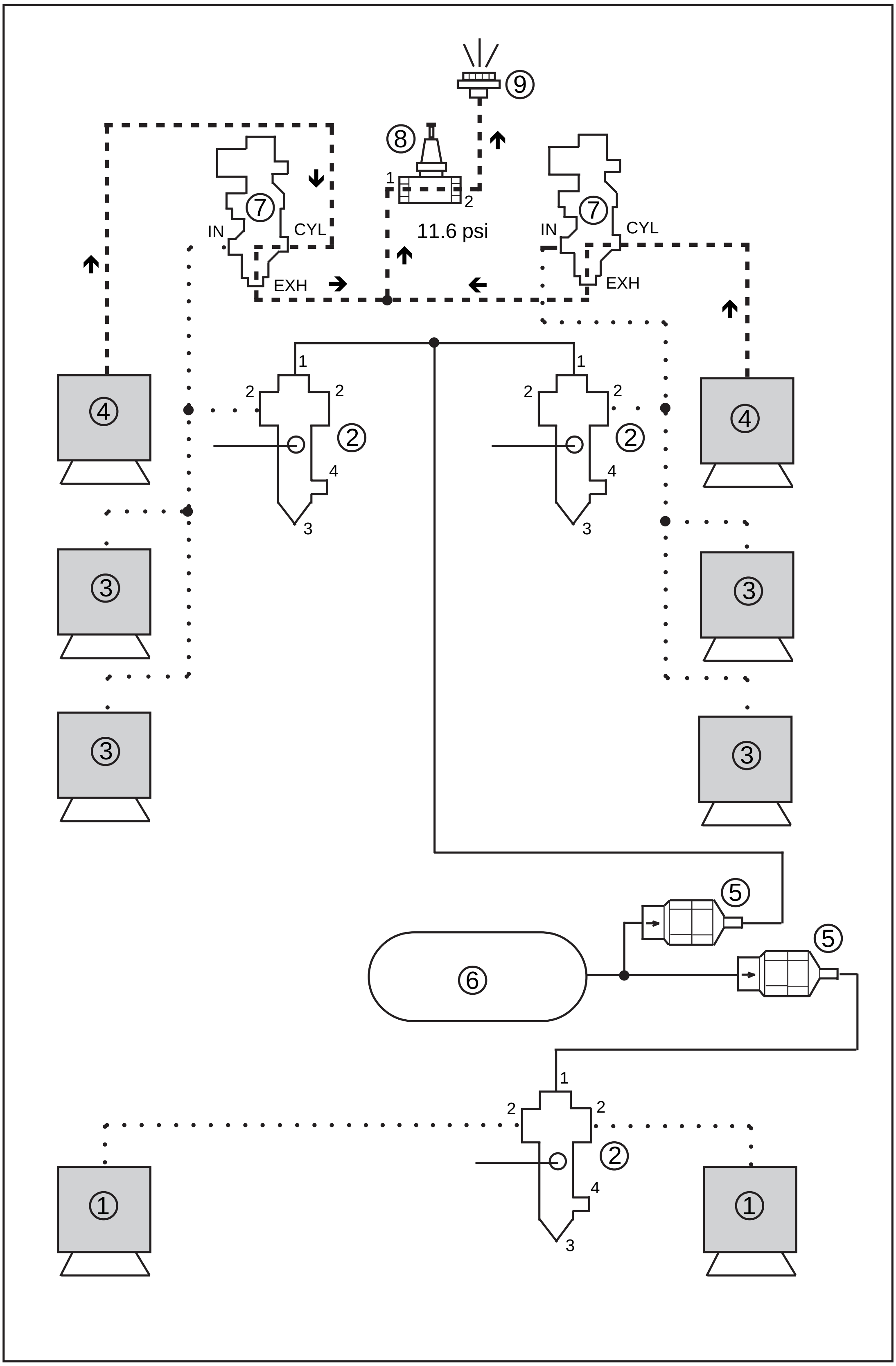

Figure 22: Air suspension pneumatic diagram (basic + tag axle unloading). Diagram shows an activated tag axle unloading system (see arrows).

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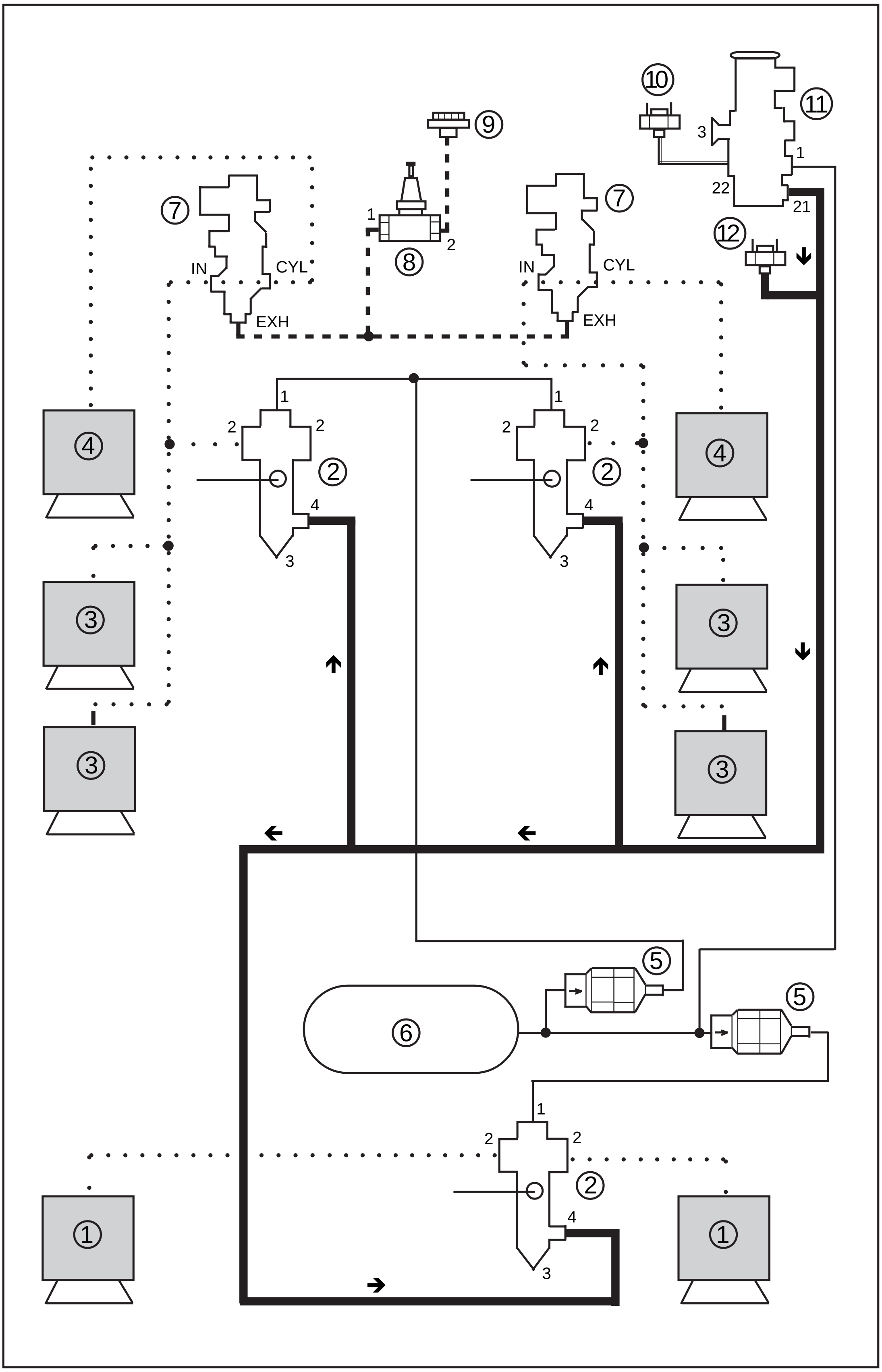

Figure 23: Air suspension pneumatic diagram (basic + tag axle unloading + raising). Diagram shows an activated raising system (see arrows).

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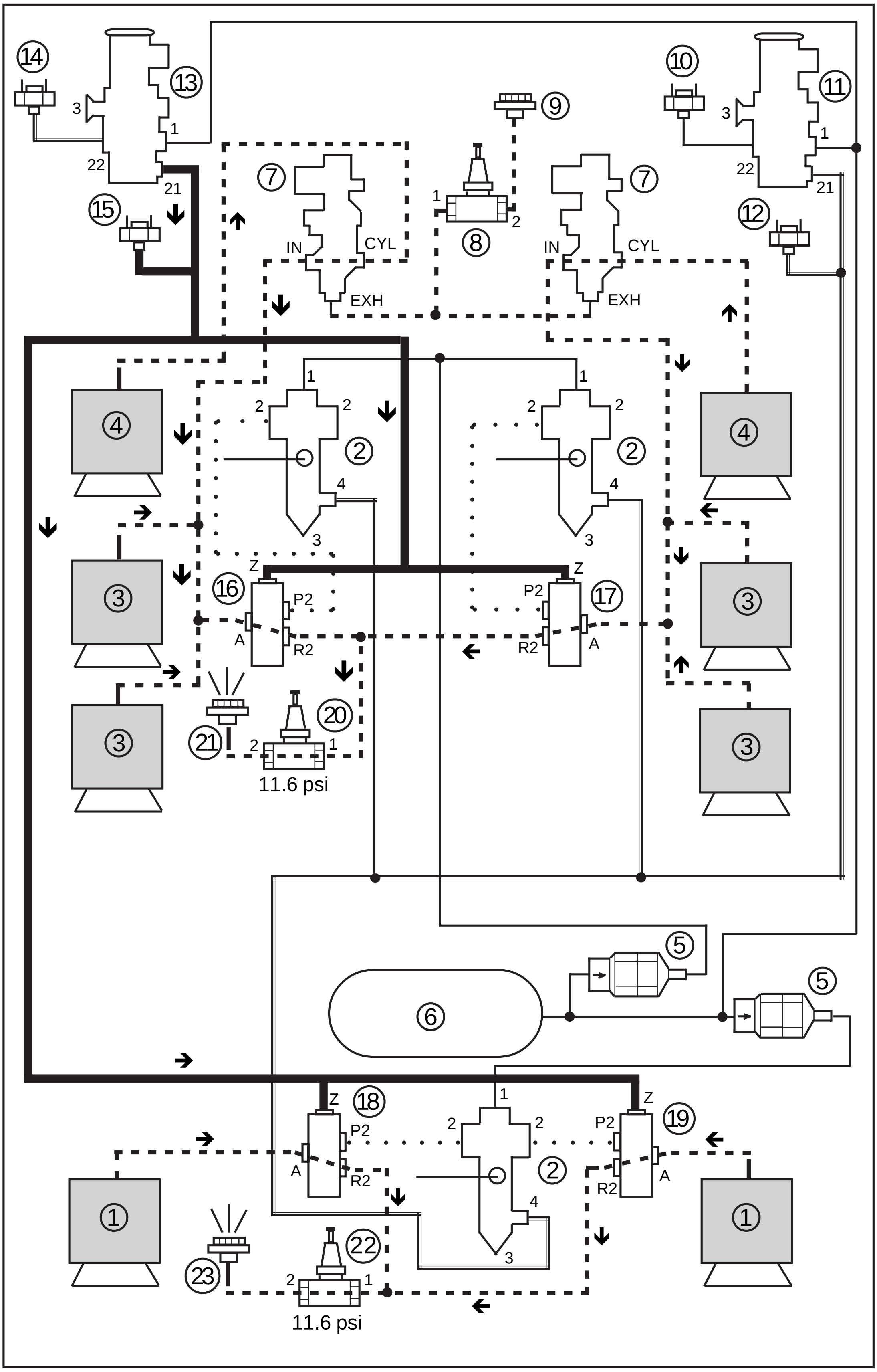

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Figure 24: Air suspension pneumatic diagram (basic + tag axle unloading + raising + lowering). Diagram shows an activated lowering system.

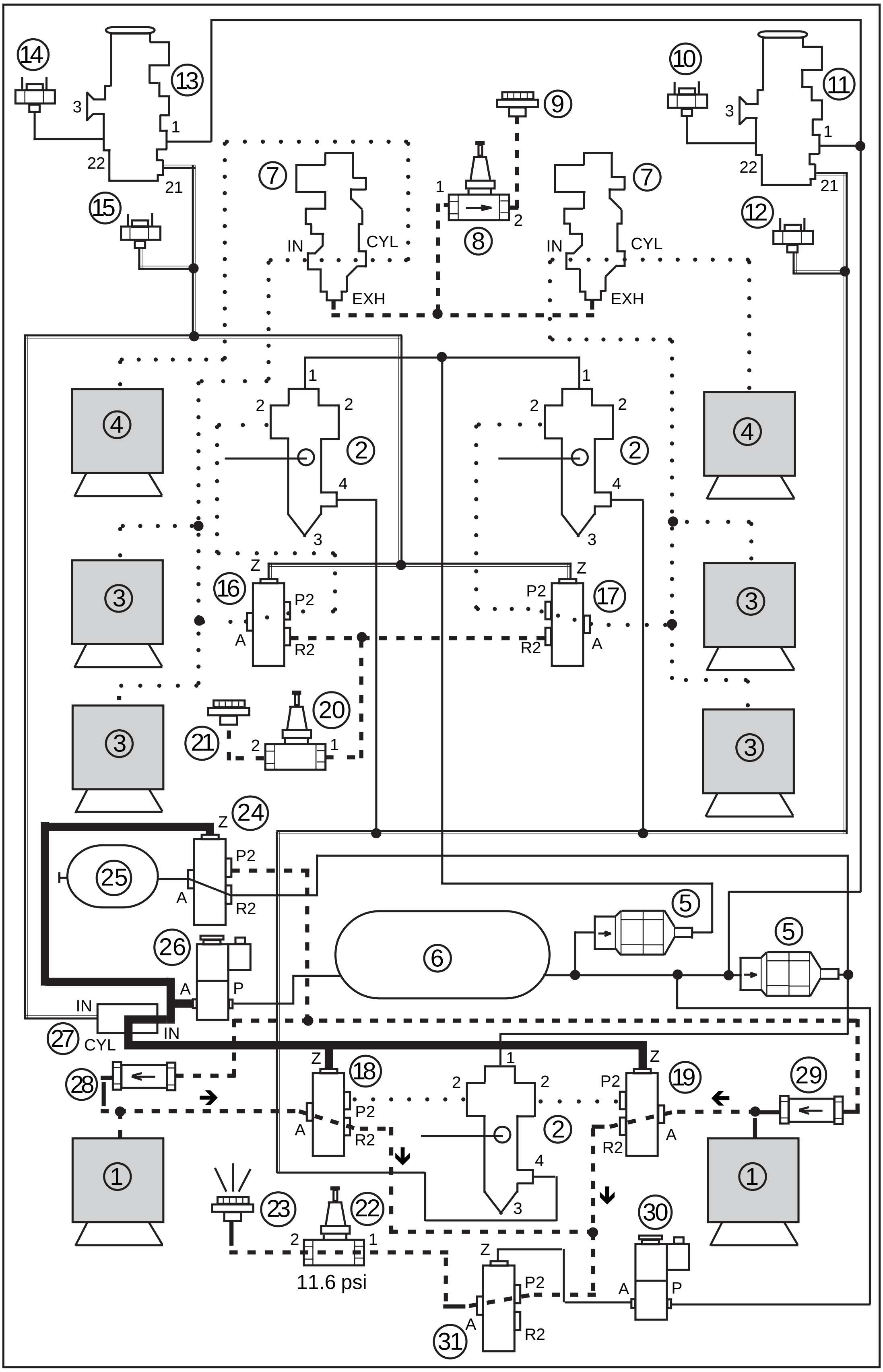

Figure 25: Air suspension pneumatic diagram (basic + tag axle unloading + raising + lowering + front kneeling). Diagram shows an activated front kneeling system.

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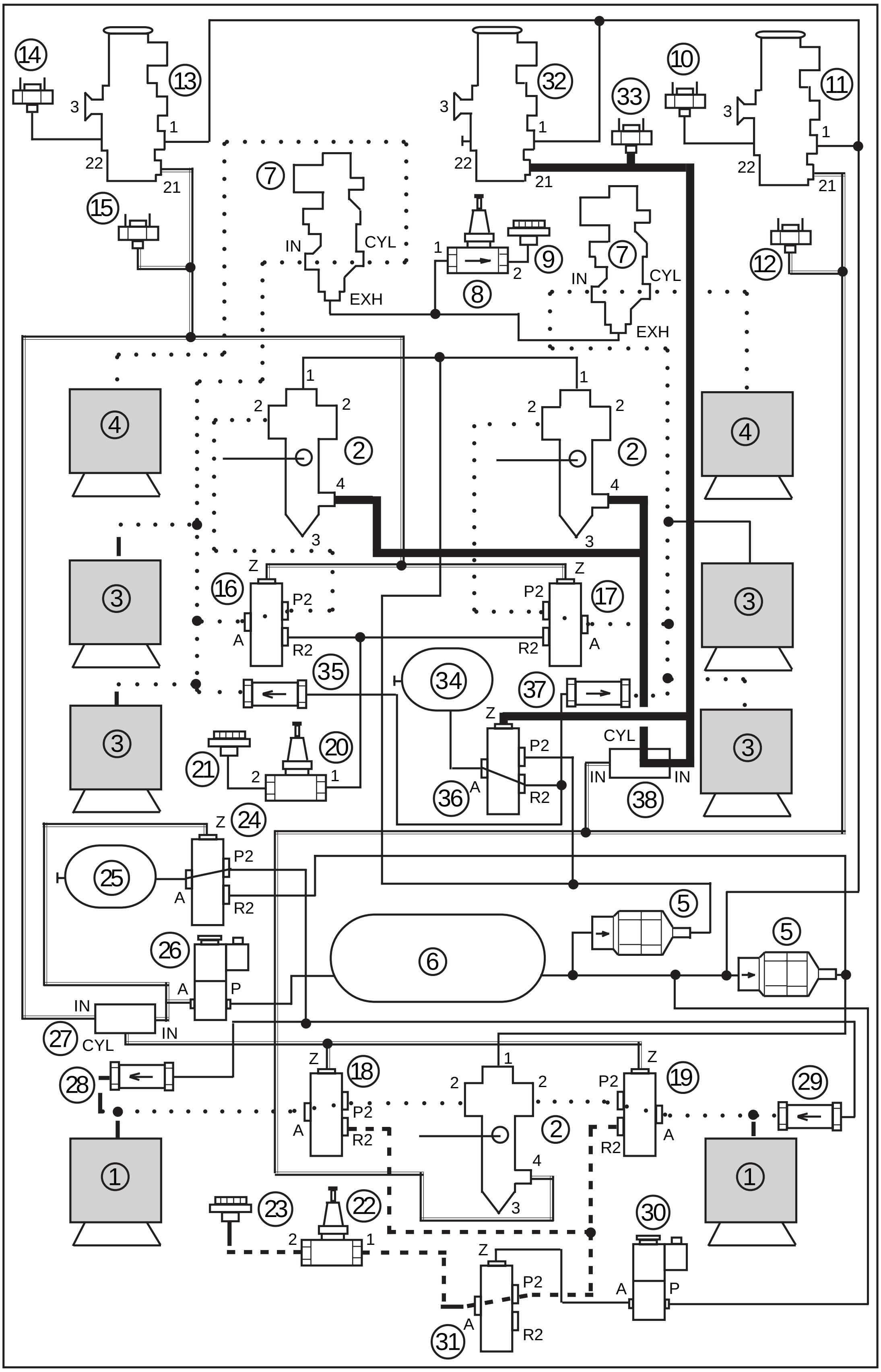

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Figure 26: Air suspension pneumatic diagram (basic + tag axle unloading + raising + lowering + front kneeling + rear raising). Diagram shows an activated rear raising system.

OVERHAUL

TO REMOVE AND MOUNT AIR BAG

!!! CAUTION !!!
ONLY APPLY JACKS AT CORRECT JACKING POINTS, AS SPECIFIED IN OPERATOR'S GUIDEBOOK. USE BLOCKS OR AXLE STANDS WHENEVER WORKING ON COACH.

To remove

1. Place coach over inspection pit.
2. Prevent vehicle from rolling away and position a suitable jack under chassis frame jacking points. Lift vehicle understructure until road wheels clear the floor.
3. Discharge all air from auxiliary tank by opening tank drain valve.
4. Disconnect levelling valve control rod (one at front and two at rear) from its lower attachment bracket. Exhaust air bellows by pulling control rod to its lowest point.
5. Use a tire lever or similar tool to remove air bag. Insert tire lever between air bag bead and piston (or between bag bead and upper attachment plate) and lever off bag.

To mount

Clean both bead seats on piston and upper attachment plate thoroughly. Remove any tar deposits with a suitable solvent. Disconnect levelling valve delivery line from air bellows upper attachment plate.

1. Apply tire soap on upper and lower sealing surfaces of air bag.
2. Collapse new air bag.

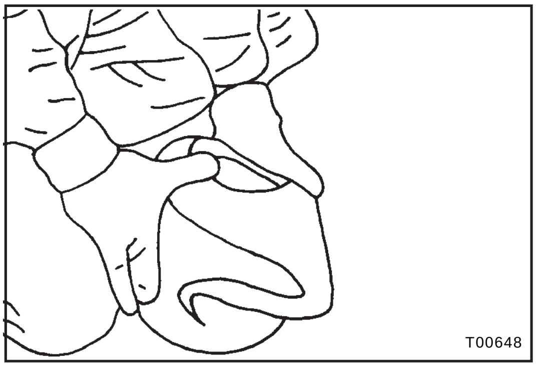


Figure 27

US0810AG

3. Mount air bag between piston and upper attachment plate. Make air bag edges fit as evely as possible around upper and lower seats.

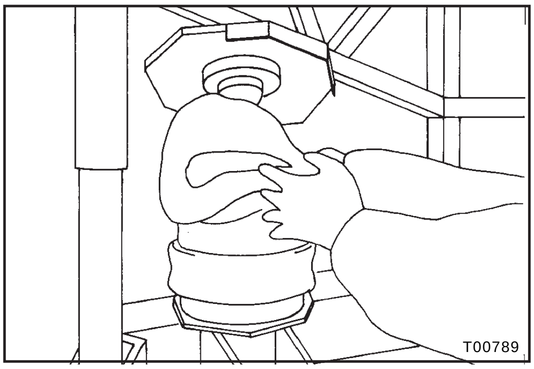


Figure 28

4. Quickly inflate air bag by means of a shop air line.

!!! CAUTION !!!
DO NOT EXCEED MAXIMUM RATED OPERATING PRESSURE FOR AIR BAG (115 PSI).

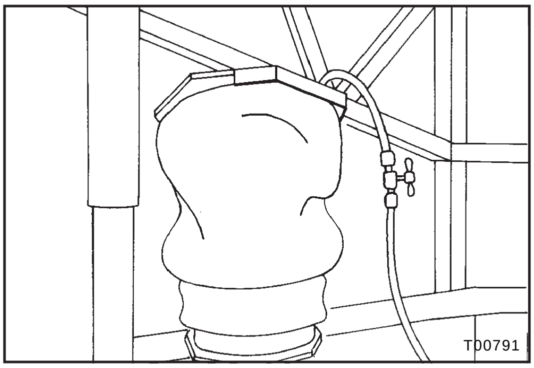


Figure 29

Use both hands to hold bag as squarely as possible in contact with its seats while internal pressure builds up. If rate of airflow is sufficiently high, the bag should virtually 'snap' onto its seats and self-seal.

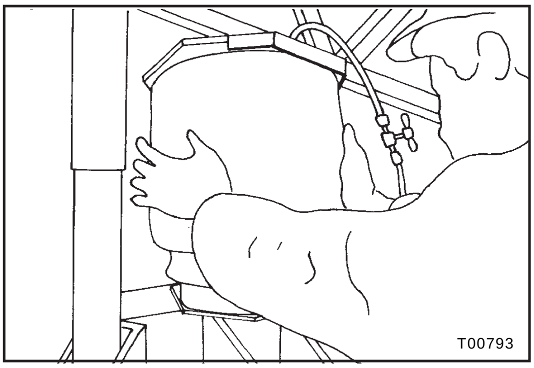


Figure 30

5. Exhaust air bag by removing air line and partially lower jack.

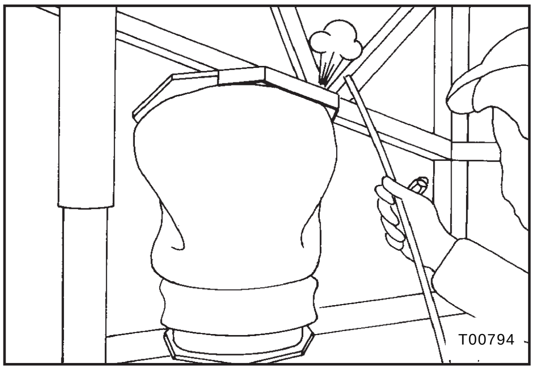


Figure 31

US0810AG

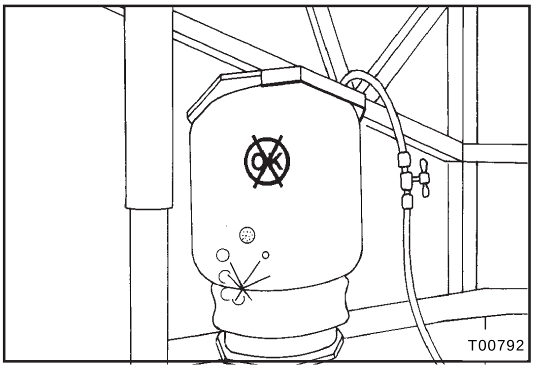


Figure 32

6. Reinflate air bag to maximum operating pressure (115 psi) and check whether air bag seals properly (apply a soap solution to beads and watch whether air bubbles appear). Lower jacking device until jack lift pads are free from understructure.

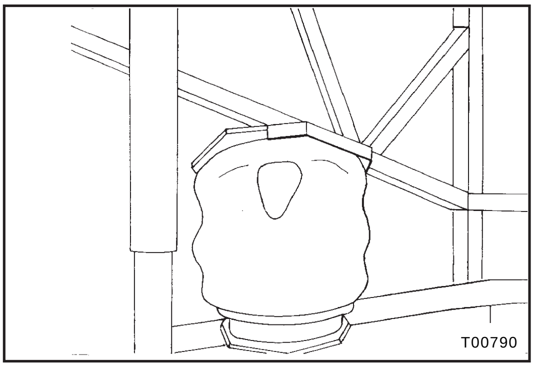


Figure 33

7. Exhaust air from air bag once more. This action lowers vehicle body and causes air bag to roll onto piston.

8. Reconnect levelling valve delivery line to upper attachment plate.

9. Raise valve operating lever to charge air bag and reconnect valve control linkage to suspension yoke or axle.

The above operation can also be carried out by solely using the vehicle's own compressed air system. In that case, line connection at upper attachment plate needs to remain fastened.

Air bags are then charged or exhausted by manually operating the levelling valve control rod.

NOTE
MAKE SURE THAT THE SYSTEM PRESSURE IS MAINTAINED AT MAXIMUM OPERATING PRESSURE DURING OPERATION.

US0810AG

SUSPENSION - MECHANICAL SYSTEM

SHOCK ABSORBERS

PURPOSE

The purpose of shock absorbers is to absorb the energy caused by the movement of the suspension. The extent of the absorption is carefully determined for each vehicle under all circumstances. Shock absorbers contain carefully calibrated orifices and spring loaded valves through which oil is forced.

PERIODIC INSPECTIONS

Check shock absorber chamber periodically for:

- Fatigue cracks on rubber
- Damage at housing
- Oil leakage

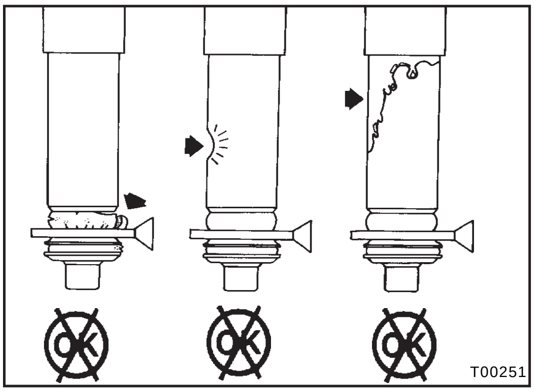


Figure 1: Shock absorber

TO REMOVE AND INSTALL

To remove

1. Remove dust cap, nut, cupped washers,spacing ferrule and rubber bushings.
2. Pull stud end out of upper mounting hole and lift shock absorber out of lower mounting hole.

To install

NOTE
WHEN REPLACING SHOCKS, BE SURE THAT SAME TYPE OF SHOCK IS USED. CHECK MANUFACTURER'S NUMBER ON OLD SHOCK ABSORBER. *ALWAYS USE NEW RUBBER BUSHINGS.*

1. Smear stud threads lightly with "Never-Seez" to make nut removal easier at a later stage.
2. Installation is the reversal of removal. Be sure that the arrow marked "TOP" is in upward position (see Figure 2 for right location of cupped washers,spacing ferrule and rubber bushings).
3. Tighten nuts to a torque of 70 ft.lbf.

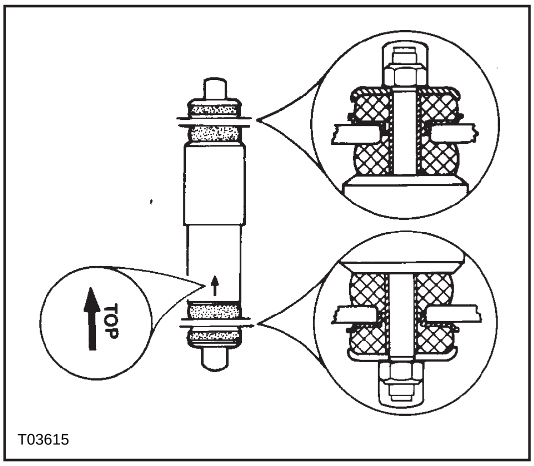


Figure 2: Shock absorber mounting

US0820AH

TO ADJUST

If-after many thousands of miles of use-the damping effect of the shock absorbers requires adjustment, this can be done as follows:

1. Remove the shock absorber from the coach and hold it vertically with the lower pin attachment in a vice. Use clamp plates to prevent damage.

2. Fully close the shock absorber and turn at the same time the dust cap slowly to the left(counterclockwise) until it is felt that the cams of the adjusting nut engage in the recess of the foot valve assembly.

3. The shock absorber may have already been adjusted. Therefore check whether the shock absorber is in the unadjusted position or not by keeping it closed and gently turning further to the left counting at the same time the half turns until a stop is felt. Stop turning then and do not use force.

4. Keeping the shock absorber closed make 2 half turns(360°) to the right(clockwise). In case of prior adjustment add the number of half turns previously found. The total range is about 5 half turns.

5. Pull the shock absorber out vertically without turning for at least 0.5 inch to disengage the adjusting mechanism. The dust cap may now be turned freely.

6. Refit shock absorber.

NOTE
ADJUSTMENT MUST ALWAYS BE CARRIED OUT IN PAIRS.

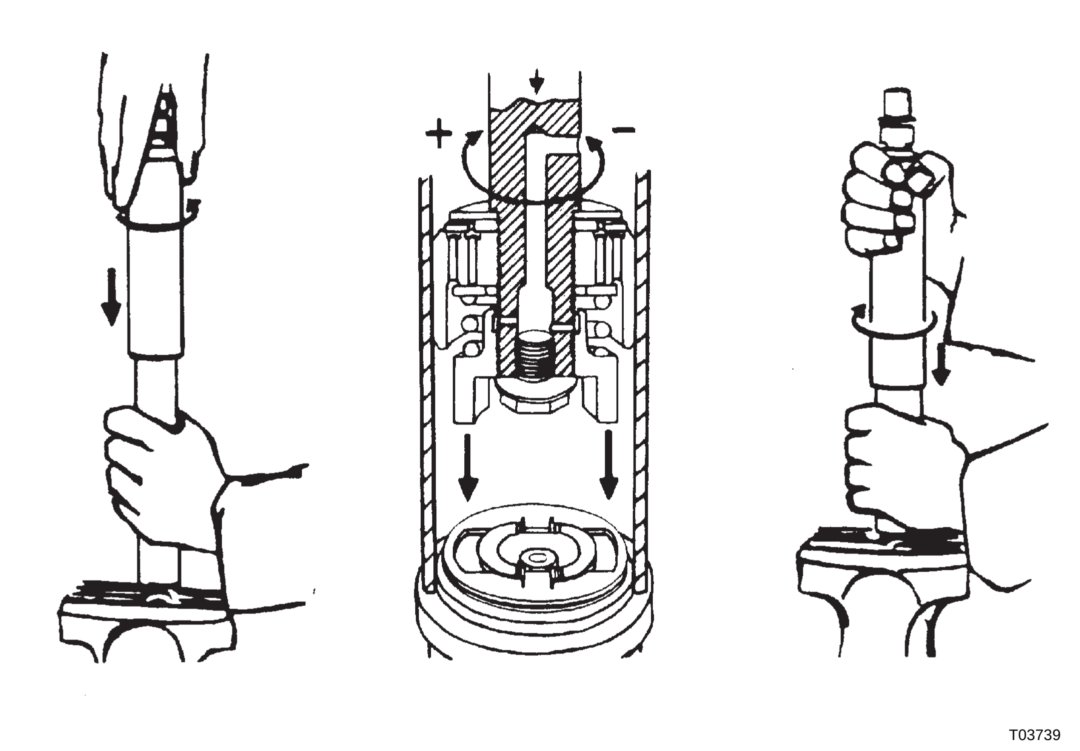


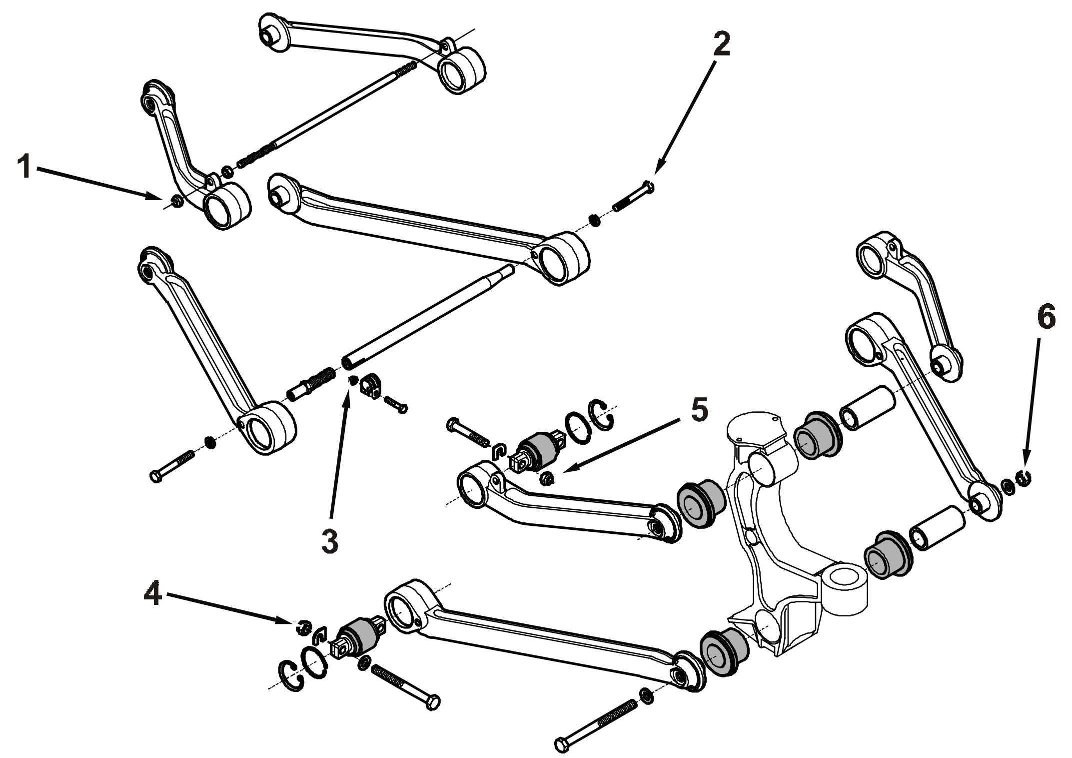
Figure 3: To adjust shock absorber

US0820AH

SUSPENSION TIGHTENING TORQUES

Periodically check and tighten suspension fasteners. Proper tightness of suspension components is very important in determining serviceability and life expectancy of coach. Refer to figures on this and next pages for tightening torques.

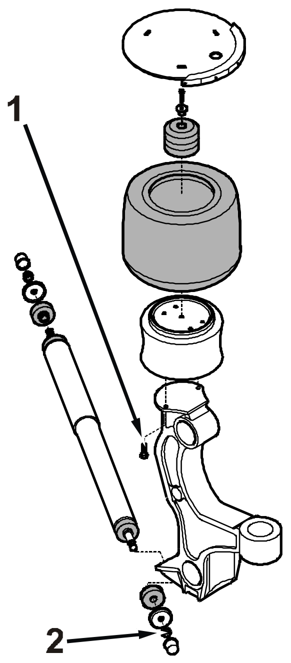
!!! CAUTION !!!
NEVER RETIGHTEN THOSE SCREWS, BOLTS OR NUTS THAT ARE FITTED WITH LOCKING ADHESIVE (INDICATED IN FIGURE), AS THIS WOULD DESTROY THE LOCKING PROPERTIES.



1. 70-90 ft.lbf.
2. 105-110 ft.lbf.
3. 35-40 ft.lbf.
4. 245-325 ft.lbf.
5. 205-225 ft.lbf.
6. 220-255 ft.lbf.

T05851

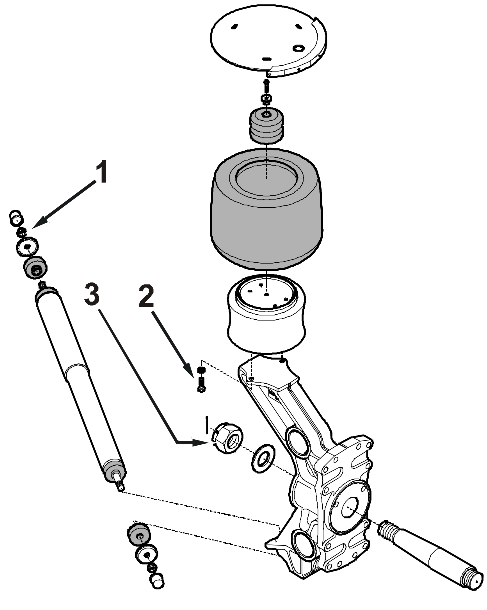
Figure 4: Front suspension torque recommendations



1. 45-60 ft.lbf.
2. 70 ft.lbf.

T05850

Figure 5: Front suspension torque recommendations



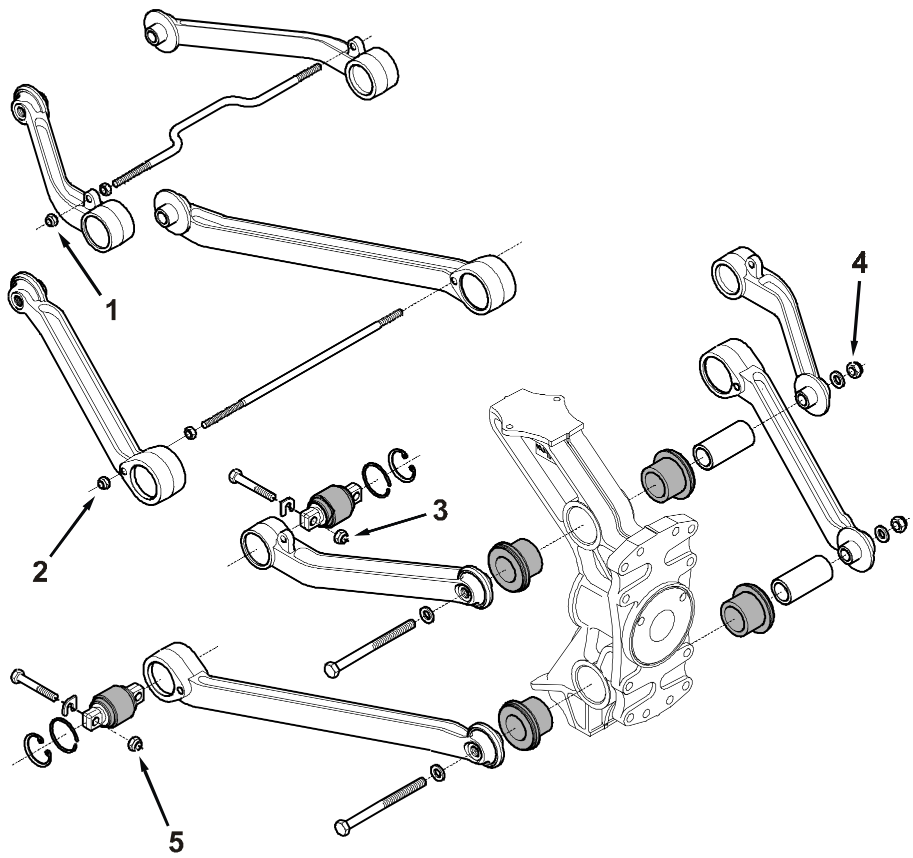
1. 70 ft.lbf.
2. 45-60 ft.lbf.
3. 370 ft.lbf.*

*If necessary, turn nut further until cotter pin can be installed. Never turn back to install cotter pin!

T05857

Figure 6: Tag suspension torque recommendations

US0820AH

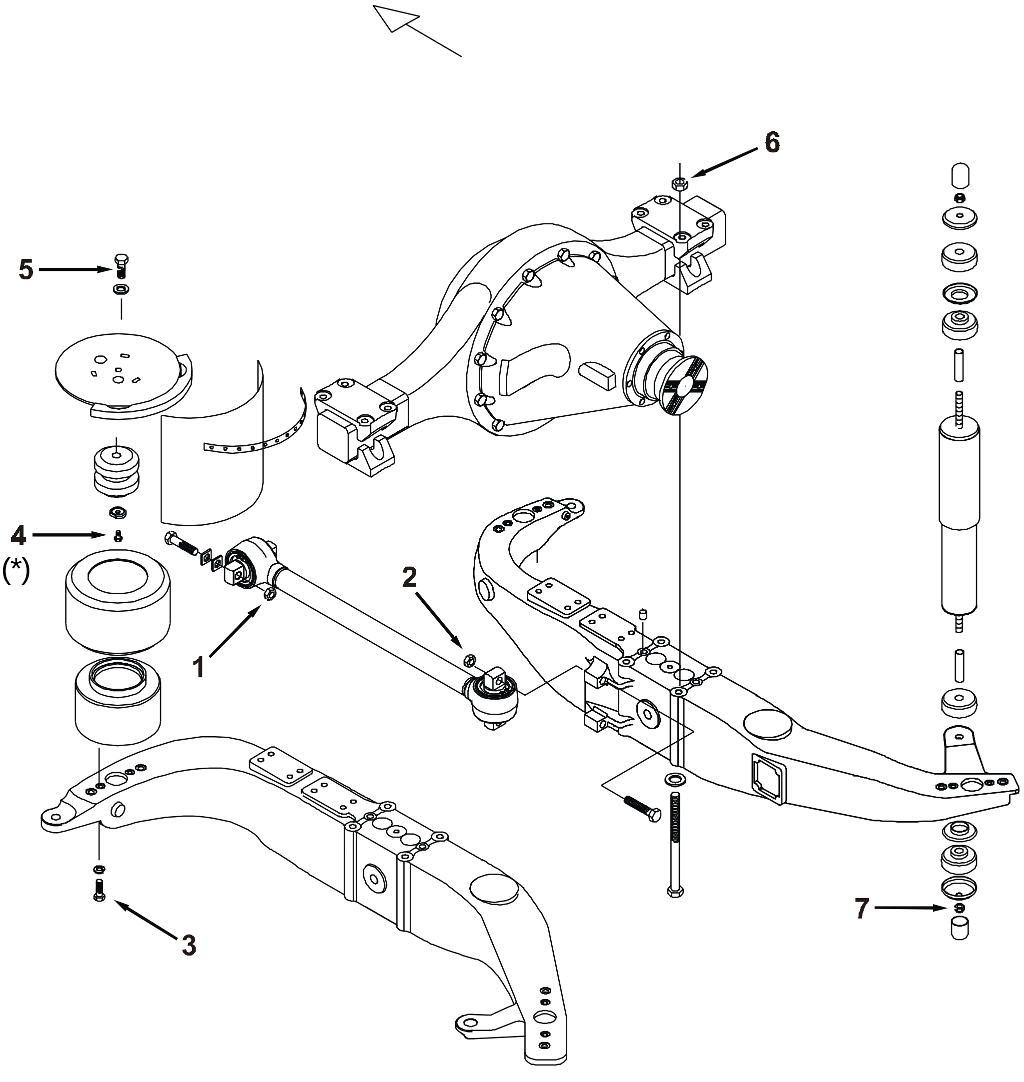


1. 70-90 ft.lbf.
2. 70-90 ft.lbf.
3. 205-225 ft.lbf.
4. 220-255 ft.lbf.
5. 205-225 ft.lbf.

T05858

Figure 7: Tag suspension torque recommendations

US0820AH



1. 180-235 ft.lbf.
2. 180-235 ft.lbf.
3. 30-35 ft.lbf.
4. 15-18 ft.lbf.
5. 50-60 ft.lbf.
6. 285-380 ft.lbf.
7. 70 ft.lbf.

(*) Screw fitted with Loctite 243 or similar

T05784

Figure 8: Drive suspension torque recommendations

US0820AH

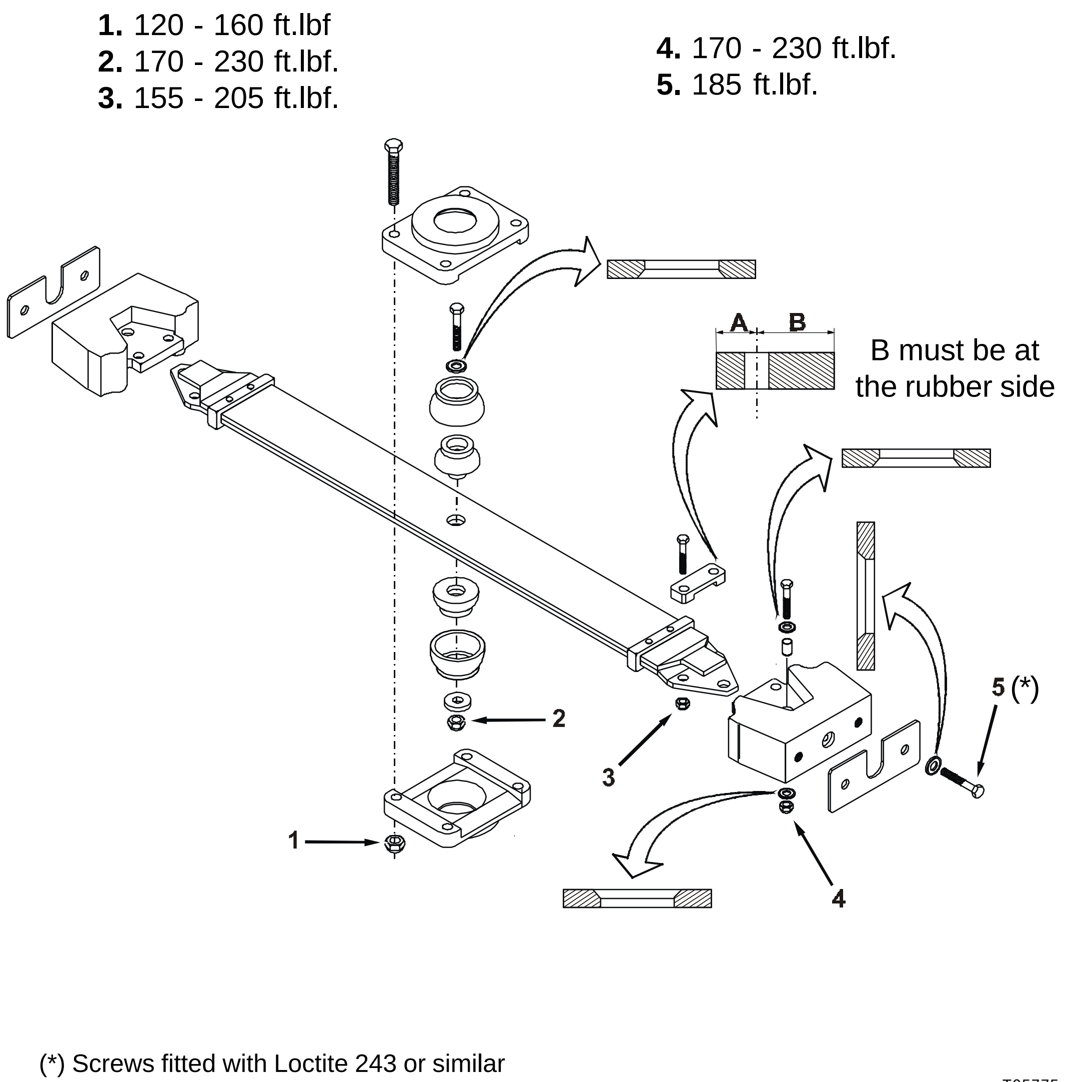
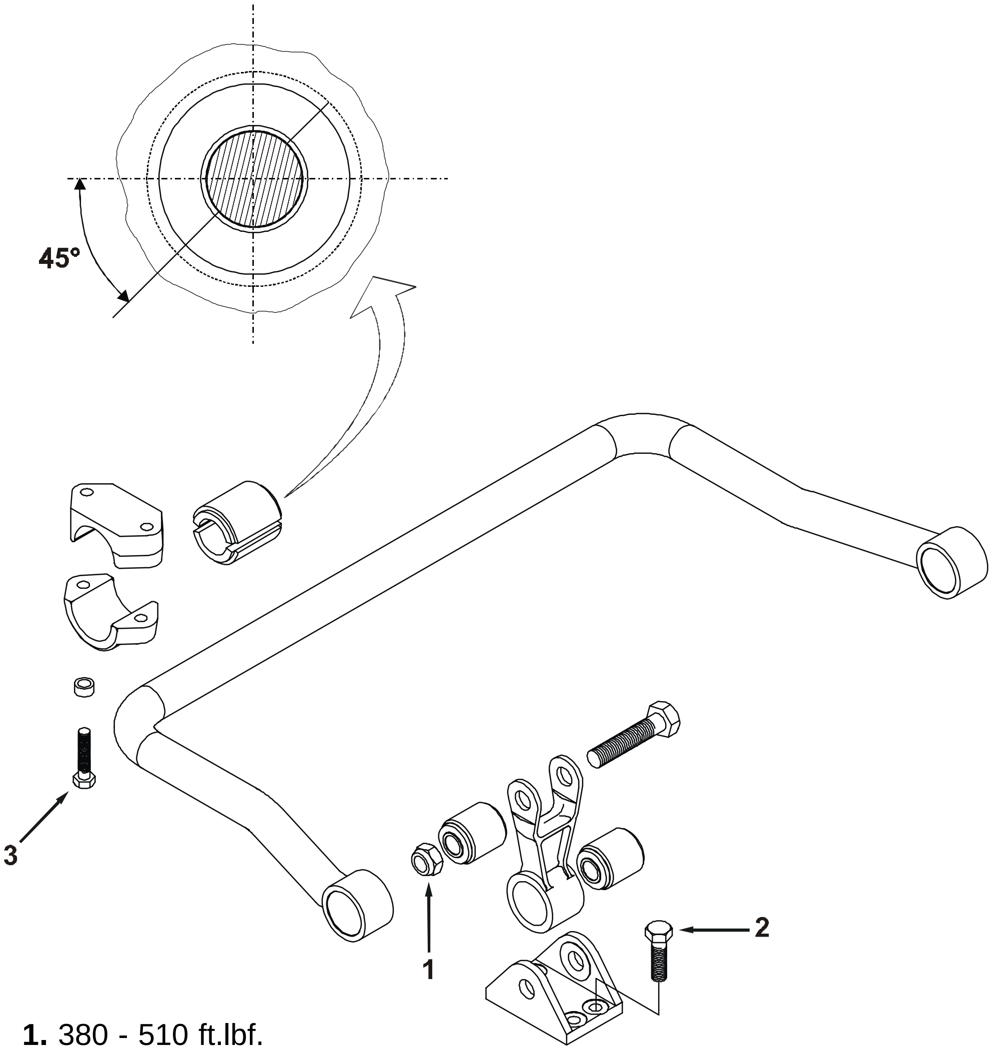


Figure 9: Drive axle suspension torque recommendations

!!! CAUTION !!!
AS THEY ARE MADE OF A HARD TYPE OF STEEL, THE SUSPENSION LOCATING LINKS ARE FAIRLY VULNERABLE TO NOTCHES,BLOWS AND HEAT. DO NOT WELD, GRIND OR DRILL. AVOID HITTING WITH A HAMMER WHILE ASSEMBLING OR DISASSEMBLING. WHEN WELDING OR GRINDING IN THE VICINITY, APPLY A PROTECTION AGAINST WELDING SPECKS OR ACCIDENTAL SLIP OF THE GRINDING DISC. THE LOCATING LINKS SHOULD REMAIN BARE: DO NOT WRAP IN ANY WAY OR COAT WITH SPRAY GUN OR HAND BRUSH(PROTECT WHEN SPRAYING THE CHASSIS WITH ANTI-RUST LIQUID). LOCATING LINKS ACCIDENTALLY NOTCHED OR AFFECTED BY WELDING SPECKS SHOULD BE REPLACED IMMEDIATELY BECAUSE OF THE RISK OF BREAKING.

US0820AH



1. 380 - 510 ft.lbf.
2. 80 - 105 ft.lbf.
3. 120 - 160 ft.lbf

Figure 10: Drive axle suspension torque recommendations

US0820AH

SPECIAL SERVICE TOOLS

TOOL08AC

TOOL08AC

SERVICE BULLETINS

Service Bulletins are issued to supplement or supersede information in the Van Hool manuals. Note below number, date and subject of Bulletins pertaining to this chapter. File Bulletins separately by number for future reference.

Number	Date	Subject

CHAPTER 9
ELECTRICAL SYSTEM

PAGE

MAIN09AD

MAIN09AD

CONTROLLER AREA NETWORK (CAN) OF DRIVE LINE

MULTIPLEX SYSTEM

LOCATION OF MAIN COMPONENTS ON NON-MULTIPLEXED VEHICLES

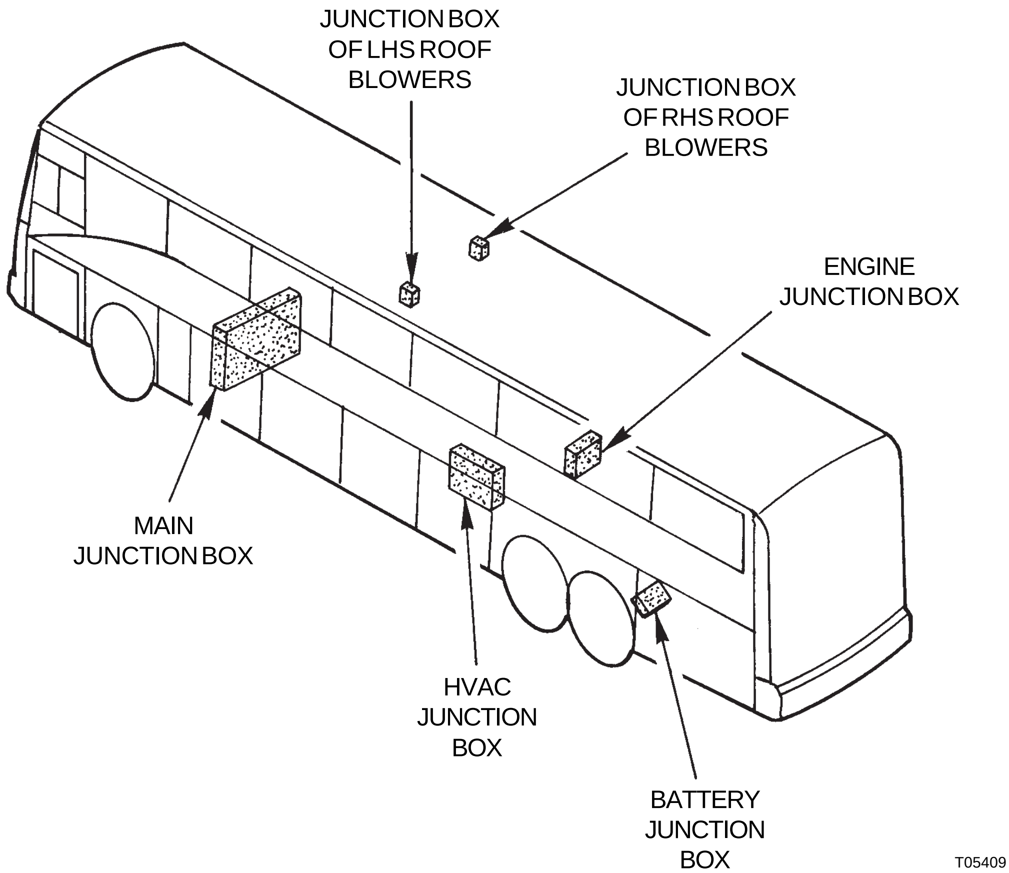


Figure 1: Location of junction boxes

The electrical system is a 24VDC system and consists of:

- Two 12VDC batteries, connected in series.
- Two alternators with internal, non-adjustable voltage regulator (second alternator only on vehicles with HVAC).
- A battery equalizer to ensure equal charge of the two batteries.
- A battery disconnect solenoid to disconnect from electrical system by means of master/ignition switch located on instrument panel.
- Six junction boxes which house various fuses, relays and other electrical components.
- A main wire harness which is routed between the main junction box and the battery junction box.
- Other wire harnesses.

US0910AF

CONTENTS OF JUNCTION BOXES

MAIN JUNCTION BOX

The main junction box is mounted against the front wall of the luggage compartment. It can be divided in four main sections: "ELECTRONICS", "INTERCONNECTIONS", "BASIC ELECTRICS" and "FUSES".

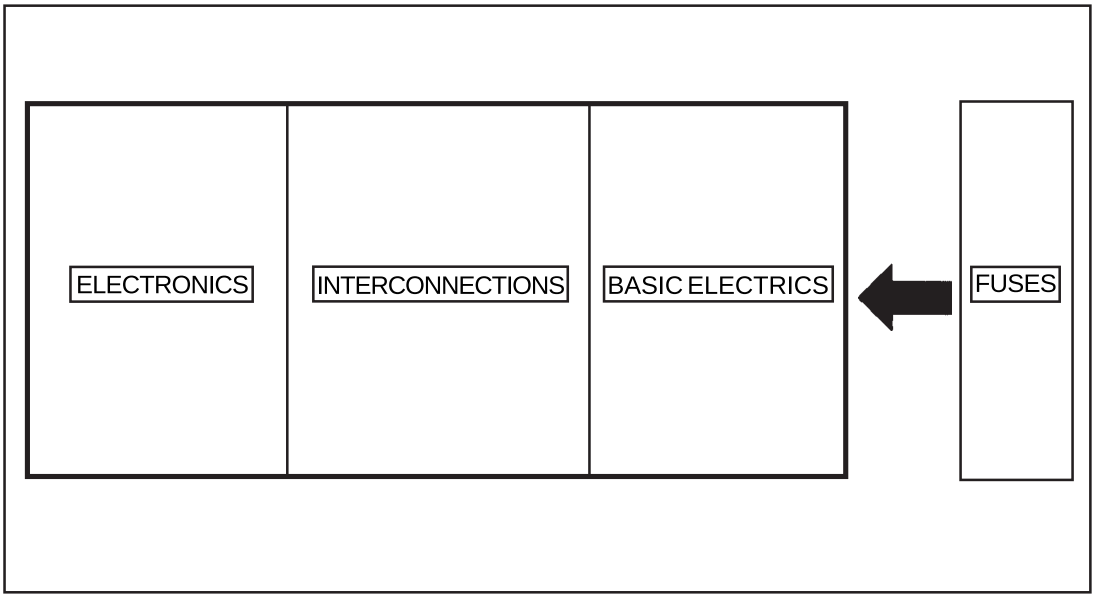


Figure 2: Main junction box sections

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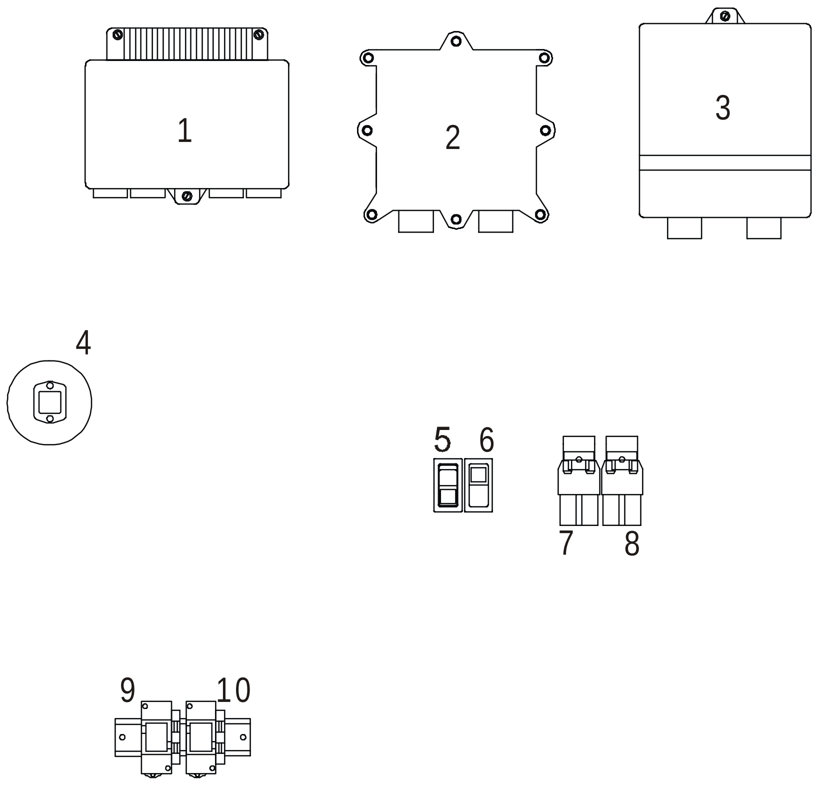

Figure 3: "Electronics" section of main junction box

1. Electronic control unit of Meritor Wabco ABS/ASR system (ABS)
2. Vehicle interface module of WT-transmission (VIM ALLISON)
3. Electronic control unit of WT-transmission (ECU + CAL)
4. Socket to connect an external voltage source for illumination of the aisle fluorescent lights (refer to Section 9.6 for more information) (LICHT)
5. ABS/ASR diagnostic switch (S512.2)
6. ABS indicator light (KL721.2)
7. Fuse Z151
8. Fuse Z10 (from VIN 45021 (Cummins) and VIN 45521 (Detroit Diesel) onwards located in battery junction box)
9. Relay RL568.2
10. Relay RL568.3

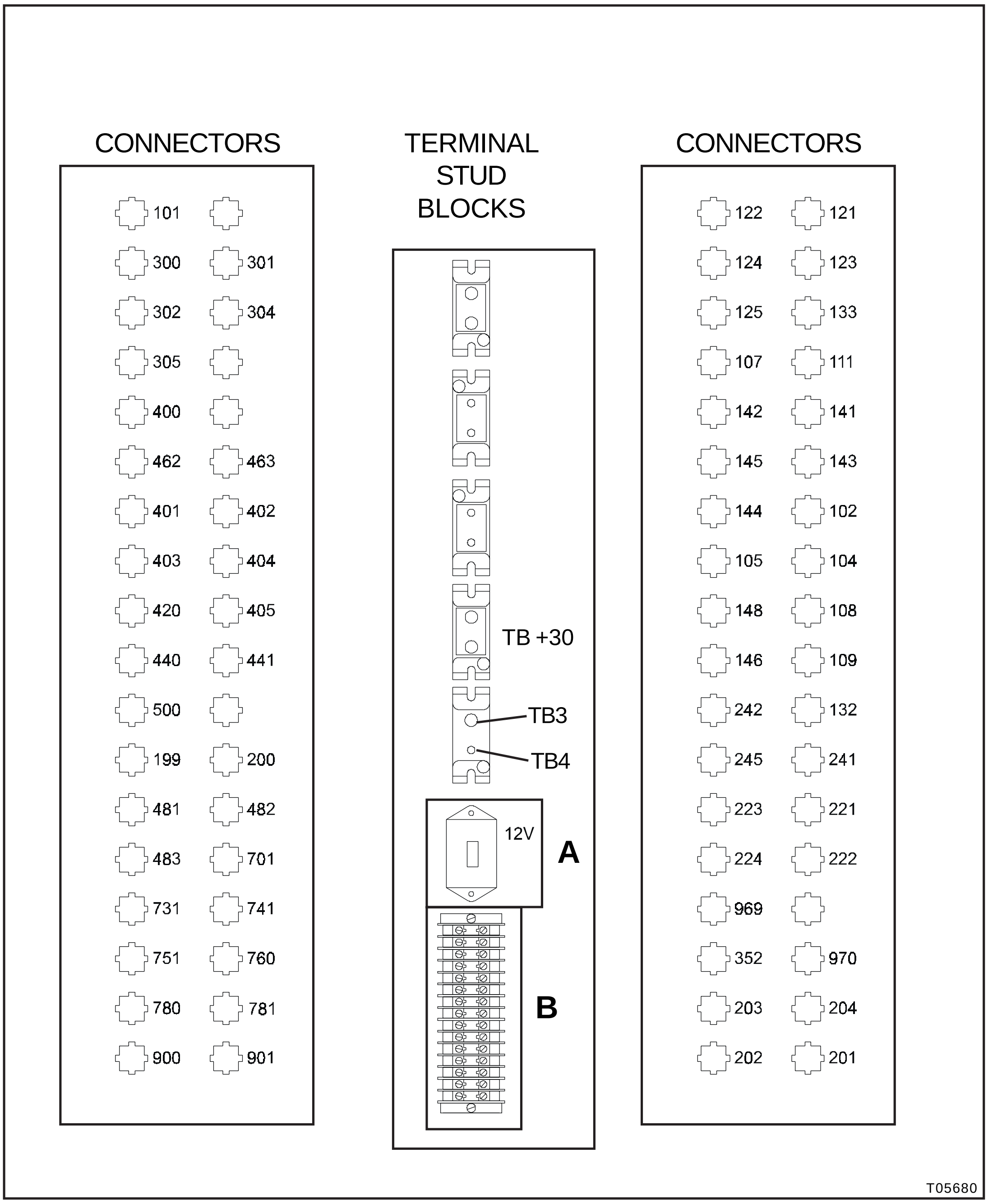

Figure 4: "Interconnections" section of main junction box

Refer to Figures 5 and 6 for identification of terminal stud blocks A and B

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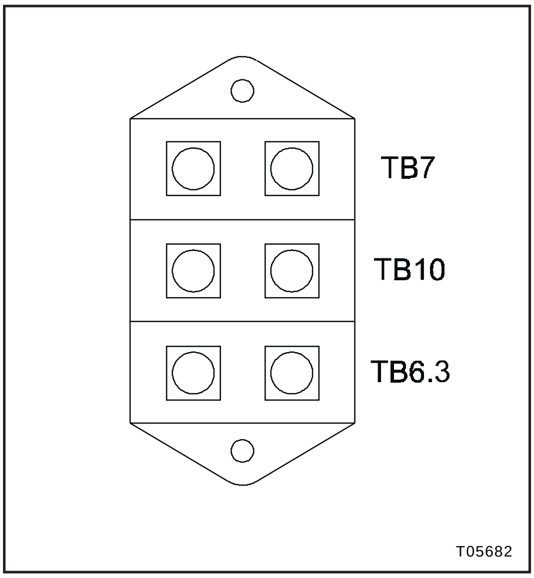

Figure 5: Terminal stud block "A" of Figure 4

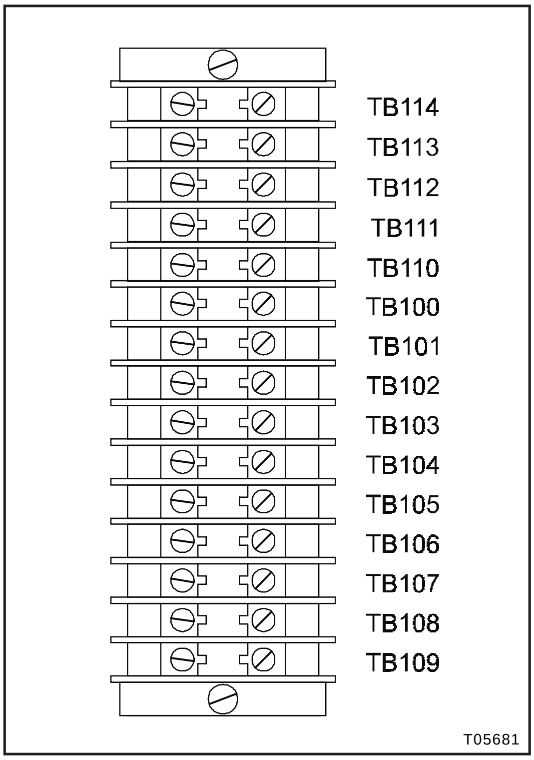

Figure 6: Terminal stud block "B" of Figure 4

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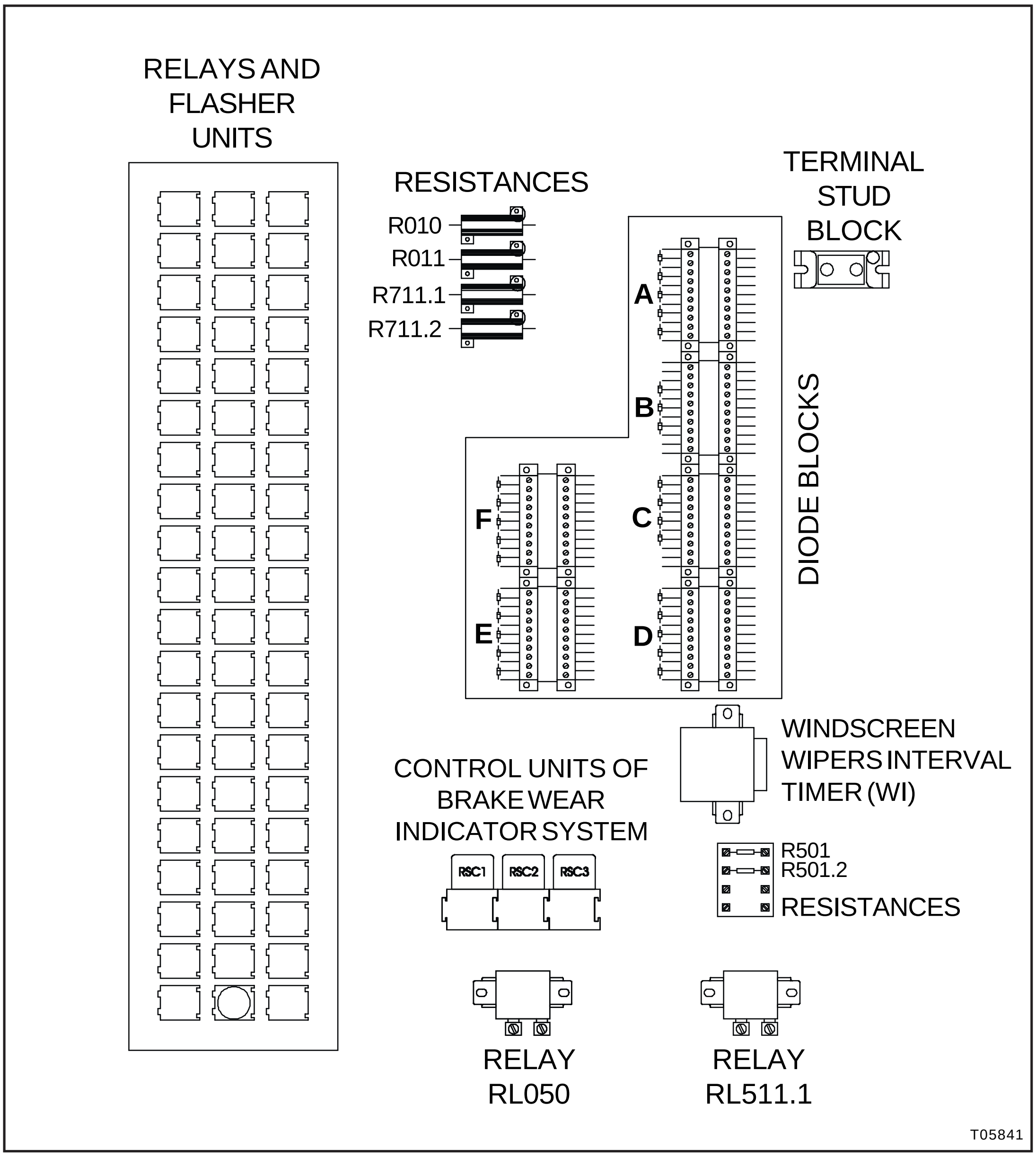

Figure 7: "Basic electrics" section of main junction box

For identification of relays and flasher units refer to Figure 8
For identification of diodes refer to Figure 9

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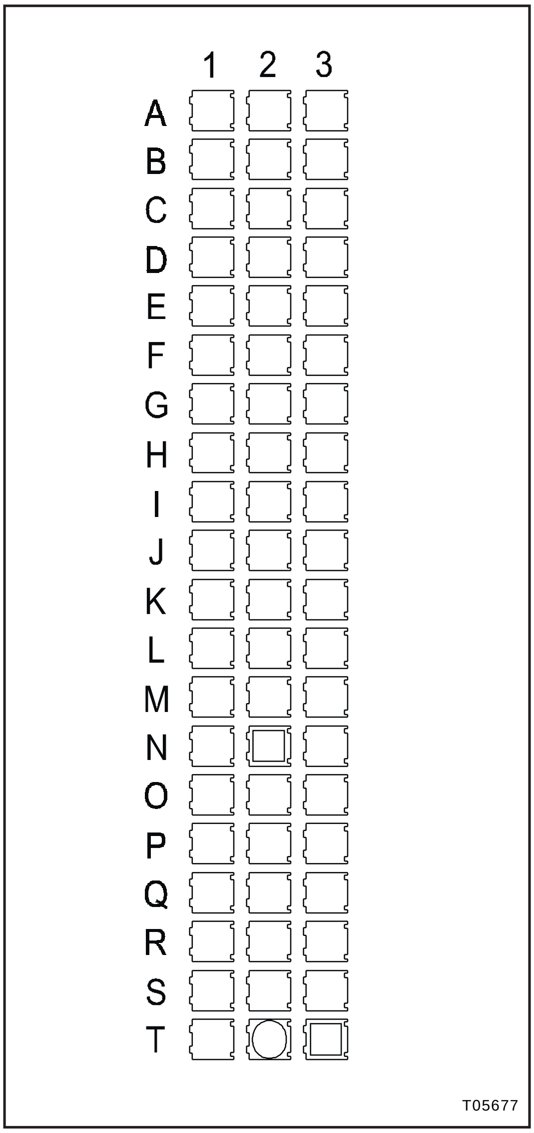

Figure 8: Relays and flash units in "Basic electrics" section of main junction box

A1: RL014.2	**E1: RL042.1**	**I1: RL049.2**	**M1: RL098.1**	**Q1: RL711.2**
A2: RL014.1	**E2: RL037**	**I2: RL049**	**M2: RL077**	**Q2: RL711**
A3: RL004.2	**E3: RL036**	**I3: RL046**	**M3: RL076**	**Q3: RL568.4**
B1: RL021	**F1: RL043**	**J1: RL054.2**	**N1: RL505**	**R1: RL714.3**
B2: RL018	**F2: RL042.3**	**J2: RL054.1**	**N2: RL098.3**	**R2: RL714.2**
B3: RL015.2	**F3: RL042.2**	**J3: RL053**	**N3: RL098.2**	**R3: RL714.1**
C1: RL026	**G1: RL044.2**	**K1: RL075**	**O1: RL521.3**	**S1: RL714.6**
C2: RL025	**G2: RL044**	**K2: RL75.2**	**O2: RL521.2**	**S2: RL714.5**
C3: RL023	**G3: RL043.2**	**K3: RL055**	**O3: RL511.2**	**S3: RL714.4**
D1: RL029	**H1: RL045.3**	**L1: not used**	**P1: RL543**	**T1: PD2**
D2: RL028	**H2: RL045.2**	**L2: RL082**	**P2: not used**	**T2: PD**
D3: RL027	**H3: RL045.1**	**L3: RL75.3**	**P3: RL522**	**T3: LKT**

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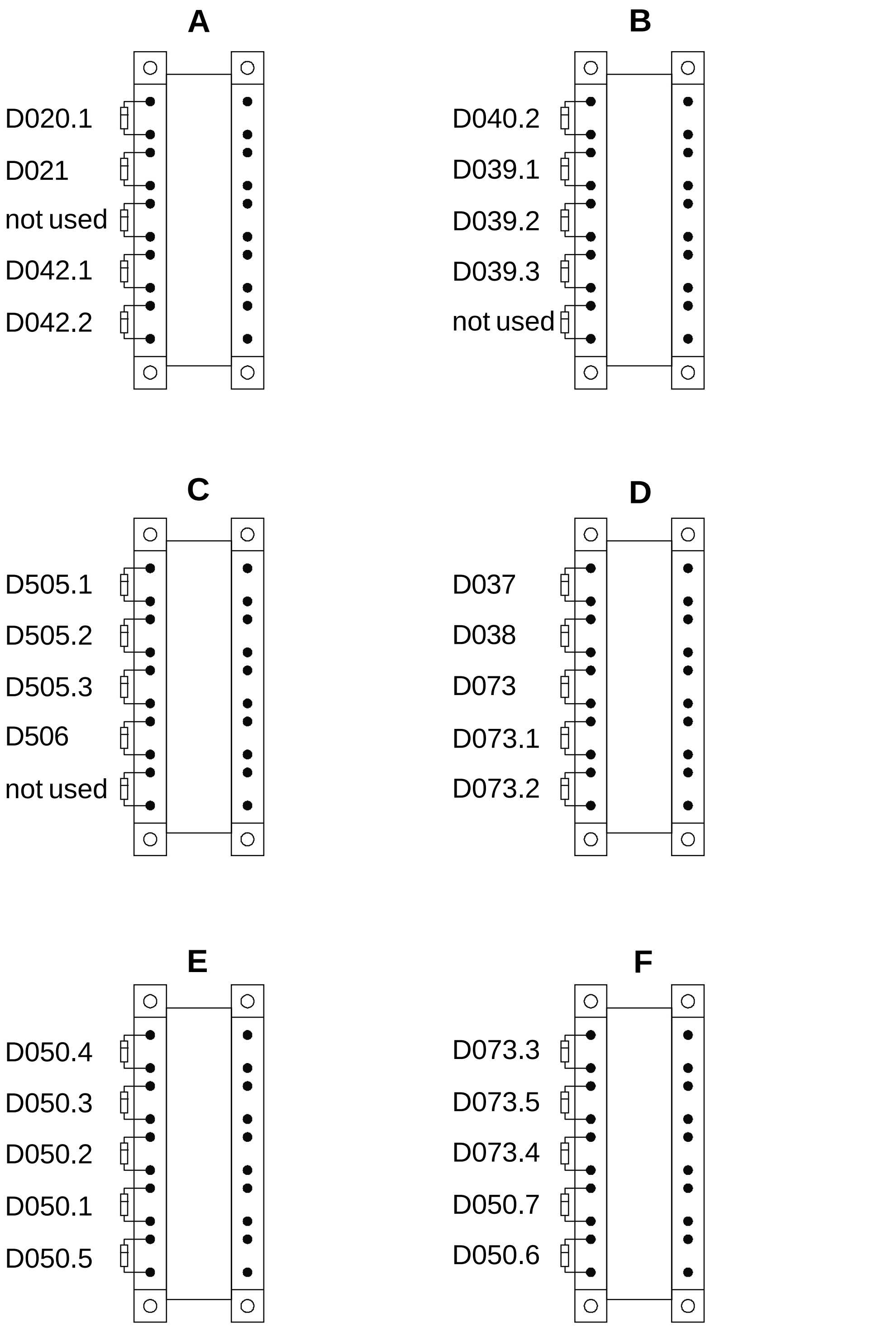

Figure 9: Diode blocks in "Basic electrics" section of main junction box

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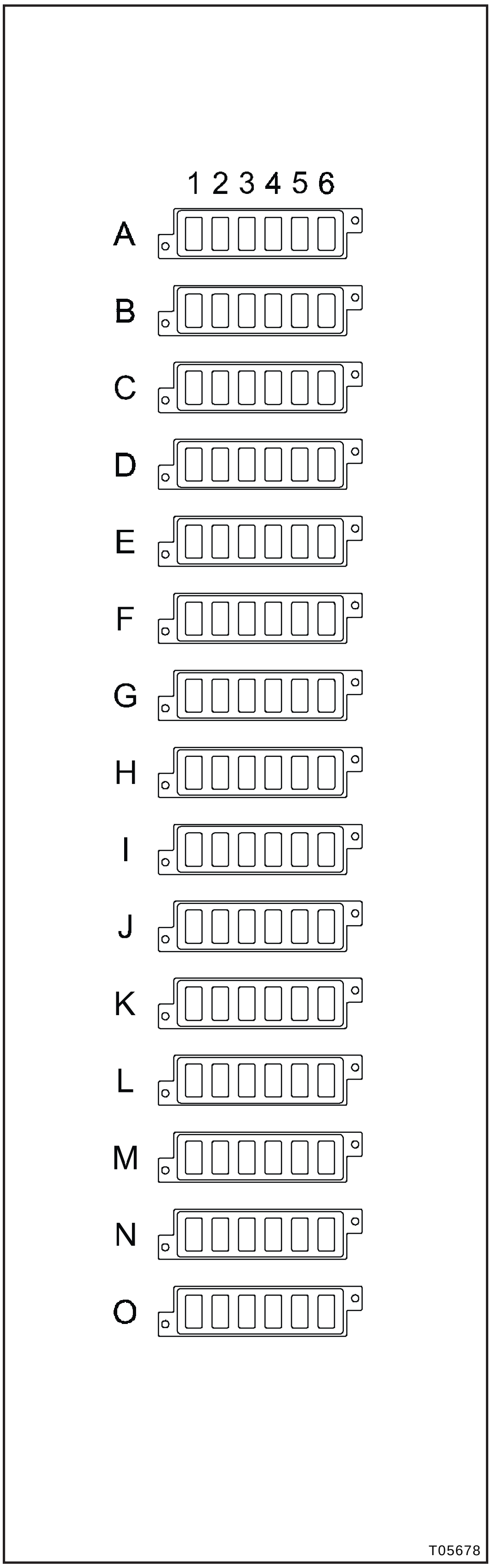

Figure 10: Circuit breakers and fuses in right side of main junction box

A1: Z20
A2: Z22.1
A3: Z22.2
A4: Z22.3
A5: Z23
A6: Z23.1

B1: not used
B2: Z25
B3: Z26
B4: Z27.1
B5: not used
B6: not used

C1: not used
C2: not used
C3: Z28
C4: Z29.2
C5: Z29
C6: Z30

D1: Z31
D2: Z32
D3: Z33
D4: not used
D5: Z34
D6: Z35

E1: Z36.1
E2: Z36.2
E3: Z37.1
E4: Z37.2
E5: not used
E6: Z39

F1: not used
F2: not used
F3: Z42
F4: not used
F5: not used
F6: not used

G1: Z46.1
G2: not used
G3: not used
G4: Z47
G5: • Z48 (Cummins)
• not used (DD)
G6: • Z49 (Cummins)
• not used (DD)

H1: not used
H2: Z131
H3: not used
H4: not used
H5: Z158
H6: not used

I1: Z80
I2: Z81.1
I3: not used
I4: Z82
I5: Z84.1
I6: not used

J1: not used
J2: Z185
J3: not used
J4: Z83.1
J5: Z83.2
J6: not used

K1: Z50
K2: Z51
K3: Z52
K4: Z53
K5: Z54
K6: Z55

L1: Z56
L2: Z57
L3: Z58
L4: Z59
L5: Z60
L6: Z61

M1: Z65
M2: Z66
M3: Z96
M4: Z95
M5: Z98
M6: Z97

N1: Z152
N2: Z62
N3: Z153
N4: Z93
N5: Z94.1
N6: Z94.2

O1: Z155
O2: Z154
O3: Z156
O4: not used
O5: not used
O6: • Z43 (DD)
• not used (Cummins)

BATTERY JUNCTION BOX

The battery junction box is located in the front wall of the compartment behind the left tag wheel.

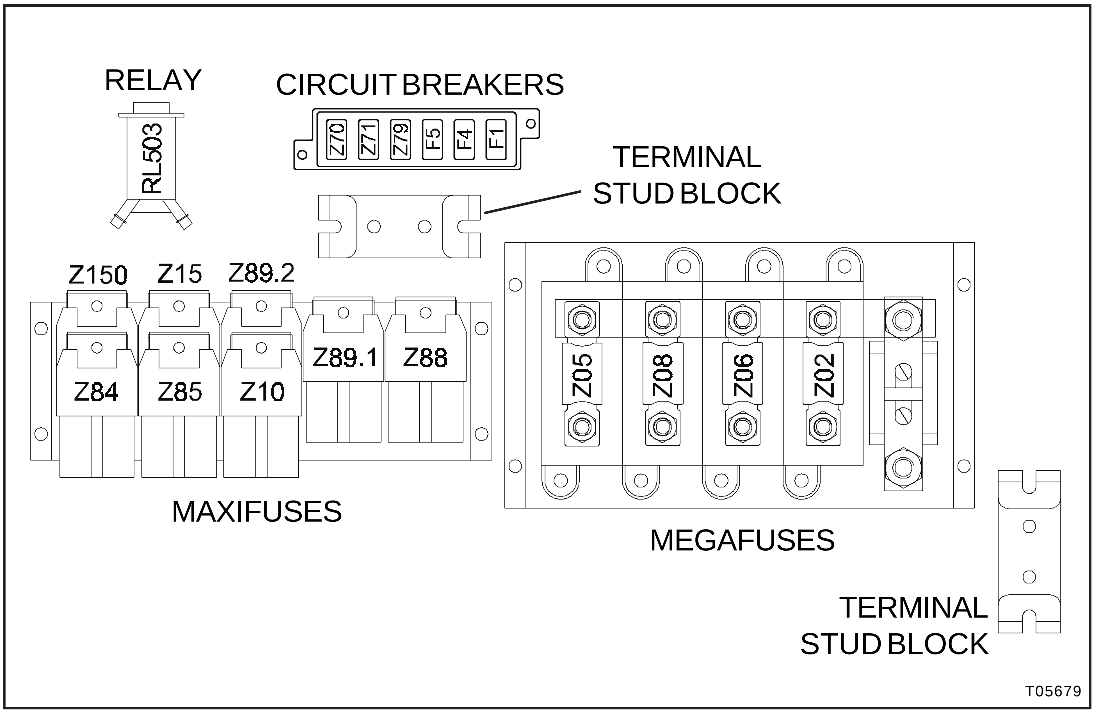

Figure 11: Battery junction box

Fuse Z10 and relay RL503: Prior to VIN 45021 (Cummins) and VIN 45521 (Detroit Diesel) located in main junction box
Fuses Z84 and Z85: From VIN 45021 (Cummins) and VIN 45521 (Detroit Diesel) onwards
Circuit breakers F1, F4, F5: only with Cummins engine

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ENGINE JUNCTION BOX

The engine junction box is located in the rear wall of the luggage compartment, in front of the right drive wheel.

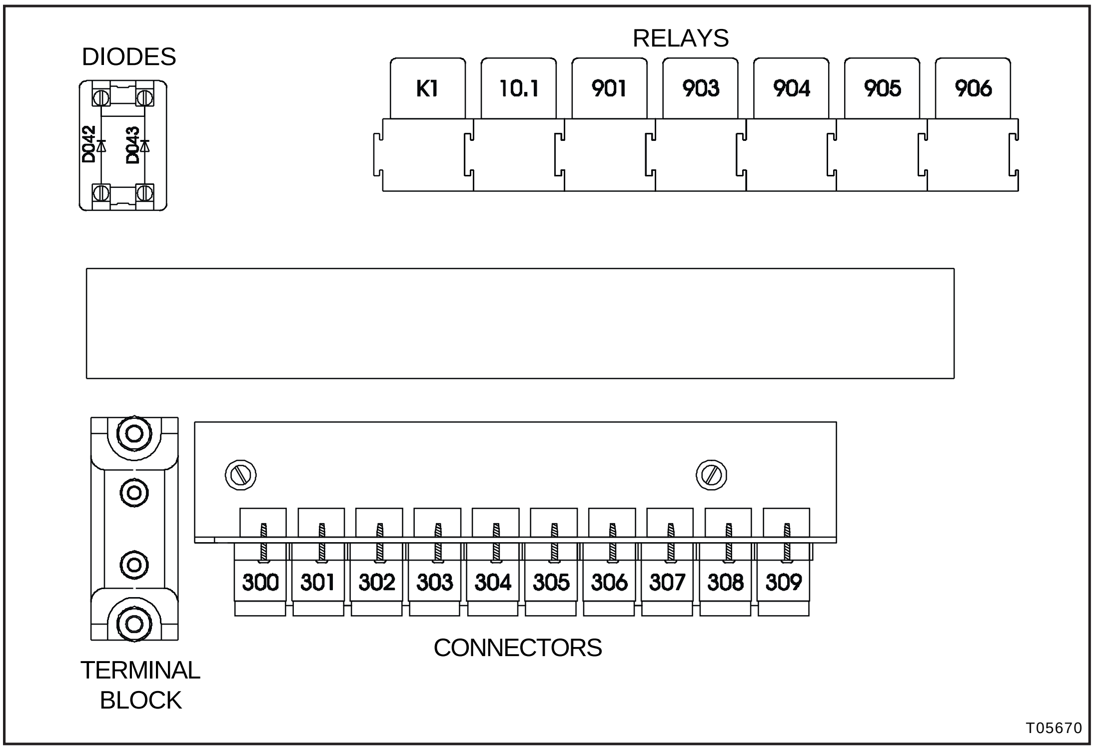

Figure 12: Engine junction box (Cummins ISM Engine)

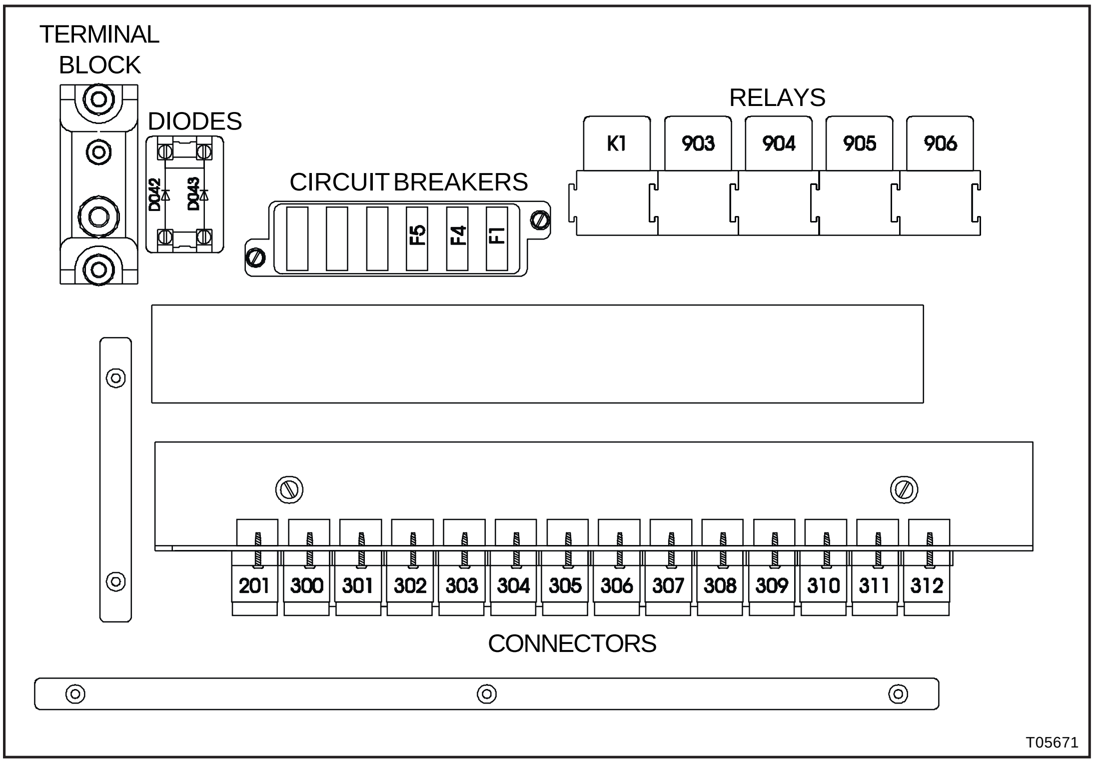

Figure 13: Engine junction box (Detroit Diesel Engine)

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HVAC JUNCTION BOX

The HVAC junction box which is mounted against the wall of the condenser compartment is accessible through the luggage compartment.

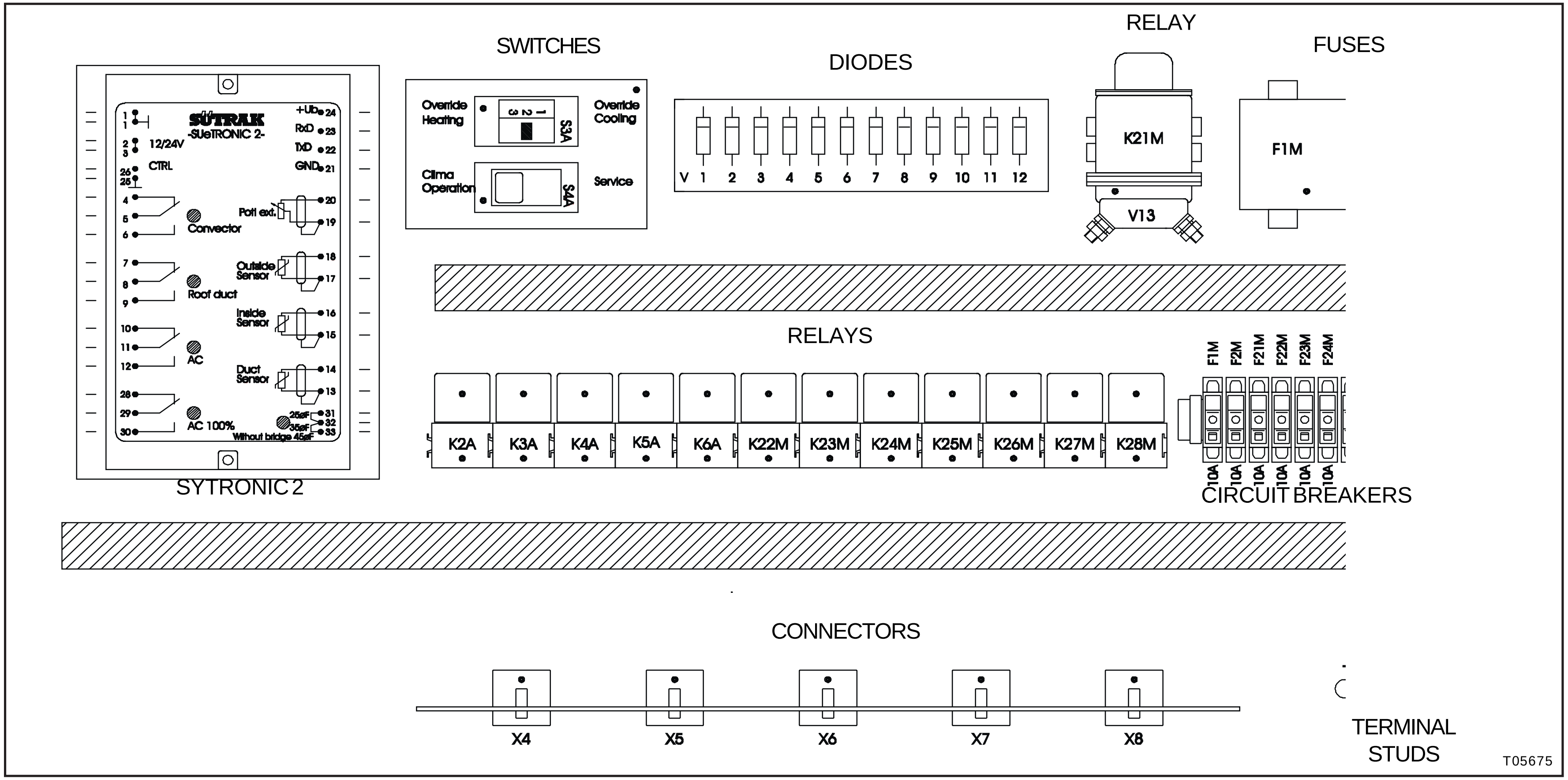

Figure 14: HVAC junction box

ROOF BLOWERS JUNCTION BOX

The roof blowers junction boxes (at LHS and RHS of the aisle) are located behind the air filter access panels in the parcel rack halfway the aisle.

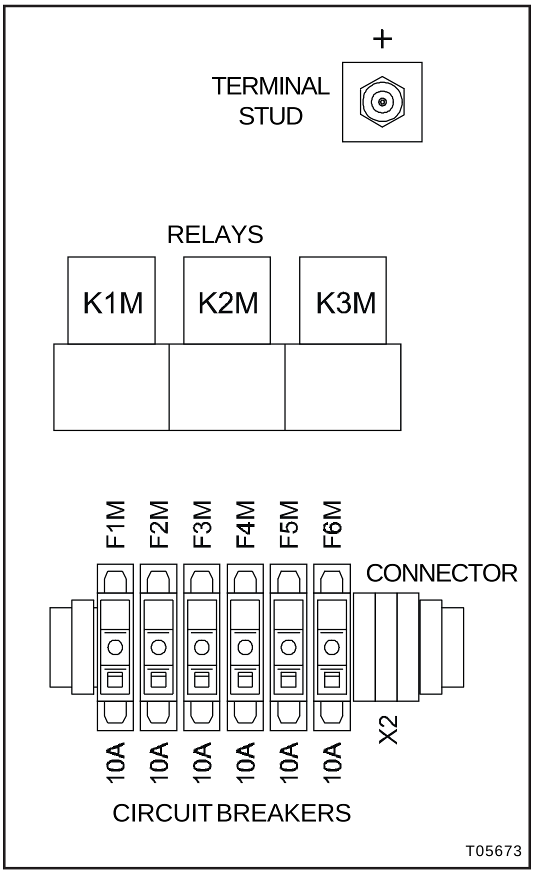

Figure 15: Roof blowers junction box

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LOCATION OF MAIN COMPONENTS ON MULTIPLEXED VEHICLES

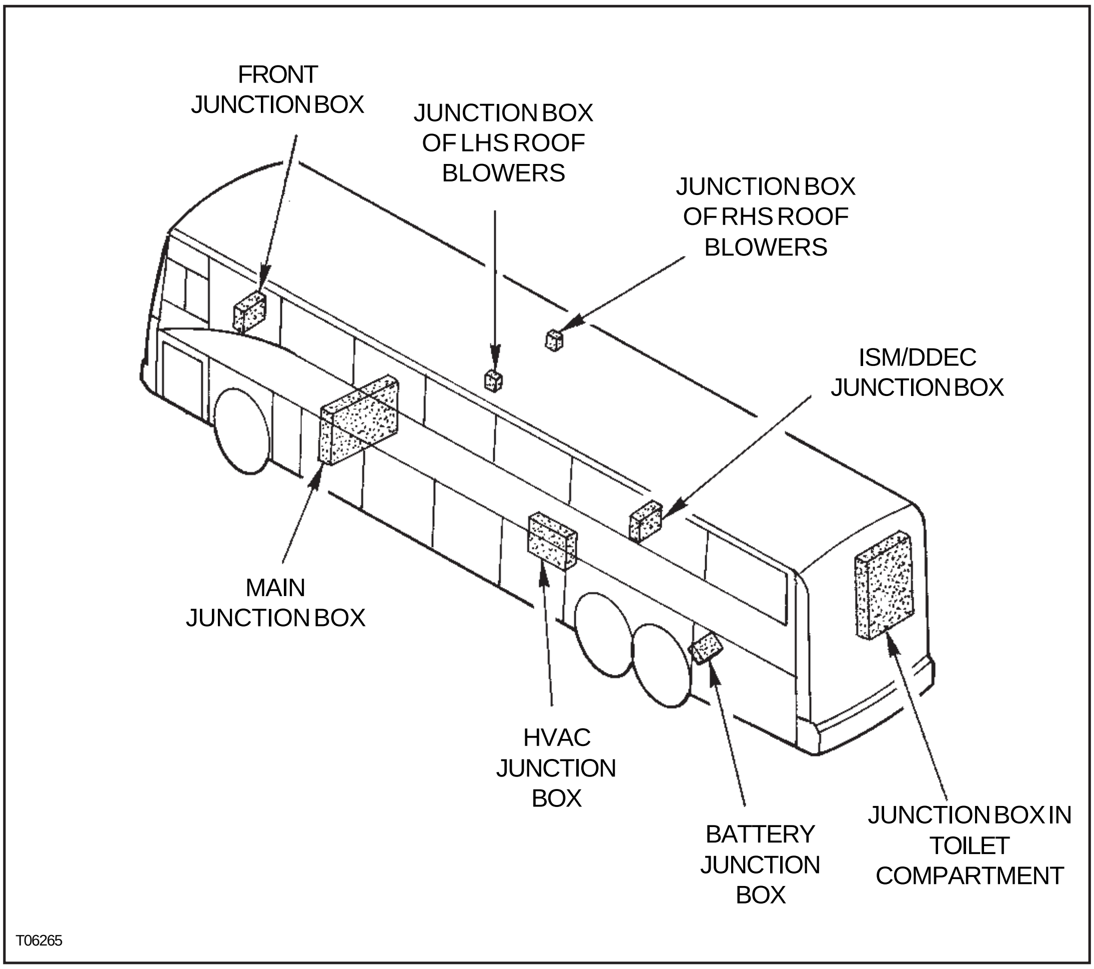

Figure 1: Location of junction boxes

The electrical system is a 24VDC system and consists of:

- Two 12VDC batteries, connected in series.
- Two alternators with internal, non-adjustable voltage regulator (second alternator only on vehicles with HVAC).
- A battery equalizer to ensure equal charge of the two batteries.
- A battery disconnect solenoid to disconnect from electrical system by means of master/ignition switch located on instrument panel.
- Eight junction boxes which house various fuses, relays and other electrical components.
- A main wire harness which is routed between the main junction box and the battery junction box.
- Other wire harnesses.

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CONTENTS OF JUNCTION BOXES

MAIN JUNCTION BOX

The main junction box is mounted against the front wall of the luggage compartment.

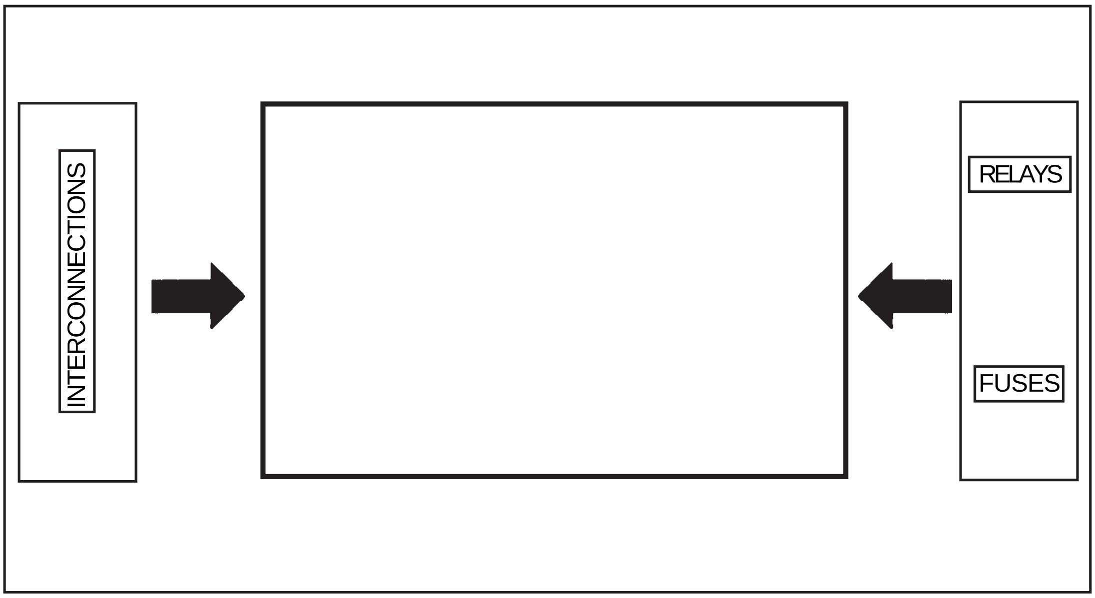

Figure 2: Main junction box sections

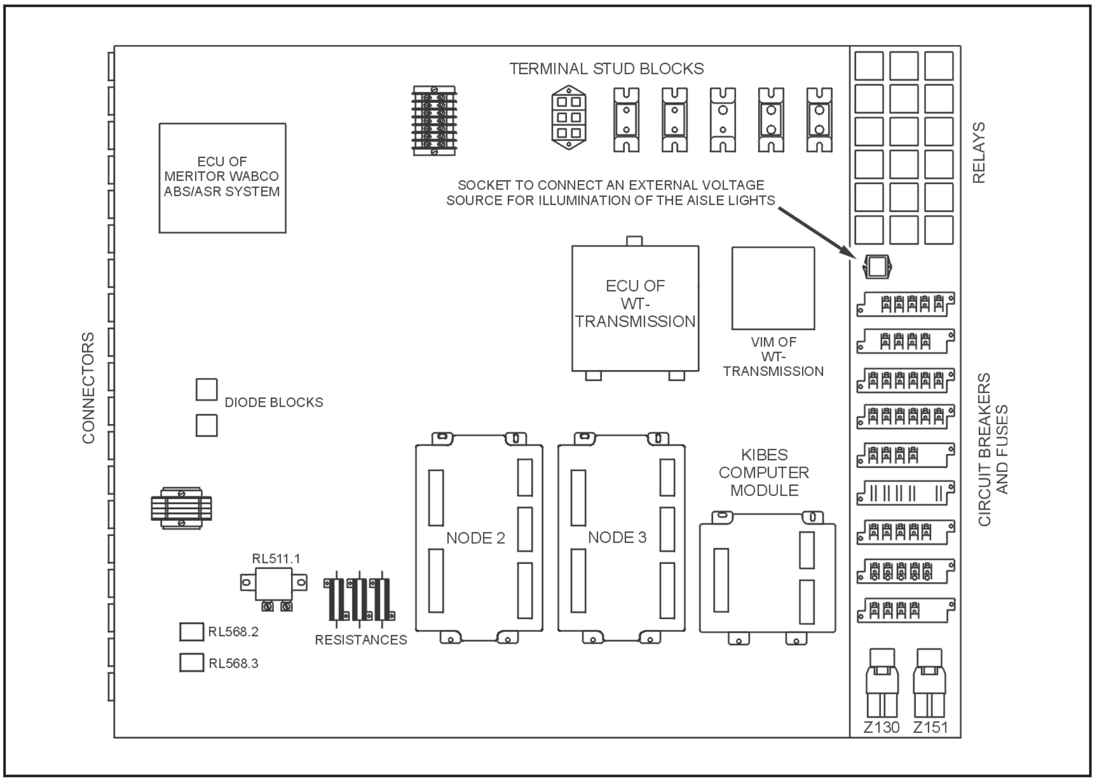

Figure 3: Main junction box

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JUNCTION BOX IN TOILET COMPARTMENT

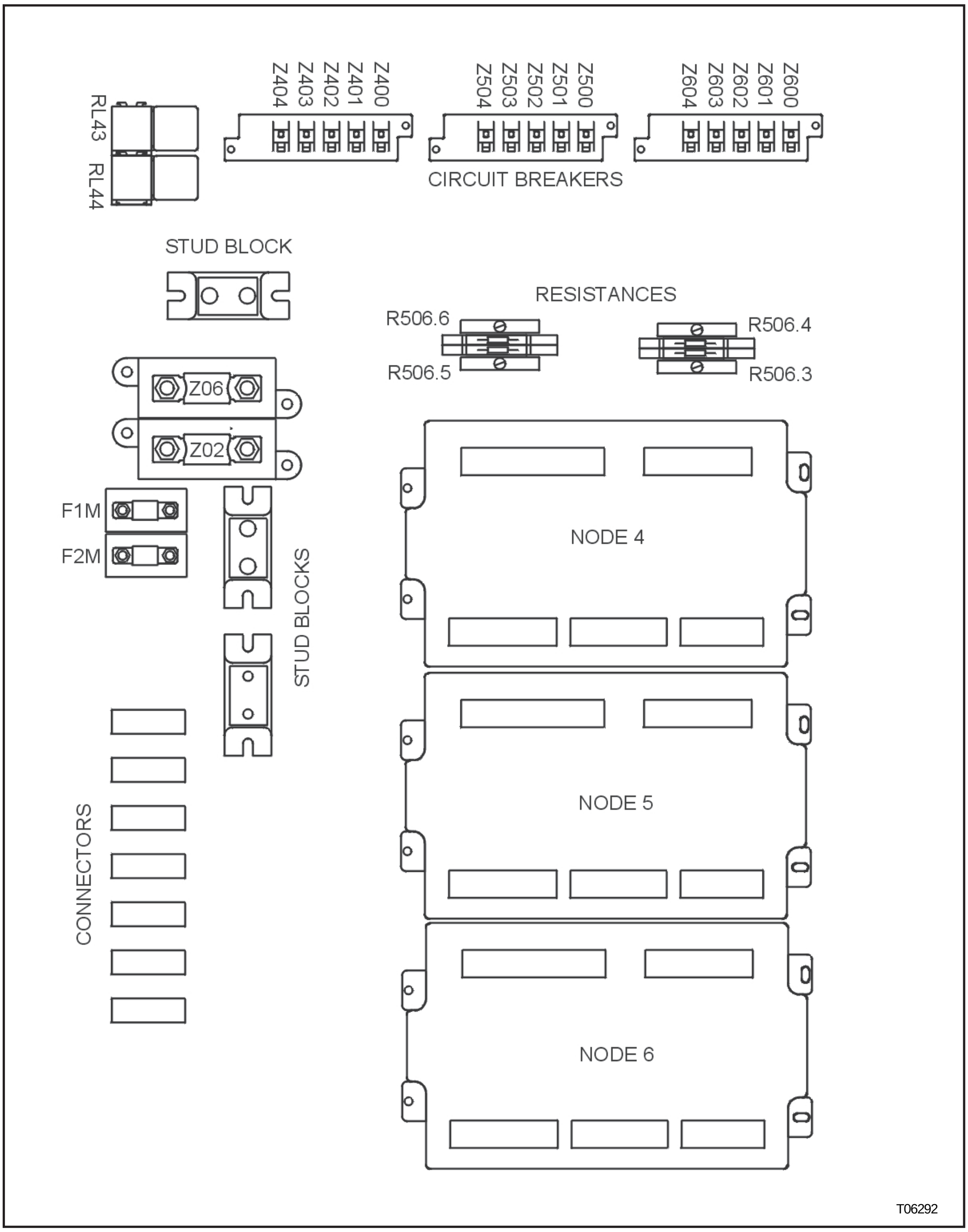

Figure 4: Junction box in toilet compartment

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FRONT JUNCTION BOX

The front junction box is located behind the dash panel at the right-hand side of entrance.

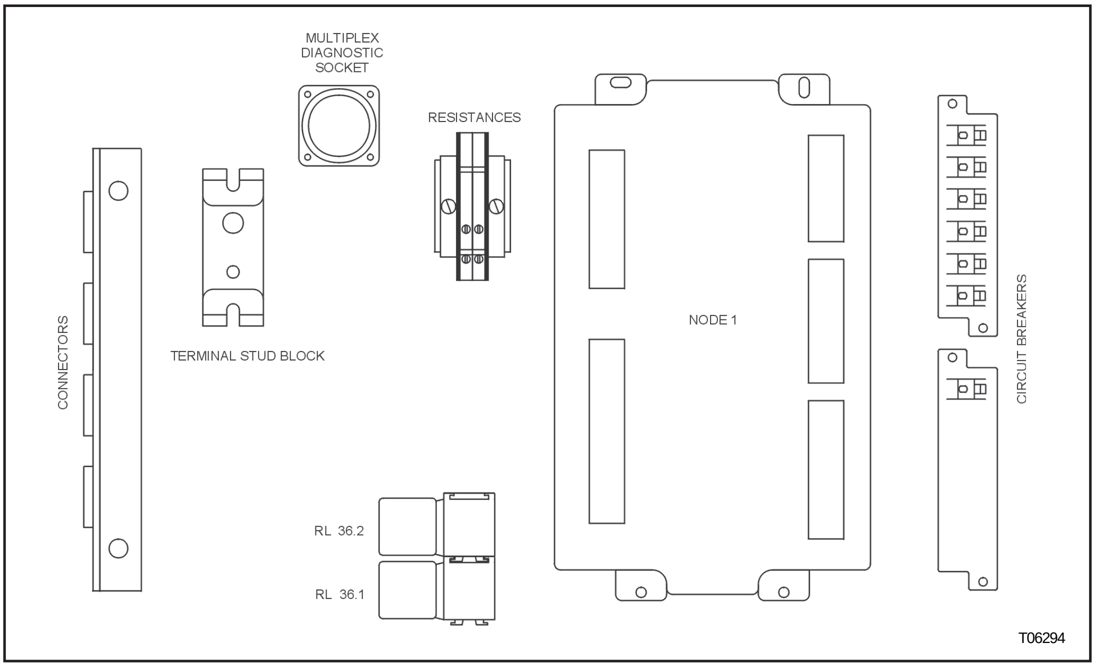

Figure 5: Front junction box

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BATTERY JUNCTION BOX

The battery junction box is located in the front wall of the compartment behind the left tag wheel.

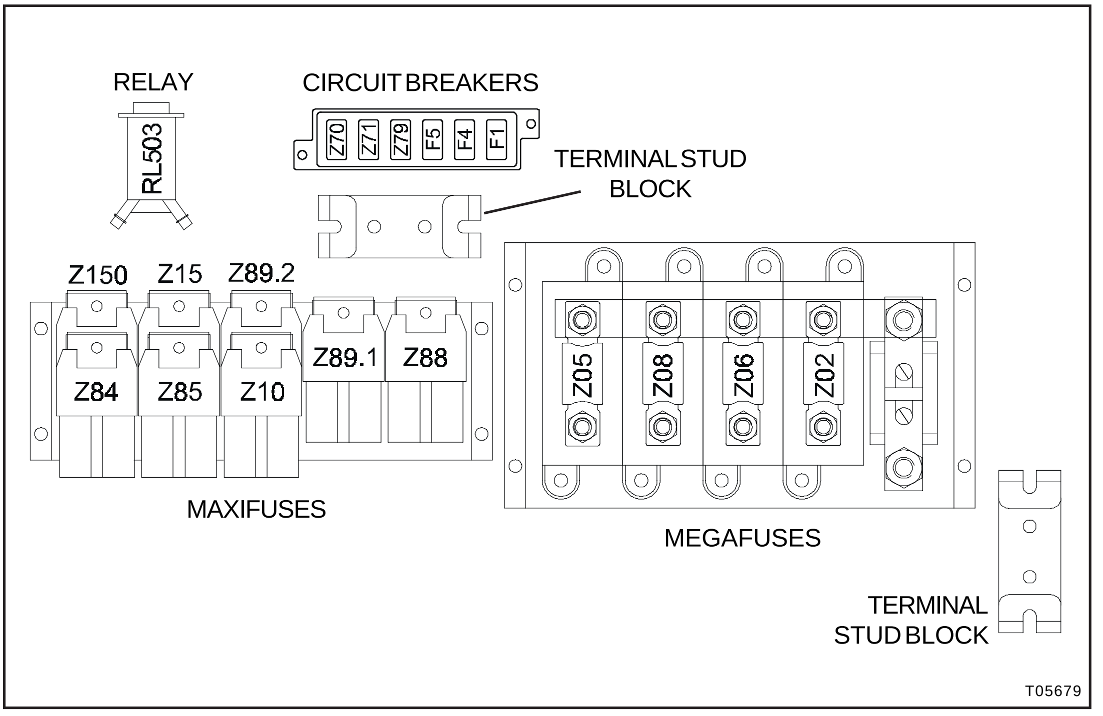

Figure 6: Battery junction box

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ENGINE JUNCTION BOX

The engine junction box is located in the rear wall of the luggage compartment, in front of the right drive wheel.

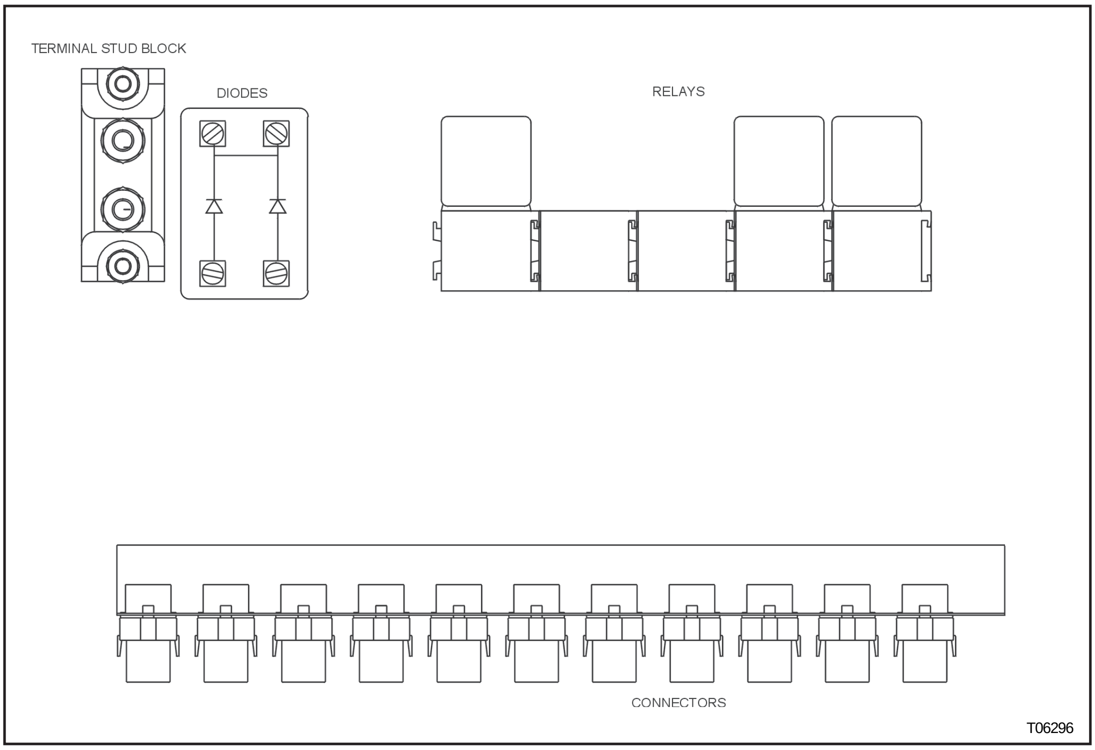

Figure 12: Engine junction box (Cummins ISM Engine)

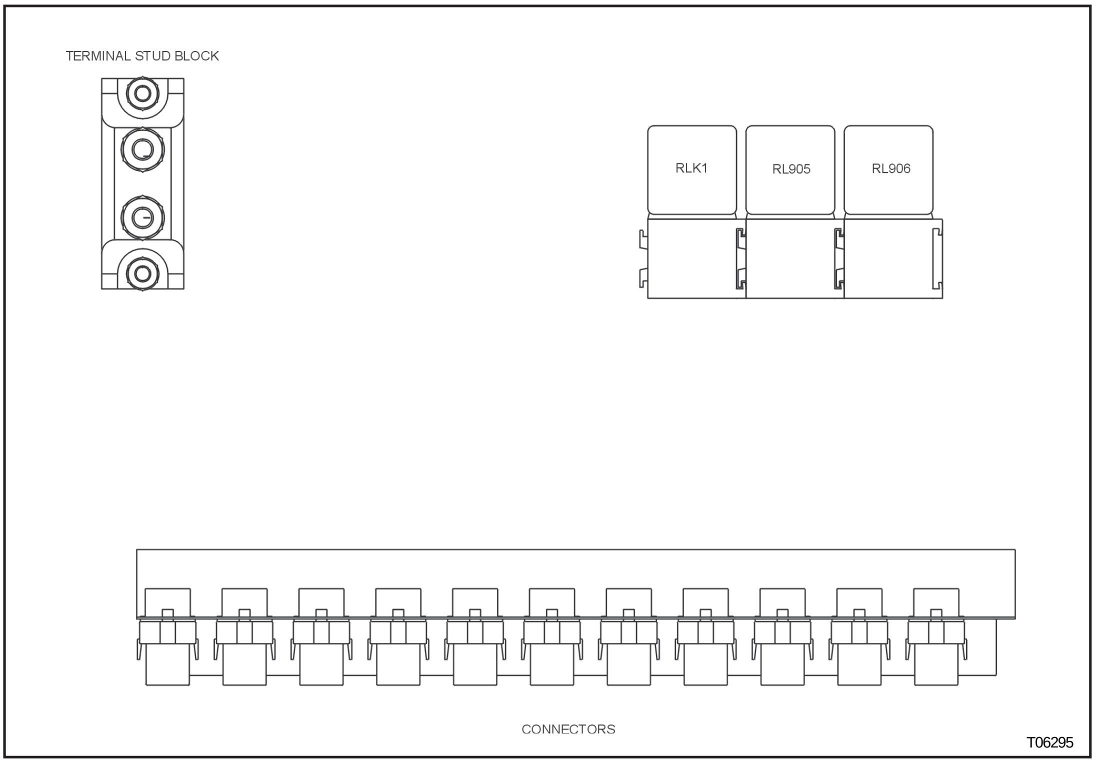

Figure 13: Engine junction box (Detroit Diesel Engine)

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HVAC JUNCTION BOX

The HVAC junction box which is mounted against the wall of the condenser compartment is accessible through the luggage compartment.

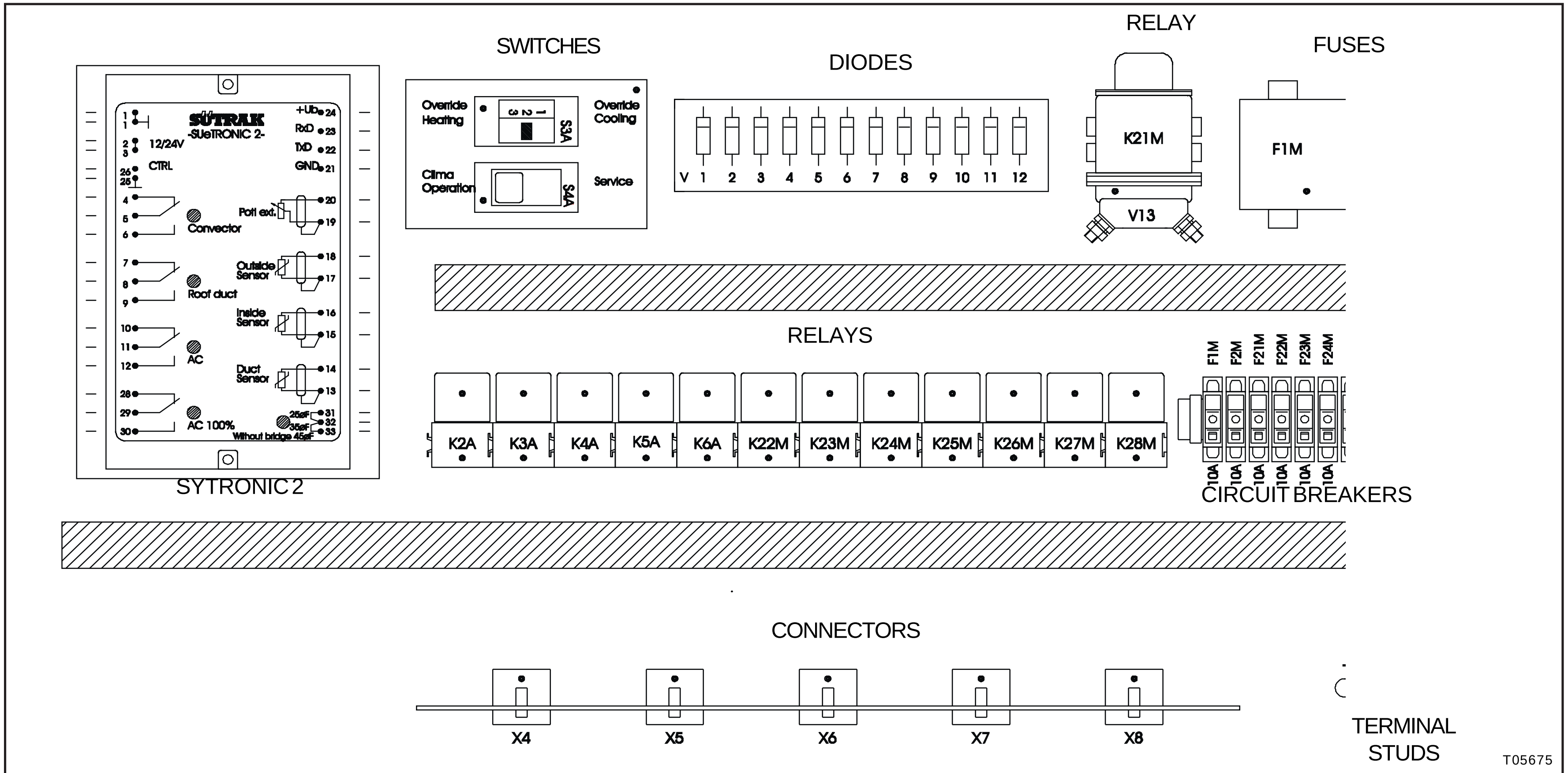

Figure 14: HVAC junction box

ROOF BLOWERS JUNCTION BOX

The roof blowers junction boxes (at LHS and RHS of the aisle) are located behind the air filter access panels in the parcel rack halfway the aisle.

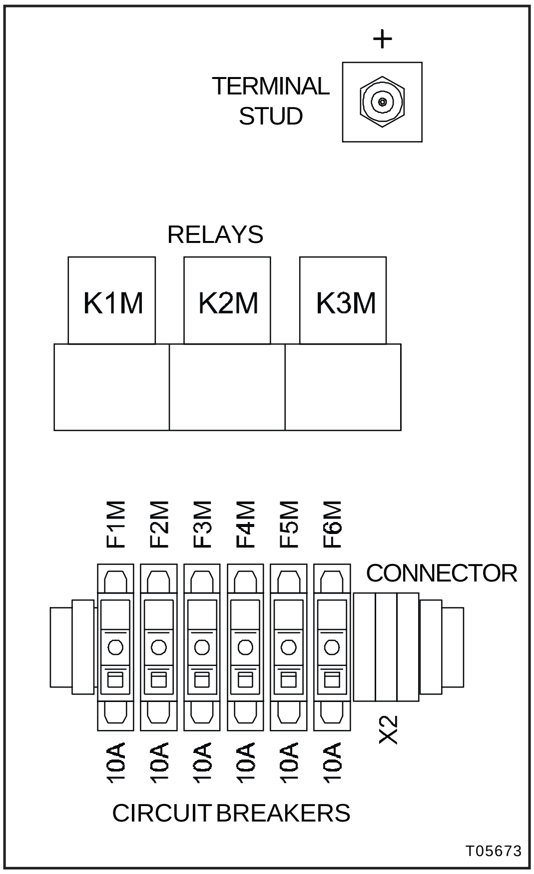

Figure 15: Roof blowers junction box

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POWER SUPPLY SYSTEM

The electrical power supply system includes:

- Two 12VDC batteries (BA1 and BA2)connected in series.
- Two alternators (AL1 and AL2) with internal non-adjustable voltage regulators.
- A battery disconnect solenoid (RL511).
- A battery equalizer (EQ).

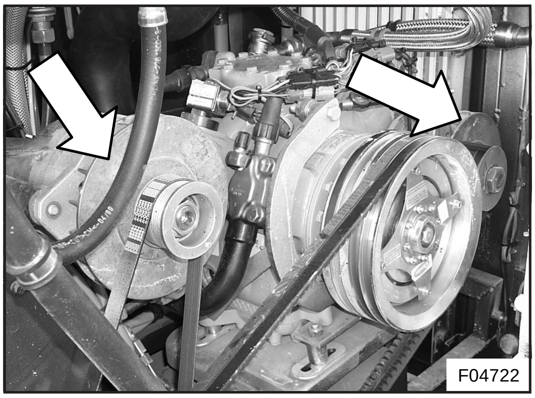

Figure 3: Location of alternators on coaches with Cummins engine (in engine compartment)

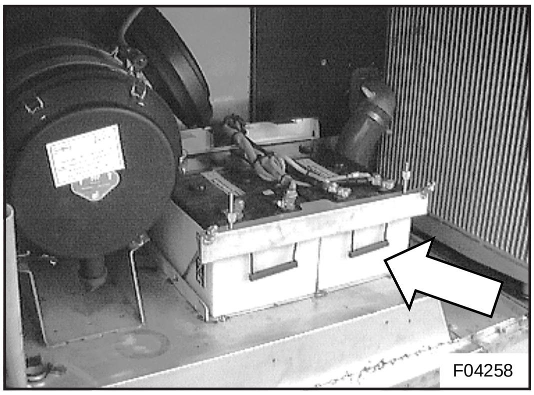

Figure 1: Batteries (behind the rear door at the left side of the coach, protective cover above alternators removed)

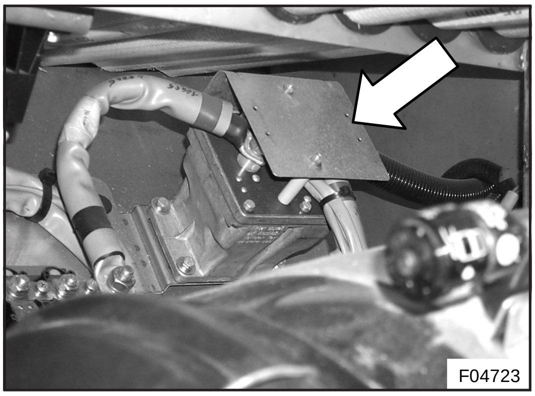

Figure 4: Battery disconnect solenoid (in battery junction box, behind the rear door at the left side of the coach)

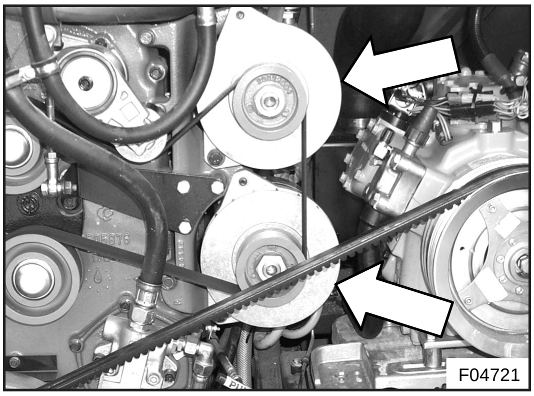

Figure 2: Location of alternators on coaches with Detroit Diesel engine (in engine compartment)

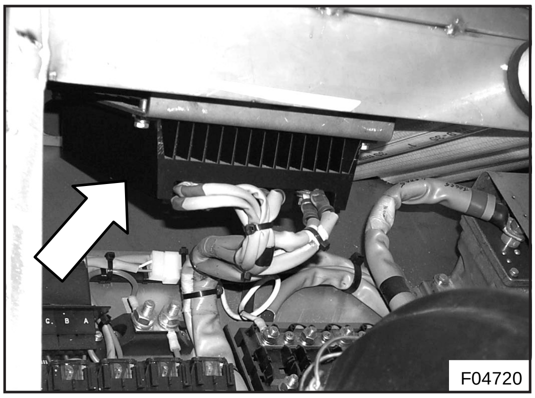

Figure 5: Battery equalizer (in battery junction box, behind the rear door at the left side of the coach,)

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By depressing the master/ignition switch (S068/S080) in the "batteries connected" position, the battery disconnect solenoid (RL511) will close. +24VDC power is provided to the B+ terminals of the alternators (AL and AL2).

When the master/ignition switch (S068/So80) is depressed in the "ignition on" position, the pre-exciter current flows from +15 through circuit breaker Z051, resistances R501(AL) and R501.2(AL2), and circuit breakers Z070 (AL2) and Z071 (AL) to the D+ terminals of the alternators. The current then goes from the regulator to the excitation winding where it is grounded.

KL510 will illuminate when alternator AL is not charging the electrical system or when the battery equalizer is not working properly. KL511 will illuminate when alternator AL2 is not charging the electrical system.

Once the engine is started, +24VDC power is generated by the D+ terminal of each alternator, thus taking away the ground for KL510 and KL511. RL049 will be energized and supplies power to various circuits.

+15 : **Power supplied with "ignition on"**
+30 : **Power supplied with "batteries connected"**
D+ : **Power supplied with engine running**
EKB : **Battery junction box**
EKV : **Main junction box**
IB : **Instrument panel**
AL : **Alternator**
AL2 : **Alternator**
BA1 : **Battery**
BA2 : **Battery**
D505.1 : **Diode**
D505.2 : **Diode**
D505.3 : **Diode**
D506 : **Diode**
EQ : **Battery equalizer**
KL510 : **Alternator No.1 warning light on instrument panel**
KL511 : **Alternator No.2 warning light on instrument panel**
R501 : **Resistance**
R501.2 : **Resistance**
RL049 : **D+ relay**
RL049.2 : **Relay**
RL 511 : **Batteries disconnect solenoid**
S068/S080 : **Master/ignition switch**
TB2 : **+ 30 stud in battery junction box**
Z051 : **Circuit breaker**
Z057 : **Circuit breaker**
Z070 : **Circuit breaker**
Z071 : **Circuit breaker**

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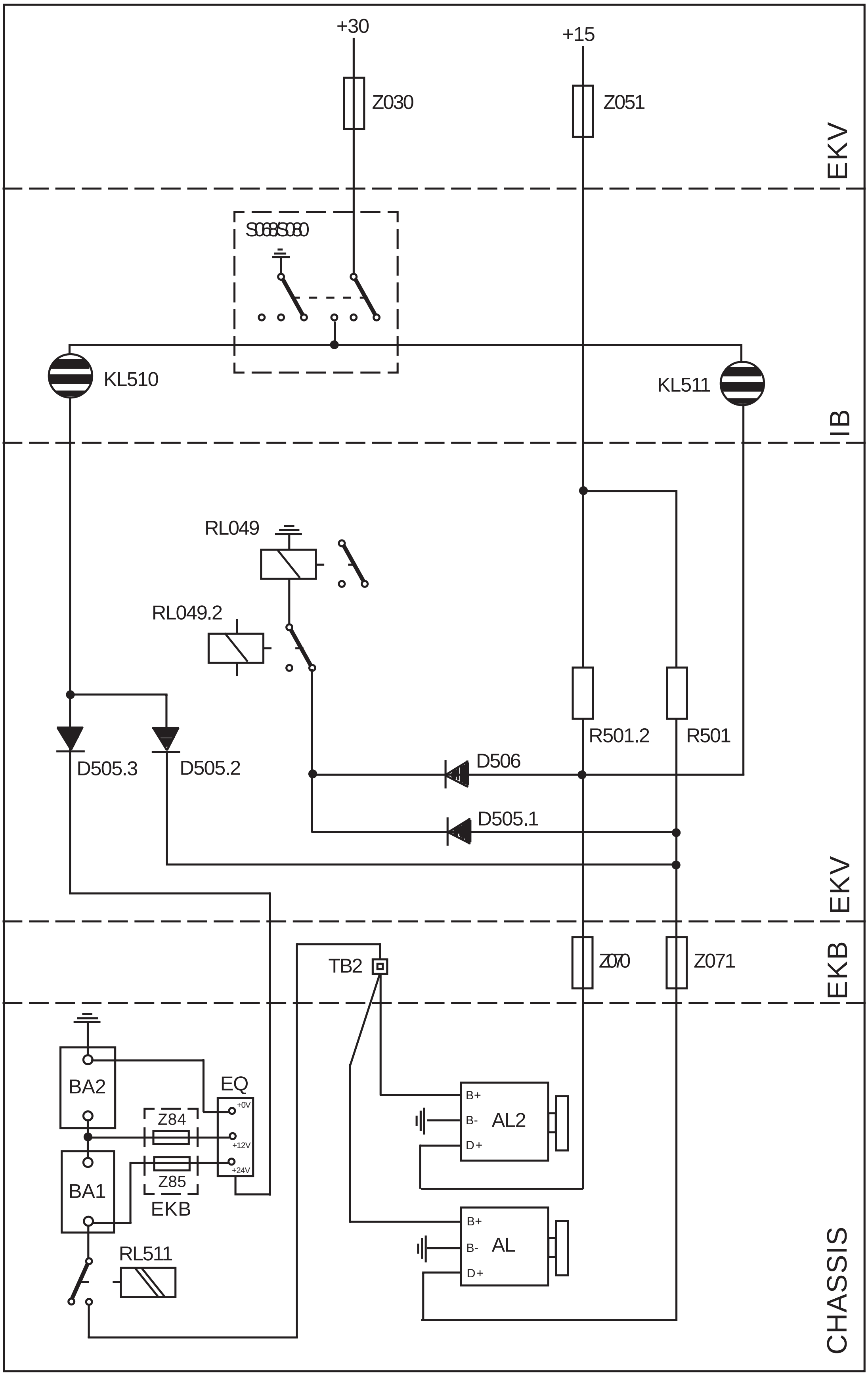

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Figure 6: Power supply electrical circuit (non-multiplexed vehicles)

BATTERIES

!!! CAUTION !!!

DO NOT SMOKE NEAR BATTERIES. BATTERIES GIVE OFF A GAS, WHICH IS FLAMMABLE AND EXPLOSIVE. AVOID PROLONGED BREATHING OF FUMES. KEEP FLAMES AND SPARKS AWAY FROM BATTERIES.

BATTERIES CONTAIN SULFURIC ACID WHICH IS HIGHLY CORROSIVE AND CAN CAUSE INJURY AND DAMAGE TO EQUIPMENT. AVOID SPILLING ELECTROLYTE.
KEEP BATTERIES IN UPRIGHT POSITION AT ALL TIMES.

TO LESSEN THE RISK OF INJURY IN CASE AN EXPLOSION DOES OCCUR, WEAR EYE PROTECTION OR SHIELD YOUR EYES, WHEN WORKING NEAR ANY BATTERY. DO NOT LEAN OVER THE BATTERIES.

IF SPLASHED INTO YOUR EYES, FLUSH EYES WITH COOL AND CLEAN WATER FOR AT LEAST 5 MINUTES. HAVE SOMEONE CALL A PHYSICIAN IMMEDIATELY.
IF SPLASHED ONTO THE SKIN, CLOTHING OR OTHER ARTICLES, NEUTRALIZE IMMEDIATELY WITH BAKING SODA AND WATER, 1/4 LB. PER QUART OF WATER.

WORK IN A WELL VENTILATED AREA.

ALWAYS WEAR RUBBER GLOVES.

IF ANY WELDING HAS TO BE DONE ON THE VEHICLE, FIRST DISCONNECT BOTH VEHICLE BATTERY CABLES.

BEFORE CONNECTING A "QUICK CHARGER" TO THE BATTERIES, DISCONNECT BOTH VEHICLE BATTERY LEADS. IF THE VEHICLE IS TO BE OPERATED WITHOUT BATTERIES, REMOVE ALTERNATOR DRIVE BELT(S) BEFORE STARTING THE ENGINE.

CHECK POLARITY OF THE CABLES AT THE BATTERIES BEFORE CONNECTING UP THE BATTERIES. CROSSED POLARITIES WILL INSTANTLY DESTROY THE RECTIFIER ZENER DIODES.

DO NOT GROUND A CONNECTION TO CHECK CURRENT FLOW.

WHEN REMOVING OR INSTALLING BATTERY CABLES, ALWAYS REMOVE GROUND CABLE FIRST AND REPLACE GROUND CABLE LAST TO AVOID DAMAGE TO BATTERY EQUALIZER.

NEVER CONNECT OR DISCONNECT BATTERY CABLES, JUMPER CABLES AND BATTERY CHARGES WITHOUT FIRST MAKING SURE THE ELECTRICAL LOADS HAVE BEEN TURNED OFF.

Access to the batteries is provided by the rear door at the left side of the coach.

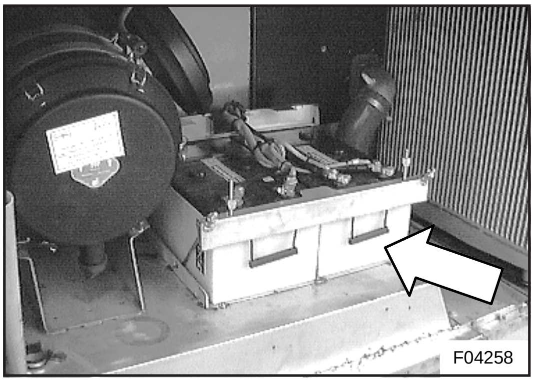

Figure 7: Batteries

PURPOSE

The main fuction is to provide energy required to start the engine.

SPECIFICATIONS

MAKE .... PRESTOLITE

AMP.HR. 200AH

COLD CRANKING
AMPERES .... 630 AMP (DIN)
730 AMP (IEC)

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Cold cranking amperes

The cold cranking Amp. rating is the load in Amperes that a battery can withstand for 30 seconds at 0°F and not fall below 7.2 VDC or 1.2 VDC per cell.

Amp. hours (reserve capacity rating)

The Amp. hour rating is the time it takes for a fully charged battery to withstand a 25 Amp. load at 80°F until battery voltage drops to
10.5 VDC or 1.75 VDC per cell. It indicates the amount of power the battery can provide to the electrical system in case of an alternator failure.

MAINTENANCE

To check battery fluid level

!!! CAUTION !!!
BATTERIES CONTAIN SULFURIC ACID, WHICH IS HIGHLY CORROSIVE AND MAY CAUSE INJURY AND DAMAGE TO EQUIPMENT.

The level should reach the bottom of the vent cap opening. Only use distilled water.

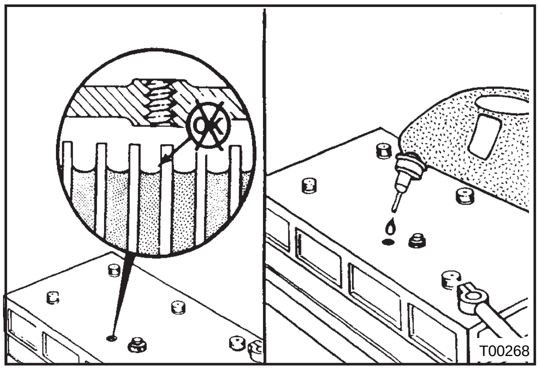

Figure 8: To check battery fluid level

To check battery cables

!!! CAUTION !!!
WHEN REMOVING OR INSTALLING BATTERY CABLES, ALWAYS REMOVE THE GROUND CABLE FIRST AND RECONNECT THE GROUND CABLE LAST TO AVOID DANGEROUS SHORT CIRCUITS.

Check to make sure the cable connections are in good condition, tight and free of corrosion.

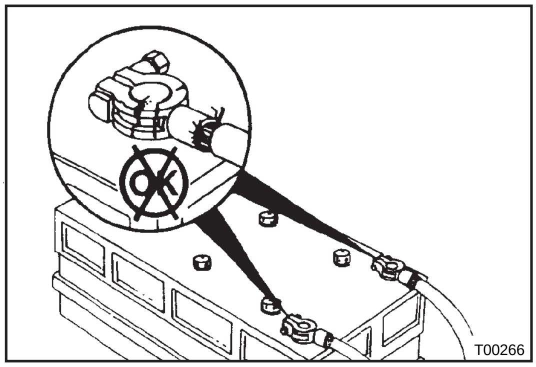

Figure 9: To check battery cables

To check battery exterior

Make sure battery exterior is clean and free from corrosion. Use baking soda to neutralize any acid.

To check battery tray

The batteries are secured in a pull-out tray. Check battery tray for corrosion. Clean by neutralizing first with baking soda, then scrub with a stiff bristle brush. Wire brush and paint, if necessary. Lubricate slide rail.

TO TEST BATTERY

To test state of charge with hydrometer

The hydrometer is used to measure specific gravity of the electrolyte. Since

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Specific Gravity	Charge %	Freezing Point
1.260	100%	-70°F
1.230	75%	-16°F
1.200	50%	0°F
1.100	0%	19°F

the electrolyte is made up of water and acid, the higher the water content, the lower the specific gravity reading becomes.

Take a reading from each cell and note the number. Make sure that all electrolyte is clear form the hydrometer before going on to the next cell.

The temperature will greatly affect the results of the specific gravity test results. If the temperature of the electrolyte is above 80°F, add 0.004 for every 10°F and if below 80°F, subtract 0.004 from the results. If a difference of 0.05 specific gravity is found between the cells, replace the battery.

To test state of charge with voltmeter

This is basically a quick test which can be used to test state of charge. It can only be done if batteries are at rest, not being charged or discharged. If a system has just been operating, a surface charge may be present and

Voltmeter Reading	Charge %
12.66 VDC	100 %
12.48 VDC	75 %
12.30 VDC	50 %
11.76 VDC	0 %

the batteries should be allowed to rest for at least one hour. Connect digital Voltmeter to the 12 VDC battery posts. Positive to positive and negative to negative.

To test battery performance

Since the primary purpose of the coach batteries is to supply cranking power for the engine, a cold cranking performance battery test is the most meaningful test to determine the condition of the batteries. It is based on the requirement that a 12V battery be able to maintain 7.2V for a 20 second period while turning over an engine at 0°F.

The following procedure will be useful in determining the condition of the batteries while they are installed in the coach. The batteries are assumed to be in satisfactory condition if the test readings agree with those in the table following the procedure.

To test the batteries, follow this procedure:

1. Prepare engine shutoff fuel system so that the engine can be turned over by the starter, but in a way it does not start.
2. Connect digital voltmeter to one of the 12VDC batteries.
3. Turn the engine over for 15 seconds and record the voltmeter at the end of the 15 second test period. Refer to the table below for voltage readings to determine the relative condition of the batteries.
4. Perform steps 1-3 for the other 12VDC battery.

Defective battery condition is indicated if the voltage reading after 15 seconds

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Temperature	Minimum test voltage
70°F	9.6
60°F	9.4
50°F	9.3
40°F	9.1
30°F	8.7
20°F	8.2
10°F	7.9
0°F	7.2

of engine cranking is less than the minimum test voltage for the appropriate ambient temperature. The above procedure requires fully charged batteries, with cells filled to capacity with electrolyte of correct specific gravity.

JUMP STARTING

The instructions below must be followed, otherwise personal injury or damage to property may result.

!!! CAUTION !!!

THIS COACH HAS TWO 12 VOLT BATTERIES CONNECTED IN SERIES TO PROVIDE POWER TO THE NEGATIVE GROUND ELECTRICAL SYSTEM. MAKE SURE THE OTHER VEHICLE ALSO HAS A NEGATIVE GROUND ELECTRICAL SYSTEM OF SUFFICIENT CAPACITY TO START THE OTHER VEHICLE. IF NOT SURE OF THE OTHER VEHICLE VOLTAGE (OR IF THE VOLTAGE AND/OR GROUND ON THE OTHER VEHICLE ARE DIFFERENT FROM YOUR COACH), DO NOT TRY TO JUMP START, BECAUSE THIS MAY RESULT IN PERSONAL INJURY OR SEVERE DAMAGE TO ELECTRIC AND ELECTRONIC COMPONENTS.

CHECK BATTERY FLUID LEVEL. (DO NOT CHECK WITH AN OPEN FLAME AND DO NOT SMOKE). ADD CLEAN OR DISTILLED WATER BEFORE JUMP STARTING. DO NOT ALLOW BATTERY FLUID TO CONTACT EYES, SKIN, FABRIC, OR PAINTED SURFACES BECAUSE BATTERY FLUID IS A CORROSIVE ACID. FLUSH ANY CONTACTED AREA IMMEDIATELY AND THOROUGHLY WITH WATER. IN CASE THE EYES ARE AFFECTED, CALL AN OCULIST OR A PHYSICIAN.

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To connect booster battery cables

1. First:
   - apply the parking brake;
   - place the transmission in neutral;
   - turn off the engine;
   - turn off the ignition;
   - switch off the master switch;
   - turn off all electrical accessories.

   Make sure that these conditions are met on both vehicles when you jump start with another vehicle.

2. Disconnect the wires from the GND (ground) terminal of the battery equalizer. Do not allow this cable to touch any other connection on the equalizer because the other terminals are connected to the batteries.

3. Connect the first jumper cable from the positive terminal on the charged battery (identified by a red collar, "+" or "P" on the post or clamp) to terminal (1, Figure 10). To connect

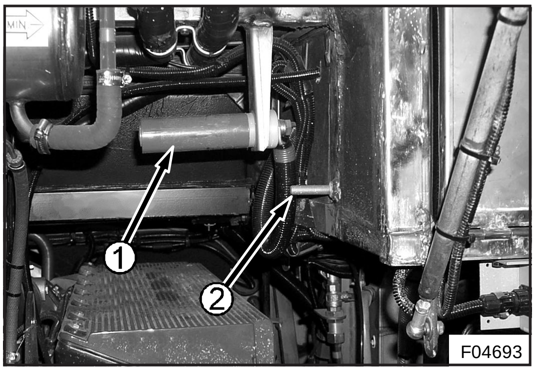

Figure 10: To check battery fluid level

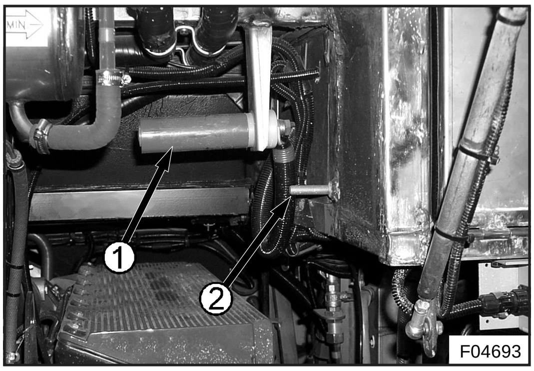

Figure 10: To check battery fluid level

the cable to terminal (1, Figure 10), first pull the spring-loaded protective cover back. Never connect the positive terminal to the ground stud (2, Figure 10) or the negative terminal to the positive one.

4. Connect one end of the second cable to the grounded negative ("-", black, blue or "N") terminal of the charged battery. Connect the other end to the ground stud (2, Figure 10) for jump starting on the vehicle being started. *Do not connect directly to the negative post of the discharged battery*.
   Do not connect it with or attach it near pulleys, fans, or other parts that will move when the engine is started.

5. Start the engine of the vehicle with the discharged batteries.

6. Let the engine idle for a few minutes so that the voltage of the batteries can equal. This will reduce the formation of sparks when disconnecting the jumper cables.

To disconnect the booster battery cables

1. Take care that the clamps from one jumper cable do not inadvertently touch the clamps on the other jumper cable, disconnect the jumper lead from the ground stud (2, Figure 10) on the vehicle being started.

2. Remove the remaining end of the negative jumper cable from the booster battery.

3. Remove one end of the remaining jumper cable from the positive (red) terminal (1, Figure 10) on the discharged battery, then remove the other end of the same cable from the positive terminal of the booster battery.

4. Reconnect wires onto the GND (ground) terminal of the battery equalizer.

NOTE
Always check the battery equalizer circuit breaker after jump starting the vehicle.

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ALTERNATORS

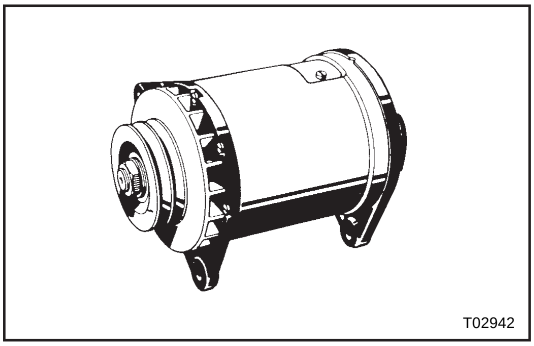

Figure 11: Alternator

PURPOSE

The alternator provides current for operation of all electrical systems on the coach. After the battery supplies the initial starting power, the alternator generates current to recharge the battery and to power the systems. An alternator is used instead of a generator, because it is capable of supplying current at any engine speed from idle to full speed.

OPERATION

Alternators convert magnetic power into electrical power through a principle known as "EMF" or "Electro Motive Force". EMF is based on the principle that when an electric conductor passes through a magnetic field, an electric current is "induced" in the wire.

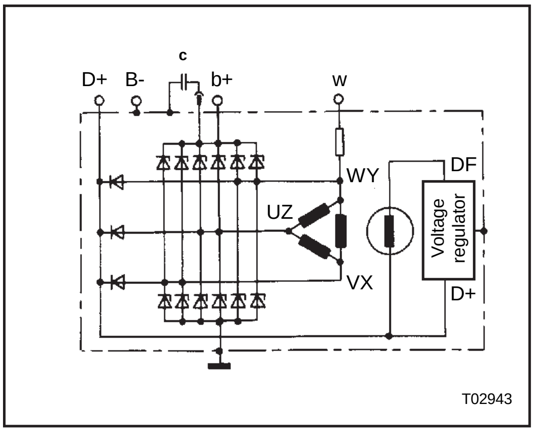

Figure 12: Alternator circuit

The conductor is the stator because it is stationary. The magnet is the "rotor" (also an "armature") because it rotates. The rotor is made to turn with a drive belt connected to the engine.

By adding additional stator conductors and by winding these conductors into coils, a higher Amperage of induced current can be created. In a three-winding alternator, each winding is 120 degrees out of phase with the two other windings. This creates a continuous alternating current (AC). The alternating current (AC) is then converted to direct current (DC) by rectifier zener diodes arranged into a three-phase bridge circuit with stator windings.

At start-up, the alternator draws initial current from the battery through the alternator warning lamp. When the ignition is switched on, pre-exciter current flows through the alternator warning lamp to terminal D+ of the alternator.

MAINTENANCE

1. The exterior of the alternator should be kept clean.
2. Check mounting bolts for security.
3. All electrical connections must make firm, clean contact.
4. Inspect drive belts. Refer to Chapter 3.

ALTERNATOR LOAD TEST

Since both the alternators are connected in parallel into the system, a weak or defective alternator can sometimes be difficult to determine unless each alternator is tested in the system individually. This can be

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accomplished by removing the alternator belt and running one alternator at the time (if posssible).

!!! CAUTION !!!
NEVER REMOVE BATTERY CABLES WITH THE ENGINE RUNNING. THIS CAN LEAD TO SEVERE ALTERNATOR DAMAGE.

Before making the following load test, make certain that 24 VDC and ground cable connections are in good condition. The batteries must be in good condition and fully charged. Ambient air temperature should be between 65° and 85°F.

1. Connect an accurate voltmeter to the batteries.
2. Start engine and run above 1,000 rpm.
3. Load the system by turning on lights, fans, climate control etc. If ammeter is available, load the system to 100 to 120 Amps.
4. Voltage should be between 27.4 and 28.4 VDC. If the engine is hot, the voltage may be 0.5 Volts lower.
5. Before removing a suspected alternator, replace voltage regulator by a new one.

VOLTAGE REGULATOR

Purpose

The voltage regulator is mounted at the rear of the alternator and is used to maintain a constant voltage regardless of alternator rotor speed or system load demands, when the engine is above idle speed. The regulator is non-adjustable and non-repairable.

Maintenance

Check the wear of the carbon brushes at the intervals given in the Maintenance Schedule.

Procedure:

1. Remove nuts (1, Figure 13) retaining cover (2, Figure 13) to the alternator. Pull cover back.
2. Remove screws (3, Figure 13) retaining the voltage regulator (4, Figure 13) to the rear bearing shield. Take off the voltage regulator.
3. Measure the length of the carbon brushes.

Replace regulator assembly at the latest when brushes (1, Figure 14) are

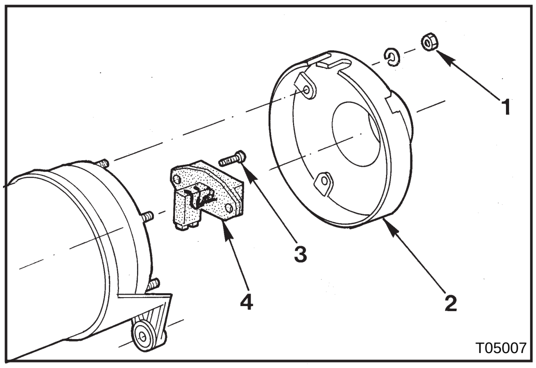

Figure 13: To remove voltage regulator

1. Nut **3. Screw**
2. Cover **4. Voltage regulator**

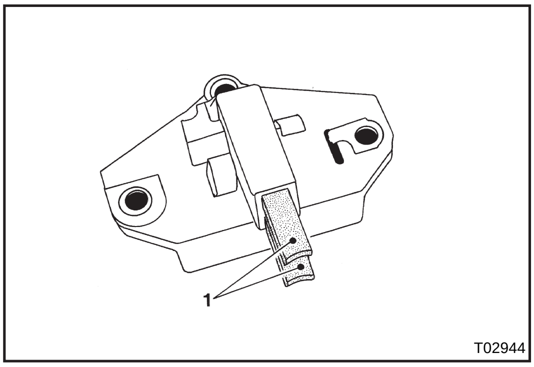

Figure 14: Voltage regulator of alternator

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worn below a length of 0.28 inch. Replace the regulator also if a brush is broken. To minimize the risk of a failure during operation, it is recommended to overhaul the alternator when you have to replace the brushes for the second time.

PRECAUTIONS WHEN INSTALLING A NEW OR EXCHANGE ALTERNATOR

The distance between the front and rear pivoting arm of the alternator is not always equal on alternators of the same model. A sliding bush (3, Figure 1) should compensate this difference. The sliding bush can be fitted in one of the pivoting arm eyes or in the alternator support (depends on the alternator mounting on your vehicle).

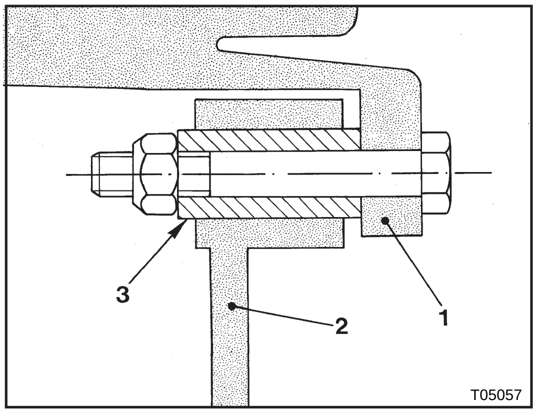

Figure 15: Example of rear alternator mounting

1. Alternator (detail of pivoting arm)
2. Alternator support
3. Sliding bush

!!!CAUTION!!!
BEFORE INSTALLING AN ALTERNATOR, CHECK SLIDING BUSH FOR EASY SLIDING SO THAT IT CAN MOVE WHEN YOU TIGHTEN THE PIVOTING BOLT. FREE THE BUSH IF IT IS STUCK. OTHERWISE THE PIVOTING ARMS ARE STRAINED AND CAN BREAK.

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BATTERY DISCONNECT SOLENOID

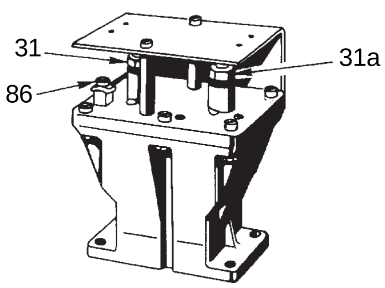

Figure 16: Battery disconnect solenoid (in battery junction box

PURPOSE

Used to disconnect batteries from electrical system by means of the master switch on the dashboard.

OPERATION - Figure 17

By depressing the master/ignition switch (S068/S080) to the "batteries connected" position, a ground is supplied to the coil of the battery disconnect solenoid. The solenoid will activate since the other side of the coil has a constant battery voltage from circuit breaker Z080 supplied to it.

The solenoid consists of a two-stage coil. When the solenoid is activated, both the "pull in" coil and the "hold in" coil are energized and the main battery contacts are pulled together, after which the "pull in" coil is de-energized by means of a small set of contacts opened toward the end of the throw. Now just the "hold in" coil remains energized to hold contacts together, reducing current draw of the solenoid.

Relay RL511.2 is supplied to hold the battery disconnect solenoid engaged while the engine is running. The coil of relay RL049 is energized by the D+ terminal of either alternator, after the engine is running. Relay RL049 then connects +30 to battery disconnect relay RL511.2 until the engine is turned off. This eliminates severe damage to the alternator. A master switch indicator light (KL523) is provided to let the driver know that the master/ignition switch (S068/S080) is in the "batteries connected" position. The light only illuminates when the engine is off.

+15 : Power supplied with "ignition on"
+30 : Power supplied with "batteries connected"
B+ : Power supplied directly from battery
EKV : Main junction box
EKB : Battery junction box
IB : Instrument panel
AL : Alternator
AL2 : Alternator
BA1 : Battery
BA2 : Battery
D505.1 : Diode
D506 : Diode
KL523 : Master switch indicator light
R501 : Resistance
R501.2 : Resistance
RL049 : D+ relay
RL049.2 : Relay
RL511 : Batteries disconnect solenoid
RL511.2 : Batteries disconnect relay
S068/S080 : Master/ignition switch
TB2 : + 30 stud in battery junction box
Z020 : Circuit breaker
Z051 : Circuit breaker
Z080 : Circuit breaker
Z070 : Circuit breaker
Z071 : Circuit breaker

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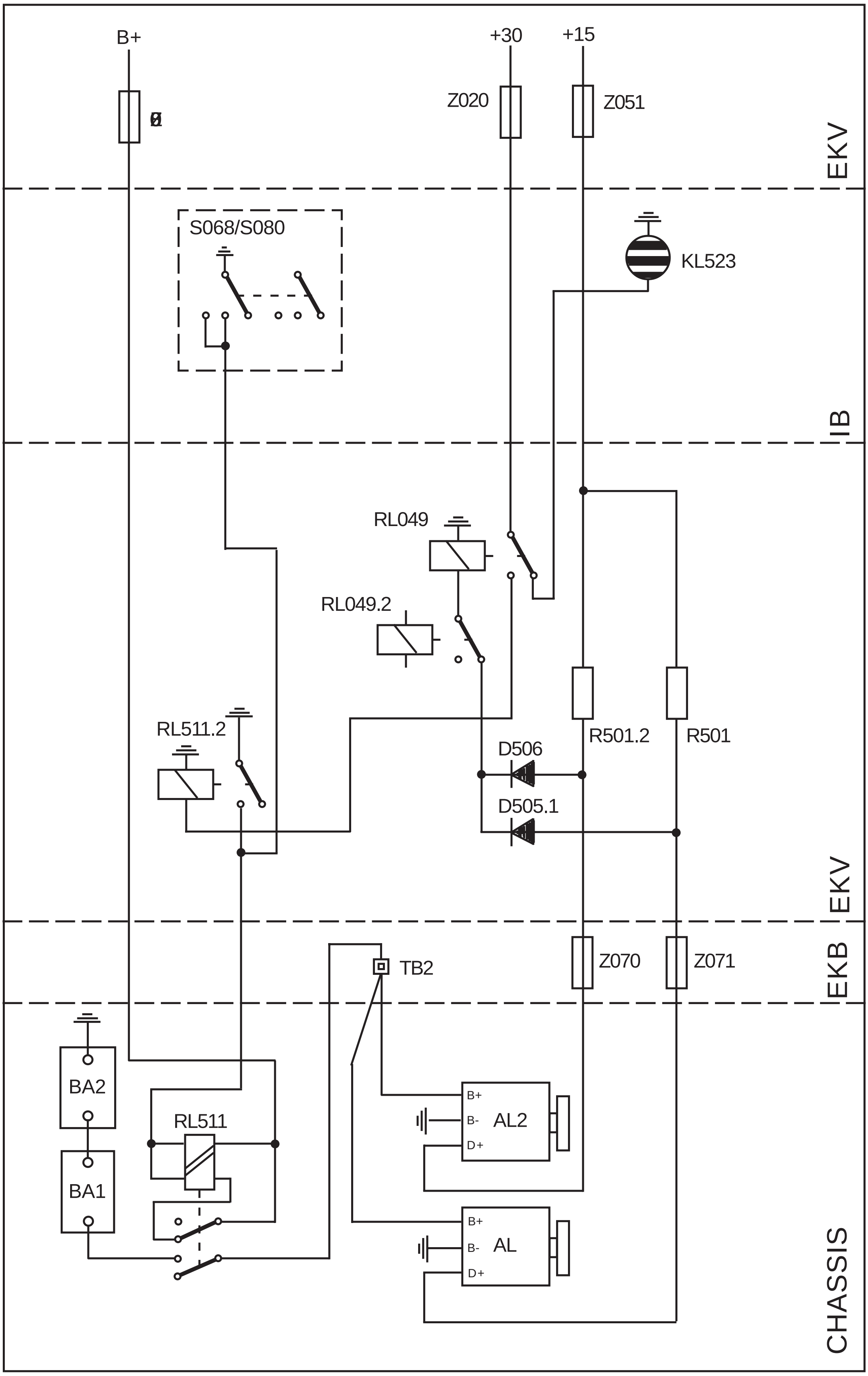

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Figure 17: Battery disconnect solenoid circuit (non-multiplexed vehicles)

BATTERY EQUALIZER

PURPOSE

Keeps batteries in equal state of charge, regardless of the 12 VDC or the 24 VDC loads.

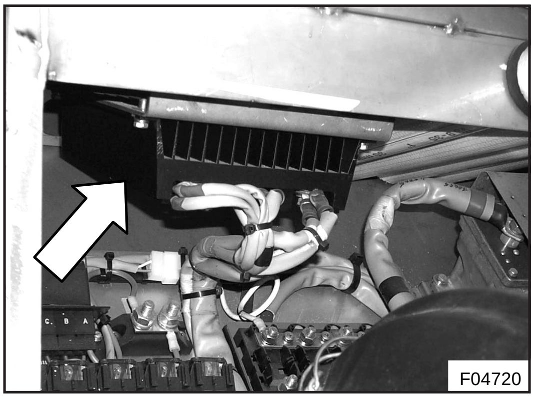

Figure 18: Battery equalizer (in battery junction box, behind the rear door at the left side of the coach)

OPERATION

The battery equalizer constantly monitors the batteries, whether the engine is running or not. It allows12 VDC power to be taken from both batteries simultaneously. If a 10 Amps and 12 VDC load is present, the equalizer will allow 5 Amps to be drawn from each battery. If one battery is found to be defective, both batteries do not have to be replaced since the equalizer wil sense an imbalance and will automatically equalize.

SPECIFICATIONS

Make .... VANNER
Model 60-60
Input Voltage range ....18 to 32 VDC
Max. input current (24 VDC) .. 32 Amps
Output current (12 VDC) ... 0-60 amps
Weight ....6 lbs
Length .... 9"
Height .... 2.5"
Width .... 8.5"

MAINTENANCE

Generally, no maintenance is required. However, a periodic check of cable connections, circuit breaker and mounting is good preventive maintenance practice. Note that battery equalizer is not repairable.

TEST PROCEDURE

Equipment required:

• Voltmeter having 0.01 volt resolution (Fluke Model 87 Multimeter recommended)
• Clamp-on amp meter (Fluke Model 36 Clamp On Meter recommended)

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. The equalizer 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. Measure and record at the equalizer:

   • Battery A voltage (voltage between the equalizer +12 and GND terminals);

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- Battery B voltage (voltage between the equalizer +24 and +12 terminals);
- Equalizer indicator light status (on or off).

5. Subtract battery A voltage from battery B voltage and compare readings (see table).

Voltage comparison	**Indicator light**	**Equalizer Status**	
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 volt.
Battery A is lower than battery B by 0.05 to 0.10 volt	On	On	Battery A is lower than battery B by 0.05 to 0.10 volt
Battery A is lower than battery B by more than 0.10 volt	On	On	Battery A is lower than battery B by more than 0.10 volt
Battery A is lower than battery B by more than 0.10 volt	Off	Off	Battery A is lower than battery B by more than 0.10 volt
Battery A is higher than batter B	Abnormal condition. Suspect Battery B is defective or a 12 volt load is connected to battery B.		

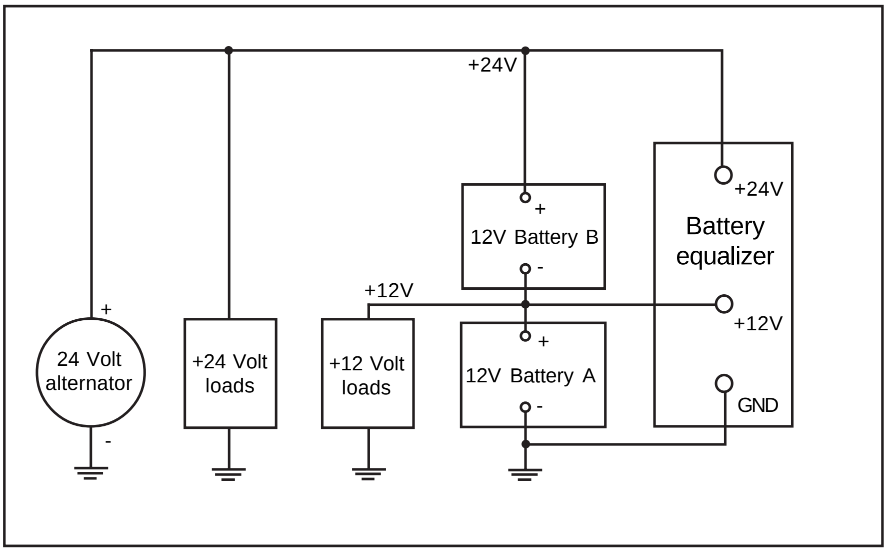

Figure 19: System diagram

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STARTER MOTOR

!!! CAUTION !!!
TO PREVENT DAMAGE TO THE STARTER MOTOR, DO NOT ENGAGE THE STARTER MOTOR FOR MORE THAN 30 SECONDS. WAIT TWO MINUTES BETWEEN EACH ATTEMPT TO START. AFTER THREE ATTEMPTS LET THE STARTER MOTOR COOL TO AMBIENT TEMPERATURE BEFORE TRYING AGAIN.

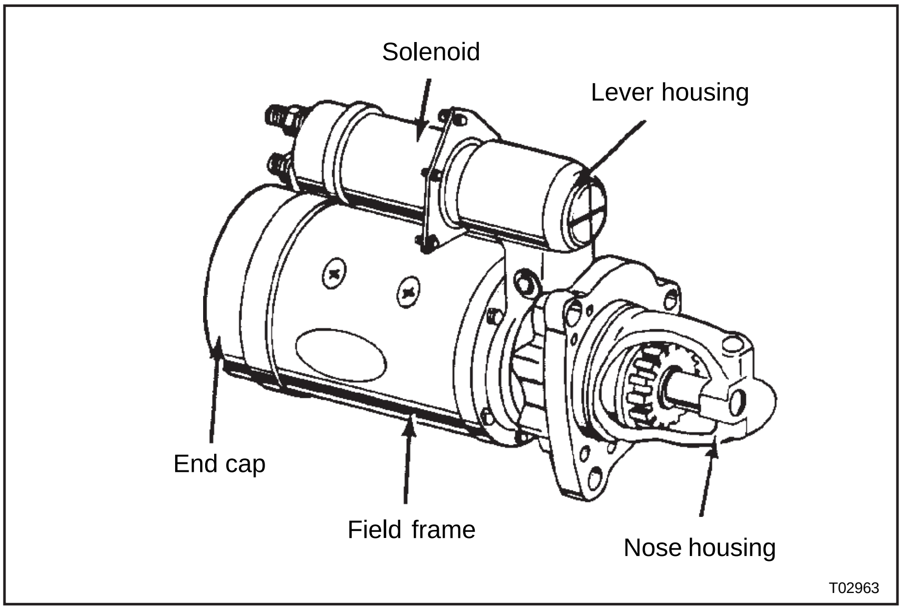

Figure 1: Starter motor

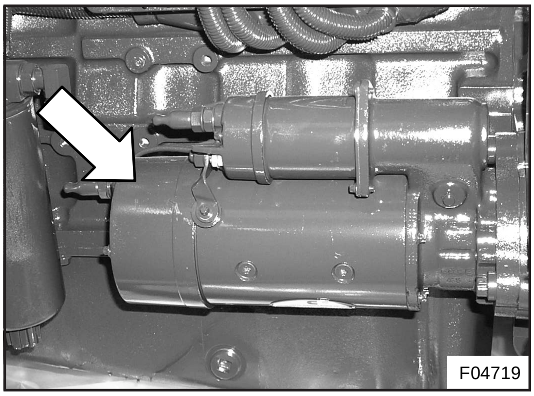

Figure 2: Starter motor on Cummins engine

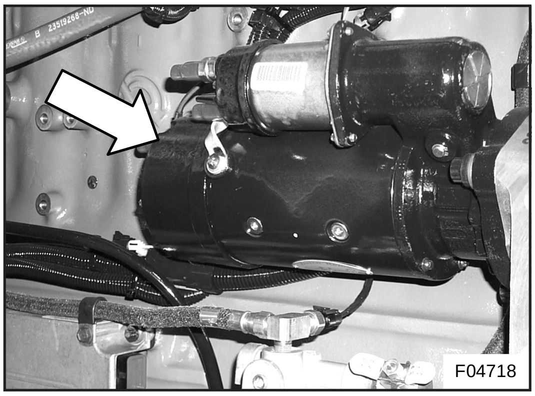

Figure 3: Starter motor on Detroit Diesel engine

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OPERATION- Figure 4

+15 is fed from Z056 through the starting prevention switch(S079) in the engine compartment and then to RL521.2. Before RL521.2 can be energized , a ground must be supplied through the VIM of the transmission. This ground is supplied when the transmission is in neutral.
When the master/ignition switch (S068/ S080) is placed in the "ignition on" position and the luggage compartment light switch (S048) is depressed and the starter switch (S077) is held in the depressed position, +30 is fed from Z030 through the contact points of RL521 and then through the contact points of RL521.3 and then to RL503. Once RL503 is energized, +30 is fed from fuse Z10 to the starter motor solenoid. The starter motor solenoid then engages pinion gear to flywheel gear and simultaneously the engine is being cranked. Once the engine is started, the pinion overrun takes place to protect the armature from excessive speed until the starter switch (S077) is released. To prevent relay RL521.3 from energizing during the cranking cyclus, RL049.2 will interrupt the D+ signal to RL049. The starter motor can also be activated by the starter switch (S078) in the engine compartment.

+30 : **Power supplied with "batteries connected"**
+15 : **Power supplied with "ignition on"**
D+ : **Power supplied with "engine running"**
EKV : **Main junction box**
IB : **Instrument panel**
AL : **Alternator**
BA1 : **Battery**
BA2 : **Battery**
KS : **Ignition switch**
RL049 : **D+ relay**
RL049.2 : **Relay**
RL511 : **Batteries disconnect solenoid**
RL511.2 : **Relay**
RL521.2 : **Relay**
RL521.3 : **Relay**
S048 : **Luggage compartment light switch**
S068/S080 : **Master/ignition switch**
S077 : **Starter switch on instrument panel**
S078 : **Starter switch in engine compartment**
S079 : **Starting prevention switch in engine compartment**
SM : **Starter motor**
TB2 : **+30 stud in battery junction box**
TB100 : **Terminal stud**
VIM :**Vehicle interface module of WT- automatic transmission**
Z10 : **Maxifuse**
Z025 : **Circuit breaker**
Z030 : **Circuit breaker**
Z056 : **Circuit breaker**

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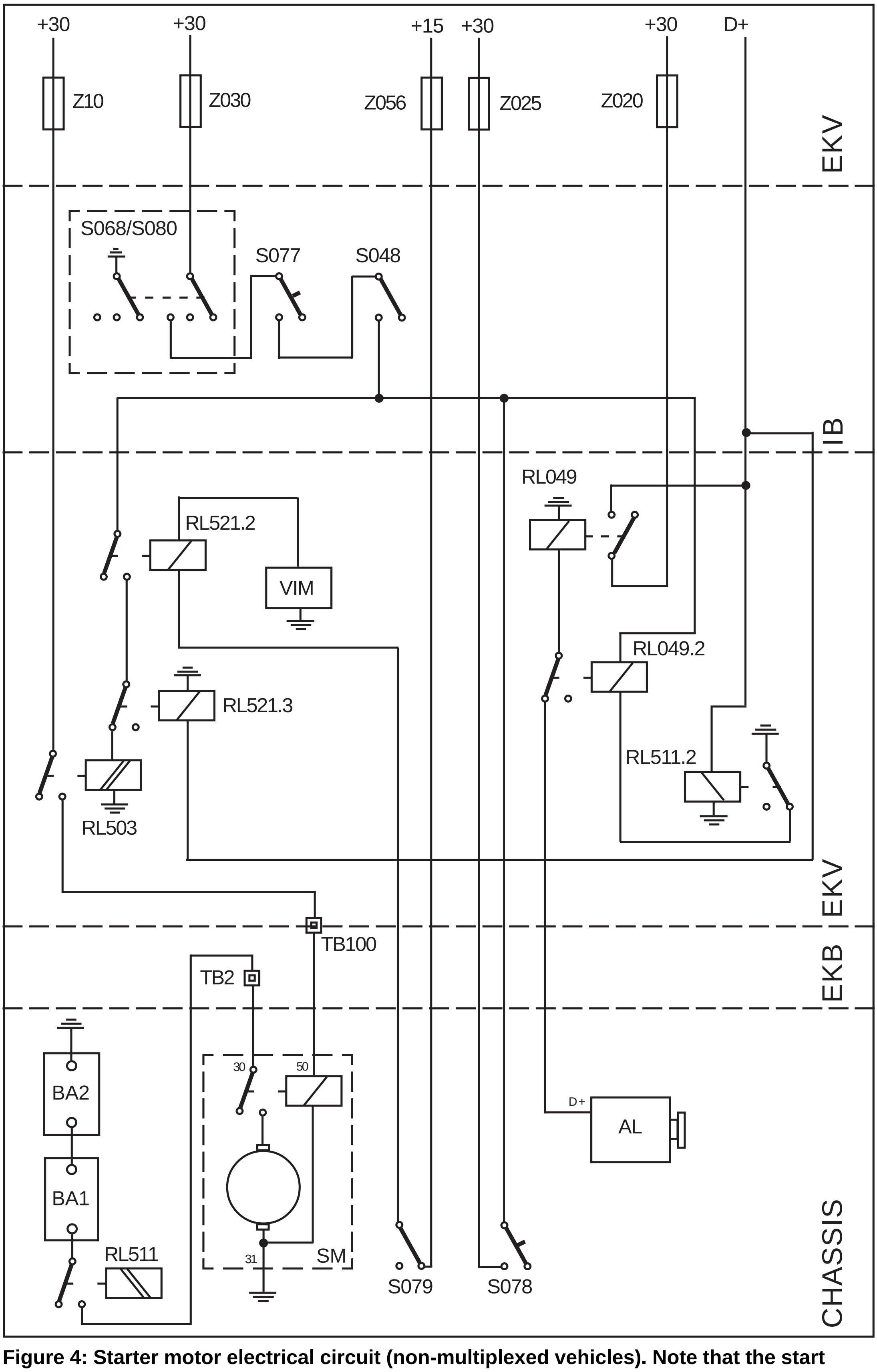

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Figure 4: Starter motor electrical circuit (non-multiplexed vehicles). Note that the start prevention function on current vehicles is achieved with S022 (stepwell lighting switch, second position) instead of S048.

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MISCELLANEOUS

RELAYS

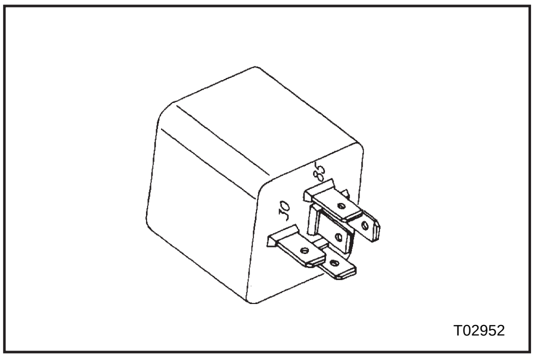

Figure 1: Example of relay

The most common relay on your coach is of the type shown in figure 1.

Most of the relays used in the electrical system have a diagram stamped on the relay housing. The terminals of the relay are also numbered. Information such as amperage rating and part number are also mentioned.

PURPOSE

Relays can be used:

- To automatically open or close a circuit as operating conditions may require...
- ... or to provide a direct connection between batteries and an electrically operated device, with only a small amount of current required to energize the operating coil flowing through the controlling switch. This eliminates the use of great lengths of heavy wire.

OPERATION

A basic relay consists of a coil wrapped around an iron core and a set of contacts.

When a current flows through the coil, the iron core becomes magnetized. A set of contacts is arranged at the end of the coil. When the coil is energized, the contacts will open or close, depending on the type of relay.

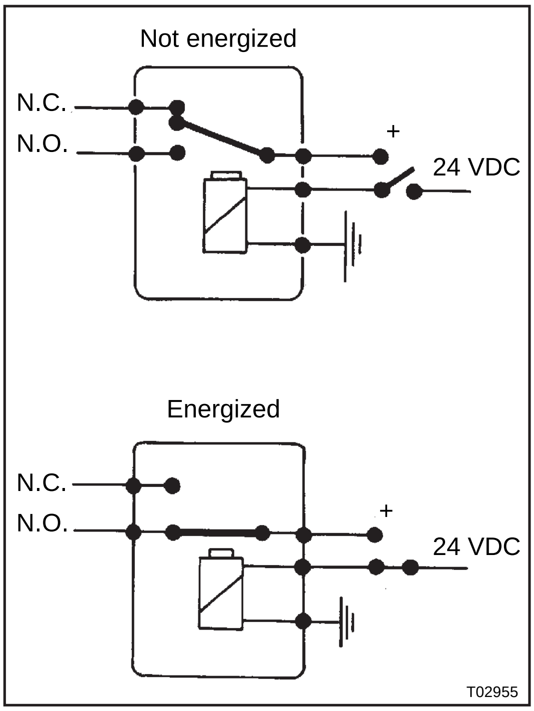

Figure 2: Relay operation

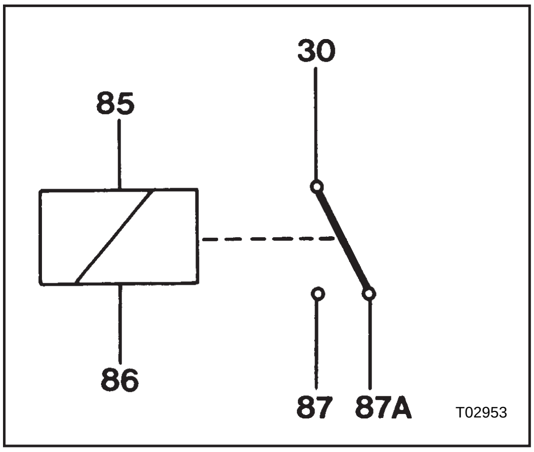

Figure 3: Numbering of relay terminals

85 and 86	**:**	**Coil assembly**
30	**:**	**Common contact**
87	**:**	**Normally open contact**
87A	**:**	**Normally closed contact**

The numbering system will hold true with different relay types used.

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ELECTRIC CONNECTORS

Most electric connectors in the vehicle are of the "AMP" type. These connectors range from a single tab connector to an eleven tab connector with both male and female mating counterparts.

Special crimping tools are required to make the double type crimp on the tab. You can purchase these locks through your Van Hool distributor.

Assembly: Ensure that the locking lance is angled upwards and slide the tab into the receptacle until the locking lance has engaged.

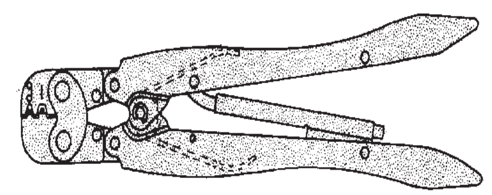

Figure 4: Crimping tool

Crimping tool: ABC part no. S7998
Crimping jaws: ABC part no. S7999

Disassembly: With a pick or a similar tool bend the locking lance flush with the tab and remove from the receptacle.

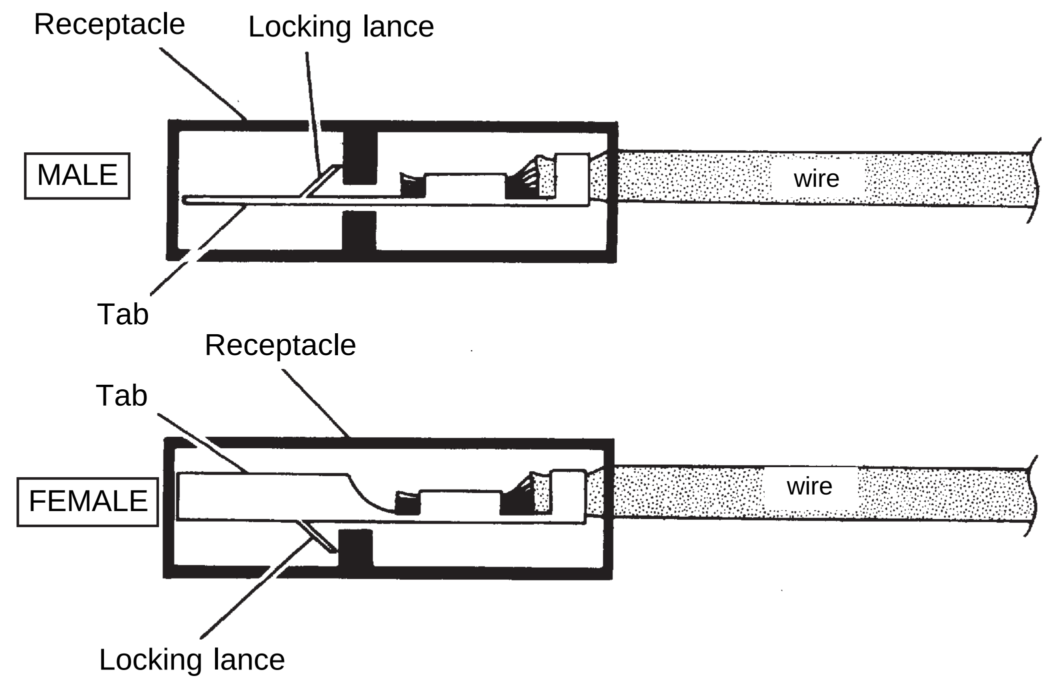

Figure 5: Tab in receptacle (not 9-pin connector)

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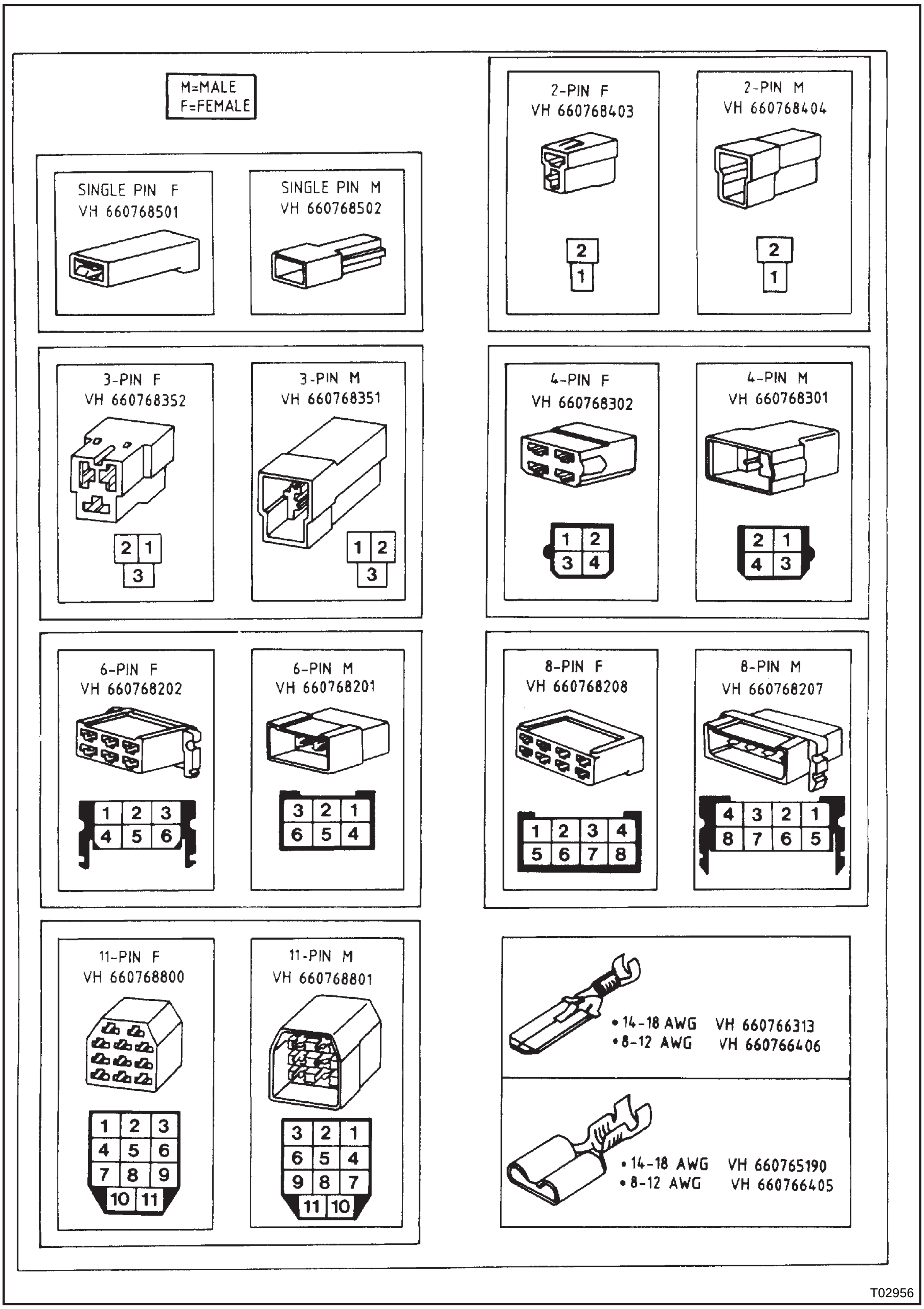

Figure 6: Connector/tab identifications (all connector tab numbers are viewed from the rear of the connector)

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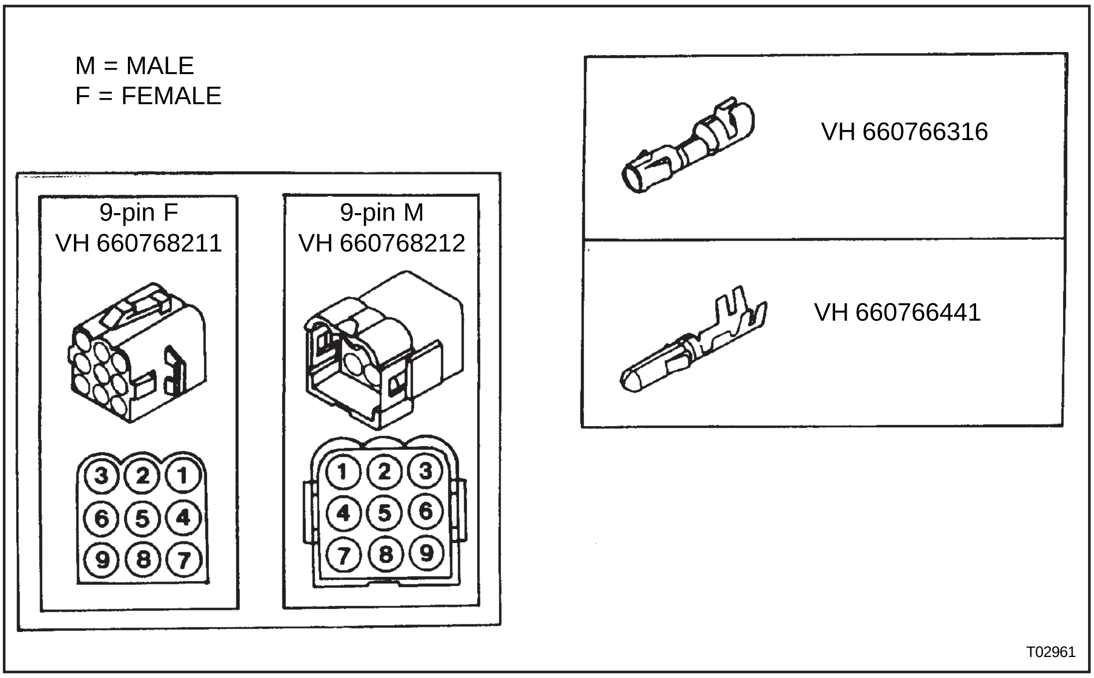

Figure 7: Connector/tab identifications (all connector tab numbers are viewed from the rear of the connector)

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GENERAL MAINTENANCE

To ensure proper operation of the electrical system, the following service and inspections should be performed during normal coach maintenance.

- Inspect all power feed cables and terminals for tightness and condition.
- Inspect all ground cables for tightness and condition
- Inspect fan and blower motor for unusual noise or vibration
- Inspect instrument panel for proper indicator lights (refer to Operator's Guide Book).

ELECTRICAL PARTS CLEANING

Cleaning electrical parts may be done with the following:

- Gasoline (except for plastic parts)
- Trichloethylene
- Perchloroethylene

Gasoline, acetone and ethanol (ethyl alcohol) are inflammable liquids. Mixing them with air can cause explosion. Only wash parts in tanks or containers intended for this purpose and equipped with a "melt" safety device which is a lid that closes automatically in case of fire. In the case of larger containers (20 x 20 inches) some form of suction extraction must be provided.

Alternators, wiper motors, small power motors and other electrical equipment often have capacitors with a long storage life. When washing these parts, it is possible that a capacitor discharge can occur when the part is immersed in the cleaning agent. Care must be taken, as there is a risk that the liquid catches fire. Parts on which a capacitor is fitted should only be washed in trichlorethylene or perchloroethylene.

Starter motors that have been washed in gasoline should be thoroughly dried, in particular the windings. With sliding-gear starting motors, the first test after washing must be performed without the closure gap to prevent the possibility of explosion.

For continuous or regular cleaning of parts in trichlorethylene, only use tanks or containers intended for this use. Make sure the suction device is turned on and do not bend over the container.

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LIGHTING

EXTERIOR LIGHTING EQUIPMENT

HEADLIGHTS

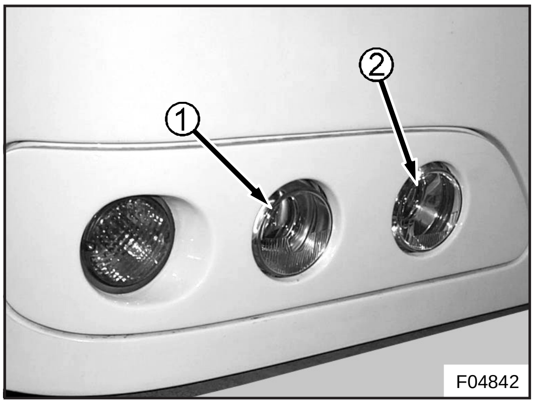

Figure 1: Headlight assembly

1. **Low beam**
2. **High beam**

Headlight adjustment

Headlights must be properly aimed to provide maximum legal accepted illumination. Follow the procedure below to adjust the headlights. The headlight adjusting screws are located at the rear of the headlight assembly.

The adjusting screws of the RHS headlight assembly are accessible via the access panel in the stepwell of the entrance door (see figure 2).

The adjusting screws of the LHS headlight assembly are accessible via the exterior access door below the driver's side window.

Each headlight assembly has four adjusting screws: two for the low beam unit and two for the high beam unit (see Figure 3A).

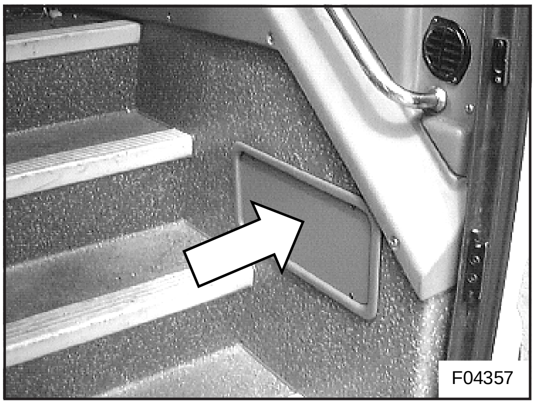

Figure 2: Access panel in the stepwell of the entrance door

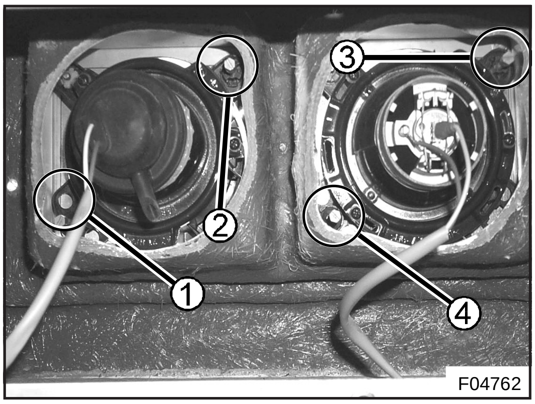

Figure 3A: Location of adjusting screws (view from the rear on the right headlight assembly)

1. **Vertical aim screw of high beam unit**
2. **Horizontal aim screw of high beam unit**
3. **Horizontal aim screw of low beam unit**
4. **Vertical aim screw of low beam unit**

Aiming procedure for inner lights- Figure 3B

1. Position the vehicle on a level floor with the headlights 25 feet from a bright wall. Make sure that the vehicle is perfectly square with regard to the wall.

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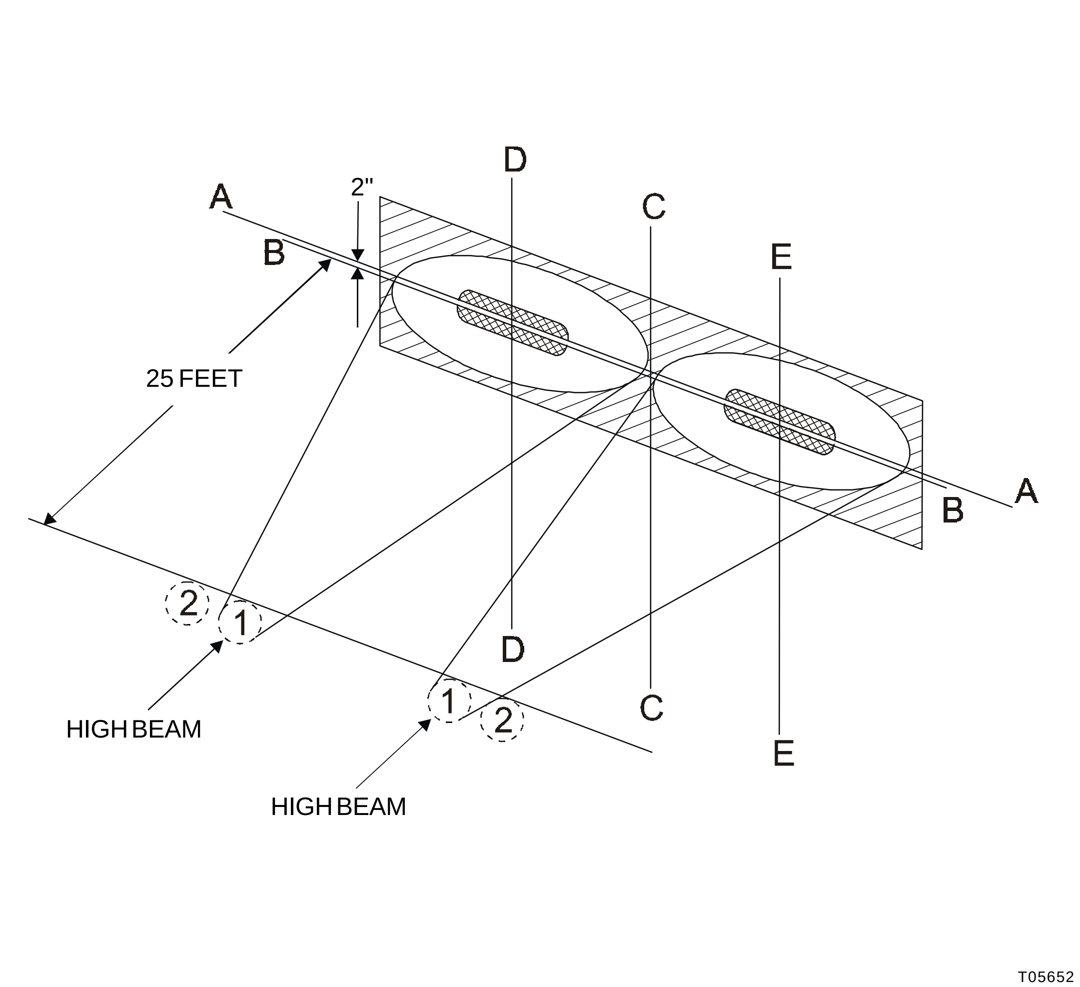

Figure 3B: Inner light (high beam) aiming chart

2. Measure the height of the headlight centers from the floor and mark this height on the wall. Draw a horizontal line (A-A) on the wall at this height. Draw a second horizontal line (B-B) parallel with and two inches below line (A-A).

3. Locate point at which projected centerline of vehicle intersects these lines and draw a vertical line (C-C) on the wall.

4. Measure distance between centers of inner lights, then divide this distance equally on both sides of centerline (C-C). Draw a vertical line (D-D and E-E) through each of these points.

5. Cover all lights except one inner light. Select the high beam.

6. The high intensity zone of the beam pattern should center at the point where vertical line (D-D and E-E) intersects horizontal line (B-B). Turn vertical aim screw (1, Figure 3A) to raise or lower the beam pattern, and turn horizontal aim screw (2, Figure 3A) to move it to the right or left.

7. After completing adjustment on one inner light, cover that light, uncover other inner light, and adjust in the same manner.

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Aiming procedure for outer lights - Figure 3C

1. Locate projected centerline of vehicle and height of headlight centers in same manner as in steps 2 and 3 under "Aiming procedure for inner lights", except that horizontal line (B-B) is omitted.

2. Measure distance between centers of outer lights and divide this distance equally on both sides of centerline (C-C). Draw a vertical line (D-D and E-E) through each of these points.

3. Select low beam. Cover one light while adjusting the other. The edge of the intensity zone of the beam pattern must be just below the horizontal centerline (A-A) and two inches to the right of the vertical centerline (D-D or E-E). Turn vertical or horizontal adjusting screws as necessary to obtain this condition.

4. After completing adjustment on one outer light, cover that light, uncover other outer light, and adjust in the same manner.

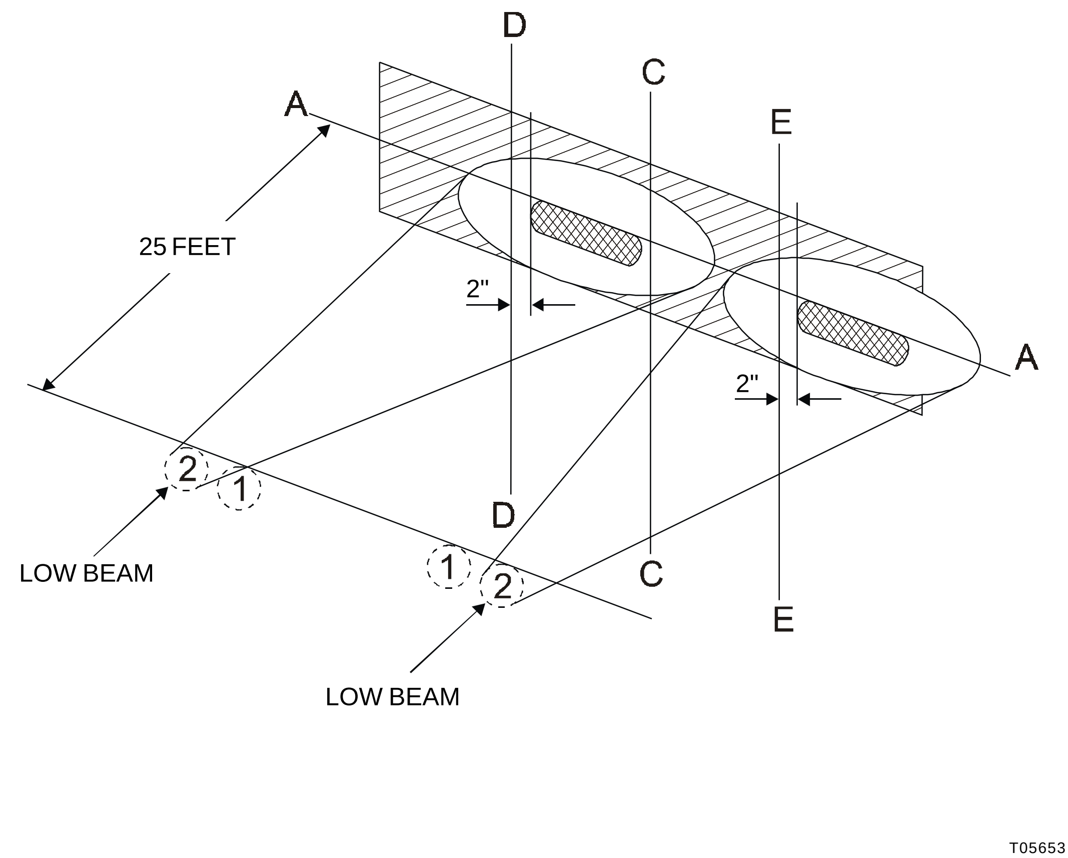

Figure 3C: Outer light (low beam) aiming chart

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Bulb replacement

NOTE
Different lighting applications require different candle power. Make sure appropriate replacement is used for defective bulb.

!!! CAUTION !!!
BEFORE REPLACING A BULB, ALLOW IT TO COOL DOWN. TOUCHING HOT BULBS MAY CAUSE SERIOUS INJURY.

1. If installed, pull the rubber cap back.
2. Pull connecting plug from bulb base.
3. Unhook springs that retain the bulb base and swing them backwards. Extract defective bulb from reflector.

!!! CAUTION !!!
HOLD A NEW BULB BY ITS BASE ONLY. FINGER PRINTS OR TRACES OF GREASE ON THE GLASS WILL REDUCE LIFESPAN CONSIDERABLY. WHEN IN DOUBT OVER THE CLEANLINESS OF THE GLASS, CLEAN IT WITH ALCOHOL.

NOTE
The headlight aim must be checked after each headlight bulb replacement.

FRONT TURN SIGNAL

The front turn signal is located in the headlight assembly. Its light bulb can be reached in the same way as the headlight bulbs.

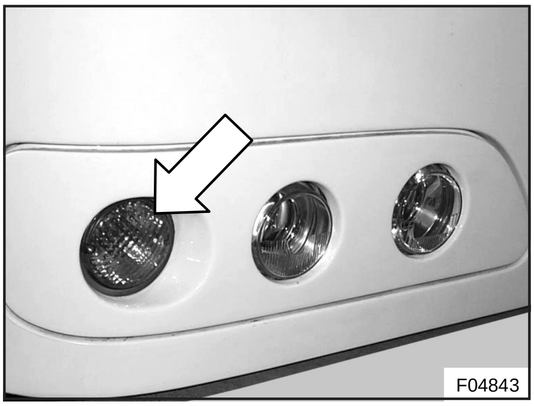

Figure 4: Front turn signal

Bulb replacement

1. Separate the connector from the socket by lifting the tab and pulling the connector apart.
2. Turn the socket 30° counterclockwise and pull it out.
3. Remove the bulb by pushing and rotating it out of the socket.
4. Install the new bulb by reversing the previous procedure.

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FRONT FOG LIGHTS (OPTIONAL)

The front fog lights are mounted in the front bumper.

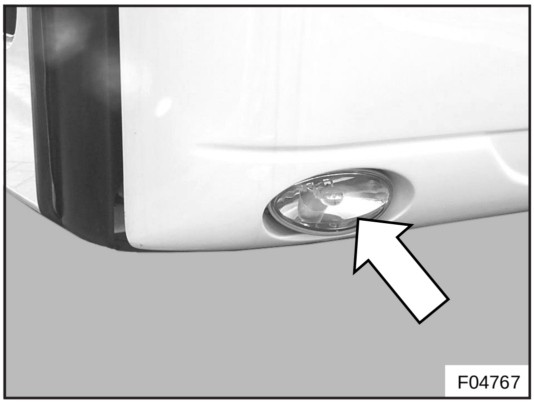

Figure 5: Front fog light

Bulb replacement

1. Put the tip of a flat screwdriver as indicated in figure 5 and pry out the complete reflector assembly.

2. Separate the bulb connector.

3. Unhook spring that retains the bulb base and swing it backwards. Extract defective bulb from reflector.

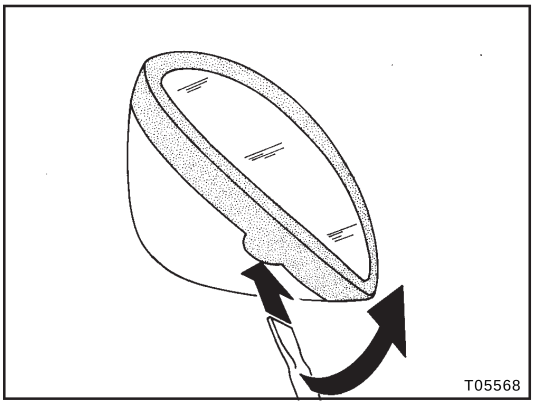

Figure 6: Push here to separate the reflector from its housing

!!! CAUTION !!!

HOLD A NEW BULB BY ITS BASE ONLY. FINGER PRINTS OR TRACES OF GREASE ON THE GLASS WILL REDUCE LIFESPAN CONSIDERABLY. WHEN IN DOUBT OVER THE CLEANLINESS OF THE GLASS, CLEAN IT WITH ALCOHOL.

5. Install the new bulb by reversing the previous procedure. Install the reflector with the "TOP" inscription on the lip upwards (see Figure 7).

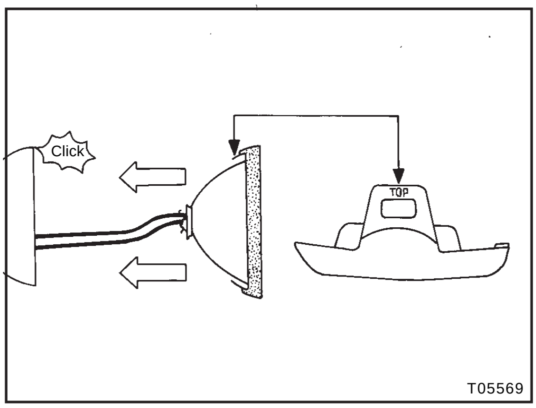

Figure 7: To install the reflector in its housing

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REAR TURN SIGNAL, STOP, TAIL, BACK-UP LIGHT ASSEMBLY

These lights are mounted at the rear, on each side of the vehicle. All lights contain their own light bulbs. Each light is serviced individually from the back of the light.

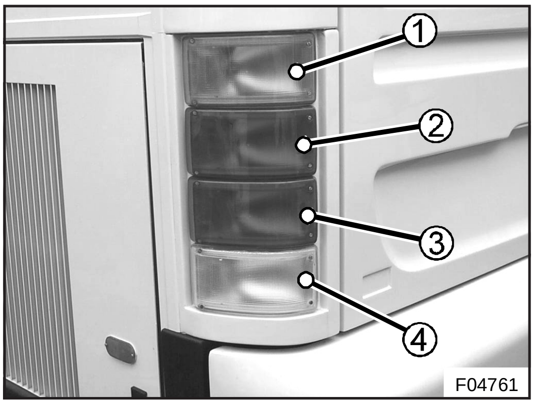

Figure 8: Rear light assembly (previous model)

1. Turn signal light
2. Stop light
3. Tail light
4. Back-up light

Bulb replacement

Previous model: to reach the back of the rear light assembly, open the rear engine compartment door.

Current model: to reach the back of the rear light assembly, open the rear engine compartment door. Remove the wing nut at the front of the light assembly and swing the light assembly door open.

!!!CAUTION!!!
SET THE OVERRIDE SWITCH IN THE ENGINE COMPARTMENT TO THE "OFF" POSITION TO PREVENT ACCIDENTAL STARTING OF THE ENGINE.

1. Pull back the protective rubber cover.
2. Place thumb on tab and gently press in on tab to release from housing.
3. Install the new light bulb by reversing the previous procedure.

SIDE TURN SIGNAL LIGHTS

Three amber turn signal lights are mounted on both the left and right hand side of the vehicle. One is located ahead of the front wheel, one halfway the side and one behind the tag axle.

Bulb replacement

1. Unscrew the two lens retaining screws and remove the lens.
2. Remove the bulb in the center by pushing and rotating it out of the socket.

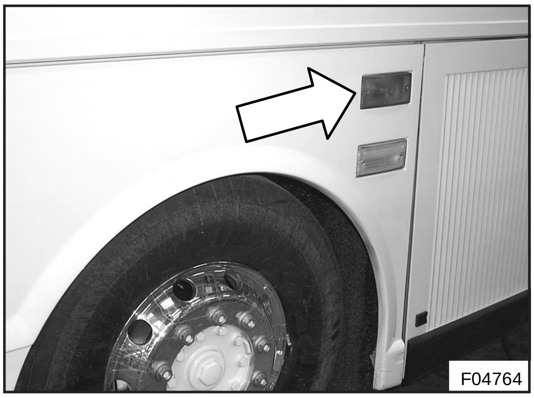

Figure 9: Side turn signal light behind the left tag wheel

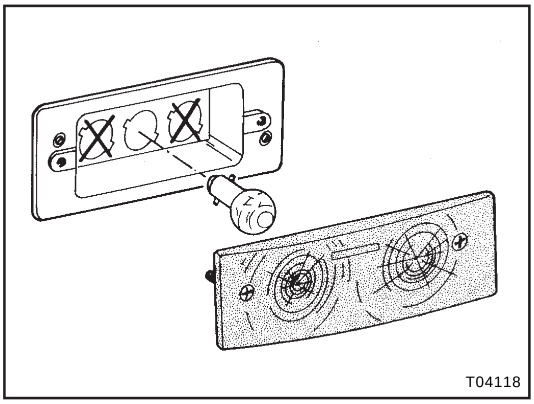

Figure 10: Side turn signal light assembly

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3. Install the new bulb by reversing the previous procedure. Install the lens. Make sure the inscription "TOP" points upwards.

DOCKING LIGHTS

The coach is fitted with four docking lights. Two docking lights (white) are mounted on both the left and right hand side of the vehicle. One is located ahead of the front wheel, and one behind the tag axle. The front docking lights illuminate together with the turn signal flashers to increase lateral visibility while turning. The rear docking lights illuminate automatically when the reverse (R) range is selected to increase visibility while backing-up or docking the coach.

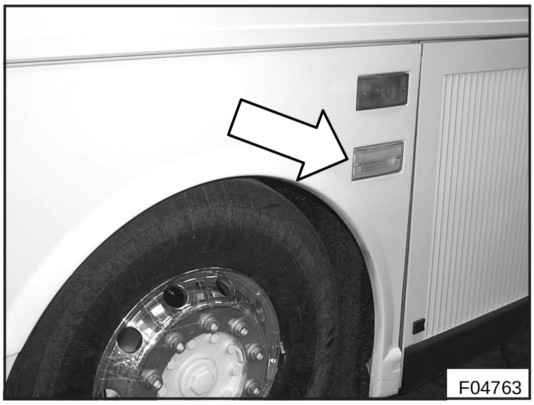

Figure 11: Docking light behind the left tag wheel

Bulb replacement

1. Unscrew the two lens retaining screws and remove the lens.
2. Remove the defective bulb by pushing and rotating it out of the socket.
3. Install the new bulb by reversing the previous procedure. Install the lens. Make sure the inscription "TOP" points upwards.

CENTER STOP LIGHT

When braking, a red center stop light comes on simultaneously with the stop lights on the sides at the back of the vehicle for increased safety. The red center stop light is a sealed unit and contains leds (light-emitting diodes) instead of an ordinary light bulb. Current vehicles are fitted with three red center stop lights.

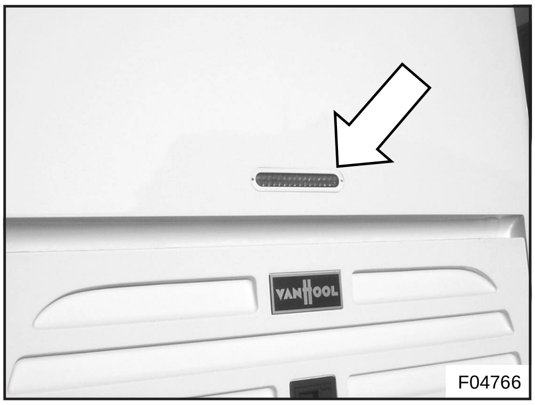

Figure 12: Center stop light

Replacement

When the red center stop light is defective, the whole unit should be replaced by a new one.

1. Unscrew the two rim retaining screws.
2. Remove the rim.
3. Pull the unit out.
4. Separate the connector.
5. Connect the new unit to the vehicle wiring.
6. Install the new unit with the rim and the two retaining screws.

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LICENSE PLATE LIGHT

Two separate white license plate lights are mounted above the license plate at the rear of the coach.

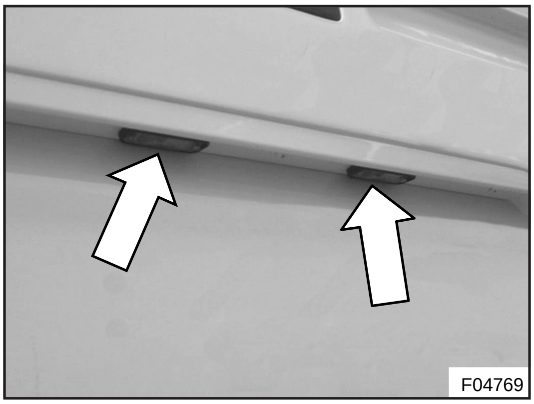

Figure 13: License plate lights

Bulb replacement

1. Unscrew the two lens retaining screws and remove the lens and gasket.

2. Pry out the defective bulb with a screwdriver.

3. Fit the new bulb between the contact brackets. Make sure it fits snug and cannot drop out again.

4. Reinstall lens and gasket, taking care the gasket seats properly.

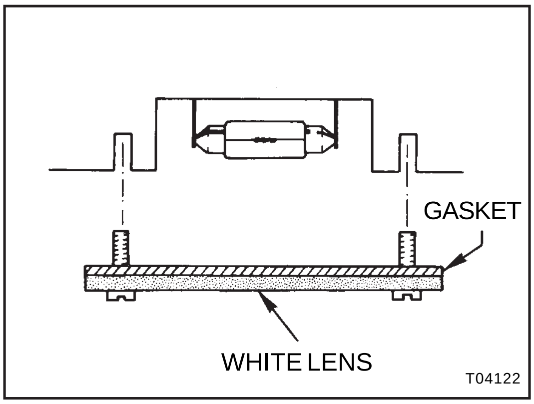

Figure 14: License plate light

MARKER, IDENTIFICATION AND CLEARANCE LIGHTS

The coach is equipped with marker, identification and clearance lights. These are sealed units and contain a led (light-emitting diode) instead of an ordinary light bulb.The clearance lights are mounted at each corner of the coach near the top. The front clearance lights are amber, the rear ones are red. The identification lights are in the upper center of the rear and front sections. Again, the front ones are amber, the rear ones are red. Marker lights are located near the top on the sides of the vehicle. The front and the intermediate are amber, the rear one is red.

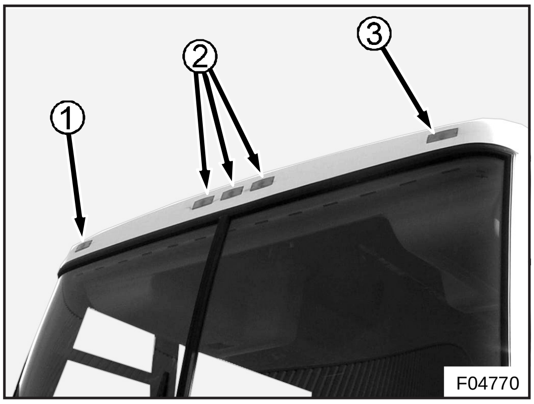

Figure 15: Clearance and identification lights at the front of the coach

1,3: Clearance lights
2: Identification lights

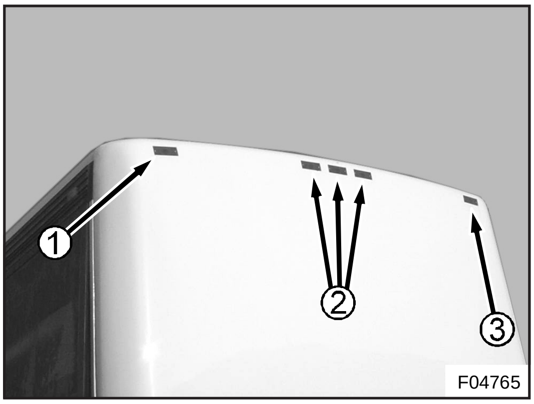

Figure 16: Clearance and identification lights at the rear of the coach

1,3: Clearance lights
2: Identification lights

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Replacement

When a marker, identification or clearance light is defective, the whole unit should be replaced by a new one.

1. Unscrew the two retaining screws and pull the unit out.

2. Separate the connector.

3. Connect the new unit to the vehicle wiring.

4. Install the new unit with the two retaining screws. Make sure the inscription "TOP" points upwards.

LIGHT UNDER STEPWELL

This light illuminates when the entrance door is open.

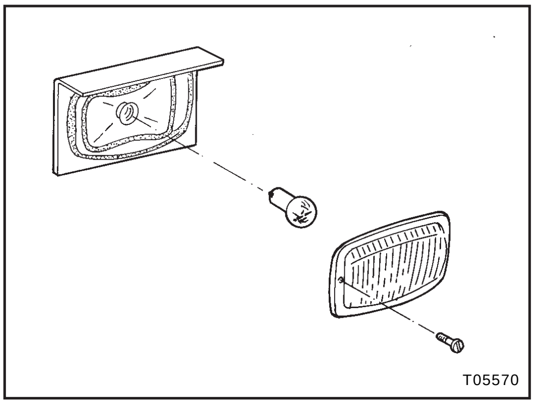

Figure 17: Light under stepwell (not on current vehicles)

Bulb replacement

1. Unscrew the two rim retaining screws. Remove the rim and lens.

2. Remove the bulb by pushing and rotating it out of the socket.

3. Install the new bulb by reversing the previous procedure. Install the lens and rim.

EXTERIOR LIGHT BULB DATA

Application	VH part No.	Category	Socket	Watts	Volts
Headlight, low beam	660718000	H1	P14,5e	55	12
Headlight, high beam	660718000	H1	P14,5e	55	12
Front turn signal	660720501	P21W	BA15s	21	24
Front fog light	660718001	H3	PK22s	55	12
Side turn signal	660720400	R15W	BA15s	15	24
Docking light	660720501	P21W	BA15s	21	24
License plate light	660725000	C5W	SV8.5	5	24
Rear turn signal	660720501	P21W	BA15s	21	24
Stoplight	660722801	P21/5W	BAY15d	21	24
Tail light	660722801	P21/5W	BAY15d	5	24
Back-up light	660720501	P21W	BA15s	21	24
Light under stepwell	660720400	R15W	BA15s	15	24

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INTERIOR LIGHTING EQUIPMENT

LIGHTS IN LUGGAGE COMPARTMENTS AND BATTERY JUNCTION BOX

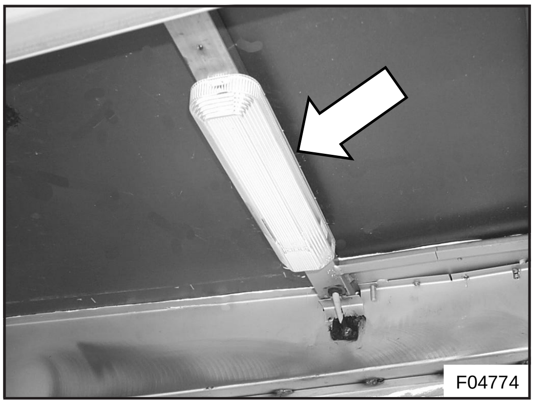

Figure 18: Light in luggage compartment behind right tag wheel

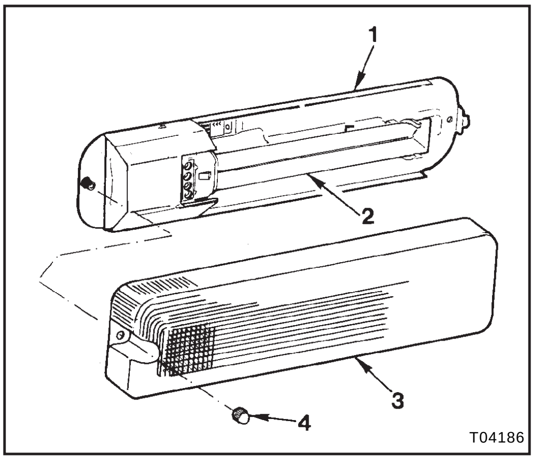

Figure 19: Exploded view of light in luggage compartments and battery junction box

Bulb replacement

1. Remove the black plastic nut (4) holding the lens (3) to the bracket (1).

2. Tilt and slide the lens to remove it.

3. Unscrew the four small screws in the center of the connector.

4. Carefully pull the fluorescent lamp (2) sideways to remove it from the connector and bracket.

5. Install a new lamp and fasten the four small screws.

6. Put the lens back and refit the black plastic nut.

LIGHT IN COMBUSTION HEATER AND ENGINE COMPARTMENT

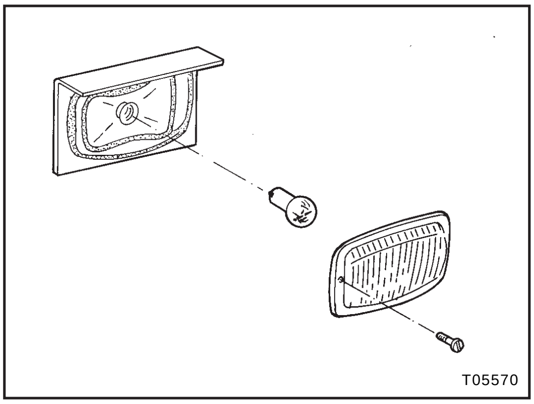

Figure 20: Light in combustion heater and engine compartment

Bulb replacement

Refer to "Light under stepwell" under "Exterior lighting equipment".

LAVATORY COMPARTMENT LIGHTS

The lavatory lighting consists of two roof lights and a flood light. The flood light will illuminate with the master/ ignition switch in the second position. Locking the door from inside will illuminate the compartment roof lights and the occupied light.

Flood light bulb replacement

1. Put the tip of a flat screwdriver in the notch at the narrow end of the lens.

2. Pry out the complete light unit.

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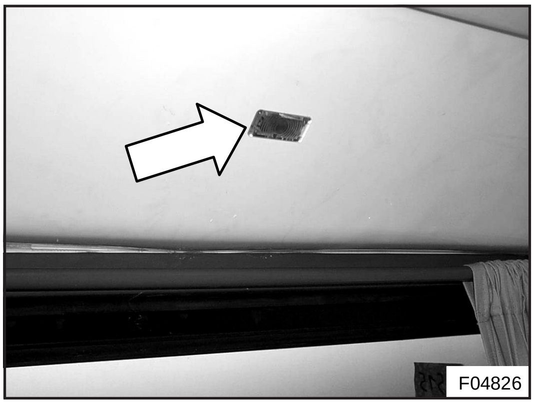

Figure 21: Flood light in lavatory compartment

3. Remove the defective bulb and replace it by a new one of the same candle power.

4. Push the light unit back in its opening.

Roof light bulb replacement

1. Remove the three screws holding the rim and lens to the lamp body.

2. Pull the defective bulb out and put a new one in.

3. Install the rim and lens with the three screws.

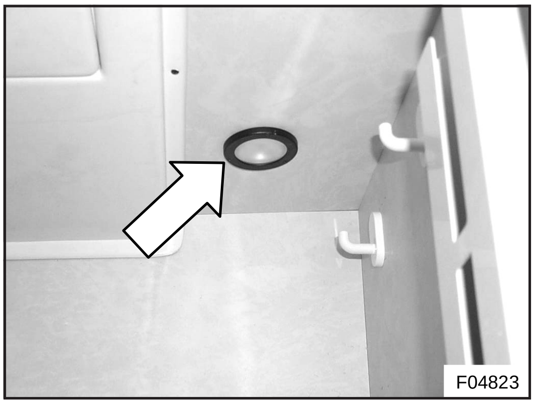

Figure 22: Roof light in lavatory compartment

Lavatory compartment occupied light bulb replacement

The lavatory compartment occupied light is mounted in the rear wall of the passengers compartment.

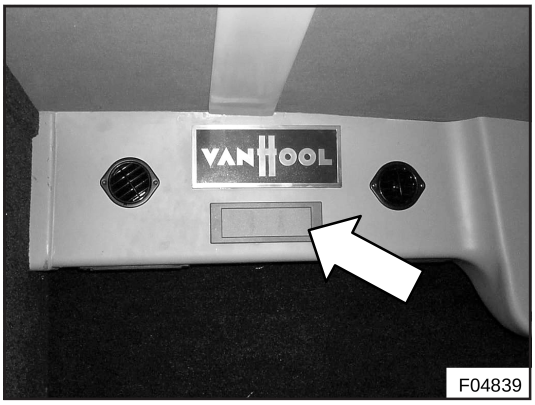

Figure 23: Lavatory compartment occupied light

1. Insert the tip of a flat screwdriver halfway the narrow end of the light unit to press the tab.

2. Pry out the complete light unit.

3. Remove the four screws at the rear of the light unit.

4. Pull the defective bulb out and put a new one in.

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STAIR WARNING LIGHT AND DOME LIGHTS

When the door opening system is activated, the following lights are illuminated:

- two white dome lights, installed over the stepwell and the driver's compartment;
- a white light, installed under the stepwell (refer to exterior lighting equipment);
- a stair warning light, mounted on the upper edge of the stair.

Dome light replacement

The dome lights are sealed unit lights and should be replaced as follows:

1. With the tip of a flat screwdriver, pry out the snap ring holding the light unit.
2. Pull the light unit out and loosen the two small screws in the connector.
3. Pull the light unit from the connector.
4. Insert a new sealed light unit into the connector and tighten the two small screws.

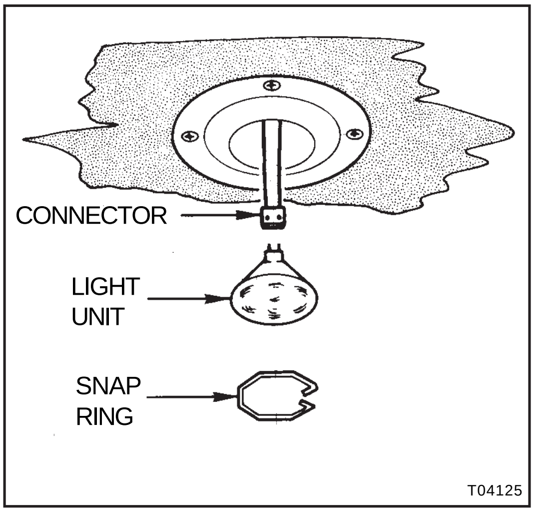

Figure 24: Dome light

5. Place the light unit back into its receptacle and reinstall the snap ring.

Stair warning light

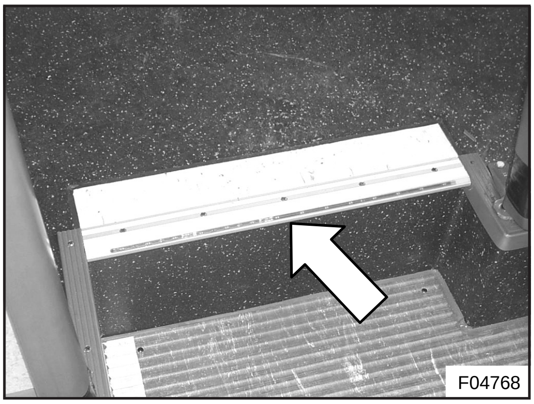

Figure 25: Stair warning light (not on current vehicles)

"Watch your step" light bulb replacement

The "Watch your step" light is mounted above the windshield.

1. Insert the tip of a flat screwdriver halfway the narrow end of the light unit to press the tab.
2. Pry out the complete light unit.
3. Remove the four screws at the rear of the light unit.
4. Pull the defective bulb out and put a new one in.

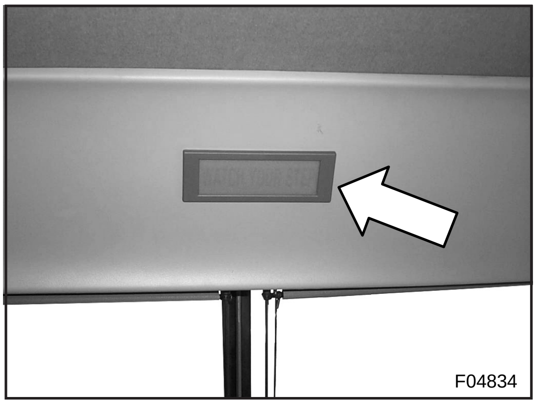

Figure 26: "Watch your step" light

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PASSENGER'S READING LIGHT- Figure 27

The passenger's reading lights make part of the passenger's individual control panels mounted above the passenger's seats.

Bulb replacement

1. Remove the four screws securing the control panel to the parcel rack and lower the control panel.

2. Pull the bulb/socket assembly out of the control panel.

3. Remove the reading light bulb by pushing and rotating it out of the socket.

4. Install the new bulb by reversing this procedure.

5. Reinstall the control panel.

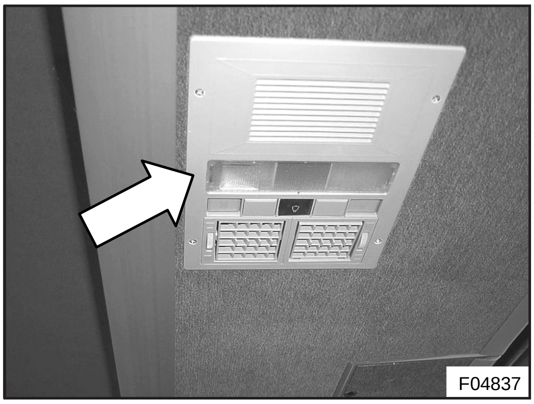

Figure 27: Control panel above passenger's seats

AISLE LIGHTING

Fluorescent lighting replacement

1. Remove the trim(s) uniting the lamp covers (see Figure 28).

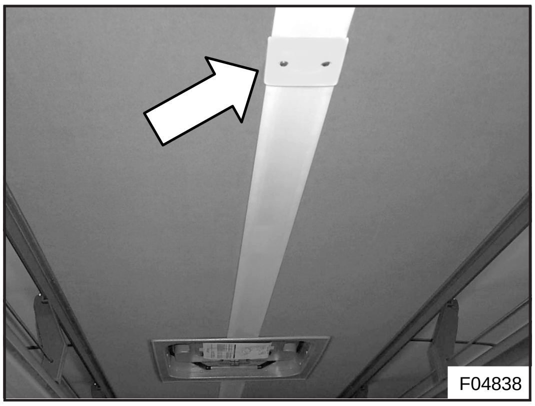

Figure 28: Trim of aisle lighting

2. Facing the gap between two lamp covers, pull the cover carefully downwards.

3. With the lamp cover aside, remove the rubber connectors at each end of the defective fluorescent lamp.

4. Now carefully pull the defective lamp from between the clamps.

!!! CAUTION !!!
BE CAREFUL NOT TO SHATTER THE FLUORESCENT LAMP WHEN REMOVING IT. GLASS FRAGMENTS FROM THE BROKEN LAMP MAY CAUSE SERIOUS INJURY TO YOUR EYES AND LUNGS.

5. Install a new fluorescent lamp and put the rubber connectors back on. Reinstall the lamp cover by applying pressure until it snaps into its seat. Reinstall the lamp cover trim(s).

Dome light replacement

Refer to "Roof light bulb replacement" under "Lavatory compartment lights".

On current vehicles the aisle is lighted by dome lights using a LED. When a light with LED fails, replace it as a unit.

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Aisle night light bulb replacement (only with fluorescent aisle lighting)

1. To reach the aisle night lighting lamps, remove the lamp covers as described under previous heading.

2. The green night lights are mounted between the fluorescent lamps. To remove the bulb, pull it out of the brackets.

3. Push a new light bulb between the mounting brackets.

INTERIOR LIGHT BULB DATA

Application	VH part No.	Type/socket	Watts	Volts
Dome light	10555447	GU5.3	20	28
Passenger's reading light	660720800	R10W/BA15s	10	24
Night light	660725002	C5W/SV8.5	5	24
Lavatory roof light	10564938	G4	20	24
Lavatory flood light	660725001	C10W/SV8.5	10	24
Aisle light, fluorescent	10690340	TL5 14W/840 HE	14	24
Aisle light, dome	10564938	G4	20	24
Aisle light, dome (LED)	10886912	LED		
Engine and combustion heater compartment light	660720400	R15W/BA15s	15	24
Luggage compartment and battery junction box light	10594378	PLS 11 W/82 4 pins	11	24
"Watch your step" and lavatory compartment occupied light	660720800	R10W/BA15s	10	24

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SOCKET AT LHS OF MAIN JUNCTION BOX

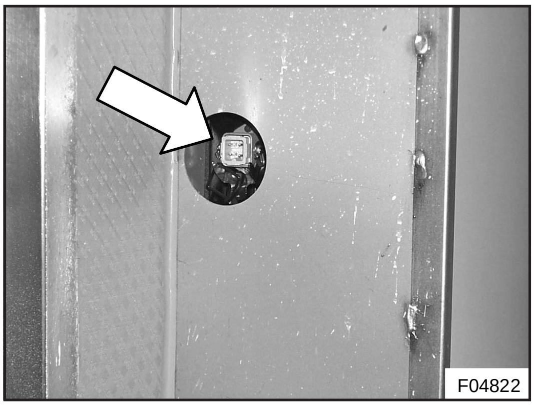

Figure 29: Socket at LHS of main junction box (at RHS on multiplexed vehicles)

!!! CAUTION !!!

THE EXTERNAL POWER UNIT MUST BE A 24 VDC SOURCE CAPABLE OF DELIVERING AT LEAST 35 AMPÈRES.

TO PREVENT DAMAGE TO THE VEHICLE ELECTRICAL SYSTEM OR TO THE EXTERNAL VOLTAGE SOURCE, MAKE SURE THAT THE INTERIOR LIGHT SWITCH IS IN THE OFF POSITION BEFORE CONNECTING THE VOLTAGE SOURCE TO THE SOCKET.

The coach is equipped with a socket to permit the use of an external 24VDC source to illuminate the aisle fluorescent lights when the coach is parked. The socket is located at the left side of the main junction box. When a power cable is connected to this point, the aisle fluorescent lighting is illuminated automatically.

The leads of the 24VDC voltage source cable should be connected to special connector 10643046, which fits on the socket in one position only, as follows (see Figure 30):

- Connect the "+" lead of the 24VDC voltage source cable to pin "2" and "3" of the connector;

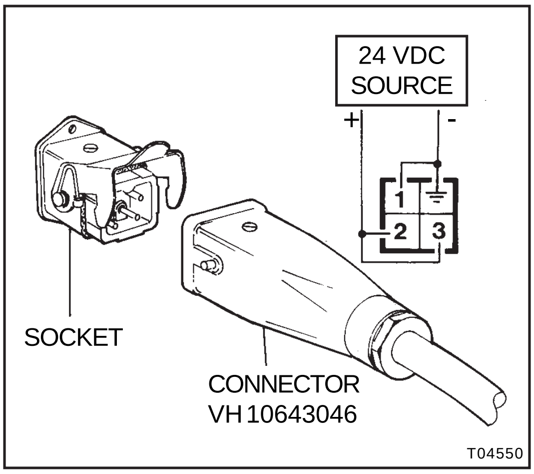

Figure 30: To connect a 24VDC source to connector 10643046

- Connect the "-" lead of the 24VDC voltage source cable to pin "1" and the "ground" pin of the connector.

!!! CAUTION !!!

THE WIRES OF THE EXTERNAL POWER SOURCE OUTPUT CABLES SHOULD HAVE A SECTION OF AT LEAST 8 AWG. CABLES WHICH ARE LONGER THAN 30FT WILL NEED WIRES WITH A LARGER SECTION DEPENDING ON THE ACTUAL CABLE LENGTH.

AN ADAPTER CABLE WILL BE REQUIRED TO CONNECT THE WIRES OF THE SUPPLY CABLE TO THE 12AWG TERMINALS OF CONNECTOR VH 10643046 (REFER TO FIGURE 31).

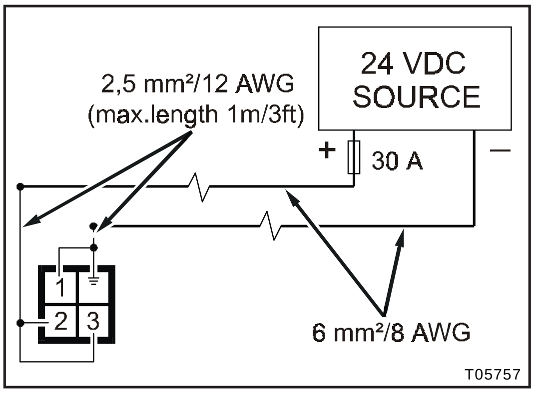

Figure 31 : Typical schematic for 24 VDC power cables not longer than 30 ft.

!!! CAUTION !!!
EXTENSION CORDS SHOULD BE UNREELED COMPLETELY BEFORE BEING CONNECTED TO THE EXTERNAL POWER SOURCE SOCKET. MAKE SURE THAT THE POWER CABLE IS DISCONNECTED BEFORE MOVING THE COACH.

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FUSES, CIRCUIT BREAKERS AND RELAYS ON NON-MULTIPLEXED VEHICLES

Figure 1: Main junction box (in the luggage compartment)

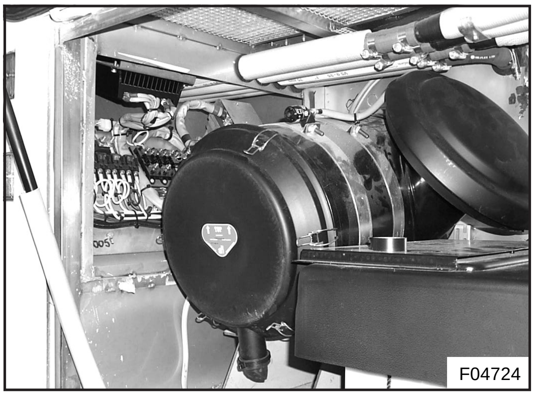

Figure 2: Battery junction box (behind the rear door at the left side of the coach)

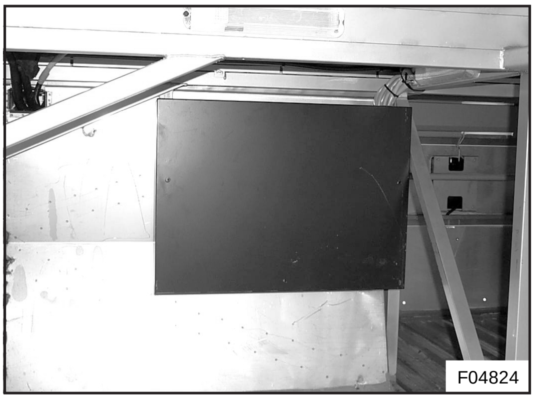

Figure 3: HVAC junction box (in the luggage compartment)

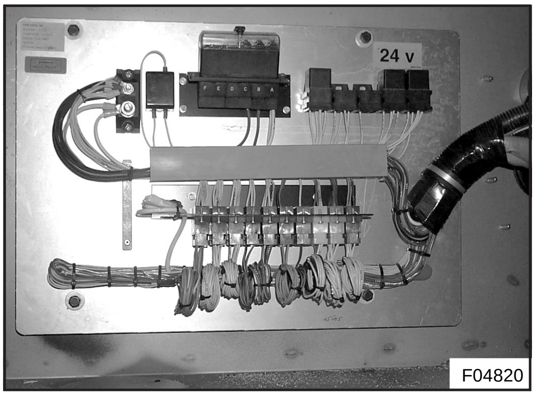

Figure 4: Engine junction box (in the luggage compartment)

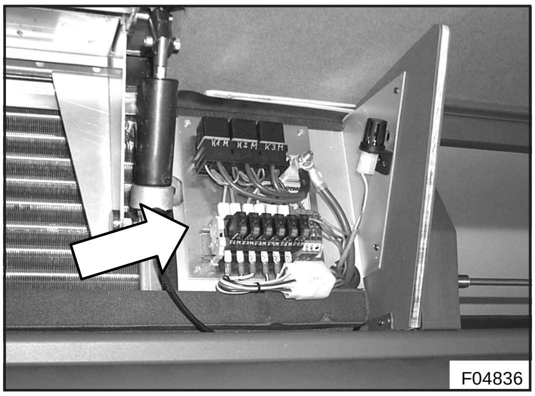

Figure 5: Junction box behind air filter access panel in parcel rack (at left and right side of aisle)

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FUSES

MEGA® FUSES

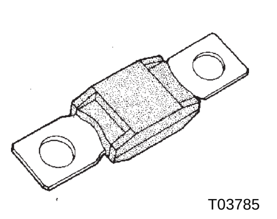

Figure 6: Mega® fuse

The main circuits are protected by Mega® fuses located in the battery junction box.

No.	AMP	PROTECTED CIRCUITS
02	125 A	• Main fuse "HVAC"
05	100 A	• Wheelchair lift Stewart & Stevenson
06	125 A	• Main fuse "Main junction box"

MAXIFUSES

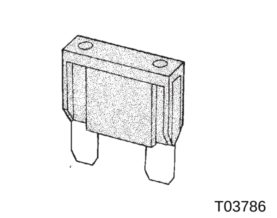

Figure 7: Maxifuses

These are located in the main junction box and the battery junction box.

In main junction box

No.	AMP	PROTECTED CIRCUITS
010(1)	30 A	• Starter motor
151	30 A	• Main fuse "+12VDC"

(1) From VIN 45021 (Cummins) and VIN 45521 (Detroit Diesel) onwards located in battery junction box

In battery junction box

No.	AMP	PROTECTED CIRCUITS
10(2)	30 A	• Starter motor
15	30 A	• Main fuse "audio/video"
84(3)	80 A	• Battery equalizer
85(3)	40 A	• Battery equalizer
88	30 A	• Main fuse "B+"
89.1	30 A	• Main fuse "engine supply"
89.2	30 A	• Main fuse "transmission supply"
150	50 A	• Main fuse "+12VDC"
201	50 A	• 110V system

(2) Prior to VIN 45021 (Cummins) and VIN 45521 (Detroit Diesel) located in main junction box
(3) From VIN 45021 (Cummins) and VIN 45521 (Detroit Diesel) onwards

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AUTOFUSES

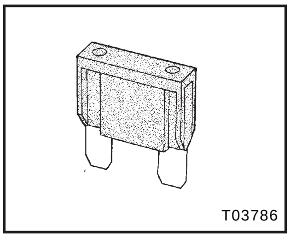

Figure 8: Autofuses

These are located in the main junction box.

No.	AMP	PROTECTED CIRCUITS
43	3 A	• DDEC ProDriver
154	10 A	• Audio/video
155	10 A	• Flasher at entrance door indicating the coach is lowering/raising, audio/video +12VDC, backup buzzer
156	3 A	• Amplifier of antenna

BLADE FUSE

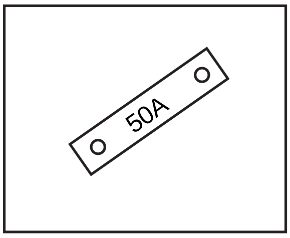

Figure 9: Blade fuse

These are located in the HVAC junction box.

No.	AMP	PROTECTED CIRCUITS
F1M	50 A	• HVAC system
F2M	50 A	• HVAC system

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CIRCUIT BREAKERS

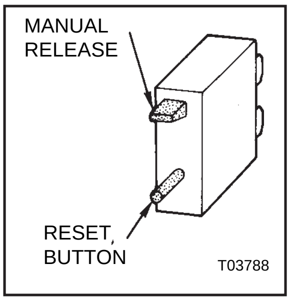

Figure 10: Circuit breaker

The subcircuits are protected by circuit breakers. They are of the manual reset type. When a circuit breaker is overloaded, the black reset button pops out, thus opening the circuit. To reset the circuit breaker, push the reset button. If the circuit breaker pops out again, have the electrical circuit checked.

IN MAIN JUNCTION BOX

No.	AMP	PROTECTED CIRCUITS
20	8 A	• Switched D+ signal
22.1	15 A	• Driver's compartment HVAC unit blower
22.2	8 A	• Rear docking lights
22.3	8 A	• Front docking lights
23	15 A	• Driver's compartment HVAC unit blower
23.1	8 A	• Stop lights
25	8 A	• Socket for +24VDC portable lamp, starter switch in engine compartment, engine compartment lights
26	8 A	• Luggage compartment lights
28	8 A	• Entrance light, "Watch your step" light, interior light control
29	8 A	• Spotlights wheelchair lift
29.2	8 A	• Amplifier of loudspeakers
30	8 A	• Marker lights relay, neutral/parking brake relay, ignition switch, DDEC/ISM security
31	15 A	• Windshield wipers (high speed)
32	10 A	• ABS
33	10 A	• ABS
34	8 A	• Aisle night lights, hatrack night lights, interior light control
35	8 A	• Map light, driver's light, first aisle light, guide/video light
36.1	15 A	• Aisle light (fluorescent lights)
36.2	15 A	• Aisle light (fluorescent lights)
37.1	15 A	• Reading lights (right side)
37.2	15 A	• Reading lights (left side)
39	8 A	• Luggage compartment lights control, cigarette lighter
42	8 A	• Road Relay (Cummins)
43	3 A	• ProDriver (Detroit Diesel)
46.1	8 A	• Toilet compartment (lights, occupied light, exhaust fan)
47	8 A	• +12VDC main relay control
49	8 A	• ISM diagnostics (Cummins)
50	8 A	• Digital clock, transmission

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No.	AMP	PROTECTED CIRCUITS
51	8 A	• Exitation alternator D+, engine stop, stop lights
52	8 A	• Tag axle unloading, warning system at entrance door indicating coach is lowering/raising, suspension raise/lower system
53	8 A	• Windshield wipers/washers, side mirror adjustment and heating, horn
54	8 A	• Exterior lights control
55	8 A	• Turn signals
56	8 A	• Starter override switch in engine compartment, driver's side window heating
57	8 A	• Battery equalizer, dashboard supply, Jake Brake
58	8 A	• Stepwell lights, fire alarm
59	8 A	• Road Relay control (Cummins), backup lights, transmission
60	8 A	• Cooling fan clutch
61	8 A	• Air dryer
62	8 A	• Destination sign
65	8 A	• Passengers compartment fresh air flaps
66	6 A	• ABS
80	8 A	• Battery disconnect solenoid
81.1	10 A	• Turn signals, Road Relay (Cummins)
82	8 A	• Digital clock, combustion heater timer
83.1	15 A	• Combustion heater
83.2	15 A	• Combustion heater
93	8 A	• Marker lights(RHS), Road Relay (Cummins)
94.1	8 A	• Transmission selector light, dashboard lights
94.2	8 A	• Marker lights(LHS), lights in switches
95	8 A	• Headlights, low beam
96	8 A	• Headlights, low beam
97	8 A	• Headlights, high beam
98	8 A	• Headlights, high beam
131	8 A	• Fresh air intake flap and hot water control of driver's compartment HVAC unit
152	8 A	• +12V CB socket
153	15 A	• Audio/video +12VDC, marker lights
185	8 A	• Entrance door

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IN BATTERY JUNCTION BOX

No.	AMP	PROTECTED CIRCUITS
F1	6 A	• Engine fuel control system (Cummins)
F4	15 A	• Engine fuel control system (Cummins)
F5	15 A	• Engine fuel control system (Cummins)
70	8 A	• D+ alternator 2
71	8 A	• D+ alternator 1
79	6 A	• "W" terminal of alternator

IN ENGINE JUNCTION BOX

No.	AMP	PROTECTED CIRCUITS
F1	6 A	• Engine fuel control system (Detroit Diesel)
F4	15 A	• Engine fuel control system (Detroit Diesel)
F5	15 A	• Engine fuel control system (Detroit Diesel)

IN HVAC JUNCTION BOX

No.	AMP	PROTECTED CIRCUITS
F1M	10 A	• HVAC system
F2M	10 A	• HVAC system
F21M	10 A	• Condenser fan
F22M	10 A	• Condenser fan
F23M	10 A	• Condenser fan
F24M	10 A	• Condenser fan
F25M	10 A	• Condenser fan
F26M	10 A	• Condenser fan

BEHIND THE AIR FILTER ACCESS PANEL IN THE PARCEL RACK (AT LEFT AND RIGHT SIDE)

No.	AMP	PROTECTED CIRCUITS
F1M	10 A	• Blower M1
F2M	10 A	• Blower M2
F3M	10 A	• Blower M3
F4M	10 A	• Blower M4
F5M	10 A	• Blower M5
F6M	10 A	• Blower M6

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RELAYS

IN MAIN JUNCTION BOX

No.	DESCRIPTION
RL004.2	Road relay (Cummins)
RL014.1	Toilet fan
RL014.2	Toilet fan
RL015.2	Waste holding tank full
RL018	Backup buzzer
RL021	Step lights rear passengers door
RL023	Step lights front passengers door
RL025	Clearance and marker lights
RL026	Clearance and marker lights
RL027	Front fog lights
RL028	Headlights, low beam
RL029	Headlights, high beam
RL36	Windshield wipers, low speed
RL37	Windshield wipers, high speed
RL042.1	Stop lights
RL042.2	+15 Allison
RL042.3	Stop light switches
RL043	Reading lights
RL043.2	Reading lights
RL044	Reading lights
RL044.2	Reading lights
RL045.1	Interior lights
RL045.2	Interior lights
RL045.3	Interior lights
RL046	Luggage compartment lights
RL049	D+
RL049.2	D+
RL050	+15
RL053	Door interlock
RL054.1	Audio/video 24V
RL054.2	Audio/video 12V
RL055	Reversing camera
RL075	Flasher on kneeling system
RL075.2	Flasher on kneeling system
RL075.3	Flasher on kneeling system
RL076	Flasher on kneeling system
RL077	Flasher on kneeling system
RL082	Fire alarm
RL083	Cooling fan
RL098.1	Hazard warning lights
RL098.2	Hazard(lift)
RL098.3	Hazard(lift)

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IN MAIN JUNCTION BOX

No.	DESCRIPTION
RL503[(1)]	Starter motor
RL505	Cooling fan clutch
RL511.1	Main switch 12VDC
RL511.2	Main switch 24VDC
RL521.2	Starter interlock
RL521.3	Starter switch
RL522	Tag axle unloading
RL528	Lift light
RL543	Cruise/high idle
RL711	Day lights
RL711.2	Day lights
RL714.1	Docking lights
RL714.2	Docking lights
RL714.3	Docking lights
RL714.4	Docking lights
RL714.5	Docking lights
RL714.6	Docking lights

(1) From VIN 45021 (Cummins) and VIN 45521 (Detroit Diesel) onwards located in battery junction box

IN BATTERY JUNCTION BOX

No.	DESCRIPTION
RL503[(2)]	• Starter motor

(2) Prior to VIN 45021 (Cummins) and VIN 45521 (Detroit Diesel) located in main junction box

IN ENGINE JUNCTION BOX

No.	DESCRIPTION
RLK1	• Engine fuel control system
RL10.1	• Engine fuel control system (Cummins)
RL904	• Engine fuel control system (Cummins)
RL905	• Engine fuel control system
RL906	• Engine fuel control system

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IN HVAC JUNCTION BOX

No.	DESCRIPTION
K2A	• HVAC system
K3A	• HVAC system
K4A	• HVAC system
K5A	• HVAC system
K6A	• HVAC system
K21M	• HVAC system
K22M	• HVAC system
K23M	• HVAC system
K24M	• HVAC system
K25M	• HVAC system
K26M	• HVAC system
K27M	• HVAC system
K28M	• HVAC system

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FUSES, CIRCUIT BREAKERS AND RELAYS ON MULTIPLEXED VEHICLES

Figure 1: Main junction box (in the luggage compartment)

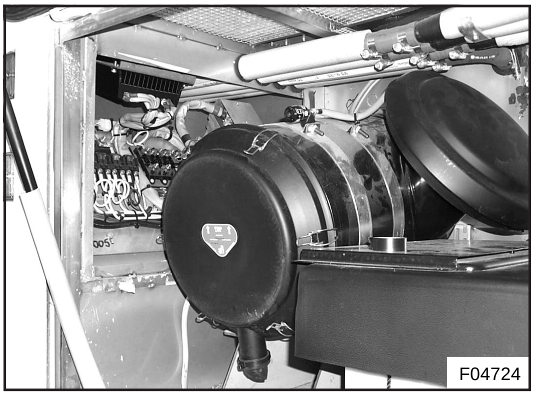

Figure 2: Battery junction box (behind the rear door at the left side of the coach)

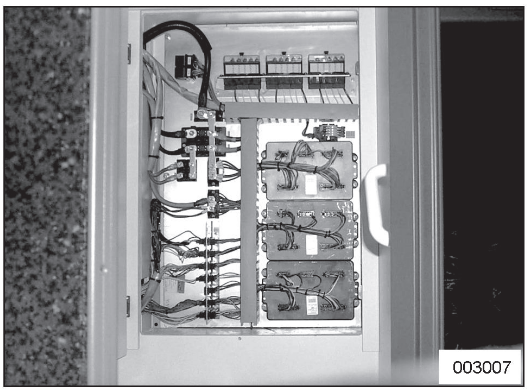

Figure 3: Toilet compartment junction box (behind rear wall of toilet compartment)

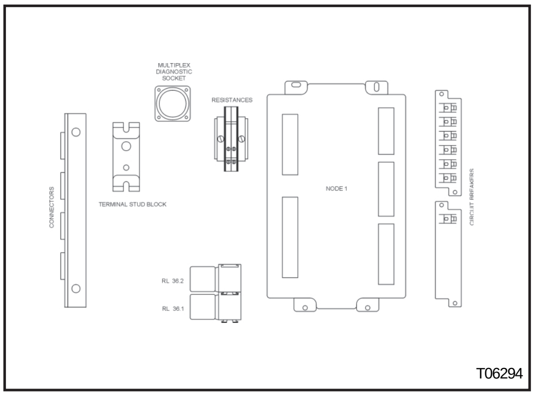

Figure 4: Front junction box (behind the right-hand dash panel)

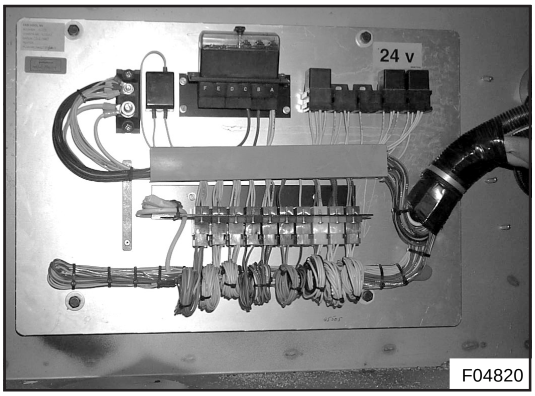

Figure 5: Engine junction box (in the luggage compartment)

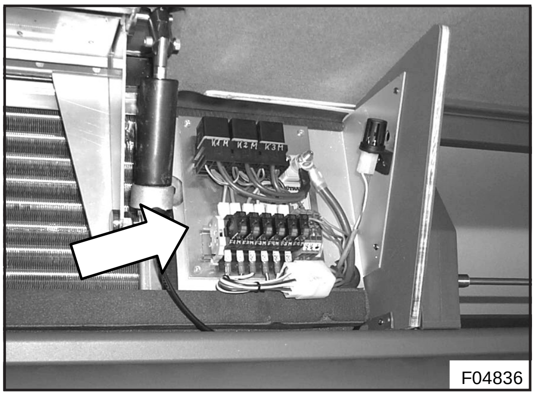

Figure 6: Junction box behind air filter access panel in parcel rack (at left and right side of aisle)

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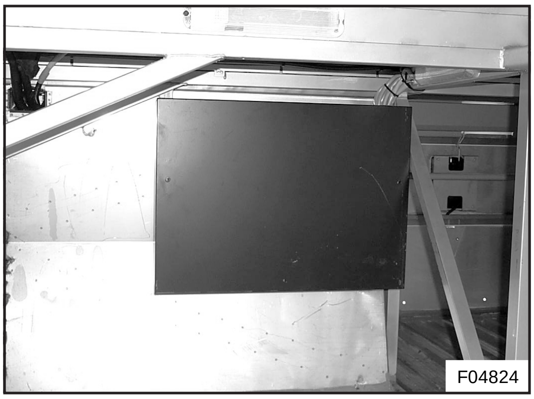

Figure 7: HVAC junction box (in the luggage compartment)

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FUSES

MEGA® FUSES

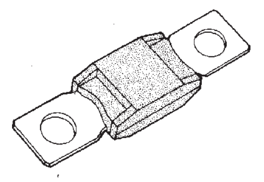

Figure 8: Mega® fuse

The main circuits are protected by Mega® fuses located in the battery junction box and in the toilet compartment junction box.

No.	AMP	PROTECTED CIRCUITS
02	125 A	• Main fuse "HVAC"
05	100 A	• Wheelchair lift Stewart & Stevenson
06	125 A	• Main fuse "Main junction box"

MAXIFUSES

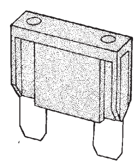

Figure 9: Maxifuses

These are located in the main junction box and the battery junction box.

In main junction box

No.	AMP	PROTECTED CIRCUITS
130	50 A	• Node 1
151	30 A	• Main fuse "+12VDC"

In battery junction box

No.	AMP	PROTECTED CIRCUITS
10	30 A	• Starter motor
15	30 A	• Main fuse "audio/video"
84	80 A	• Battery equalizer
85	40 A	• Battery equalizer
88	30 A	• Main fuse "B+"
89.1	30 A	• Main fuse "engine supply"
89.2	30 A	• Main fuse "transmission supply"
150	50 A	• Main fuse "+12VDC"

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AUTOFUSES

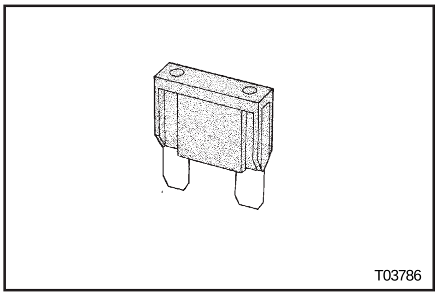

Figure 10: Autofuses

These are located in the main junction box.

No.	AMP	PROTECTED CIRCUITS
43	3 A	• DDEC ProDriver
154	10 A	• Audio/video
155	10 A	• Flasher at entrance door indicating the coach is lowering/raising, audio/ video +12VDC, backup buzzer
156	3 A	• Amplifier of antenna
158	15 A	• Front fog lights

MIDI® FUSES

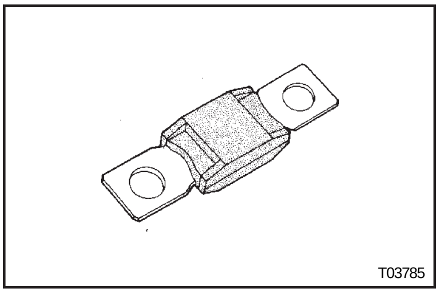

Figure 11: Midi® fuse

These are located in the toilet compartment junction box.

No.	AMP	PROTECTED CIRCUITS
F1M	50 A	• HVAC system
F2M	50 A	• HVAC system

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CIRCUIT BREAKERS

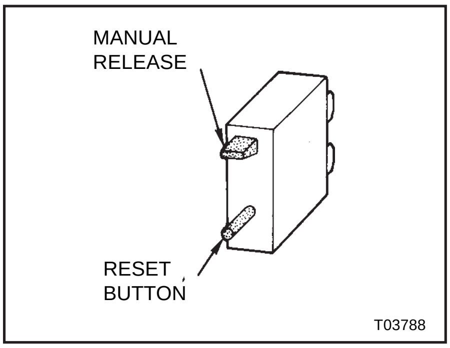

Figure 12: Circuit breaker

The subcircuits are protected by circuit breakers. They are of the manual reset type. When a circuit breaker is overloaded, the black reset button pops out, thus opening the circuit. To reset the circuit breaker, push the reset button. If the circuit breaker pops out again, have the electrical circuit checked.

IN MAIN JUNCTION BOX

No.	AMP	PROTECTED CIRCUITS
16	10 A	• Wheelchair lift
22.1	15 A	• Driver's compartment HVAC unit blower
23	15 A	• Driver's compartment HVAC unit blower
25	8 A	• Socket for +24VDC portable lamp, starter switch in engine compartment
26	15 A	• Luggage compartment lights
29.2	8 A	• Amplifier of loudspeakers
32	10 A	• ABS
33	10 A	• ABS
35	8 A	• Guide/video light
36	8 A	• Side mirror adjustment
39	8 A	• Voltage reference, cigarette lighter
42	8 A	• Road Relay (Cummins) • Starter • DDEC/ISM security • Jake Brake
46.1	8 A	• Toilet compartment (lights, occupied light, exhaust fan) • Flasher and buzzer at entrance door indicating the coach is lowering/raising • Suspension raise/lower system
47	8 A	• +12VDC main relay control, marker lights, exterior lights
49	8 A	• ISM diagnostics (Cummins)
80	8 A	• Master switch supply
81.1	10 A	• Turn signals, Road Relay (Cummins)
81.2	10 A	• Turn signals, ignition switch
82	8 A	• Digital clock, combustion heater timer
83.2	15 A	• Combustion heater
84.1	8 A	• Multiplex computermodule (ZR)
85	8 A	• Dashboard node

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No.	AMP	PROTECTED CIRCUITS
95	8 A	• Headlights RHS, low beam
96	8 A	• Headlights LHS, low beam
97	8 A	• Headlights RHS, high beam
98	8 A	• Headlights LHS, high beam
131	8 A	• Defroster
152	8 A	• +12V CB socket
153	15 A	• Audio/video +12VDC
185	8 A	• Entrance door
200	15 A	• Node 2
201	15 A	• Node 2
202	15 A	• Node 2
203	15 A	• Node 2
204	15 A	• Node 2
300	15 A	• Node 3
301	15 A	• Node 3
302	15 A	• Node 3
303	15 A	• Node 3
304	15 A	• Node 3

IN TOILET COMPARTMENT JUNCTION BOX

No.	AMP	PROTECTED CIRCUITS
400	15 A	• Node 4
401	15 A	• Node 4
402	15 A	• Node 4
403	15 A	• Node 4
404	15 A	• Node 4
500	15 A	• Node 5
501	15 A	• Node 5
502	15 A	• Node 5
503	15 A	• Node 5
504	15 A	• Node 5
600	15 A	• Node 6
601	15 A	• Node 6
602	15 A	• Node 6
603	15 A	• Node 6
604	15 A	• Node 6

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IN BATTERY JUNCTION BOX

No.	AMP	PROTECTED CIRCUITS
F1	6 A	• Engine fuel control system
F4	10 A	• Engine fuel control system
F5	10 A	• Engine fuel control system
70	8 A	• D+ alternator 2
71	8 A	• D+ alternator 1

IN FRONT JUNCTION BOX

No.	AMP	PROTECTED CIRCUITS
31	15 A	• Windshield wipers
100	15 A	• Node 1
101	15 A	• Node 1
102	15 A	• Node 1
103	15 A	• Node 1
104	15 A	• Node 1
105	8 A	• Diagnostics

IN HVAC JUNCTION BOX

No.	AMP	PROTECTED CIRCUITS
F1M	10 A	• HVAC system
F2M	10 A	• HVAC system
F21M	10 A	• Condenser fan
F22M	10 A	• Condenser fan
F23M	10 A	• Condenser fan
F24M	10 A	• Condenser fan
F25M	10 A	• Condenser fan
F26M	10 A	• Condenser fan

BEHIND THE AIR FILTER ACCESS PANEL IN THE PARCEL RACK (AT LEFT AND RIGHT SIDE)

No.	AMP	PROTECTED CIRCUITS
F1M	10 A	• Blower M1
F2M	10 A	• Blower M2
F3M	10 A	• Blower M3
F4M	10 A	• Blower M4
F5M	10 A	• Blower M5
F6M	10 A	• Blower M6

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RELAYS

IN MAIN JUNCTION BOX

No.	DESCRIPTION
RL014	Toilet fan
RL026	Marker lights
RL027	Front fog lights
RL028	Headlights, low beam
RL029	Headlights, high beam
RL035	Turn signals
RL042.2	+15 Allison
RL042.3	Stop light switches
RL045.1	Interior lights
RL045.2	Interior lights
RL046	Luggage compartment lights
RL054.1	Audio/video 24V
RL054.2	Audio/video 12V
RL055	Reversing camera
RL077	Flasher on kneeling system
RL083	Engine cooling fan (retarder)
RL511.1	Main switch 12VDC
RL511.2	Main switch 24VDC
RL539	Dashboard emergency switch
RL568.2	Jake Brake control
RL568.3	Jake Brake control
RL711.1	Day lights
RL711.2	Day lights

IN FRONT JUNCTION BOX

No.	DESCRIPTION
RL36.1	• Windshield wipers
RL36.2	• Windshield wipers

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IN BATTERY JUNCTION BOX

No.	DESCRIPTION
RL503	• Starter motor

IN ENGINE JUNCTION BOX

No.	DESCRIPTION
RLK1 RL10.1 RL904 RL905 RL906	• Engine fuel control system • Engine fuel control system (Cummins) • Engine fuel control system (Cummins) • Engine fuel control system • Engine fuel control system

IN HVAC JUNCTION BOX

No.	DESCRIPTION
K2A K3A K4A K5A K6A K21M K22M K23M K24M K25M K26M K27M K28M	• HVAC system • HVAC system • HVAC system • HVAC system • HVAC system • HVAC system • HVAC system • HVAC system • HVAC system • HVAC system • HVAC system • HVAC system • HVAC system

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ELECTRICAL WIRING DIAGRAMS

READING WIRING DIAGRAMS

GENERAL

The electrical wiring diagram is divided into several separate subdiagrams. Each subdiagram contains a number of electrical components related by their function. All subdiagrams have been collected in an "Electrical wiring diagram booklet", which is supplied separately with your vehicle.

The front page of that "Electrical wiring diagram booklet" contains following data: vehicle model, publication date and VIN numbers (only if the booklet is valid for a certain vehicle or for a series of vehicles).

COMPONENT LOCATION- Figure 1

Each subdiagram is sectioned off by horizontal lines. Most sections are marked with a letter code (EKM, IB,...) at the right side of the page. Each section corresponds with a particular location on the vehicle. The components which are drawn in the uncoded section are located somewhere on the chassis or body. The exact location of these components can usually be found from its designation or function description.

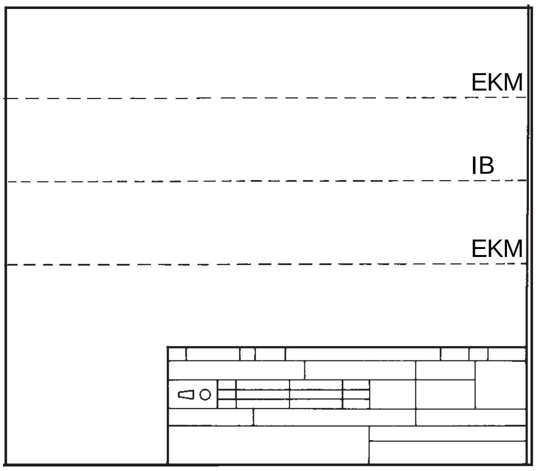

Figure 1: Diagram divided in sections by horizontal lines

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Examples of section codes:

- EKV: Main junction box;
- EKB: Battery junction box;
- EKE: ISM/DDEC junction box;
- IB: instrument panel.

ELECTRICAL SYMBOLS

All electrical components (lamps, relays, switches,...) are represented in the diagrams by a standard system of symbols. The symbols used by Van Hool are listed in figure 5.

COMPONENT NAME

The component name is found near its symbol. The letter in the name indicates the type of the component (switch, relay, lamp, ...). The legend of all the component names is shown on the facing page. Spring-loaded switches can be accompanied by the letters "NO" (=normally open) or "NC" (=normally closed). A "NO" switch is open, if no operating force acts on it. A "NC" switch is closed, if no operating force acts on it.

POWER SUPPLY INDICATION

The circuit is protected by a fuse (or circuit breaker) at the top of the page. The power supply mark (+30, B+ ...) is found at the start of the circuit. This tells you how the circuit is connected to the power source (battery, alternator) and when it is powered.

B+ : Power supplied directly from battery

+30 : Power supplied with master switch on

+15 : Power supplied with ignition on

D+ : Power supplied with engine running, from alternator(s)

+58 : Power supplied with marker lights on

+56 : Power supplied with head lights on

STANDARD CONDITIONS

All diagrams are shown under the following circumstances:

- no electrical power supply (batteries disconnected);
- normal air pressure in air tanks (115 psi);
- all doors and hatches closed;
- temperature 70 °F;
- transmission in neutral;
- brakes released;
- engine not running;
- all systems switched off.

WIRING COLOR CODE

The insulation on each wire is distinctly colored to assist in tracing and testing circuits.
There are three types of color coding used throughout the electrical diagrams:

- Solid color: GE
- Solid color with single stripe: GE-B
- Solid color with double stripe: GE-B-W.

In the diagram, next to the wire, you will find a letter code indicating the wire color.

NOTE
Color codes on "Van Hool" diagrams refer to abbreviations from the Dutch wording; on "Carrier Sütrak" diagrams to abbreviations from the English wording.

Color	Color Code on Van Hool diagram	Color Code on Carrier Sütrak diagram
Black	Z	BK
Brown	BR	BN
Red	R	RD
Orange	O	OR
Yellow	GE	YE
Green	GN	GN
Blue	B	BU
Violet	V	VO
Grey	GS	GY
White	W	WH
Transparent	T	TRANSP
Pink	RO	-

NOTE
The color of the ground wires is brown on current vehicles. Older vehicles, however, have black ground wires.

WIRE CONDUCTOR SIZE

- All wire conductor size indications are metric and refer to size in mm^2.
- All wires with no indication of conductor size in the diagram will be 1 mm^2 (1.5 mm^2 on older vehicles).
- If replacements are needed, refer to table below for appropriate replacement.

Wire size indication found in electrical diagram (mm^2)	Appropriate replacement (AWG)
0.75	18
1	16
1.5	14
2.5	12
6	8
16	4
35	1
70	3/0

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CROSS REFERENCES

If a circuit on one diagram ties-in with circuits shown on the same page or on other diagrams, cross references are made.

Examples:

19 F $\boxed{\text{XX254}}$	:	Wire continues on to another page (example: go to page 19F, look for XX254)
XY2	:	Wire continues on the same page (example: look for XY2 on the same page)

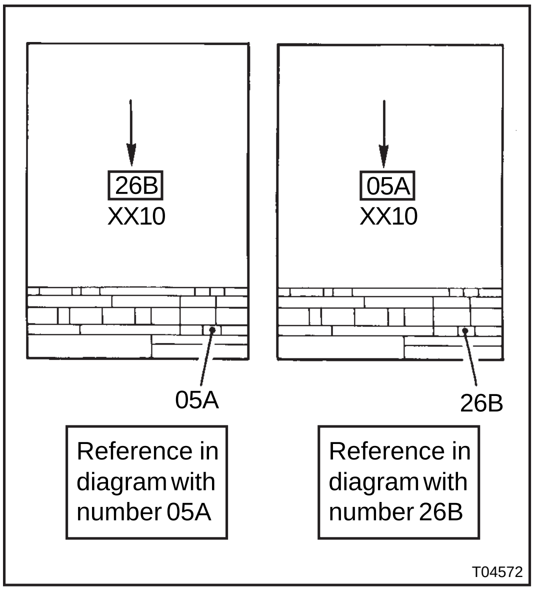

Figure 2: Reference to another subdiagram

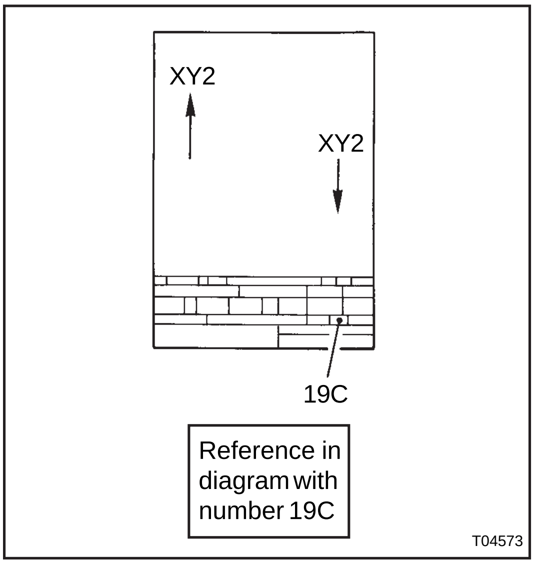

Figure 3: Reference within the same subdiagram

CONNECTORS

All connectors, with the exception of the component connectors, are represented by a letter "P", followed by the connector number, a dot and the connector pin number.

Example: P223.5

P= connector
223= connector number
5= pin number

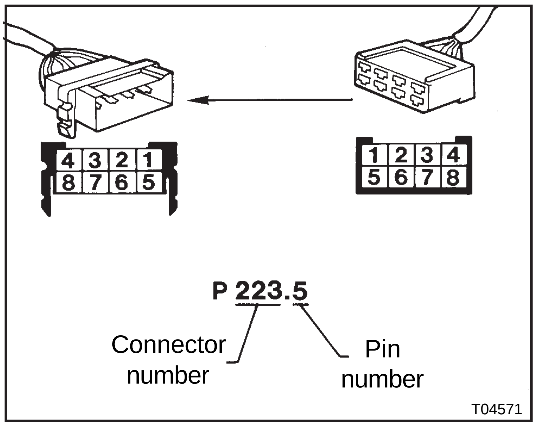

Figure 4: Pin numbering of connector P223. Male connector at the LHS, female connector at the RHS. The pin numbers are to be considered from the wire input side.

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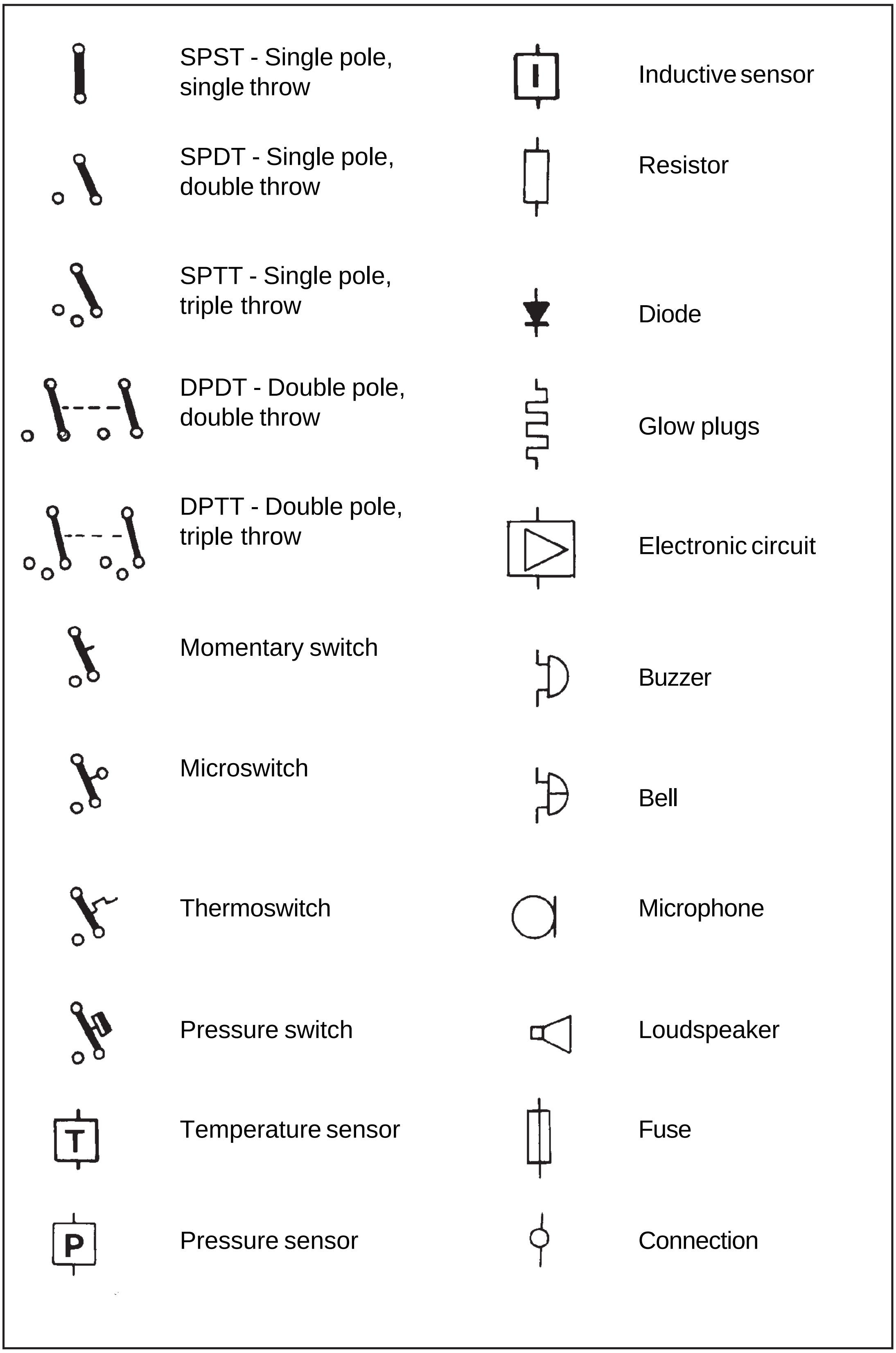

Figure 5: Electrical symbols

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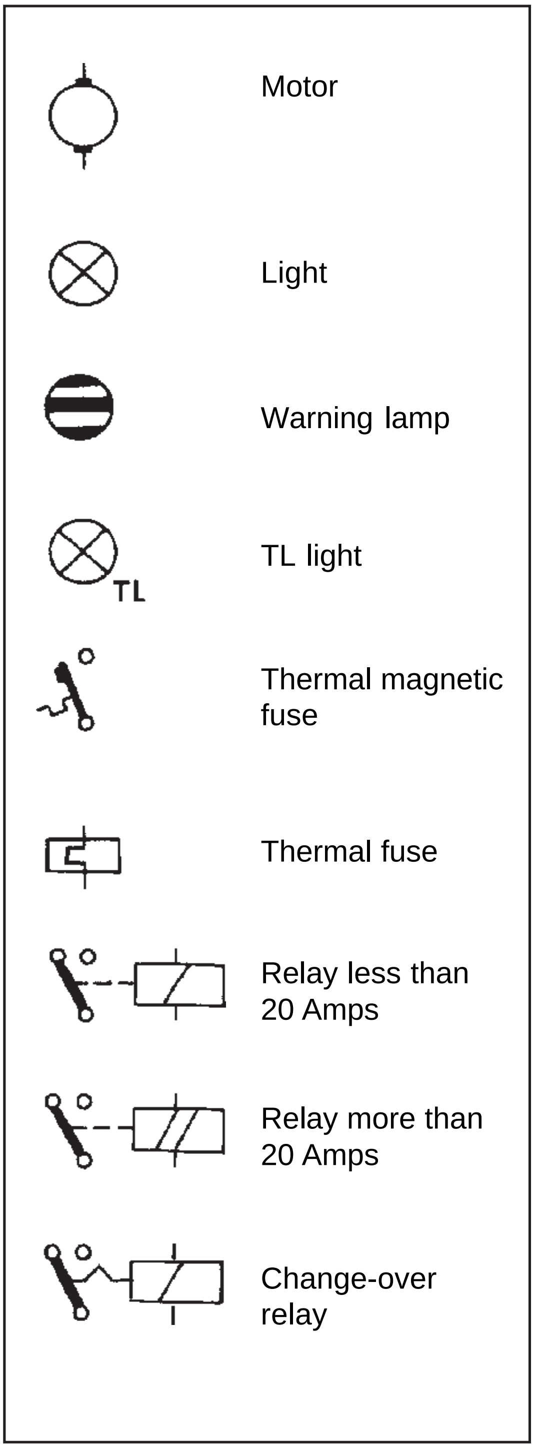

Figure 5: Electrical symbols

ELECTRICAL WIRING DIAGRAM BOOKLET

The electrical wiring diagram booklet is supplied separately with your vehicle.
A careful study of the wiring diagrams should be made to determine the source and flow of current through each electrical circuit.

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CONTROLLER AREA NETWORK (CAN) OF DRIVE LINE

GENERAL

The increasing numbers of Electronic Control Units (ECUs) used in a Van Hool coach makes it necessary to use a Controller Area Network (CAN) system. The conventional method for organizing the interrelationship between the ECUs is to assign single dedicated wires to the signals. This method no longer suffices for mastering the requirements associated with the growth in data communications between the ECUs. The wiring harness would become enormous complex and bulky, while the number of pins at the ECUs also becomes excessive. The CAN system has been especially developed to solve these communication problems.

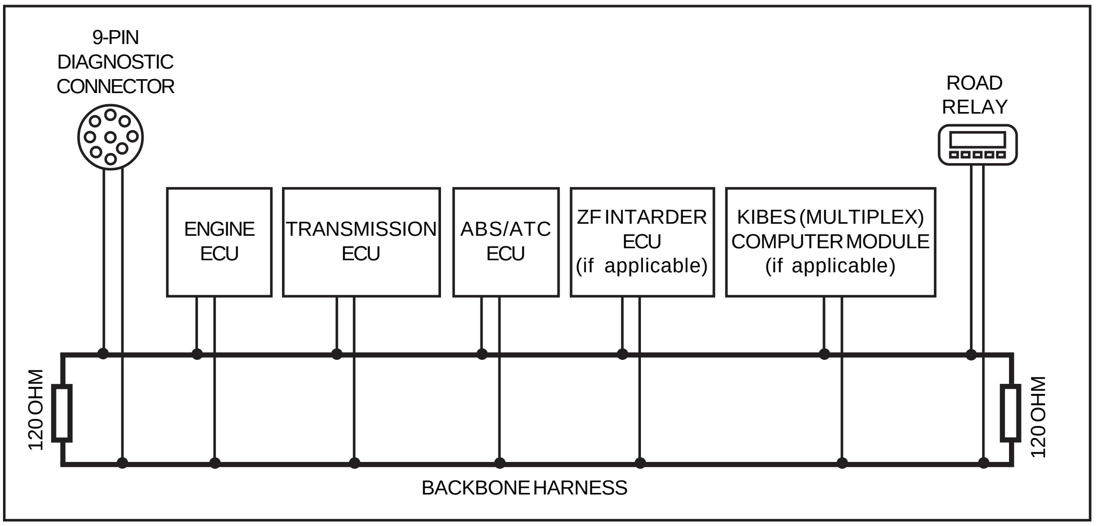

Figure 1: CAN system on a vehicle with Cummins ISM engine

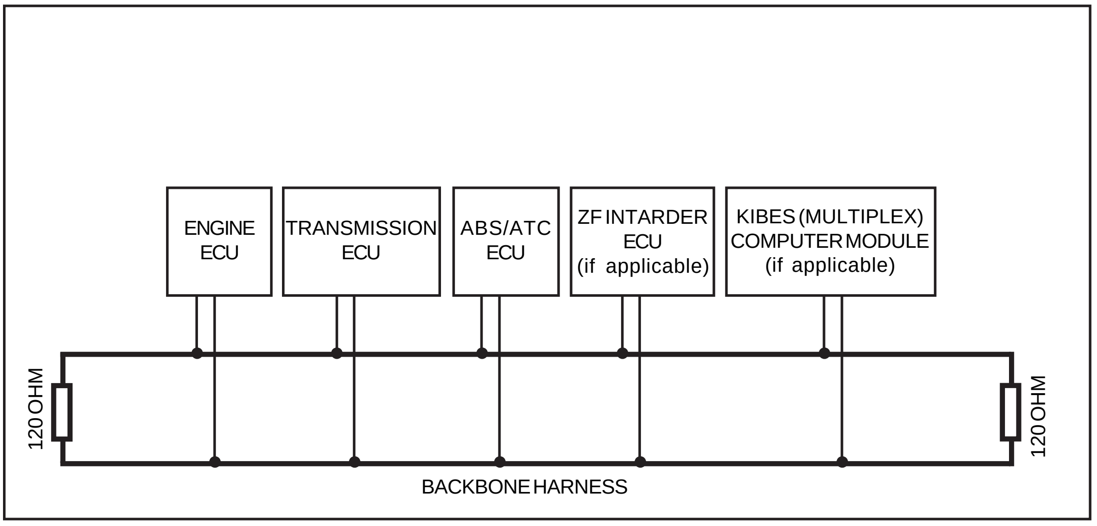

Figure 2: CAN system on a vehicle with Detroit Diesel Series 60 DDEC IV engine

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The main component of the CAN-bus system is the backbone harness. It consists of:

• several three-pin triangular connectors (plugs, receptacles and "T" receptacles). Note that the connector to attach a device (ECU, diagnostic connector or Road-Relay 4.0) to the backbone harness is called a "stub"; the connector to attach a terminating resistor to the backbone harness is called a "through".
The pinouts for the three-pin connectors are: pin "A" is CAN-H, pin "B" is CAN-L and pin "C" is "shield" (see Figure 3).

• a 120 Ohm resistor at each end. The resistors are mounted in a removable cap (see Figure 4). The terminating

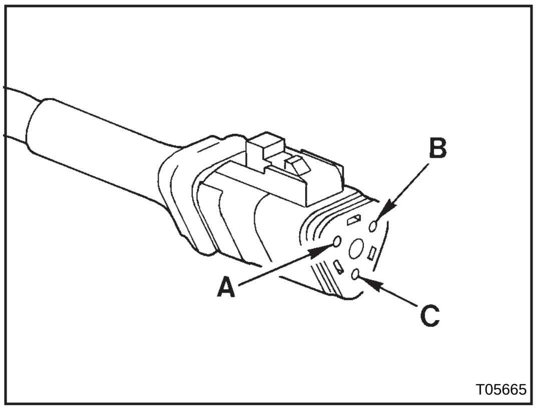

Figure 3: Pinouts of three-pin connector

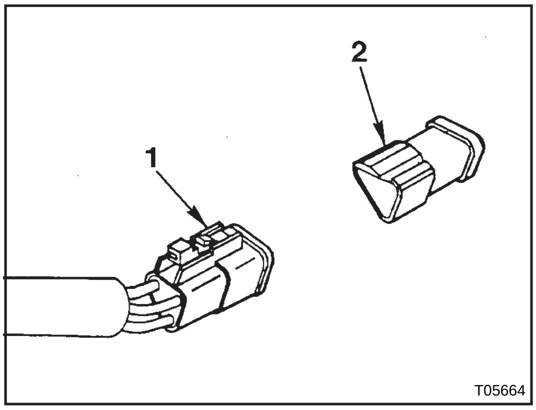

Figure 4: Backbone harness end

1. Through connector
2. Terminating resistance cap

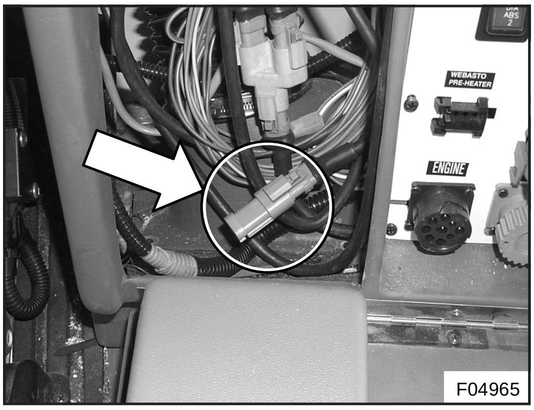

Figure 5: "Through" connector aside the diagnostic box in the R.H. console of the dashboard (Cummins ISM engine only)

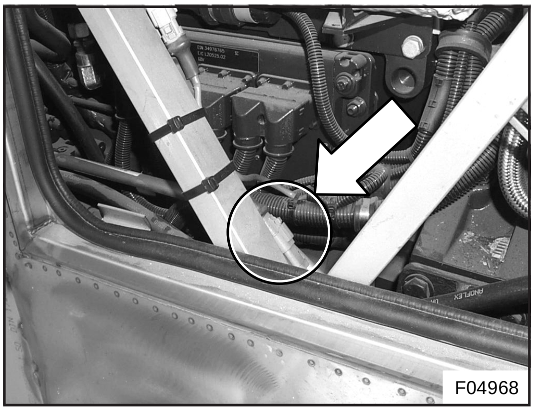

Figure 6: "Through" connector near the engine ECU. This connector is accessible after removing the access panel in the compartment behind the right tag wheel (Cummins ISM and Detroit Diesel engines)

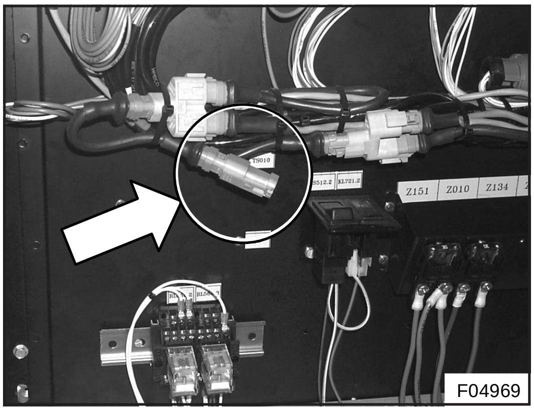

Figure 7: "Through" connector in the left part of the main junction box. This connector is accessible after removing the left access panel of the main junction box (Detroit Diesel engine only)

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resistor caps must be in place on the backbone harness to maintain proper communication. Refer to Figures 5, 6 and 7 for location of the "through" connectors.

• a special wiring cable (see Figure 8). The cable contains a green (CAN-L) conductor, a yellow (CAN-H) conductor and a braid wire (shield). The "shield" is grounded to the chassis (see Figure 9) with a ring connector. A cable between a device and the backbone harness is called a "cable tail".

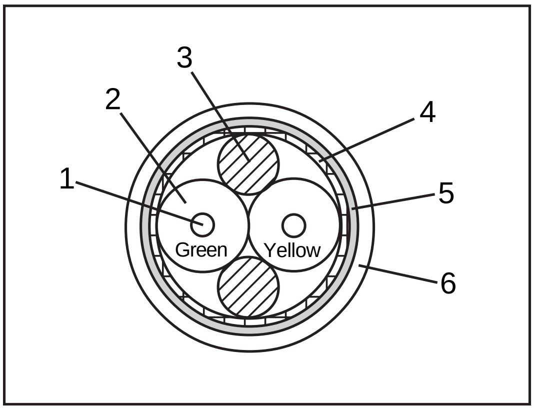

Figure 8: Section through backbone cable

1. Tinned copper conductor
2. Insulation
3. Filler
4. Braid of tinned copper wire (shield)
5. Non-woven polyesterfoil
6. Jacket

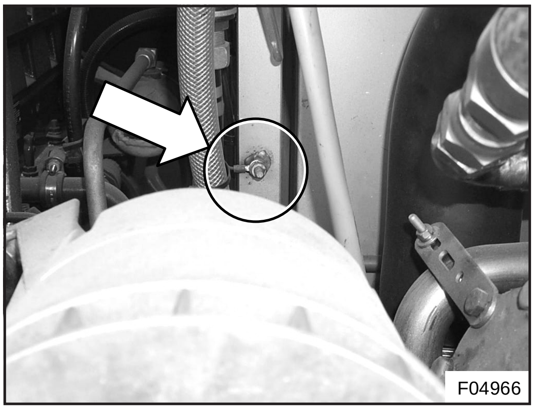

Figure 9: Ground stud in engine compartment, at right side of engine

DIAGNOSTICS

The datalink connection can be verified by using the right diagnostic tool:

• Cummins ISM engine: INSITE™ 5.1 (a personal computer-based tool) + INLINE II (adapter kit);

• Detroit Diesel engine: Prolink 9000;

• WT-transmission: Prolink 9000;

• ABS/ASR system: Prolink 9000.

TO CHECK CAN-BUS WIRING FOR OPEN CIRCUITS

!!! CAUTION !!!
PLACE THE MASTER SWITCH IN THE OFF POSITION BEFORE CHECKING THE CAN-BUS WIRING FOR OPEN CIRCUITS.

Cable tail harness

1. Disconnect the cable tail at the device and the backbone harness.

2. Check the cable tail for an open circuit (resistance check). Connect one VOM probe to the "CAN-H" pin of the connector. Touch the other VOM probe to the "CAN-H" pin of the connector at the other side of the cable tail. The VOM must show a closed circuit. If the circuit is not closed, there is an open circuit in the wiring. Repair or replace the cable tail.

3. Repeat step 2 for the "CAN-L" and "shield" wires of the cable tail.

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Backbone harness

1. Disconnect a cable tail at the "T" receptacle of the backbone harness.

2. Measure the resistance of the backbone harness as follows:

   a. Connect one VOM probe to the "CAN-H" pin of the "T" receptacle.

   b. Touch the other VOM probe to the "CAN-L" pin of the "T" receptacle.

   c. The VOM must show a resistance of 60 Ohms. If 120 Ohms is measured one of the two terminating resistance caps is missing or badly connected. If the VOM shows "infinity", there is an open circuit in the backbone harness.

TROUBLESHOOTING

The table below shows some external events that may cause failures in the CAN-bus system.

FAILURE	RESULT
Device disconnected from network	Remaining devices will continue communication.
Device power or ground loss	Remaining devices will continue communication
Unconnected shield	Communication possible, but electromagnetic interference increases
Open and short failures (see Figure 10).	
1) CAN-H interrupted	1) Communication between devices on opposite sides of interruption not possible, between devices on the same side may be possible, but with reduced signal-to-noise ratio.
2) Can-L interrupted	2) Idem 1
3) Can-H shorted to battery voltage	3) Communication not possible if battery voltage is greater than max. allowed common mode bus voltage.
4) CAN-L shorted to ground	4) Communication possible but signal-to-noise ratio reduced.
5) CAN-H shorted to ground	5) Communication not possible
6) CAN-L shorted to battery voltage	6) Communication not possible
7) Can-H is shorted to CAN-L	7) Communication not possible
8) Both buslines are interrupted at the same location.	8) Idem 1
9) Loss of terminating resistor	9) Idem 4
10) Topology parameter violations (i.e. bus length, cable tail length, device distribution)	10) Idem 4

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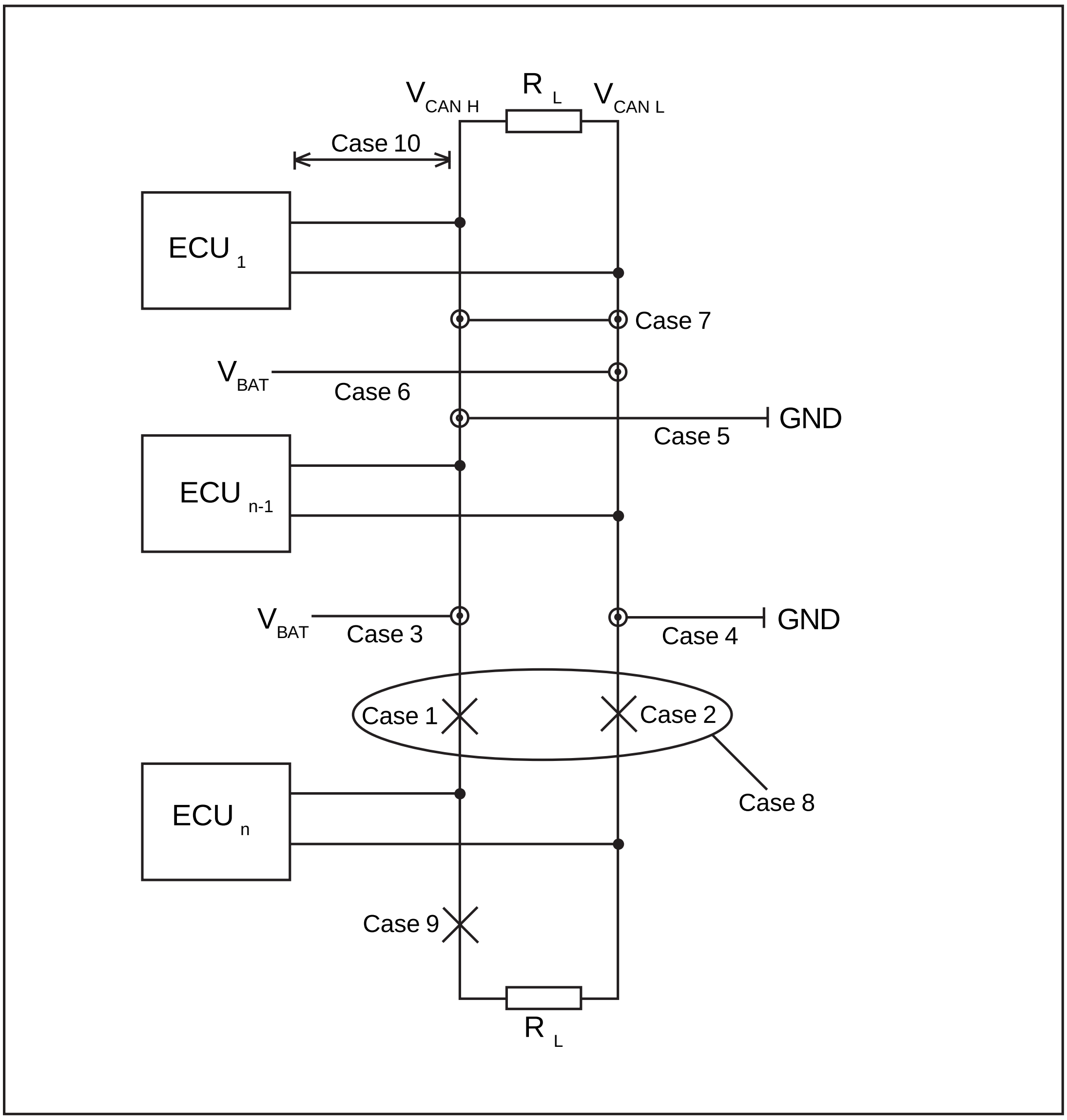

Figure 10:Possible failures due to external events

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MULTIPLEX SYSTEM

!!! CAUTION !!!
BEFORE CARRYING OUT ELECTRIC WELDING ON THE VEHICLE, SWITCH OFF THE BATTERY MASTER SWITCH AND SUBSEQUENTLY DISCONNECT ALL ELECTRONIC CONTROL UNITS. USE ONLY A MULTIMETER AS TEST DEVICE, NOT A TEST LAMP. EXCEPTION: CAN bus TEST DO NOT LENGTHEN OR SHORTEN THE CAN bus. DO NOT REMOVE TERMINATING RESISTANCES. ELECTRONICS ARE VERY SENSITIVE. INCORRECT CONNECTION CAUSES DAMAGE. DO NOT REVERSE THE POLARITY OF THE CONNECTIONS. REPAIR WIRES ALWAYS ACCORDING TO THE RULES OF GOOD WORKMANSHIP. SOLDER AND CRIMP WITH CARE.

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1.1 INTRODUCTION

1.1.1 WHAT IS MULTIPLEX?

Multiplex is a collective term for the technology used to transmit multiple signals (data/commands) through one single conductor between two or more components in an electronic network.

1.1.2 WHY MULTIPLEX?

The advantages of a multiplex system in relation to classic electrical equipment:

- a considerable reduction of the number of wires;
- thinner main cable looms in the vehicle.

The fact that all kinds of switching conditions can be built into a circuit easily means that the entire arrangement of electrical connections is simplified. This leads to:

- a reduction of the number of relays;
- simplification of the junction boxes;
- a reduction of the vehicle mass (= reduced fuel consumption).

The fact that one or more diagnosis possibilities are available in the program makes it easier to test the vehicle or trace faults. Testing can be done through on-board diagnostics or by connecting an external PC. On-board diagnostics means the possibilities provided without the use of special equipment.
The multiplex system also reduces the number of separate electronic connections (for example: turn signal box, windshield wiper interval, timers,...).
The multiplex system can also read messages that are available on the CAN bus of the drive line (SAE J 1939).

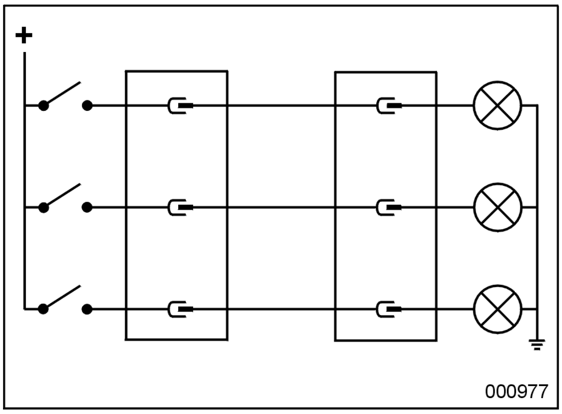

Figure 1: Schematic of classic wiring

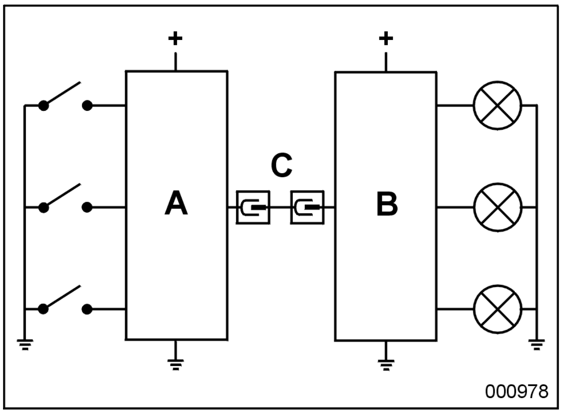

Figure 2: Schematic of multiplex wiring

A. Electronics box
B. Electronics box
C. Signal line

This also leads to a reduction of the number of wires and components in the periphery of the drive line.

1.1.3 WHAT SYSTEM IS USED BY VAN HOOL?

Van Hool use the KIBES multiplex system. KIBES is the abbreviation of “Kienzle Bord Elektronik System”.

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1.2 LAYOUT

1.2.1 INTRODUCTION

The system is assembled with "hardware" components (= all apparatus in the system). This "hardware" is controlled by the "software" (= program required in order to enable the "hardware" to function according to your needs).

1.2.2 HARDWARE COMPONENTS

The Kibes system consists of the following "hardware" components:

- a computer module (master) that contains the driver, in other words the programmable intelligence;
- a number of nodes (slaves) without programmable intelligence, just inputs and outputs;
- CAN bus (connection between the elements of the multiplex system).

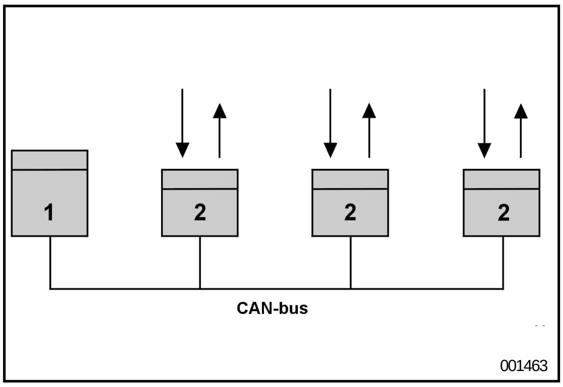

Figure 3: Layout

1. **Master**
2. **Slave**

1.2.3 SOFTWARE VERSIONS

Up to now two software versions have been applied at Van Hool: version 1 and version 2.

1.2.4 WHICH SOFTWARE VERSION APPLIES TO YOUR VEHICLE?

Refer to "Overview of inputs and outputs" to find out which software version applies to your vehicle.

NOTE
"OVERVIEW OF INPUTS AND OUTPUTS" IS A PUBLICATION SUPPLIED SEPARATELY WITH YOUR VEHICLE.

- Software version **1:** "node inputs" table contains the columns **F, N, D1** and **D2**.
- Software version **2**: "node inputs" table contains the columns **F, N** and **D**.

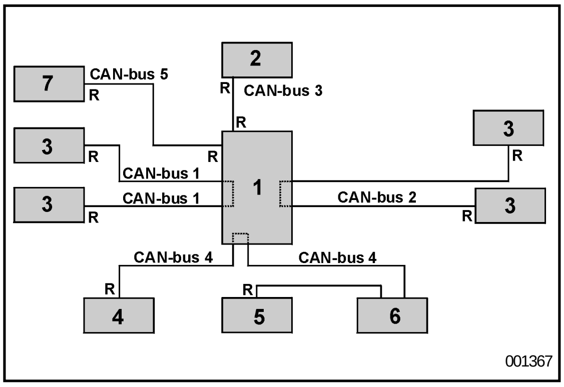

Figure 4: Example of a KIBES multiplex network

1. **Computer module**
2. **Dashboard node**
3. **Node**
4. **Engine electronic control unit**
5. **Transmission electronic control unit**
6. **Door controls**

R. Terminating resistance

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1.3 VISUAL IDENTIFICATION OF HARDWARE COMPONENTS

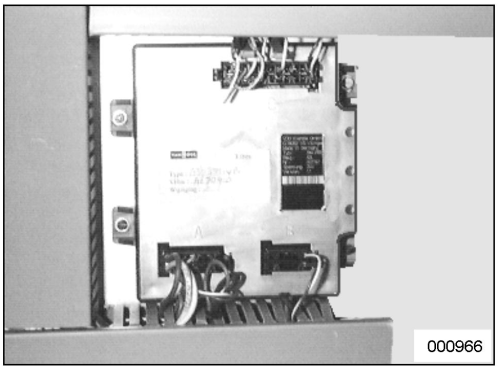
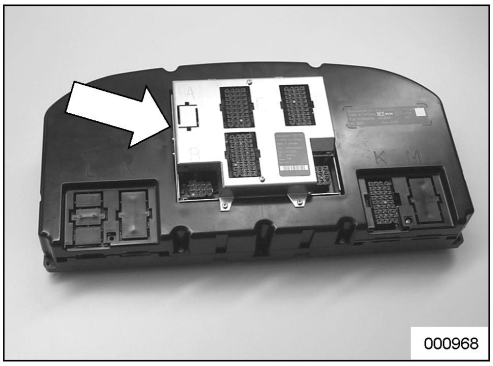
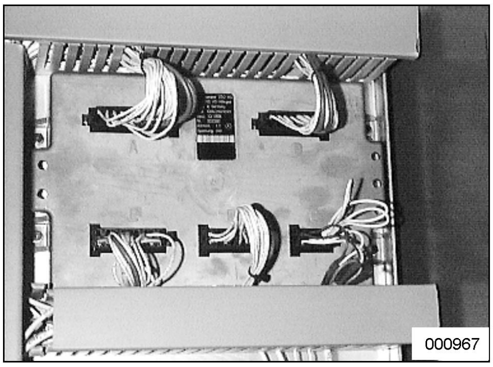
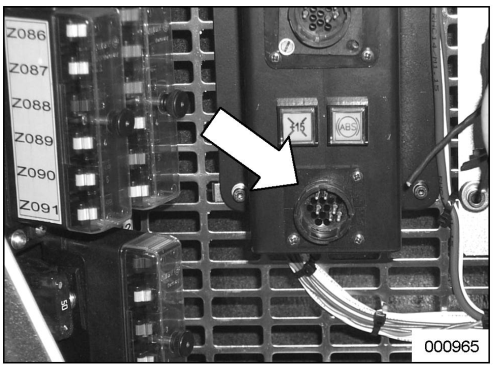
COMPUTER MODULE (ZR2-BD)	
DASHBOARD NODE (DMUX)	
NODE	
MULTIPLEX DIAGNOSTIC SOCKET (IN FRONT JUNCTION BOX)	

Figure 5: Hardware components

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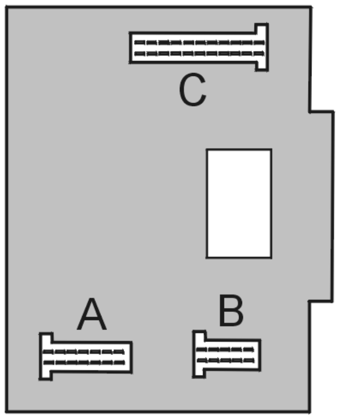
1.4 KIBES COMPUTER MODULE

C

AUS_C3_04	21	22	AUS_C3_05
AUS_C3_02	19	20	AUS_C3_03
EIN_C3	17	18	AUS_C3_01
reserved J1708_BUS-	15	16	reserved J1708_BUS+
K_LINE	13	14	Reserved
AUS_01_G1_LS	11	12	AUS_02_G1_LS
EIN_C4	9	10	EIN_KL.W
IBIS_TX	7	8	IBIS_TX_GND
IBIS_RX	5	6	IBIS_RX_GND
CAN_H_IBIS	3	4	CAN_L_IBIS
CAN_H_FAP	1	2	CAN_L_FAP



A

EXT_WAKE_UP01	2	1	MINUS
EXT_WAKE_UP02	4	3	PLUS
CAN_L1_MX1	6	5	CAN_H1_MX1
CAN_L2_MX1	8	7	CAN_H2_MX1
CAN_L_MX1_AB	10	9	CAN_GND_ANT
CAN_L2_ANT	12	11	CAN_H2_ANT
CAN_L1_ANT	14	13	CAN_H1_ANT

B

CAN_L1_KAR	2	1	CAN_H1_KAR
CAN_L2_KAR	4	3	CAN_H2_KAR
CAN_L_MX2_AB	6	5	CAN_H_KAR_AB
CAN_L2_MX2	8	7	CAN_H2_MX2
CAN_L1_MX2	10	9	CAN_H1_MX2

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Figure 6: Contact numbering of plugs on computer module. Plugs as seen from wire connection side.

1.4.1 WHAT DOES COMPUTER MODULE CONTAIN?

The computer module contains the driver (the “software”) that controls the system.

Refer to “Function diagram (FUP)” for the logic of this program.

1.4.2 HOW TO PROCEED IN CASE OF DEFECTIVE COMPUTER MODULE

The computer module does not contain repairable parts. If there is a defect, it has to be replaced as a whole by a unit with identical Van Hool ordering number. This number contains the code of the program in the computer module.

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1.5 NODES

1.5.1 WHAT IS A NODE?

A node is an electronic “switchbox” with inputs and outputs that operate (through the outputs) or monitor (through the inputs) the electrical functions of the vehicle.

1.5.2 OVERVIEW OF INPUTS AND OUTPUTS

Refer to “Overview of inputs and outputs”.

1.5.3 INPUTS

There are two types of inputs: static and analog.

- A static input is indicated with Ein_Status_
- An analog input is indicated with Ein_Analog_

1.5.4 OUTPUTS

The outputs are protected against overloads and short-circuits. An output is indicated with “Aus_”.

A

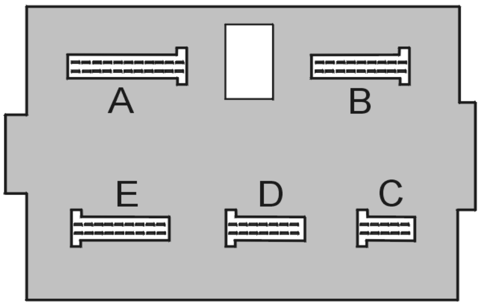
EIN_STATUS_13	21	22	AUS_01_G1_HS
EIN_STATUS_14	19	20	AUS_02_G1_HS
EIN_STATUS_15	17	18	AUS_03_G1_HS
EIN_STATUS_16	15	16	AUS_04_G1_HS
EIN_STATUS_17	13	14	AUS_05_G1_HS
EIN_STATUS_18	11	12	AUS_06_G1_HS
MINUS	9	10	PLUS_G1
MINUS	7	8	PLUS_G2
EIN_STATUS_19	5	6	AUS_07_G2_HS
EIN_STATUS_20	3	4	AUS_08_G2_HS
EIN_STATUS_21	1	2	AUS_09_G2_HS

B

EIN_STATUS_22	17	18	AUS_10_G3_HS
EIN_STATUS_23	15	16	AUS_11_G3_HS
EIN_STATUS_24	13	14	AUS_12_G3_HS
EIN_ANALOG_03	11	12	AUS_13_G3_HS
MINUS	9	10	PLUS_G3
MINUS	7	8	PLUS_G4
EIN_ANALOG_04	5	6	AUS_14_G4_HS
EIN_ANALOG_05	3	4	AUS_15_G4_HS
EIN_ANALOG_06	1	2	AUS_16_G4_HS

E

AUS_31_G5_HS	2	1	AUS_32_G5_LS
AUS_29_G5_HS	4	3	AUS_30_G5_LS
AUS_27_G5_HS	6	5	AUS_28_G5_LS
AUS_25_G5_HS	8	7	AUS_26_G5_LS
PLUS_G5	10	9	MINUS
AUS_23_G5_HS	12	11	AUS_24_G5_LS
AUS_21_G5_HS	14	13	AUS_22_G5_LS
AUS_19_G5_HS	16	15	AUS_20_G5_LS
AUS_17_G5_HS	18	17	AUS_18_G5_LS



C

CAN_H1	2	1	CAN_L1
CAN_H2	4	3	CAN_L2
EIN_ID_01	6	5	CAN_L_AB
EIN_ID_03	8	7	EIN_ID_02
AUS_ID_PLUS	10	9	AUS_ID_MINUS

D

EIN_STATUS_02	2	1	EIN_STATUS_01
EIN_STATUS_04	4	3	EIN_STATUS_03
EIN_STATUS_06	6	5	EIN_STATUS_05
EIN_STATUS_08	8	7	EIN_STATUS_07
EIN_STATUS_10	10	9	EIN_STATUS_09
EIN_STATUS_12	12	11	EIN_STATUS_11
EIN_ANALOG_02	14	13	EIN_ANALOG_01

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Figure 7: Contact numbering of plugs on node. Plugs as seen from wire connection side.

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1.5.5 POWER

Each node is fed via five separate circuits, each fitted with a 15 A fuse. Each fuse protects a “group” of outputs on the node.
The internal electronics are fed via the fuse in “group 1” and/or “group 2”.

1.5.6 POSITION OF NODES

The nodes are distributed throughout the vehicle, in the vicinity to the components to which they are related, thereby greatly reducing the quantity of main cables.

1.5.7 TO CHANGE NODES

All nodes are interchangeable. This is because the nodes do not contain software and the “addressing” takes place by means of an external wire combination in a connector plug. Addressing ensures that the node recognizes the relevant messages.

1.5.8 WHAT TO DO WITH A DEFECTIVE NODE?

The nodes do not contain components that can be repaired by users. Defective units must be replaced in their entirety.

1.6 DASHBOARD NODE

1.6.1 WHAT DOES DASHBOARD NODE DO?

- The dashboard node receives information relating to the positions of the dashswitches and sends this information to the computer module.
- The computer module controls the multifunction display and the indicator lights on the dashboard via the dashboard node.

1.6.2 DIFFERENCES WITH OTHER NODES

- Limited power load capacity of the outputs
- Integrated into the central dashboard panel

1.6.3 HOW TO PROCEED WITH DEFECTIVE DASHBOARD NODE

The dashboard node does not contain any components that can be repaired by users. A defective unit has to be replaced together with the central dashboard panel.

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1.7 CAN BUS

1.7.1 WHAT IS A COMMUNICATION "bus"?

The communication "bus" is an electrical conductor that transfers digital signals between the elements in a multiplex system. This conductor runs throughout the entire vehicle.

1.7.2 WHAT IS A "CAN" bus?

There are different "bus" types. The CAN bus is a type that has been established in both ISO and SAE standards. "CAN" is the abbreviation for "Controller Area Network".
Two "twisted" wires (30 twists per metre) or a double-core shielded cable are used as signal carriers in a CAN bus system.

"Twisted" wires

- CAN H(igh): blue
- CAN L(ow): brown

Double-core shielded cable

- CAN H(igh): brown
- CAN L(ow): white

1.7.3 VOLTAGES ON CAN bus

- CAN H(igh): basic voltage of 2.5V with a positive signal voltage of 1.25V.
- CAN L(ow): basic voltage of 2.5V with a negative signal voltage of 1.25V.

The signal on CAN-L is called the "mirror" signal of the CAN-H. This double signal allows for fault detection on data exchange and equally provides high interference-safety.

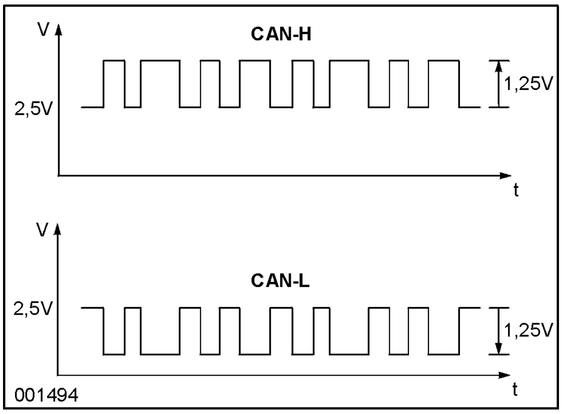

Figure 8: Voltages on CAN bus

1.7.4 COMMUNICATION SPEED

The communication speed of a CAN bus depends on the protocol used. The computer module can communicate at different speeds and with different protocols via separate CAN bus lines:
For the drive line (SAE J1939): speed of 250 kbit/s (example:communication between control units of the engine, transmission, brakes, ABS,...)
For bodywork applications (ISO): different speeds possible (example: communication between Kibes computer module and the nodes is effected at a speed of 125 kbit/s).

1.7.5 TERMINATING RESISTANCES

Each CAN bus is terminated at both ends with resistances of 120 ohm. The resistances are necessary in order to guarantee the purity of the information transfer and the stability of the network.
The nodes in the Kibes system are fitted with an internal terminating resistance. If necessary, the terminating resistance can be switched on by installing an external bridging wire between contacts "3" and "5" of plug "C".
Devices with permanently built-in resistances must be fitted at the start or end of the CAN bus.

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1.7.6 TO TEST CAN bus

The CAN bus can be tested with a multimeter.

- **Ignition on**: There should be a voltage of over 2.6 V on CAN H and under 2.4 V on CAN L. An interrupted or inverted or shorted CAN bus can be traced by measuring the voltage.

- **Ignition off**: You should measure a resistance of 60 ohms between the two wires of the CAN bus.

You can also test the CAN bus on the node.

NOTE
HOWEVER, THIS DOES NOT APPLY TO THE DRIVE LINE CAN BUS.

1. Connect a 1.4 W test lamp between contact C10 (output ID-plus) of node and ground (see figure 9).
2. Switch on ignition.

   Test lamp starts to flash according to a pattern (see figure 10).

   - Top pattern: CAN bus OK
   - Middle pattern: CAN bus interrupted
   - Bottom pattern: only visible, when starting up

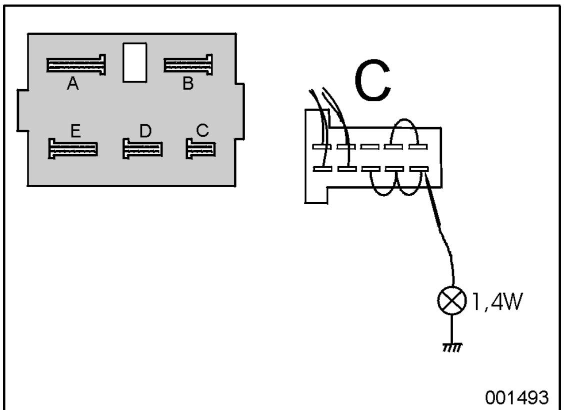

Figure 9: Test lamp connected between contact C10 of node and ground

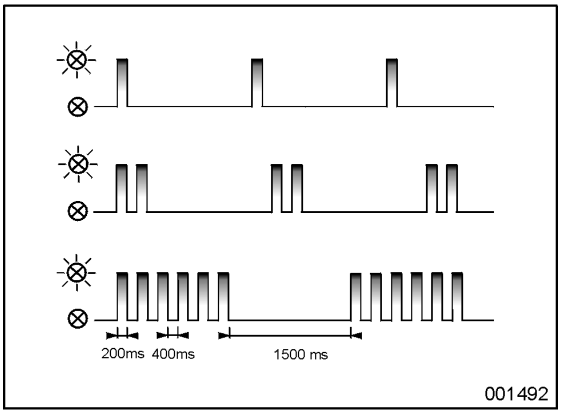

Figure 10: Flash pattern

If lamp goes out or stays out, then:

- CAN bus has been interrupted or inverted or...
- node has no power supply or;
- node is defective.

If lamp illuminates continuously, node is defective.

1.7.7 TO WORK ON CAN bus

!!! CAUTION !!!
DO NOT INTERRUPT CAN bus, WHEN IGNITION IS SWITCHED ON. IF YOU DO SO ANYWAY, FAULT MESSAGES WILL BE THE RESULT.

1.7.8 AFTER WORKING ON CAN bus

!!! CAUTION !!!
AFTER WORKING ON CAN bus, THE MULTIPLEX SYSTEM SHOULD BE RESET.

To reset the multiplex system follow the procedure below:

1. Turn ignition off.
2. Wait for 30 seconds.
3. Momentarily switch off emergency switch and switch it back on.
   The multiplex system is reset.

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1.7.9 FAILURE OF CAN bus

If the CAN bus fails, the impaired node switches to an emergency program that activates certain outputs, see column “N” under “Overview of inputs and outputs”.
In practice this means that the outputs of exterior lighting (front and tail lamps) that have been connected to this node are being activated. Thus vehicle safety (visibility) is guaranteed.

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1.8 TECHNOLOGY OF INPUTS AND OUTPUTS ON NODES

1.8.1 INPUTS ON NODES

There are two types of inputs: static and analog.

- A **static input** changes voltage level to a "0" or a "1" (e.g. switch on or off). Via the CAN bus these digital data are then sent to the computer module for processing.

NOTE
THE POWER REQUIRED TO CONTROL A STATIC INPUT IS JUST 7MA.

- An **analog input** changes voltage level to a digital value that corresponds with the magnitude of the input signal (e.g. fuel gauge float).

1.8.2 STATIC INPUTS (SEE FIGURE 11 AND TABLE 1)

The static inputs can be controlled in different ways: positive (S3), ground (S2) or by a combination of both (S1).

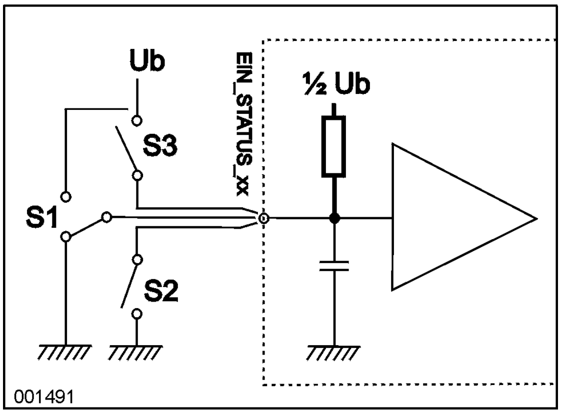

Figure 11: Switching options for a static node input
Ub. On-board voltage
S1. Routing circuit
S2. Ground switched
S3. Positively switched

NOTE
WHEN THE SWITCH IS OPEN, YOU MEASURE A VOLTAGE THAT IS APPROXIMATELY HALF THE ON-BOARD VOLTAGE AT THE INPUT.

Table 1

	Switch setting	Voltage at node input	Digital signal
S1[a]	ground switched	lower than 5 V	0
	positively switched	higher than 19 V	1
S2	closed (ground)	lower than 5 V	0
	open	higher than 7 V	1
S3	open	lower than 16 V	0
	closed (positive)	higher than 19 V	1

a. This way of connecting gives the possibility to determine by means of a voltmeter whether the switch itself is faulty or whether the wiring toward the node is interrupted. This way of switching is sometimes applied to the dashboard node.

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1.8.3 ANALOG INPUTS (SEE FIGURE 12)

On each node a number of inputs are specific analog inputs. You can connect a variable resistance between 0 and 500 ohms to these inputs for further analog processing.
The analog inputs can be used as static inputs (see table 2).

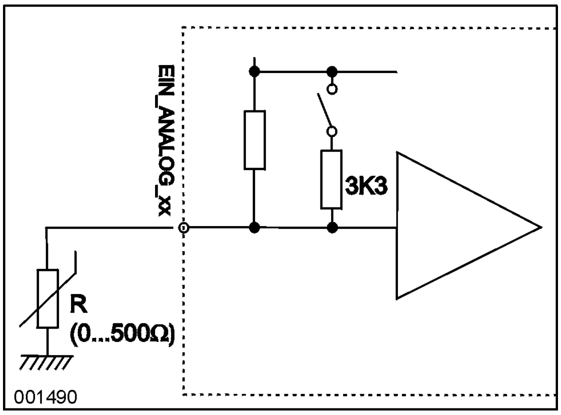

Figure 12: Variable resistance on analog input

Table 2	
Voltage at node input	**Digital signal**
lower than 5 V	0
higher than 19 V	1

1.8.4 ELECTRONIC SWITCHING ON NODE INPUT (SEE FIGURE 13)

In “Static inputs” has been mentioned that there is a voltage equal to approximately half the on-board voltage on the node input, when the switch is open. If you connect an electronic switch to the input parallel to the switch, this voltage may influence the voltage of the input of the electronic connection. To avoid this a diode (see figure 13 for the correct direction) is placed in the wiring to the electronic connection.

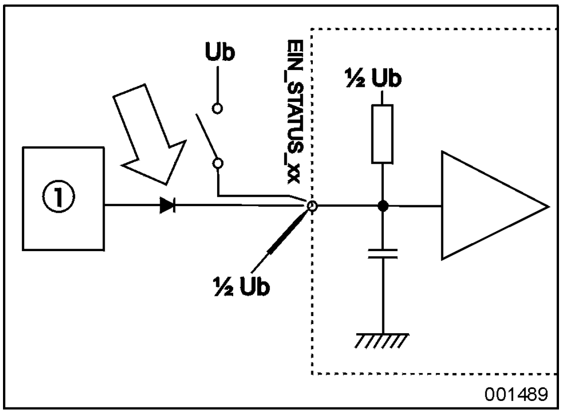

Figure 13: Electronic circuit on input node
Ub. On-board voltage
1. Electronic circuit

1.8.5 OUTPUTS ON NODES

The outputs are divided into the following types:

- **High or low switching**: Each node has outputs that are positive (high switching) and outputs that are ground (low switching) switched. The “positive” outputs are indicated with “HS”, the “ground” outputs with “LS”.
- **Maximum current**: All outputs on the nodes are protected against short-circuits and overloads. Nevertheless each output has a maximum output current. There are outputs of 1A, 3A, 5A and 10A.
- **Group**: The outputs are divided into five groups. The total load on all outputs in a group may be a maximum of 15 A. The groups are indicated with the letter “G”, followed by a group number. For example “G3”

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1.8.6 LOAD WITH EXTREMELY HIGH IMPEDANCE AT NODE OUTPUT (SEE FIGURE 14)

A test current of approximately 30µA flows through the internal resistance (R). The voltage at the output is measured via the internal feedback. If this is under load and not active, a voltage of approximately 0 V should be measured. If nothing is connected, or if there is an interruption, the voltage may increase to several volts. A load with an extremely high impedance gives a similar voltage.

On the one hand this means that loads with extremely high impedance cannot be checked for interruptions. On the other hand this remnant voltage causes side effects that can only be solved by placing a resistance (R1) parallel to this load. This resistance provides an extra load, and this reduces the voltage on the output.

A short-circuit on the node output is detected through the same internal feedback. With an active output port on-board voltage has to be measured. In the case of failing on-board voltage a short-circuit has occurred.

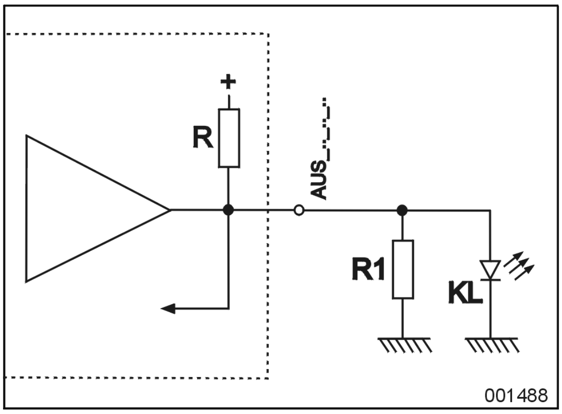

Figure 14: Load with extremely high impedance on node output

- **R. Internal resistance**
- **R1. "Pull-down" resistance**
- **KL. Load with extremely high impedance (for example: LED)**

An overload on the node output is detected by the thermal protection device on the final stage and reported to the electronics.

1.8.7 NUMBERING OF INPUTS AND OUTPUTS

The numbering of the inputs and outputs takes place on the basis of a code. This numbering is also noted in the schematics and in the error code during diagnostics.

Example: N5E12

- N: Node
- 5: Node number
- E: Name of the plug
- 12: Contact number on the plug.

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1.9 COMPONENT LOCATION

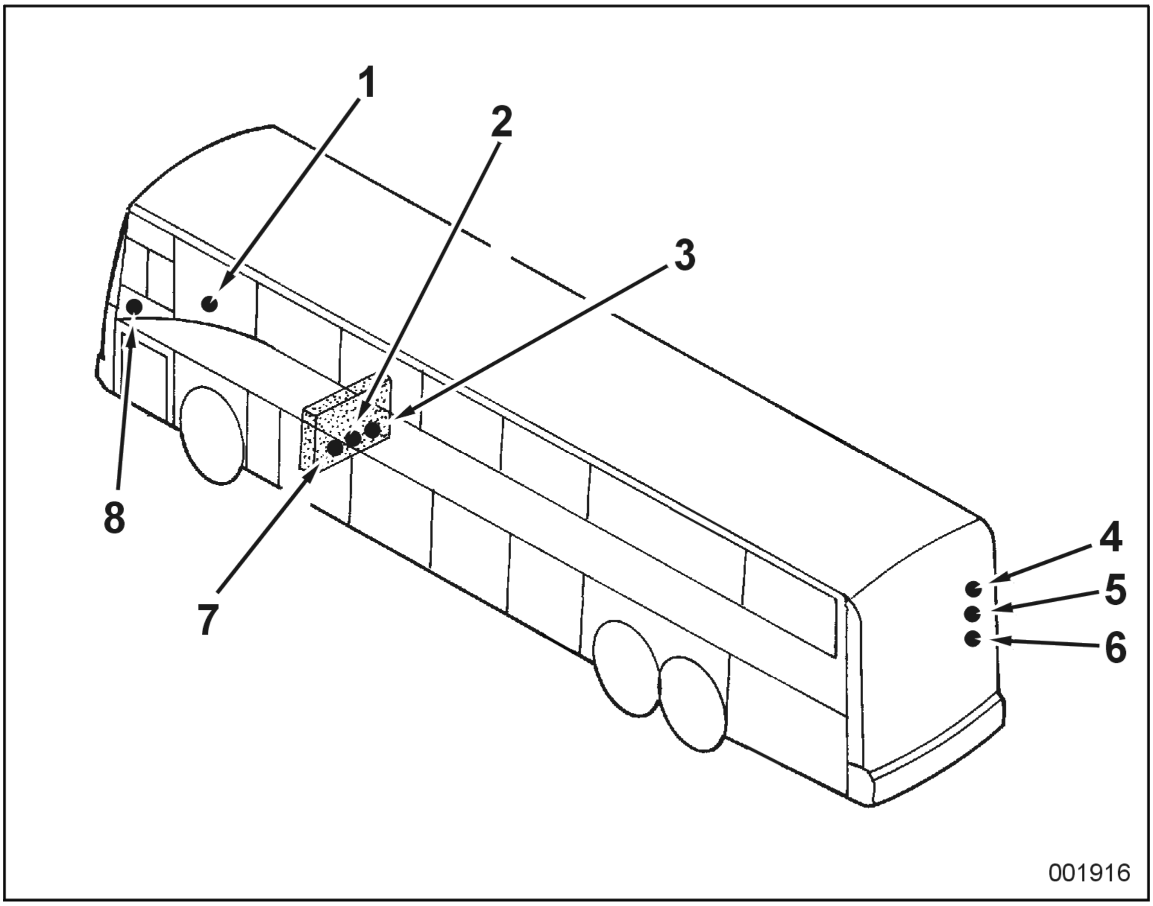

Figure 15: Component location

1. Node 1 and diagnostic socket
2. Node 3
3. Computer module (ZR2-BD)
4. Node 4
5. Node 5
6. Node 6
7. Node 2
8. Dashboard node (DMUX)

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1.10 ON-BOARD DIAGNOSTICS: SELF-DIAGNOSIS

1.10.1 INTRODUCTION

As soon as the ignition (+15) is switched on, the computer module checks the outputs of the nodes for interruptions and short-circuits. A distinction is made between **active** and **inactive** outputs.

NOTE
AN ACTIVE OUTPUT IS AN OUTPUT THAT IS CURRENTLY ACTIVATED BY THE COMPUTER MODULE.

- An active output will only be checked for short-circuit.
- An inactive output will only be checked for interruption.

1.10.2 SOFTWARE VERSIONS

Refer to “Software versions” under “Layout”.

1.10.3 HOW ARE YOU NOTIFIED?

The wrench symbol appears on the multifunction display when the electronics detect an error. At the same time the error is stored as a code in the computer module memory.

- **Software version 1**: Only the first error is stored in the memory.
- **Software version 2**: The error memory can hold up to seven error messages at the same time. The error memory retains the seven last errors that occurred.

1.10.4 TO CALL UP ERROR CODE

Press the “Entrance door” dashswitch and the multifunction display selection button simultaneously for no longer than 5 seconds.
The text “ERROR CODE” appears on the display, followed by the node number and the plug pin. Example: “NODE 3-B-12”.

NOTE
ONLY FOR SOFTWARE VERSION 2. YOU CAN RUN THROUGH THE ERROR MEMORY BY PUSHING THE MULTIFUNCTION DISPLAY SELECTION BUTTON EACH TIME FOR NOT LONGER THAN 5 SECONDS.

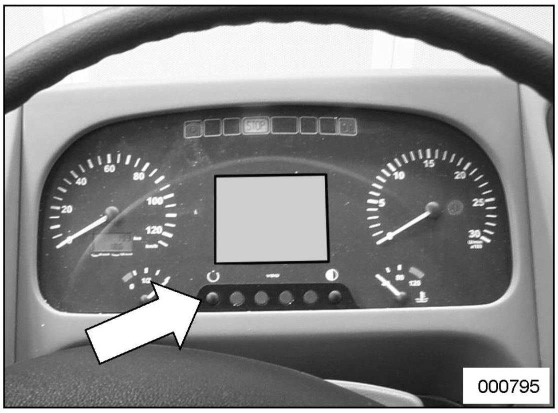

Figure 16: Multifunction display selection button

1.10.5 TO TROUBLESHOOT

Error finding is performed bu using a multimeter and the wiring diagrams.

1.10.6 TO EXIT ERROR MEMORY

• **Software version 1**: The driving program will appear on the display after 10 seconds.

• **Software version 2**: The driving program will not reappear on the display, until all error codes have been called up.

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1.10.7 TO CLEAR ERROR MEMORY WITH SOFTWARE VERSION 1

NOTE
EVEN AFTER THE ERROR HAS BEEN REPAIRED OR HAS RESOLVED SPONTANEOUSLY, THE ERROR MESSAGE WILL REMAIN ON THE DISPLAY AND THE ERROR CODE WILL REMAIN IN THE MEMORY, UNTIL YOU CLEAR THE MEMORY MANUALLY.

Switch on ignition, while you press the multifunction display selection button.

- If there is only **one error** then the error message on the display disappears.
- If there are **several errors** then the error message will remain on the display. In that case repeat the procedure “To call up error code”. In this case, repair the error and repeat the “To erase error memory” procedure, until the error code disappears.

1.10.8 TO CLEAR ERROR MEMORY WITH SOFTWARE VERSION 2

NOTE
EVEN AFTER THE ERROR HAS BEEN REPAIRED OR HAS RESOLVED SPONTANEOUSLY, THE ERROR MESSAGE WILL REMAIN ON THE DISPLAY AND THE ERROR CODE(S) WILL REMAIN IN THE MEMORY, UNTIL YOU ERASE THE MEMORY MANUALLY.

Switch on ignition, while you press multifunction display selection button.

- If **all errors** have been repaired or are no longer then the error message on the display disappears.
- If **not all errors** have been repaired or are still active then the error message will remain on the display.

Only the inactive errors have been erased. In that case repeat the procedure “To call up error code”. Repair error and repeat “To erase error memory” procedure, until error code disappears.

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1.11 ON-BOARD DIAGNOSTICS: MANUAL DIAGNOSIS

1.11.1 INTRODUCTION

During this type of diagnosis, the electronics first check the outputs for interruptions by making them inactive. Then they are checked for short-circuits by being activated.

1.11.2 SOFTWARE VERSIONS

Refer to “Software versions” under “Layout”.

1.11.3 WHAT OUTPUTS ARE CHECKED WITH SOFTWARE VERSION 1?

Only the outputs crossed in columns “D1” and “D2” (refer to “Overview of the inputs and outputs, software version 1”) are checked.

- The outputs crossed in column **D1** are checked for **interruption**.
- The outputs crossed in column **D2** are checked for **short-circuit**.

1.11.4 WHAT OUTPUTS ARE CHECKED WITH SOFTWARE VERSION 2?

Only the outputs crossed in column “D” (refer to “Overview of the inputs and outputs, software version 2”) are checked.

• The outputs indicated by letter **A** in column D are checked for **interruption and short-circuit**.

• The outputs indicated by letter **K** in column D are checked for **short-circuit**.

1.11.5 TO START DIAGNOSTICS

!!! CAUTION !!!
THE MANUAL DIAGNOSIS MUST ONLY BE CARRIED OUT, WHEN THE COOLING AND HEATING CIRCUIT IS FILLED AND ALL MANUAL VALVES ARE OPEN. **DURING MANUAL DIAGNOSIS, THE ENTRANCE DOOR IS CLOSED AND ALL LIGHTING IS TURNED OFF. THE VEHICLE IS ALSO BROUGHT TO ITS NORMAL RIDE HEIGHT.**

1. Place the vehicle in a well lit location.

2. Stop the engine.

3. Press the “Entrance door” dashswitch and the multifunction display selection button simultaneously for 5 to 10 seconds (no longer than 10 seconds).

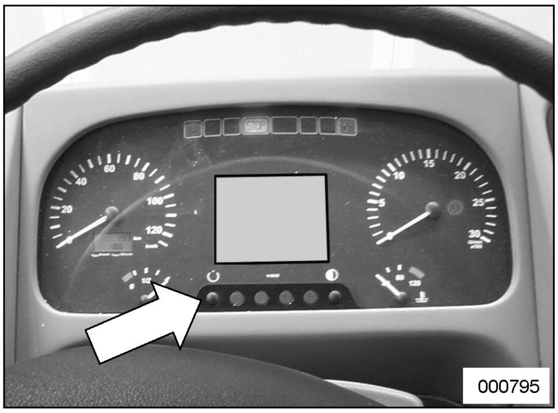

Figure 16: Multifunction display selection button

1.11.6 DIAGNOSIS RESULT WITH SOFTWARE VERSION 1

- If an error is found then the text “ERROR CODE” appears on the display, followed by the node number and the plug pin.
  Example: “NODE 3-B-12”.

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NOTE
THE PUBLICATION "OVERVIEW OF THE PORTS" LISTS THE POWER CIRCUITS USED FOR THIS OUTPUT.

To go back to the driving program, press the selection button on the display for longer than 5 seconds.

- If no error is detected then close the diagnosis electronics and proceed to the driving program.

1.11.7 DIAGNOSIS RESULT WITH SOFTWARE VERSION 2

- If an error is found then the wrench symbol appears on the display. The errors detected are stored as codes in the computer module memory. They can be retrieved as has been described under "On-board diagnostics system: self-diagnosis". The electronics exit diagnosis and proceed with the driving program.

- If no error is detected then the electronics exit diagnosis and proceed with the driving program.

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1.12 ON-BOARD DIAGNOSTICS: FUNCTION CHECK

1.12.1 INTRODUCTION

The program in the computer module also contains a “function check”. It has several purposes, including checking the outputs several consumers are connected to in parallel.

When starting the function check, a number of outputs are activated simultaneously. This allows you to check the functioning of the vehicle functions controlled by those outputs.

The node outputs which are activated during the function check can be found by the numbers “1”, “2”, “3”, “4” in column “F” of “Overview of inputs and outputs”.

- “1”: All exterior lights
- “2”: All interior lights
- “3”: Climate control fans at half speed (not on all vehicles)
- “4”: Climate control fans at full speed (not on all vehicles)

NOTE
NUMBERS “3” AND “4” OCCUR WITH SOFTWARE VERSION 1 ONLY. IN ORDER TO FIND OUT WHICH SOFTWARE VERSION HAS BEEN APPLIED TO YOUR VEHICLE, SEE “LAY-OUT”.

1.12.2 TO START FUNCTION CHECK

1. Place the vehicle in a well lit location.

2. Stop the engine.

3. Press the “Entrance door” dashswitch and the multifunction display selection button simultaneously for at least 10 seconds.

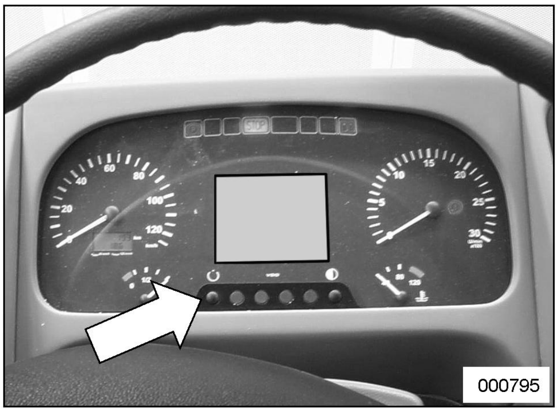

Figure 16: Multifunction display selection button

The text “FUNCTION TEST” appears on the display and the electronics activate the first group of outputs.

Press the multifunction display selection button for a maximum of 5 seconds to activate the next group of outputs.

1.12.3 TO STOP FUNCTION CHECK

Press multifunction display selection button for at least 5 seconds.

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1.13 AIDS DURING TESTING: GARAGE FEATURE

1.13.1 INTRODUCTION

During service it may be necessary to have an information screen permanently visible on the multifunction display. The “garage feature” allows for this.
Depending on the drive line built into the vehicle, the following information screens can be displayed:

- coolant level;
- air pressure;
- coolant temperature;
- transmission temperature;
- turbo boost pressure;
- engine oil pressure
- ....

NOTE
WHEN ACCESSING THE INFORMATION SCREEN IN THE DRIVING PROGRAM, THE SCREEN WILL BE DELETED AFTER APPROXIMATELY 10 SECONDS. THIS IS BECAUSE THE WARNING MESSAGES IN THE “DRIVING PROGRAM” HAVE TO REMAIN VISIBLE.

1.13.2 TO START GARAGE FEATURE

Press the “Deep snow and mud” switch and the multifunction display selection button simultaneously for less than 5 seconds.

The air pressure information screen will appear on the multifunction display.

1.13.3 TO GO TO THE NEXT INFORMATION SCREEN

Press the multifunction display selection button to go to the next information screen.

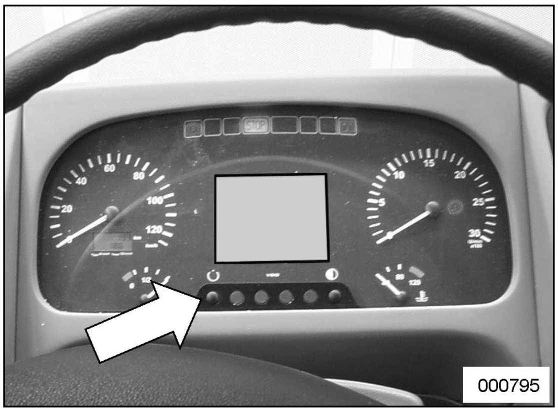

Figure 16: Multifunction display selection button

When you have gone through all the information screens, the system returns to the driving program.

1.14 AIDS DURING TESTING: “ENGINE RUNNING” SIMULATION

1.14.1 INTRODUCTION

A number of electrical circuits are powered, when the vehicle engine is running only. It may occasionally be necessary to simulate the electrical "engine running" signal (D+) in order to test these electrical circuits without the engine actually running.

1.14.2 TO START D+ SIMULATION

Press the “Deep snow and mud” switch and the multifunction display selection button simultaneously for 5 to 10 seconds (not longer than 10 seconds).

1.14.3 TO STOP D+ SIMULATION

Press the multifunction display selection button for longer than 5 seconds, or... turn off the ignition.

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1.15 AIDS DURING TESTING: "VEHICLE IN MOTION" SIMULATION

1.15.1 INTRODUCTION

A number of electrical circuits are powered, when the vehicle is in motion only. It may occasionally be necessary to simulate the electrical signal of a "vehicle in motion" to enable these circuits to be tested without the vehicle actually moving.

NOTE
WHEN YOU START THIS FUNCTION, THE "ENGINE RUNNING" SIMULATION WILL ALSO START. THIS IS IN ORDER TO APPROXIMATE ACTUAL CONDITIONS AS MUCH AS POSSIBLE.

1.15.2 TO START "VEHICLE IN MOTION" SIMULATION

Press the "Deep snow and mud" switch and the selection button of the display simultaneously for at least 10 seconds.

1.15.3 TO STOP "VEHICLE IN MOTION" SIMULATION

Press the multifunction display selection button for longer than 5 seconds, or... turn off the ignition.

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1.16 TO TROUBLESHOOT WITH THE AID OF A PC

1.16.1 INTRODUCTION

If the on-board diagnostics does not yield a solution, you can carry out a complete test by using a PC (or laptop).

1.16.2 EQUIPMENT CONDITION

- Kibes RT software installed on PC (refer to “To install Kibes RT software on PC”)
- PC connected to diagnostic socket (refer to “To connect PC to diagnostic socket”)
- Master switch closed.

1.16.3 TO START DIAGNOSTICS WITH O.S. WINDOWS NT/9X/ME/2000

1. Double click on the KIBES pictograph.

   The following is displayed:

Figure 17

2. Press any key.

   The following is displayed:

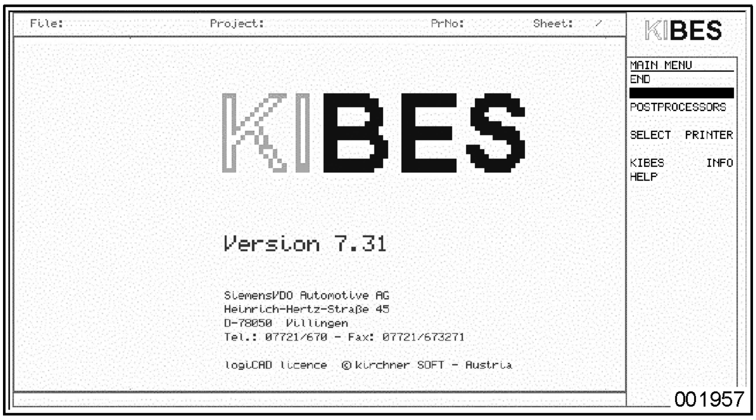

Figure 18

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3. Select “POSTPROCESSORS” in the menu and press ENTER.

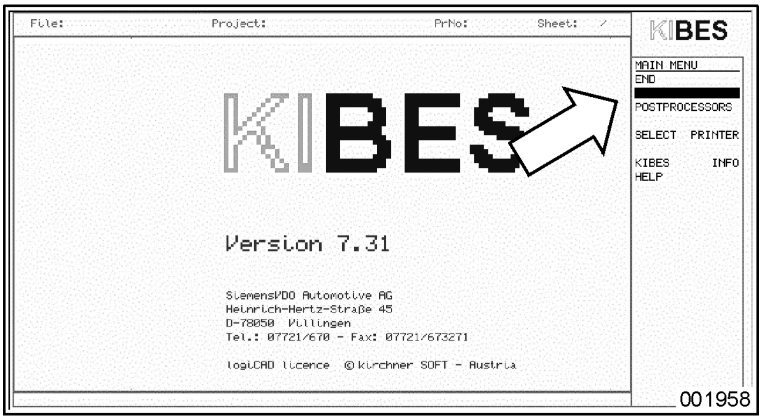

Figure 19

4. Select “ONLINE TEST” in the menu and press ENTER.

The program is now being loaded from the computer module into the PC. The progress is displayed on the screen as percent.

NOTE
THIS SCREEN ONLY APPEARS WHEN YOU CARRY OUT THIS TEST FOR THE FIRST TIME.

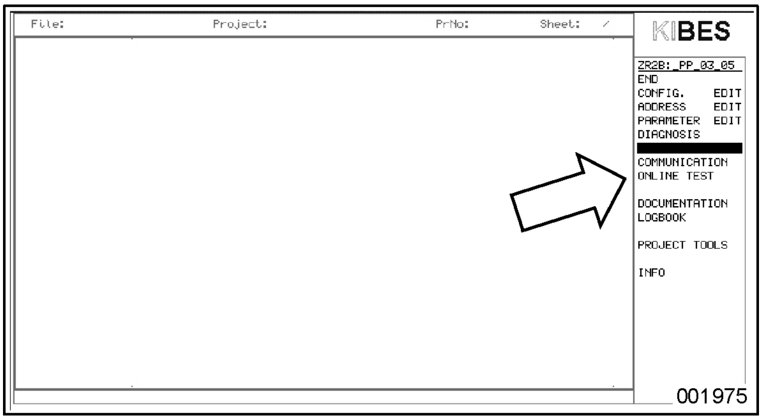

Figure 20

If the program on the PC is an older version than that in the computer module, the following text appears on the screen. Continue with step 5.

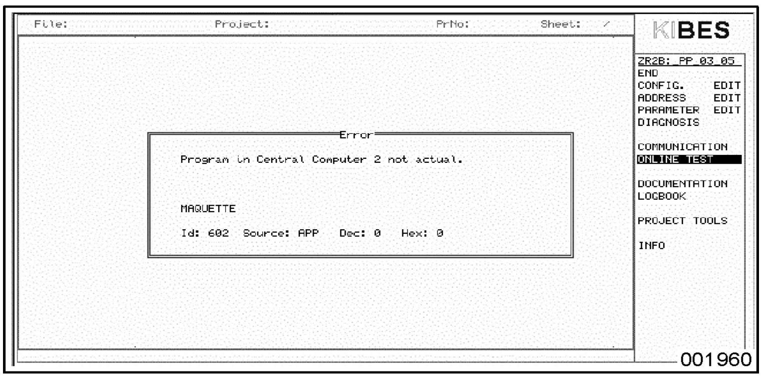

Figure 21

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5. Press ENTER.

   The following is displayed:

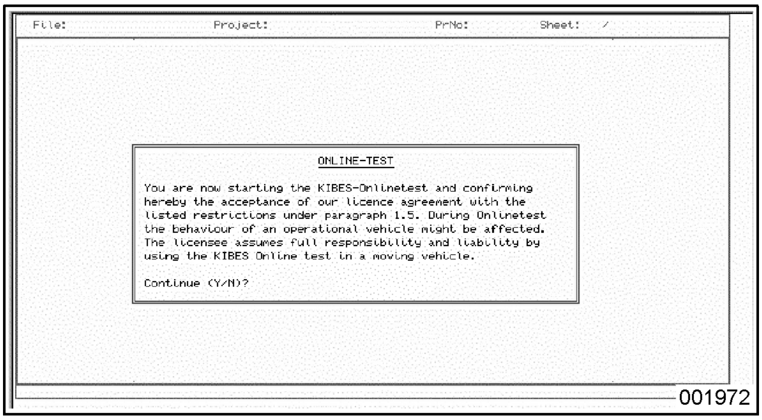

Figure 22

6. Press ”Y” and then ENTER.

NOTE
THE OVERVIEW PAGE WILL BE DISPLAYED IMMEDIATELY (SEE LATER IN THE PROCEDURE) WHEN THE PROGRAM HAS ALREADY BEEN READ BEFORE FROM THE COMPUTER MODULE.

The following is displayed:

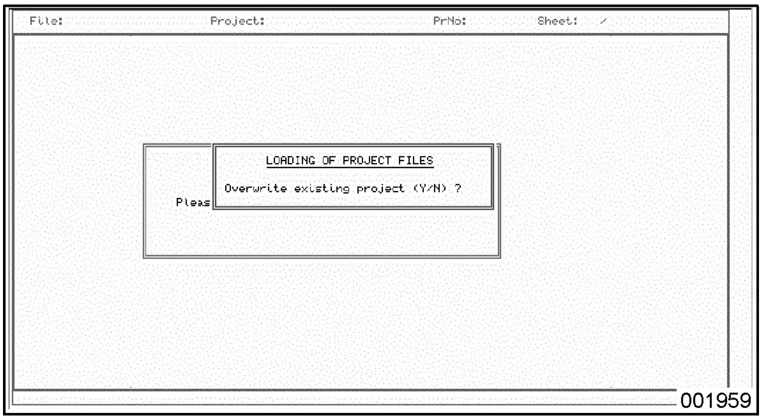

Figure 23

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7. Press “Y” and then ENTER.

   The program is now being read from the computer module. The progress is displayed on the screen in percent. When the program has been read completely, the overview page of the program will be displayed on the PC.

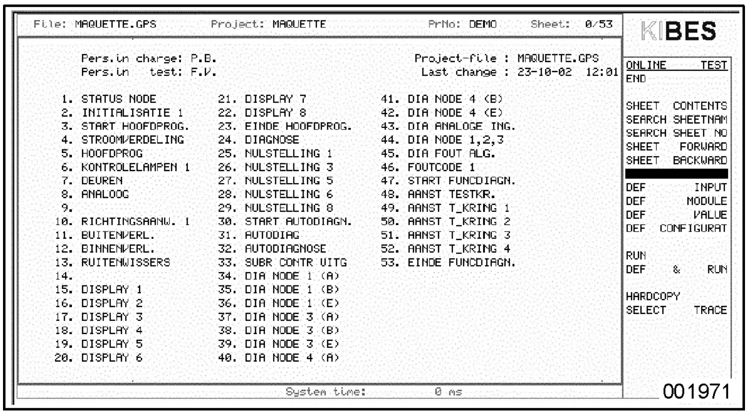

Figure 24

8. Select the page that contains the logic of the function to be tested.

   You can make your selection:

   - via the table of contents. Select “SHEET CONTENTS” and press ENTER. The table of contents is displayed. Select the correct page with the arrow keys.
   - via the page name or number. Select “SEARCH SHEETNAM” or “SEARCH SHEET NO” and press ENTER. Enter the page name or number. The desired page will be displayed immediately.
   - with keys F9 and F10. Use the F10 key to browse forwards, and F9 to browse backwards. This function will remain available, even when the computer is “on line”.

9. Select “DEF & RUN” in the menu and press ENTER.

   The “ON LINE” function is now active.

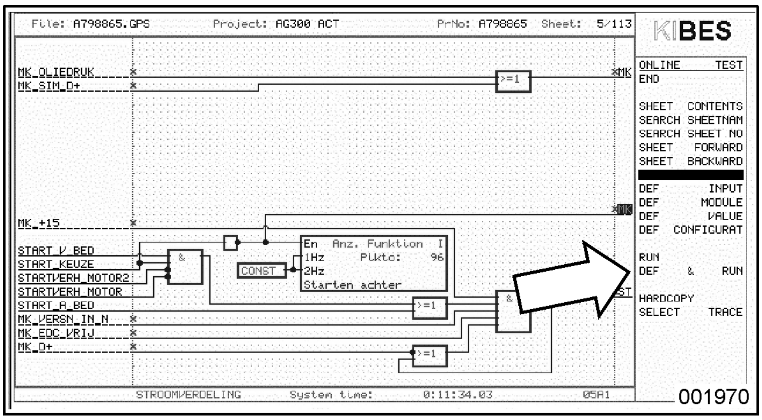

Figure 25

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The status of the inputs and outputs can now be followed on the screen. A thick blue line means “active”, a thin line means “inactive”.

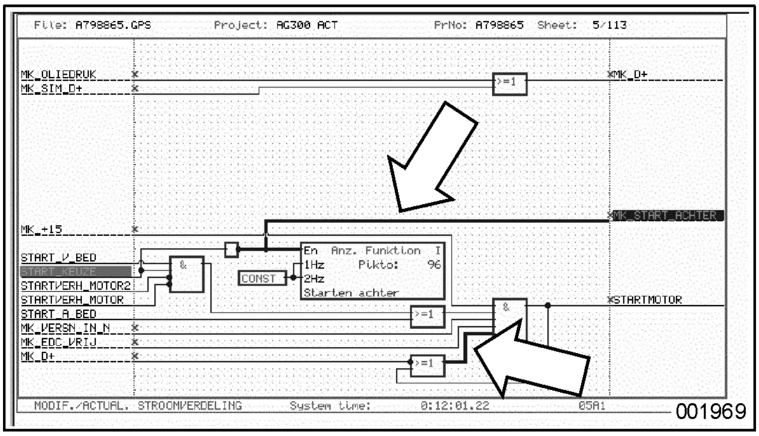

Figure 26

1.16.4 TO STOP DIAGNOSTICS

1. Press “ESC”.

2. Select “END” in the menu and press ENTER to end the diagnostics.

   The following is displayed:

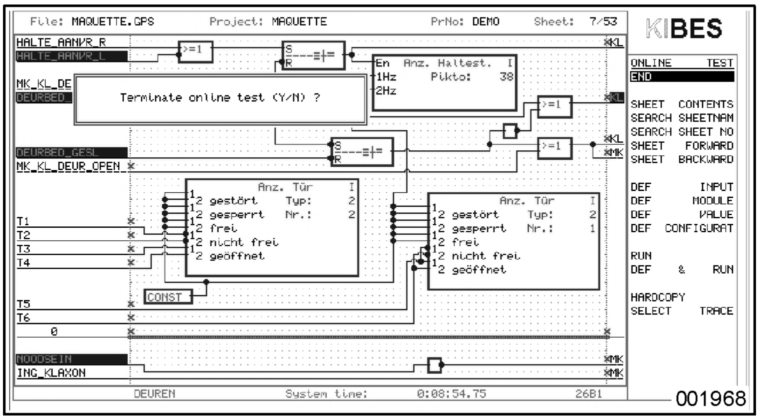

Figure 27

US09100AA

!!! WARNING !!!

IF THE “ON-LINE” TEST IS CARRIED OUT DURING DRIVING, DO NOT SELECT “Y” NOW. “Y” MEANS THAT ALL ELECTRICAL CIRCUITS CONNECTED TO THE MULTIPLEX SYSTEM ARE TEMPORARILY DEACTIVATED. THIS CAN BE DANGEROUS WITH A MOVING VEHICLE.

3. Moving vehicle: Press the “N” key.
   Stationary vehicle: Press the “N” or “Y” key.

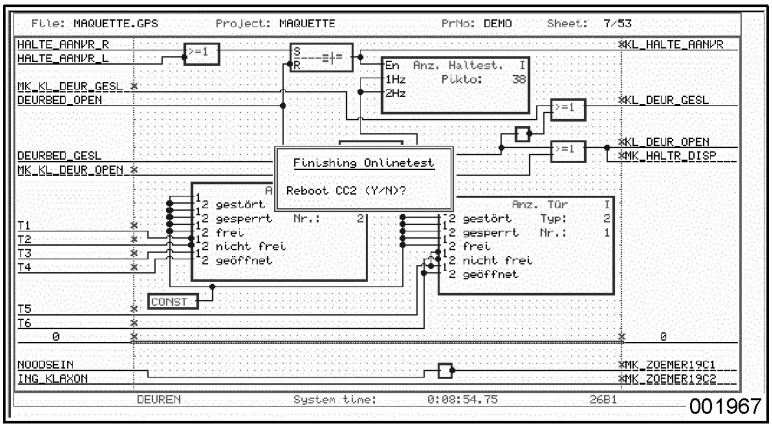

Figure 28

1.16.5 TO START DIAGNOSTICS WITH O.S. WINDOWS 3.11

1. Double click on the DOS pictograph or restart in DOS.
2. Type “KS" and press ENTER.
3. Go on with steps 2 to 9 under “To start diagnosis with O.S. Windows NT/9x/Me/2000”.

1.16.6 TO START DIAGNOSTICS WITH O.S. DOS

1. Type "KS" and press ENTER.
2. Continue with steps 2 to 9 under “To start diagnostics with O.S. Windows NT/9x/Me/2000”.

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1.17 SWITCH TO OVERRIDE SAFETY SYSTEMS (only for vehicles with software version 2)

1.17.1 INTRODUCTION

The multiplex system has been provided with a switch (S546), located in the junction box, which allows you to switch off a number of safety systems. The switch has been fitted with a guard.

NOTE
IN ORDER TO FIND OUT WHICH SOFTWARE VERSION HAS BEEN INSTALLED ON YOUR VEHICLE, SEE "LAYOUT".

1.17.2 TO BE USED WHEN?

Use the switch only to move the vehicle out of a dangerous situation, when it has been blocked by the safety system.

1.17.3 WHAT SAFETY SYSTEMS ARE SWITCHED OFF?

- Automatic door brake operation
- Automatic throttle pedal disabling
- Conditions for kneeling
- Conditions to start engine

!!! CAUTION !!!
USE THE SWITCH ONLY TO MOVE THE VEHICLE OUT OF A DANGEROUS SITUATION. TAKE INTO ACCOUNT THAT A NUMBER OF IMPORTANT SAFETY SYSTEMS ARE NO LONGER IN OPERATION.

1.17.4 TO SWITCH OFF SAFETY SYSTEMS

1. Switch on vehicle ignition.
2. Lift switch guard.
3. Momentarily move spring-loaded toggle switch lever in direction of arrow (see figure 29).

   The safety systems have now been switched off.

1.17.5 TO SWITCH SAFETY SYSTEMS BACK ON

Again momentarily move toggle switch lever in direction of arrow (see figure 29).

NOTE
THE SAFETY SYSTEMS WILL BE SWITCHED ON AGAIN, WHEN YOU TURN OFF THE IGNITION.

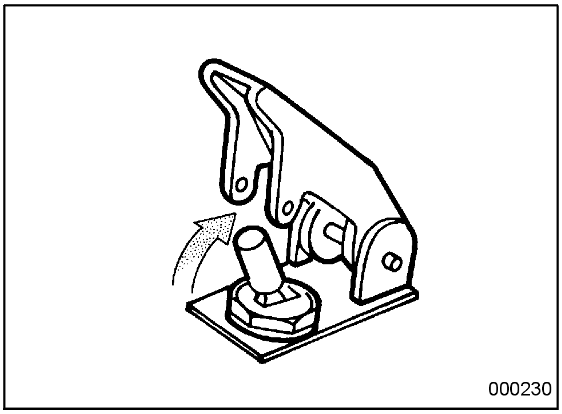

Figure 29: Switch for safety systems override

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1.18 TO LOAD PROGRAM IN KIBES COMPUTER MODULE

1.18.1 INTRODUCTION

Sometimes it is necessary to update the program in the Kibes computer module. This update will be provided by Van Hool on disc or via e-mail, and always consists of two files (one with the extension “prg” and one with the extension “zip”).

1.18.2 EQUIPMENT CONDITION

- PC connected to diagnostic socket (refer to “To connect PC to diagnostic socket”)
- Kibes RT software installed on PC (refer to “To install Kibes RT software on PC”)
- Vehicle stationary

1.18.3 TO CALL UP PROGRAM NUMBER AND MODIFICATION INDEX

NOTE
THIS FUNCTION IS ONLY AVAILABLE WITH SOFTWARE VERSION 2.

Simultaneously press the switches “exterior lighting”, “high beam” and “hazard warning flasher”.

The program number and modification index appear on the display for 30 seconds.

!!! CAUTION !!!
DO NOT LOAD THE PROGRAM WHILE YOU ARE DRIVING. ALL THE ELECTRICAL CIRCUITS CONNECTED TO THE MULTIPLEX SYSTEM ARE TEMPORARILY DEACTIVATED DURING THE LOADING OF THE PROGRAM. THIS MAY CAUSE YOU TO LOSE CONTROL OF THE VEHICLE.

1.18.4 PROCEDURE

!!! CAUTION !!!
THE “ZIP” FILE CAN ONLY BE OPENED WITH THE KIBES RT SOFTWARE, NOT WITH “WINZIP”. OTHERWISE THE FILE WILL BE DAMAGED.

The new program can be installed as follows:

- either directly from disc, or
- first copied to hard disc and then loaded from there. Look for the location of the files, as you will be required to enter it further on.

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1. Doubleclick on KIBES icon.

   The following is displayed:

Figure 30

2. Press any key.

   The following is displayed:

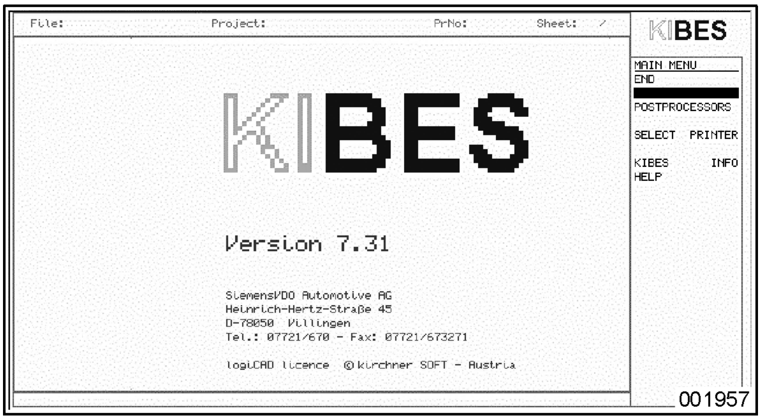

Figure 31

3. Select “POSTPROCESSORS” from the menu and press ENTER.

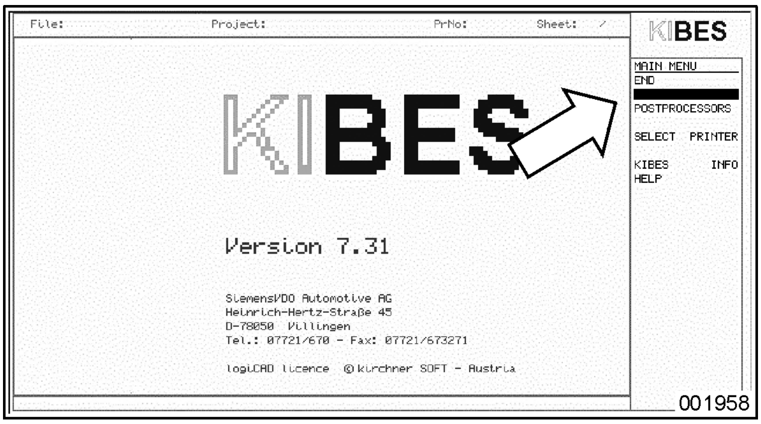

Figure 32

US09100AA

NOTE

STEPS 4 THROUGH 9 ONLY HAVE TO BE CARRIED OUT, WHEN THE PROGRAM IS LOADED FOR THE FIRST TIME.

4. Select "PROJECT TOOLS" from the menu and press ENTER key.

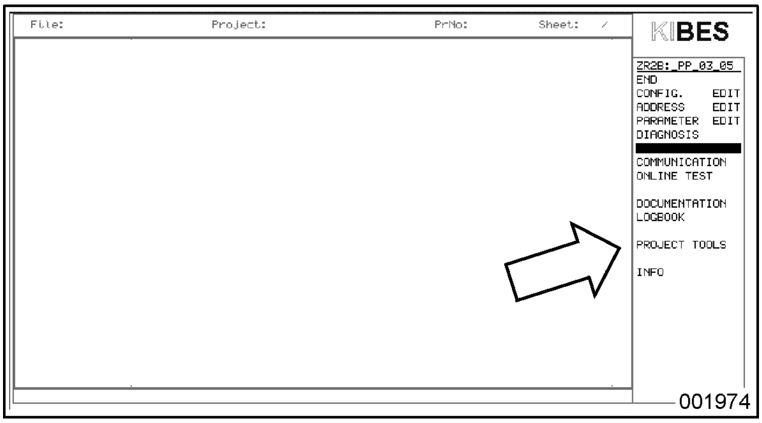

Figure 33

5. Select "PLC PROG REST" from the menu and press ENTER key.

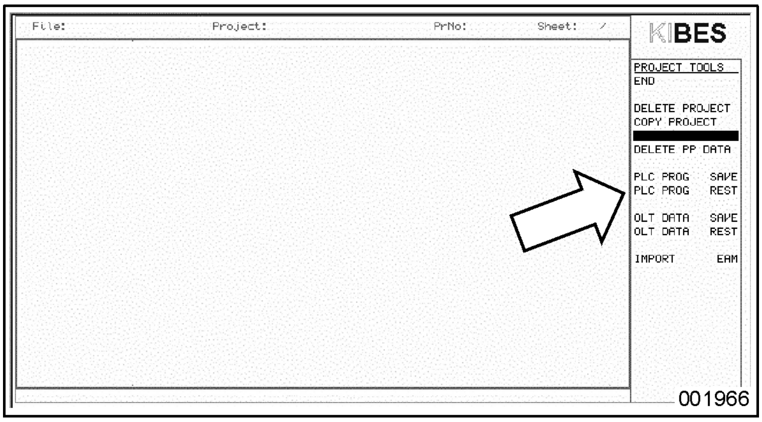

Figure 34

6. Enter program location:

- "a:\", if loading directly from disc;
- "c:\" followed by the name of the folder you have copied the files to, when loading is done from the hard disc.

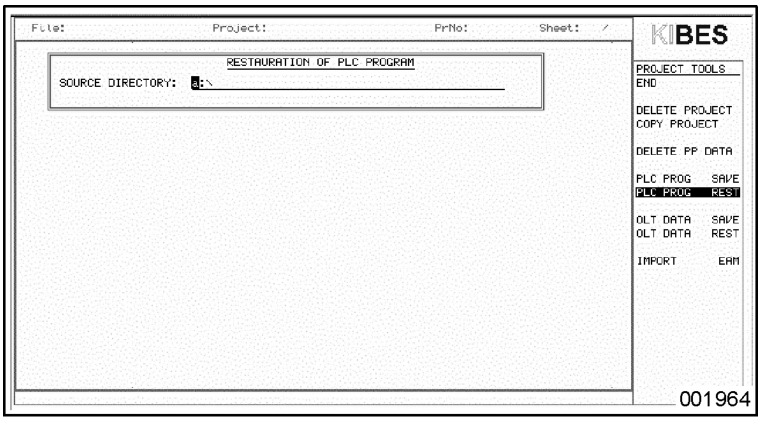

Figure 35

US09100AA

7. Press ENTER key.

8. Enter program number.

   You will find this number on the disc, in the e-mail or on the Kibes computer module.

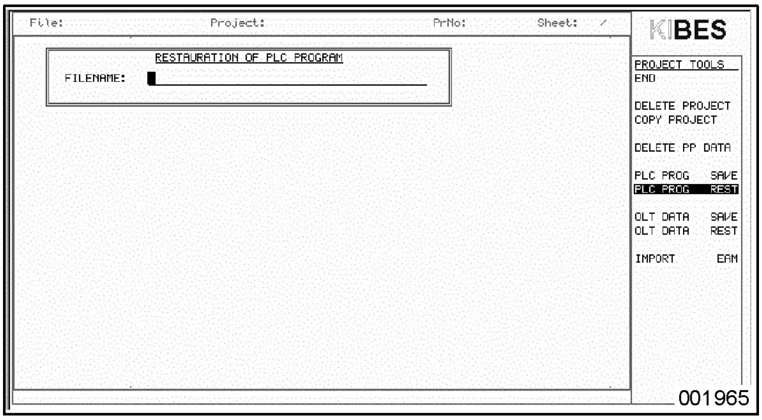

Figure 36

9. Wait for approximately 4 seconds. Choose “END” from the menu and press ENTER key.

10. Choose “COMMUNICATION” from the menu and press ENTER key.

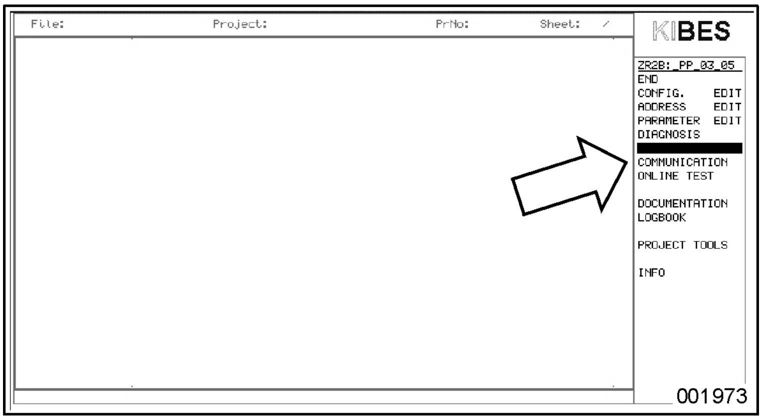

Figure 37

11. Select “LOAD PLC PROG” from the menu and press ENTER key.

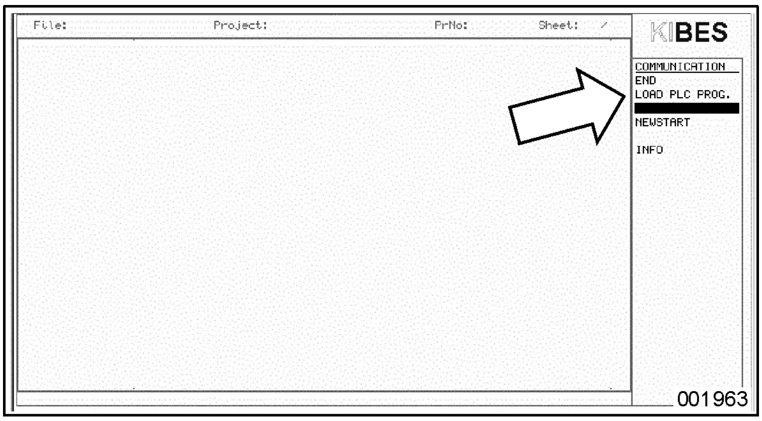

Figure 38

US09100AA

!!! CAUTION !!!

BEFORE CONTINUING, CHECK THAT THE CORRECT PROGRAM NUMBER HAS BEEN ENTERED. INSTALLING THE WRONG PROGRAM CAN LEAD TO HAZARDOUS SITUATIONS.

12. Enter program number.

You will find this number on the Kibes computer module.

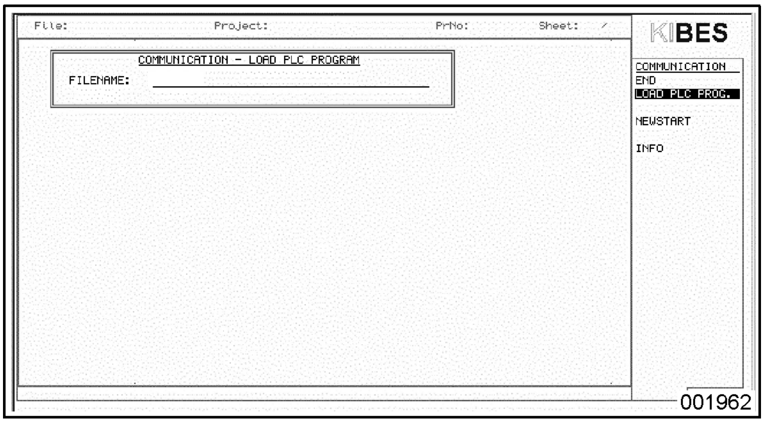

Figure 39

13 Press ENTER key.

The program is now being installed in the Kibes computer module. The progress is displayed in percentage. This screen will disappear, when the program has been fully installed.

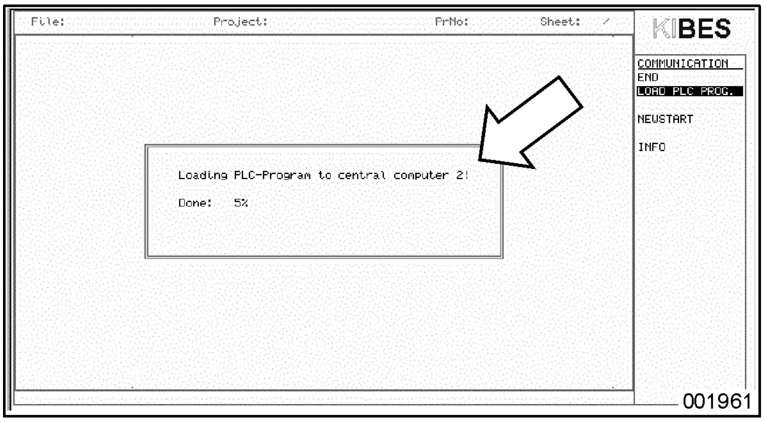

Figure 40

14. Select “END” from the menu and press ENTER key to stop installation.

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15. Write the change code on the sticker of the Kibes computer module. The change code consists of one or more characters.

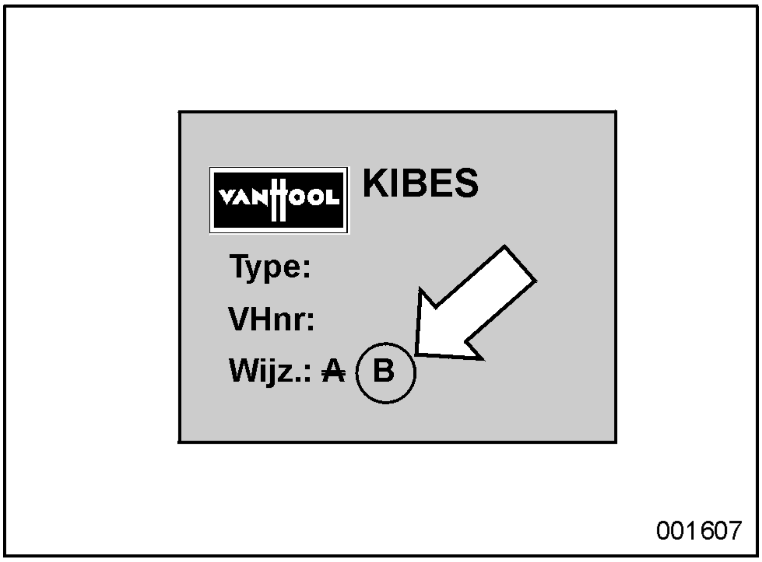

Figure 41

US09100AA

1.19 TO CONNECT PC TO DIAGNOSTIC SOCKET

1.19.1 INTRODUCTION

You have to use a special adapter module to connect the PC to the multiplex diagnostic socket.

1.19.2 SPECIAL TOOL

Adapter module K-Line V24: Van Hool ordering No. 10797942

1.19.3 PC SYSTEM REQUIREMENTS

- Processor at least Intel 386 or equivalent
- Internal memory at least 8 MB RAM
- Conventional memory at least 580 kB
- Graphics card: EGA (640 x 350) or VGA (640 x 480)
- Disc drive 3,5”
- Free space on hard disc at least 10 MB
- Ports: parallel port (Centronics); serial port for mouse; serial port (RS232) for connection to computer module ZR2-BD (Kibes)
- Driver: DOS 5.0 or higher, or... Windows 95, 98 or NT

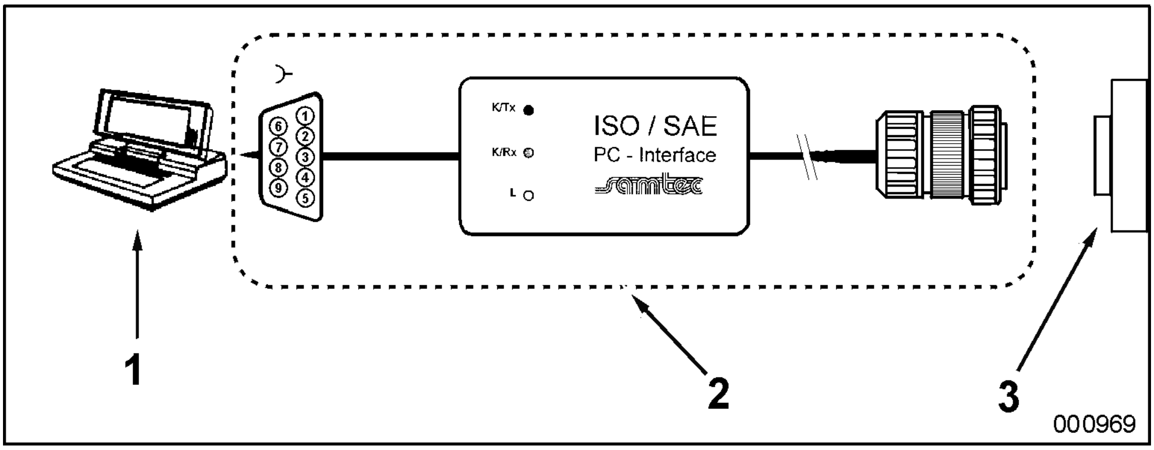

Figure 42: Connection diagram

1. **PC**
2. **Adapter module K-Line V24**
3. **Multiplex diagnostic socket on vehicle**

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1.20 FUNCTION DIAGRAM (FUP)

1.20.1 INTRODUCTION

The function diagram (delivered separately with your vehicle) shows the sequence of logic circuits in the program. You have to be familiar with the logic functions to understand the function diagram (see “Logic circuits”).

Use the function diagram to:

- comprehend the functioning of the electrical system and...
- to evaluate the “ON-LINE” test (refer to “To troubleshoot using a PC”).

1.20.2 “MK” MARKING

You will regularly come across “MK” markings on the function diagram. This marking is a software link between different pages of the function diagram. Example: “MK_KLR19B1”. The letters “MK” are followed by a description of the marking. This example refers to page 19B1.

NOTE
THE “MK” MARKING IS NOT IN THE PUBLICATION “OVERVIEW OF INPUTS AND OUTPUTS”, SINCE ONLY THE HARDWARE INPUTS AND HARDWARE OUTPUTS ARE SHOWN HERE.

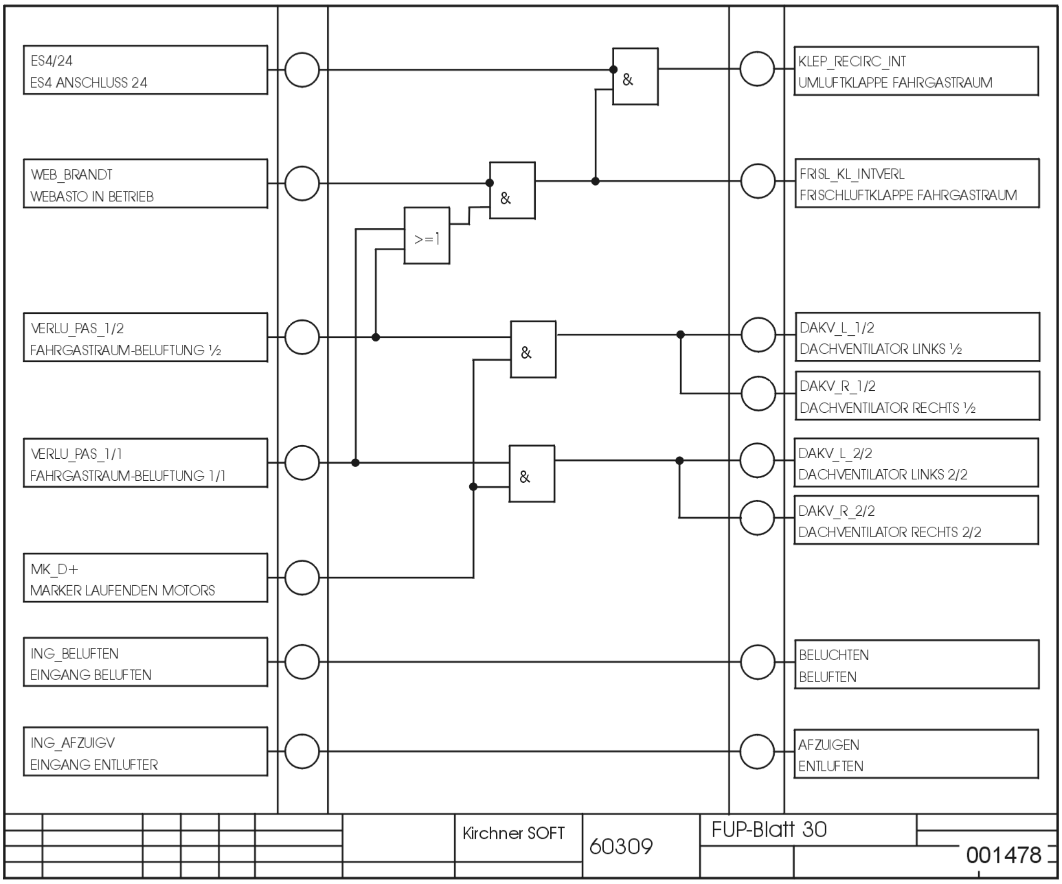

Figure 43: Function diagram page

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1.21 LOGIC CIRCUITS

1.21.1 INTRODUCTION

The links between all inputs and outputs are brought together in a program. The function diagram (FUP) shows the sequence of logic circuits in the program. You have to be familiar with the logic functions to understand the function diagram.

1.21.2 AGREEMENT

In digital systems elements are used that can adopt only two clearly distinguished statuses (“0” and “1”). In digital technology a logic “0” is considered to be equal to 0V or “ground”, whereas a logic “1” is considered as +24V or “on-board voltage”.

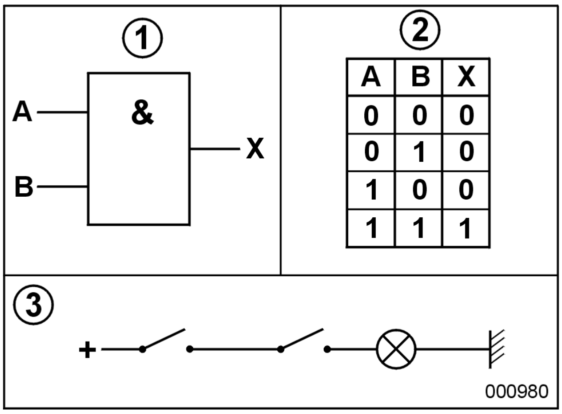
1.21.3 SIMPLE LOGIC FUNCTIONS

Simple logic functions are:

- “AND” function;
- “OR” function;
- “NOT” function.

“AND” function (see figure 44)

If the output signal “X” is present, only if both the input signal “A” and the input signal “B” are present, this circuit fulfills an “AND” function.



A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

Figure 44: “AND” gate

1. **Symbolic representation**
2. **Truth table (shows all circuit statuses)**
3. **“AND” function with switches**

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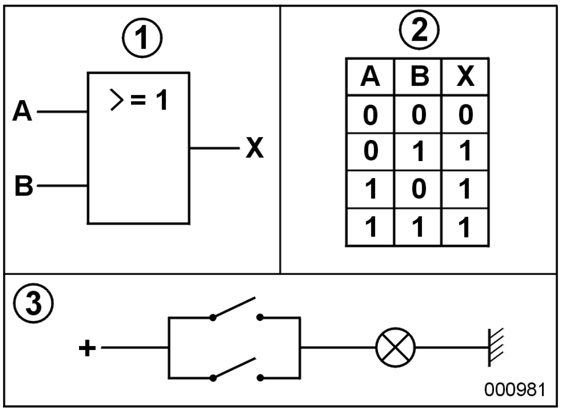
“OR” function (see figure 45)

If the output signal ”X“ is present, when either the input signal “A“ or “B” is present, this circuit fulfills an “OR” function.



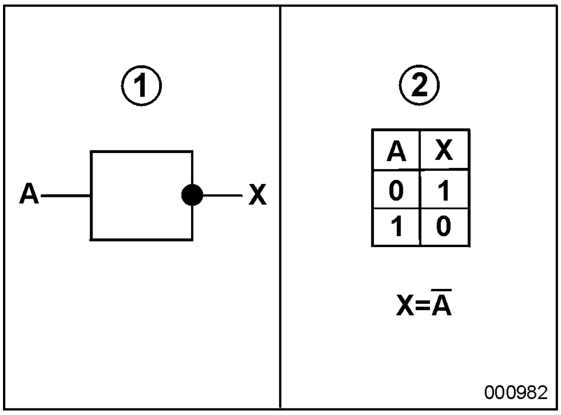
A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

Figure 45: “OR” gate

1. **Symbolic representation**
2. **Truth table (shows all circuit statuses)**
3. **“OR” function with switches**

“NOT” function (see figure 46)

A circuit fulfills a “NOT” function (= inverter), when the output signal is present, when the input signal “A” is not present and vice versa.
Note: In the illustration “X” is the inverted signal “A”. This is indicated in logic system algebra by placing a bar above the “A”.



A	X
0	1
1	0

$X=\overline{A}$

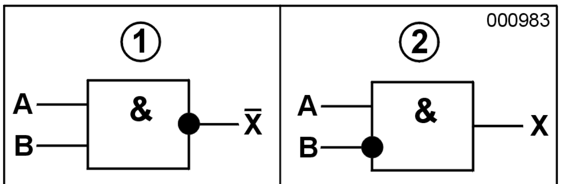
Figure 46: “NOT” gate

1. **Symbolic representation**
2. **Truth table (shows all circuit statuses)**

1.21.4 COMBINED LOGIC FUNCTIONS

The previous simple logic functions can be combined in one and the same circuit. The following functions will be discussed briefly:

- "NAND" function;
- "AND" function with an inverted input.



A	B	X	$\overline{X}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

A	B	$\overline{B}$	X
0	0	1	0
0	1	0	0
1	0	1	1
1	1	0	0

Figure 47: Combined gates

1. **"NAND" gate**
2. **"AND" gate with inverted input**

1.21.5 POSITIVE AND NEGATIVE LOGIC

The fact that the inputs and outputs can be inverted makes it possible to use positively and negatively switched inputs.

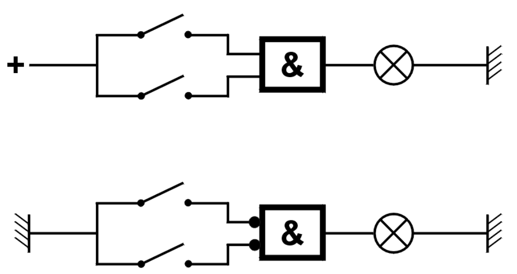
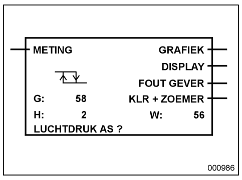


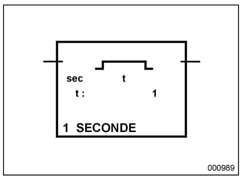
Figure 48: Example of positive and negative logic. The logic function of both circuits is identical. Both switches have to be closed to light the lamp.

1.21.6 SPECIAL MODULES

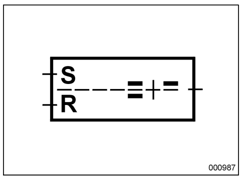
Figure 49 contains a list of preprogrammed modules that may be included in a function diagram.



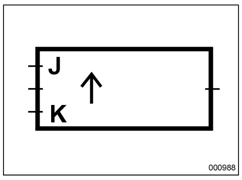
MACRO



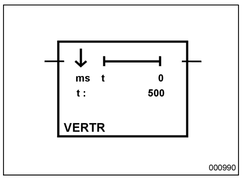
MONOFLOP



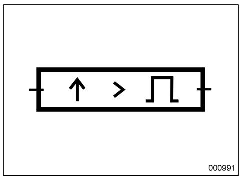
SET-RESET-FLIP-FLOP



J-K-FLIP-FLOP



TIME DELAY



FLANK RECOGNITION

Figure 49: Special modules

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1.22 OVERVIEW OF INPUTS AND OUTPUTS, SOFTWARE VERSION 1

1.22.1 INTRODUCTION

The overview of the inputs and outputs on a node are listed in a publication with the title “Overview of inputs and outputs”, which is supplied separately with your vehicle.

1.22.2 EXPLANATION OF ABBREVIATIONS USED IN OVERVIEW

- **PIN** Letter: name of the plug
  Number: plug pin
- **FUP** Name of the input or output mentioned on the function diagram
- **F** Function check
- **N** Emergency program
- **D1** Manual diagnosis: output is checked for interruption...
- **D2** Manual diagnosis: output is checked for short-circuit...
- **HS** High switching (results in “+” output)
- **LS** Low switching (results in “-” output)

1.23 OVERVIEW OF INPUTS AND OUTPUTS, SOFTWARE VERSION 2

1.23.1 INTRODUCTION

The overview of the inputs and outputs on a node are listed in a publication with the title “Overview of inputs and outputs”, which is supplied separately with your vehicle.

1.23.2 EXPLANATION OF ABBREVIATIONS USED IN OVERVIEW

- **PIN** Letter: name of the plug
  Number: plug pin
- **FUP** Name of the input or output mentioned on the function diagram
- **F** Function check
- **N (in column header)** Emergency program
- **D** Manual diagnosis
- **A** Output is checked for interruption and short-circuit
- **K** Output is checked for short-circuit
- **N** Output is not diagnosed
- **HS** High switching (results in “+” output)
- **LS** Low switching (results in “-” output

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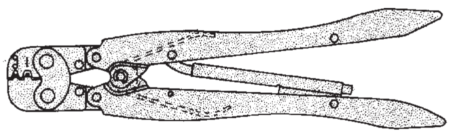
SPECIAL SERVICE TOOLS

TOOL NO. + ILLUSTRATION	DESCRIPTION
Van Hool 313640610  T02954	**Crimping tool** To make the double type crimp on the tab at the end of the wiring.
Van Hool 10797942  002424	**Adapter module K-Line V24** To connect PC to the multiplex diagnostic socket on the vehicle (for multiplexed vehicles only)

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SERVICE BULLETINS

Service Bulletins are issued to supplement or supersede information in the Van Hool manuals. Note below number, date and subject of Bulletins pertaining to this chapter. File Bulletins separately by number for future reference.

Number	Date	Subject

CHAPTER 10

HVAC SYSTEM

PAGE

AIRSIDE SYSTEMS - VENTILATION

HEATING WATER SYSTEM

MAIN10AD

REFRIGERANT SYSTEM

CONTROL SYSTEM

TROUBLESHOOTING

PERIODIC SERVICE GUIDE

ADDITIONAL INFORMATION (annexed at the end of this chapter)

Proheat M Series Service Manual

MAIN10AD

INTRODUCTION AND SAFETY PROCEDURES

STATEMENT OF NONLIABILITY

This chapter contains the most complete and accurate information obtained from various authoritative sources at the time of publication. While every precaution has been taken in the preparation of this chapter, the publisher and authors cannot assume responsibility for the accuracy of data, for errors or for omissions. Neither is any liability assumed for damages resulting from the use of the information contained herein. Persons using the information in this chapter should do so with regard to their own safety, the safety of others and the safety of property.

ABOUT THIS CHAPTER

This chapter is a general guide to the climate control systems found on C2045 coaches. It provides you with the necessary information to acquire a basic knowledge of mobile HVAC systems and explains in detail the relevant equipment installed.

The location of the components and the system lay-out are handled first. Then, maintenance and troubleshooting are discussed, so that you know how each climate control element relates to the general system and what to look for when a problem arises.

All the jobs required by the maintenance schedules should be executed in due time by skilled and trained personnel.

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A NOTE ON SAFETY

Safety warnings have been provided, and should be read and taken seriously. Many operations can be executed by skilled and trained personnel only. When you perform for the first time each of the service procedures hereafter, you should be under the supervision of an instructor or another individual with HVAC service experience. You should be careful to follow the stipulated safety procedures.

HVAC SYSTEM SAFETY PROCEDURES

- The refrigerant circuit is pressurized. Never attempt to open, perforate, weld, solder or braze a pressurized refrigerant circuit. Maintenance of the refrigerant circuit should be left to a qualified technician.
- Before opening ANY system, make sure the pressure in the system is brought to and remains at atmospheric pressure. Failure to comply may result in system damage and/ or personal injury.
- Do not attempt any procedure that may result in the uncontrolled release into the environment of refrigerant or coolant (water with antifreeze or cooling additives).
- Do not weld or steam clean near the HVAC system components.

- HVAC components such as the compressor may have a considerable weight. Extreme care should be taken when removing these components. Use adequate sling and hoist.

- Components must not be lifted by connecting pipes, hoses or capillary tubes.

- Before draining or working on the cooling system, check that the coolant has cooled down.

- The combustion heater system must be shut off when the vehicle is parked inside a building or during refueling stops.

- Never experiment with the electrical system. Because of the high current loads, high capacity fuses and relays are installed. Be aware of the constant danger of shock hazard. Short circuits can also cause overheating and fire.

- Do not attempt to solder or braze where this could cause fire.

- After repairing body or piping in rear section, make sure the ducts between engine compartment and interior are properly sealed.

!!! CAUTION !!!
TOXIC EXHAUST FUMES MAY ENTER THE PASSENGER'S COMPARTMENT IF DUCTS ARE NOT PROPERLY SEALED OFF.

- Avoid contact with rotating parts or parts that may rotate. System controls may activate fans at unexpected times.

SAFE HANDLING OF REFRIGERANT

- Avoid breathing any escaped refrigerant. Refrigerant vapor is heavier than air and can accumulate in low places. The vapor will displace air, if it is present in very large quantities. Although the refrigerant is virtually harmless, it does exclude oxygen and that makes it dangerous.

- Refrigerant vapor will decompose if exposed to flames or very hot metal surfaces. Decomposition products are toxic. If decomposition occurs, evacuate the area and ventilate thoroughly. DO NOT smoke in areas where refrigerant is stored, or where an installation or components are serviced.

- Always wear gloves and eye protection when working on the refrigerant unit or when handling service cylinders. If the liquid refrigerant spills on the skin, rapid evaporation may lower the skin temperature to considerably below the freezing temperature. Liquid refrigerant in the face or in the eyes is extremely critical.

- Never overfill refrigeration systems or cylinders. If the temperature of an overfilled system or cylinder rises, the increased pressure may cause the components to burst.

- Do not subject a refrigerant cylinder to high temperatures. Always replace a cap over the refrigerant cylinder service valves.

- Recover refrigerant from the refrigerant system before welding or brazing. Flush pipes with dry nitrogen 4.6 when brazing or

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welding parts of the refrigeration system. Never use pressurized air to clean pipes or parts of the system. Oxygen and refrigerant oil can form explosive mixtures. Make sure that the area is well ventilated.

FIRST AID FOR REFRIGERANT ACCIDENTS

- **Frostbite**: Warm the affected skin to body temperature as soon as possible.

- **Eyes**: If refrigerant is splashed into the eyes, rinse with a lot of water. Immediately consult a physician or an optometrist.

- **Overcome by vapor**: Immediately move the victim into fresh air and call a physician. Meanwhile, keep the victim prone and inactive. If the victim is unconscious, start artificial respiration until help has arrived.

Do not use chemical products of the adrenalinephedrine group. In combination with excessive refrigerant vapor concentration, these can produce cardiac arrhythmia leading to ventricular fibrillation.

DISPOSAL PROCEDURES

Various state and federal guidelines regulate the proper disposal of oils, chemicals and other fluids. Be aware of the potential of point source pollution and of other dangers to the environment. Dispose of these materials at authorized disposal sites. Contact Environmental Protection Agency for advice.

NOTE CONCERNING THE USE OF REFRIGERANTS

Scientists are concerned about the possible release of refrigerants into the atmosphere. There is some evidence that the balance of nature may be affected by the release of refrigerants.

There is an increased amount of recycling systems, which enable you to clean and re-use the refrigerant in your system.

You can also substantially limit refrigerant emission following a few simple steps:

- Properly maintain your airconditioning system. Be aware of any refrigerant loss. Check and repair at an early stage.

- Recover and recycle or reclaim refrigerants. Contact an airconditioning service center with recycling equipment, if not available in your shop.

NOTE
Specific operations as to the use of recovery and/or recycling equipment are not mentioned here. Contact a Carrier/Sütrak service center or a refrigeration equipment supplier.

TYPE OF REFRIGERANT CHARGE

All HVAC systems on C2045 coaches use ozone friedly refrigerant R-134a.

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HVAC OPERATION

PURPOSE

The two major aspects of automotive climate control are air conditioning and heating comfort. Both depend upon "perception" of comfort by passengers. This perception of comfort is highly subjective, differing widely from individual to individual.

Factors internal to the vehicle affecting comfort include interior temperature, pressure, and humidity, as well as airflow patterns within the vehicle. These airflow patterns are functions of the flow from air supply outlets, internal cabin geometry (such as seating layout, space around stairs and under seats), leak paths from the vehicle (such as door seals), distance from, and surface of glazed areas, and location and size of air exhausts.

Factors external to the vehicle affecting comfort include outside temperature, relative air speed, and sunload.

THEORY OF OPERATION

To provide the best-possible interior climate, the following comfort elements must be controlled:

- air temperature and radiant temperature;
- relative humidity;
- air velocity;
- air freshness and purity.

When the body picks-up more radiant heat, it feels warmer with the air temperature remaining the same.

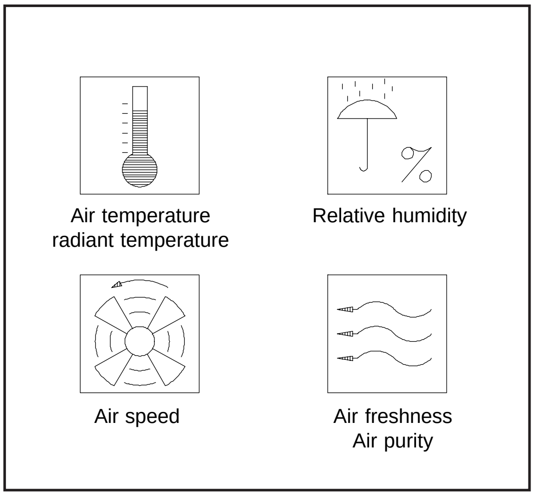

Figure 1: HVAC comfort elements

Each individual reacts differently to climate conditions. The air nozzles in the overhead luggage rack allow individual "fine-tuning" of the air flow. Dry air allows perspiration to evaporate and cool the body. Warm, humid air does not allow the evaporation process to occur.

The heavier the clothing, the lower the temperature that feels comfortable.

There is always a "net heat gain" inside the coach from body heat. In addition, each passenger introduces a significant amount of moisture into the air via perspiration and breathing.

TEMPERATURE CONTROL

With the coach in operation, and the airconditioning system off, the interior temperature is always higher than the outside temperature. There is always a heat gain from solar radiation and passengers.

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Heating, cooling and fresh air ventilation influence the interior temperature.

- **Heating:** Directly raises the interior air temperature. Radiant heat gives the sensation of a higher temperature.

- **Cooling:** Directly lowers the interior air temperature.

- **Fresh air ventilation:** Brings the interior air temperature closer to the outside air temperature. When the cooling system is off, the fresh air supply cools the interior.

HUMIDITY CONTROL

Air can carry heat. It will remove heat from a place, or take it to a place. The heat content changes as the temperature or humidity changes.

Normally, air carries less moisture than the maximum amount it can hold. When the actual amount of moisture in the air is compared to the maximum amount it can hold, this measurement is called "relative humidity". Relative humidity is connected to air temperature.

At higher temperatures the air can hold more moisture. When a sample of air is heated, relative humidity lowers as the temperature rises.

For example: When air of 50°F with a relative humidity of 75% is heated to 77°F, the relative humidity lowers to 40%.

Moisture can also be introduced into the coach by the passengers through respiration and perspiration, and by persons entering the vehicle with wet clothes.

For example: At an interior temperature of 77°F, 50 passengers introduce 3.4 quarts of water vapor per hour.

Moisture can be removed by:

- **Fresh air ventilation**: When the moisture content of the outside air is lower than the moisture content of the interior air. This will occur more easily when:

  - outside air temperature is low;
  - outside air relative humidity is low;
  - outside air flow to interior is high.

- **Cooling**: If the air is cooled, less moisture can be held, and the excess condenses into water. This condensate is drained to the exterior. The cooled air contains less moisture.

- **Reheat**: When the interior air temperature is more or less equal to the outside temperature, no cooling is required and ventilation is not effective. The air is first cooled, with condensation as a result. Condensate is drained to the exterior. The cold air is then reheated to the appropriate supply air temperature.

To obtain adequate control the proper HVAC operating mode in relation to the outside temperature needs to be selected.

- Low outside temperature: fresh air ventilation

- Moderate outside temperature: reheat

- High outside temperature: cooling

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GENERAL DESCRIPTION

GENERAL

The climate control system contains:

- an air side system;
- a heating water system;
- a refrigerant system;
- and a control system.

AIR SIDE SYSTEM

Contains all air handling and air distribution components.

Most of the air side system components of the driver's HVAC system are integrated in the unit below the driver's compartment floor. It consists of an air filter, two blowers and a fresh air intake damper. The air is distributed to the windshield and to the front of the coach through hoses and air ducts. The unit is accessible via the exterior door below the driver's side window.

The air side system components of the passenger's compartment HVAC system are located, halfway the aisle, at the left and right side in the parcel racks. Each side contains six blowers, two air filters, condensate drains and a fresh air intake damper. The air is forced into the passenger's compartment through an air duct and air distributors in the parcel rack.

The lavatory compartment is equipped with an air exhaust fan.

HEATING WATER SYSTEM

The components of the heating water system are:

- a combustion heater;
- an electric water circulating pump;
- floor heaters;
- heaters in parcel racks and in driver's compartment HVAC unit;
- water valves, piping, accessories.

REFRIGERANT SYSTEM

The refrigerant system consists of:

- a compressor;
- a compressor clutch;
- a condenser compartment which contains the condensor coil, the condensor cooling fans, the receiver tank and the filter/drier;
- three evaporator coils (two in the passenger's compartment and one in the driver's compartment HVAC unit);
- three thermostatic expansion valves, piping, accessories.

CONTROL SYSTEM

All instruments, plus electric and pneumatic circuits necessary to operate and control the HVAC system.

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AIRSIDE SYSTEMS - VENTILATION

AIR CIRCULATION IN THE DRIVER'S COMPARTMENT

The fresh or recirculated air is drawn through a filter, forced through the heater and evaporator and then distributed via flexible air hoses to the windshield and to air outlets in the driver's compartment by two blowers. The blowers are mounted in the HVAC unit under the driver's compartment floor and are accessible through the exterior door in front of the left front wheel.

FRESH OR RECIRCULATED AIR INTAKE

The fresh air intake flap, mounted at the front of the HVAC unit, allows to select "fresh air" or "recirculated air" intake.

AIR FILTER

The unit should never be operated without the air filter properly installed. Otherwise dirt will accumulate in the cores and on the blowers. Check the filter cloth for dirt according to the Periodic Service Guide , Section 10.9.

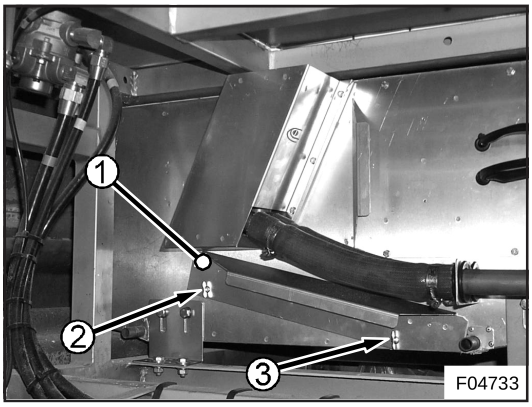

Figure 1: HVAC unit (accessible through exterior door in front of left front wheel)

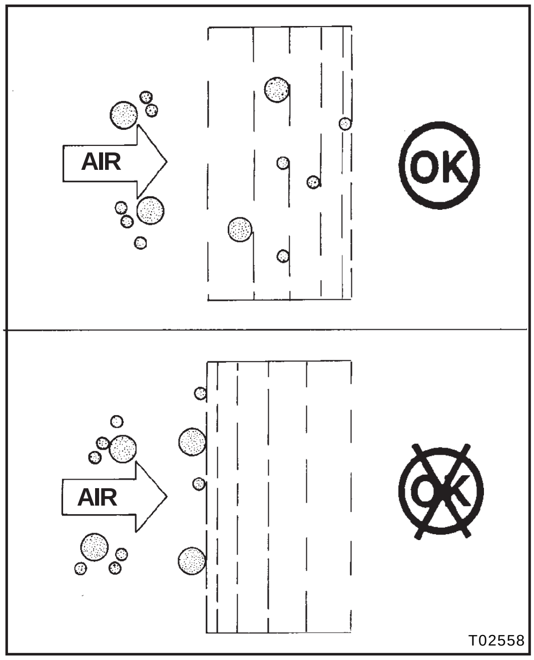

Figure 2: Diagrammatic section of "one-way" filter material, showing air flow in right and wrong directions

A dirty filter will give rise to complaints about insufficient air flow.

The filter cloth has a coarse-textured and a fine-textured side. See to it that the filter cloth is always installed with the coarse-textured side facing to the ground. If the cloth is reversed, there will be no depth filtration: larger dirt particles will quickly clog the fine-textured surface, thus blocking the air passage (see Figure 2).

To remove the filter cloth- Figure 1

1. Open the exterior door in front of the left front wheel.
2. Remove the two wing nuts (2 and 3).
3. Pull out filter drawer (1).
4. Remove filter cloth from the drawer.

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To clean filter cloth

1. Shake out excessive dirt and grit.
2. Wash in luke-warm water and if extremely dirty, use a mild laundry or dishwashing detergent.
3. Rinse with clean water and shake out excessive water. Do not wring or squeeze. Be sure cloth is completely dry before re-installing.
4. Re-install filter cloth (reverse operation of to "Remove filter cloth").

NOTE
Make sure that the new or cleaned filter cloth covers the complete air passage. Never install a cloth that is damaged or too small.

BLOWERS

The blower motor is not repairable. When blower is faulty , noisy or when there is excessive play on the motor shaft, change the complete motor and blower wheel assembly. A dirty air filter or an air filter not covering the full air passage may considerably reduce the blower motor life.

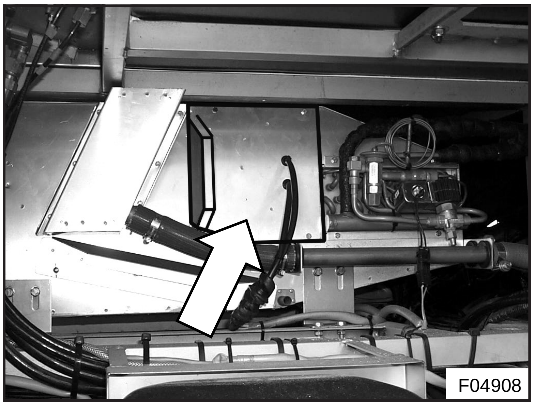

Figure 3: Location of blower assembly in driver's compartment HVAC unit (accessible through the exterior door in front of the left front wheel)

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AIR CIRCULATION IN THE PASSENGERS COMPARTMENT

The fresh or recirculated air is drawn through a gauze filter, the evaporator and heater and then distributed via the main air duct in the parcel rack to the air distributors at the window side of the parcel rack, to the individual air outlets above the seats and to several other air outlets in the passengers compartment.

FRESH OR RECIRCULATED AIR INTAKE

The fresh air intake flap (see Figure 5), mounted behind the air filter access panel in the parcel rack (see Figure 4), allows you to select "fresh air" or "recirculated air" intake.

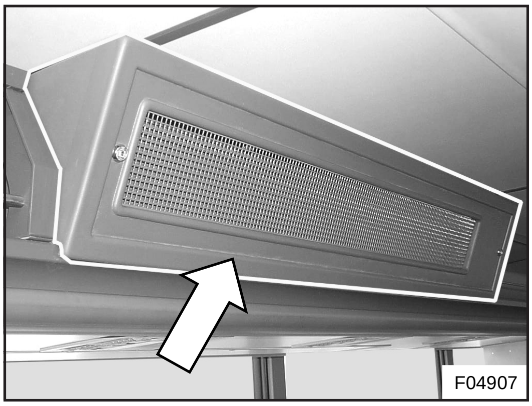

Figure 4: Air filter access panel in parcel rack

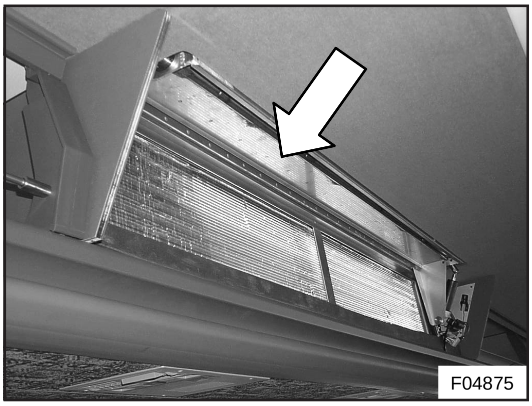

Figure 5: Fresh air intake flap

AIR FILTERS

Each unit is fitted with two screen filters. The units should never be operated without the air filters properly installed. Otherwise dirt will accumulate in the cores and on the blowers. Check the gauze filters for dirt according to the Periodic Service guide , Section 10.9.

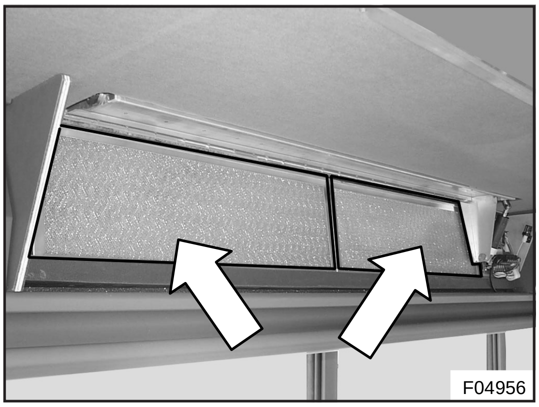

Figure 6: Air filters of HVAC unit in parcel rack (two for each unit)

To remove and clean the filter

1. Remove the air filter access panel (see Figure 4). On current coaches, the access door is equipped with check straps.
2. Remove the filters by pushing them down using the notch and pulling them out of the rail.
3. Clean the filters with compressed air.
4. Install the filters in the reverse order.

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BLOWERS

The blowers are mounted on a bracket behind the heater/evaporator coil assembly .To gain access to the blowers:

1. Turn the three quick release bolts securing the panel in the bottom of the parcel rack some turns counterclockwise (see Figure 8). Fold down the cover.

2. The blowers are now visible. To remove a blower, remove its retaining bolts.

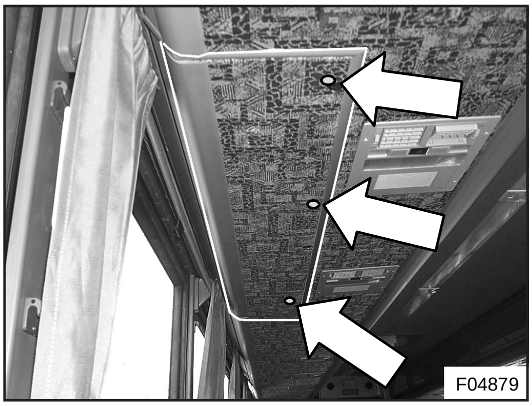
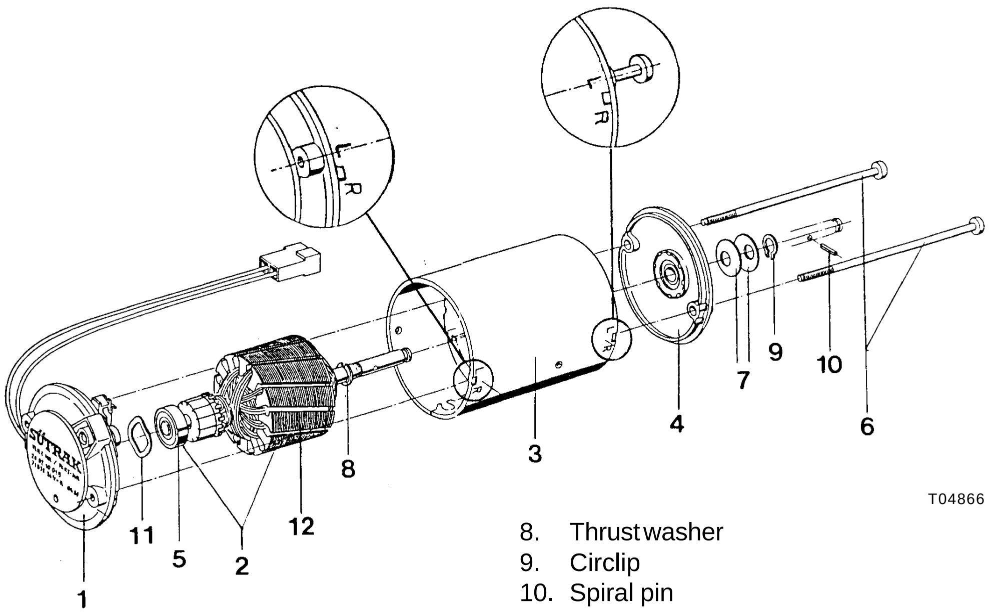


Figure 8: Blowers access panel in bottom of parcel rack



1. End cap with brushes
2. Rotor with bearing
3. Stator
4. End cap with bearing
5. Bearing
6. Bolt
7. Disk spring
8. Thrust washer
9. Circlip
10. Spiral pin
11. Compensating spring
12. Rotor

Brushes: minimum length 0.295 inch
Commutator: minimum dia. 0.902 inch

NOTE: If brush replacement is necessary, note right (R)and left (L) rotation indicator marks on stator (item 3)

Figure 7: Exploded view of Longlife blower motor (24 VDC-motor, left-handed counterclockwise rotation)

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Figure 9: View in blowers compartment (access panel folded down)

NOTE
Blower motors, fans and housings are handed. Improper assembly will impair efficiency.

Long Life blower motors have a replaceable end cap with brushes. Expected lifetime is about 10,000 operating hours with first set of brushes. Expected motor lifetime is about 15,000 operating hours.

MAIN OVERHEAD AIR DUCTS

The overhead air ducts have been designed to convey and distribute the air over the entire length and on both sides of the vehicle.

Conditioned air is distributed through:

- individually adjustable overhead nozzles;
- permanently open vents to side windows (with extra vents front and rear);
- permanently open air vent holes in handrails.

Uncontrolled air flow caused by defective air distributors may cause passenger discomfort. Regularly check condition of individual air outlets, inspect proper sealing of transition airducts and sealing of airducts against the roof. Repair or replace sealant and defective parts.

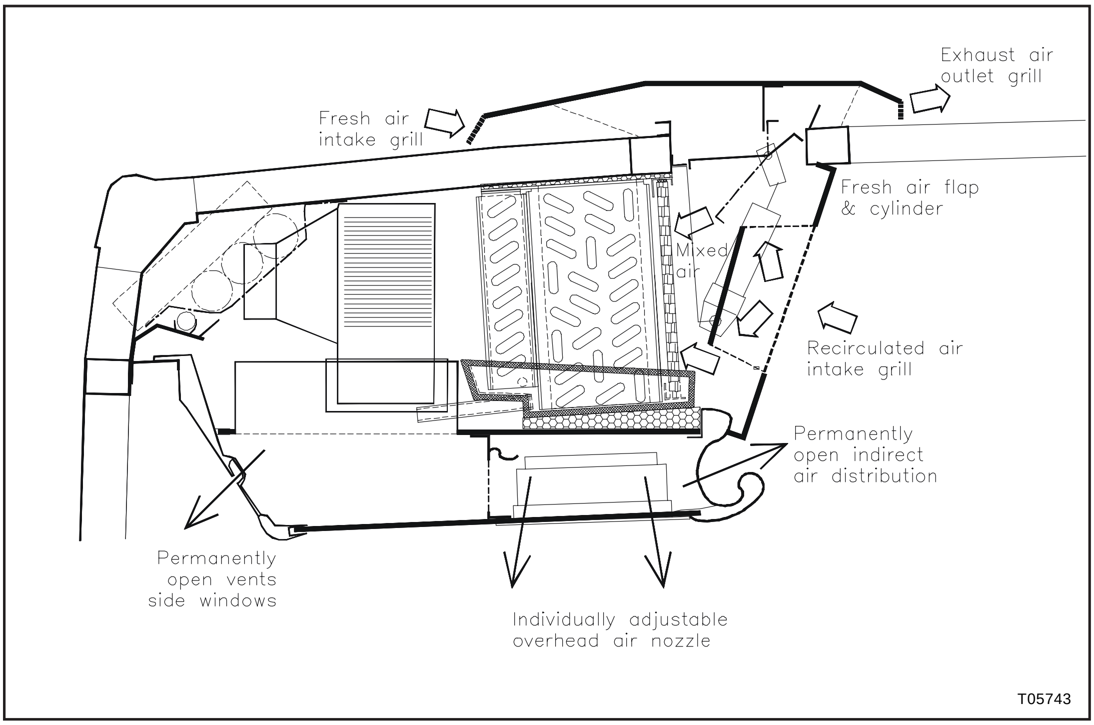

Figure 10: Airduct cross-section and air flow pattern

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AIR CIRCULATION IN LAVATORY COMPARTMENT

A roof mounted extractor fan constantly removes air from the lavatory to the outside of the coach, so that odors do not penetrate the passenger compartment. Conditioned air is introduced through an air outlet in the front wall of the lavatory compartment.

Check regularly that the:

- fan operates at low speed with the engine running;
- fan operates at high speed with the engine running and lavatory compartment door locked.

When fan does not operate in low or high speed mode, check power supply. When fan is defective, makes abnormal noises or when there is excessive play on the motor shaft, replace motor.

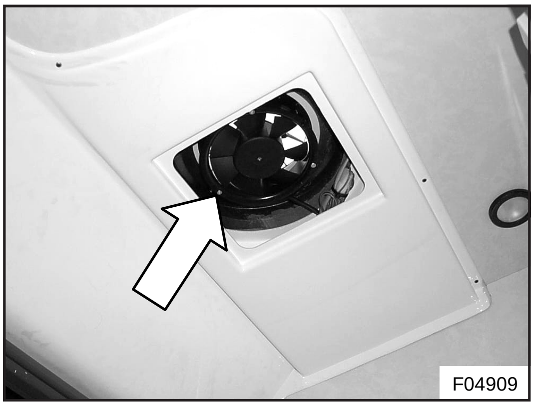

Figure 11: Exhaust fan in toilet compartment (cover panel removed)

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HEATING WATER SYSTEM

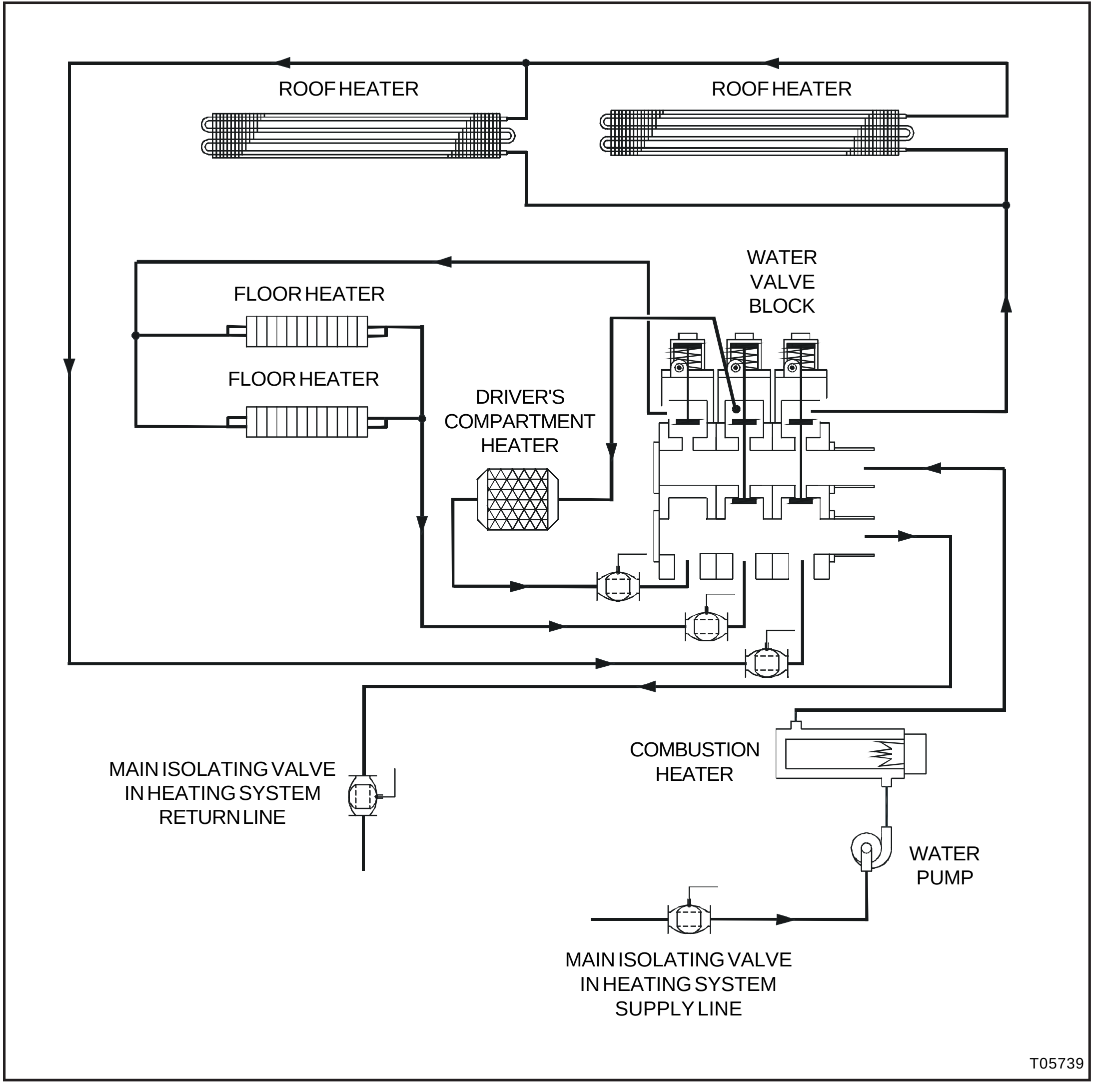

Figure 1A: Heating water system schematic

The heating water system consists of the following:

- a "Proheat" combustion heater;
- an electric water circulating pump, near the combustion heater;
- two air pressure actuated two-way water valves and one air pressure actuated shut-off valve in the combustion heater compartment;
- a heater coil in the driver's compartment HVAC unit, located under the driver's compartment floor;
- two heater coils in the parcel racks of the passenger's compartment;
- floor heaters at the LHS and RHS of the passengers compartment;
- piping accessories.

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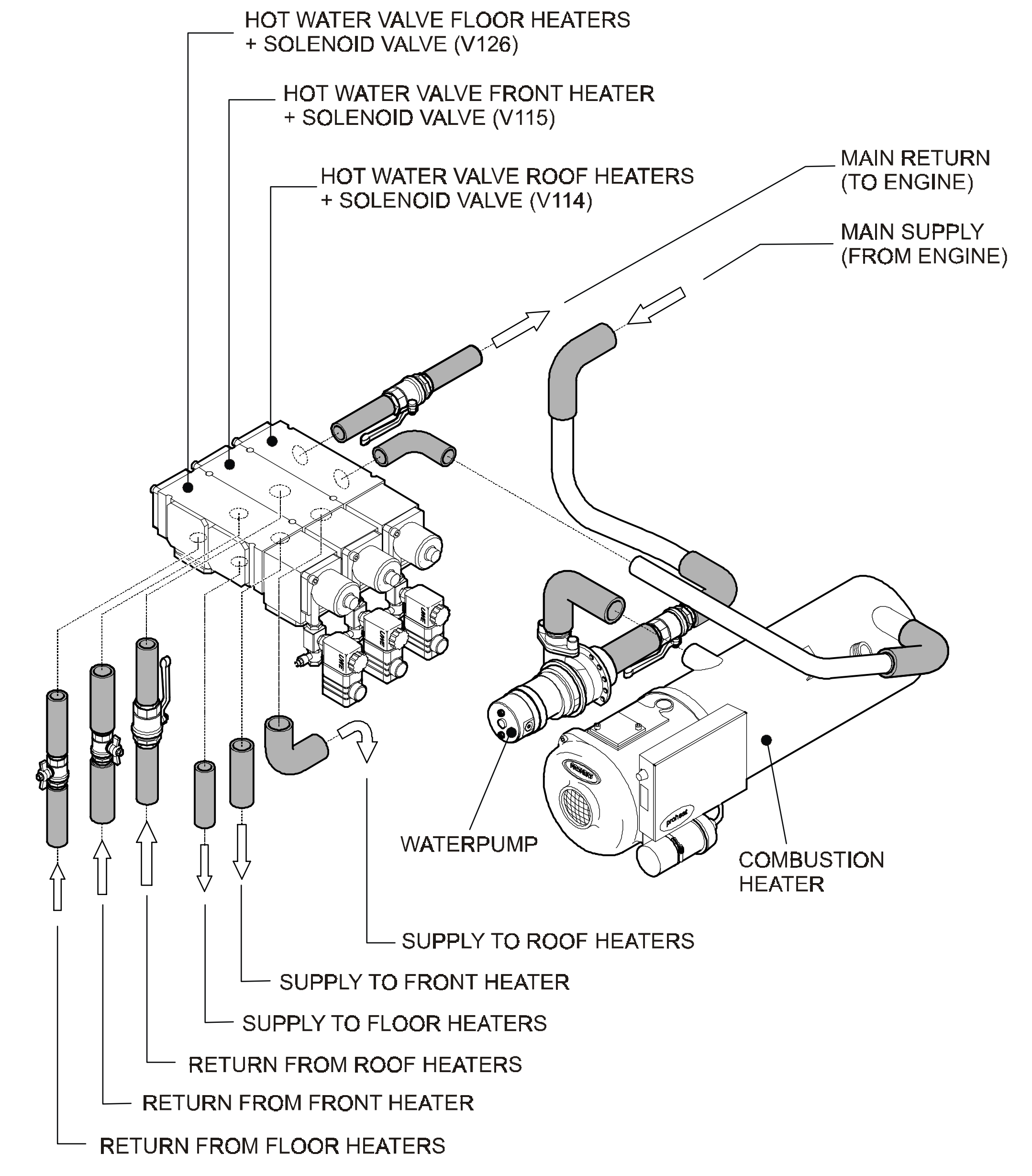

Figure 1B: Components of the heating water system in the combustion heater compartment (in front of left drive wheel)

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"PROHEAT" COMBUSTION HEATER

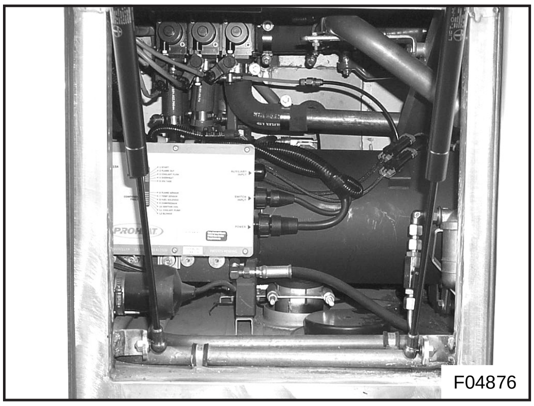

Figure 2: Combustion heater compartment (in front of left drive wheel)

SAFETY INFORMATION

!!! CAUTION !!!
DUE TO DANGER OF POISONING AND SUFFOCATION, THE HEATER MUST NOT BE OPERATED IN CLOSED AREAS SUCH AS GARAGES OR WORKSHOPS WITHOUT PROPER VENTILATION. MAKE SURE THE TIMER IS NOT SET WHEN THE VEHICLE IS PARKED IN A GARAGE.

TECHNICAL SPECIFICATIONS

Model .... Bravo 80
Heat output ....80,000 BTU/hr
Volt range ....20 to 30 Volts
Current range .... 3 to 4.5 Amps
Fuel rate .... 0.7 US Gal/hr

PRINCIPLE OF OPERATION

Blower

Combustion air is provided by an impeller style fan to supply approximately 90% of the combustion air. The fan impeller is driven by the blower motor. The speed of the blower motor is checked once per minute to ensure proper operation. There is an external adjustment for combustion air but it should not be necessary to adjust combustion air under normal circumstances.

Fuel system

The fuel system consists of a FDU (Fuel Delivery Unit) and an air compressor. The FDU consists of a fuel gear pump, fuel regulator, nozzle and fuel shut-off solenoid.

• The fuel gear pump supplies low pressure fuel to the fuel regulator. The fuel gear pump is driven by the blower motor and contains a recirculation system so that no return line is required.

• The fuel regulator reduces the fuel, supplied by the fuel pump at low pressure, to atmospheric pressure. Siphoning action from the nozzle, caused by the compressor air, draws fuel from the regulator. Without this siphoning there is no fuel flow.

• The fuel nozzle is an air aspirating type spray nozzle. The compressed air flows through the nozzle at high speed creating a venturi effect. This siphons fuel from the regulator and combines it with the air creating an atomized mist which is sprayed into the combustion chamber.

• The fuel solenoid is a normally closed device that unless activated, prevents fuel flow to the nozzle.

Compressor

A diaphragm type air compressor supplies air to the fuel nozzle.

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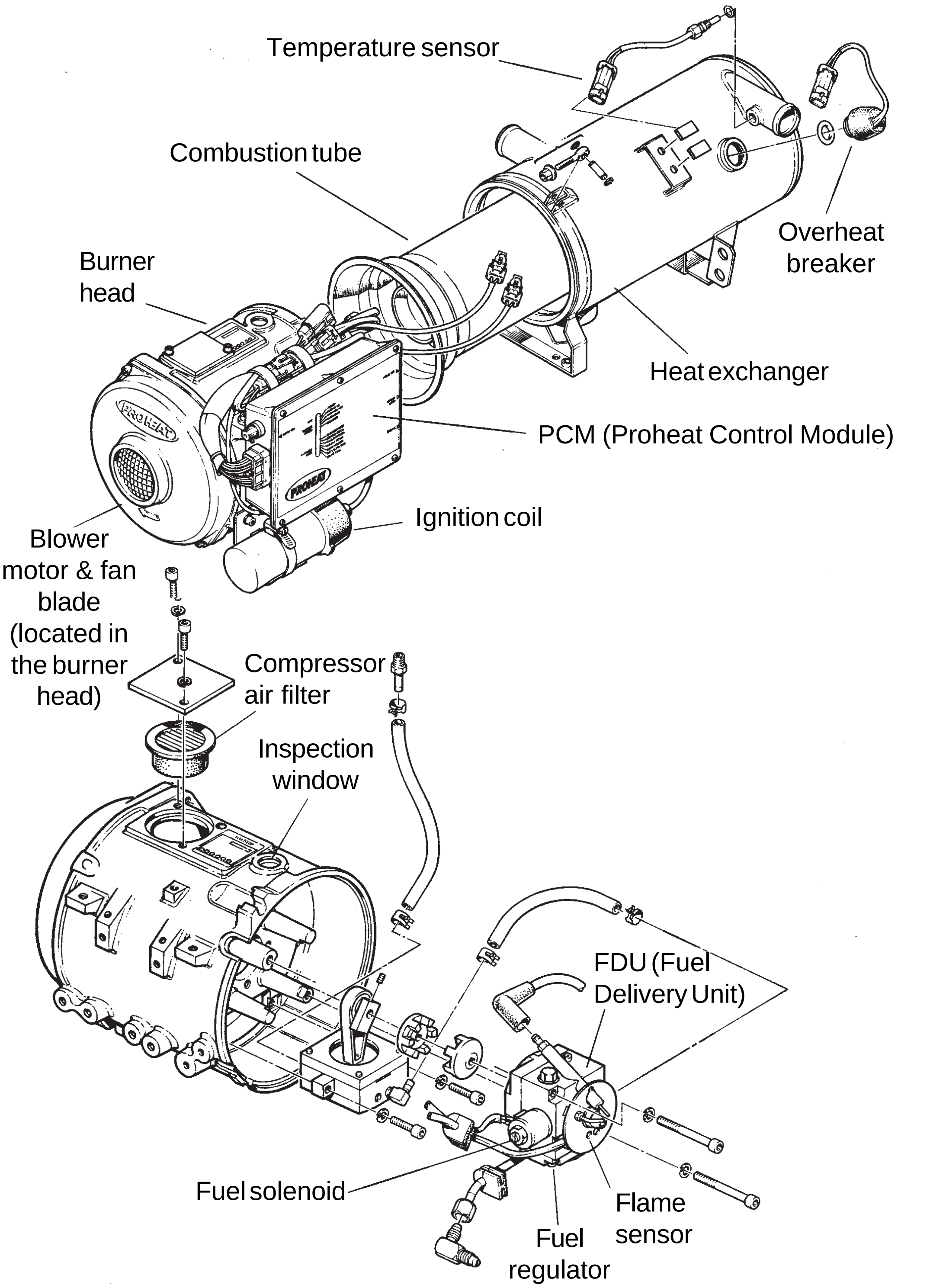

Figure 3: Combustion heater main components

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Ignition system

The ignition system consists of an automotive style ignition coil and ignition electrodes. The spark and ground electrodes are located near the nozzle just out of the air-fuel spray path. During the ignition sequence the spark jumps the electrode gap igniting the air-fuel mixture. Spark duration is 30 seconds although as long as fuel is provided ignition is instantaneous. The ignition coil and spark electrode are connected by a high tension lead. The spark energy goes through the ground electrode and the burner head ground wire back to the battery.

Flame sensor

The flame sensor photo-electrically measures the intensity of the flame. It is the flame sensor that signals to the PCM that the heater is burning properly. The flame sensor is located on the FDU.

Combustion tube

The combustion tube contains an air swirler which mixes the air/fuel mist from the nozzle with the combustion air provided by the blower. The combustion tube also provides a chamber for the air/fuel mixture to burn and directs the hot gases to recirculate through the heat exchanger fins.

Heat exchanger

A welded assembly which circulates coolant around the hot combustion gases. The coolant absorbs the heat from the hot combustion gases. Coolant temperature will typically rise 10 to 15°F as it passes through the heat exchanger, depending on the coolant flow rate.

Coolant pump

The coolant pump circulates the engine coolant through the heater.

Temperature sensor

The temperature sensor measures the coolant temperature at the outlet port of the heat exchanger. This sensor signals the heater to cycle on when the coolant temperature is less than 150 °F and cycle off when the coolant temperature reaches 185 °F.

Overheat breaker

The overheat breaker protects the heater from damage should it be operated without coolant. When the temperature of the inner jacket of the heat exchanger reaches 286 °F, the breaker trips and the heater shuts down. Once tripped the breaker must be reset by pushing down on the red button (located under the rubber cap). A heater with coolant but no coolant flow will generally result in a coolant flow error, not an overheat error.

PCM (Proheat Control Module)

The PCM controls all aspects of heater operation and utilizes microprocessors to monitor operating conditions and sensors and control outputs to components. It has powerful diagnostics to assist in throubleshooting. One of the key features is the PCM Diagnostic Display panel at the front of the controller which has LEDs to indicate function errors or components faults.

Inspection window

Located on top of the burner head. Used for visual inspection of the flame and ignition.

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NORMAL OPERATING SEQUENCE

Switch on

The PCM "ON" LED will light. If the coolant temperature is above 150 °F the combustion heater goes to *"Standby"*. If the coolant temperature is below 150 °F the combustion heater goes to *"Precheck"*.

Precheck

The controller performs a short self diagnostic check. This takes several seconds, checking components for proper ranges, short circuits and open circuits. If there are no problems indicated, the combustion heater goes to *"Ignition"*.

Ignition

The blower motor and coolant pump start first, followed by the ignition spark, and fuel solenoid. The ignition electrode sparks for 30 seconds but combustion is usually established instantly. After the ignition period is complete and the flame sensor sees a good flame, the combustion heater goes to *"Full Output"*.

Full output

The combustion heater runs at full output until the coolant temperature reaches 185 °F at the combustion heater outlet. At this time, the combustion heater shuts the flame off and goes to *"Purge"*.

Purge

The fuel solenoid shuts off immediately. The blower motor and coolant pump continue to run. After 3 minutes, the blower motor stops and the combustion heater goes to *"Standby"*.

Standby

The coolant pump continues to circulate the coolant throughout the system. When the coolant temperature drops to 150 °F, the cycle repeats starting at *"Precheck"*.

Switch off

If combustion heater is in "ignition" on or "full output", it will "purge" first, then shut off. If combustion heater is in "Standby", it will shut off immediately.

NOTE
The combustion heater will "purge" for three reasons: • *the coolant temperature reaches 185 °F;* • *there is a function or component diagnostic error;* • *the combustion heater is operating in "Ignition" or "Full Output" when it is shut off.*

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TROUBLESHOOTING & REPAIR

The troubleshooting guide is divided into four sections:

• *Function Diagnostic Codes*: LEDs displayed on the function section of the PCM diagnostic panel (see Figure 4) are usually the result of a vehicle system or installation problem.

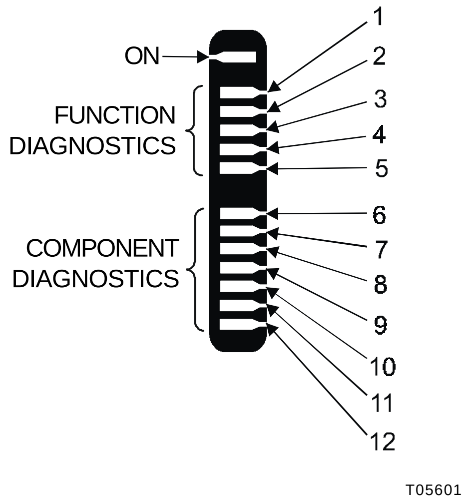
• *Component Diagnostic Codes*: LEDs displayed on the component section of the PCM diagnostic panel (see Figure 4) indicate an electrical problem with the wiring to that component, within the component itself or in that particular component's circuit on the PCM.

NOTE
The PCM can display two or more diagnostic codes at the same time.

• *Components (No Diagnostic Code)*: This section includes the compressor, fuel pump, fuel regulator, nozzle, electrode gap and PCM fuse.

• *Operational problems*: Problems that are not specifically described in the "Function" or "Component" sections.

!!!CAUTION!!!
THE COMBUSTION HEATER WILL ALWAYS ATTEMPT TO START TWICE. THIS MEANS THAT WHEN THE PCM DETECTS A DIAGNOSTIC CODE IT WILL SHUT DOWN THE HEATER. THE HEATER WILL PURGE FOR THREE MINUTES. IF THE COOLANT TEMPERATURE IS BELOW 150 °F THE HEATER WILL ATTEMPT TO RESTART. IF THE COOLANT TEMPERATURE IS ABOVE 150 °F THE HEATER WILL WAIT UNTIL THE TEMPERATURE DROPS BELOW 150 °F AND THEN ATTEMPT TO RESTART. ALWAYS LET THE HEATER ATTEMPT TWO CYCLES. THE PCM WILL THEN INDICATE WHAT IT THINKS IS WRONG.



Code No.	Type of diagnostic	No. of flashes
1	Start error	1
2	Flame out	2
3	Coolant flow	3
4	Coolant overheat	4
5	Voltage (High/low)	5
6	Flame sensor	6
7	Temperature sensor	7
8	Fuel solenoid	8
9	**(Not Used)**	9
10	Ignition coil	10
11	Coolant pump	11
12	Blower (combustion)	12

Figure 4: PCM diagnostic panel and diagnostic codes

A continuously flashing "ON" LED on the PCM diagnostic panel indicates a problem in the PCM microprocessor. Follow in this case the procedure below:

1. Switch the heater off.

2. Reset the PCM by disconnecting the power connector for 10 seconds and then re-connecting. Normally the PCM "ON" LED will flash once when power is restored. If the "ON" LED flashes continuously, replace the PCM.

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Function & Component diagnostics

The microprocessor in the PCM continually monitors the combustion heater system. If the internal diagnostics discover a problem, a LED will lit on the PCM diagnostics panel. The combustion heater timer red "ON" light will repeatedly flash a diagnostic code separated by a pause. The number of flashes correspond to the numbered diagnostic code (eg. five flashes indicates a "Voltage Error". See Figure 4 for a complete list of error flash codes.

Start error

A "Start Error" code indicates that the flame sensor did not see a flame during the 30 seconds ignition period.

If the "Start Error" is displayed, reset the PCM by switching the heater OFF and then ON. Let the heater attempt and finish two start cycles. Observe the heater operation either through the inspection window and/or by listening to the combustion process.

SYMPTOM:	CHECK:
A flame is visible The heater shuts down after the 30 seconds ignition period.	**Flame sensor** Check the flame sensor as per test procedure. (see further in this Section)
No flame (spark is visible) The spark continues for the 30 seconds ignition period. The heater shuts down after the 30 seconds ignition period.	**Fuel system** • Is there sufficient fuel in the tanks or has the fuel gelled? • Is there an air leak in the fuel system? • Is there a restriction in the fuel system or is the fuel filter plugged? • Is the fuel pump operating? • Is the fuel regulator defective? • Is the compressor functioning? • Is the fuel solenoid functioning? • Is the nozzle plugged? *NOTE: If there is no flame, a spark and/or spark reflection should be visible through the inspection window.*
Heater is backfiring Backfiring is usually caused by a severe restriction of combustion air or air in the fuel line.	**Combustion air flow** • Is there a restriction at the blower inlet or in the exhaust system? • Has the combustion air adjustment on the burner head been moved or come loose? **Fuel system** • Fuel level • Is there a leak in the fuel system?

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SYMPTOM:	CHECK:
No visible flame. **No spark.** **The heater shuts down after the 30 seconds ignition period.**	**Ignition system** • Check for a poor electrical connection between the ignition coil and the high tension lead. • Check for a poor electrical connection between the electrode and the high tension lead. • Check the coil harness wires and connections to the coil. • Check the coil. • Check the heater ground wire for damage or corrosion. • Check the spark electrode gap. • Check spark electrode. *Do not over-tighten the set screw for the ignition electrode as this may result in a cracked ceramic insulator resulting in a failed spark.*

Flame out

A "Flame Out" code indicates that a flame was established but was not maintained. If at any time during the run mode the flame sensor does not see a flame, the ignition spark is switched on immediately. If the flame is nor re-established within 10 seconds the heater will shut down and the "Flame out" diagnostic will be displayed. The heater will go into the "purge" mode and attempt to re-start in 3 minutes if the coolant temperature is below 150 °F.

A "Flame Out" code indicates that there was ignition and therefore there was a spark. "Flame Out" or a combination of "Flame Out" and "Start Error" are usually an indication of an interruption in fuel flow.

SYMPTOM:	CHECK:
Combustion hesitation. **Smoking.** **Coughing heater.**	**Fuel system** • Is there sufficient fuel in the tanks or has the fuel gelled? • Is there an air leak in the fuel system? • Is there a restriction in the fuel system or is the fuel filter plugged? • Is the fuel pump operating? • Is the fuel regulator defective? • Is the compressor functioning? • Is the fuel solenoid functioning? • Is the nozzle plugged?

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Coolant Flow

A "Coolant Flow" code is displayed when the coolant temperature reaches 185 °F in less than one minute after ignition. This indicates that the coolant flow is severely restricted or blocked. Check the coolant flow.

Overheat

An "Overheat" code is displayed when the overheat breaker has tripped, shutting the heater down. This occurs if the heater has been started with little or no coolant in the heat exchanger. Thermo switch trips at 286 °F. Check the coolant system.

The breaker contains a normally closed thermo switch. When the thermo switch reaches the preset temperature, the contacts open, instantly shutting the heater down. It can not be restarted until the breaker is manually reset.

!!!CAUTION!!!
DO NOT RESET THE OVERHEAT BREAKER UNTIL THE CAUSE OF THE OVERHEAT CONDITION HAS BEEN DETERMINED.

The overheat breaker is reset by removing the rubber cap on the top of the breaker and pressing the red reset button underneath. If the breaker will not reset, allow the heater to cool. Overheat breaker test procedure:

a) Disconnect the overheat breaker connector from the PCM wire harness.

b) Connect a multimeter (adjusted to measure resistance) to the overheat breaker connector (see Figure 5). The sensor should be normally closed. Only if the sensor has tripped should it be an open circuit. Breaker resistance when closed should be less than 1 ohm. (Ensure your measuring device is capable of measuring this low resistance before replacing the overheat breaker based on this test.)

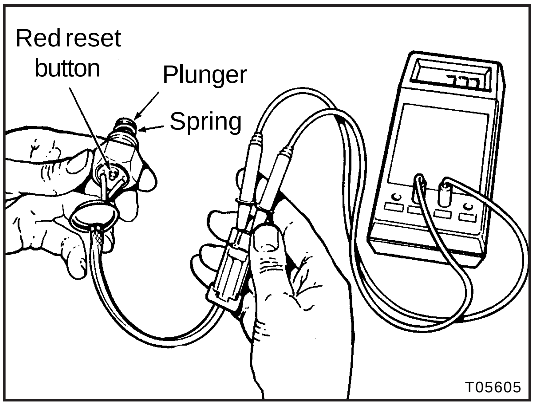

Figure 5: To test overheat breaker with a multimeter

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Voltage Error

A "Voltage Error" code indicates that the supply voltage to the heater is out of the normal operating range. Operating range: 20 to 30 Volts.

The positive terminal of the ignition coil is always hot relative to the heater chassis ground as long as power is connected to the heater. This is the supply voltage to the heater.

Test procedure:

a) Locate the rubber boot on the end of the ignition coil and peel it back to expose the positive and negative terminals.

b) Select the DC volts range of the multimeter. The positive lead of the multimeter should be attached to the positive stud of the coil lead. The negative lead of the multimeter should be attached to the heater chassis ground.

c) Measure the heater voltage at the ignition coil while the heater is turned off.

d) Measure the heater voltage at the ignition coil while the heater is running.

Heater voltage must remain within the specified range. Poor connections may show full voltage under no load conditions but not under full load. If the voltage at the ignition coil is more than one volt less when the heater is running than when it is turned off, check the vehicle battery connections and the power connection at the controller and harness.

NOTE
If the vehicle batteries are marginal, starting the vehicle while the heater is running may drop the voltage enough to cause a "voltage error" or cause random component errors. Switch the heater "OFF" and then back "ON" with the dashswitch to clear any errors. If the problem continues, load test the batteries to confirm their condition.

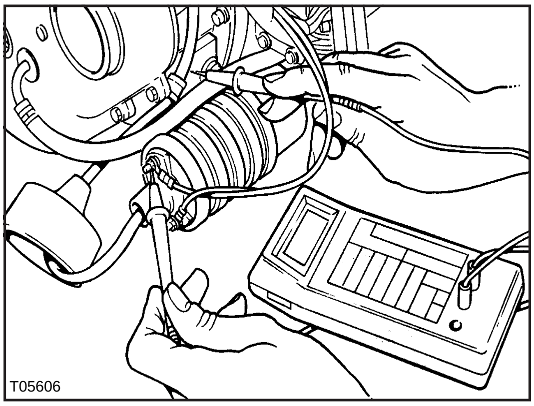

Figure 6: To test heater voltage

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Flame Sensor

A "Flame Sensor" code indicates an electrical short circuit in the flame sensor wiring, within the flame sensor itself or in the PCM flame sensor circuit. The PCM does not check for an open circuit on this component. A flame sensor open circuit failure will show up as a "Start Error". A flame sensor diagnostic can also indicate a problem with flame shut off.

NOTE
The flame sensor is an optical device which "sees" the flame. If the sensor lens is dirty or has an open circuit, it cannot "see" the flame and results in either a "Start Error" or a "Flame Out".

SYMPTOM:	CHECK:
Flame sensor code appears in "Precheck".	**Flame sensor** Check the flame sensor as indicated in Figure 7.
Flame sensor code appears in "Purge". If the flame sensor still "sees" a flame 10 seconds after the purge period starts, a flame sensor code is displayed and the blower motor is shut off. This is a safety feature in the event of a failed or obstructed fuel shut-off solenoid.	**Flame shut off** Test procedure: a) Start the heater and allow a flame to continue for three minutes. b) Disconnect the fuel solenoid connector without turning off the heater. c) Does the flame extinguish immediately? If not, check the fuel solenoid.

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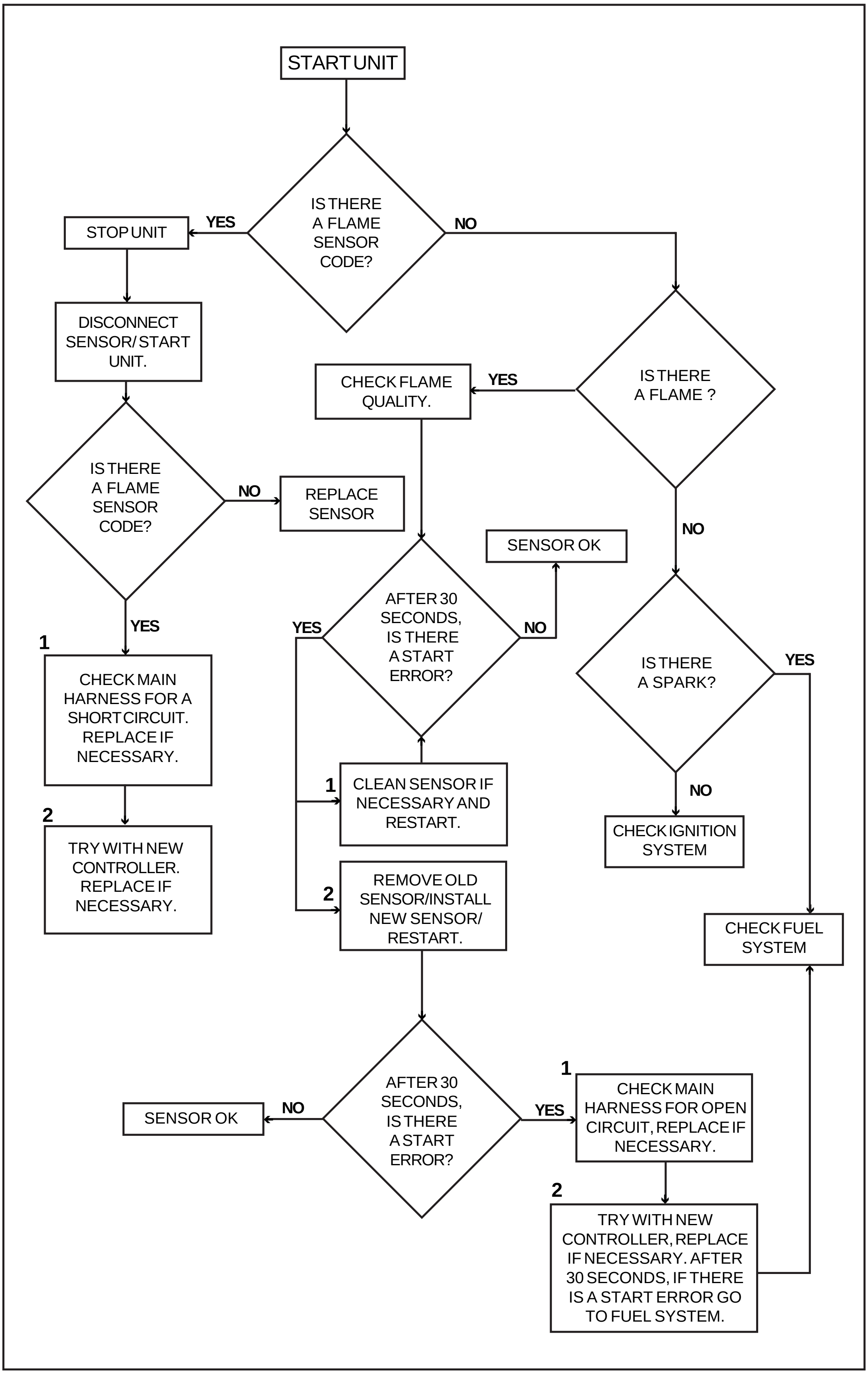

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Figure 7: Flame sensor test procedure

Temperature Sensor

A "Temperature Sensor" code indicates an electrical open or short circuit in the wire harness, within the temperature sensor itself or in the PCM temperature sensor circuit.

!!!CAUTION!!!
THE COMBUSTION HEATER CHASSIS IS GROUNDED FROM THE CONTROLLER. ENSURE THE GROUND IS SECURELY CONNECTED. FAILURE TO ENSURE A PROPER GROUND MAY RESULT IN AN ELECTRICAL SHOCK.

SYMPTOM:	CHECK:
Heater shut down (code indicated)	**Temperature sensor & wiring** Test procedure: a) Inspect temperature sensor harness for loose and/or corroded connectors. b) Inspect for worn or abraded wires in the wire harness. c) Connect a multimeter, adjusted to measure resistance, to the temperature sensor (see Figure 8). d) Measure the sensor resistance versus temperature. Refer to graph in Figure 9.
Heater shut down (code indicated) Temperature sensor and wire harness test OK.	**PCM** Isolate the PCM temperature sensor circuit using the component substitution plug (TFX part number 982526). Replace the PCM if the temperature sensor code remains on after starting the heater with the substitution plug in place of the component.

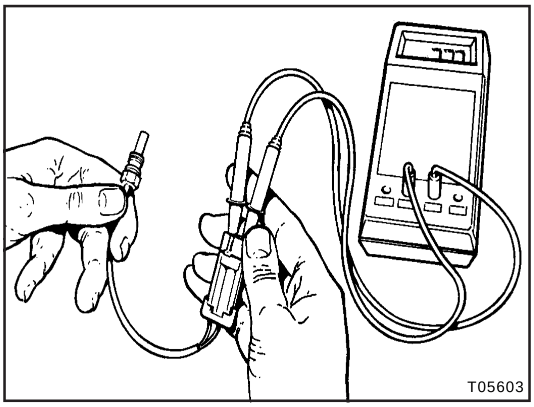

Figure 8: To test temperature sensor

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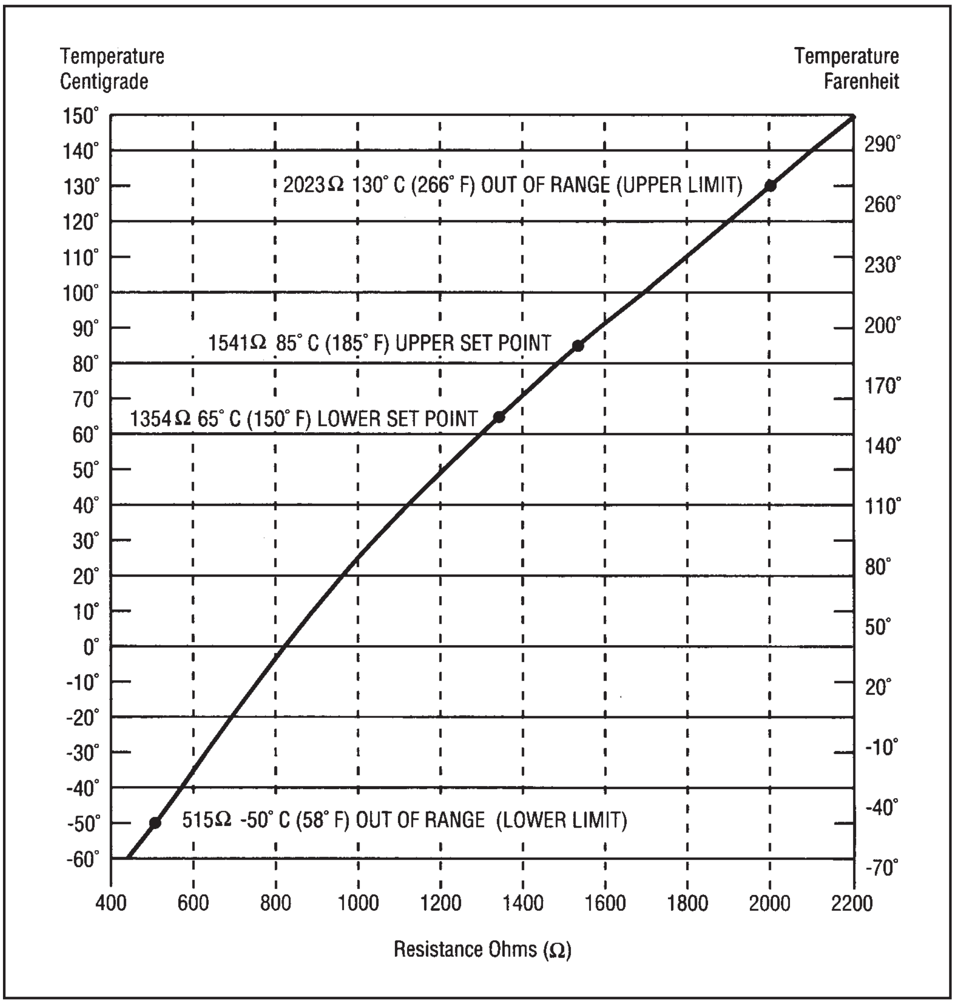

Figure 9: Coolant temperature sensor graph

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Fuel Solenoid

A "Fuel Solenoid" code indicates an electrical open or short circuit in the wire harness, within the fuel solenoid itself or in the PCM fuel solenoid circuit. This component is positive side switched.

SYMPTOM:	CHECK:
Heater shut down (code indicated)	**Fuel solenoid coil & wiring** Test procedure: a) Inspect fuel solenoid harness for loose and/or corroded connectors. b) Inspect for worn or abraded wires in the wire harness. c) Disconnect the fuel solenoid from the main harness. d) Connect a multimeter, adjusted to measure resistance, to the fuel solenoid (see Figure 10). If the resistance is between 100 ohm and 180 ohm the solenoid is OK. If it reads outside this range, replace the solenoid.
Flam out and/or Start Error code (no fuel solenoid code indicated)	**Fuel solenoid** Test the mechanical operation of the fuel solenoid. Check for contamination in the fuel solenoid plunger. Test procedure: a) Disconnect and remove the fuel solenoid from the FDU (Fuel Delivery Unit). b) Operate the fuel solenoid remotely by connecting to a 24 Volts source. Feel and listen to the operation while applying and removing power. *NOTE: Ensure that the voltage used is within the normal operating range of the fuel solenoid.*
Heater shut down (code indicated). Fuel Solenoid coil and wire harness test OK.	**PCM** Isolate the PCM fuel solenoid coil circuit using the component substitution plug (TFX part number 982526). Replace the PCM if the fuel solenoid diagnostic remains on after starting the heater with the substitution plug in place of the component.

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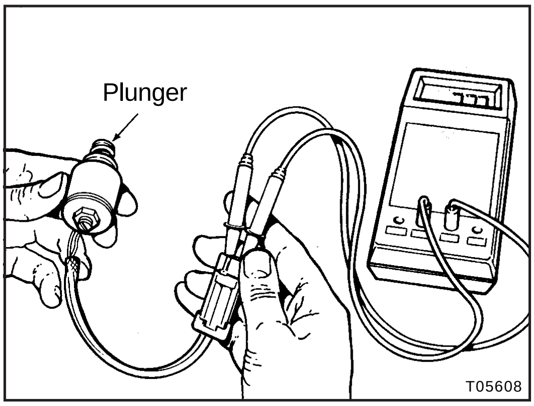

Figure 10: To test the fuel solenoid

Ignition coil

An "Ignition Coil" code indicates an electrical open or short circuit in the wire harness, within the ignition coil itself or in the PCM ignition coil circuit. This component is negative side switched.

!!!CAUTION!!!
THE COMBUSTION HEATER CHASSIS IS GROUNDED FROM THE CONTROLLER. ENSURE THE GROUND IS SECURELY CONNECTED. FAILURE TO ENSURE A PROPER GROUND MAY RESULT IN ELECTRICAL SHOCK.

SYMPTOM:	CHECK:
No spark at electrode (code indicated).	**Coil & wiring** Test procedure: a) Inspect the coil harness for loose and/or corroded connections. b) Inspect for worn or abraded wires in the wire harness. c) Connect a multimeter to measure the resistance across the positive and negative terminals (see Figure 11). The resistance should be between 0.2 and 1 ohm. If the measurement is outside this range, replace the coil.
No spark at electrode (no code indicated). 15 Amp fuse blown in PCM.	**Coil and wiring** • Measure from coil positive terminal to coil secondary terminal. • Check coil positive wire for short to chassis ground.
No spark at electrode (code indicated). Coil and wire harness test OK.	**PCM** Replace the PCM.

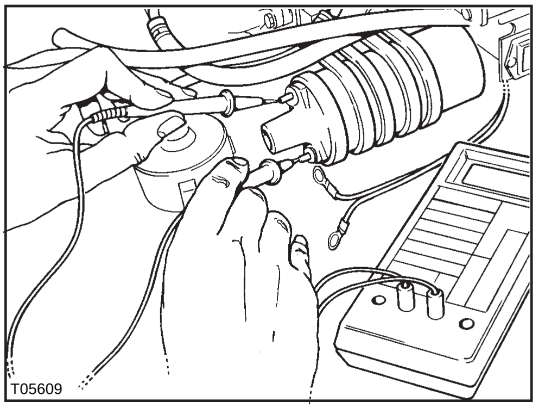

Figure 11: To test ignition coil

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Coolant Pump

Check coolant pump and coolant pump wiring.

Blower

A "Blower" code indicates an electrical open or short circuit in the wire harness, within the motor itself or in the PCM blower circuit. This component is negative side switched.

NOTE
The PCM performs an RPM check on the motor. This feature regularly measures the blower RPM and will indicate a code should it fall below the necessary speed to maintain sufficient air/fuel combustion mixture. *When a blower fails, the combustion chamber must be checked for carbon build up and cleaned if necessary.*

!!!CAUTION!!!
THE BLOWER MOTOR IS DESIGNED TO BE ACTIVATED ONLY BY THE "SOFT-START" PCM CIRCUITS AND DAMAGE MAY OCCUR TO THE MOTOR IF CONNECTED DIRECTLY TO A POWER SOURCE SUCH AS A BATTERY. **REPEATED REPLACEMENT OF THE FUSE OR USING INCORRECTLY RATED FUSES WITHOUT CORRECTING THE PROBLEM CAN DAMAGE THE PCM.**

SYMPTOM:	CHECK:
Heater shut down (code indicated).	**Blower motor & wiring** Test procedure: a) Inspect the blower harness for loose and/or corroded connectors. b) Inspect for broken or abraded wires in the wire harness. c) Connect a multimeter to measure for an open or short circuit across the positive and negative terminals (see Figure 12).
Heater shut down (no diagnostic indicated). **15 Amps fuse blown in PCM.**	**Blower electrical and mechanical function** • Measure for short circuit between blower motor body and the positive wire. • Check for seized and/or worn bearings.

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SYMPTOM:	CHECK:
Blower turning slowly (code indicated). The PCM regularly measures the RPM of the motor. If it falls below the necessary RPM required to maintain combustion, a diagnostic will be displayed.	**Blower electrical and mechanical function** • Is fan blade rubbing or loose on the shaft? • Test blower motor. Use a multimeter and test lead (TFX part number 967632) to measure for voltage and current.
Heater shut down (code indicated). Blower motor and wire harness test OK.	**PCM** Isolate the PCM blower circuit using the component substitution plug (TFX part number 984643). Replace the PCM if the blower diagnostic remains on after starting the heater with the substitution plug in place of the component.

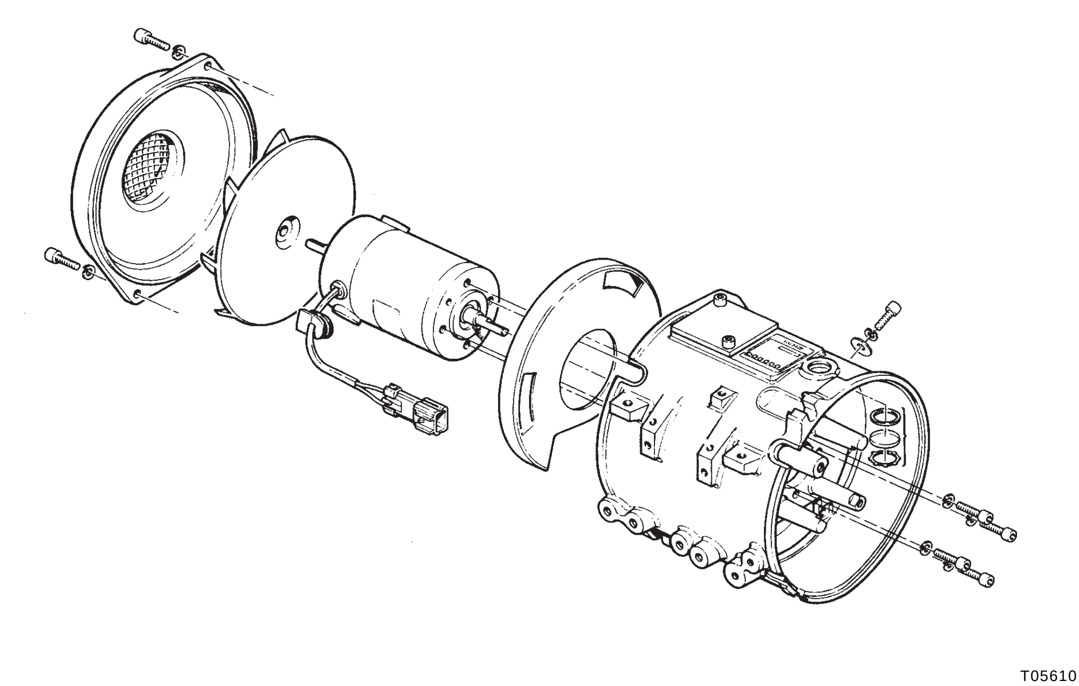

Figure 12: Blower motor mounting

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Components (no diagnostic)

Compressor

Test procedure:

a) Disconnect the overheat breaker and temperature sensor connectors and remove the burner head. Also disconnect the fuel solenoid. This will cause the combustion heater to go directly to "purge" when started and ensures that no combustion will occur.

b) Remove the air hose from fuel delivery unit and connect the pressure test gauge (TFX part number PK0060) between the compressor outlet and fuel delivery unit.

c) Start the combustion heater and read the nozzle air pressure from the gauge.

The pressure should be approximately 3.5 psi at 24 volts. A pressure lower than the performance limits suggests a plugged filter, blocked or kinked compressor intake hose, a loose compressor set screw on the blower motor shaft or a damaged compressor. A pressure higher than performance limits suggests a plugged nozzle or port within the fuel delivery unit.

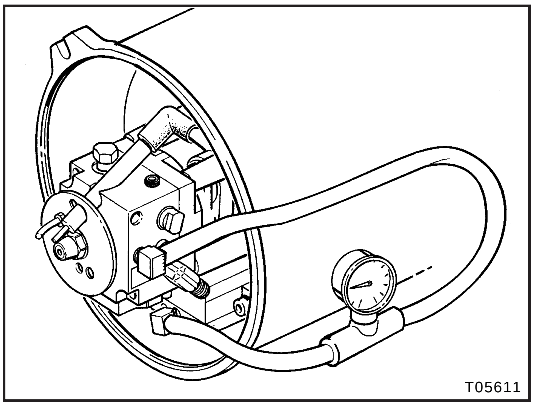

Figure 13: Air pressure test

Fuel Pump

Test procedure:

a) Disconnect the overheat breaker and temperature sensor connectors and remove the burner head. Also disconnect the fuel solenoid. This will cause the combustion heater to go directly to "purge" when started and ensures that no combustion will occur. Leave the fuel line connected to the burner head.

b) Remove the O-ring plug from the fuel pump and connect the pressure test gauge (TFX part number PK0067).

c) Start the combustion heater and read the fuel pressure from the gauge while ensuring that the blower motor is running.

d) Check for any fuel leaks from any part of the fuel delivery unit.

The pressure should be approximately 9 psi but any positive pressure of fuel will allow the heater to run correctly. A fuel pressure lower than 1 psi or higher than 17 psi suggests a faulty relief valve. A pressure of 0 psi suggests a missing or stripped motor shaft coupler or seized fuel pump.

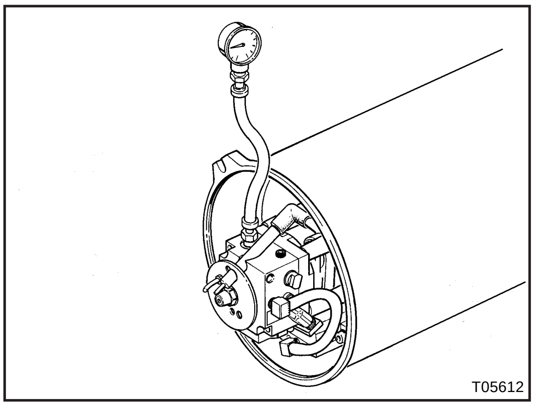

Figure 14: Fuel pressure test

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Electrode Gap

Check the electrode gap while the burner head is removed from the heat exchanger. Gap should be as shown in Figure 15.

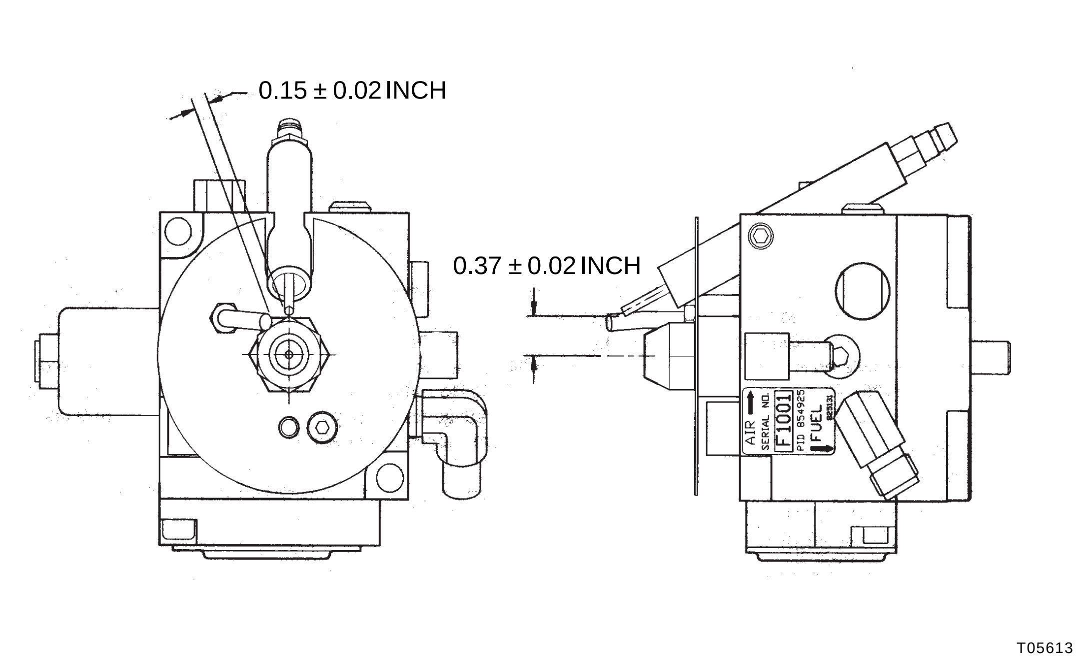

Figure 15: Electrode gap

Fuse

If, when the heater is switched on, the heater does not run and the "ON" light does not light, check the fuse in the controller. The fuse will blow if there is a short to ground in a positive lead or internally for the following components: on/off switch, air compressor, ignition coil, coolant pump, blower motor, flame indicator harness.

!!!CAUTION!!!
REPEATED REPLACEMENT OF THE FUSE OR USING INCORRECTLY RATED FUSES WITHOUT CORRECTING THE PROBLEM CAN DAMAGE THE PCM.

A reverse polarity connection at the battery will also cause the fuse to blow. This will not harm the controller. Check the heater wiring.

The following page describes the test procedure for a blown fuse with power connected and the combustion heater switched off.

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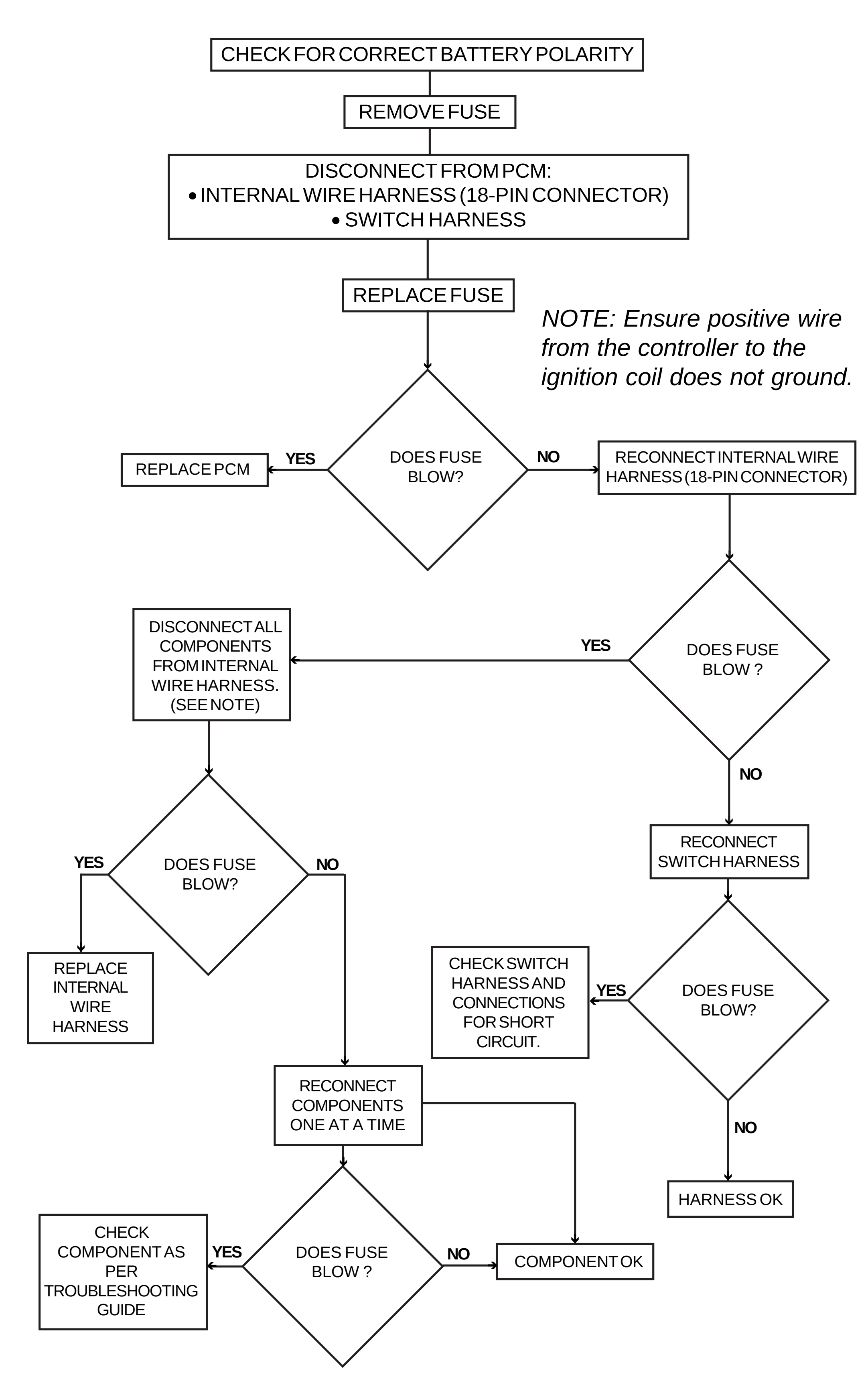

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Figure 16: Fuse blown test procedure with power connected and heater switched off

Nozzle

The nozzle (and the compressor) regulates the fuel air mixture. A set orifice size allows a certain amount of fuel and air to flow through the distributor of the nozzle. Problems in the nozzle can cause poor burning. This will be indicated by "Start Error" or "Flame Out" code on the PCM display panel.

Inspect the nozzle for blockage. Clean or replace nozzle as necessary.

Nozzle cleaning procedure:

a) Remove the nozzle from the fuel block. Blow the remaining fuel out of the passage. You should be able to see down the center of the nozzle when held up to a light source. If it is blocked then it can be disassembled (there are three pieces) for cleaning. Note that debris can be lodged in the air passage slots of the nozzle as well. Use a pin to remove debris from the nozzle.

b) Lubricate the O-ring on the nozzle with diesel fuel prior to re-installing it in the FDU.

NOTE
Cleaning the nozzle does not always remove the restriction. If, after the nozzle has been disassembled and cleaned and the heater still does not operate properly, replace the nozzle by a new one. The restriction does not have to completely block the flow of the fuel/air mixture, a partial blockage will cause the heater to malfunction.

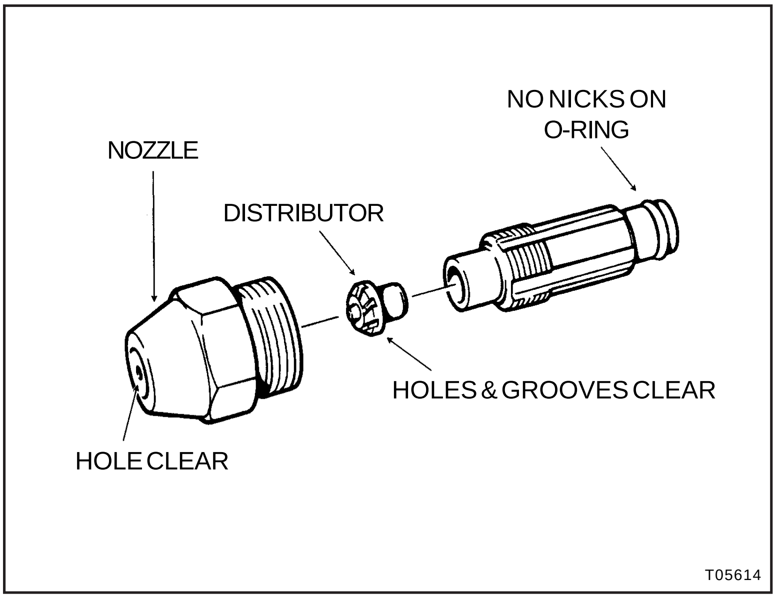

Figure 17: Fuel nozzle detail

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Fuel regulator

The fuel regulator reduces the fuel pressure supplied by the fuel pump from approximately 9 psi to atmospheric pressure. Compressed air flowing through the nozzle creates a venturi effect which siphons fuel from the regulator. If the compressed air flow through the nozzle stops, the regulator closes, shutting off the fuel flow.

Check the fuel regulator. Ensure that the vent hole in the regulator is not plugged. Ensure that all fuel line connections and clamps are tight.

NOTE
Should a fuel regulator fail, the combustion chamber must be checked for carbon build up and cleaned as necessary.

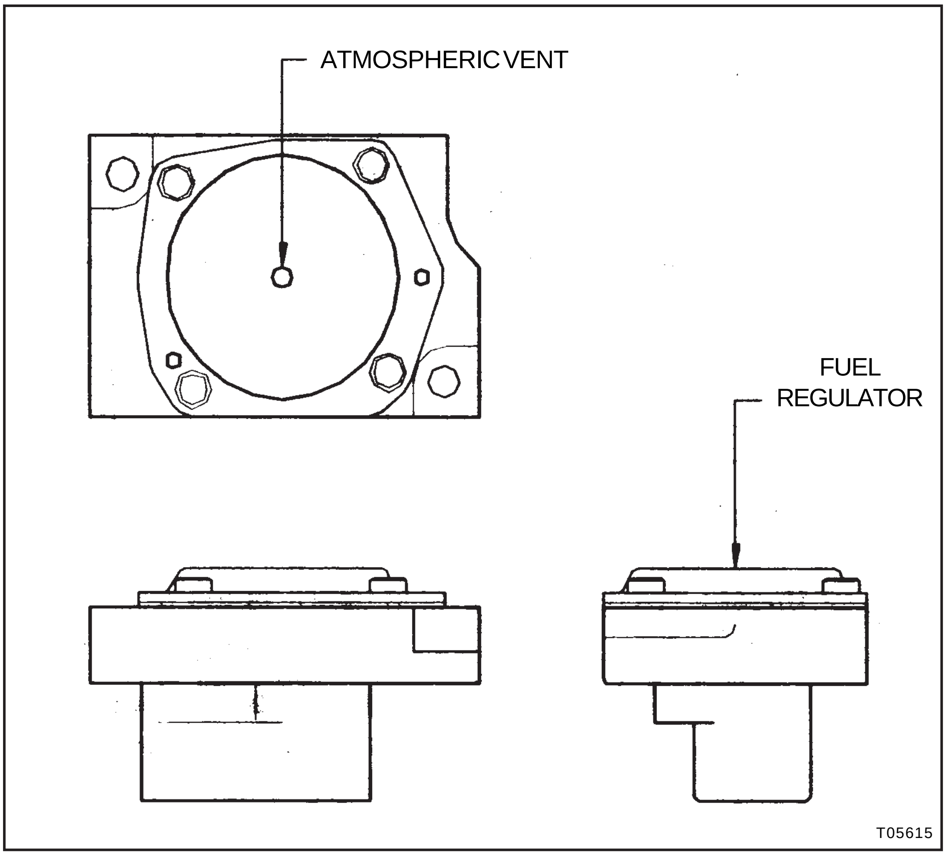

Figure 18: Fuel regulator

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Operational problems

COMPLAINT	
Smoking exhaust. **Smelly exhaust fumes.**	These symptoms are usually an indication of an extremely rich air/fuel mixture. Check: a) Is the blower functioning? Is the air inlet restricted? b) Is the compressor functioning? c) Is this a new heater? New heaters may smoke for 15 minutes as oil is burned off the exhaust pipe.
Low heat output	If the heater appears to be functioning properly but the driver complains of low heat this is often indicative of a coolant flow restriction or possibly air intrusion into the fuel system.
Backfiring	Backfiring occurs when there is air in the fuel supply lines. Check: a) Fuel level in tank - is the pick-up submerged? b) Air leaks - are all the fuel line clamps tight? c) For severely restricted combustion air blockage at the blower inlet, in the combustion chamber, or in the exhaust system.

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WATER CIRCULATING PUMP

The heating system is provided with an electrically operated water circulating pump which is located in the combustion heater compartment. The water pump assembly consists in a centrifugal pump and an electric motor which are mounted on a common shaft.

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.

The pump requires no periodic maintenance other than replacement of the motor brushes. Replacement of the motor brushes can be performed without removing the pump assembly. Visual inspection of the pump should be made while the pump is in operation to determine if the shaft seal is intact. If there is evidence of coolant leakage, the unit must be disassembled for corrective measures. Disassembly of the pump will be necessary only in case of a seal leak, bearing failure, or motor failure.

To remove water pump assembly

1. Stop engine and allow engine coolant to cool.
2. Drain the cooling/heating system as explained in chapter 2 of this manual.
3. Open the exterior door of the condensor compartment and swing the condensor assembly open.

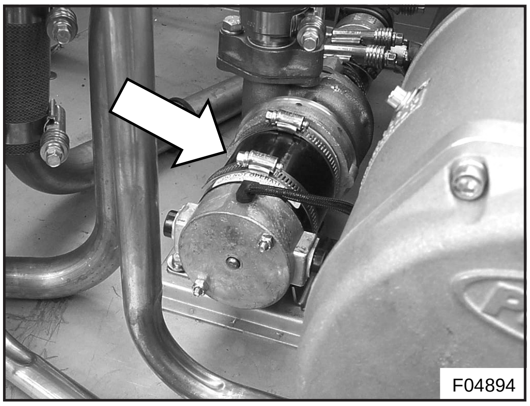

Figure 19: Electrically operated circulating pump in combution heater compartment (accessible through the condenser compartment)

4. Disconnect the electrical wiring from the motor.

!!!CAUTION!!!
CHECK THAT COOLANT HAS COOLED DOWN.

5. Remove the drain plug at the bottom of the pump and place a container to recover the residual coolant in the line.
6. Disconnect water lines from the pump at the flange connections.
7. Remove the two clamps holding the pump motor to its mounting bracket. Remove the pump with the motor as an assembly.

To disassemble water pump assembly- Figure 20

1. Remove the two brush caps (16) and the two brush assemblies (15). When removing the brushes, note the position of the brush in the tube. Brush life is significantly decreased if brushes are not re-installed properly.
2. Remove pump cover (2) by removing the eight screws.

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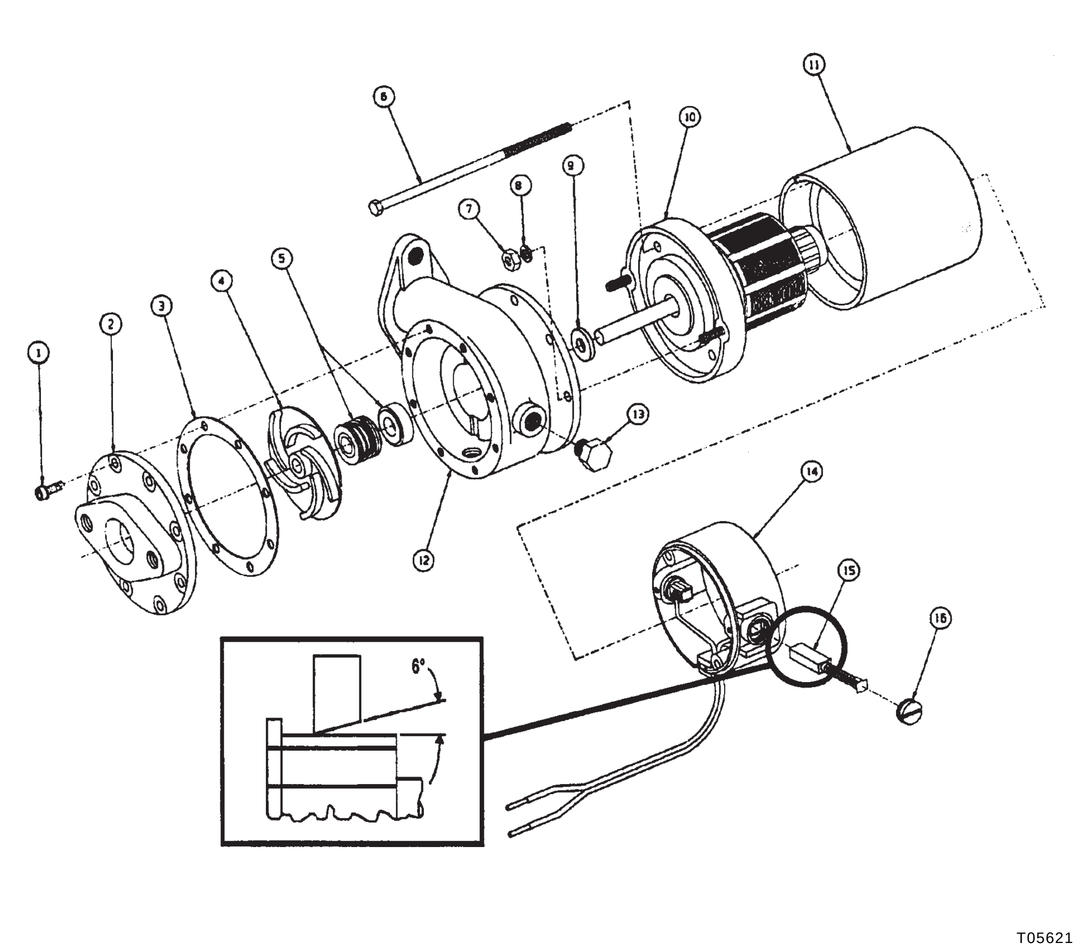

Figure 20: Exploded view of electrically operated water circulating pump

Remove cover carefully to prevent damage to gasket (3).

3. Remove gasket (3).

4. Remove the two hex nuts and lock washers which hold pump assembly to the motor.

5. Remove the pump from the motor as follows:

    a. Install puller tool assembly (MP Co. part number 24702 or equivalent) to pump body (12) using four pump cover screws.

    b. Tighten the puller screw to press the motor shaft out of the impeller hub. The pump is now free from the motor.

6. Remove the puller tool.

7. Remove impeller (4) and components of the pump seal assembly (5).

!!!CAUTION!!!
DO NOT SCRATCH OR MAR THE SEALING SURFACE OF THIS SEAT, AS ITS SEALING FEATURE WILL BE AFFECTED, THUS RESULTING IN CONTINUOUS LEAKAGE.

8. Inspect the components of the pump/motor assembly by comparing them with new parts to determine the degree of wear.

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To inspect the brushes

Examine the brushes for the following:

- <u>Wear</u>
  Replace the brushes if less than 25% of the usable brush is left (less than 0.3 inch (8 mm)).

- <u>Chipped edges</u>
  Chips can be caused by improper handling or installation. Badly chipped brushes should be replaced regardless of their length.

- <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.

- <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.

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 degree angle. The brush should be inserted so that the angle is open away from the pump end of the assembly (see inset in Figure 20).

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.

To inspect the bearings

- Rotate the motor shaft. If the ball bearings show evidence of wear, they should be replaced.

- The use of a bearing puller is recommended when removing the bearings to help prevent damaging the armature winding or the commutator.

- Replacement bearings should be pressed into the same exact location as the original bearings.

- 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.

- 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.

To inspect the commutator

- 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.

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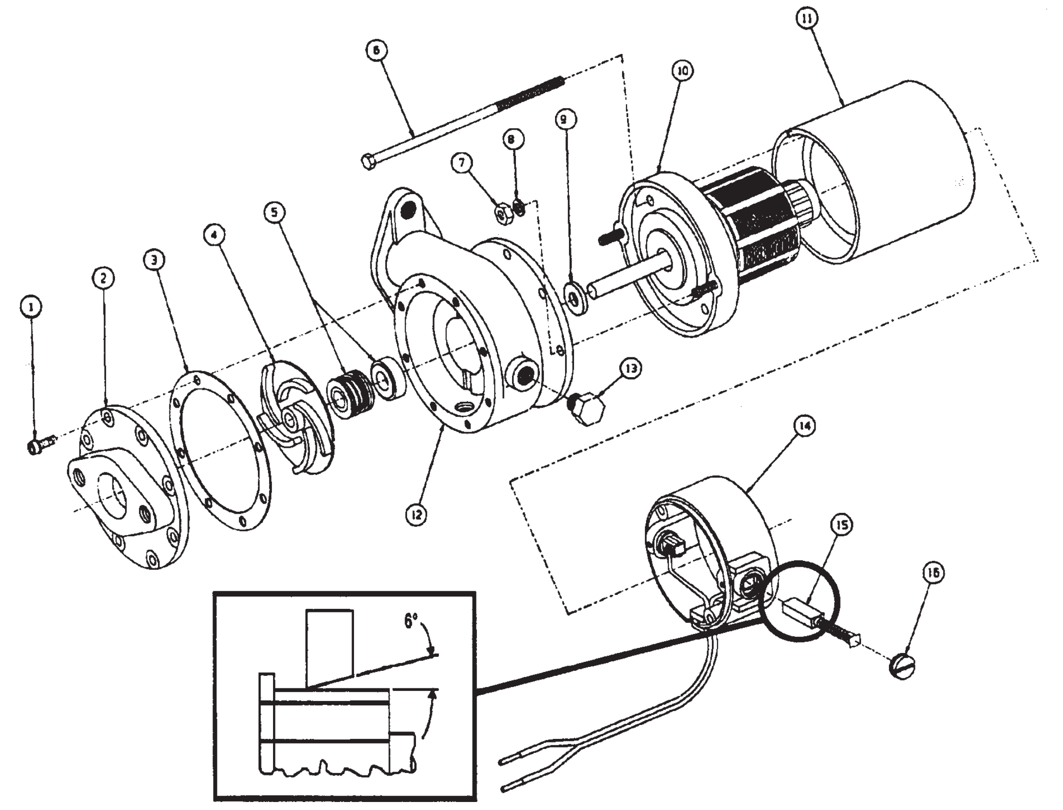

Figure 20: Exploded view of electrically operated water circulating pump

- The commutator should be refinished only on equipment which provides good concentricity and the proper finish.
- The commutator should be refinished if a micrometer reading shows a difference between "in track" and "off track" diameter of 0.187 inch (4.7 mm) or more.
- The commutator should be carefully undercut with a 0.025 inch (0.6 mm) or less slot width.
- A 25 to 50 micromesh finish is desirable on a new or refinished commutator.
- The commutator should not be touched with the fingers since sweat and body oils wil rapidly discolor and oxidize its surface.

To inspect miscellaneous- Figure 20

- Check shaft slinger (9) to make sure it is tight on the motor shaft. If the slinger slips on the shaft, it should be replaced.
- Inspect seal assemblies (5) to determine wear. If the seal has leaked, or is badly worn, it is recommended to install a complete new seal assembly.

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- The impeller (4) is a press fit on the armature shaft. This press fit must be maintained to prevent the impeller from slipping. Install a new impeller if necessary.

To assemble water pump- Figure 20

1. Install slinger (9) on the motor shaft.
2. Assemble body (12) to the motor
3. Install seal assembly (5).
4. Install impeller (4) as follows:
   a. Place the impeller on a flat surface with the vanes against the flat surface.
   b. Invert the motor and pump body assembly, then pilot the pump shaft into the impeller bore. *Do not hammer* on the motor shaft extension at the rear of the motor.
   c. Press on motor and pump body until the machined face of the pump body is flish with the face of the flat surface on which the impeller is resting. The face of the impeller vanes must now be flush with the machined face of the pump body.
5. Install gasket (3). This gasket serves both to seal the cover and to establish the proper clearance between the face of the impeller and the pump cover.
6. Attach cover (2) to the pump body using the eight screws (1).
7. Install motor brushes assembly (15) and brush caps (16).

To install the water pump

1. Apply gasket cement to the pump body line adapter and to the line flanges, put the two gaskets in place, and connect water lines from 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 them.
2. Apply pipe sealant on threads of drain plug, and screw it in place.

!!!CAUTION!!!
NEVER OPERATE THE PUMP DRY AS THIS WILL DESTROY THE PUMP SEAL.

3. Connect electrical wiring to the pump motor.
4. Fill and bleed the cooling/heating system as explained in chapter 2 of this manual.

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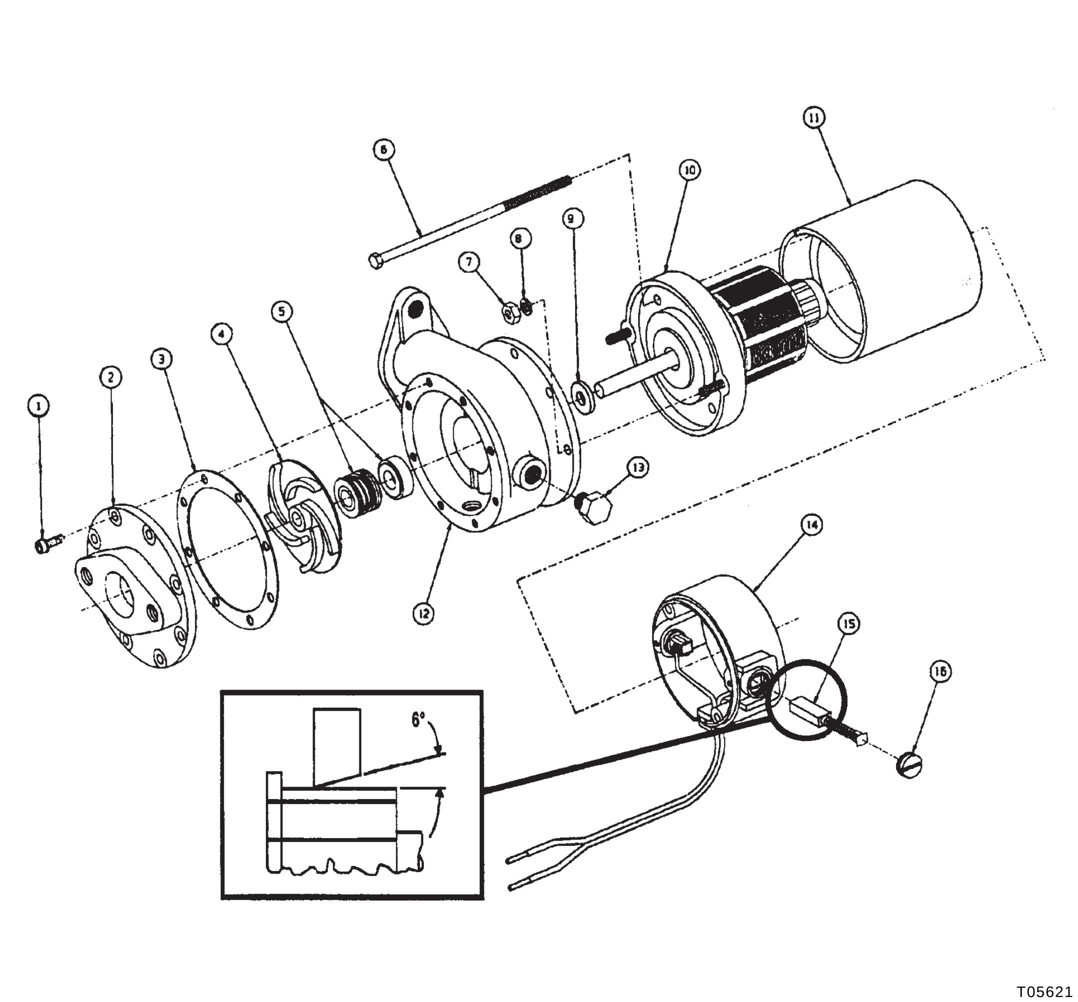

Figure 20: Exploded view of electrically operated water circulating pump

AIR PRESSURE ACTUATED WATER VALVES

The water flow through the heaters is controlled by two air pressure actuated two-way water valves and one air pressure actuated shut-off valve. They are located in the combustion heater compartment.

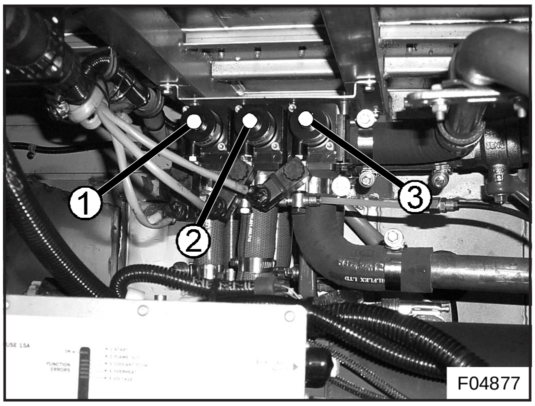

Figure 21: Hot water valves in combustion heater compartment (in front of left drive wheel)

1. **Hot water valve of floor heaters in passenger's compartment + solenoid (V126)**
2. **Hot water valve of driver's compartment heater + solenoid (V115)**
3. **Hot water valve of roof heaters in passenger's compartment + solenoid (V114)**

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HEATER COILS

DRIVER'S COMPARTMENT HEATER

The purpose of this heater is to supply heated air to the driver's compartment and to the windshield for defrosting.

The heater is located in the HVAC unit below the driver's compartment floor and is accessible through the exterior access door in front of the left front wheel.

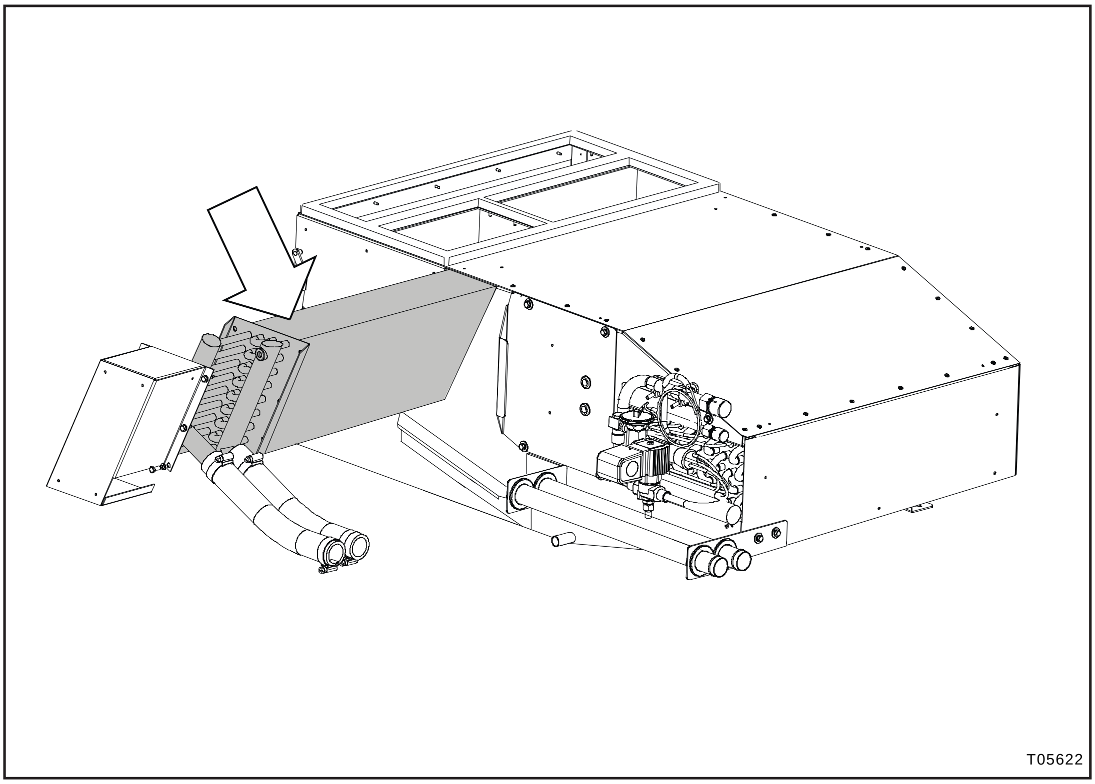

Figure 22: Exploded view of HVAC unit under driver's compartment floor (arrow shows heater coil)

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PASSENGER'S COMPARTMENT FLOOR HEATERS

The vehicle is equipped with floor heaters over the full length of the passenger's compartment.

Figure 23: Floor heater in passenger's compartment

PASSENGER'S COMPARTMENT ROOF HEATERS

The vehicle is equipped with two roof heaters in the passenger's compartment. The coil assembly in the parcel rack halfway the passenger's compartment consists of a heater coil and an evaporator coil.

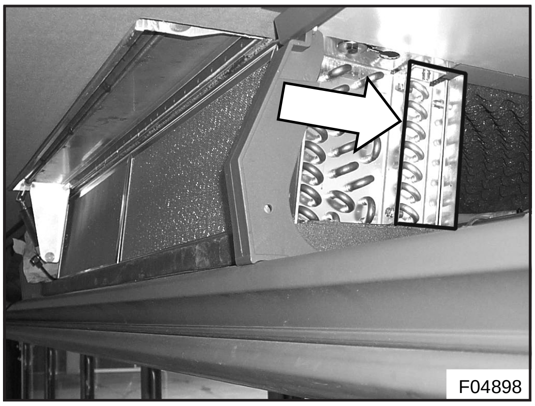

Figure 24: Roof heater

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PIPING ACCESSORIES

Refer to chapter 2 of this manual

INHIBITORS-ANTIFREEZE

The heating system is connected to the engine cooling system. For specific coolant additives and antifreeze, see Chapter 2 of this manual.

SERVICE PROCEDURES

Procedures for draining and filling: see Chapter 2 of this manual.

HEATING SYSTEM ISOLATING VALVES

Refer to chapter 2 of this manual

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REFRIGERANT SYSTEM

SERVICE PROCEDURES

GENERAL-GOOD PRACTICE

1. Sealing plugs must stay on all replacement components and hoses until just before installation.
2. Any part offered for installation without sealing plugs fitted must be returned to the supplier as defective.
3. It is important to use a backing wrench when tightening all fittings and couplings to minimize distortion and strain on components and connecting pipes.
4. Components must not be lifted by connecting pipes, hoses or capillary tubes.
5. Care must be taken not to damage fins of condenser or evaporator coils. Any damage must be rectified using fin combs.
6. Before installing tube and hose fittings, apply a small amount of clean new refrigerant oil to the flare.
7. Refrigerant oil must be kept very clean and capped at all times. This will prevent the oil from absorbing moisture.
8. Before installation, the condition of couplings and flares must be checked. Dirt or even minor damage can cause leaks due to the high pressures encountered in the system.
9. Dirty fittings should only be cleaned using a clean cloth, soaked in alcohol.
10. When removing sealing plugs and immediately before installation, visually check the bore of pipes and components. When any dirt or moisture is discovered, the part must be rejected.
11. All components must be allowed to reach ambient temperature before sealing plugs are removed. This prevents condensation should the component be cold initially.
12. Before finally tightening hose connectors, ensure that the hose is fitted in the right position, is not kinked or twisted and will not be obstructed by other equipment.
13. Check that hoses are correctly secured with clamps or properly strapped to body and chassis.
14. Components or hoses must be sealed off immediately after removal.
15. If the system has been opened, the filter/drier must be replaced.
16. All tubing lines should be free of kinks; otherwise, the refrigerant capacity of the entire system can be greatly reduced.
17. Use only sealed lines from parts stock.
18. 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.
19. Cleaning products are flammable and may explode under certain conditions. Always handle in well-ventilated areas.

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20. Before brazing any part of the refrigerant system, make sure the area is well ventilated.
21. When using heat or near a valve, wrap with water saturated rag to prevent overheating of vital parts.

REFRIGERANT CIRCUIT

DESCRIPTION

The refrigeration (cooling) system in the C2045 coaches is of the “closed” type.

1. Refrigerant, as a gas, is drawn from the evaporator into the compressor. During compression, the refrigerant gas increases both in temperature and in pressure. The hot, high-pressure gas is discharged into the condenser.

2. The gas is condensed through a combination of air movement over the condenser coils, decreasing the temperature, plus the increased pressure created by the compressor. During this process, the heat is released by the condenser coils and expelled by the condenser fans, through air movement across the cooling fins.

3. From the condenser, the liquid refrigerant is forced into the receiver tank, then into the filter/ drier. The receiver tank acts as a storage or surge container for the refrigerant, until needed by the evaporators. The function of the filter/drier is to remove any moisture from the system.

4. From the filter/drier, the refrigerant travels through the high-pressure liquid line to the expansion valve.

   The expansion valve meters the amount of liquid refrigerant entering the evaporator coils, so that proper refrigerant vaporization occurs.
   This valve is pre-set at the factory to control the “evaporator outlet superheat” between 9°F and 13°F.
   The expansion valve is controlled by the bulb and by the pressure diaphragm, which senses evaporator suction gas temperature and pressure at the evaporator outlet. So the valve controls, modulates or throttles by opening and closing, based on the temperature and pressure at the evaporator outlet, and thereby meters the amount of liquid refrigerant entering the evaporator coil. After the liquid refrigerant has traveled through the valve, it enters a series of small distributor tubes, which lead into the evaporator itself. The function of these capillary tubes is to ensure that the refrigerant is distributed evenly in the evaporator coils.

5. The last step in the cooling cycle is the evaporation of the low pressure liquid refrigerant within the evaporator coils. Because the expansion valve allows only a controlled amount of liquid refrigerant into the evaporator coils, the internal pressure of the coils is reduced. This reduction in pressure causes the refrigerant to become a gas and heat is absorbed in the process.
   As air, from the coach interior, is drawn over the evaporator fins, the coils of the evaporator absorb the heat from the relatively warmer moving air. Thus as the air is moved over the evaporator coils, it is cooled. This air is normally

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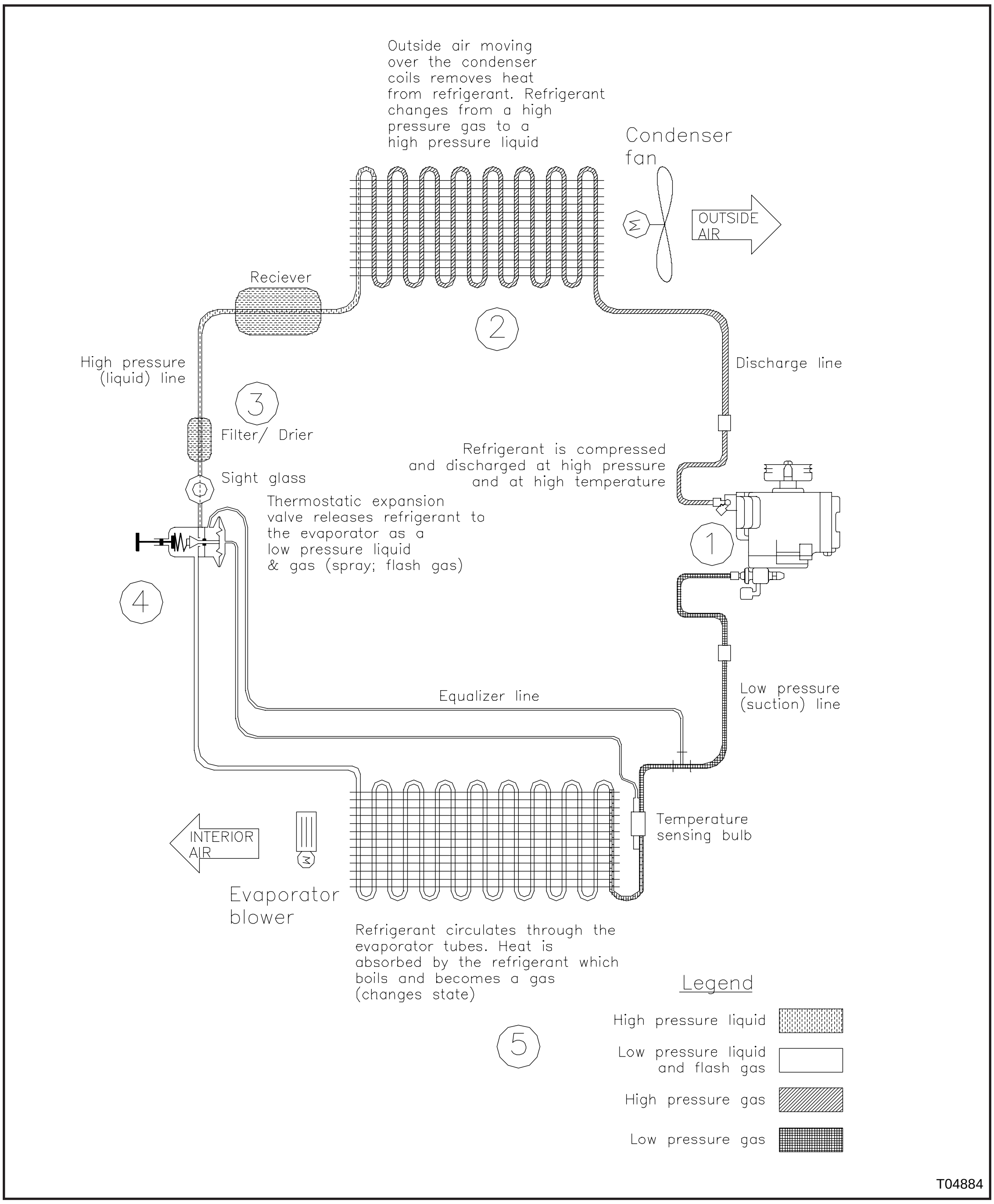

Figure 1: Main components of refrigerant system

drawn from the bus interior through the return air grille and from the exterior via the fresh air flaps on the roof (LHS& RHS), in a ratio of about 50% return air to 20% fresh air.
The net result is the cooling and drying (due to condensation) of all cooled air entering the bus.
Condensate accumulating on the evaporator coils runs into drain pans located below the evaporator coils and is removed through drain hoses.
The vaporized refrigerant then leaves the evaporators carrying the interior coach heat, and starts a new cycle through the compressor, then condenser, etc.

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OPERATING PRESSURES

During operation, two pressure levels are maintained by compressor and expansion valve.

The system pressures and temperatures depend on the operating conditions which are not constant and include:

- interior temperature;
- outside temperature, sun-load;
- relative humidity;
- passenger load, opening doors;
- varying engine speed, etc.

The following information can therefore only be approximate.

High side pressure

The pressure at the discharge side of the compressor and in the condenser depends upon the temperature at which the refrigerant changes state from gas to liquid (condensing).
Under normal operating conditions, condensation takes place at a temperature between 36 and 54°F above the outside air temperature.

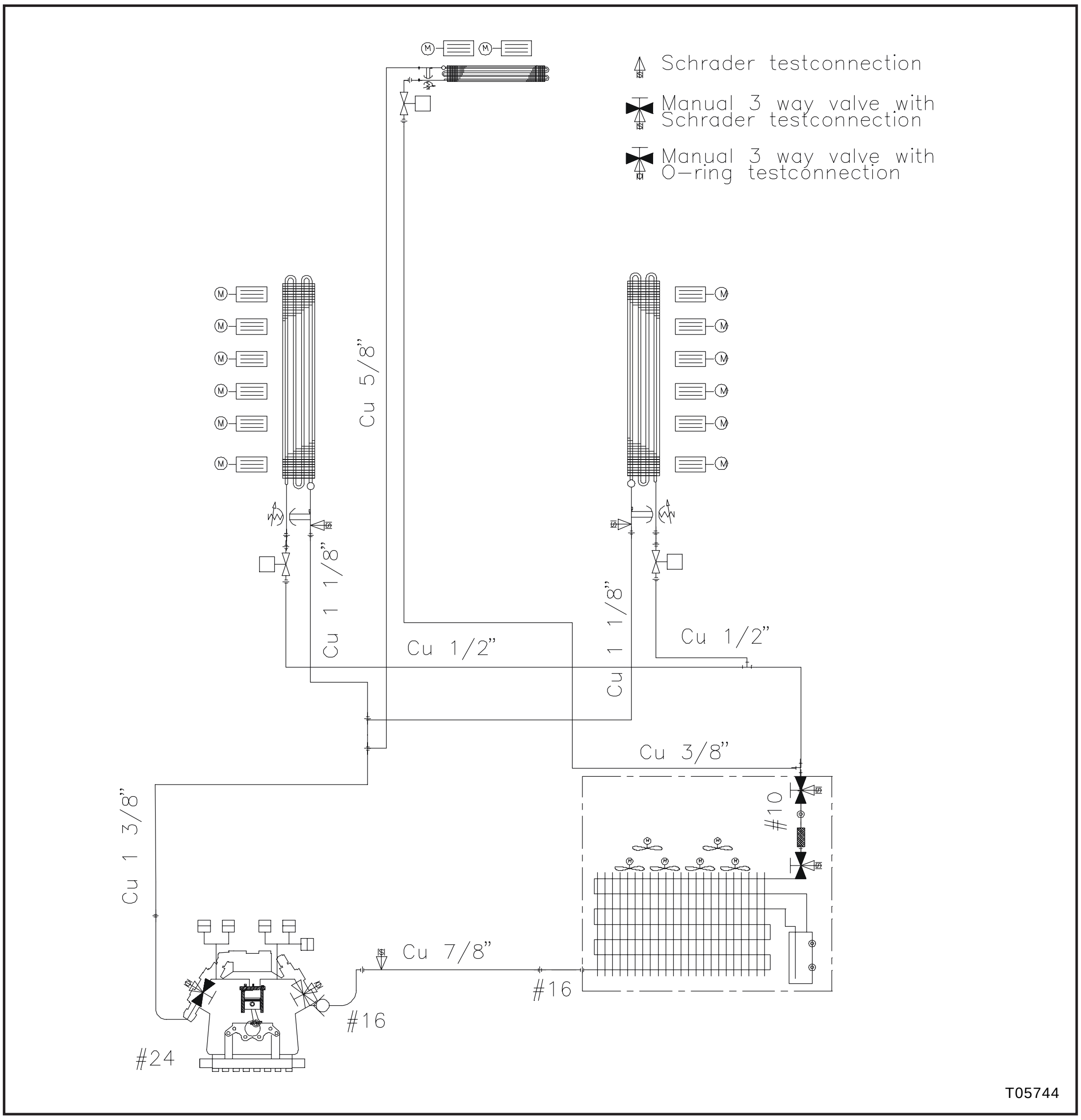

Figure 2: Refrigerant system lay-out

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Example: Outside temperature of 95°F.
Condensation temperature between 131 and 149°F. High side pressure between 201.6 and 259.6 psig.

NOTE
The pressure will be at a higher level when there is a high cooling load (passengers, sun...),a high compressor speed, when the condenser is dirty or when there is restricted condenser air flow.   *The pressure will be at a lower level when there is a low cooling load, a low compressor speed or when the compressor is partially unloaded.*

Low side pressure

The pressure in the evaporator and at the suction side of the compressor depends upon the temperature at which the refrigerant changes state from liquid to gas (evaporating). Under normal operating conditions evaporating takes place at a temperature between 36 and 54°F lower than the interior temperature.

Example: Interior temperature 77°F. Evaporating temperature between 23 and 41°. Low side pressure between 20.8 and 36.2 psig.

NOTE
The pressure will be at a lower level when there is a low cooling load (passengers, sun...),a high compressor speed or when there is a restricted air flow over the evaporator.   *The pressure will be at a higher level when there is a high cooling load, a low compressor speed or when the compressor is partially unloaded.*   *At the limits of the normal operating conditions, unusual pressures and temperatures may occur.*

For example: Engaging the system at high outside temperature, at high interior temperature and high compressor speed leads to:

- high pressure in the evaporator;
- high pressure and very high temperature after compression;
- compressor clutch cycling a few times (high pressure switch cuts out the clutch) until the interior temperature lowers.

Table 1: Approximate pressures at different outside and inside temperatures

Outside temperature (°F)	Condensation temperature (°F)	High side pressure R-134a systems (psig)	Interior temperature (°F)	Evaporating temperature (°F)	Low side pressure R-134a systems (psig)
77	113 - 131	153.7 - 201.7	68	14 - 32	14.5 - 27.6
86	122 - 140	176.9 - 229.2	77	23 - 41	20.3 - 36.3
95	131 - 149	201.6 - 259.6	86	32 - 50	27.6 - 45.0
104	140 - 158	229.2 - 293.0	95	41 - 59	36.3 - 56.6
113	149 - 167	259.4 - 327.78			

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REFRIGERANT COMPRESSOR

The coach is fitted with a carrier 05G refrigerant compressor. The compressor is accessible via the engine rear compartment door. This Section contains general information only . For more specific information and repair instructions refer to the manufacturer's literature.

COMPRESSOR DRIVE SYSTEM

The compressor, mounted on a pivoting frame, is driven from the engine crankshaft by means of V-belts. The drive belts are tensioned by air bellows which receive regulated air pressure from a pressure regulator. The belt tension is thereby constant in all operation modes.

The compressor drive pulley is fitted with a housing mounted clutch assembly. The clutch is an electrically operated, friction-faced clutch. When the air-conditioning is off, the clutch rotor (pulley) is free-wheeling and driven by the engine through V-belts. When the HVAC system actuates the clutch system, the compressor clutch field coil is energized. The magnetic field produced by the coil attracts the clutch armature engaging its face with the rotating face of the rotor. Since the armature is coupled directly to the compressor crankshaft, the compressor begins operating when the pulley transmits its rotation to the armature. The compressor will operate as long as the clutch field coil remains energized and armature and rotor are magnetically coupled. When the field coil is de-energized, the armature is pulled back out of contact with the rotor (by spring tabs) and the armature (and compressor shaft) ceases rotation.

NOTE
For belt drive system, refer also to chapter 3 "Drive train" of this manual.

COMPRESSOR LUBRICATION SYSTEM

Force-feed lubrication of the compressor is accomplished by a low-speed oil pump driven directly from the compressor crankshaft. Refrigerant 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 crankshaft seal. The lubricating oil is pumped, under pressure, through the lube system by a lobed rotor type oil pump.

COMPRESSOR UNLOADERS

The compressor is fitted with two electrically operated capacity unloaders. These normally closed unloaders are controlled by a separate set of compressor pressure switches. The unloaders control the first stage discharge of both the right and left compressor cylinder banks. The electrically operated unloaders are non-adjustable.

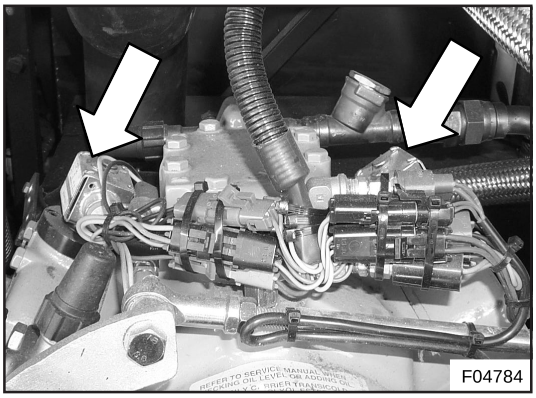

Figure 3: Electrically operated unloaders

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To install unloaders on a replacement compressor-Figure 4

Replacement compressors are normally furnished with cylinder head bypass piston plugs installed on the unloader flanges in stead of the unloader valves. The unloaders must be removed from the defective compressor and transferred to the replacement compressor as follows:

1. Remove the three socket head capscrews (1) holding piston plug (5) to the cylinder head of the replacement compressor.

2. Remove flange cover (2), gasket (3), spring (4), bypass piston plug (5) and seat ring (6). A tapped hole is provided in the piston plug (5) for use with a jackscrew to enable removal of the plug. One of the socket head capscrews may be used as a jackscrew.

3. Remove the three socket head capscrews holding the unloader in the cylinder head of the detective 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.

4. Using a new gasket and unloader ring pliers (CARRIER P/N 07/00223), install the unloaders in the cylinder heads of the replacement compressor. Tighten the capscrews to a torque of 12 to 16 ft.lbf.

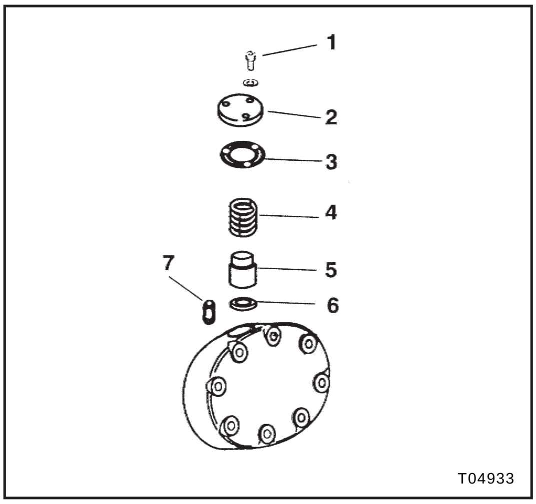

Figure 4: Hot gas bypass piston plug removal

1. Capscrews
2. Flange cover
3. Gasket
4. Spring
5. Bypass piston plug
6. Seat ring
7. Strainer

5. If the defective compressor is to be returned for overhaul or repair, install the bypass piston plug (5), spring (4), seat ring (6) and flange cover (2) onto the cylinder heads.

SERVICE VALVES - Figure 7

The system contains four service valves: two on the refrigerant compressor and one at each side of the filter/drier.

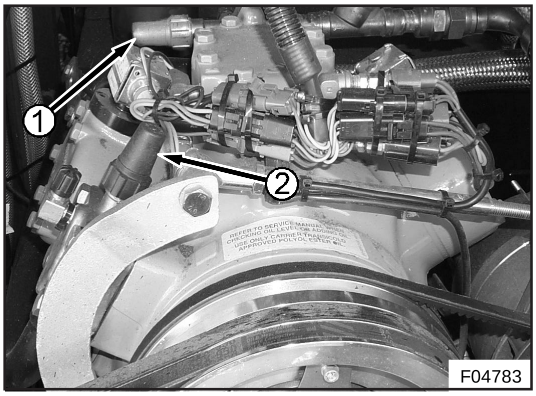

Figure 5: Service valves on refrigerant compressor

1. Discharge service valve
2. Suction service valve

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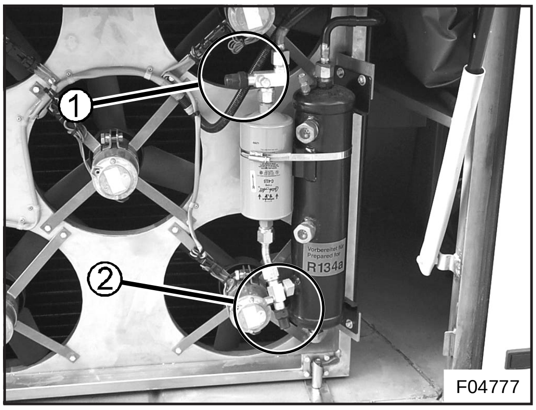

Figure 6: Service valves (1,2) at both sides of the filter/drier

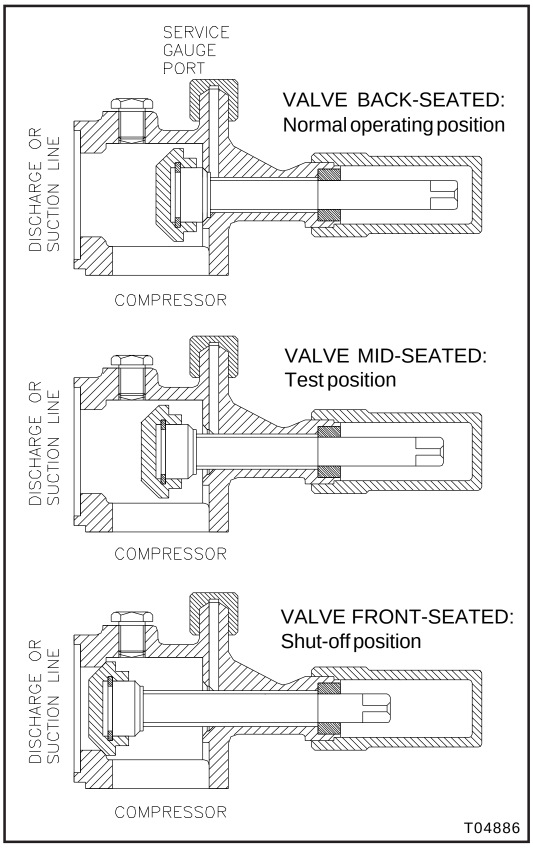

Figure 7: Service valve positions

The purpose of the service valves is:

• to isolate the compressor or filter/ drier from the rest of the system;

• to perform several refrigerant system services via the service gauge connections (such as evacuating, flushing with nitrogen, high pressure check, charging the system, ...).

The service valve is a three-position, internal double seating valve. The three positions are front-seated, mid-seated and back-seated.

Front-seated

This is the shut-off position. The valve stem is rotated all the way in a clockwise direction. This will seat the front valve face and isolate the compressor from the rest of the refrigeration system.

!!! CAUTION !!!
NEVER OPERATE THE COMPRESSOR WITH THE DISCHARGE SERVICE VALVE FRONT-SEATED.

Back-seated

The back-seated position is the normal position when the unit is operating. The valve stem is rotated all the way out in a counterclockwise direction. This will seat the rear face, and seal off the service gauge port.

Mid-seated

This is the test position of the service valve. In this position the gauge port is open, enabling the service technician to obtain the systems’ pressure readings. Starting from the back-seated position rotate the valve stem inward approximately 2 turns in a clockwise direction.

NOTE
Protective caps have been installed on the service gauge ports and valve stems of all service valves.

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It is necessary that the caps be removed for test gauge connections and valve operations. When service work has been completed, the protective caps must be replaced. The caps service as an extra seal to prevent valve leakage and to keep dirt and moisture out of the refrigeration system.

When operating service valve stem, never force wrench with a hammer or bar. In case of tight valve stem, loosen stem package nut on service valve.

COMPRESSOR REMOVAL

1. If the compressor is still operational, pump down the refrigerant system; shut down the coach engine and front-seat the compressor suction and discharge service valves.

   If the compressor is faulty, front-seat the compressor suction and discharge service valves to trap the refrigerant in the system.

2. Remove the compressor drive belts.

3. Reclaim refrigerant remaining in the compressor.

4. Loosen the capscrews securing the compressor suction and discharge service valves, and tap the valves with a hammer to free them from the mounting flanges. Remove capscrews and service valves, but do not remove hoses from valves.

5. Disconnect electrical wiring from compressor.

6. Remove the four nuts that secure the compressor to the mounting plate and remove the compressor from the coach.

!!! CAUTION !!!
THE COMPRESSOR AND CLUTCH ASSEMBLY WEIGHS APPROXIMATELY 145 LBS. BE EXTREMELY CAUTIOUS DURING REMOVAL PROCEDURE. USE ADEQUATE SLING AND HOIST.

REPLACEMENT COMPRESSOR INSTALLATION

Replacement compressors are furnished without suction and discharge service valves and unloaders. Blank-off pads are installed on the service valve flanges. These pads must be removed prior to compressor installation. If the defective compressor is to be returned for overhaul or repair, install the blank-off pads or plugs on the compressor for sealing purposes during shipment.

!!! CAUTION !!!
DO NOT BACK-SEAT (OPEN) SUCTION AND DISCHARGE SERVICE VALVES UNTIL THE COMPRESSOR HAS BEEN LEAK TESTED AND EVACUATED.

1. Recover the unloaders from the faulty compressor and install them in the cylinder heads of the replacement compressor (see earlier in this Section).

2. Install compressor with clutch on compressor plate.

3. Using new gaskets, install compressor suction and discharge service valves.

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4. Check oil level in oil level sight glass. Oil level should be between minimum indication and 1/2 of sight glass. If necessary, add or remove oil.
5. Leak test, evacuate, and dehydrate the compressor.
6. Install compressor drive belts.
7. Connect electric wiring to compressor clutch and high and low pressure switches.
8. Mid-seat compressor suction and discharge service valves.
9. Check compressor for proper operation.
10. Check for leaks in the refrigerant system.
11. Recheck compressor oil level.
12. Check operation of capacity control unloaders.
13. Check operation and proper pressure settings of high and low pressure switches.

DRAINING OIL BEFORE COMPRESSOR DISASSEMBLY

Prior to disassembly of the compressor, oil must first be drained from the crankcase.

1. Slowly loosen the oil fill plug to vent the crankcase.

!!! CAUTION !!!

COMPRESSOR MAY BE UNDER PRESSURE. SLOWLY LOOSEN OIL FILL PLUG TO BLEED PRESSURE TO ATMOSPHERE.

2. Remove the drain plug and allow the oil to drain completely.

NOTE

If dismantled parts are to be left overnight or longer, dip them in clean refrigerant compressor oil and wrap them in oil soaked rags to prevent rusting.

!!! CAUTION !!!

DO NOT UNSCREW CAPSCREWS ALL THE WAY BEFORE BREAKING SEAL. ENTRAPPED PRESSURE COULD RESULT IN INJURY.

NOTE

For compressor repair and overhaul, refer to refrigeration compressor Carrier O5G operation and service manual.

For clutch repair and overhaul, refer to Carrier/Linnig type LA 17.7.5.2 service manual.

When compressor drive belts are not installed, and the vehicle engine must run, do not operate the HVAC system, or remove the power supply to the clutch coil.

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CONDENSER COIL

The condensor is located behind the exterior access door in front of the left drive wheel. The function of the condenser unit is to remove the heat from the refrigerant passing through the condenser coils, and to expel it to the ambient (outside) air. The condenser compartment includes:

- stainless steel frame;
- condenser coil with subcooler, copper pipes, copper fins;
- condenser fans;
- receiver tank and filter/drier;
- filter/drier service valves;
- sight glasses;
- associated refrigerant lines and fittings.

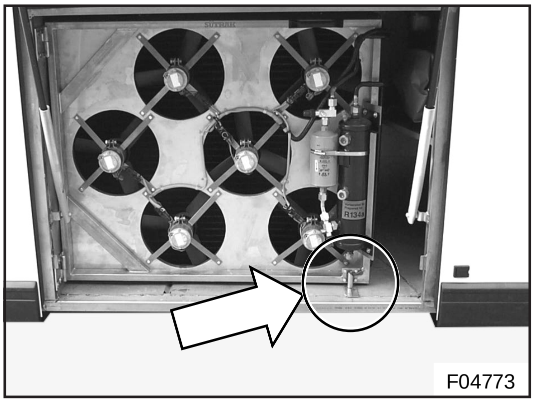

Figure 8: Compartment in front of left drive wheel (arrow shows bolt securing the condensor home). On current vehicles, the condensor is secured home with two bolts.

CONDENSER MAINTENANCE

• Regularly apply a drop of oil on the bolt(s) (see Figure 8) securing the condenser home.

• It is important that maximum air flow is maintained through the air cooled condenser. A reduced air flow decreases the heat transfer.
So check:

- fans operation;
- the condenser coil condition (clean, fins straight and not damaged).

To clean condenser: flush the condenser coil from inside out, using a low pressure water jet. Do not use high pressure. Direct the pressure straight through the coil to prevent bending of fins. Do not use hot water, steam or caustic soap.

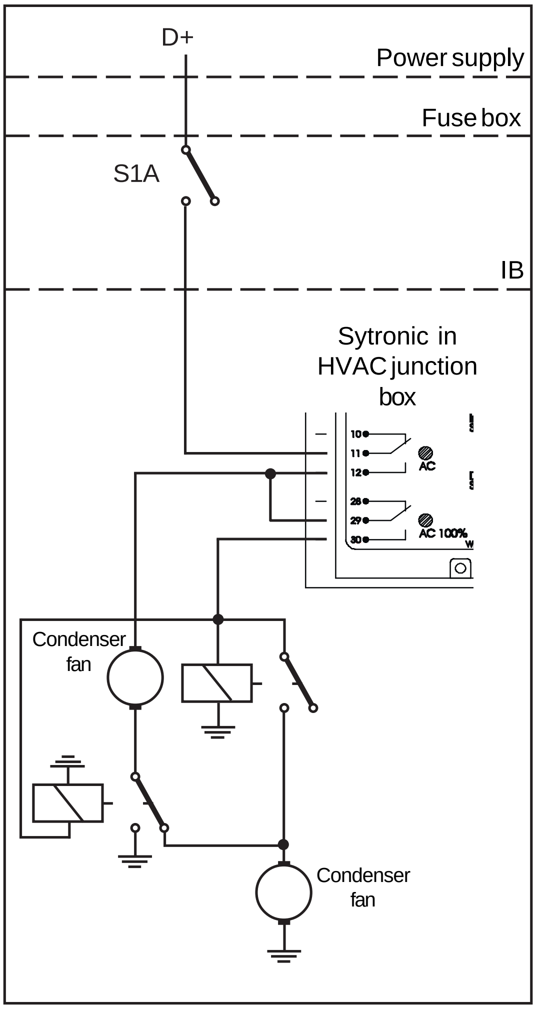

Figure 9: Condenser fan 2-speed control by series-parallel switching

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RECEIVER TANK

The function of the receiver tank is to store the liquid refrigerant until needed by the evaporators.

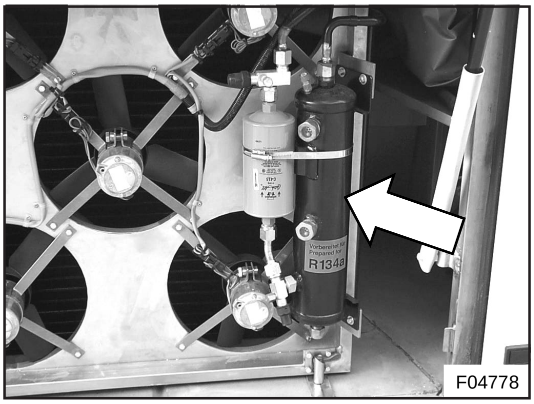

Figure 10: Receiver tank in condensor compartment

FILTER/DRIER

The filter/drier is used to remove moisture from the refrigeration system. If the filter/drier restricts the flow of refrigerant to the expansion valve, the inlet of the filter/drier will be warmer than the outlet when the unit is in operation. This is caused by evaporation due to the rapid pressure drop across the restriction.

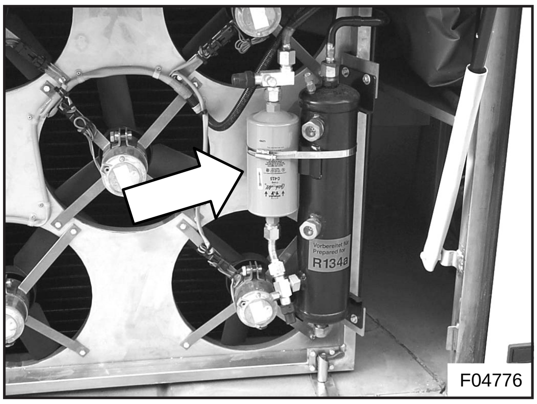

Figure 11: Filter/drier in condensor compartment

To remove

NOTE
Before removing the filter/drier, note the direction of the indicator arrow on the body. The filter/drier allows flow in one direction only. *The system does not require pump-down to replace the filter/drier. Service valves are provided to aid replacement. However, the refrigerant contents of the filter/drier must be reclaimed.*

1. Front-seat both service valves (1 and 2, Figure 6) by turning clockwise to fully closed position.
2. Install a recovery station and remove the refrigerant from the filter/drier.
3. Loosen the coupling nut at each end of the filter/drier.
4. Remove the filter/drier.

To Install

1. Install the new filter/drier.
2. Connect the coupling nuts.

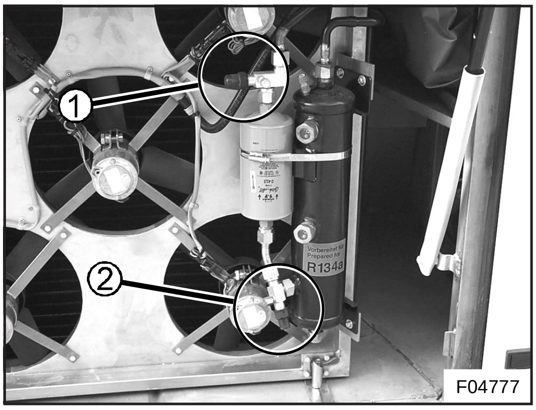

Figure 6: Service valves (1,2) at both sides of the filter/drier

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3. Evacuate the air from the filter/drier.
4. Back-seat both service valves (1 and 2, Figure 6) by turning counterclockwise to full open position.
5. Check for leaks.

EVAPORATOR COILS

The coach is fitted with three evaporator coils : two in the parcel racks of the passengers compartment and one in the HVAC unit of the driver's compartment.

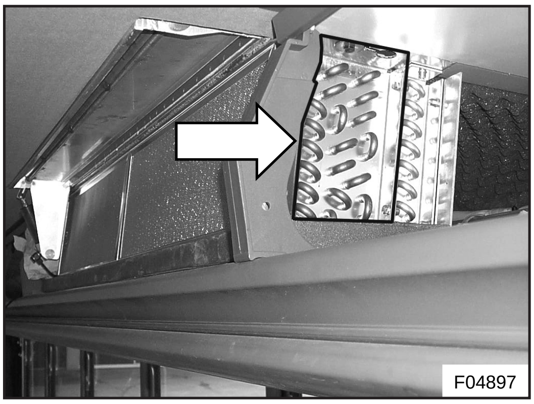

Figure 12A: Evaporator coil in parcel rack

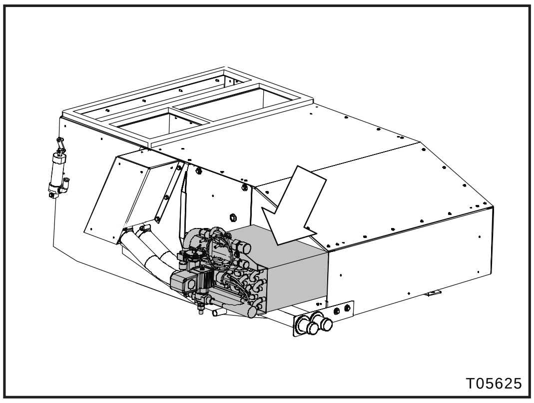

Figure 12B: Evaporator coil in HVAC unit under driver's compartment floor (accessible through the exterior door in front of the front left wheel)

The two coil assemblies in the parcel racks of the passengers compartment are each fitted with a drain pan. Regulary inspect the hoses connected to the drain pan for freedom of obstruction. Fill the drain pan with water and check for drainage. The hoses of the drain pan end up at the lower body edge in front of the drive axle.

THERMOSTATIC EXPANSION VALVE

The system contains three thermostatic expansion valves. One for each parcel rack evaporator and one for the driver's evaporator.

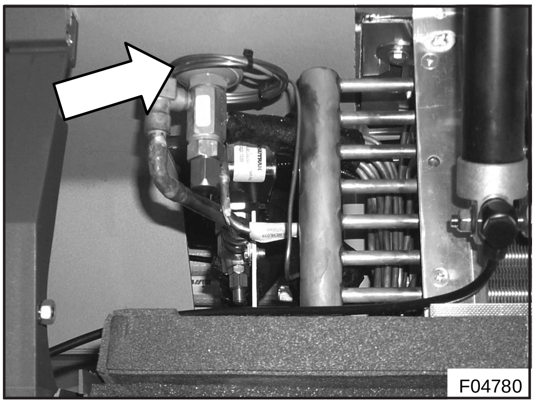

Figure 13: Thermostatic expansion valve of a parcel rack evaporator (one for each parcel rack evaporator, located behind the roof blowers junction box)

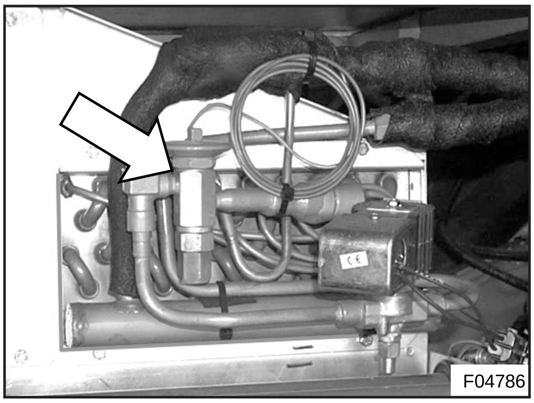

Figure 14: Thermostatic expansion valve of the driver's evaporator (accessible via the exterior door below the driver's side window)

The thermostatic expansion valve regulates the flow of liquid refrigerant into the evaporator coil.
The spring of the thermostatic expansion valve is factory set, and compensates between sensor bulb pressure and evaporator pressure to operate with a superheat of 9 to 13°F.

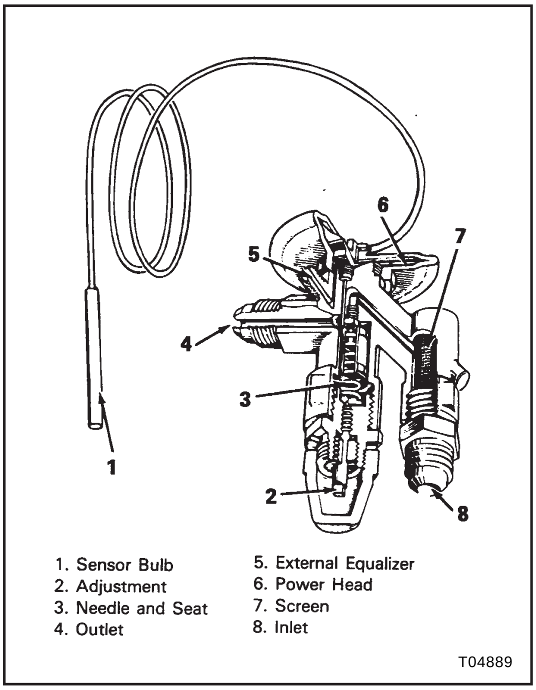

Figure 15: Thermostatic expansion valve and sensor bulb

EXPANSION VALVE MAINTENANCE

!!! CAUTION !!!

ALL OTHER POSSIBLE CAUSES OF SYSTEM MALFUNCTIONS SHOULD BE ELIMINATED BEFORE SERVICING THE EXPANSION VALVE.

EXPANSION VALVE ADJUSTMENT SHOULD ONLY BE PERFORMED IN WORKSHOPS AUTHORIZED BY CARRIER/SÜTRAK OR ABC.

FAILURES RESULTING FROM IMPROPER ADJUSTMENT OF THE EXPANSION VALVE ARE NOT COVERED BY WARRANTY.

IMPROPERLY ADJUSTING THE EXPANSION VALVE CAN RESULT IN SEVERE COMPRESSOR DAMAGE.

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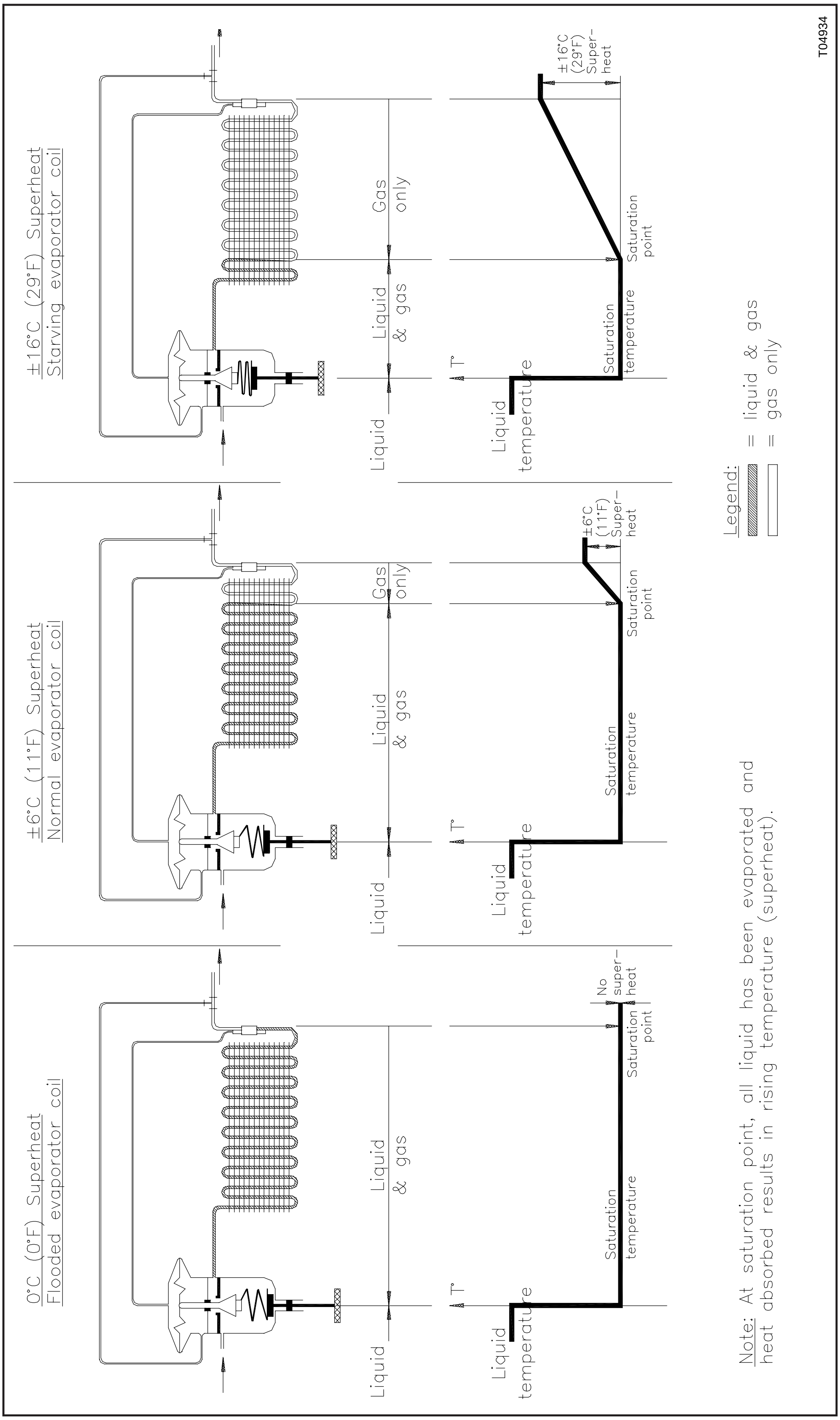

Figure 16: Thermostatic expansion valve (superheat setting)

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SENSOR BULB CONTACT WITH SUCTION LINE

The sensor bulb should make good contact with the suction line leaving the evaporator.

Poor contact of the sensor bulb causes the valve to operate by sensing the surrounding air temperature or to react not fast enough to prevent the return of liquid to the compressor. This will be indicated by frosting of the suction line and a slight rise in suction pressure, due to flooding of the evaporator coil.

If good contact is doubtful, or if elements are corroded:

1. Remove insulating tape from sensor bulb.

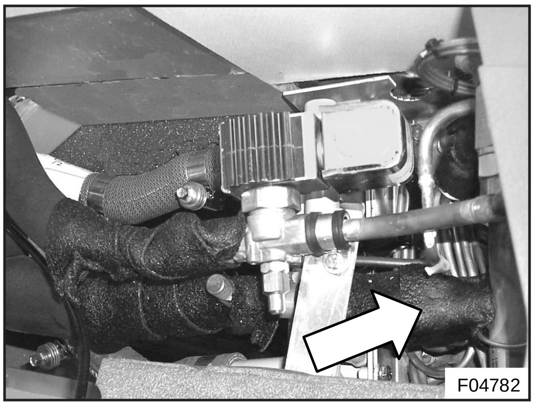

Figure 17: Thermostatic expansion valve sensor of a parcel rack evaporator (one for each thermostatic expansion valve, located behind the roof blowers junction box)

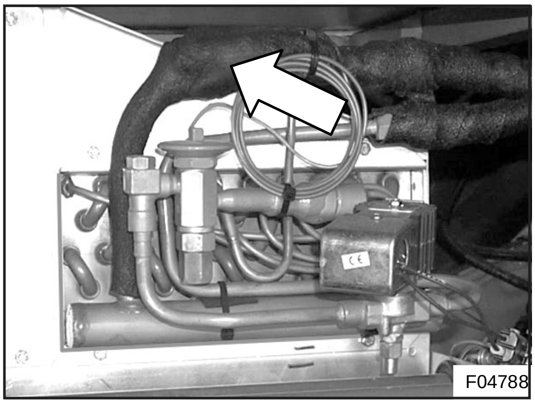

Figure 18: Thermostatic expansion valve sensor of driver's evaporator (accessible via the exterior door below the driver's side window)

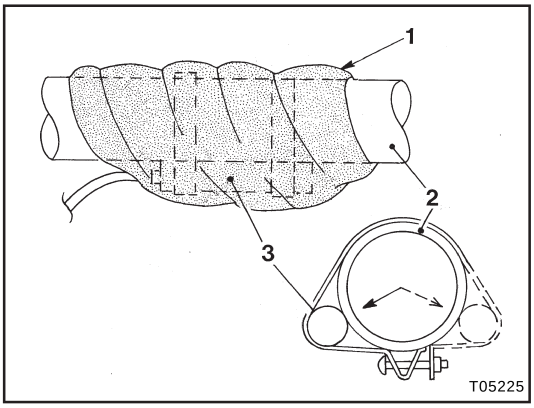

Figure 19: Sensor bulb installation

1. Insulating tape
2. Copper tube
3. Sensor of thermostatic expansion valve

2. Note the exact location of the sensor bulb on the line; i.e. lengthwise in the horizontal position and crosswise in the 4 or 8 o'clock position (see Figure 19).

3. Remove the sensor bulb from the suction line. Avoid tight bends in the capillary tube.

4. Clean suction line and sensor bulb with fine abrasive paper or emery cloth. Do not use acids or copper polish.

5. Coat sensor bulb and suction line with light film of heat transfer paste to prevent oxidation.

6. Reinstall sensor bulb in proper location, attach clamps and replace insulation around sensor bulb and suction line.

TO CHECK SUPERHEAT

1. Connect the high side gauge of an accurate manifold gauge to the discharge service valve of the compressor.

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2. Remove the air filter access panel in the parcel rack.

3. Remove the screws of the rear cover plate and slide it out.

4. Install an accurate remote reading thermometer to the evaporator outlet next to the expansion valve sensor bulb, or under one of the straps, which clamp the valve bulb to the suction line.

NOTE
Expansion valve bulb and thermometer probe must be a tight fit and have good contact with the suction line.

Thermal insulating tape must be wrapped around the bulb, evaporator outlet line and thermometer probe to get a true reading of the line temperature.

5. Install the low side of the manometer to the Schrader valve of figure 21.

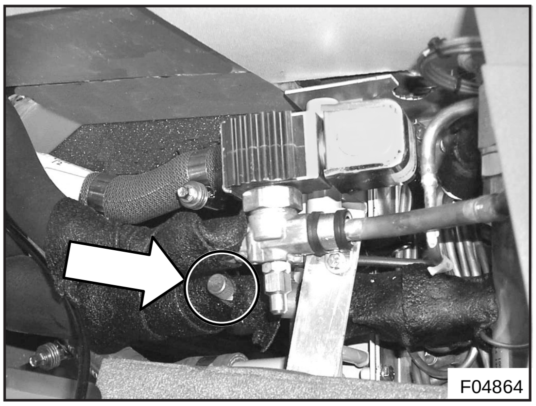

Figure 21: Schrader valve near liquid solenoid valve in parcel rack, located behind the roof blowers junction box

6. Re-install the rear cover plate and the air filter access panel.

7. Run the air conditioning unit a minimum of 15 minutes at fast idle. Return air temperature must be a steady approx. 72°F; the compressor must be operating fully loaded. Disconnect compressor unloaders if needed. Reheat may come on. Discharge pressure to be maintained at a minimum of 120 to 145 psig. At low ambient

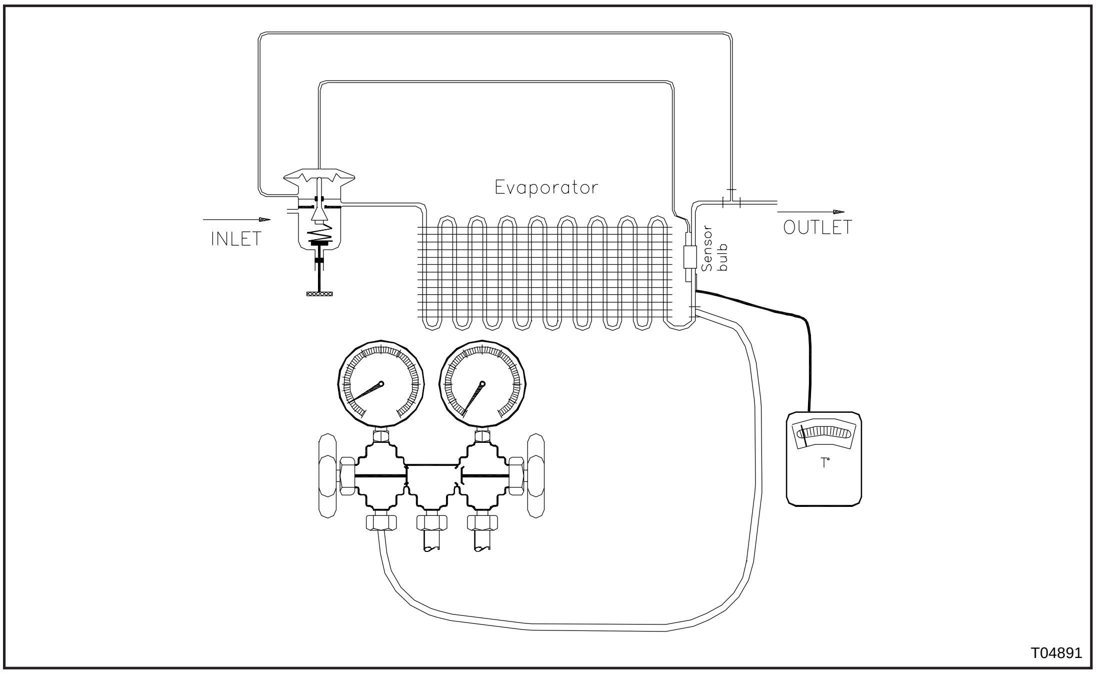

Figure 20: Checking superheat - Thermometer and gauge connection

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temperatures, restrict airflow to condenser or disconnect some condenser fans.

8. Check and record the gauge suction pressure and expansion valve sensor bulb temperature simultaneously. Record minimum 5 pressures and temperatures with 2 minutes interval. Pressure and temperature will cycle between maximum and minimum. Records must include higher and lower measures, and extend over a time span longer than 1 cycle.

9. Convert the pressure readings to temperature by using the "Temperature - pressure chart" at the end of this chapter.

10. Calculate superheat at evaporator outlet with the average of recorded values.

    Superheat = suction line temperature minus saturation temperature corresponding to suction gas pressure

<u>Example:</u>

Average line temperature .... 50°F

Average suction line temperature at 35.5 psig .... 39°F

Superheat .... 50°F - 39°F = 11°F

Superheat should be between 9 and 13°F.

ACCESSORIES

LIQUID LINE SOLENOID VALVES

Solenoid valves are installed ahead of the expansion valves in the liquid refrigerant lines going to the parcel rack evaporator coils and in the liquid line to the driver's evaporator. The

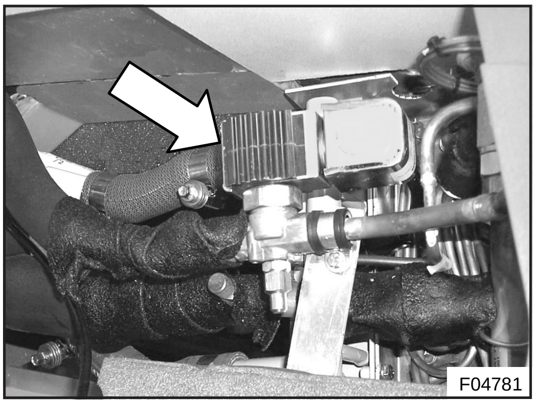

Figure 22: Liquid line solenoid valve of parcel rack evaporators (one for each parcel rack evaporator)

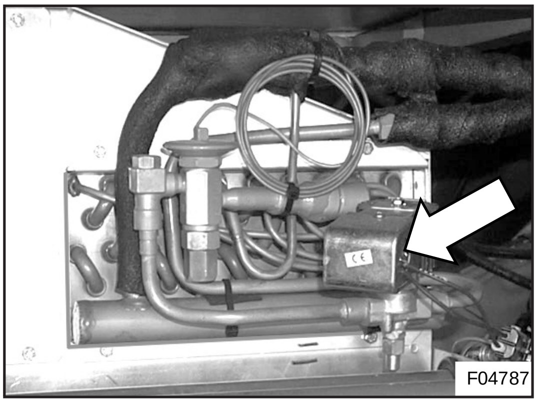

Figure 23: Liquid line solenoid valve of the driver's evaporator (accessible via the exterior door below the driver's side window)

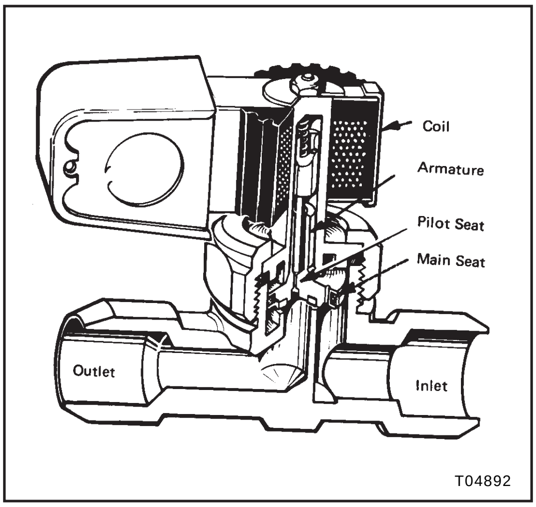

Figure 24: Section through liquid line solenoid valve

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valves are activated by the same control signal that activates the clutch. When the clutch is energized, the solenoid valves open to allow refrigerant to flow to the expansion valves.
Whenever the refrigerant system is being serviced, or when an insufficient cooling problem is being investigated, these valves should be checked to determine if they are opening so that refrigerant is able to circulate through the system. If the valves are not functioning properly, check the electrical connections and check for damage to the wiring.

PRESSURE SWITCHES/ SYSTEM PROTECTION - Figures 25, 26A, 26B and 26C

The refrigerant system is protected against abnormal operating pressures by means of pressure sensitive switches, mounted on high- and low side of the compressor.
In case of extreme ambient temperatures and high compressor speeds, the system could exceed its operating limits, therefore the pressure switches adapt the compressor output to suit the capacity of the system and prevent it from being overloaded.

- The high (UPS) and low (LPS) pressure cut-out switches disconnect the compressor clutch to prevent over or under pressure in the system.
- The supplementary high pressure switch (UPS3) activates 1 unloader (2 cylinders are disabled) when pressure reaches the upper limit of the operating range.
- Up to VIN 45221 (Cummins) and VIN 45685 (Detroit Diesel): two supplementary low pressure switches (UPS1 and UPS2) activate

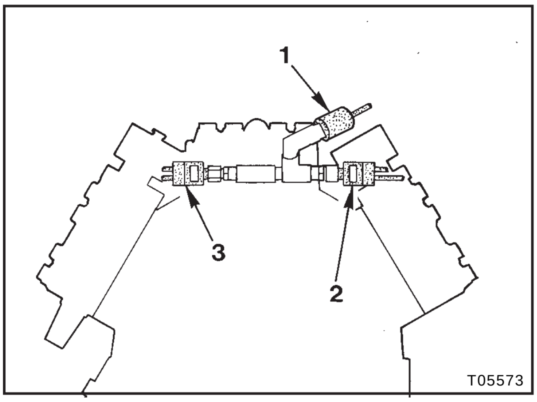

Figure 25: Pressure switches on the refrigerant compressor (Up to VIN 45221 (Cummins) and VIN 45685 (Detroit Diesel))

1. Low pressure switch (LPS)
2. UPS2 switch
3. UPS1 switch

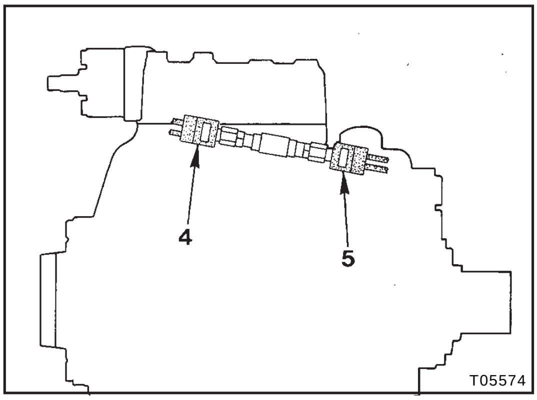

Figure 26A: Pressure switches on the refrigerant compressor (Up to VIN 45221 (Cummins) and VIN 45685 (Detroit Diesel))

4. High pressure switch (UPS)
5. UPS3 switch

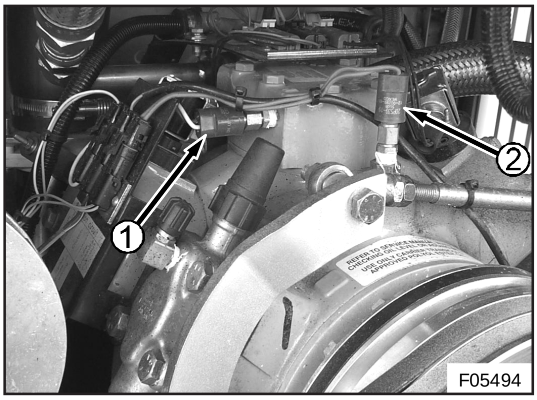

Figure 26B: Pressure switches on the refrigerant compressor (From VIN 45222 (Cummins) and VIN 45686 (Detroit Diesel))

1. High pressure switch (UPS)
2. Low pressure switch (LPS)

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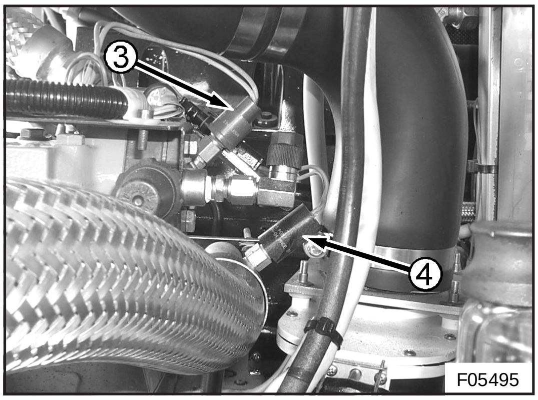

Figure 26C: Pressure switches on the refrigerant compressor (From VIN 45222 (Cummins) and VIN 45686 (Detroit Diesel))

3. UPS1 switch
4. UPS3 switch

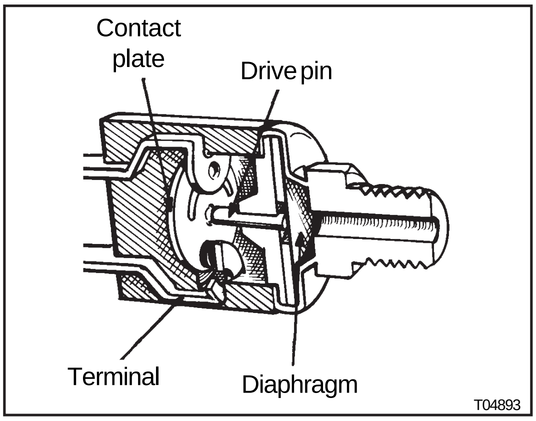

Figure 27: Pressure switch

gradually 1 or 2 unloaders (2 or 4 cylinders are disabled) when suction pressure reaches the lower limit of the operating range. This protects the evaporator against freezing-up.

- From VIN 45222 (Cummins) and VIN 45686 (Detroit Diesel): a supplementary low pressure switch (UPS1) activates 1 unloader (2 cylinders are disabled) when suction pressure reaches the lower limit of the operating range. This protects the evaporator from freezing-up. The second unloader is controlled directly by the electronic control unit.

Low pressure test

Low pressure cut-out is extremely important. The system will not function satisfactorily and possible damage to the compressor will result if switch contacts fail to open upon reaching the designated pressure. In making the following test, an accurate compound (pressure and vacuum) gauge should be used.

1. Remove cap from suction pressure line test gauge fitting on compressor. Then connect pressure gauge line to valve. Front seat suction valve on compressor slowly by turning valve stem in (clockwise) until valve seats.

2. Start coach engine and operate compressor. Observe pressure reading on gauge at the moment that the low-pressure switch disengages the clutch.
   Pressure reading should be 3 to 7 psig.

3. Next, allow pressure to build up. Pressure reading on gauge when switch points close (and clutch engages) should be 26 to 35 psig.

4. If switch points do not open and close at gauge reading specified in Steps 2 and 3, replace low-pressure switch.

!!! CAUTION !!!
DO NOT ALLOW PRESSURE TO FALL BELOW 0 PSIG.

High pressure test

The high pressure side switch should open the contacts and disengage the

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Table 2: Settings of pressure switches

Name	CTD part No.	Description	Contacts close at		Contacts open at	
			bar gauge (°C)	psig (°F)	bar gauge (°C)	psig (°F)
HPS	12-00299-14	High pressure cut-out	15,6→17,6 (59,6→64,5)	230→255 (139,3→147,9)	23,1→23,9 (76→77,5)	330→360 (168,8→171,5)
LPS	12-00299-01	Low pressure cut-out	1,8→ 2,4 (-1,2→4,2)	26→35 (29,8→39,6)	0,2→0,5 (-22,5→-17,2)	3→7 (-8,5→ -1)
UPS3	12-00299-17	Unloader 1; high pressure	20,6→21,7 (71→73,3)	295→315 (159,8→163,9)	15,9→17,1 (60,4→63,3)	230→250 (140,7→145,9)
UPS1	12-00334-02	Unloader 1;low pressure	1,5→1,65 (-4,3→-2,7)	21,5→24,5 (24,3→27,1)	1,95→2,35 (0,2→3,8)	28→34 (32,4→38,8)
UPS2	12-00334-04	Unloader 2;low pressure	1,25→1,45 (-7,1→-4,9)	18→21 (19,2→23,2)	1,7→1,95 (-2,2→0,2)	25→28 (28→32,4)

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compressor clutch at about 330 to 360 psig discharge pressure and close at about 230 to 255 psig pressure. Using an accurate high pressure gauge, test and adjust as follows:

1. Remove cap from discharge pressure line test gauge fitting at compressor, then connect the gauge set high pressure line to valve.

2. With both the suction and discharge valves in operating position (cracked 1/2 to 1 turn away from backseat position), operate the compressor. Disconnect the condenser fans or cover the condenser coil while the system is operating and observe the pressure reading on the gauge at the instant the compressor clutch stops. If the gauge reading when the compressor clutch stops is more or less than 330 to 346.6 replace the pressure switch.

!!! CAUTION !!!
DO NOT ALLOW THE PRESSURE DIFFERENCE (BETWEEN HIGH AND LOW PRESSURE SIDE) TO EXCEED 362.6 PSIG.

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PIPING - HOSES - FITTINGS

Van Hool uses full stainless steel hoses with welded-on couplings.

They are very flexible, unaffected by refrigerant and have a virtually indefinite life span. Since they have welded-on fittings for leakproof operation, they cannot be reused when damaged, and must be replaced.

Before assembling tube and hose joints, use a small amount of clean new refrigerant oil on the sealing seat.

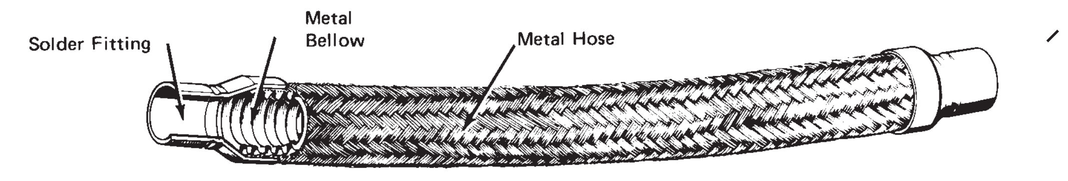

Figure 28: Stainless steel hose

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HIGH SIDE CHECK VALVE

In order to prevent liquid refrigerant from returning to the compressor when the system is shut down, a check valve is installed in the compressor discharge line.
When the valve is damaged or broken, replace the entire valve or replace parts of the valve interior with new valve parts.The high side check valve is located in the engine compartment.

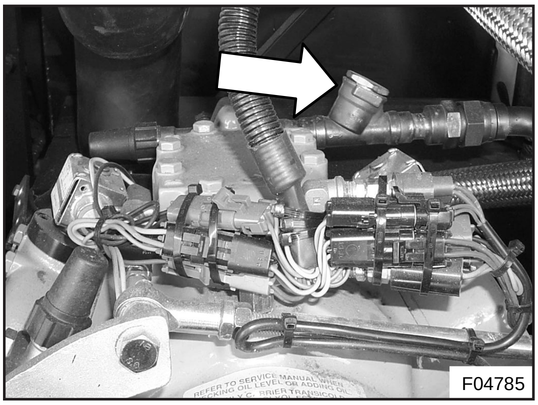

Figure 29: High side check valve in engine compartment

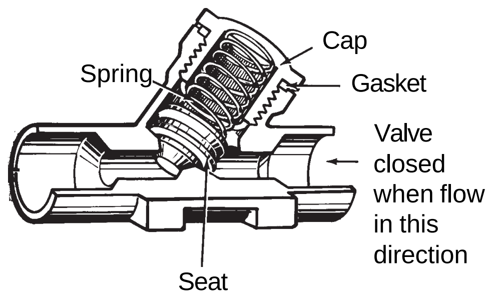

Figure 30: Section through high side check valve

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REFRIGERANT OIL (COMPRESSOR OIL)

OIL SPECIFICATIONS

The following oils are approved:

- Castrol Icematic SW68
- Mobil EAL Arctic 68
- ICI Emkerate RL68H

QUANTITY OF OIL IN THE SYSTEM

The total oil quantity depends on the type of compressor and installation. In R-134a systems, oil and refrigerant do not mix in the same way as in R12 systems and consequently less oil is transported through the system.

NOTE
After system clean-up and major breakdown, oil shortage may occur if only the compressor is filled. Oil level should be checked after minimum 20 minutes of operation under normal conditions.

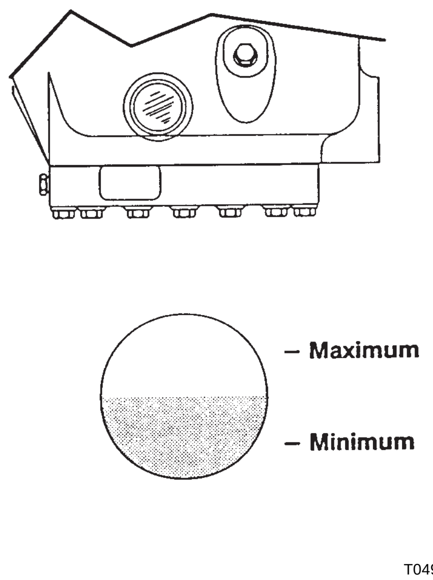

Figure 31: Sight glass location

Air-conditioning units R-134a - CARRIER O5G:

Total oil charge: 3.4 quarts

- The oil level in the compressor can be checked through the oil level sight glass in the compressor body. The refrigerant system is sealed, and the unit does not consume oil. It is only necessary to add oil if there has been a significant leak in the system, or if a major component, such as an evaporator coil or a condenser coil, has been replaced.

- Refrigerant oil is specially designed for use in refrigerant systems. Never use anything except one of the specified refrigerant oil types.

- When oil has been removed from a refrigerant system it must be replaced with fresh, new oil.

!!! CAUTION !!!
NEVER OVERFILL THE SYSTEM WITH OIL. OVERFILLING MAY SERIOUSLY DAMAGE THE COMPRESSOR OR OTHER PARTS OF THE SYSTEM, AS WELL AS AFFECT THE SYSTEM'S PERFORMANCE.

TO CHECK FOR REFRIGERANT OIL LEAKS

Visually inspect fittings, flexible hoses and compressor crankshaft seal for oil leaks.

Oily flexible hose

- Wash (steam clean) oily surface.
- Check for refrigerant leakage.

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- Leaks caused by flexible hoses which have become porous may be hard to detect.
- Replace hose if in doubt.

Oily fittings, hose oily in proximity of fittings

- Clean up and check for refrigerant leaks
- An oily hose in the proximity of a fitting may be caused by a badly installed hose fitting or hose wear.
- Unscrew and retighten fittings.
- Repair/replace if needed.

Oil drops at bottom of crankshaft seal

In order to work effectively, the crankshaft seal must be saturated with oil. A moist or sweating seal shedding a few droplets is proof that the seal works well.
A dry seal, or a seal that leaks constantly must be replaced.

NOTE
If the compressor has not run for a long time, the crankshaft seal may dry out. If after 200 hours of operation, a leak is still detected, the seal must be replaced.

TO ADD COMPRESSOR OIL

NOTE
The compressor does not consume oil. If the compressor requires additional oil, it is likely there is a leak.

Procedure:

1. With compressor running, front-seat suction service valve (2, Figure 5) and pump compressor down (at least 2 times until low pressure switch cuts out the clutch). Shut down the engine and front-seat discharge service valve (1, Figure 5).
2. Connect a recovery station to the service gauge port of discharge service valve (1, Figure 5).
3. Connect a manifold hose, with a tap at one end, to the service gauge port of suction service valve (2, Figure 5), evacuate (with vacuum pump) the air from the hose and put the end with the tap into the oil container.
4. Open the tap, run the vacuum pump and open manifold valve slowly while checking the oil level through the compressor sight glass.
5. Add oil until proper level is obtained (see figure 31).
6. Remove charging equipment and vacuum pump. Back-seat suction and discharge service valves.

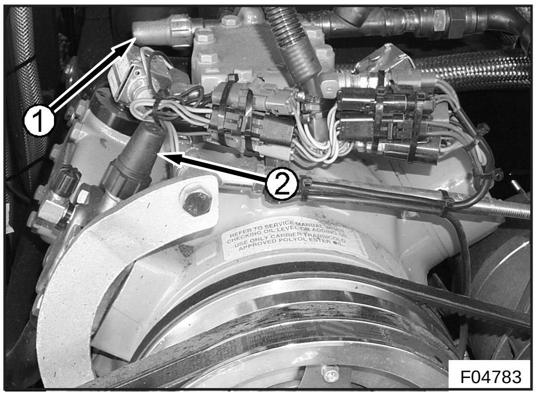

Figure 5: Service valves on refrigerant compressor

1. Discharge service valve
2. Suction service valve

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NOTE

Refrigerant oil, open to air for an extended period of time, will absorb moisture and should be discarded. Open container shortly before use only.

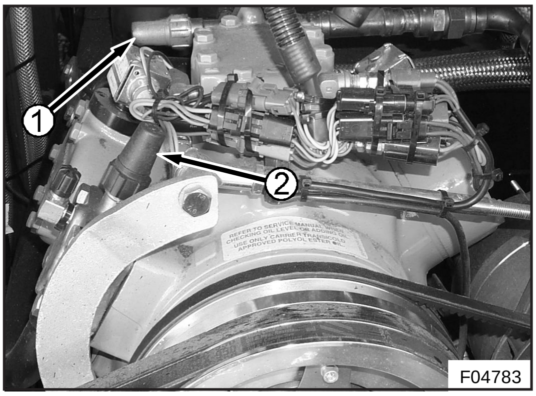

Figure 5: Service valves on refrigerant compressor

1. Discharge service valve
2. Suction service valve

TO REMOVE COMPRESSOR OIL

When the system contains an excessive amount of oil, removal of some of the oil is required.

Proceed as follows:

1. Front-seat suction service valve (2, Figure 5) and pump compressor down (at least 2 times until low pressure switch cuts out the clutch). Shut down the engine and front-seat discharge service-valve (1, Figure 5) . Reclaim all remaining refrigerant.

2. Loosen drain plug just enough to allow oil to flow out by the threads of the plug. *Do not remove the plug!*

3. Drain excess oil to proper level into a suitable container and retighten plug.

4. Back-seat suction and discharge service valves.

5. Run compressor for at least 20 minutes and check oil level.

6. Check refrigerant level.

CHANGING COMPRESSOR OIL

The risk for contamination of R-134a systems is much bigger than for R-12 and R-22 systems.

To change the compressor oil, proceed as follows:

1. Perform low side pump down, and shut down A/C system & coach engine.

2. Isolate the compressor from the refrigerant system by closing (front-seating) the discharge and suction service valves.

3. Connect a recovery station, through a manifold gauge set, to the service gauge ports on the discharge and suction service valves.

4. Run recovery station to obtain a slight positive pressure of 2 to 3 psig inside the compressor.

5. With the slight positive pressure in the compressor, loosen drain plug just enough to allow oil to flow out by the threads of the plug. When pressure has been relieved, remove the plug and allow oil to drain into a suitable container.

6. Drain maximum amount of oil, reinstall and tighten drain plug.

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7. Connect a manifold hose, with a tap at one end, to the service port of the suction service valve, evacuate air from the hose and put the end with the tap into the oil container.
8. Open the tap; run the vacuum pump and open manifold valve slowly while checking oil level through compressor sight glass.
9. Add oil until proper level is obtained.
10. Back-seat suction service valve. Evacuate compressor body through service valve gauge ports with recovery station. Back-seat discharge and suction service valves. Remove charging equipment and recovery station.
11. Run the compressor for at least 20 minutes and check for leaks.
12. Check refrigerant level.
13. Recheck compressor oil level.

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USE OF MANIFOLD GAUGE

PRECAUTIONS

When using a manifold gauge set to diagnose, recharge or otherwise service the refrigerant system:

- Ensure that all equipment hose lines are fitted with quick release valves at their ends. If quick release valves cannot be used, make sure that the hose lines are provided with shut-off valves within 12 inches of their ends and that the valves are closed; this to minimize refrigerant loss to the atmosphere.

- Be sure that all equipment, including the connecting hose lines and manifolds are compatible with the refrigerant in the system being serviced, free of all contaminants, and used only for the same type of refrigerant.

- Be certain that all shut-off valves are shut tight before connecting them to the refrigerant system or charging station.

- Close shut-off valves after servicing and before removing them from the system or charging station.

- When the manifold gauge set is disconnected from the refrigerant system and you want to empty it of refrigerant, or when the center hose is to be removed to another device, which cannot accept refrigerant pressure, the hoses should first be attached to a recovery or reclaiming station, to remove the refrigerant, oil, and contaminants from the hoses.

TO INSTALL MANIFOLD GAUGE SET

The following procedure should be followed for proper servicing and troubleshooting:

1. Thoroughly clean compressor service valves and surrounding area.

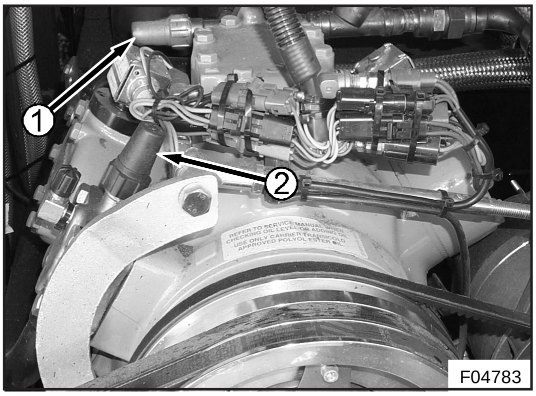

Figure 5: Service valves on refrigerant compressor

1. Discharge service valve
2. Suction service valve

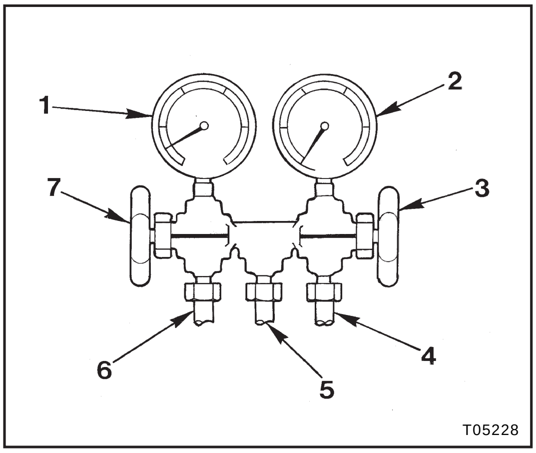

Figure 32: Manifold gauge set

1. Low pressure gauge
2. High pressure gauge
3. High pressure cock
4. High pressure hose
5. Utility hose
6. Low pressure hose
7. Low pressure cock

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2. Check that manifold gauges, hoses, rubber gaskets and fittings are ready to use.

3. Remove valve stem caps from compressor suction and discharge service valves.

4. Ensure that both compressor service valves are in back-seated position.

5. Remove the small service gauge port caps from the compressor suction and discharge service valves.

6. Check that both manifold valves are closed (turn cocks fully clockwise).

7. Attach the high pressure hose to the service gauge port of the compressor discharge service valve (DSV).

8. Attach the low pressure hose to the service gauge port of the compressor suction service valve (SSV).

9. Connect central utility hose to service equipment.

10. Check that all hose fittings on the manifold gauge set are tight.

11. Turn the DSV counterclockwise 1/4 to 1/2 turn. Purge to manifold by turning high pressure cock of manifold counterclockwise and allowing a small amount of refrigerant to escape from the center port of the manifold into a reclaimer. Tighten valve, high pressure side is now purged.

12. Turn the SSV counterclockwise 1/4 to 1/2 turn. Purge the manifold by turning low pressure cock of manifold counterclockwise and allowing a small amount of refrigerant to escape into a reclaimer. Tighten valve. Low pressure side is now purged.

NOTE
The manifold hand shut-off valves do not in any way admit or close off pressure to the gauges. The shut-off valves close the opening to the center connector and to each other. *Failure to purge lines will result in air or contaminants entering the system.*

TO REMOVE MANIFOLD GAUGE SET

1. Back-seat the compressor discharge and suction service valves to close the service gauge ports.

2. Close high and low side manifold gauge valves (turn cocks fully clockwise).

3. Disconnect the manifold gauge hoses from the compressor service valve service ports and service equipment. Slowly open fitting to bleed remaining refrigerant to reclaimer.

4. Refit service valve and service gauge port caps handtight.

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REFRIGERANT LEAK CHECK PROCEDURE

ROUTINE CHECK (SYSTEM HAS NOT BEEN OPENED)

All automotive refrigerant systems leak to some extent. Much of the leakage comes from slow seepage of refrigerant through the flexible hoses. Other common sources of leaks are joints between the flexible hoses and the tubing or at the threaded connections. Furthermore, during its first 50 hours of operation, the refrigerant losses through the crankshaft main bearing seal of the "open" type compressor are considerable. For the refrigerant system to operate efficiently and for environmental reasons, it is important that leakage be minimized.

An electronic leak detector is required to perform the routine check. Make sure that it is designed to detect leaks of the refrigerant (R-134a) that is used in the system. It should be able to measure at least 500 ppm.

1. Make sure the system is fully charged.

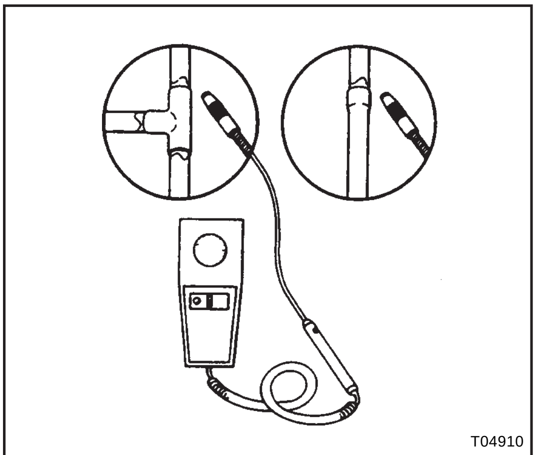

Figure 33: Routine check

2. Make sure there is adequate pressure in the system to detect a leak.

3. Connect manifold gauge set to compressor.

4. Put air conditioning override switch on HVAC switchboard in luggage compartment in "Override cooling" position.

5. Operate unit for 10 to 15 minutes.

6. Turn system off.

7. Ventilate engine compartment before you test for leaks. In addition to refrigerants, leak detectors can also sense some non-refrigerant chemicals such as antifreeze, brake cleaners, diesel fuel and other common automotive chemicals such as solvents.

8. Switch electronic leak detector on. Follow the instructions included with the equipment.

9. Set detector to maximum sensitivity.

10. Test for leaks by tracing along all system components with the leak detector probe. Hold the probe tip ¼" or closer to the system components being checked. The slower you go, the more likely you are to find a leak. Pay special attention to those areas that show oil leakage, damage, corrosion or any other visible signs of a potential leak.

11. Verify all detected leaks at least once by blowing pressurized air at the suspected leak and check again.

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12. If a leak is found, continue to check the remainder of the system. Always be sure that you have found all of the leaks.

If required, evacuate and/or pump down the system, repair it, and recharge it, making sure you don't overfill it.

REFRIGERANT LEAK CHECK AFTER THE SYSTEM HAS BEEN OPENED

A refrigerant leak check should always be performed after the system has been opened to repair or replace a component. To check for leaks in the refrigerant system, perform the following procedure:

1. Ensure the main liquid line and driver solenoid valves are open. Use the "service override" switch in the HVAC junction box in the luggage compartment, or in case of lack of electric power, open the solenoid valves with a wrench.

2. Ensure the receiver shut-off valves are open.

3. If the system is without refrigerant, charge the system with dry nitrogen 4.6 (99,996% nitrogen and max. 5 ppm water) through the compressor discharge service valve.

4. Add sufficient nitrogen to raise the pressure to 480 psig.

5. Test for leaks with a soapy solution, or leave the nitrogen at least 24 hours on the system, then check for a pressure drop. Spray the soapy solution on the point being checked. Using a strong light, carefully inspect for signs of bubbles or foam, which indicate a leak.

6. If a leak is found, continue to check the remainder of the system. If required, evacuate and repair the system, then check again for leaks.

7. If no more leaks are found, dump the nitrogen through the compressor suction service valve and evacuate the system.

8. Recharge the system with new refrigerant.

NOTE
When a leak is suspected, torque all connections. Never overtighten to stop a leak. If a connector leaks when properly torqued, disassemble the joint to determine the cause. *It is good practice to leak test a system before opening it for repairs. In this manner, any leaks may be repaired at the time the system is open, and air and moisture will not be drawn in when evacuating the system prior to charging.*

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PROCEDURE TO CHECK REFRIGERANT CHARGE AND ADD REFRIGERANT IN EXPANSION TANK WITH TWO SIGHTGLASSES

The following conditions must be met to accurately check the refrigerant charge:

1. Install manifold gauge set.

2. Coach engine must be operating at high idle (engine speed: 1,250 ± 50 rpm).

3. Compressor unloaders must be disconnected.

4. Maintain head pressure between 173.5 and 203.5 psig. At low ambient temperature this pressure can be maintained by reducing the airflow through the condenser. To obtain less airflow, cover the fins of the lower part of the condenser coil or disconnect condenser fans as required. When doing so, make sure the condenser coil is being cooled evenly from bottom to top. One of the top condenser fans should always remain operational to ensure airflow through the liquid sub cooler.

5. At the evaporator inlet, the interior temperature must be between 74 and 78°F. Set the interior temperature to 78 °F. Keep the interior temperature stable by adding heat from the heating system, by opening windows or roof hatches,... .

6. Fresh air flaps must be closed and the covers of the evaporators in place.

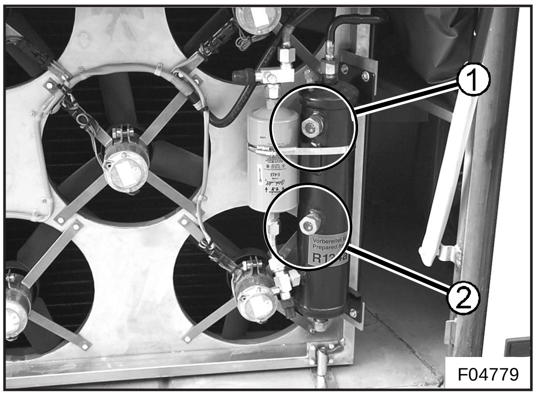

Figure 34: Sight glasses on receiver tank

1. Upper sight glass
2. Lower sight glass

7. All evaporator blowers must be operating. Air filters must be clean to allow full evaporator air flow. Make sure no outside air is circulating. Front unit blowers must operate at full speed with hot water valve closed (if the front unit is switched off, the system will overcharge as liquid refrigerant accumulates in the front unit evaporator and liquid line).

8. Maintain these conditions for about 20 minutes.

9. When the ball in the lower sight glass is on top, the system is sufficiently charged. When the ball in the lower sight glass is not on top, continue this procedure. Maintain the test conditions mentioned in items 4 and 5 during the rest of the test, and during charging.

10. Check operating pressures.

!!! CAUTION !!!
EXCESSIVE HEAD PRESSURE ALONG WITH A NORMAL LOW SIDE PRESSURE INDICATES AN OVERCHARGE OF REFRIGERANT OR AIR IN THE SYSTEM.

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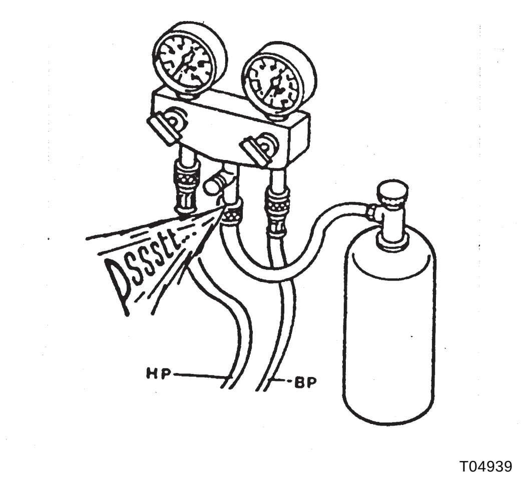

Figure 35: Purge charging hose

11. Attach the charging hose to the container of refrigerant and (loosely) to the center port of the manifold gauge.

12. Crack-open (vapor side) dispensing valve of container, purge charging hose and tighten hose fitting (see Figure 35).

13. Open the dispensing valve (vapor side) of the refrigerant container and adjust the flow of refrigerant to the system via the manifold gauge low pressure side.

14. Observe the sight glass and fill the system until the ball in the lower sight glass is on the top. The ball in the upper sight glass must not float. Charging is now completed. Check again items 4 and 5 of this procedure.

15. Close all valves, remove all hoses and install protective caps over fittings.

NOTE
The total system refrigerant charge is 32.50 to 33.60 lbs.

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PROCEDURE TO PUMP DOWN LOW SIDE

When certain procedures require the disconnection of refrigerant lines, it is necessary to pump down the system first to minimize loss of refrigerant. To pump down the system means to pump most of the refrigerant into the liquid receiver tank.

System pump down procedure:

1. Connect the manifold gauge set to the compressor service valves.
2. Start system and operate compressor.
3. Front-seat the filter/drier liquid line service valve by turning the valve clockwise to the fully closed position.
4. Continue to operate compressor, observing pressure gauge, until low pressure switch disengages compressor clutch.
5. When the suction pressure builds up to low pressure cut-in (31.9 psig), after approximately 5 minutes, the compressor restarts and runs until the clutch disengages again.
6. Front-seat compressor discharge service valve.
7. Remove the center hose from the manifold gauge set and connect it to a reclaimer or evacuated cylinder. This will allow the refrigerant in the lines to escape to the recovery station.
8. When indicator on low pressure gauge drops to 0, refrigerant line on low pressure side may by safely removed.

NOTE
All lines between the compressor and the liquid receiver tank are pressurized. If you want to remove units from this section, the refrigerant must first be reclaimed.

PROCEDURE TO EVACUATE A SYSTEM

To "evacuate" the system means to remove all contaminants such as air and moisture from the refrigeration system by means of a vacuum.

!!! CAUTION !!!
MOISTURE IN THE SYSTEM CAN CAUSE EITHER FREEZING OF THE EXPANSION VALVE OR FORMATION OF ACID, WHICH CAN DAMAGE OR PLUG THE SYSTEM. AIR TRAPPED IN THE SYSTEM WILL CAUSE HIGH HEAD PRESSURE AND REDUCE THE COOLING CAPACITY.

When the refrigerant system has been opened to the atmosphere or pressure tested with nitrogen, it is necessary to thoroughly evacuate the system before recharging.

The solenoid valves open when the compressor clutch is activated.
If these valves are closed, proper evacuation is not possible because liquid refrigerant / contaminants may be trapped between the expansion valve and the liquid line solenoid valve. When master switch is ON (+30) the solenoid valves can be opened by positioning the service switch in the HVAC junction box in the “SERVICE” position.

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NOTE
For normal operation, the service switch must always be in the "CLIMA OPERATION" position.

1. Install a manifold gauge set. Connect the low pressure side with a quick release connector to the compressor, and the high pressure side to a ¼" SAE connector located behind the check valve.
   Remark: if the high pressure side of the manifold gauge set is connected to the discharge service valve, evacuation may take longer, because the check valve is closed and evacuation will take place from one side only.

2. Install vacuum pump line to manifold gauge center port.

3. Evacuate system to 1500 microns.

4. Break vacuum with dry nitrogen to "absorb" moisture. Pressurize to 10 psig and allow to stand for 10 minutes.

5. Evacuate system to 500 microns.

6. Stop vacuum pump and isolate it from the air conditioning system with a shut off valve. The system pressure should not exceed 2000 microns after 5 minutes (start timing after 500 microns reading is reached).

7. Charge system with proper amount of refrigerant.

8. Return the service switch to the "CLIMA OPERATION" position.

Remark: The only way to ensure that a system is properly evacuated is by using an electronic vacuum gauge – the standard manifold gauge is not acceptable.

!!! CAUTION !!!
MOST TYPES OF MICRON GAUGE WILL BE PERMANENTLY DAMAGED IF THE SYSTEM IS PRESSURIZED WHILE THE GAUGE IS STILL HOOKED UP. THESE GAUGES ARE MADE TO READ VACUUM LEVELS OR PRESSURES BELOW ATMOSPHERIC. THE MANUFACTURERS' PROCEDURES MUST BE FOLLOWED EXACTLY AND ALL PERSONNEL USING THEM MUST BE TRAINED IN THE PROPER USE OF THIS EQUIPMENT.

REPAIRING REFRIGERANT CIRCUITS

When repairing or replacing refrigerant circuits and related components such as evaporator and condenser coils, following guidelines must be strictly observed to ensure the efficiency of the system:

Pipes should be cut square to length with a pipe cutter. Don't use a hacksaw or an angle cutter. Remove burr from edge by using the reamer blade on the cutter tool. When reaming, hold the end of the pipe downward so that the chips will fall free.

After cutting and reaming, seal off the pipe with plastic plugs or tape to prevent foreign material from entering. Piping must be kept spotless!

Under no circumstances use compressed air to blow out the line; compressed air contains moisture, which renders the pipe useless. Should any dirt enter, use dry nitrogen instead.

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Pipes and related components must be joined by silver brazing, while being purged with a shielding gas, containing 95% nitrogen and 5% hydrogen. The nitrogen in the shielding gas displaces the air inside the workpiece, thus preventing the formation of oxides when brazing heat is applied. The oxides form a black scale inside the workpiece, which may clog valves and damage the compressor. The hydrogen in the shielding gas combines with the remaining oxygen, preventing formation of any minute oxides.

When purging, it is important to maintain a slight overpressure in all sections of the workpiece to prevent air from flowing back in. Connect a shielding gas cylinder with a pressure regulator/ flowmeter to the workpiece “inlet” port. Restrict the “outlet” port with a drilled cap. Adjust the regulator for the flowmeter to read 0.2 ft^3/min. Allow ample time to make sure that all air is expelled from inside the workpiece before starting brazing.

Silver brazing requires the joint surfaces to be rough and thoroughly clean. While brazing, make sure no filler or flux enters the piping. Brush off remainder of filler and flux on the outside when finished. Continue purging to cool down the workpiece for 3 to 4 minutes. Cap workpiece when finished.

RECYCLING OF REFRIGERANT

Recycled refrigerant has been recovered in the shop from a mobile refrigerant system and has been chemically cleaned, in a recycling station, to meet the R-134a purity levels.

RECLAIMING OF REFRIGERANT

Reclaimed refrigerant has been recovered from a variety of shops and has been reprocessed by a specialized company to the same standards of purity as virgin refrigerant.

REFRIGERANT SYSTEM CLEANOUT AFTER COMPRESSOR FAILURE OR MAJOR REPAIRS

Although the vast majority of reciprocating compressors manufactured today are very reliable, a small percentage do fail. These failures usually result in system contamination. When an open type compressor becomes damaged internally, this provokes small particles of bearing, steel, brass, copper, and aluminum and, in severe cases carbonized oil, which could contaminate the system. To prevent repeated failures, the problem that caused the failure must be corrected, and the system should be thoroughly cleaned out.

1. Recycle the refrigerant.
2. Remove broken compressor and repair if possible.
3. Fit new or overhauled compressor with suction filter sock (CTD pn# 58-00869-00) installed.
4. Replace filter-drier.
5. Clean out as many contaminants as possible that may have collected in the thermostatic expansion valves, solenoid valves, check valve and any other mechanical component.

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6. Charge system with recycled refrigerant.
7. Run the system for at least 3 hours: engine 1200 to 1500 rpm, compressor fully loaded, head pressure 145 to 217.5 psig. Put service switch, in HVAC junction box, in override cooling. If necessary disconnect some condenser fans or cover the condenser coil with a plate to block the airflow and raise the head pressure. Interior temperature must be between 68 and 77°F. Supplement with heating if the interior temperature cannot be maintained. Remove electric connectors from heating water valve solenoids to open the heating to the interior (located on heater valve board).
8. Reclaim refrigerant.
9. Remove filter sock.
10. Replace filter-drier.
11. Change refrigerant oil.
12. Flush system with nitrogen.
13. Evacuate the system.
14. Recharge the system with new refrigerant.

After approximately 7 days of operation, recheck the compressor oil level and the system performance.

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Table 3: Temperature-pressure chart

Temperature		R-12				R-22				R-134a			
		Pressure											
°C	°F	bar abs.	bar gauge	psia	psig	bar abs.	bar gauge	psia	psig	bar abs.	bar gauge	psia	psig
-25,0	-13.0	1,2	0,2	17.9	3.4	2,0	1,0	29.1	14.6	1,1	0,1	15.5	1.0
-20,0	-4.0	1,5	0,5	21.9	7.4	2,4	1,4	35.5	21.0	1,3	0,3	19.3	4.8
-15,0	5.0	1,8	0,8	26.5	12.0	3,0	2,0	42.9	28.4	1,6	0,6	23.8	9.3
-10,0	14.0	2,2	1,2	31.8	17.3	3,5	2,5	51.4	36.9	2,0	1,0	29.1	14.6
-7,5	18.5	2,4	1,4	34.7	20.2	3,9	2,9	56.1	41.6	2,2	1,2	32.2	17.7
-5,0	23.0	2,6	1,6	37.8	23.3	4,2	3,2	61.1	46.6	2,4	1,4	35.3	20.8
-2,5	27.5	2,8	1,8	41.2	26.7	4,6	3,6	66.5	52.0	2,7	1,7	38.9	24.4
0,0	32.0	3,1	2,1	44.7	30.2	5,0	4,0	72.2	57.7	2,9	1,9	42.5	28.0
2,5	36.5	3,3	2,3	48.5	34.0	5,4	4,4	78.2	63.7	3,2	2,2	46.6	32.1
5,0	41.0	3,6	2,6	52.6	38.1	5,8	4,8	84.6	70.1	3,5	2,5	50.7	36.2
7,5	45.5	3,9	2,9	56.8	42.3	6,3	5,3	91.5	77.0	3,8	2,8	55.4	40.9
10,0	50.0	4,2	3,2	61.4	46.9	6,8	5,8	98.7	84.2	4,1	3,1	60.1	45.6
15,0	59.0	4,9	3,9	71.2	56.7	7,9	6,9	114.4	99.9	4,9	3,9	70.8	56.3
20,0	68.0	5,7	4,7	82.3	67.8	9,1	8,1	131.9	117.4	5,7	4,7	82.9	68.4
25,0	77.0	6,5	5,5	94.5	80.0	10,4	9,4	151.4	136.9	6,7	5,7	96.5	82.0
30,0	86.0	7,4	6,4	108.0	93.5	11,9	10,9	172.8	158.3	7,7	6,7	111.7	97.2
35,0	95.0	8,5	7,5	122.9	108.4	13,5	12,5	196.4	181.9	8,9	7,9	128.6	114.1
40,0	104.0	9,6	8,6	139.3	124.8	15,3	14,3	222.4	207.9	10,2	9,2	147.3	132.8
45,0	113.0	10,8	9,8	157.2	142.7	17,3	16,3	250.7	236.4	11,6	10,6	168.2	153.7
50,0	122.0	12,2	11,2	176.8	162.3	19,4	18,4	281.6	267.1	13,2	12,2	191.1	176.6
55,0	131.0	13,7	12,7	198.1	183.6	21,7	20,7	315.3	300.8	14,9	13,9	216.2	201.7
60,0	140.0	15,3	14,3	221.3	206.8	24,3	23,3	351.9	337.4	16,8	15,8	243.7	229.2
65,0	149.0	17,0	16,0	246.3	231.8	27,0	26,0	391.5	377.0	18,9	17,9	273.9	259.4
70,0	158.0	18,9	17,9	273.4	258.9	30,0	29,0	434,4	419.9	21,2	20,2	306.8	292.3
75,0	167.0	20,9	19,9	302.7	288.2	33,2	32,2	480.8	466.3	23,6	22,6	342.6	328.1
80,0	176.0	23,0	22,0	334.2	319.7	36,6	35,6	531.0	516.5	26,3	25,3	381.6	367.1
85,0	185.0	25,4	24,4	368.0	353.5	40,4	39,4	585.3	570.8	29,3	28,3	424.1	409.6
90,0	194.0	27,9	26,9	404.3	389.8	44,4	43,4	644.2	629.7	32,4	31,4	470.2	455.7

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CONTROL SYSTEM

PASSENGER'S COMPARTMENT CLIMATE CONTROL SYSTEM

The passenger's compartment HVAC system is controlled by an electronic control unit (Sytronic 2) located in the HVAC junction box. The ECU receives information from climate control on/off switch (1, Figure 2), temperature rotary knob (4, Figure 2) and three temperature sensors (see Figures 3,4,5).

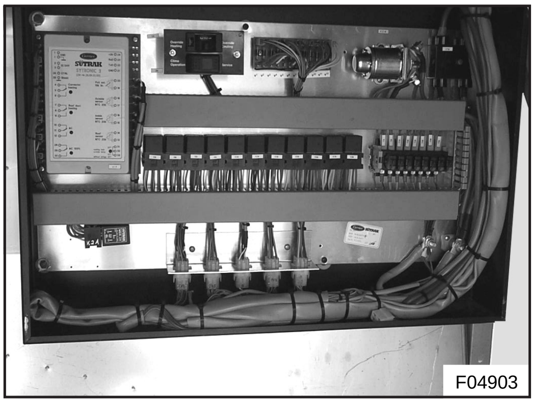

Figure 1: HVAC junction box in luggage compartment

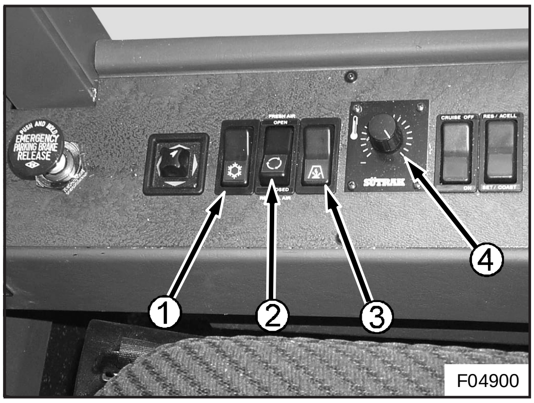

Figure 2: Passenger's compartment HVAC system controls on instrument panel

1. Climate control on/off switch
2. Air flap control switch
3. Combustion heater on/off switch
4. Temperature rotary knob

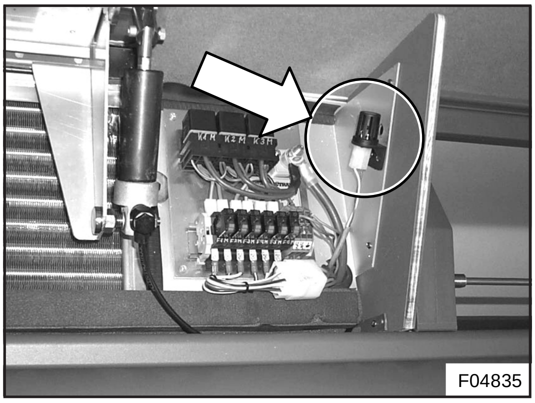

Figure 3: Return air temperature sensor (behind roof heater/evaporator access panel in parcel rack)

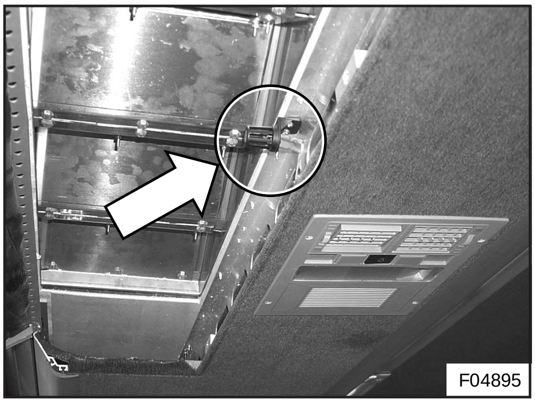

Figure 4: Duct air temperature sensor (behind blower access panel in bottom of parcel rack)

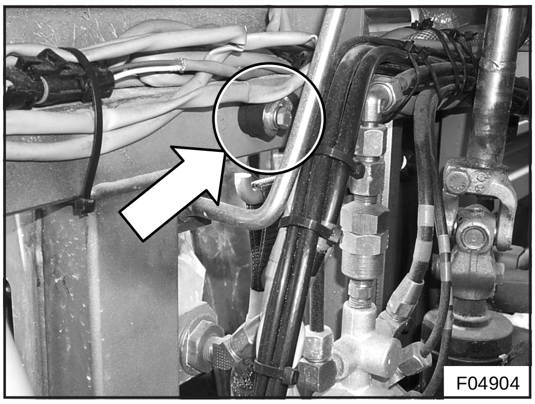

Figure 5: Outside air temperature sensor (accessible through exterior door in front of left front wheel)

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Depending of the signals received, the system automatically selects one of the following operating modes:

• *AC 100%*: air conditioning on, condenser fans at high speed;

• *AC*: air conditioning on, condenser fans at low speed;

• *Reheat*: air conditioning on, hot water circulates through the roof heaters only, roof blowers at low speed;

• *Ventilation*: air conditioning off, no hot water supply, roof blowers at low speed;

• *Heating*: air conditioning off, hot water circulates through the roof and floor heaters, blowers at low speed;

The passenger's compartment HVAC system is an automatic system with the exception of the fresh air flaps which can be manually controlled with switch (2, Figure 2). It is recommended to place the air flaps in the "FRESH AIR" position at all times except when the system efficiency is affected by extreme outside temperatures. It is also helpful to temporarily place the air flaps in the "RECIRCULATED AIR" position for rapid cooling and heating.

NOTE

To operate the climate control system when the coach is stationary, run the engine at high idle to prevent discharge of the batteries.

Do not start the engine with the climate control system on.
Allow the engine to reach its normal idle speed before switching on the climate control system. The extra current draw due to the engagement of the compressor clutch would put an unnecessary load on the engine causing unwanted vibrations, low idle speed and engine shut down.

Frequent on/off switching of the climate control system or changing the temperature setting within short intervals, may cause the compressor clutch to cycle rapidly. This will result in overheating of the clutch, and early wear of coil and clutch components.

!!! CAUTION !!!

DO NOT OPERATE THE CLIMATE CONTROL SYSTEM:

• IN CONFINED AREAS UNLESS THE COMBUSTION HEATER IS CONNECTED TO AN EXHAUST VENTILATION SYSTEM.

• WHILE FUELLING OR NEAR A SOURCE OF FUEL.

EXHAUST GASES ARE HARMFUL AND CONSTITUTE A FIRE HAZARD.

ELECTRONIC CONTROL UNIT (SYTRONIC)

The output of the "Sytronic" is directly affected by the input of the return air temperature sensor of Figure 3.

The outside air temperature sensor prevents the refrigerant compressor from starting when ambient temperature is lower than a preset value. This value can be set at either 25, 35 or 45 °F (see further for setting procedure). The factory setting is 45 °F. The refrigerant compressor control circuit will be activated only when the ambient temperature is above this preset value.

The setpoint of the Sytronic can be adjusted between 61°F and 83°F with rotary knob (4, Figure 2).

With an assumed setpoint of 75°F, the following will take place:

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- When the inside temperature is below 72°F, the Sytronic will activate the floor and roof heating systems.
- When the inside temperature rises above 72°F, the heating circuits are deactivated with the blowers operating in the ventilation mode.

Table 1: Function diagram of passenger's compartment HVAC system with engine running

	Climate control switch					
	Off	On				
Sytronic mode	/	AC 100%	AC	Reheat	Ventilation	Heating
Roof blowers	Off	High speed (1)	Low speed (1)	Low speed (1)	Low speed (1)	Low speed (1)
Condenser cooling fans	Off	High speed	Low speed	Low speed	Off	Off
Compressor clutch(Y1M)	Disengaged	Engaged (2)	Engaged (2)	Engaged (2)	Disengaged	Disengaged
Compressor unloader (Y4A)	0 Volt	0 or 24 Volt (3)	0 or 24 Volt (3)	0 or 24 Volt (3)	0 Volt	0 Volt
Compressor unloader (Y5A)	0 Volt	0 or 24 Volt (4)	0 or 24 Volt (4)	0 or 24 Volt (4)	0 Volt	0 Volt
Hot water valve "roof"	Bypass	Bypass	Bypass	Supply/ bypass (5)	Bypass	Supply/ bypass (5)
Hot water valve "floor"	Closed	Closed	Closed	Closed	Closed	Open/ closed (5)
Water circulating pump (6)	Off	Off	Off	On	Off	On

(1) Speed is determined by the difference between the setpoint and the interior temperature.

(2) The electrical circuit to compressor clutch (Y1M) will be opened by:

- high pressure switch (UPS) when the pressure at the discharge side of the compressor exceeds 345 ± 15 psig. The switch will close again when the pressure drops to 242.5 ± 12.5 psig.
- low pressure switch (LPS) when the pressure at the suction side of the compressor drops to 5 ± 2 psig. The switch will close again when the pressure exceeds 30.5 ± 4.5 psig.

(3) The electrical circuit to unloader (Y4A) will be closed by:

- high pressure switch (UPS3) when the pressure at the discharge side of the compressor exceeds 305 ± 10 psig. The contacts of high pressure switch (UPS3) will open again when the pressure drops to 240 ± 10 psig.
- low pressure switch (UPS1) when the pressure at the suction side of the compressor drops to 23 ± 1.5 psig. The contacts of low pressure switch (UPS1) will open again when the pressure exceeds 31 ± 3 psig.

(4) The electrical circuit to unloader (Y5A) will be closed by low pressure switch (UPS2) when the pressure at the suction side of the compressor drops to 19.5 ± 1.5 psig. The contacts of low pressure switch (UPS2) will open again when the pressure exceeds 26.5 ± 1.5 psig.
!!! From VIN45222 (Cummins) and 45686 (Detroit Diesel) onwards the compressor unloader valve (Y5A) is directly controlled by the Electronic Control Unit.

(5) The solenoid valve of the hot water valve receives a pulse signal with a frequency determined by the Sytronic.

(6) The water circulating pump is switched on by the Sytronic when the HVAC system is in the heating mode. In the other modes the water circulating pump will only run when the combustion heater is switched on (or is standby).

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- If the inside temperature drops below 72°F again, the heating cycle will be restarted.
- When the inside temperature rises above 75°F, the refrigerant compressor will be activated.
- In the event the temperature continues to rise to 77°F, the blowers run at high speed.
- When the inside temperature drops below 77°F, the blowers return to low speed.
- When the inside temperature drops below 75°F, roof heating is switched on. The refrigerant compressor continues to work. The blowers run at low speed (i.e. reheat).
- Should the inside temperature drop further, the refrigerant compressor will be deactivated when 72°F is reached. Blowers will keep running at low speed, but the heat is turned fully up (roof + floor heating).
- In case the inside temperature rises again, heating is deactivated on passing 72°F.

LED indicators on Sytronic cover- Figure 6

- The four LED indicator lights (1,2,3,4) show which operating mode the ECU has selected at a particular time.
- LED indicator light (5) shows when the refrigerant compressor clutch is locked.

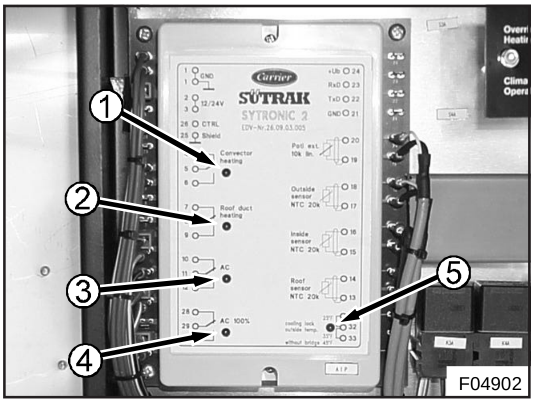

Figure 6: LED indicators on Sytronic cover

Table 2: Sytronic indicator lights

Sytronic Indicator lights				Operating Mode
Convector heating	Roof duct heating	AC	AC 100%	
❍	❍	❁	❁	Cooling II
❍	❍	❁	❍	Cooling I
❍	❁	❁	❍	Reheat
❍	❍	❍	❍	Ventilation
❁	❁	❍	❍	Heating

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Sytronic emergency override - Figure 7

In case of a Sytronic failure or for servicing purposes, an override switch is provided in the HVAC junction box. The override switch has three positions:

- "OVERRIDE HEATING": system runs at full heating;
- "AUTO": normal operating position;
- "OVERRIDE COOLING": system runs at full cooling.

NOTE
There is no temperature control when the system operates in an override mode. You must cycle the climate control on/off switch in order to maintain a comfortable temperature.

The two-position switch, installed below the override switch, allows the liquid line solenoid valves to be opened while evacuating the system.

!!! CAUTION !!!
OPERATING BOTH SERVICE SWITCHES AT THE SAME TIME CAN RESULT IN DAMAGE TO THE ELECTRONICS.

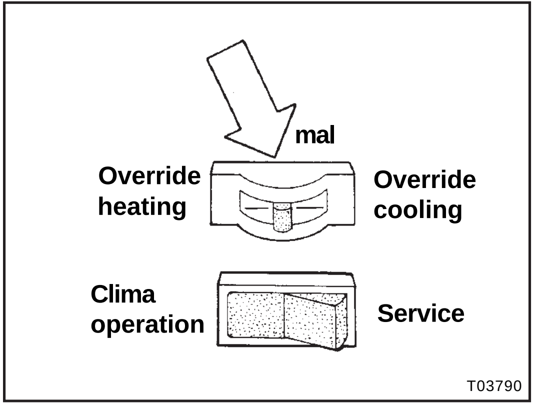

Figure 7: Climate control override switch (in HVAC junction box)

To set the lock out temperature on the Sytronic

The outside air temperature at which the cooling modes are locked out can be set at either 25, 35 or 45°F. The setting is carried out by using jumper wire(s) between the pins "31", "32", and "33" of the Sytronic. Proceed as follows to set the lock out temperature:

- 45 °F (=factory setting): no jumper wires between the pins "31", "32" and "33";
- 35 °F: a jumper wire between the pins "32" and "33";
- 25 °F: a jumper wire between the pins "31" and "32".

To test the Sytronic

The following is a quick test to check if the Sytronic is working properly:

1. Override the Sytronic with the override switch until the interior temperature reads 68 to 72°F.
2. Make sure the outside temperature is above the lock out point. The lock indicator light (5, Figure 6) on the Sytronic should be extinguished.
3. Have an assistant turn the rotary knob (4, Figure 2) from minimum to maximum temperature. Monitor the LED indicator lights on the Sytronic.
4. All five operation modes should switch on in sequence. If they do not, check the Sytronic wiring, the air temperature sensors and rotary knob (4, Figure 2).

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AIR TEMPERATURE SENSORS

Check the air temperature sensors as follows:

1. Detach the return air temperature sensor, duct air temperature sensor and/or outside air temperature sensor from the Sytronic.

2. Check the resistance of each sensor with an ohmmeter capable of reading at least 200,000 Ohm.

   Refer to table 3 to determine if the sensor is faulty. If sensor resistance varies more than ± 10%, the sensor is faulty and must be replaced.

3. The air temperature sensors are NTC (negative temperature coefficient) type sensors of 20kOhm. This means that the resistance drops when the temperature rises and that at 77°± 2.7 °F the resistance is 20,000 Ohm.

Table 3: Temperature/resistance air temperature sensors

Temp. °F (°C)	Resistance (Ohm)	Temp. °F (°C)	Resistance (Ohm)	Temp. °F (°C)	Resistance (Ohm)
14 (-10)	122,380	69.8 (21)	24,162	125.6 (52)	6,195
15.8 (-9)	115,580	71.6 (22)	23,038	127.4 (53)	5,951
17.6 (-8)	109,220	73.4 (23)	21,970	129.2 (54)	5,718
19.4 (-7)	103,220	75.2 (24)	20,960	131 (55)	5,495
21.2 (-6)	97,600	77 (25)	20,000	132.8 (56)	5,282
23 (-5)	92,320	78.8 (26)	19,098	134.6 (57)	5,078
24.8 (-4)	87,340	80.6 (27)	18,225	136.4 (58)	4,883
26.6 (-3)	82,660	82.4 (28)	17,404	138.2 (59)	4,697
28.4 (-2)	78,260	84.2 (29)	16,625	140 (60)	4,518
30.2 (-1)	74,100	86 (30)	15,884	141.8 (61)	4,347
32 (0)	70,200	87.8 (31)	15,181	143.6 (62)	4,184
33.8 (1)	66,520	89.6 (32)	14,512	145.4 (63)	4,027
35.6 (2)	63,060	91.4 (33)	13,876	147.2 (64)	3,877
37.4 (3)	59,800	93.2 (34)	13,271	149 (65)	3,734
39.2 (4)	56,720	95 (35)	12,696	150.8 (66)	3,596
41 (5)	53,820	96.8 (36)	12,149	152.6 (67)	3,464
42.8 (6)	51,080	98.6 (37)	11,628	154.4 (68)	3,338
44.6(7)	48,500	100.4 (38)	11,132	156.2 (69)	3,217
46.4 (8)	46,060	102.2 (39)	10,659	158 (70)	3,100
48.2 (9)	43,740	104 (40)	10,210	159.8 (71)	2,989
50 (10)	41,560	105.8 (41)	9,781	161.6 (72)	2,882
51.8 (11)	39,512	107.6 (42)	9,373	163.4 (73)	2,779
53.6 (12)	37,568	109.4 (43)	8,983	165.2 (74)	2,681
55.4 (13)	35,730	111.2 (44)	8,612	167 (75)	2,586
57.2 (14)	33,990	113 (45)	8,258	168.8 (76)	2,496
59 (15)	32,346	114.8 (46)	7,921	170.6 (77)	2,409
60.8 (16)	30,790	116.6 (47)	7,599	172.4 (78)	2,325
62.6 (17)	29,316	118.4 (48)	7,292	174.2 (79)	2,245
64.4 (18)	27,922	120.2 (49)	6,998	176 (80)	2,167
66.2 (19)	26,600	122 (50)	6,718		
68 (20)	25,348	123.8 (51)	6,451		

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BLOWER SPEED CONTROL

The blower speed is controlled by a electronic speed control device called "chopper" and which is mounted on the blower housing. It controls the blower speed as a function of the regulated voltage input (depends on the operating mode of the system) coming from the Sytronic 2.

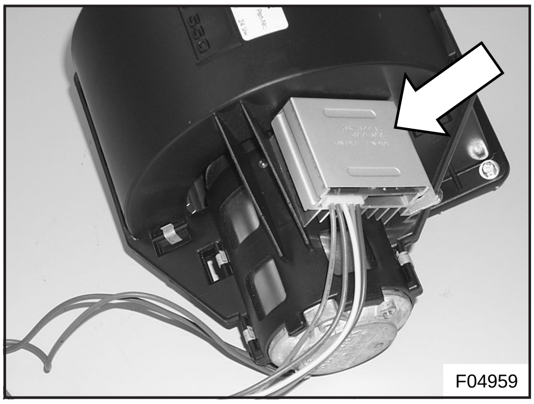

Figure 8: Electronic speed control device (chopper) mounted on blower housing

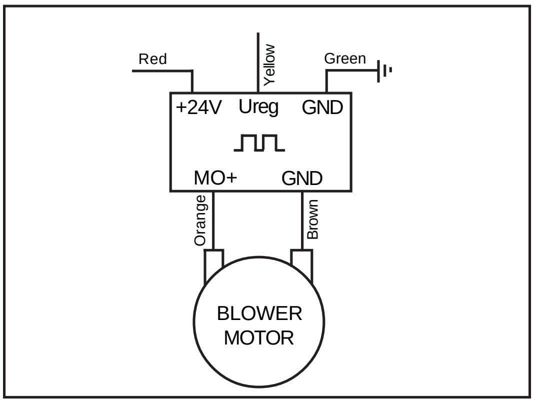

Figure 9: Chopper connections

FRESH AIR INTAKE FLAP CONTROL SYSTEM

With the fresh air intake flap, mounted behind the air filter access panel in the parcel rack, you can select "fresh air" or "recirculated air" intake. The position of the flap is controlled by dashswitch (2, Figure 2). With the upper part of the switch depressed the HVAC system works with fresh air; with the lower part depressed it works with recirculated air. The other main components of the control system are a solenoid valve (1, Figure 10) and a single action, spring-returned air cylinder for each of the two intake flaps (see Figure 11).

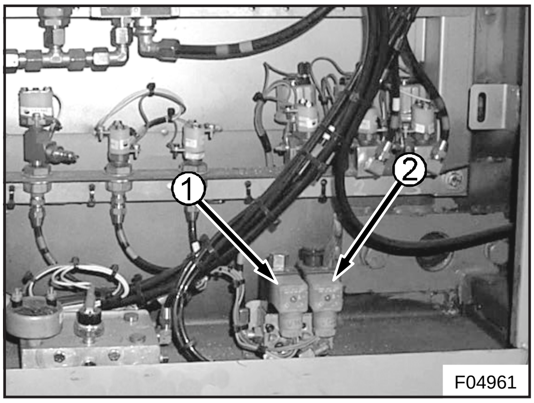

Figure 10: Pressure switch box in rear wall of luggage compartment

1. **Solenoid valve (V111) of passengers compartment fresh air intake system**
2. **Solenoid valve (V127) of driver's compartment fresh air intake system**

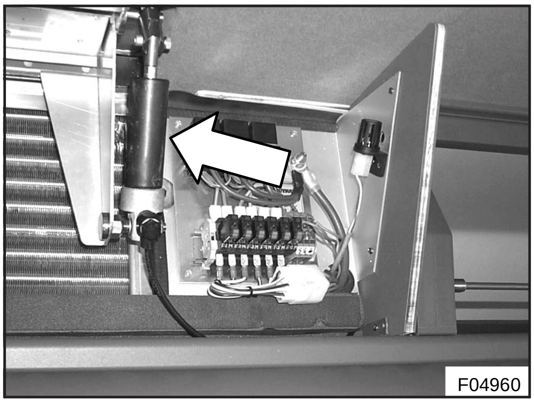

Figure 11: Air cylinder of fresh air intake flap control system (located behind the air filter access panel)

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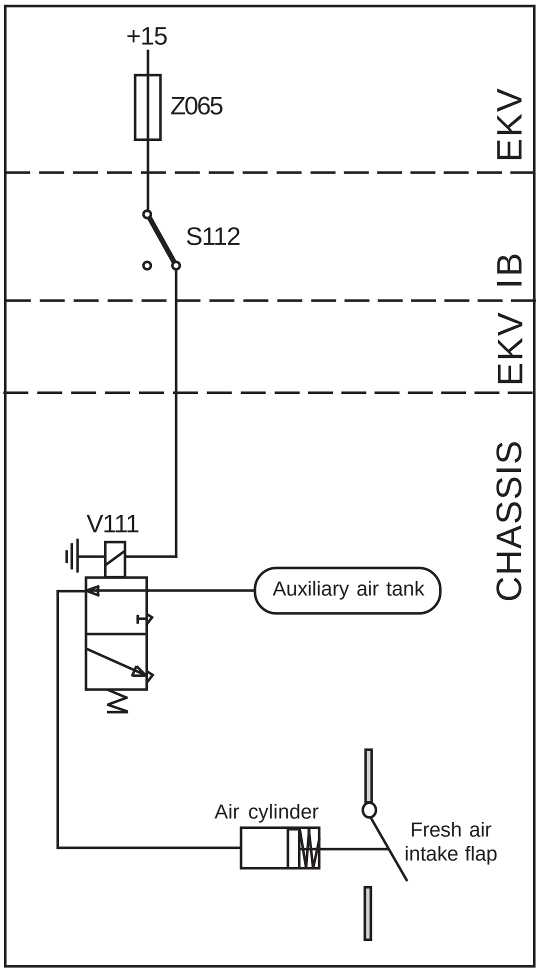

Figure 12: Passengers compartment fresh air intake control system (non-multiplexed vehicles)

+15	**: Power supplied with ignition on**
EKV	**: Main junction box**
IB	**: Instrument panel**
S112	**: Passengers compartment fresh air intake switch**
V111	**: "Normally closed" solenoid valve**
Z065	**: Circuit breaker**

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DRIVER'S COMPARTMENT CLIMATE CONTROL SYSTEM

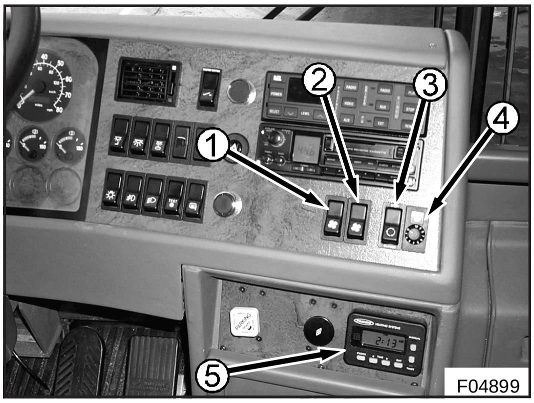

Figure 13: Driver's compartment HVAC system controls and combustion heater timer on instrument panel

1. Blower switch
2. Blower switch
3. Air flap control switch
4. Temperature rotary knob
5. Combustion heater timer

The driver's compartment HVAC system controls are located on the RH part of the instrument panel.

The heater of the driver's compartment HVAC unit operates independently of the passenger's compartment heating system. The temperature in the driver's compartment is controlled by rotary knob (4, Figure 13). The electronic control unit mounted under the rotary knob controls the water flow to the heater by opening and closing the air-pressure operated two-way water valve in the hot water lines to the unit. The electronic control unit receives information from an air temperature mounted in the air duct at the outlet side of the HVAC unit (see Figure 14) .

With the switches (1 and 2, Figure 13) you can set the blower speed (off/low/ high) for each of the two blowers. With switch (3, Figure 13) you can choose between fresh (outside) air or recirculated (inside) air.

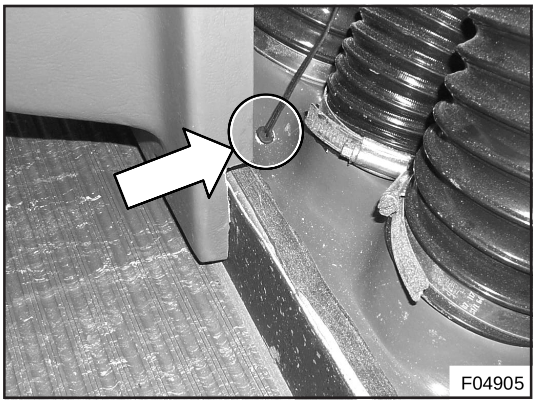

Figure 14: Air temperature sensor of driver's compartment heating system

When used in conjunction with the passenger compartment air conditioning system, the driver's compartment HVAC unit operates in reheat mode, providing increased defroster capacity for the windshield.

AIR TEMPERATURE SENSOR

The air temperature sensor of the driver's compartment heating system is located in the air duct at the outlet side of the HVAC unit. To gain access:

1. Remove the four screws of the central dash panel (see Figure 15).
2. Take away the central dash panel.

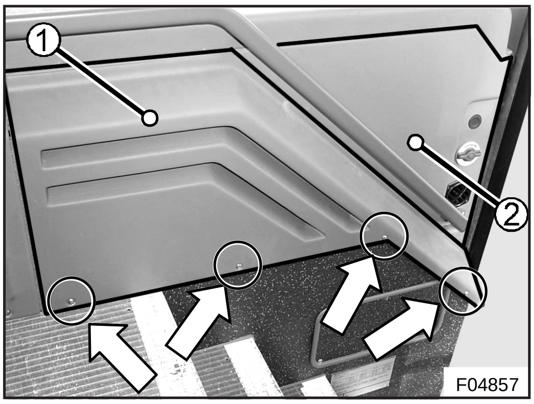

Figure 15: Dash panels at righ-hand side of entrance

1. **Central dash panel (arrows show mounting screws of central dash panel)**
2. **Right-hand dash panel**

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FRESH AIR INTAKE FLAP CONTROL SYSTEM

With the fresh air intake flap, mounted in the driver's compartment HVAC unit, you can select "fresh air" or "recirculated air" intake. The position of the flap is controlled by dashswitch (3, Figure 13). With the upper part of the switch depressed the HVAC unit works with fresh air; with the lower part depressed it works with recirculated air. The other main components of the control system are a solenoid valve (2, Figure 16) and a single action, spring-returned air cylinder (see Figure 17).

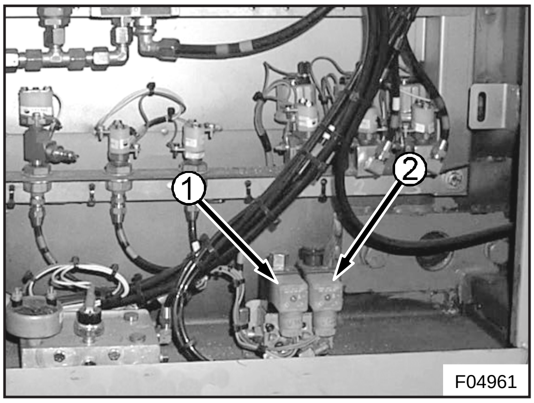

Figure 16: Pressure switch box in rear wall of luggage compartment

1. **Solenoid valve (V111) of passengers compartment fresh air intake system**
2. **Solenoid valve (V127) of driver's compartment fresh air intake system**

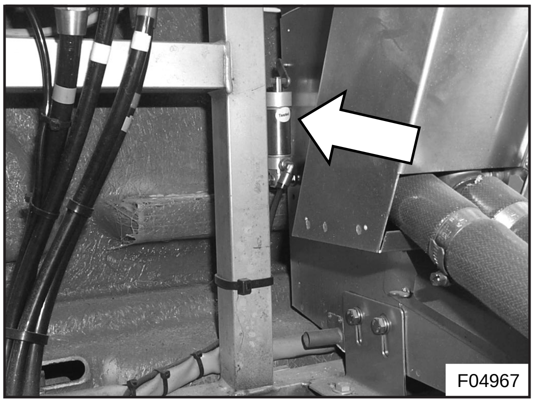

Figure 17: Air cylinder of fresh air intake flap control system (accessible through exterior door in front of left front wheel)

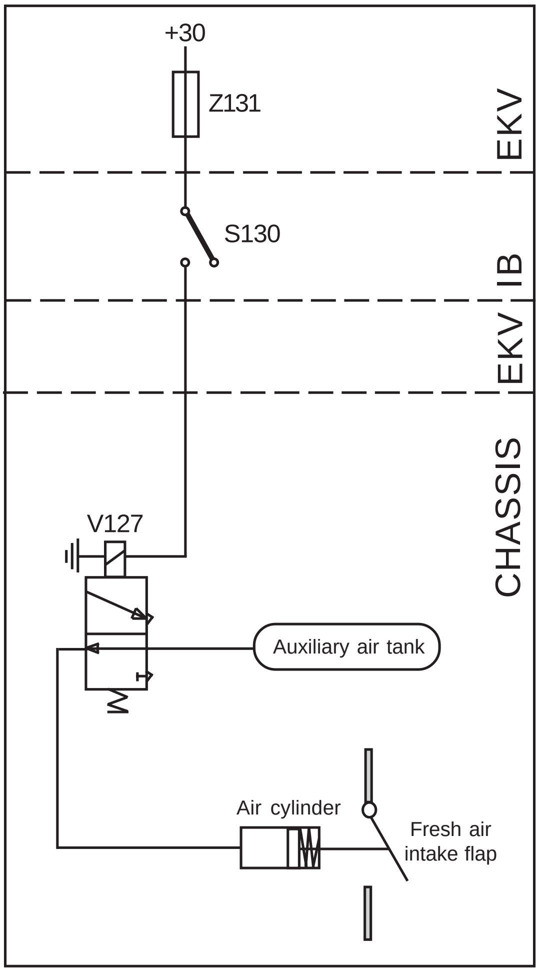

Figure 18: Driver's compartment fresh air intake control system (non-multiplexed vehicles)

+30	**: Power supplied with "batteries connected"**
EKV	**: Main junction box**
IB	**: Instrument panel**
S130	**: Driver's compartment fresh air intake switch**
V127	**: "Normally open" solenoid valve**
Z131	**: Circuit breaker**

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BLOWER CONTROL SYSTEM

The driver's compartment HVAC unit contains two blowers which are activated each with a separate switch. Each of the two switches has three positions: off/low speed/high speed. A 3.2 Ohm, 35 Watt resistance, mounted near the blower in the HVAC unit is used for low speed control.

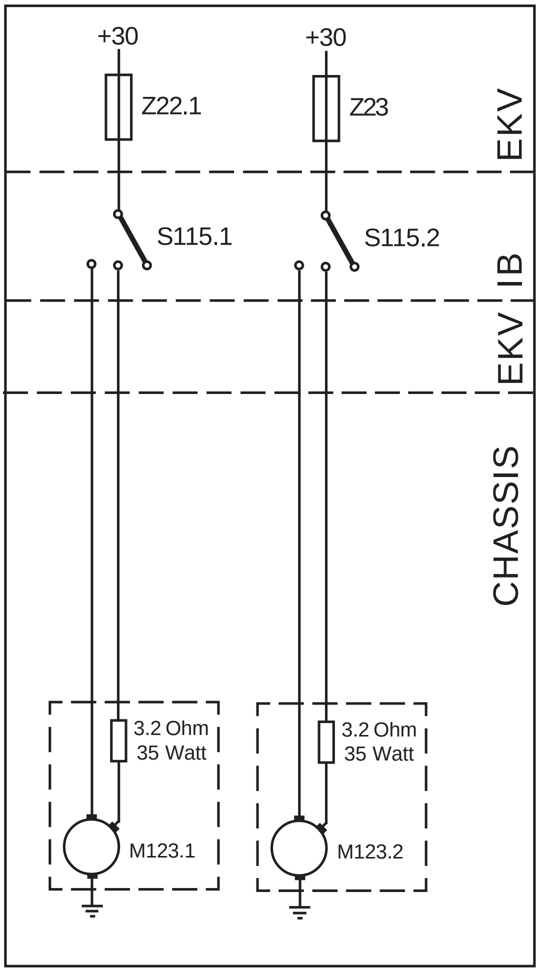

Figure 19: Blower control system

+30	**: Power supplied with "batteries connected"**
EKV	**: Main junction box**
IB	**: Instrument panel**
M123.1	**: Blower motor**
M123.2	**: Blower motor**
S115.1	**: Blower switch**
S115.2	**: Blower switch**
Z22.1	**: Circuit breaker**
Z23	**: Circuit breaker**

LAVATORY COMPARTMENT EXTRACTOR FAN CONTROL SYSTEM

Regularly check that the extractor fan:

- operates at low speed with the engine running;
- operates at high speed with the engine running and the lavatory compartment door locked.

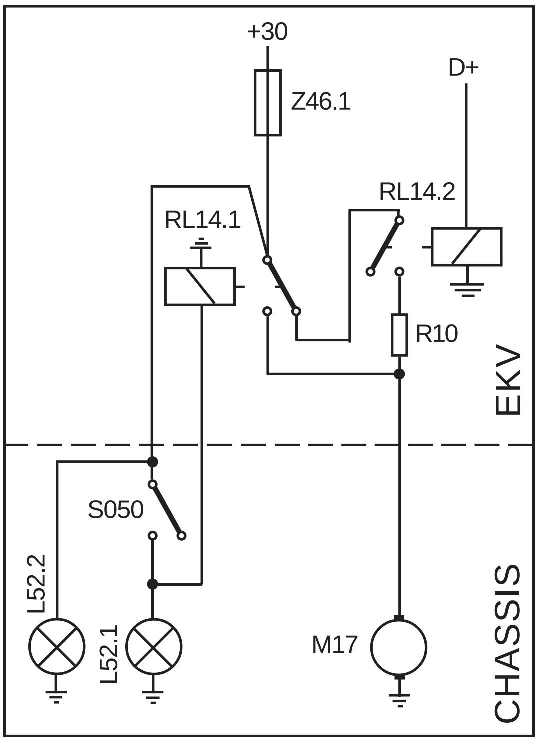

Figure 20: Lavatory compartment extractor fan electrical circuit (non-multiplexed vehicles)

+30	**: Power supplied with "batteries connected"**
D+	**: Power supplied with engine running**
EKV	**: Main junction box**
L52.1	**: Lavatory compartment roof lights**
L52.2	**: Lavatory compartment flood light**
M17	**: Lavatory compartment extractor fan motor**
R10	**: Resistance**
RL..	**: Relay**
S50	**: Lavatory compartment door microswitch**
Z46.1	**: Circuit breaker**

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COMBUSTION HEATER CONTROL SYSTEM

The electronic control unit is located on the combustion heater. For more information, refer to "Proheat Combustion heater" in Section 10.5.

ELECTRICAL CIRCUITS AND DEVICES

MAINTENANCE

To ensure proper operation of the electrical system, the following service actions and inspections should be performed during normal coach maintenance:

- Inspect all main power cables and terminals for tightness and condition;
- Inspect all ground cables and terminals for tightness and condition;
- Inspect fan and blower motors for unsusual noise or vibration;
- Inspect operator's control panel for proper functioning of indicator lights.

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TROUBLESHOOTING

PRELIMINARY TESTS

The following checks are designed to be carried out with the minimum of test equipment. They are confined to those areas of the coach that are easily accessible. The checks must be carried out to ensure that the system is basically sound. If one of the systems proves and remains unsatisfactory in any way, refer to the troubleshooting guide further in this Section.

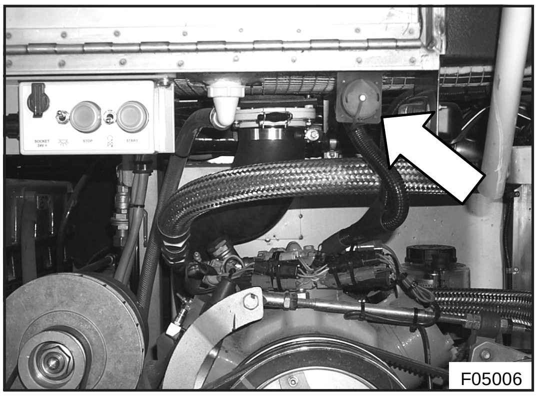

Figure 1: Refrigerant system diagnostic plug (in engine compartment)

AIRSIDE SYSTEMS

- Check that blowers/fans give sufficient air flow as can be expected from the position of the control switches.
- Check the condition of the air filters. Clean or replace if necessary.

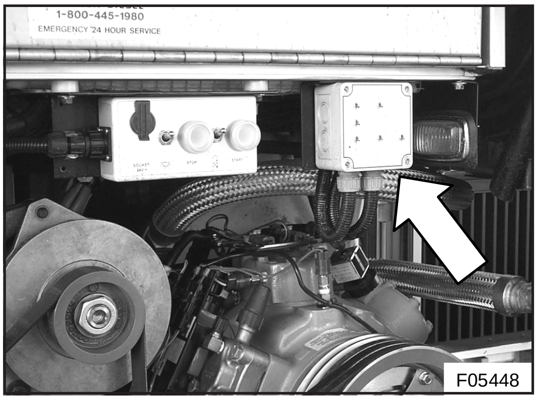

Figure 2: Refrigerant system diagnostic direct readout box (in engine compartment)

HEATING WATER SYSTEM

- Check that all hand shut-off valves of the heating system are open.
- Check operation of the water circulating pump with system set to "override heating".

REFRIGERANT SYSTEM

Diagnostic system

Your coach is fitted with a diagnostic plug (see Figure 1) or a diagnostic direct readout box (see Figure 2). Location is in the engine compartment, next to the control box. Both plug and direct readout box allow service technicians to check the operation of the refrigerant control system without interfering with the wiring.

It is important to know exactly what mode the HVAC is operating in if you check the refrigerant control system with the plug or direct readout box. It is therefore recommended that the tests be made by a HVAC technician and that a manifold gauge set is being used in conjunction with the diagnostic plug/box.

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Use of the diagnostic plug

Checks can be made with a multimeter or a test light bulb, inserting one probe into terminal 6 (ground) and the other one into the terminal of the line you want to check.

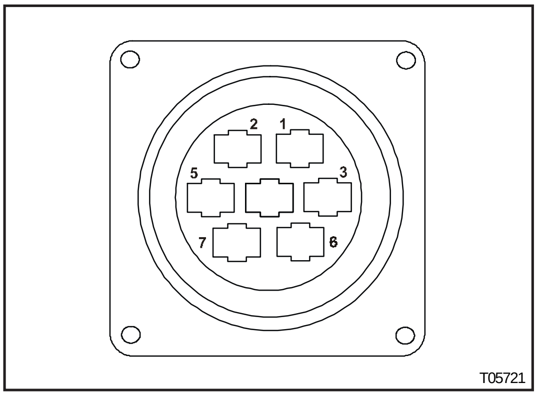

Figure 3: Plug terminal numbers

Terminal 1

• *Voltage is present*: The refrigerant system is activated by the electronic control unit. Depending on the operating conditions, compressor clutch (Y1M) and unloaders (Y4A and Y5A) may be active.

• *No voltage is present*: The operating conditions do not require the activation of the refrigerant system or the control system and/or the wiring is faulty.

Make sure voltage is present at terminal 1 before continuing testing.

Terminal 2

• *Voltage is present*: Pressure switch (UPS1) or (UPS3) is closed and unloader (Y4A) is activated. If this is not the case, check unloader (Y4A). Make sure the operating conditions of the refrigerant system require activation of the unloader.

• *No voltage is present*: Both pressure switches (UPS1) and (UPS3) are open. Unloader (Y4A) is not activated.

Terminal 3

• *Voltage is present*: High pressure switch (UPS) is closed. This is the normal operating mode.

• *No voltage is present*: High pressure switch (UPS) is open. Check why this safety device has been activated. Make sure that high pressure switch (UPS) is operating properly.

Terminal 4

• *Voltage is present*: High pressure switch (UPS) and low pressure switch (LPS) are closed. This is the normal operating mode. Compressor clutch (Y1M) should be activated. If this is not the case, check the compressor clutch.

• *No voltage is present*: High pressure switch (UPS) or low pressure switch (LPS) is open. If voltage was present at terminal 3, the power cut is caused by low pressure switch (LPS). Check why this safety device has been activated. Make sure that low pressure switch (LPS) is operating properly.

Terminal 5

• *Voltage is present*: Low pressure switch (UPS2) is closed and unloader (Y5A) should be activated. If this is not the case, check the operation of the unloader. Make sure that the operating conditions require activation of the unloader.

• *No voltage is present*: Low pressure switch (UPS2) is open and unloader (Y5A) is not activated.

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Use of the diagnostic direct readout box

The direct readout diagnostic box is a further development of the diagnostic plug. The use of a test light bulb or multimeter is no longer required. On the box cover is a decal showing the section of the electric wiring diagram the box is connected to (see Figure 4). Positioned on the diagram, at 6 points of measurement, are green LEDs. These show what part of the circuit is active/ inactive by lighting up or going out according to the mode of operation of the refrigerant system. The hook-up of the box is similar to the one of the plug. Tables 1 and 2 show the operation of the different subsystems which keep AC compressor operation within safe limits.

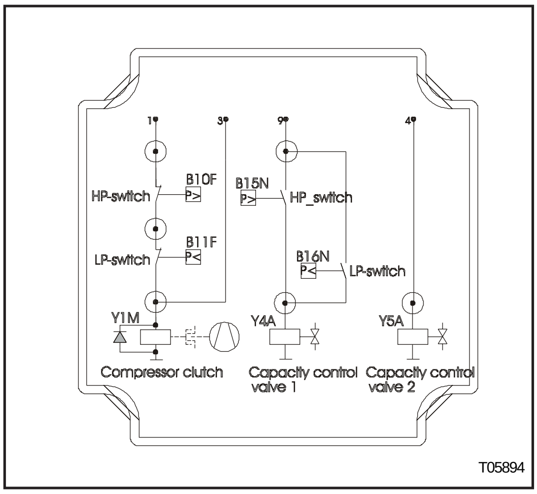

Figure 4: Wiring diagram section on direct readout diagnostic box (LEDs shown as circles with dot)

Table 1: Compressor clutch operation

Cooling signal (pin 1)	LED A	HP protection switch (UPS)	LED B	LP protection switch (LPS)	LED C	Compressor clutch
No	Off	Open	Off	Open	Off	Not activated
Yes	On	Open	Off	Closed	Off	Not activated
Yes	On	Closed	On	Open	Off	Not activated
Yes	On	Closed	On	Closed	On	Activated

Table 2: Unloader operation

Cooling 1 signal (pins 1 & 9)	LED D	HP control switch (UPS3)	LP control switch (UPS1)	LED E	Unloader 1 (Y4A)	NOT cooling 2 signal (pin 4)	LED F	Unloader 2 (Y5A)	Compressor capacity
0V/Off	Off	Open	Open	Off	OV/Loaded	OV/Off	Off	OV/Loaded	Off
24V/On	On	Open	Open	Off	OV/Loaded	24V/On	On	24V/Unloaded	66%
24V/On	On	Closed	Open	On	24V/Unloaded	24V/On	On	24V/Unloaded	33%
24V/On	On	Open	Closed	On	24V/Unloaded	24V/On	On	24V/Unloaded	33%
24V/On	On	Open	Open	Off	OV/Loaded	OV/Off	Off	OV/Loaded	100%
24V/On	On	Closed	Open	On	24V/Unloaded	OV/Off	Off	OV/Loaded	66%
24V/On	On	Open	Closed	On	24V/Unloaded	OV/Off	Off	OV/Loaded	66%

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Checks

- Check that the compressor clutch is functioning properly, engaging and disengaging swiftly when the override switch is thrown from "override heating" to "override cooling" and back.

NOTE
This test must be performed with the engine running.

- Check that the HVAC compressor drive belt is properly adjusted. It should not slip at idle, at high engine speeds, or on sudden acceleration of the engine with the compressor engaged.

- Check that the condenser cooling fans start to operate when the compressor clutch engages.

- Make sure that the condenser is free of mud, road dirt, leaves or insects that would restrict air flow. If necessary clean the condenser coil.

- With the engine running at idle speed (not fast idle) check the sight glass of the receiver tank for frothing or bubbles. Slowly increase engine speed and repeat check at 3/4 of maximum rpm.

NOTE
Slight foaming is normal when the outside temperature is below 70°F.

- Check the refrigerant lines and hoses for leaks and tightness; refer to Section 10.6 for proper leak detection procedure.

- Make sure the liquid line solenoid valves are functioning properly and that all refrigerant is able to circulate through the system. Also, check that there is sufficient refrigerant in the system.

CONTROL SYSTEM

- Perform the ECU test as described in the Section on "Control system". All five operating modes should switch on in sequence.

NOTE
Do not change temperatures up and down continuously. Allow the system to settle for a few minutes before changing the temperature setting again.

Checking basic factory settings

Check that all settings comply with the preset factory settings and that the system hasn't been tampered with.

Checking wiring

Loose or corroded terminals; frayed, bare or broken wires; and cracked, oil soaked or porous insulation are frequent causes of malfunctioning equipment. Before troubleshooting a problem, check wires, fuses and connections carefully. Remember that wires can separate with no break in the insulation. A terminal may be tight and still be corroded. Also check the condition of the batteries; if tests indicate a borderline condition, discard the batteries. Make sure the charging system is operating properly.

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TROUBLESHOOTING GUIDE

PROBLEM	POSSIBLE CAUSE			
	AIRSIDE SYSTEMS	HEATING WATER CIRCUIT	REFRIGERANT CIRCUIT	SYSTEM CONTROLS
INTERIOR AIR TEMPERATURE TOO LOW	• Blower(s) inoperative • Dirty air filter(s) • Dirty heater core(s)/ evaporator(s) • Too much outside air allowed inside vehicle	• Heating water valve(s) sticking, clogged or damaged • Heating circuit hand shut-off valves closed or partially closed • Air in heating water system • Engine coolant temperature too low • Water circulating pump not working • Combustion heater out of service	• Compressor clutch remains engaged	• Temperature setting on instrument panel too low/damaged • Temperature sensors out of calibration • Excessive heat from front unit heater coil affects interior temperature sensor • Compressor not disengaging at low outside temperature (outside temperature sensor + electric circuit) • Override switch in cooling position

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PROBLEM	PROBABLE CAUSE			
	AIRSIDE SYSTEMS	**HEATING WATER CIRCUIT**	**REFRIGERANT CIRCUIT**	**SYSTEM CONTROLS**
OVERHEATING (COMPRESSOR NOT ENGAGED)	• Blower motors out of service	• Heating water valve(s) sticking, clogged or damaged • Leakage in air lines and fittings • Air supply to heating water valves interrupted		• Override switch in override heating position • Temperature setting on instrument panel too high/ damaged • Temperature sensors out of calibration • Incoming outside air affects interior temperature sensor • Compressor protection systems (pressure switches etc. interrupted) • power supply to clutch interrupted
INTERIOR AIR TEMPERATURE ALTERNATING (TOO HIGH/TOO LOW)	• Dirty heater core(s)/ evaporator core(s)	• Foreign material in heating water circuit	• Evaporator freezing up • Humidity in refrigerant (ice in expansion valve)	• Incoming outside air affects interior temperature sensor
NO COOLING			• Compressor fails to start or "short cycles" • See troubleshooting guide of refrigerant system	

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PROBLEM	PROBABLE CAUSE			
	AIRSIDE SYSTEMS	**HEATING WATER CIRCUIT**	**REFRIGERANT CIRCUIT**	**SYSTEM CONTROLS**
INSUFFICIENT COOLING	• Blower(s) inoperative or speed too low • Dirty air filter(s) • Dirty heater core(s)/ evaporator core(s) • Too much outside air admitted	• Heating water valve(s) sticking, clogged or damaged • Leakage in air lines and fittings. Air supply to close heating supply water valve interrupted	• Shortage / overcharge of refrigerant • Restricted air flow through condenser (dirt/fans) • Air in system • Compressor damaged • Restriction in refrigerant circuit • Sticking compressor unloader valve *NOTE: See also troubleshooting guide "Refrigerant System"*	• Temperature setting on instrument panel too high/ damaged • Temperature sensors out of calibration

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REFRIGERANT CIRCUIT TROUBLESHOOTING GUIDE

POSSIBLE CAUSE / SYMPTOMS	High head pressure	Low head pressure	No head pressure	High suction pressure	Low suction pressure	No suction pressure	Unit operating in vacuum	Bubbles in sight glass	Suction line freezing up	Unable to pump down low side of system	Unable to pull vacuum in compressor	Unable to hold vacuum in compressor	Noisy compressor	Unit not cooling
Overcharge of refrigerant	●												●	
Shortage of refrigerant		●			●		●	●						●
Air through condenser too hot	●													
Air flow through condenser restricted	●													
Condenser fan blades bent or broken	●													
Faulty condenser motor(s) or low voltage	●													
Air through condenser too cold		●			●			●						
Air in system	●												●	●
Air through evaporator restricted					●									
Compressor discharge valve plates leaking		●								●	●	●		
Compressor piston suction valves leaking				●						●	●			
Too much oil in system					●								●	
Defective oil pump in compressor													●	
Loose compressor pulley/ drive clutch													●	
Compressor bearing loose or burned out													●	
Broken discharge valve plate in compressor		●								●	●	●	●	
Expansion valve power element (bulb) lost its charge					●									●
Expansion valve sensing bulb improperly mounted				●					●					
Expansion valve sensing bulb making poor contact				●					●					●
Expansion valve open too much (low superheat)				●					●					
Expansion valve closed too much (high superheat)					●									●
Expansion valve needle eroded or leaking				●					●				●	
Expansion valve partially closed by ice, dirt or wax					●	●	●							●
Liquid refrigerant entering compressor				●					●				●	
Restricted line in the low side					●		●		●					
Restricted filter/ drier					●									●
Discharge service valve fully closed			●											
Suction valve fully closed						●								
Leaky receiver tank outlet valve										●	●	●		
Restricted line in the high side	●						●							
Slow compressor RPM		●												●
Defective evaporator motor or low voltage					●									
Low pressure cut-out switch defective							●							
Receiver outlet valve closed (front seated)							●							
Leaky suction service valve											●	●		
Low pressure cut-out switch not jumped										●	●			
Receiver line shut-off valve closed			●											
Liquid line shut-off valve closed						●								

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PERIODIC SERVICE GUIDE

NOTE

1. *Once a year, before the start of the cold season, the combustion heater needs to be inspected by an authorized technician.*
2. *In winter time, (outside temperature below 55°F) the refrigerant compressor should be engaged every month for about 10 minutes, to avoid drying out of the crankshaft seal.*
3. *Once a year, before the start of the hot season, the vehicle needs to be inspected by a refrigerant mechanic. All procedures listed under "Once a year" should then be executed.*

SERVICE INTERVAL			MAINTENANCE OPERATION
Every 100 hrs	Every 1000 hrs	Once a year (before hot season)	
AIRSIDE SYSTEMS			
●		●	Check installation and sealing of ducts.
●		●	Clean/renew air filters.
	●	●	Check/clean condensate drains.
	●	●	Check/clean heater cores and evaporator coils.
	●	●	Check air handling blowers.
	●	●	Check air intake flaps (operation & sealing).
	●	●	Check lavatory exhaust fan.
HEATING WATER SYSTEM			
●		●	Check level in cooling surge tank.
	●	●	Check condition of water pump.
	●	●	Check condition of water hoses.

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SERVICE INTERVAL			MAINTENANCE OPERATION
Every 100 hrs	Every 1000 hrs	Once a year (before hot season)	
REFRIGERANT SYSTEM			
		●	Check operating pressures/system capacity.
	●	●	Check clutch bearing.
	●	●	Check/clean condenser coils.
	●	●	Check condenser fans.
	●	●	Check function high and low pressure switches.
		●	Check for loose refrigerant tubes and fittings and tighten all refrigerant connectors
		●	Replace filter/drier.
	●	●	Check piping/hose connections for refrigerant oil leaks/refrigerant leaks
		●	Renew compressor oil. Check oil level.
		●	Check sight glass on receiver for refrigerant charge.
CONTROL SYSTEM			
		●	Check basic operation of all systems
		●	Check all operating modes.
		●	Check condition of wires, terminals, indicator lights.
COMPRESSOR DRIVE SYSTEM			
	●	●	Check belt tension of compressor drive system. *NOTE* *If air pressure of coach pneumatic system is too low, do not engage the HVAC unit; this may cause belts to slip.*
	●	●	Tighten compressor mounting bolts.

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PROHEAT BRAVO 80 COMBUSTION HEATER ANNUAL MAINTENANCE

The Proheat heater has been designed to operate with a minimum of maintenance. Check the system annually before each heating season.

Electrical system

Check all wire harnesses for damage. Replace if required.

Heat exchanger and combustion tube

To maintain optimum heat output, clean any combustion deposits that may have accumulated on the heat exchanger fins or the combustion tube. Remove the burner head and combustion tube to access the inside of the heat exchanger. Use a wire brush to loosen the deposits and compressed air to blow them out.

Exhaust system

Check the exhaust system carefully. Check the pipe for dents, restrictions or severely corroded areas. Replace the exhaust pipe and clamps if necessary. Ensure the exhaust pipe clamp is tight.

Fuel filter

Remove and inspect fuel filter. Clean or replace as required.

Air inlet

Check the combustion air inlet screen for restrictions. Clean as required.

Compressor air filter

The compressor is fitted with an inlet air filter to ensure clean air is supplied to the nozzle. Replace annually or more often if dusty conditions are encountered.

Cooling system

Check all heater hoses and connections for signs of leakage or damage. Repair or replace as required.

Fuel system

Check the fuel system for damaged fuel lines or leakage. Make sure all fittings and hoses are secure and air tight.

Vehicle batteries

Check the condition of the batteries and the power connections. The heater will not function properly with weak batteries or corroded connections.

Operation test

Run the system for at least 15 minutes or until the heater cycles off and then on again.

PROHEAT M80 COMBUSTION HEATER ANNUAL MAINTENANCE

Refer to "Proheat M Series Service manual" annexed at the end of this chapter.

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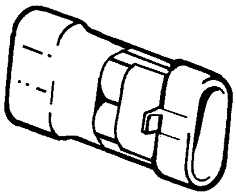
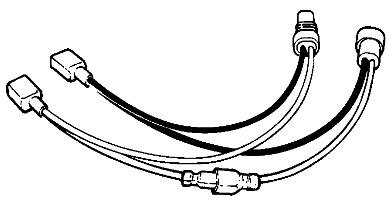
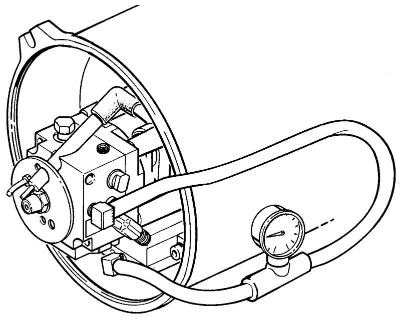
SPECIAL SERVICE TOOLS

TOOL NO. + ILLUSTRATION	DESCRIPTION
Proheat 982526  T05616	**Proheat Bravo 80: component substitution plug** This plug can be used in place of a component or to test component or PCM function.
Proheat 967632  T05617	**Proheat Bravo 80: test lead**
Proheat PK0060  T05611	**Proheat Bravo 80: air pressure test gauge**

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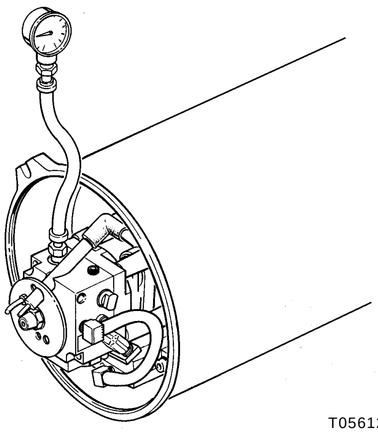
TOOL NO. + ILLUSTRATION	DESCRIPTION
Proheat PK0067  T05612	**Proheat Bravo 80: fuel pressure test gauge**

TOOL10AC

SERVICE MANUAL
M50/M80/M105

CONTENTS

A. SAFETY

Throughout this manual, you will see notes labeled **DANGER, WARNING, CAUTION**, and **NOTICE** to alert you to special instructions or precautions concerning a particular procedure that would be hazardous if performed incorrectly or carelessly.

Observe them carefully!

These safety alerts alone, cannot eliminate hazards that can occur. Strict compliance with these special instructions when performing the installation and maintenance, plus common sense, are major accident prevention measures.

⚠ DANGER

Immediate hazards that will result in severe injury or death.

⚠ WARNING

Hazards or unsafe practices that could result in severe personal injury or death.

⚠ CAUTION

Hazards or unsafe practices that could result in minor injury or product or property damage.

NOTICE

Information that is important to proper installation or maintenance, but is not hazard-related.

SAFETY CONSIDERATIONS

⚠ WARNING

Exhaust

Inhalation of exhaust gas (containing carbon monoxide) may cause severe personal injury and/or death. Anyone suspected of suffering from CO inhalation should be removed from the hazardous area and given medical assistance immediately.

⚠ DANGER

California Proposition 65 Warning

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

Electrical components in this product may contain lead, a chemical known to the State of California to cause cancer and birth defects and other reproductive harm.

⚠ WARNING

Fuel

Exercise extreme caution when working near fuel or fuel-filled equipment. Do not operate equipment during fueling operations.

⚠ WARNING

Batteries

Use eye protection when working near batteries, which contain acid and can explode. Do not smoke or use open flames near batteries.

⚠ WARNING

Electrical

Electric shock can cause severe personal injury, burns, and death. Before working on any unit, disconnect the batteries. Use only approved materials and methods when working on the electrical system, and follow local electrical codes. Never work with electricity in wet conditions or when you are tired.

⚠ WARNING

Poisons/Toxins

Fuel and coolant are toxic and in some cases, carcinogenic. Wear eye and hand protection at all times. Remove contaminated clothing immediately and wash contaminated skin. Do not breathe in vapors.

⚠ WARNING

Hot Parts

Moving parts can cause severe injury and or death. Before working on any unit, shut it off. Do not operate any unit until protective covers have been replaced. Always ensure bolts and clamps are correctly torqued and secured. Inspect mechanical components periodically for damage and corrosion.

⚠ WARNING

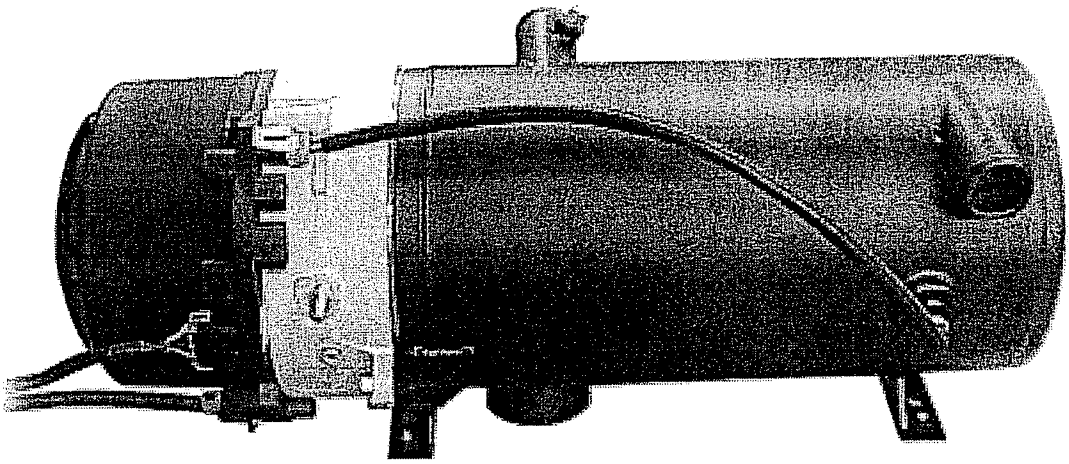
Coolant

Never remove the filler cap when the engine is hot – escaping steam or scalding water could cause serious personal injury. The coolant level in the expansion tank should be checked at least weekly (more frequently in high mileage or arduous conditions). Always check the level *when the system is cold*. Unscrew the filler cap slowly, allowing the pressure to escape before removing completely. Never run the engine without coolant.

Prevent anti-freeze coming in contact with the skin or eyes. If this occurs, rinse immediately with plenty of water. Anti-freeze will damage painted surfaces.

Never top-up with salt water. Even when travelling in territories where the water supply contains salt, always ensure you carry a supply of fresh (rain or distilled) water.

B. INTRODUCTION
MODEL: M50/M80/M105



This manual is provided to assist in troubleshooting and maintaining the PROHEAT M-Series heater. They are designed for use on any diesel-equipped vehicle including trucks, buses (school, transit and coach), construction equipment, off road equipment, military equipment and cargo.

PROHEAT heaters are used for the following applications:

(1) Engine Block Heat – A PROHEAT will preheat an engine block to ensure reliable starting in cold weather. Its' use throughout the year will reduce engine wear caused by cold starts.

(2) Supplemental Heat (engine running) – The PROHEAT can be used while the vehicle is operating to provide supplemental heat for the engine and/or passenger compartment.

(3) Cargo Heat – The PROHEAT can supply heat to individual compartments as a stand-alone heating system, or it can provide supplemental heat to an existing heating system.

(4) Marine -- Marine applications typically involve the engineering and installation of a complete hot-water heating system of which PROHEAT is only one component. **Teleflex recommends that only an expert in marine hot-water heating systems install a PROHEAT for marine applications.**

NOTE: It is the installer's responsibility to ensure that an installation complies with all applicable codes and regulations.

1.0 TECHNICAL SPECIFICATIONS

⚠ DANGER

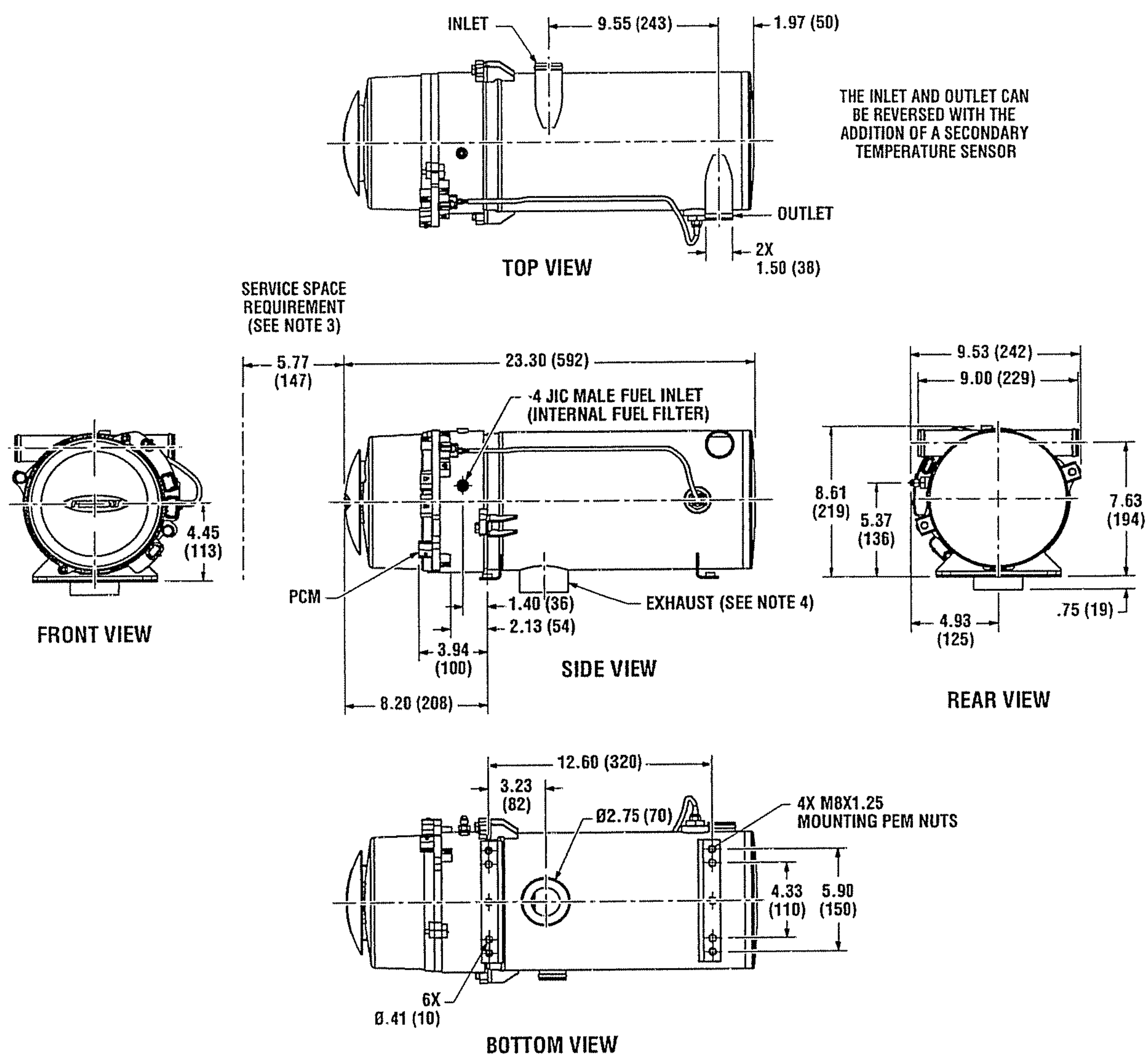
Do not use gasoline.

	M50	M80	M105
HEAT OUTPUT ± 10% BTU/hr (kW)	50,000 (15)	80,000 (23)	105,000 (30)
SYSTEM VOLTAGE Nominal Voltage (Range)	24 (20 – 30)	24 (20 – 30)	24 (20 – 30)
CURRENT DRAW Amps	2.7	4.0	7.5
FUEL CONSUMPTION US gph (lph)	0.48 (1.8)	0.75 (2.6)	1.04 (3.6)
IGNITION TYPE	Electronic Spark Ignition		
FUEL TYPES	Diesel, JP8, Jet A1, Arctic		
COOLANT OUTPUT TEMPERATURE MAX.	185°F (85°C)	185°F (85°C)	185°F (85°C)
AMBIENT OPERATING TEMPERATURE	-40°F to +122°F (-40°C to +50°C)	-40°F to +122°F (-40°C to +50°C)	-40°F to +122°F (-40°C to +50°C)
WEIGHT lbs (kg)	53 (23.5)	53 (23.5)	53 (23.5)
HEAT EXCHANGER CAPACITY US gal (l)	0.5 (2)	0.5 (2)	0.5 (2)
COOLANT SYSTEM **Minimum Capacity** US gal (l)	2.64 (10)	2.64 (10)	2.64 (10)
Recommended Flow Rate Through Heater US gpm (lpm)	5 (19)	7 (26.5)	9 (34)

SYSTEM OUTPUTS	
AUXILIARY OUTPUT	Same as System Voltage Maximum 1 Amp draw (over-load shut-off protection)
SWITCH/TIMER POWER	Same as System Voltage Maximum 1 Amp draw (over-load shut-off protection)
COOLANT PUMP	Same as System Voltage Maximum 10 Amp draw (over-load shut-off protection)
INDICATOR LIGHT	Same as System Voltage Maximum 1 Amp draw (over-load shut-off protection)

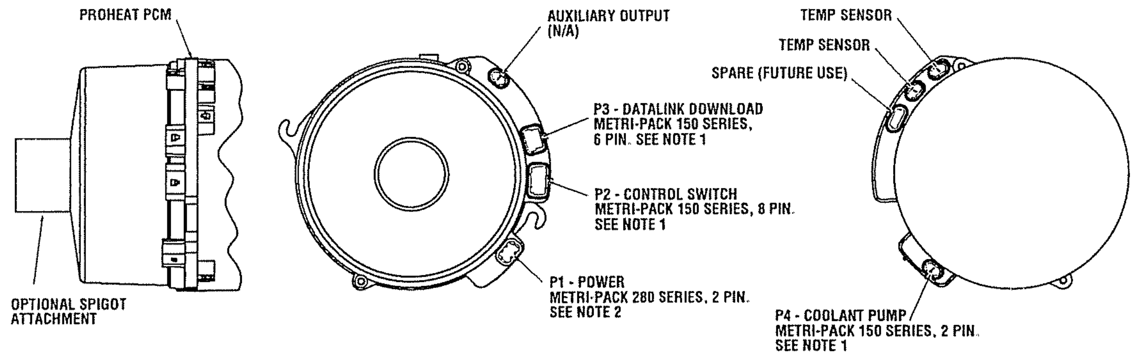
SYSTEM INPUTS	
SWITCH	10 – 30V Standard Run Mode Preheat Run Mode Supplemental Run Mode
COOLANT PUMP AUXILIARY	10 – 30V Allows independent operation of Coolant Pump

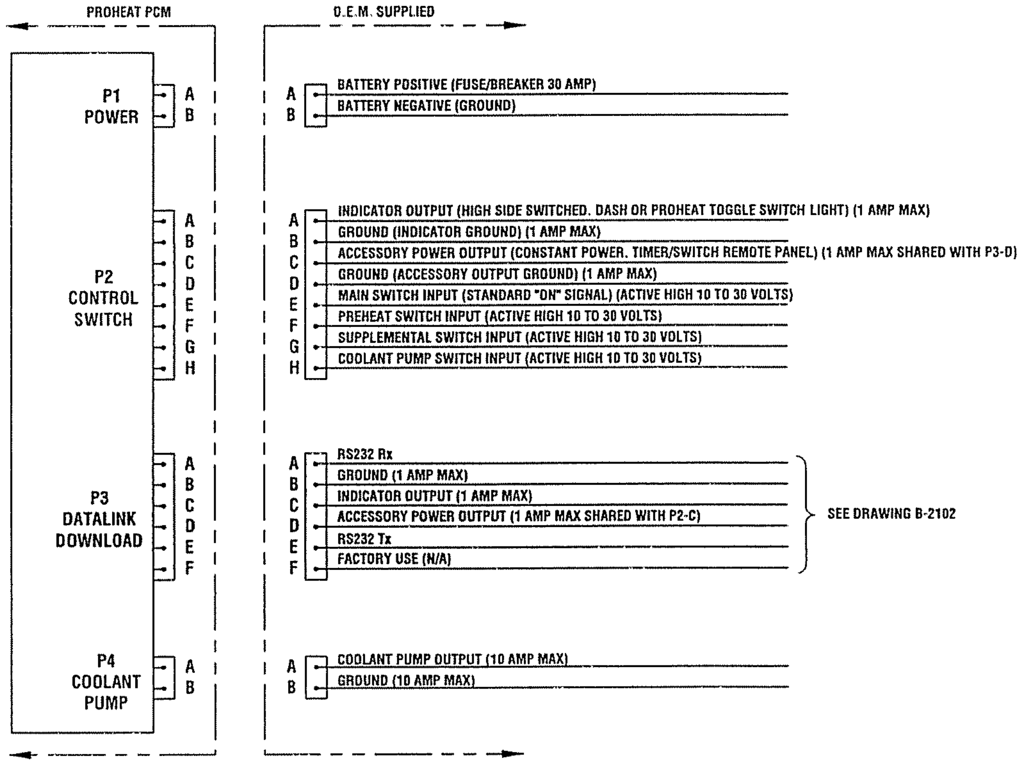
1.1 PHYSICAL



NOTES:
1. DIMENSIONS ARE IN INCHES (MILLIMETERS IN BRACKETS).
2. TYPICAL EXHAUST CUTOUT 3.25" CENTERED ON EXHAUST.
3. SERVICE SPACE REQUIRED TO REMOVE BURNER HEAD AND COMBUSTION TUBE FOR PERIODIC INSPECTION AND CLEANING.
4. THE EXHAUST PIPE SHOULD HAVE A MINIMUM DIAMETER OF 2.75", A MAXIMUM LENGTH OF 5' AND HAVE NO MORE THAN 180 DEGREES OF BENDS.

1.2 ELECTRICAL





PCM CONNECTOR	CONNECTOR PART#	LOCK PART#	TERMINAL PART#	WIRE SEAL PART#	CAVITY SEAL PART#
P1-POWER	15300027	15300014	12077413	12015193	----
P2-CONTROL SWITCH	12047937	12066304	12048074	12048086	12059168
P3-DATALINK	12052848	12052850	12048074	12048086	12059168
P4-COOLANT PUMP	12052641	12052634	12048074	12048086	12059168

NOTES:

1/ 150 SERIES CONNECTOR ASSEMBLIES TO BE USED WITH 18AWG WIRE WITH MAXIMUM .1" INSULATION DIAMETER. WIRE MUST MEET OR EXCEED SAE J1128 GPT SPECIFICATIONS.

2/ 280 SERIES CONNECTOR ASSEMBLIES TO BE USED WITH 10AWG WIRE WITH MAXIMUM .161" INSULATION DIAMETER. WIRE MUST MEET OR EXCEED SAE J1128 TWP SPECIFICATIONS.

3/ ALL UNUSED CONNECTIONS ON THE PCM MUST BE PLUGGED (PROHEAT SUPPLIED).

2.0 PRINCIPLE OF OPERATION

2.1 COMPONENT DESCRIPTIONS

Combustion Air Blower: Impeller-style blower driven by the Motor provides the principle combustion air.

Motor: Drives the Combustion Air Blower, Air Compressor and Fuel Supply Pump.

Fuel Supply Pump: A positive displacement, gear-type pump that draws fuel from the vehicle fuel tank and supplies it to the Fuel Regulator. Pressure is regulated between 7 – 10 PSI by means of an internal relief valve. Fuel is re-circulated within the pump, therefore a fuel return line to the tank is not required.

Fuel Regulator: Diaphragm-type pressure reducing valve. The Fuel Regulator drops the fuel supply pressure to atmospheric pressure (0 PSI).

Fuel Nozzle: Air-aspirating type burner nozzle. Compressed air flows through the air passages, exiting the nozzle in front of the fuel orifice creating a vacuum in the fuel supply. This draws fuel from the Fuel Regulator and the combined fuel/air mixture is atomized into the combustion chamber.

Fuel Shut-off Valve: Electrically operated solenoid valve which controls fuel flow to the Fuel Nozzle.

Air Compressor: Rotary vane compressor that supplies air pressure (in the range of 3 – 5 PSI) to the Fuel Nozzle.

Ignition Module: Electronic Ignition Module with plug-in electrode.

PCM: (PROHEAT Control Module) Electronic control module monitors the PROHEAT sensors, operating conditions, and controls the Motor and other devices. Diagnostics are utilized for both safety in operations and detection of component faults to aid in service and troubleshooting. The PCM contains the flame sensor which senses the flame intensity. This information can be retrieved by a personal computer using PROHEAT Datalink software.

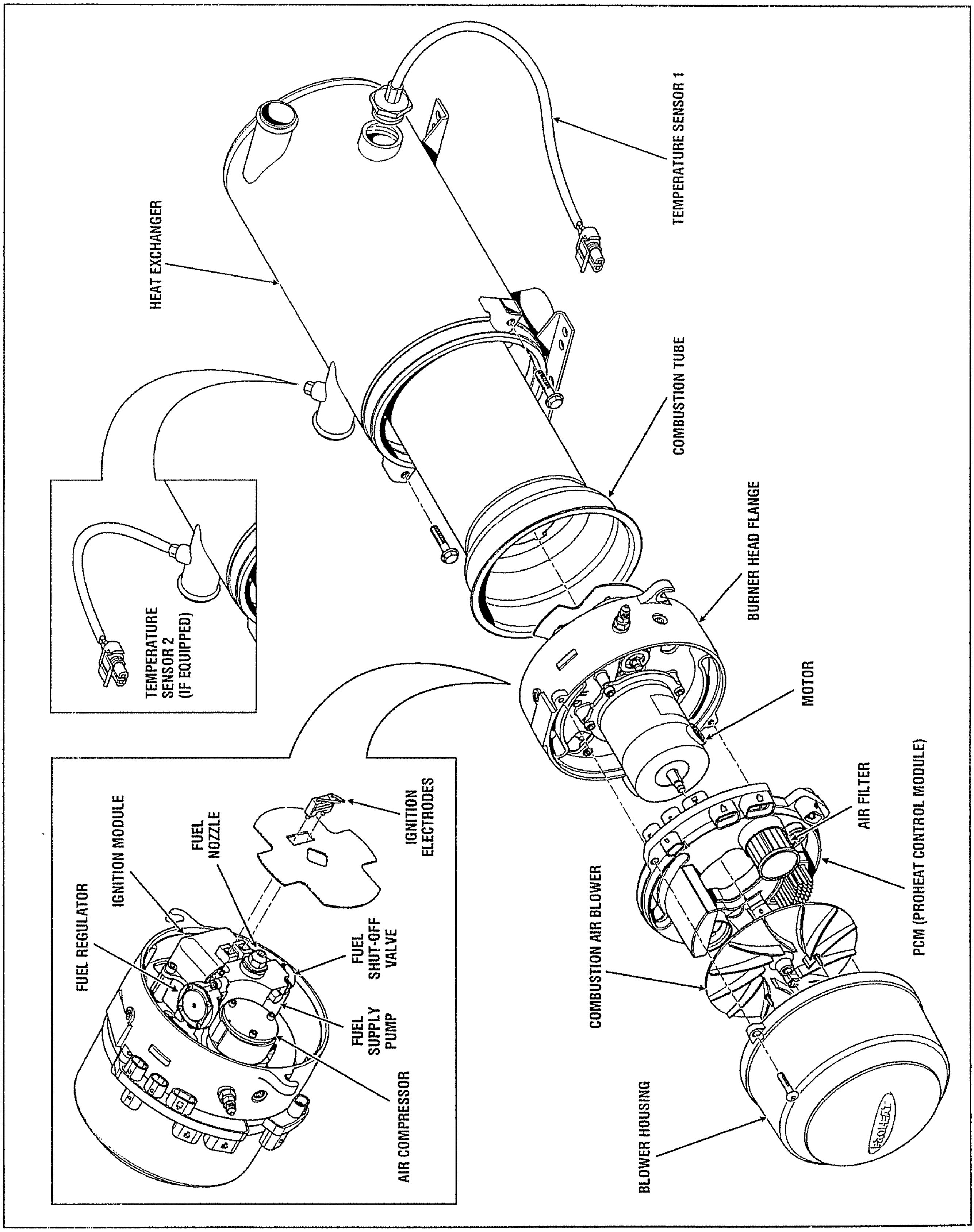
Combustion Tube: Directs the air supplied by the blower through a swirler into the combustion zone, mixing it with the atomized fuel/air mixture from the Fuel Nozzle.

Heat Exchanger: Coolant is circulated through the heat exchanger via the inlet and outlet ports. Heat is transferred from the heat exchanger through the inner wall of the exchanger into the coolant. The exhaust gases are directed out through the exhaust port.

Temperature Sensor 1: Measures the coolant temperature near the outlet port of the heat exchanger and sends this information to the PCM. **It must be connected at all times for overheat protection.**

Temperature Sensor 2: For installations where the coolant flow through the heat exchanger is opposite of what is specified on page 1-2. This sensor also measures the inner heat exchanger surface temperature for an overheat condition.

Coolant Pump: Circulates coolant through the PROHEAT and vehicle heating system. Depending on the PROHEAT installation, it may be operated by the PCM.


HEAT EXCHANGER
TEMPERATURE SENSOR 1
COMBUSTION TUBE
TEMPERATURE SENSOR 2 (IF EQUIPPED)
BURNER HEAD FLANGE
MOTOR
FUEL REGULATOR
IGNITION MODULE
FUEL NOZZLE
IGNITION ELECTRODES
FUEL SHUT-OFF VALVE
FUEL SUPPLY PUMP
AIR COMPRESSOR
COMBUSTION AIR BLOWER
AIR FILTER
PCM (PROHEAT CONTROL MODULE)
BLOWER HOUSING

2.2 NORMAL OPERATING SEQUENCE

1. . . . . Switch On: If the coolant temperature is below 160°F (71°C) the PROHEAT enters **Pre-check.** If the coolant temperature is above 160°F (71°C) the PROHEAT enters **Standby**.

2. . . . . Pre-check: The PCM performs self diagnosis checking sensors for correct range and electrical components for over-load. Also during the first **Pre-check**, the Ignition Module is powered for five seconds to allow a service technician to visually check for a spark.

3. . . . . Ignition: The Motor and Coolant Pump start first, followed by the ignition spark, and Fuel Shut-off Valve. The Ignition Module sparks for 30 seconds during which time the flame sensor must detect correct combustion.

4. . . . . Combustion Check: At the end of the **Ignition** cycle the Flame Sensor checks the combustion. If acceptable, the PROHEAT enters **Full Output.** If not acceptable, the PROHEAT goes to **Cool Down** and then will start again at **Pre-check**. If the second start cycle fails the PROHEAT will enter **Fault Shut Down.**

5. . . . . Full Output: The PROHEAT will continue in **Full Output** until the coolant temperature reaches 185°F (85°C) at the PROHEAT outlet Temperature Sensor.

6. . . . . Cool Down: The Motor and Coolant Pump continue to operate for up to three minutes, the Motor stops and the PROHEAT enters **Standby**. The PROHEAT will **Cool Down** for three reasons:

- Coolant reaches 185°F (85°C).
- A fault is detected. *Go to Troubleshooting and Repair*
- The PROHEAT is operating in **Ignition** or **Full Output** when it is switched off.

7. . . . . Standby: The Coolant Pump continues to circulate coolant throughout the system *(go to Auxiliary Input Section for alternative operating modes)*. When the coolant temperature drops to its cycle on temperature, the PCM will repeat the cycle starting at **Pre-check**.

8. . . . . Switch Off: If the PROHEAT is in **Ignition** or **Full Output**, it will **Cool Down** first, then shut OFF. If the PROHEAT is in **Standby**, it will shut OFF immediately.

9. . . . . Fault Shut Down: If the PROHEAT diagnostics sense a system or component fault, the PROHEAT will shut down all components and flash a fault code(s) which best represents the conditions. To reset the PROHEAT, it must be switched off and then on again.

NOTE: Damage may occur it the fault codes are ignored and the PROHEAT is repeatedly switched off and on without addressing the problem.

3.0 TROUBLESHOOTING AND REPAIR

Problems with the PROHEAT and its operation will be indicated in two ways:

1. PROHEAT Diagnostic Faults indicated by means of a flashing diagnostic code on an indicator light (if equipped). *Go to page 3-2.*
2. Operational problems may not be identified with a flashing diagnostic code (e.g., blown fuse, obstructed coolant flow, air leaks in fuel supply line). *Go to page 3-40.*

Troubleshooting a Problem

STEP 1 Locate the PROHEAT, remove the enclosure lid if used and visually check for any problems with wiring harnesses, fuel leaks, coolant leaks, exhaust pipe damage and environmental condition.

STEP 2 If equipped with a diagnostic indicator light, and it is flashing, determine the code based on *page 3-2.*

STEP 3 If no code is indicated, turn the PROHEAT off and then on again using the existing operational switches, timer or a PROHEAT remote start switch (PROHEAT P/N PK0091).

STEP 4 Let the PROHEAT attempt to start and/or operate. Observe the operation.

NOTE: The PROHEAT will always attempt to start twice, as long as the coolant temperature is below 160°F (71°C). If a fault is detected it will shut down, go through a **Cool Down** and attempt a second start. After both attempts to start or operate, an indicator light will flash a diagnostic code. *Go to page 3-2.*

- If the indicator light flashes, count the number of flashes and refer to the troubleshooting diagnostic code description for that number on the following pages.
- If the PROHEAT runs but is not performing or operating correctly, *consult the Operational Problems section, page 3-40.*

Troubleshooting and Repair Tools Required

- **Remote Start Switch** (PROHEAT P/N PK0091)
  Allows the service technician to work at the PROHEAT. Isolates the PROHEAT from the existing vehicle system controls and comes with a built-in indicator light.
- **Temperature Sensor** (PROHEAT P/N 200301K)
  Allows the service technician to start a PROHEAT when the coolant temperature is greater than 160°F (71°C). To be used only for troubleshooting.

3.1 SYSTEM AND COMPONENT DIAGNOSTICS

The PCM continually monitors the PROHEAT operating conditions. If the PCM detects a problem, the indicator light flashes a diagnostic code(s).

The diagnostic indicator light may be located:

- In the toggle of the ON/OFF Switch provided by PROHEAT (standard installation kit).
- In the PROHEAT Timer manual ON light (red).
- In an OEM indicator light package.
- In the remote switch (PROHEAT P/N PK0091) used for troubleshooting.

	NO. OF FLASHES	DIAGNOSTIC CODE DESCRIPTION	PAGE
SYSTEM DIAGNOSTICS	1	Start	3-3
	2	Flame Out	3-24
	3	Coolant Flow	3-25
	4	Overheat	3-27
	5	Voltage	3-27
	6	Flame Fault	3-29
COMPONENT DIAGNOSTICS	7	Temperature Sensor T1	3-29
	8	Fuel Shut-off Valve	3-31
	9	Temperature Sensor T2	3-32
	10	Ignition Module	3-32
	11	Coolant Pump	3-33
	12	Motor	3-34
	13	Auxiliary Output	3-35
	14	Switch Output	3-36

3.1.1 START Diagnostic Code

(1 Flash)

Indicates that the PCM Flame Sensor did not detect a flame or the flame was too weak to be detected during the FULL ignition period (M50/M80/M105 – 30 second ignition period).

Troubleshoot the Start diagnostic code based on the following symptoms:

1. **Fuel System.** *Go to page 3-4 to 3-15, Steps 1 through 7.*
   a) There is no fuel, fuel odor or atomized fuel coming from the exhaust pipe.
   b) There is no hot exhaust coming from the exhaust pipe.
2. **Ignition System.** *Go to page 3-18.*
   a) There is raw fuel and/or atomized fuel and a raw fuel odor coming from the exhaust pipe.
   b) There is no hot exhaust coming from the exhaust pipe.
3. **PCM (PROHEAT Control Module) Flame Sensor circuit.** *Go to page 3-20.*
   a) There is a flame and the combustion sounds good, the PROHEAT appears to be operating normally.
   b) No smoke, raw fuel odor or atomized fuel is coming from the exhaust pipe.
4. **Motor and/or PCM fault.** *Go to page 3-22.*
   a) The Motor is NOT running. Ignition and Coolant Pump are operating.
   b) No smoke, raw fuel odor or atomized fuel coming from the exhaust pipe.

START: Fuel System Step 1

(1 Flash)

Fuel and fuel supply – Check:

a) Vehicle fuel level and/or for fuel gelling during cold weather.

b) Air leaks and/or restrictions in the fuel supply lines to the PROHEAT.

c) The PROHEAT operation when supplying fuel from a direct source.

NOTICE

When fuel system is open, the PROHEAT will smoke and stumble until the air is purged from the system. It may be required to cycle more than one time.

⚠ WARNING

Flammable.

Test Procedure – Supplying fuel from a remote source:

a) Remove the fuel supply line from the PROHEAT fuel inlet.

b) Using a length of fuel line connected from the PROHEAT fuel inlet to a direct source of CLEAN fuel. Switch the PROHEAT on and operate for at least one complete cycle. Observe the operation.

If the PROHEAT functions correctly, the fault is in the vehicle fuel system. Check fuel lines, connections and routing back to fuel tank. Consult OEM for service requirements.

If a Start diagnostic code is indicated, the problem is in the PROHEAT fuel system. Proceed to Step 2.

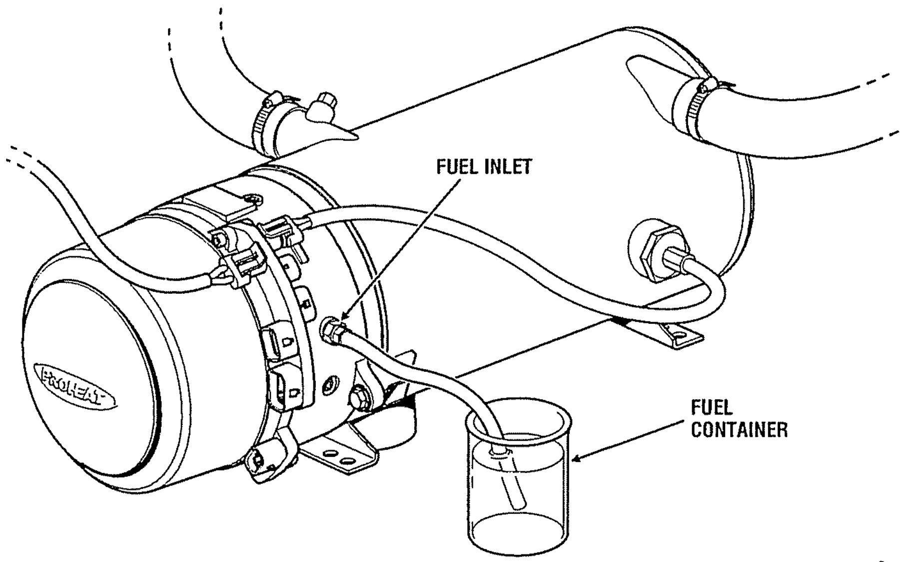


Figure 3-1: Remote Fuel Supply

START: Fuel System Step 2

(1 Flash)

PROHEAT fuel filter – Check:

a) For filter contamination and restrictions.

b) For damaged inlet fitting.

⚠ WARNING

Flammable.

Test Procedure – Fuel filter inspection, cleaning and/or replacement:

a) Disconnect the fuel supply line at the PROHEAT.

b) Remove the fuel filter adapter and fuel inlet fitting located in the burner head.

c) Remove O-ring and filter. Inspect for contamination and/or restrictions. Clean filter using electrical contact cleaner, brake cleaner or warm soapy water. Replace if necessary.

d) Inspect the O-rings for contamination and/or damage. Clean O-rings with a cloth or replace as necessary.

e) Inspect and clean the filter cavity and O-ring seat as necessary using contact or brake cleaner.

f) Reinstall filter, O-rings and inlet adapter. Tighten the adapter until it bottoms out against the face.

g) Reconnect the fuel supply line.

h) Switch the PROHEAT on and operate for at least one complete cycle. Observe the operation.

If a Start diagnostic code is indicated, proceed to Step 3.

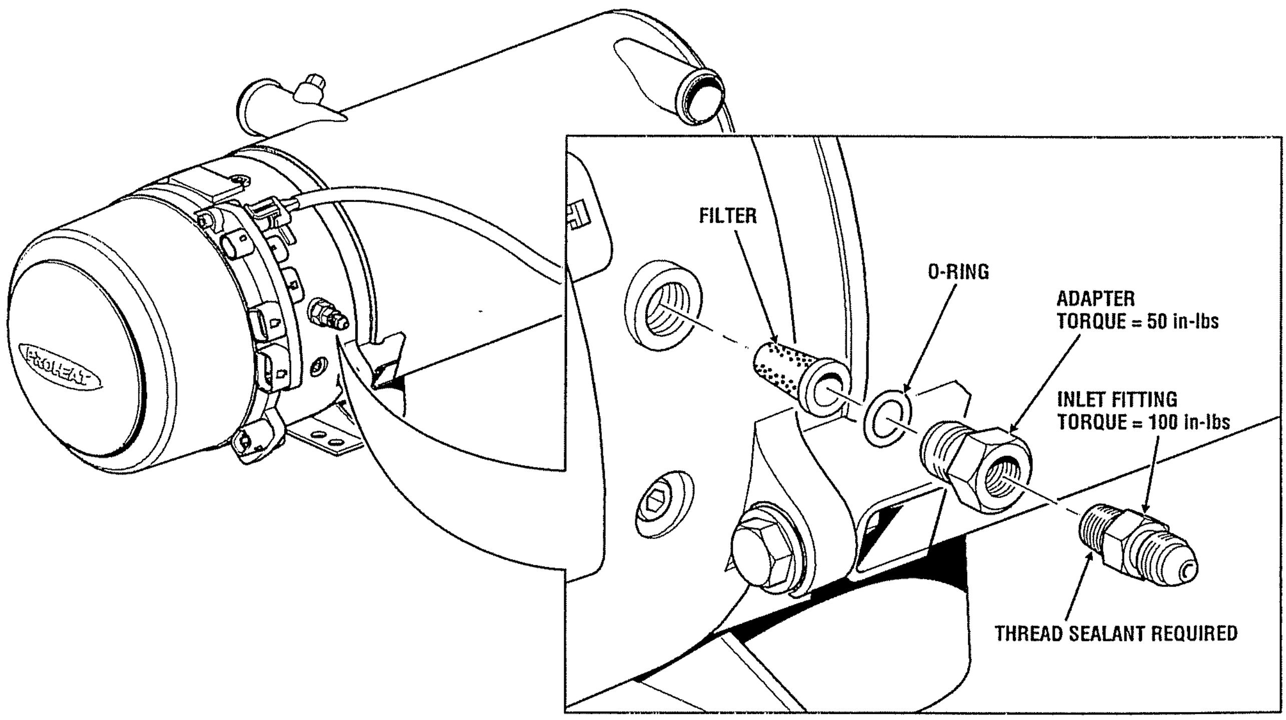


Figure 3-2: Fuel Filter Assembly and Location

START: Fuel System Step 3

(1 Flash)

Fuel Nozzle and Fuel Nozzle cavity – Check:

a) For Fuel Nozzle and O-ring damage and/or contamination.

b) For correct Fuel Nozzle for the PROHEAT BTU rating.

Test Procedure – Fuel Nozzle removal, inspection and cleaning or replacement:

a) Disconnect all harnesses at the PCM.

b) Disconnect the fuel supply line.

c) Loosen and back out the burner head mounting (2) bolts five to six turns allowing enough room to rotate the burner head 15° counter-clockwise and remove.

d) Remove Fuel Nozzle. Verify the Fuel Nozzle number ensuring it is the correct Fuel Nozzle for your PROHEAT model. *See table below.*

MODEL	NUMBER
M50	30609-50
M80	30609-9
M105	30609-11

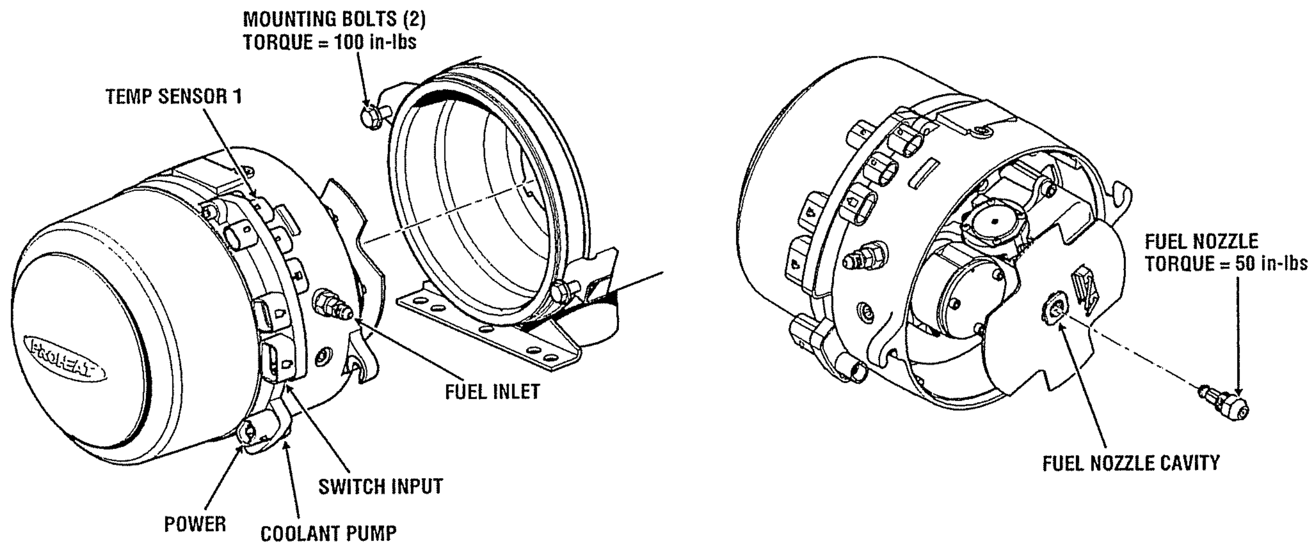


Figure 3-3: Burner Head Removal and Fuel Nozzle Removal

e) Disassemble, inspect, clean, and reassemble Fuel Nozzle.

Fuel Nozzle disassembly, inspection, cleaning and reassembly:

- Hold the Fuel Nozzle stem lightly but firmly in a vise, take care not to cause damage. Disassembles in three pieces.
- Inspect Fuel Nozzle stem and O-ring for contamination and/or damage. Inspect and clean distributor fuel orifice, air passages, head and stem with electrical contact cleaner, brake cleaner or warm soapy water.

NOTICE

Fuel Nozzle parts are a matched set and not interchangeable.

- Re-clamp the Fuel Nozzle stem lightly but firmly in a vise, take care not to cause damage. Reinstall the distributor and Fuel Nozzle head. Ensure that the distributor is seated correctly. The Fuel Nozzle assembly is self-aligning.

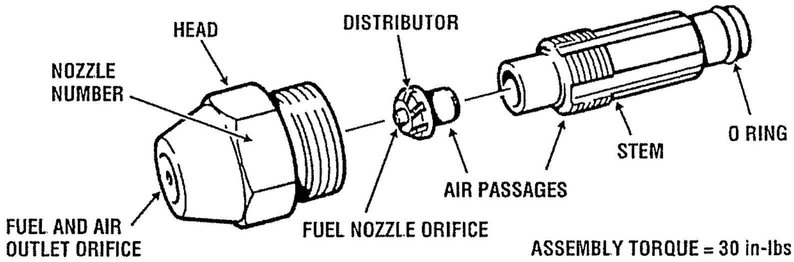


Figure 3-4: Fuel Nozzle Assembly

f) Inspect the Fuel Nozzle cavity and clean as necessary using electrical contact cleaner or brake cleaner.

g) Reinstall the Fuel Nozzle.

h) Reinstall the burner head by mounting it against the heat exchanger face, turning clockwise to engage the mounting ears on the bolts.

i) Tighten mounting bolts.

j) Reconnect the electrical harnesses and fuel supply line.

k) Switch the PROHEAT on and operate for at least one complete cycle. Observe the operation.

If a Start diagnostic code is indicated, proceed to Step 4.

START: Fuel System Step 4

(1 Flash)

Fuel Shut-off Valve – Check:

a) Fuel Shut-off Valve and PCM - electrical open circuit fault.

b) Valve plunger – mechanical fault. Test the PROHEAT operation; Fuel Shut-off Valve plunger removed.

NOTICE

It is recommended that the Fuel Regulator be serviced at the same time as the Fuel Shut-off Valve. *Go to page 3-11, Step 5.*

Procedure – Coil and PCM – electrical fault:

a) Disconnect all harnesses at the PCM.

b) Disconnect the fuel supply line.

c) Loosen and back out the burner head mounting (2) bolts five to six turns allowing enough room to rotate the burner head 15° counter-clockwise and remove.

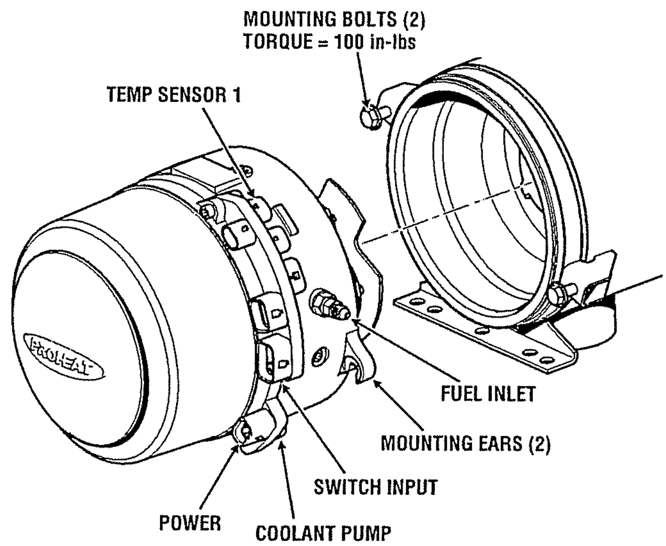


Figure 3-5: Burner Head Removal

d) Remove the Fuel Shut-off Valve connector. Use a small flat head screwdriver to lift the connector locking tab, pulling up on the connector to remove.

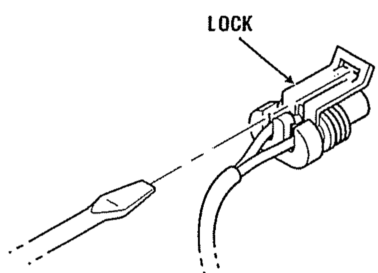


Figure 3-6: Connector Removal

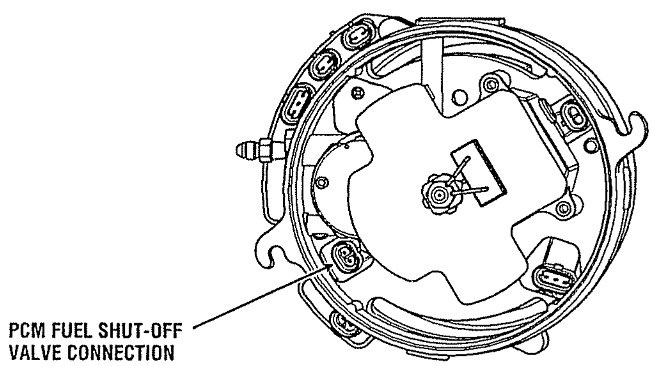


Figure 3-7: PCM Fuel Shut-Off Valve Connection

⚠ WARNING

Shock hazard due to high voltage.

e) Measure the Fuel Shut-off Valve coil using a multimeter set to read Ohms.

If the coil measures between 35 and 45 Ohms, coil is OK. Go to:

- *Fuel Shut-off Valve output voltage measurement.*
- *Procedure – Fuel Shut-off Valve – Mechanical function.*

If the coil measures open circuit, coil is faulty. Replace the Fuel Shut-off Valve. Go to Fuel Shut-off Valve replacement, page 3-10.

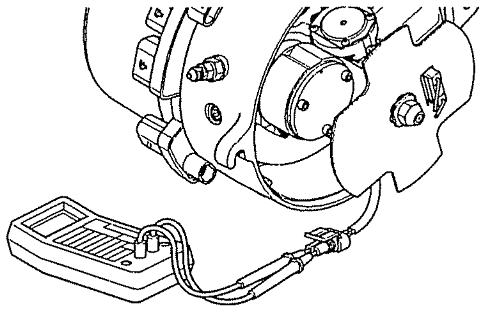


Fig 3-8: Coil Electrical Resistance Measurement

⚠ WARNING

To avoid the risk of shock and to ensure that the PROHEAT does not fire, disconnect the Ignition Module connector at the PCM.

NOTICE

All PROHEAT external harnesses must be connected to ensure that the PROHEAT attempts to start after Pre-check.

Fuel Shut-off Valve output voltage measurement:

a) Reconnect the power, Temperature Sensor(s) and switch harnesses at the PCM.

b) Disconnect Ignition Module connector at the PCM.

c) Switch the PROHEAT on and measure across pins A and B of the PCM Fuel Shut-off Valve connection.

If no voltage is measured, the PCM is faulty. Go to PCM replacement, page 3-39.

If the correct voltage (10 – 15V for 12V system or 20 – 30V for 24V system) is measured, the PCM is OK. Go to Procedure – Fuel Shut-off Valve – Mechanical function.

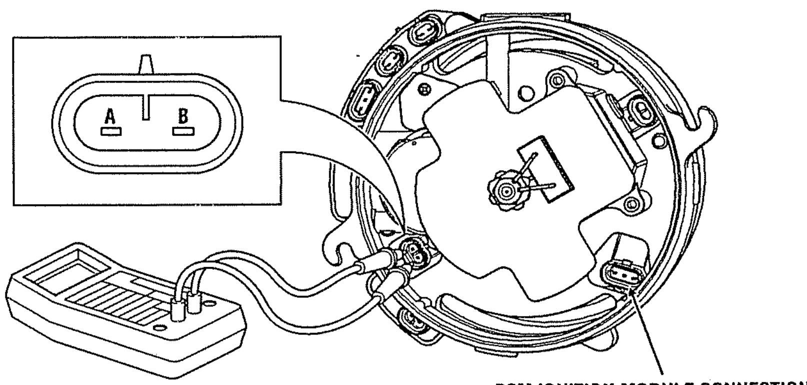


Figure 3-9: PCM Fuel Shut-off Valve Output Voltage Measurement

Procedure – Fuel Shut-off Valve – Mechanical function:

a) Using a flat head screwdriver hold the valve stem while loosening the coil nut. Remove the coil.

b) Loosen and remove the valve stem. Remove the O-ring, plunger and spring. Save the parts.

c) Inspect the O-ring and plunger seat for contamination. Clean as necessary using electrical contact cleaner or brake cleaner. Reinstall the valve stem and seal. DO NOT INSTALL THE PLUNGER AND SPRING.

d) Reinstall the coil, coil nut and reconnect the Fuel Shut-off Valve to the PCM.

e) Reinstall the burner head by mounting it against the heat exchanger face, turning clockwise to engage the mounting ears on the bolts.

f) Reconnect electrical harnesses and fuel supply line.

g) Switch the PROHEAT on and operate for at least one complete cycle. Observe the operation.

If the PROHEAT runs OK, the Fuel Shut-off Valve is faulty. Go to Fuel Shut-off Valve replacement.

If a Start diagnostic code is indicated, proceed to Step 5.

⚠ WARNING

ammable.

Fuel Shut-off Valve replacement:

a) Using a flat head screwdriver, hold the stem in place while loosening the coil nut. Remove the coil.

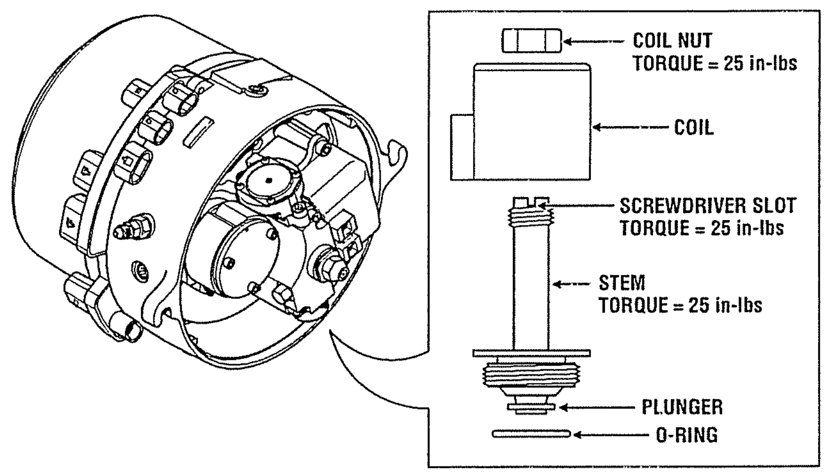


Figure 3-10: Fuel Shut-Off Valve Assembly

b) Loosen and remove the valve stem. Remove the O-ring, plunger and spring.

c) Inspect the O-ring and plunger seat in the fuel block for contamination. Clean as necessary using electrical contact cleaner or brake cleaner.

d) Install the new valve stem and seal using a slot screwdriver.

e) Reinstall the coil, coil nut and reconnect the Fuel Shut-off Valve connector at the PCM.

f) Reinstall the burner head by mounting it against the heat exchanger face, turning clockwise to engage the mounting ears on the bolts.

g) Reinstall electrical harnesses and fuel supply line.

h) Switch the PROHEAT on and operate for at least one complete cycle. Observe the operation.

START: Fuel System Step 5

(1 Flash)

Fuel Regulator – Check:

a) For damage and/or contamination and mechanical operation.

Procedure – Fuel Regulator removal, inspection and reinstallation:

a) Disconnect all harnesses at the PCM.

b) Disconnect the fuel supply line.

c) Loosen and back out the burner head mounting (2) bolts five to six turns allowing enough room to rotate the burner head 15° counter-clockwise and remove.

d) Remove ignition electrode assembly. Use a flat head screwdriver to pry the electrode assembly out.

⚠ WARNING

Flammable.

e) Remove the flame shield. Rotate to match the mounting square.

f) Remove the Fuel Regulator (2) screws, Fuel Regulator and O-rings.

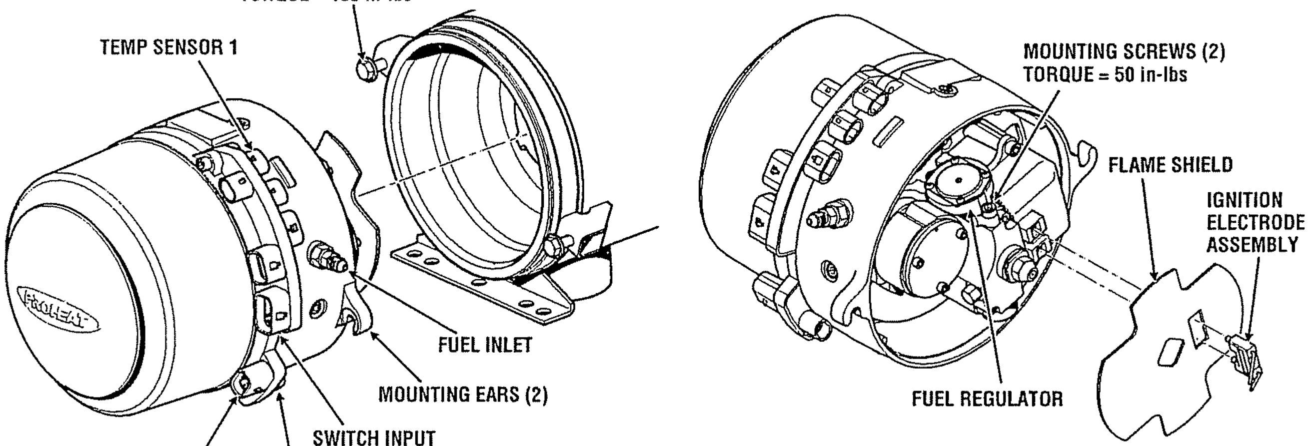


Figure 3-11: Burner Head Removal and Fuel Regulator Removal

g) Inspect O-rings and O-ring seats for contamination and/or damage. Replace if necessary.

h) Reinstall regulator ensuring that the O-rings are seated properly.

i) Reinstall the burner head by mounting it against the heat exchanger face, turning clockwise to engage the mounting ears on the bolts.

j) Reconnect the electrical harnesses and fuel supply line.

k) Switch the PROHEAT on and operate for at least one complete cycle. Observe the operation.

If a Start diagnostic code is indicated, proceed to Step 6.

START: Fuel System Step 6

(1 Flash)

Air Compressor – Check:

a) Air Compressor pressure and operation.

Test Procedure – Air Compressor pressure:

a) Disconnect all harnesses at the PCM.

b) Remove blower housing (2) screws and blower housing.

c) Remove the Air Compressor filter. Inspect for contamination and replace if necessary.

d) Disconnect the fuel supply line.

e) Loosen and back out the burner head mounting (2) bolts five to six turns allowing enough room to rotate the burner head 15° counter-clockwise and remove.

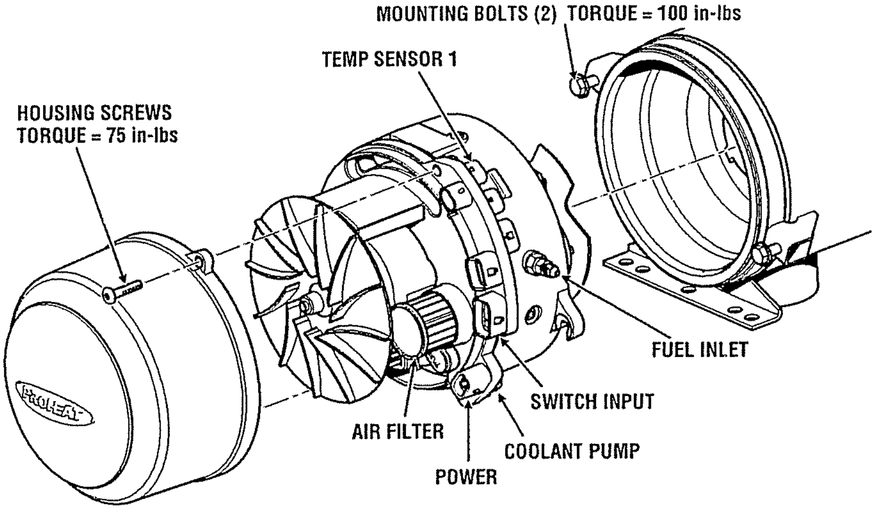


Figure 3-12: Burner Head and Blower Housing Removal

f) Remove ignition electrode assembly. Use a flat head screwdriver to pry the electrode assembly out.

g) Remove the flame shield. Rotate to match the mounting square.

h) Disconnect the Fuel Shut-off Valve and Ignition Module connectors at the PCM. This ensures that fuel will not spray and/or light during testing.

i) Remove the Air Compressor test port plug and install pressure test gauge.

⚠ WARNING

To avoid the risk of shock and to ensure that the PROHEAT does not fire, disconnect the Ignition Module connector at the PCM.

NOTICE

Leaving the Temperature Sensor(s) disconnected ensures that the burner head will only run in purge for a maximum of three minutes. It will not try to fire up.

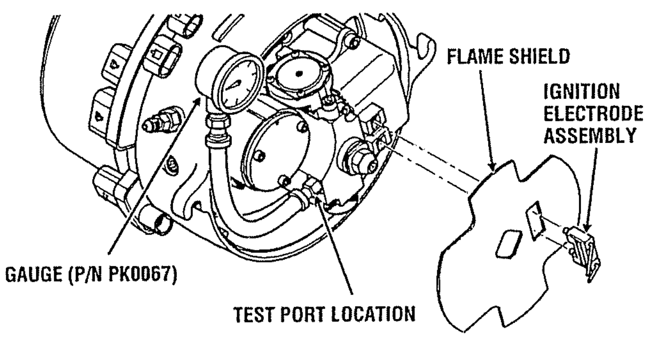


Figure 3-13: Air Pressure Test

j) Reconnect the power, Temperature Sensor(s) and switch harnesses at the PCM.

k) Switch the PROHEAT on and read the air pressure:

If the Air Compressor reading is out of range, attempt resetting it to the required PSI output as per table below. If the Air Compressor cannot be set to the correct PSI output, replace Air Compressor. Go to Air Compressor removal and reinstallation.

If a Start diagnostic code is indicated, proceed to Step 7.

MODEL	AIR PRESSURE BAR (PSI)
M50	0.42 ± 0.01 bar (6.2 ± 0.2 PSI)
M80	0.22 ± 0.01 bar (3.2 ± 0.2 PSI)
M105	0.26 ± 0.01 bar (3.8 ± 0.2 PSI)

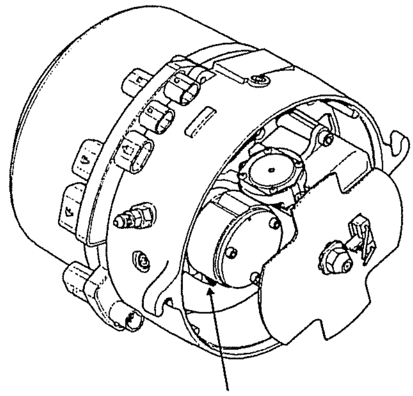


Figure 3-14: Air Compressor Adjustment

Air Compressor removal and reinstallation:

a) Disconnect Motor, Fuel Shut-off Valve and Ignition Module connectors at the PCM.

b) Remove blower housing (2) screws and blower housing.

c) Remove blower retaining snap ring and slide the blower off the Motor shaft.

d) Remove the PCM.

e) Remove Motor (4) screws and slide the Motor shaft out of the Fuel Supply Pump taking care not to damage the Fuel Supply Pump seal. Note the Motor drive gear size and location for reassembly.

f) Remove the Air Compressor gear retaining snap ring and gear. Inspect gears and replace if necessary. If gears are worn out it is not necessary to replace compressor (spin and check for mechanical interference).

g) Remove Air Compressor (2) screws, Air Compressor, (2) O-rings and the gear locating snap ring from the Air Compressor shaft.

h) Install new Air Compressor; ensure that the O-ring and seats are clean and dry. Assembly lubricant not required.

i) Reinstall gear locating snap ring, gear and gear retaining ring.

j) Reinstall the Motor, with drive gear, take care to ensure that the Fuel Pump seal is not damaged.

k) Reinstall the PCM, blower, blower retaining snap ring, Air Compressor filter and blower housing.

l) Reconnect the Motor, Fuel Shut-off Valve and Ignition Module connectors at the PCM.

m) Test the Air Compressor. Adjust if necessary to correct pressure setting. *Go to items 'i', 'j' and 'k' in Test Procedure – Air Compressor pressure, page 3-12.*

n) Reinstall the flame shield and ignition electrode assembly to the PCM.

o) Reinstall the burner head by mounting it against the heat exchanger face, turning clockwise to engage the mounting ears on the bolts.

p) Reinstall electrical harnesses and fuel supply line.

q) Switch the PROHEAT on and operate for at least one complete cycle. Observe the operation.

If a Start diagnostic code is indicated, proceed to Step 7.

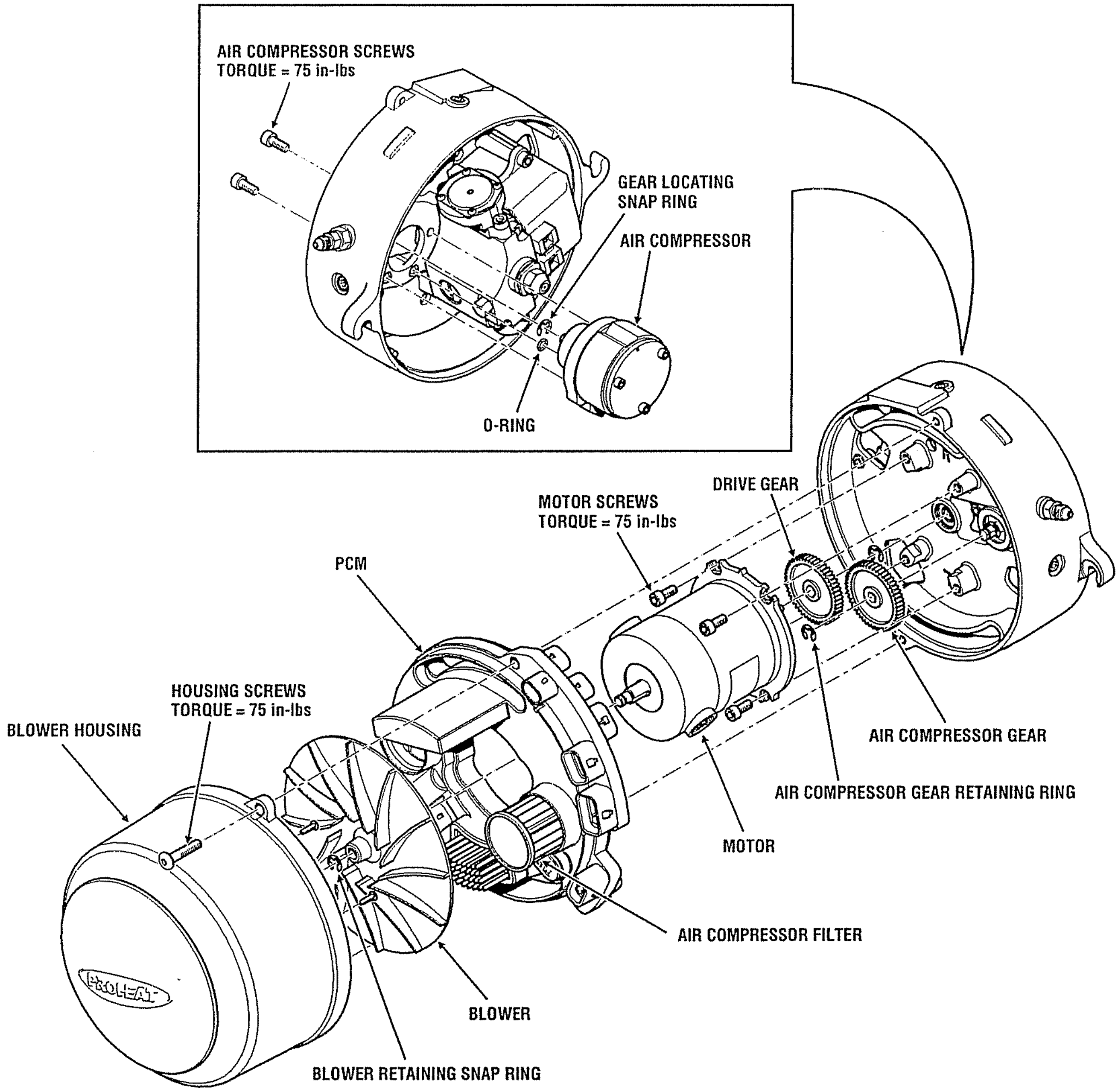


Figure 3-15: Air Compressor Replacement

START: Fuel System Step 7

(1 Flash)

Fuel Supply Pump – Check:

a) Fuel Supply Pump pressure and operation.

Test Procedure – Fuel Supply Pump pressure:

a) Disconnect all harnesses at the PCM.

b) Disconnect the fuel supply line.

c) Loosen and back out the burner head mounting (2) bolts five to six turns allowing enough room to rotate the burner head 15° counter-clockwise and remove.

d) Remove ignition electrode assembly. Use a flat head screwdriver to pry the electrode assembly out.

e) Remove the flame shield. Rotate to match the mounting square.

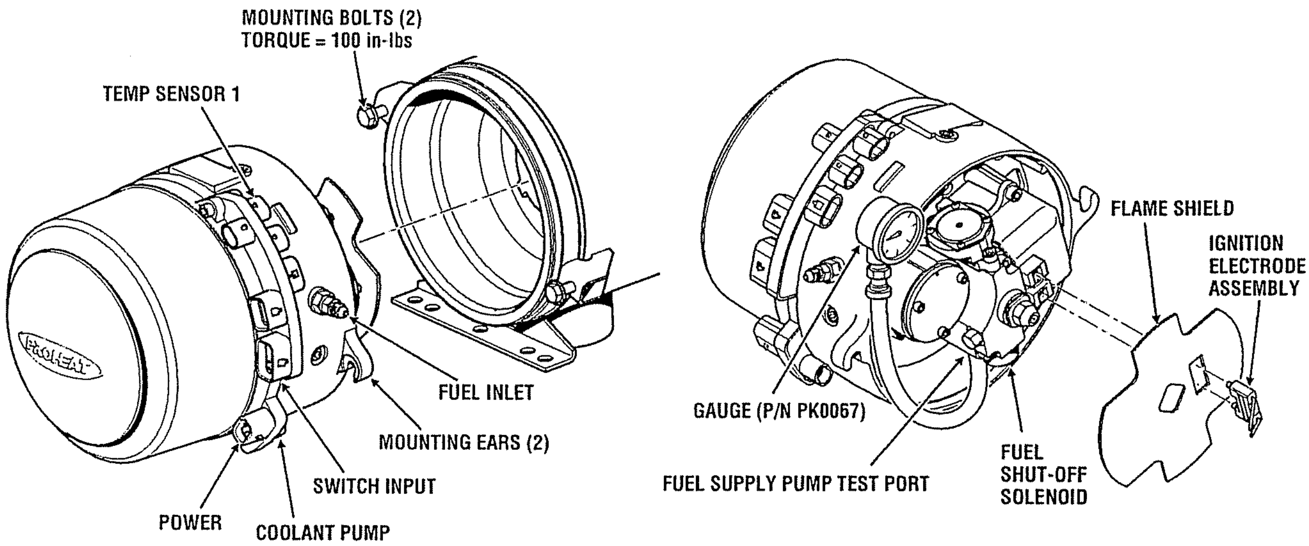


Figure 3-16: Burner Head Removal and Fuel Pressure Test

⚠ WARNING

Flammable.

⚠ WARNING

To avoid the risk of shock and to ensure that the PROHEAT does not fire, disconnect the Ignition Module connector at the PCM.

NOTICE

Leaving the Temperature Sensor(s) disconnected ensures that the burner head will enter purge mode and run for a maximum of three minutes.

f) Disconnect the Fuel Shut-off Valve and Ignition Module connectors at the PCM. Ensures that fuel will not spray and/or light during testing.

g) Remove the Fuel Supply Pump test port plug and install test gauge.

h) Reconnect the power and switch harnesses at the PCM.

i) Reconnect the fuel supply line.

j) Switch the PROHEAT on and read the fuel pressure (should be 3 – 12 PSI):

If the pressure is out of range, Go to Fuel Supply Pump cleaning, page 3-16.

If the pressure reads OK, review Fuel System troubleshooting, page 3-3.

Fuel Supply Pump cleaning:

a) Disconnect all harnesses at the PCM.

b) Disconnect the fuel supply line.

c) Loosen and back out the burner head mounting (2) bolts five to six turns allowing enough room to rotate the burner head 15° counter-clockwise and remove.

d) Locate the pressure relief valve cap and remove with a slot screwdriver. Careful not to lose any of the internal components that may fall out.

e) Remove the spring from the cavity.

f) Remove the ball bearing from the cavity.

g) Inspect and clean all components.

h) Inspect and clean the cavity. Pay close attention to the center hole in the cavity for any debris or a damaged edge. The edge of the hole should be smooth with no nicks, do not use any tool that may damage this edge as this will cause loss of fuel pressure.

i) Place ball bearing back in cavity on the center hole.

j) Place spring back in hole with brass ball guide on top of ball bearing.

k) Install pressure relief valve cap.

l) Re-test the Fuel Supply Pump. *Start from item 'e' in Test procedure – Fuel Supply Pump pressure, page 3-15.*

If the Fuel Supply Pump pressure tests OK, go to item 'm'.

If the Fuel Supply Pump pressure is still incorrect, go to Fuel Supply Pump replacement

m) Reassemble the burner head.

n) Reinstall electrical harnesses and fuel supply line.

o) Switch the PROHEAT on and operate for at least one complete cycle. Observe the operation.

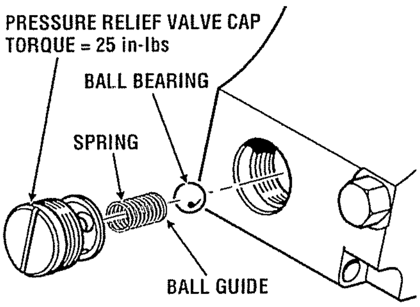


Figure 3-17: Pressure Relief Valve Cap

Fuel Supply Pump replacement:

a) Disconnect and remove the Ignition Module. *Go to page 3-19.*

b) Remove Fuel Nozzle. *Go to page 3-6.*

c) Remove Fuel Regulator. *Go to page 3-11.*

d) Disconnect and remove Fuel Shut-off Valve. *Go to page 3-8.*

e) Remove blower housing (2) screws and blower housing.

f) Remove blower retaining snap ring and slide the blower off the Motor shaft.

g) Disconnect the Motor connector at the PCM. Remove the PCM.

h) Remove Motor (4) mounting screws using a 4 mm Allen wrench.

i) Remove the Motor.

j) Remove the Air Compressor gear retaining snap ring and gear.

k) Remove Air Compressor (2) screws, Air Compressor, (2) O-rings from the Fuel Supply Pump.

l) Reinstall all components in reverse order to new Fuel Supply Pump.

m) Reinstall the burner head by mounting it against the heat exchanger face, turning clockwise to engage the mounting ears on the bolts.

n) Reinstall electrical harnesses and fuel supply line.

o) Switch the PROHEAT on and operate for at least one complete cycle. Observe the operation.

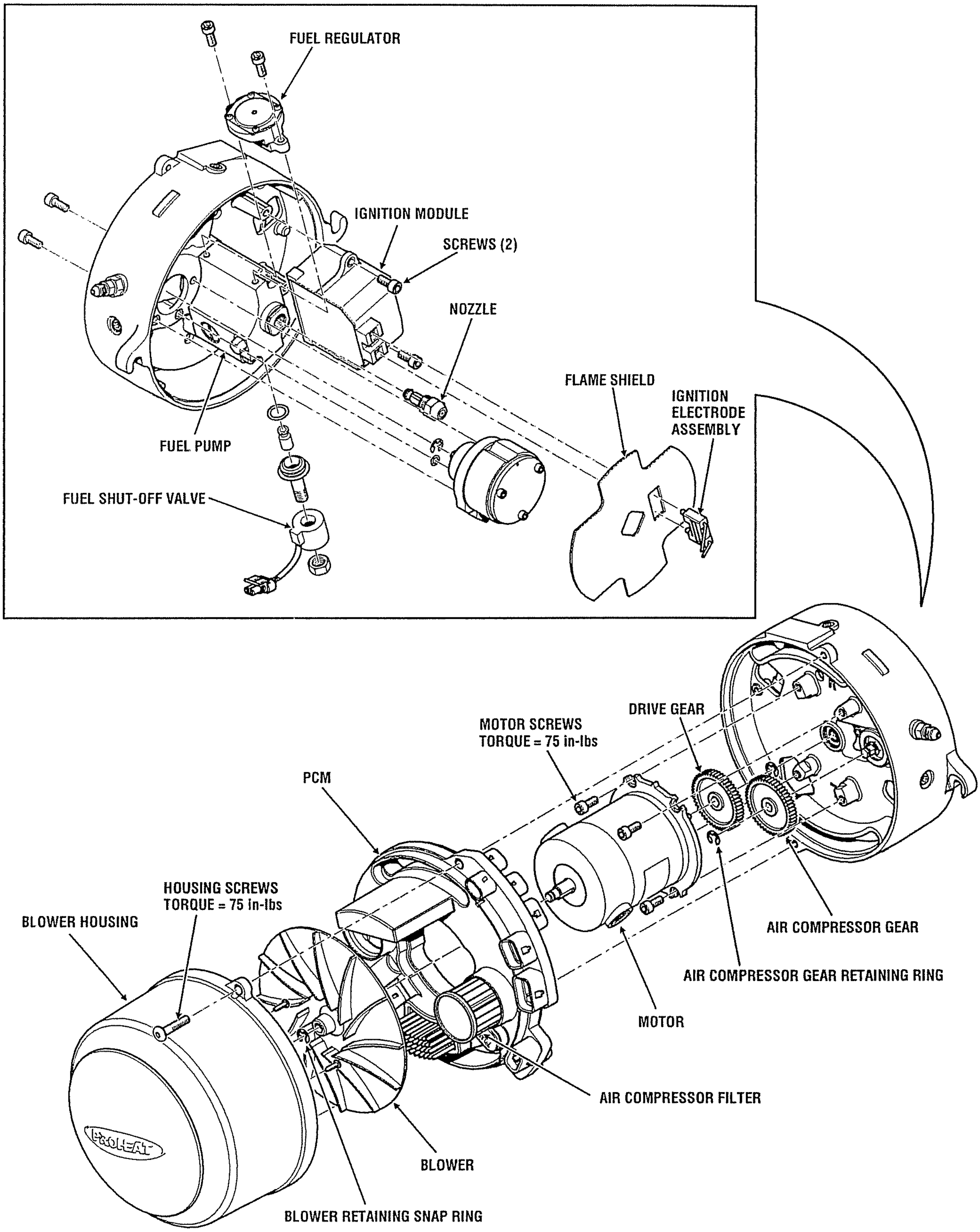


Figure 3-18: Fuel Supply Pump Removal

START: Ignition System

(1 Flash)

⚠ WARNING

Do not connect Temperature Sensor to avoid flame.

⚠ WARNING

Shock hazard due to high voltage.

⚠ WARNING

Keep blower housing on to avoid injury when Motor starts up.

Ignition Module – Check:

a) Ignition Operation using Ignition mode.

b) Ignition Module and PCM – electrical open circuit fault.

Test Procedure – Ignition service diagnostic:

a) Disconnect all harnesses at the PCM.

b) Disconnect the fuel supply line.

c) Loosen and back out the burner head mounting (2) bolts five to six turns allowing enough room to rotate the burner head 15° counter-clockwise and remove.

d) Check Electrodes for carbon bridging and/or damage. Replace if necessary.

e) Reconnect the power and switch harnesses.

f) Switch the PROHEAT on and observe for a spark. Spark will continue for five seconds.

If the spark is OK, reinstall the burner head and review Fuel System troubleshooting, page 3-3.

If there is no spark check PCM ignition output voltage.

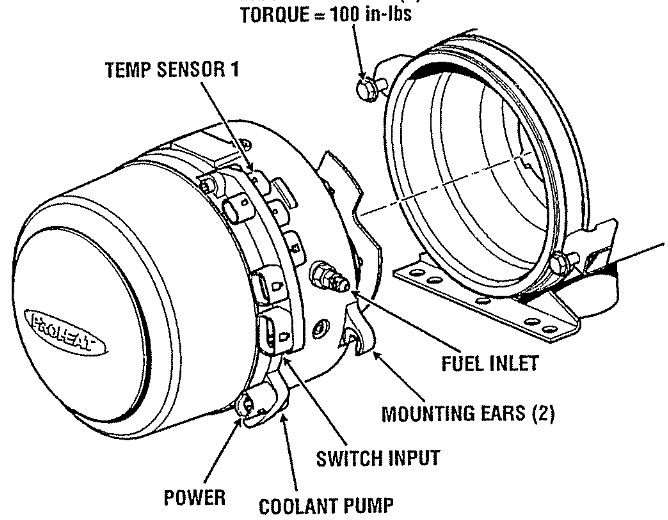


Figure 3-19: Burner Head Removal

Test Procedure – PCM ignition output voltage:

a) Disconnect the Ignition Module and the Fuel Shut-off Valve connectors (ensure no flow) at the PCM.

b) Reconnect all external harnesses at the PCM.

c) Switch the PROHEAT on and measure across pins A and C of the PCM Ignition Module connection.

If the correct system voltage (12 or 24) is measured, then measure across pins B and C (should read 0 Volts).

If both of the measurements are correct, then replace Ignition Module. Go to Ignition Module replacement.

If either of these measurements are incorrect, the PCM is faulty. Go to PCM replacement, page 3-39.

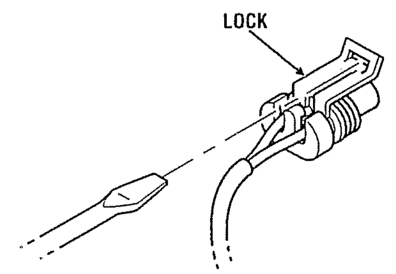


Figure 3-20: Connector Removal

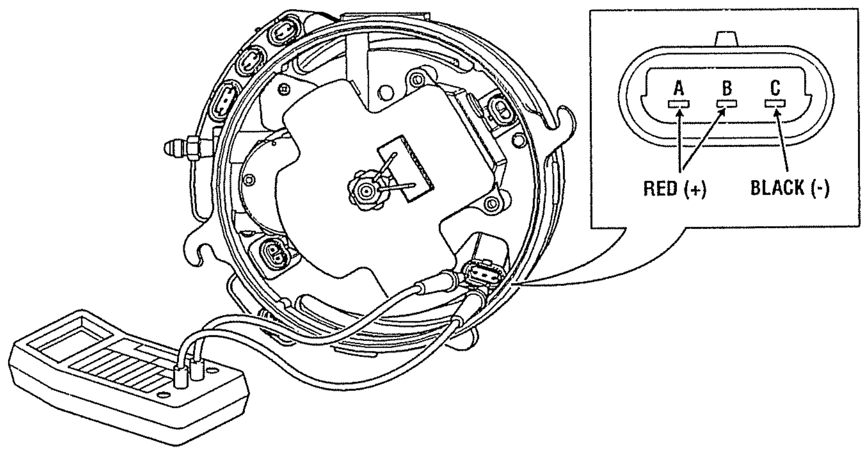


Figure 3-21: PCM Ignition Module Connection Measurement

Ignition Module replacement:

a) Remove ignition electrode assembly. Use a flat head screwdriver to pry the electrode assembly out.

b) Remove the flame shield. Rotate to match the mounting square.

c) Remove Ignition Module (2) mounting screws and Module.

d) Reinstall the new Ignition Module.

e) Reinstall flame shield and electrode assembly.

f) Reconnect Ignition Module connector at the PCM.

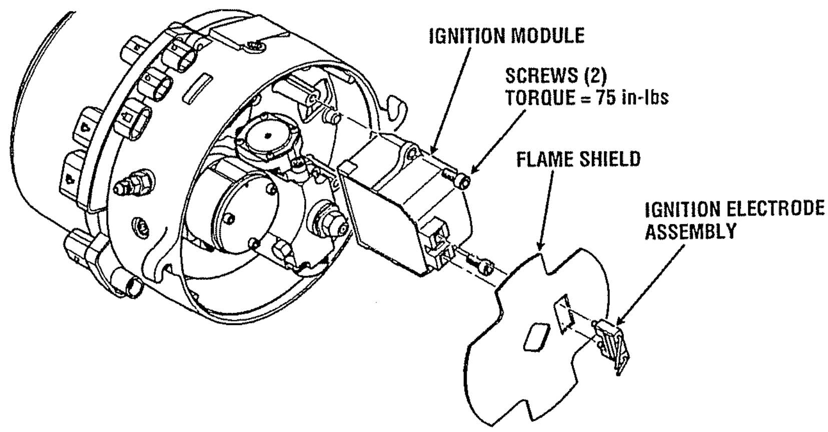


Figure 3-22: Ignition Module Replacement

START: PCM Flame Sensor Circuit *(1 Flash)*

Flame Sensor – Check:

a) Flame Sensor operation.

b) Combustion tube orientation.

Test Procedure – Flame Sensor circuit:

a) Disconnect all harnesses at the PCM.

b) Disconnect the fuel supply line.

c) Loosen and back off the burner head mounting (2) bolts five to six turns allowing enough room to rotate the burner head 15° counter-clockwise and remove.

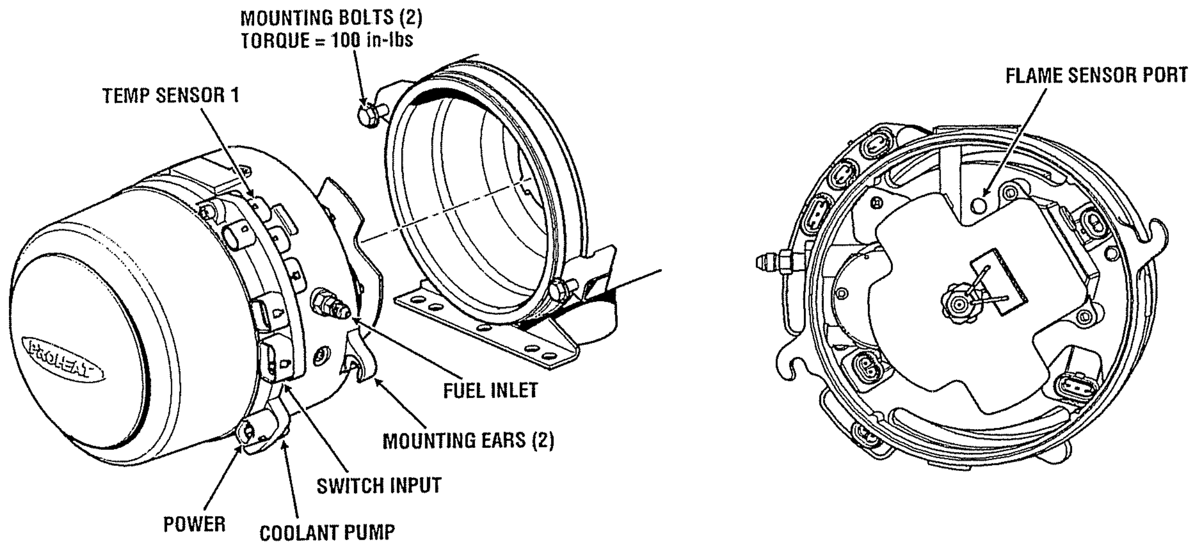


Figure 3-23: Burner Head Removal and Flame Sensor Location

⚠ WARNING

To avoid the risk of shock and to ensure that the PROHEAT does not fire, disconnect the Ignition Module)nnector at the PCM.

d) Disconnect the Ignition Module connector at the PCM.

e) Check for contamination on the Flame Sensor. Clean if necessary using electrical contact cleaner or warm soapy water.

f) Reconnect the power harness and the remote test switch with the switch in the off position.

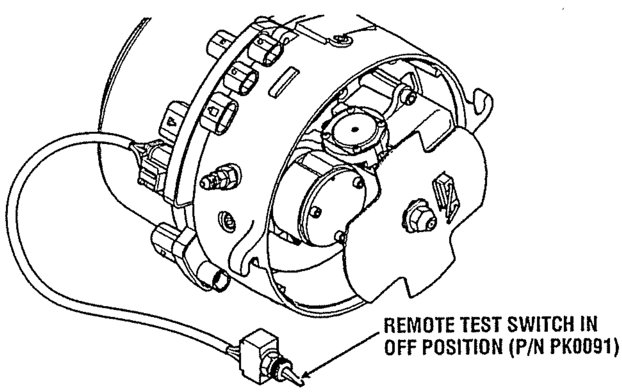


Figure 3-24: Remote Test Switch Connection

g) Place a finger over the sensor port located on the burner head flange. The indicator light should go out. Remove your finger and shine a flashlight into the sensor, the indicator light should come on.

If the indicator light reacts correctly, the Flame Sensor is OK. Go to Test Procedure – Combustion Tube orientation.

If the indicator light does not react, the Flame Sensor is faulty. Go to PCM replacement, page 3-39.

Test Procedure – Combustion Tube orientation:

a) Ensure that the combustion tube orientation boss is aligned with the heat exchanger flange notch.

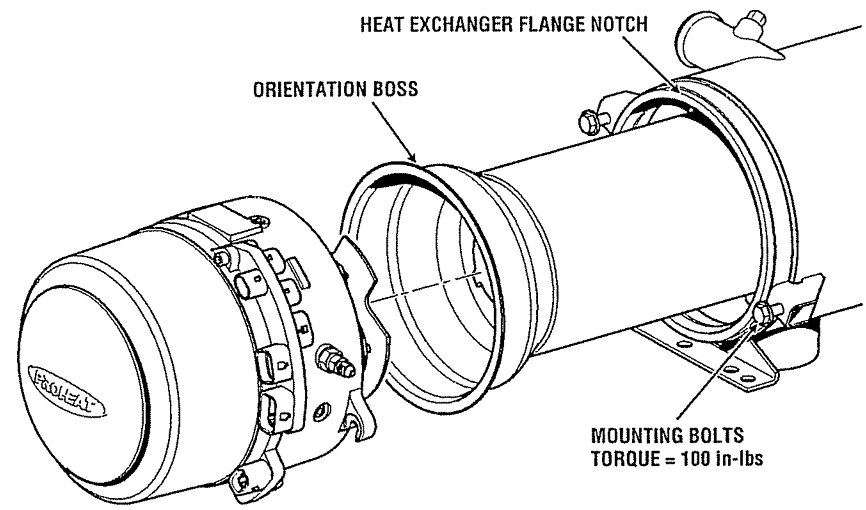


Figure 3-25: Combustion Tube Orientation

START: Motor and/or PCM fault *(1 Flash)*

Motor or PCM – Check:

a) Electrical function – Open circuit motor.

b) Electrical function – Open circuit PCM.

⚠ CAUTION

DO NOT connect Motor directly to batteries or another power source as it will damage the Motor.

Test Procedure – Open circuit Motor:

a) Disconnect the Motor connector at the PCM.

b) Using a multimeter set for resistance (Ohms) measure across pins A and B.

c) Check for an open circuit.

If and open circuit is detected, go to Motor replacement, page 3-23.

If an open circuit is not detected, go to Test Procedure – Open circuit PCM.

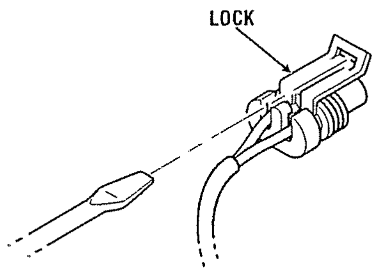


Figure 3-26: Connector Removal

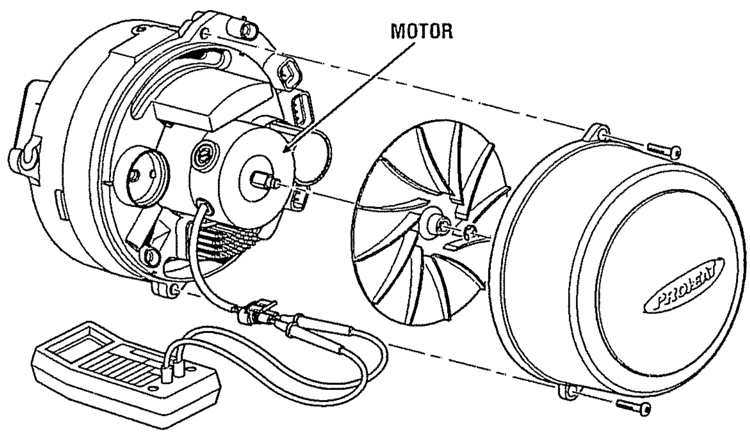


Figure 3-27: Motor Electrical Resistance Measurement

Test Procedure – Open circuit PCM:

a) Disconnect the Motor connector and Temperature Sensor 1 at the PCM.

b) Reconnect the power and switch harnesses at the PCM.

c) Switch the PROHEAT on and measure voltage across pins A and B of the PCM Motor connection.

If the correct nominal system voltage (12 or 24) is measured, the PCM is OK. Go to Test Procedure – Open circuit Motor.

If no voltage is measured, the PCM is faulty. Go to PCM replacement, page 3-39.

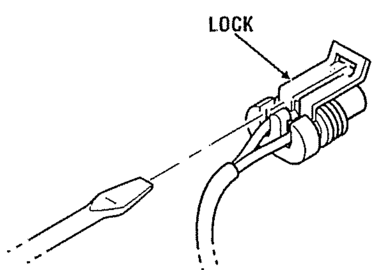


Figure 3-28: Connector Removal

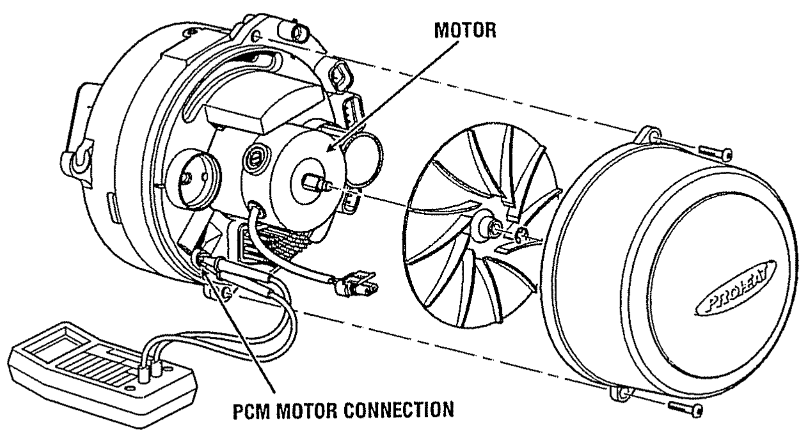


Figure 3-29: PCM Motor Output Voltage Measurement

Motor replacement:

a) Disconnect all harnesses at the PCM.

b) Disconnect the fuel supply line.

c) Loosen and back out the burner head mounting (2) bolts five to six turns allowing enough room to rotate the burner head 15° counter-clockwise and remove.

d) Remove blower housing (2) screws and blower housing.

e) Remove blower retaining snap ring and slide the blower off the Motor shaft.

f) Disconnect the Motor connector at the PCM.

g) Remove Motor (4) mounting screws using a 4 mm Allen wrench.

h) Remove the Motor. Take care when removing that the Fuel Supply Pump seal is not damaged.

i) Remove the gear retaining snap ring and gear from the old Motor and install on the new Motor.

j) Install the new Motor. Take care when installing the Motor shaft in the Fuel Supply Pump seal. Lubricate with clean diesel fuel.

k) Reinstall (4) screws.

l) Reconnect the Motor connector at the PCM.

m) Reinstall the blower, blower retaining snap ring, Air Compressor filter and blower housing.

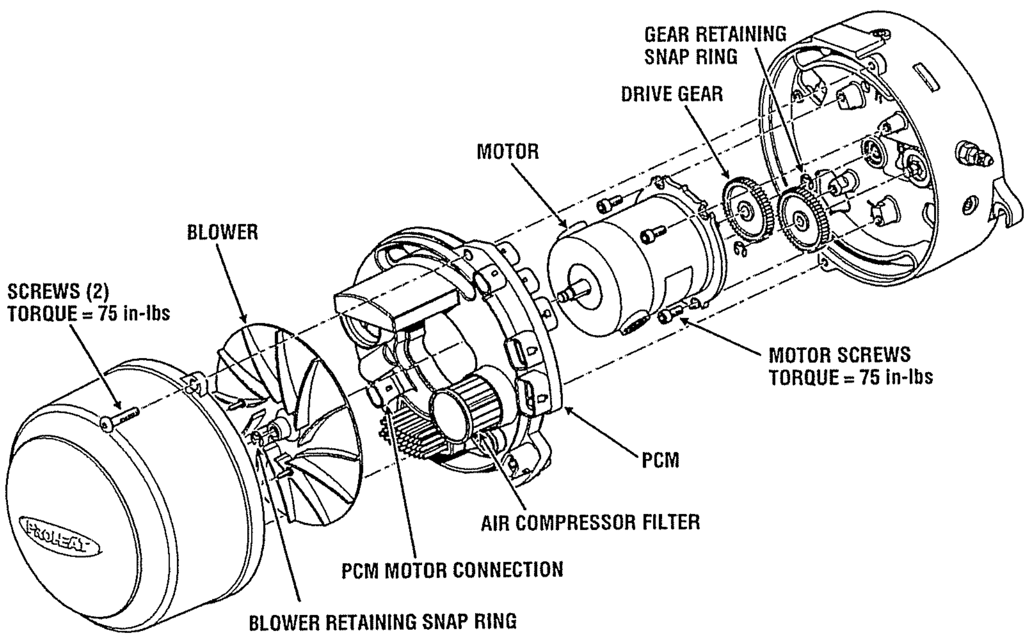


Figure 3-30: Motor Replacement

3.1.2 FLAME OUT Diagnostic Code

(2 Flashes)

Indicates that a flame was detected but it could not be maintained or after being established the flame went out before reaching the cycle off temperature of 185°F (85°C).

Flame Out sequence:

a) A flame is detected during the Ignition period or during Full Output.

b) The flame goes out.

c) The ignition is switched on for a maximum of 10 seconds to try and reestablish the flame (Ignition periods will be 10 seconds longer in cases where the Flame Out occurred during the Ignition period).

d) If the flame is not established the Flame Out diagnostic code is displayed.

A Flame Out diagnostic code distinguishes that:

a) A flame was detected therefore there was a spark and the Ignition system works.

b) The flame was detected therefore the Flame Sensor works.

c) The fault is in the fuel supply system.

Troubleshoot the Flame Out diagnostic code based on:

1. **Fuel supply to the PROHEAT.** *Go to page 3-4 and 3-5, Steps 1 and 2.*
   - Fuel tank pick-up.
   - Fuel fittings.
   - Fuel lines.
   - OEM supplied filters and check valves.
2. **PROHEAT fuel system.** *Go to page 3-6 to 3-15, Steps 3 to 7.*
   - Fuel Supply Pump
   - Air Compressor
   - Fuel Regulator
   - Fuel Shut-off Valve
3. **Operational symptoms that may occur in conjunction with a Flame Out code.** *Go to pages 3-4 to 3-15, Steps 1 to 7.*
   - Combustion hesitation or coughing.
   - Backfiring.
   - Smoke.
   - Strong diesel fuel odor.

3.1.3 COOLANT FLOW Diagnostic Code

(3 flashes)

Indicates that the coolant temperature in the PROHEAT reached 185°F (85°C) within 90 seconds from the beginning of Ignition. There is coolant in the system but its flow rate is too low.

Troubleshoot the Coolant Flow diagnostic code based on:

1. **Vehicle coolant system.** *Go to Step 1.*
   - The PROHEAT starts and runs for 90 seconds or less and shuts down with a Coolant Flow diagnostic code indicated.
2. **Coolant Pump system electrical or mechanical fault.** *Go to Step 2.*
   - The PROHEAT starts and runs for 90 seconds or less and shuts down with a Coolant Flow diagnostic code indicated.

COOLANT FLOW: Step 1

(3 Flashes)

⚠ WARNING

NEVER remove coolant lines when the engine is hot – escaping steam or scalding water could cause serious personal injury. Loosen the coolant line clamps slowly, allowing the pressure to escape before removing completely.

Vehicle coolant system – Check:

a) For restrictions and blockages in the coolant lines.

b) OEM system shut-off valves for correct operation.

c) For loose hose clamps -- air introduced into the system.

d) Coolant line size, fittings. Are they too restrictive?

e) Direction of flow. Are the PROHEAT Coolant Pump and the engine Coolant Pump pumping in the same direction when they are operating at the same time?

f) Coolant capacity. Is there enough coolant in the system? *Go to Technical Specifications, page 1-1.*

g) PROHEAT location. Is the PROHEAT or Coolant Pump the high point in the system? Coolant Pumps are not self-priming and a surge tank may be required.

COOLANT FLOW: Step 2

(3 Flashes)

Coolant Pump and PCM – Check:

a) PCM electrical function.

b) Coolant Pump electrical function.

c) Coolant Pump mechanical function.

Test Procedure – Electrical:

a) Disconnect the Coolant Pump connector at the PCM.

b) Using a multimeter set for voltage, switch the PROHEAT on and measure across pins A and B on the PCM Coolant Pump connection.

If the correct nominal system voltage (12 or 24) is measured, the PCM is OK. Go to Procedure – Mechanical inspection and testing, page 3-26.

If no voltage is measured, the PCM is faulty. Go to PCM replacement, page 3-39.

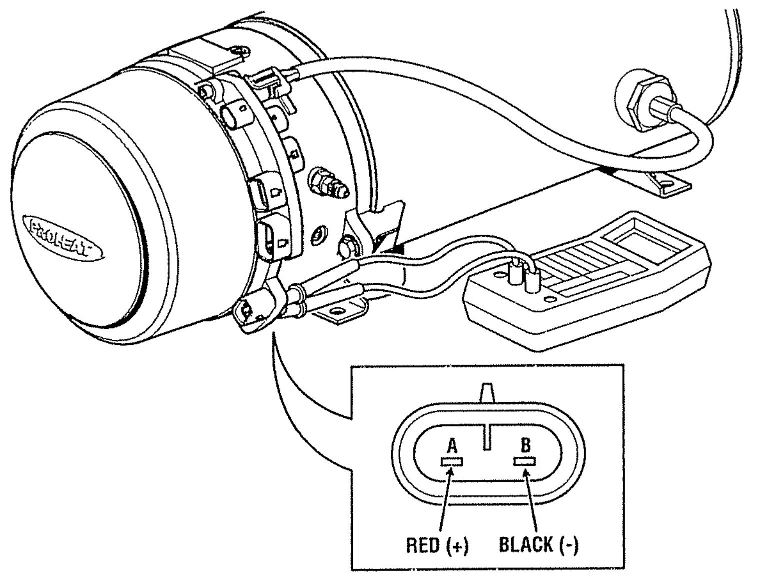


Figure 3-31: PCM Coolant Pump Output Voltage Measurement

⚠ WARNING

NEVER remove coolant lines when the engine is hot – escaping steam or scalding water could cause serious personal injury. Loosen the coolant line clamps slowly, allowing the pressure to escape before removing completely.

Procedure – Mechanical inspection and testing:

a) Connect the power directly to the Coolant Pump. Observe the operation.

If the Motor does not operate, replace the Coolant Pump.

3.1.4 OVERHEAT Diagnostic Code

(4 Flashes)

Indicates that the Temperature Sensor detected an inner heat exchanger surface temperature of 230°F (110°C) within 60 seconds after entering Cool Down.

Troubleshoot the Overheat diagnostic code based on:

1. **Lack of coolant, air or flow problems in the coolant system.** *Go to page 3-25, Steps 1 and 2.*
2. **Faulty Temperature Sensor.** *Go to page 3-29.*
3. **Faulty PCM Temperature Sensor circuit.** *Go to page 3-29.*

To reset the PROHEAT, switch it off and then on again.

⚠ CAUTION

Repeatedly resetting the PROHEAT without resolving the Overheat diagnostic code will damage the heat exchanger.

3.1.5 VOLTAGE Diagnostic Code

(5 Flashes)

Indicates that the supply voltage to the PCM is outside the operating range.

Operating Range:

- 12 volt PROHEAT – 10 to 15 volts.
- 24 volt PROHEAT – 20 to 30 volts.

Troubleshoot the Voltage diagnostic code based on:

1. **Low voltage.**
   - Voltage supply is below the rated requirement.
   - Poor or faulty electrical connections.
   - Voltage supply source is OK. Voltage drop due to high amperage load while the PROHEAT is operating or trying to operate.
2. **High voltage.**
   - Voltage supply is above the rated requirement while the vehicle engine is running.

VOLTAGE: Step 1 High Voltage – Check:

(5 Flashes)

The vehicle charging system. Consult the OEM for service requirements.

VOLTAGE: Step 2 Low Voltage – Check:

(5 Flashes)

a) System voltage supply source.

b) Wiring harnesses and connection points.

Procedure – Low voltage testing:

a) Inspect the wiring harnesses and connections for corrosion and proper fit. Clean if necessary.

b) Using a multimeter set for voltage, measure across the positive and negative battery terminals or at the supply source.

If the voltage is below the required voltage, service the batteries and/or charging system as per OEM supplier recommendations.

If the voltage level is within the operating range, go to item 'c'.

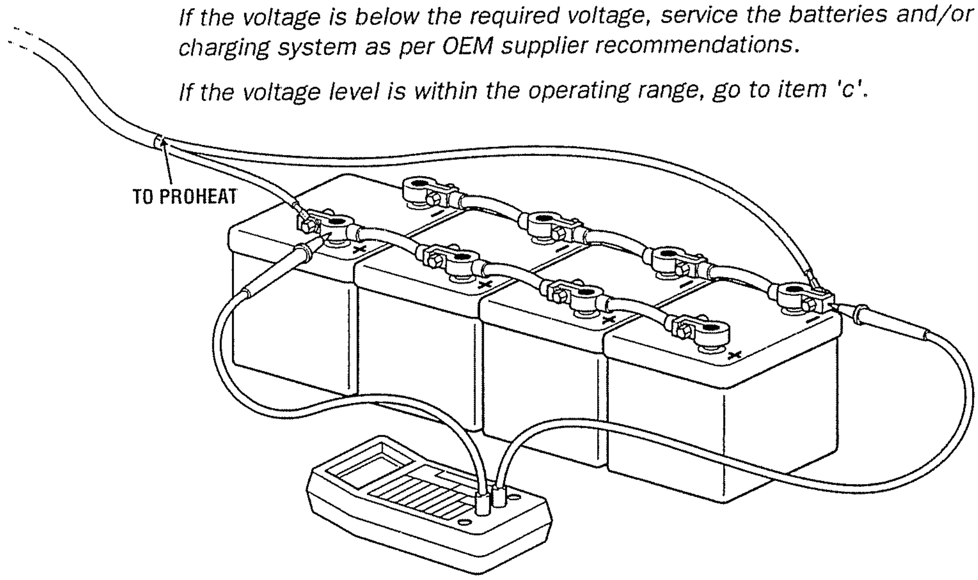


Figure 3-32: Voltage Measurement

c) Locate and measure across pins D and B in the PCM Data Link connection. Perform this with the PROHEAT off and then switched on.

If the voltage is within the operating range and a Voltage diagnostic code is indicated, the PCM is faulty. Go to PCM replacement, page 3-39.

If the voltage falls below the required voltage when the Motor starts, check the wiring from the supply source to the PROHEAT PCM. Go to page 3-22.

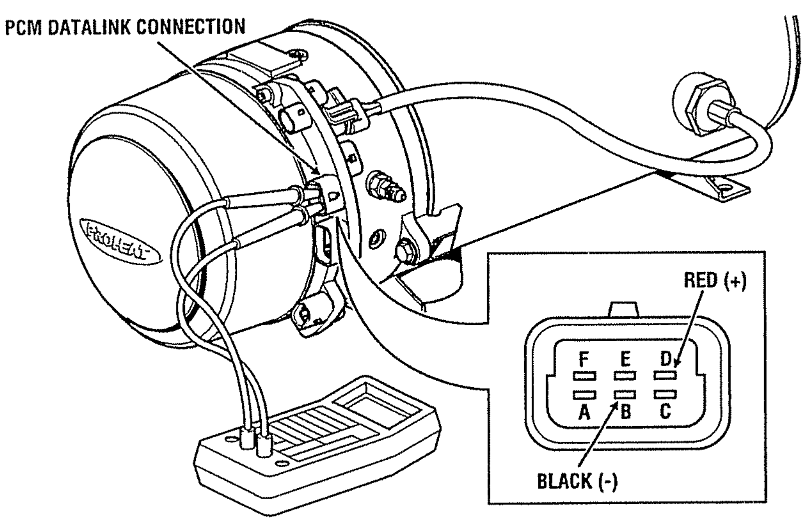


Figure 3-33: PCM Datalink Connection

3.1.6 FLAME FAULT Diagnostic Code

(6 Flashes)

Indicates that:

1. The PROHEAT reached 185°F (85°C) cycled off and entered Cool Down. After 20 seconds a flame was still detected.
2. The PROHEAT was switched on and a flame (signal) was detected in Pre-check.

Troubleshoot the Flame Fault diagnostic code based on:

1. **Fuel System fault.** *Go to pages 3-6 to 3-15, Steps 3 to 7.*
2. **PCM Flame Sensor circuit.** *Go to page 3-20.*

3.1.7 TEMPERATURE SENSOR T1 Diagnostic Code

(7 or 9 Flashes)

Indicates an electrical fault in the Temperature Sensor.

Troubleshoot the Temperature Sensor diagnostic code based on:
Whether the PROHEAT is equipped with a single Temperature Sensor or dual Temperature Sensors.

TEMP SENSOR T1: Step 1 — Temperature Sensor and PCM (single sensor) – Check:

(7 or 9 Flashes)

a) Temperature Sensor and PCM electrical function.

Test Procedure – Sensor and PCM:

a) Remove Temperature Sensor connector from PCM connection T1.

b) Remove the PCM sealing plug from PCM connection T2. Put sealing plug into PCM connection T1.

c) Reconnect the Temperature Sensor connector to PCM connection T2.

d) Switch the PROHEAT on:

If a diagnostic code is indicated, the sensor is faulty. Go to Temperature Sensor replacement.

If after changing the Temperature Sensor a diagnostic code is still indicated, the PCM is faulty. Go to PCM replacement, page 3-39.

If a diagnostic code is not indicated, the PCM T1 circuit is faulty. It is NOT necessary to change the PCM. The PROHEAT may be used with the Temperature Sensor T2 circuit if only one sensor is required. Leave the Temperature Sensor connected to PCM connection T2 and operate the PROHEAT as normal.

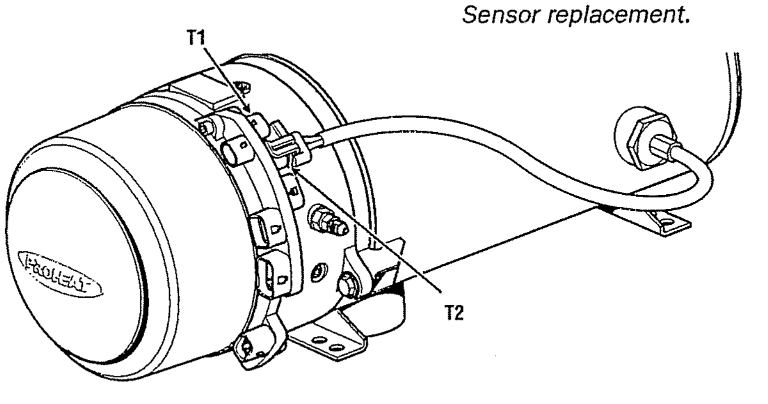


Figure 3-34: Temperature Sensors

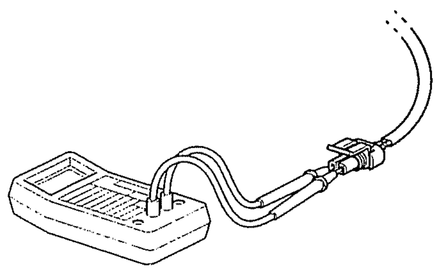


Figure 3-35: Temperature Sensor Test

Test Procedure – Temperature Sensor measurement:

a) Using a multimeter set for resistance, measure across pins A and B of the sensor at room temperature of about 70°F (21°C).

If the reading is 950 Ohms ± 50 Ohms the sensor is OK.

If the sensor measures out of this range the sensor is faulty. Go to Temperature Sensor replacement.

TEMP SENSOR T1: Step 2

(7 or 9 Flashes)

Temperature Sensor and PCM electrical (dual sensors) – Check:

a) Temperature Sensor and PCM electrical function.

Test Procedure – Sensor and PCM:

a) Remove Temperature Sensor connector from PCM connection T1.

b) Remove Temperature Sensor connector from PCM connection T2.

c) Swap the connectors. T1 to T2 and T2 to T1.

d) Switch the PROHEAT on:

If a Temperature Sensor T1 diagnostic code is now indicated, the sensor is faulty. Go to Temperature Sensor replacement.

If a Temperature Sensor T2 diagnostic code is still indicated, the PCM is faulty. Go to PCM replacement, page 3-39.

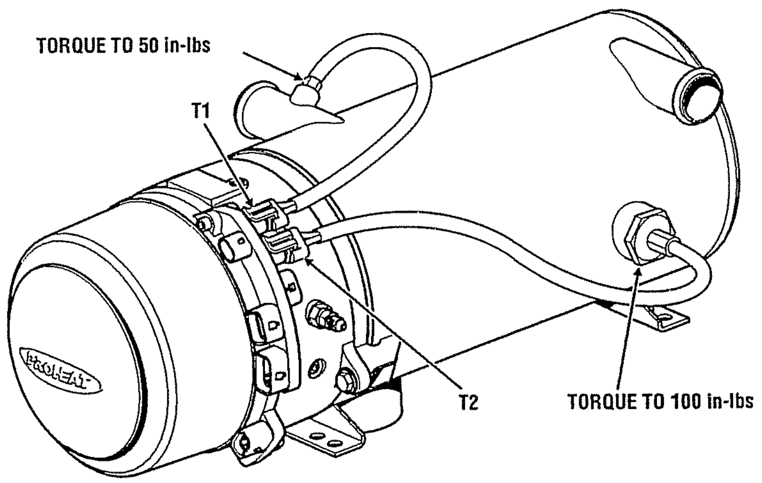


Figure 3-36: Temperature Sensors

⚠ WARNING

NEVER remove coolant lines when the engine is hot – escaping steam or scalding water could cause serious personal injury. Loosen the coolant line clamps slowly, allowing the pressure to escape before removing completely.

Temperature Sensor replacement:

a) Isolate the coolant system at the PROHEAT inlet and outlet ports for minimal coolant loss using valves in the system or hose clamps.

b) Remove sensor using a 14 mm wrench.

c) Reinstall the new sensor. Ensure that the O-ring and O-ring seat are clean. Install the sensor until it bottoms out on the mounting boss.

3.1.8 FUEL SHUT-OFF VALVE Diagnostic Code

(8 Flashes) Indicates an electrical fault in the Fuel Shut-off Valve coil or in the PCM Fuel Shut-off Valve circuit.

Troubleshoot the Fuel Shut-off Valve diagnostic code based on:
Fuel Shut-off Valve Coil or PROHEAT PCM electrical.

Test Procedure – Fuel Shut-off Valve and PCM test:

a) Disconnect all harnesses at the PCM.

b) Disconnect the fuel supply line.

c) Loosen and back out the burner head mounting (2) bolts five to six turns allowing enough room to rotate the burner head 15° counter-clockwise and remove.

d) Disconnect the Fuel Shut-off Valve connector at the PCM.

e) Disconnect the Ignition Module connector at the PCM

f) Reconnect the power, Temperature Sensor(s) and switch harnesses at the PCM.

g) Switch the PROHEAT on:

If a Fuel Shut-off Valve diagnostic code is NOT indicated and the PROHEAT attempts to operate, the Fuel Shut-off Valve is faulty. Go to Fuel Shut-off Valve replacement, page 3-10.

If the Fuel Shut-off Valve diagnostic code is still indicated, the PCM is faulty. Go to PCM replacement, page 3-39.

⚠ WARNING

To avoid the risk of shock and to ensure that the PROHEAT does not fire, disconnect the Ignition Module connector at the PCM.

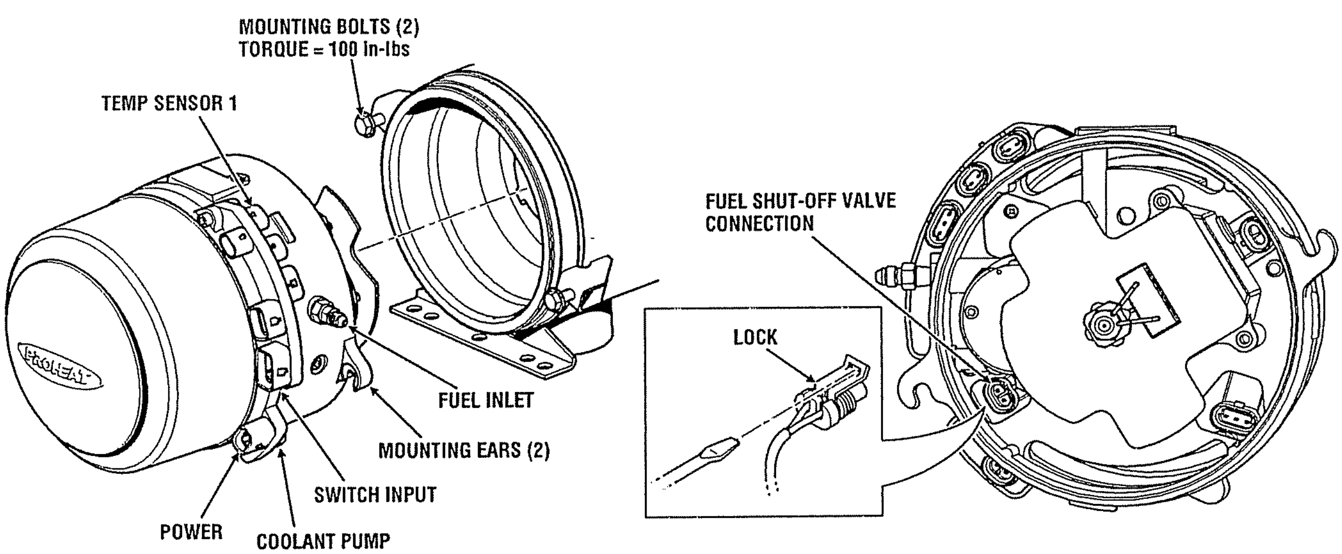


Figure 3-37: Burner Head Removal and Fuel Shut-off Valve Connection

3.1.9 TEMPERATURE SENSOR T2 Diagnostic Code

(7 or 9 Flashes)

Go to Temperature Sensor T1 Diagnostic Code, page 3-29.

3.1.10 IGNITION MODULE Diagnostic Code

(10 Flashes)

Indicates an over-load fault is detected.

Troubleshoot the Ignition Module diagnostic code based on:
Ignition Module and PCM - electrical.

Test procedure – Ignition Module and PCM:

a) Disconnect all harnesses at the PCM.

b) Disconnect the fuel supply line.

c) Loosen and back out the burner head mounting (2) bolts five to six turns allowing enough room to rotate the burner head 15° counter-clockwise and remove.

d) Disconnect the Ignition Module connector at the PCM.

e) Reconnect the power and switch harnesses at the PCM.

f) Switch the PROHEAT on and operate for at least one complete cycle. Observe the operation.

If an Ignition Module diagnostic code is NOT indicated and the PROHEAT attempts to operate, the Ignition Module is faulty. Go to Ignition Module replacement, page 3-19.

If the Ignition diagnostic code is indicated, the PCM is faulty. Go to PCM replacement, page 3-39.

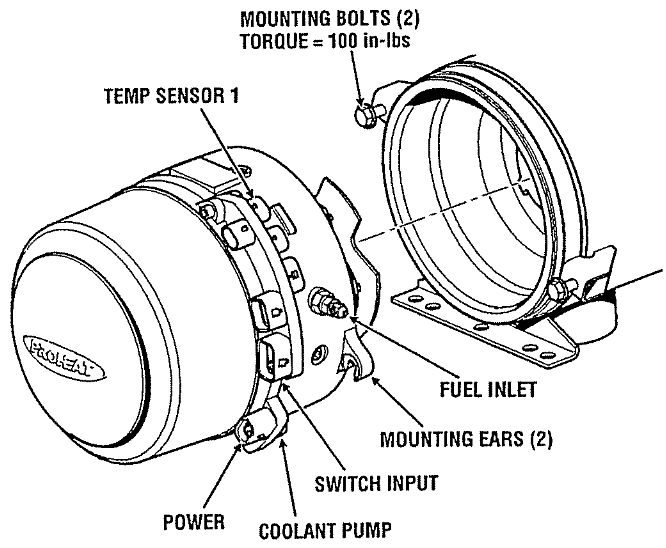


Figure 3-38: Burner Head Removal

3.1.11 COOLANT PUMP Diagnostic Code

(11 Flashes)

Indicates an over-load fault is detected.

Troubleshoot the Coolant Pump diagnostic code based on:
Coolant Pump and PCM – electrical.

Test Procedure – Coolant Pump and PCM test:

a) Disconnect the Coolant Pump at the PCM.

b) Switch the PROHEAT on and observe for a diagnostic code.

If a Coolant Pump diagnostic code is NOT indicated and the PROHEAT operates, the Coolant Pump is faulty. Go to Coolant Pump replacement.

If the Coolant Pump diagnostic code is still indicated, the PCM is faulty. Go to PCM replacement, page 3-39.

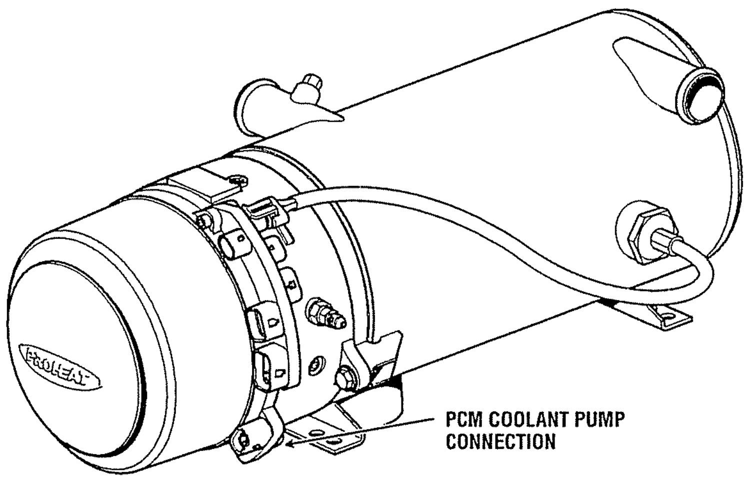


Figure 3-39: PCM Coolant Pump Connection

⚠ WARNING

NEVER remove coolant lines when the engine is hot – escaping steam or scalding water could cause serious personal injury. Loosen the coolant line clamps slowly, allowing the pressure to escape before removing completely.

⚠ CAUTION

Before starting the PROHEAT ensure that the Coolant Pump is flooded with coolant by opening all valves and running the engine until the air has been purged from the system (approximately 15 – 20 minutes). This will prevent Coolant Pump damage.

Coolant Pump replacement:

a) Isolate the Coolant Pump using shut-off valves provided in the coolant system or hose to minimize coolant loss.

b) Remove Coolant Pump.

c) Install new Coolant Pump.

3.1.12 MOTOR Diagnostic Code

(12 Flashes) Indicates that an over-load fault is detected in precheck or during operation.

Troubleshoot the Motor diagnostic code based on:

1. Motor – mechanical.
2. Motor or PCM – electrical.

Test Procedure – Motor mechanical function:

a) Disconnect all harnesses at the PCM.

b) Disconnect the fuel supply line.

c) Remove blower housing (2) screws and blower housing.

d) By hand, rotate the blower and feel for mechanical binding.

If mechanical interference is felt, isolate the Motor from the Fuel Supply Pump and Air Compressor by removing the Motor. Go to Motor replacement, page 3-23.

If the Motor spins freely and there are no obvious mechanical problems, check the Motor/PCM electrical operation. Go to Test Procedure – PCM Motor output voltage.

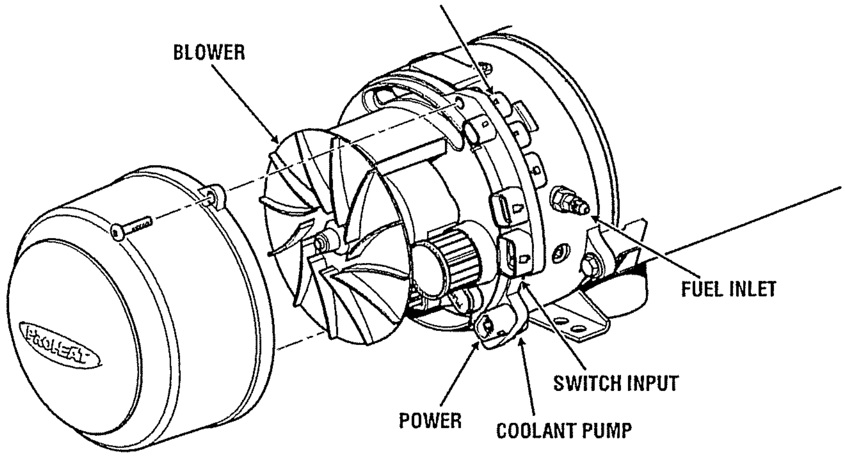


Figure 3-40: Motor Mechanical Check

Test Procedure – PCM Motor output voltage:

a) Disconnect the Motor connector at the PCM.

b) Reconnect the power and switch harnesses at the PCM.

c) Switch the PROHEAT on.

If Motor diagnostic code is still indicated, PCM is faulty. Go to PCM replacement, page 3-39.

If Motor diagnostic code is no longer indicated, Motor is faulty. Go to Motor replacement, page 3-23.

3.1.13 AUXILIARY OUTPUT Diagnostic Code

(13 Flashes)

Indicates a short circuit fault in the harness or the device being operated by the Auxiliary Output.

Troubleshoot the Auxiliary Output diagnostic code based on: PCM – electrical

Test procedure – PCM Output Signal:

a) Disconnect the Auxiliary Output harness at the PCM.

b) Switch the PROHEAT on and operate for at least one complete cycle. Observe the operation.

If the diagnostic code is not indicated the fault is in the harness or the driven device. Go to OEM for service requirements.

If the diagnostic code is still indicated, the PCM is faulty. Go to PCM replacement, page 3-39.

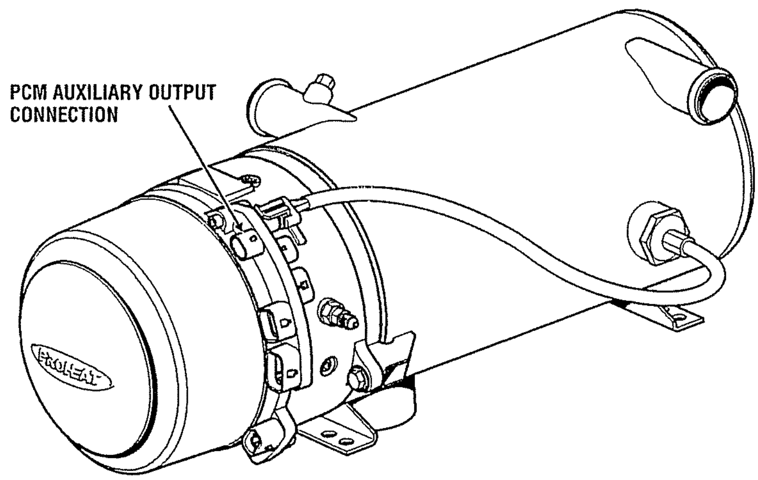


Figure 3-41: Auxiliary Output Connector

3.1.14 SWITCH/TIMER POWER Diagnostic Code

(14 Flashes)

Indicates a short circuit fault in harness or the device being operated by the Switch Output.

Troubleshoot the Switch/Timer Power diagnostic code based on:
Electrical switch circuit in the switch wiring.

Test procedure electrical, short circuit:

a) Remove the Switch Output harness at the PCM.

b) Remote start the PROHEAT using the PROHEAT remote start switch (PROHEAT P/N PK0091).

If the PROHEAT functions correctly, the fault is in the wiring from the PROHEAT back to the switch. See OEM recommended service requirements.

If the PROHEAT does not function, the PCM is faulty. Go to PCM replacement, *page 3-39.*

3.2 COMPONENT MECHANICAL OR ELECTRICAL PROBLEMS

3.2.1 Fuel Nozzle *Go to page 3-6, Step 3.*

3.2.2 Fuel Shut-off Valve *Go to page 3-8, Step 4.*

3.2.3 Fuel Regulator *Go to page 3-11, Step 5.*

3.2.4 Air Compressor *Go to page 3-12, Step 6.*

3.2.5 Fuel Supply Pump *Go to page 3-15, Step 7.*

3.2.6 Ignition Electrodes *Go to page 3-18.*

3.2.7 PCM Fuse

Protects the PCM against high current. When switched on, the PROHEAT will NOT start, attempt to start, or indicate a diagnostic code.

Troubleshoot a Blown Fuse based on:

1. Voltage supply to the PROHEAT.
2. Voltage at the output connections of the PCM.

Test Procedure – Voltage supply:

a) Disconnect the power harness at the PCM.

b) Using a multimeter set for voltage, measure across pins A and B of the harness connector for system voltage.

If there is no voltage, check the OEM voltage supply. Consult OEM for service requirements.

If the correct voltage (system voltage 12 – 24) is measured, go to item 'c'.

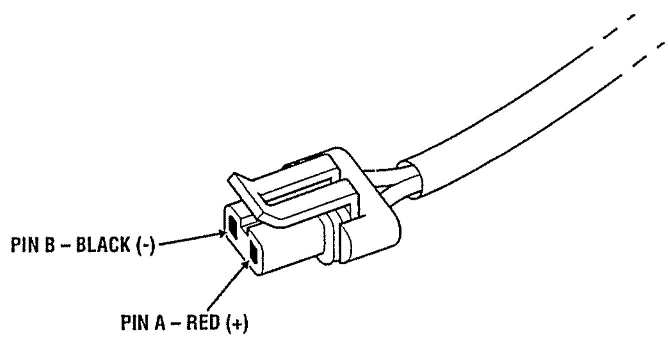


Figure 3-42: Power Harness

c) Disconnect the Datalink harness at the PCM. Using a multimeter set for voltage, measure across pins D and B in the PCM Datalink connection.

If voltage is read and it is of the correct value, the fuse is OK.

If voltage is not present, check the PCM fuse.

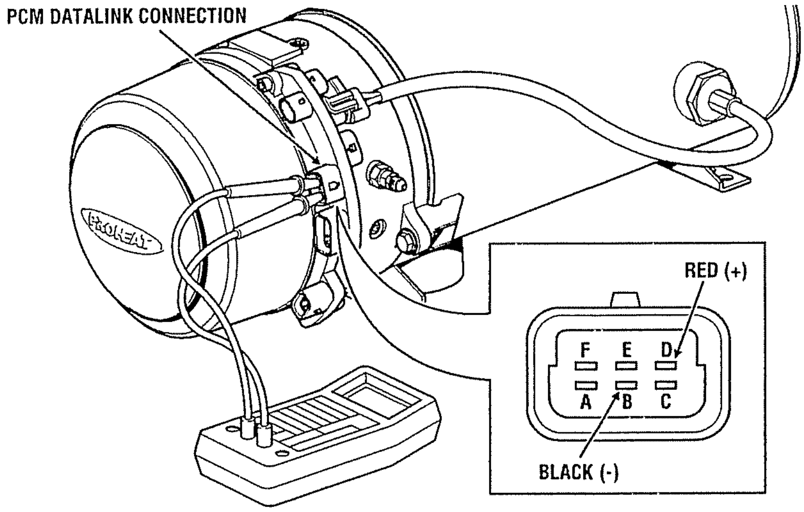


Figure 3-43: PCM Datalink Connection

Procedure – PCM fuse replacement:

a) Disconnect all harnesses at the PCM.

b) Disconnect the fuel supply line.

c) Loosen and back out the burner head mounting (2) bolts five to six turns allowing enough room to rotate the burner head 15° counter-clockwise and remove.

d) Remove blower housing (2) screws and blower housing.

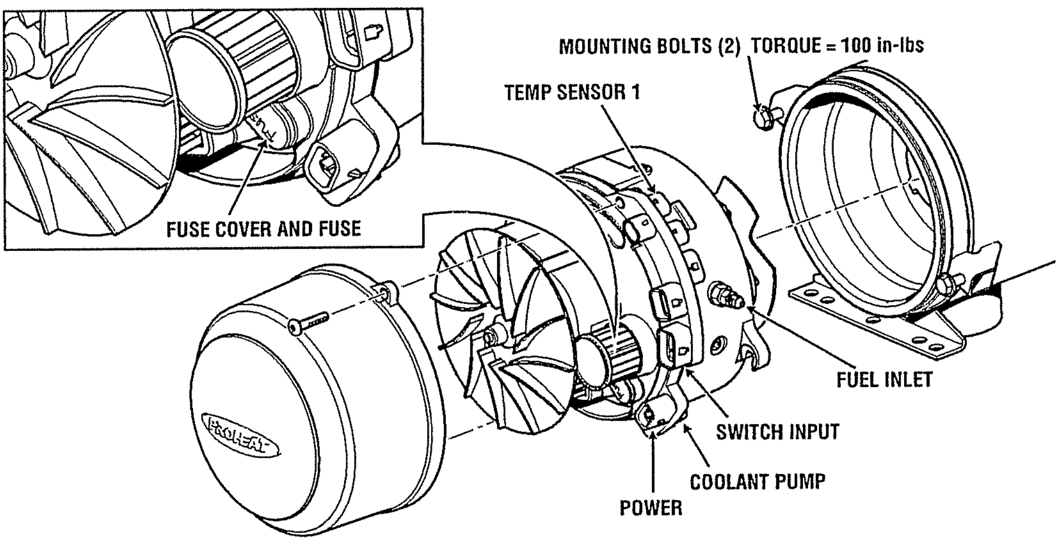


Figure 3-44: Burner Head Removal and Motor Mechanical Check

e) Remove the fuse cover and using needle nose pliers or a fuse removal tool remove the fuse.

If the fuse is blown, replace the fuse and check the PROHEAT current draw. Go to page 3-27.

If the fuse is OK, the PCM is faulty. Go to PCM replacement.

PCM replacement:

a) Disconnect the Fuel Shut-off Valve and Ignition Module connectors at the PCM.

b) Remove the blower housing (2) screws and blower housing.

c) Remove the blower retaining snap ring and slide the blower off the Motor shaft.

d) Remove the Air Compressor filter.

e) Disconnect the Motor connector at the PCM. Remove the PCM.

f) Reinstall the new PCM following items 'e' back to 'a'.

g) Reconnect the burner head by mounting it against the heat exchanger face, turning it clockwise to engage the mounting ears on the bolts.

h) Reconnect electrical harnesses and fuel supply line.

i) Switch the PROHEAT on and operate for at least one complete cycle. Observe the operation.

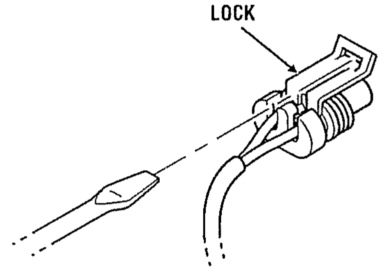


Figure 3-45: Connector Removal

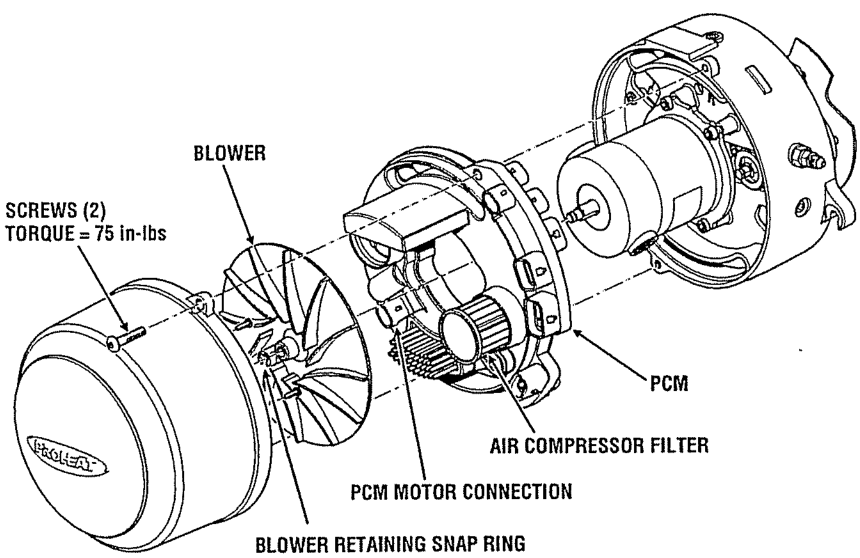


Figure 3-46: PCM Replacement

3.3 OPERATIONAL PROBLEMS

Problems with the PROHEAT and/or vehicle application that are not specifically defined but are observed during the operation of the PROHEAT and or vehicle coolant system. These fall into three categories:

1. **Fuel Supply/Combustion.** *Go to page 3-4 to 3-15, Steps 1 to 7.*
   - Smoke from the exhaust
   - Excessive raw diesel odor.
   - Backfiring and coughing during the combustion process.
   - Low heat output.
2. **Coolant system.** *Go to page 3-25, Steps 1 and 2.*
   - Short combustion cycles. The PROHEAT is turning on and off at very short intervals.
   - Low heat output in the vehicle system. *Go to pages 3-4 to 3-15, Steps 1 to 7.*
3. **Power system.** *Go to pages 3-29 and 3-30, Steps 1 and 2.*
   - Intermittent PROHEAT operation.
   - PROHEAT continues to run when not switched on.

4.0 MAINTENANCE

The following maintenance recommendations are based on the minimum maintenance required. Adjustments to this recommendation are determined by the end user based on:

- Environmental conditions
- Operating hours

Annually:

- Inspect and clean around the PROHEAT and exhaust system.
- Inspect and clean external electrical connectors.
- Test run the PROHEAT, letting it cycle at least once. *Go to page 3-4, Sequence of Operation.*

Observe:

1. **Combustion process.**
    - For smoke and raw fuel odor from the exhaust pipe.
    - Fuel system leaks and corrosion.
    - *If there is a problem go to pages 3-4 to 3-15, Steps 1 to 7.*
2. **Coolant system:**
    - For leaks
    - For correct system heating process. *Go to page 3-25, Steps 1 and 2.*
3. **Power supply system:**
    - For correct operation of the PROHEAT.

Filters:

1. **Fuel filter.** *Go to page 3-5, Step 2.*
2. **Air filter.** *Go to page 3-12, Step 6.*

Combustion chamber:

1. Remove the burner head and inspect the combustion tube and chamber for carbon build up. Clean as necessary using a wire brush.
2. Inspect and clean exhaust system. Ensure that the piping is not damaged.
3. Inspect and clean the ignition electrodes as necessary. *Go to page 3-18.*
4. Inspect and clean the flame sensor as necessary. *Go to page 3-20.*

⚠ WARNING

Shock hazard due to voltage.

Batteries:

Inspect and clean PROHEAT connections at the battery if applicable.

5.0 MAINTENANCE TOOLS

Minimum recommended tools.

1. PROHEAT remote switch (P/N PK0061)
2. Multimeter

Repair tools required:

- 5 mm – Allen wrench
- Small flat head screw driver
- 5/8″ wrench for nozzle removal
- Wire brush
- Standard wrench set

PROHEAT Serial Number:

Installation Date:

Dealer:

Teleflex Morse®
thermal technology
A Division of Teleflex Incorporated

Teleflex (Canada) Ltd.
3831 No.6 Road
Richmond, B.C.
Canada V6V 1P6

Tel: (604) 270-6899
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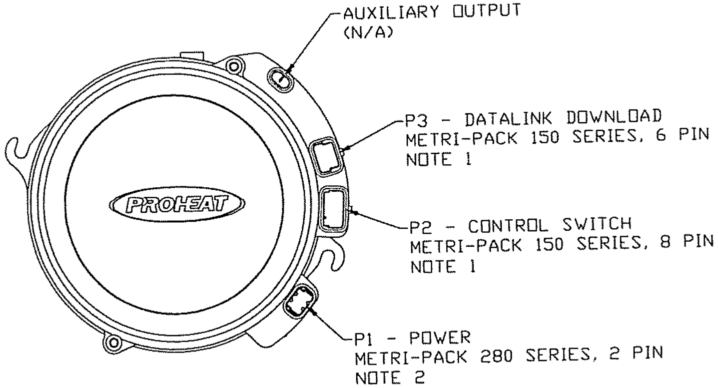
Toll Free: 1-800-667-HEAT(4328)
www.proheat.com

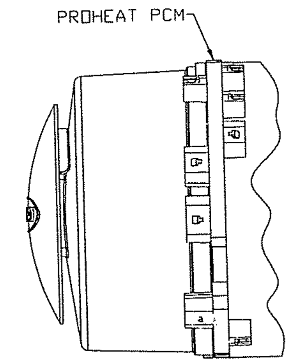
ISO 9001 QMI REGISTERED QUALITY SYSTEM

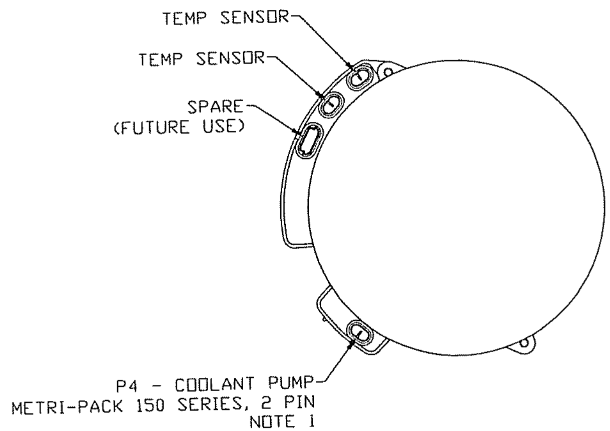
Designed and Manufactured in North America

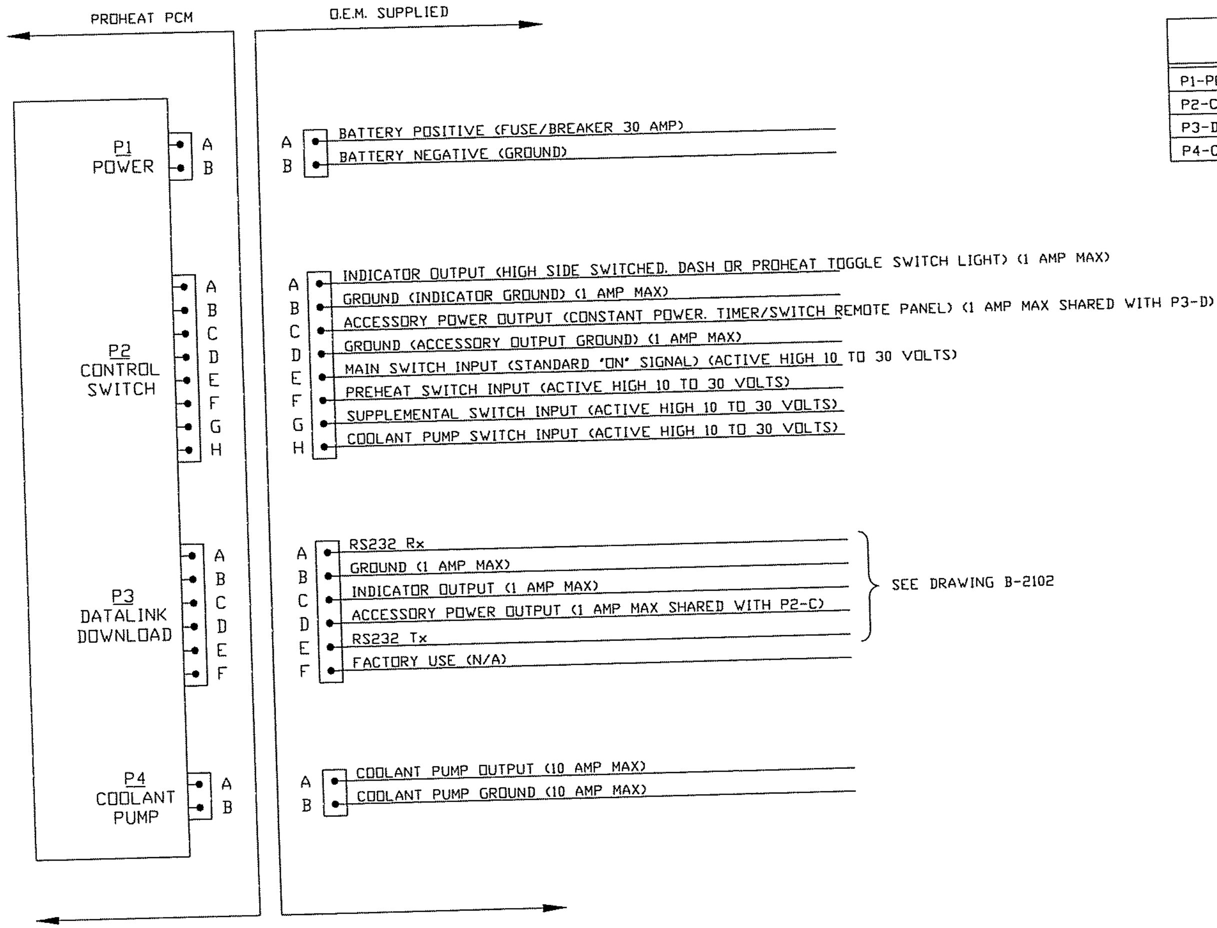
Printed in Canada

Part # SL9150 Rev. A









PCM CONNECTOR	CONNECTOR PART#	LOCK PART#	TERMINAL PART#	WIRE SEAL PART#	CAVITY SEAL PART#
P1-POWER	15300027	15300014	12077413	12015193	----
P2-CONTROL SWITCH	12047937	12066304	12048074	12048086	12059168
P3-DATALINK	12052848	12052850	12048074	12048086	12059168
P4-COOLANT PUMP	12052641	12052634	12048074	12048086	12059168

NOTES:

1/ 150 SERIES CONNECTOR ASSEMBLIES TO BE USED WITH 18AWG WIRE WITH MAXIMUM .1" INSULATION DIAMETER. WIRE MUST MEET OR EXCEED SAE J1128 GPT SPECIFICATIONS.

2/ 280 SERIES CONNECTOR ASSEMBLIES TO BE USED WITH 10AWG WIRE WITH MAXIMUM .161" INSULATION DIAMETER. WIRE MUST MEET OR EXCEED SAE J1128 TWP SPECIFICATIONS.

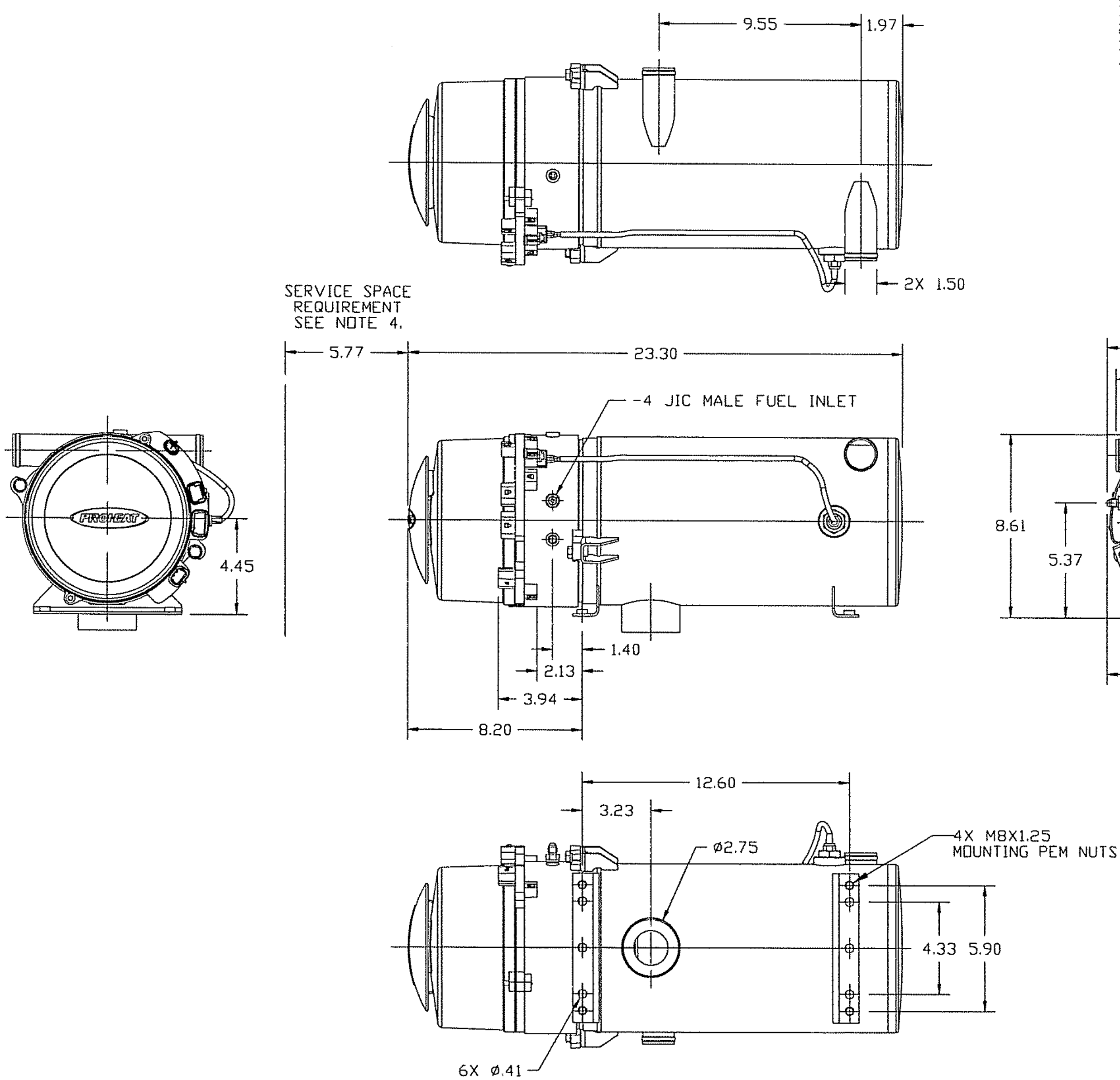
3/ ALL UNUSED CONNECTIONS ON THE PCM MUST BE PLUGGED (PROHEAT SUPPLIED).

PROTOTYPE ONLY
NOT FOR PRODUCTION

PROHEAT
THERMALTECHNOLOGY

TITLE: ELECTRICAL INSTALLATION	PRODUCT: M-SERIES
SCALE: NTS / THIRD ANGLE PROJECTION	DWG No. C-1297 / REV. 3
REVISED: 07/04/01	

NOTES
1/ DIMENSIONS ARE IN INCHES.
2/ HEATER DRY WEIGHT 63 LBS.
3/ TYPICAL EXHAUST CUTOUT 3.25" CENTERED ON EXHAUST.
4/ SERVICE SPACE REQUIRED TO REMOVE BURNERHEAT AND COMBUSTION TUBE FOR PERIODIC INSPECTION AND CLEANING.



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REV.	DESCRIPTION	BY	APP	D	M	Y
4	CHANGED TO GENERIC M80	KRB	-	05	06	01
3	ADDED SPLASHGUARD DETAIL	KRB	-	30	05	01
2	ADDED O/H AND FUEL FITTING	KRB	-	29	05	01
1	PROTOTYPE	KRB	-	03	04	01

DO NOT SCALE DRAWING
THIRD ANGLE PROJECTION

		D	M	Y
DIMENSIONS IN INCHES	DRN KRB	03	04	01
TOLERANCES .X. ±.030 " .XX. ±.010 " .XXX. ±.005 "	CHK			
	APP			
FRACTIONS 1/64" ANGLES ±1/2°	STANDARD FINISH N/A			

Teleflex (Canada) Ltd. RICHMOND, B.C.

TITLE: M80/105 HEATER OUTLINE-SPLASHGUARD

REF. ASS'Y DWG. –
P.I.D. No. –
SCALE 1:4
DWG No. C-1285
REV. 4

SERVICE BULLETINS

Service Bulletins are issued to supplement or supersede information in the Van Hool manuals. Note below number, date and subject of Bulletins pertaining to this chapter. File Bulletins separately by number for future reference.

Number	Date	Subject

CHAPTER 11

BODY AND ACCESSORIES

PAGE

BODY

PASSENGER DOOR

SEATS

GLASS/GLAZING

LAVATORY

HATCHES AND ACCESS DOORS

BODY

REPAIR

SKIN

Dents, punctures to the skin and cracked or otherwise damaged frame members can be repaired.

Check for dents with a straight edge at least 10 feet long. Inspect the plane for high and low spots. A gradual high or low spot of 1/4" or less need not be repaired.

To repair skin

Dents or slight punctures may be repaired with a repair compound such as 'Bondo".

1. Grind the area to establish a base.
2. Follow the manufacturer's instructions. Mix the compound into a thick paste.
3. Apply filler. Let harden.
4. Sand smooth and inspect for pits.

To replace skin

1. Cut the damaged area around the center of the frame members.
2. Spotweld the undamaged exposed edges of the skin to the frame.
3. Cut a replacement panel out of 19 gauge metal that is galvanized on both sides.
4. Clamp panel over back up material, stretch as necessary to remove wrinkles and assure close contact in all weld areas.
5. Tack at various points to close all gaps before spotwelding.
6. Spot or weld to frame.
7. Always apply sealer between rubber and plating.

NOTE
Pop rivets may be used as an alternative.

8. Other plates should be heated before welding.
9. Grind welds smooth and inspect area with straight edge.
10. Prepare for primer.

FRAME

To straighten bent frame members

1. Hook a 1/2" thick plate to the frame member and strike with a sledge.
2. If this does not straighten the frame member, apply heat and repeat step one.

NOTE
Do not use heat on components that carry great stress or are involved in alignment of the coach.

To replace frame members

1. Remove the damaged component at each weld joint.
2. Grind the old weld smooth and reweld the new member.

US1110AF

3. Use a straight edge to properly position and align the replacement component.

To rust proof frame tubes

Some frame tubes should be internally rust-proofed.

1. Use a spray tip with an outside diameter slightly smaller than the access holes.
2. Apply rust-preventive coating.
3. Insert a plug to seal the tube.

FIBERGLASS

Repair large holes with resin-reinforced fiberglass cloth. Repair small holes with resin and fiberglass filler paste.

Fiberglass cloth

1. Sand paint from damaged area.
2. Scrape undercoating from damaged area on underside of coach.
3. Wipe clean with solvent.
4. Grind or file damaged area into a "V" at the broken or cracked portion. Sides of "V" should have a shallow pitch for maximum bonding area.
5. If panelling is warped from original shape, use "C" clamps and improvised clamp plates to align surfaces.

NOTE
Roughening the surface improves adhesion of resin.

6. Preheat area using one or two heat lamps positioned 12 to 15 inches from repair.

!!! CAUTION !!!
200° F IS THE MAXIMUM TEMPERATURE FOR THIS MATERIAL. HIGHER TEMPERATURES CAN CAUSE MATERIAL DISTORTION OR CRYSTALLIZING.

7. Cut fiberglass with scissors or tin snips, 1 to 3 inches larger than area to be repaired.
8. Build up area to desired height.
9. Mix desired quantity of resin and hardener in proportions of half a tablespoon of M.E.K. catalyst hardener to one quart of vibrin 135 resin. Do not use wax cups for mixing and do not allow resin to enter hardener can or vice-versa. Mixture can be thickened by adding two tablespoons of powdered filler to one half pint of mix.
10. Saturate layers of fiberglass with mixture and place laminates over damaged area.
11. Smooth out bubbles and wrinkles with a roller, make sure general contour of area is maintained.

!!! CAUTION !!!
ONCE THE RESIN AND HARDENER HAVE MIXED, THE POT-LIFE IS 15 MINUTES. ANY ACCIDENTAL CONTAMINATION TO THE SKIN, CLOTHING, TOOLS, ETC. MUST BE REMOVED WITHIN THIS PERIOD. USE ACETONE TO REMOVE UNCURED RESIN.

12. Heat resin material again by placing lamps 12 to 15 inches from repaired area. Allow 12 to 15 minutes for repair to cure.

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13. After repair is cured, grind, file or sand to contour. Use files other than a body file.
14. Feather edge and finish sanding.
15. After repair, small pits or irregularities may appear. Repair using a liberal amount of chopped strand or filler mixed with resin to form a paste.

Fiberglass paste

Fiberglass paste is made by mixing resin, hardener and fiberglass strand or filler to consistency of putty.

1. Sand paint from damaged area.
2. Scrape undercoating from damaged area on underside of coach.
3. Wipe clean with solvent.
4. Preheat area using heat lamps.
5. Mix desired quantity of resin and hardener (refer to instructions on container).
6. Add powered fiberglass strand into mixture to thicken it to a putty state.

!!! CAUTION !!!
IF REPAIR IS TO BE MADE ON VERTICAL SURFACE, ADDING POWDERED FILLER TO MIXTURE WILL REDUCE TENDENCY OF HOT RESIN TO RUN.

7. Apply the material with a putty knife or similar object, building material up to desired contour.
8. For deep filling or on vertical surfaces, several layers may be used.
9. To remove excess resin, hold a hack-saw blade flat to adjacent contour and pull across the repair with a sawing motion when the resin is in the jell stage.
10. Finish repair in same manner as when using fiberglass cloth.

!!! CAUTION !!!
THE TECHNICAL INFORMATION AND SUGGESTIONS FOR USE ARE BASED ON SIKKENS RESEARCH AND EXPERIENCE AND ARE BELIEVED TO BE RELIABLE, BUT SUCH INFORMATION AND SUGGESTIONS DO NOT CONSTITUTE A WARRANTY. NEITHER SIKKENS NOR VAN HOOL HAS CONTROL OVER THE CONDITIONS UNDER WHICH THE PRODUCT IS TRANSPORTED, STORED, HANDLED, USED OR APPLIED. HENCE, COACH OPERATORS MUST DETERMINE FOR THEMSELVES, DOING PRELIMINARY TESTS, WHETHER THE PRODUCT IS SUITABLE FOR THEIR OWN PARTICULAR PURPOSES. IF TECHNICAL ASSISTANCE IS NEEDED, CONTACT YOUR NEAREST SIKKENS DEALER AND / OR VAN HOOL SERVICE CENTER.

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TO PAINT

SPOT REPAIR (NOT DASHBOARD)

Spot repair includes all repairs to damaged areas resulting in the repaired area blending invisibly into the intact finish.

Preparation

Prepare the area to be repaired by shaping and building it up with appropriate body putty or fiberglass products. Then sand the area, and extend the sanding into adjacent areas, using a feathering technique.

Using Autocryl, standard method

1. Sand with #500-#600 grit paper, using a wet sanding technique.
2. Clean and degrease the area. Degrease with M600. Use a sillicon-free compound to clean the area, then degrease again.
3. Apply single coats of autocryl until the entire area is covered. Allow 5 to 10 minutes between the coats. Fade each coat into the surrounding area, extending the faded area further each time.
4. After each application, remove dry overspray with a tack rag.
5. For a high gloss finish, mix Autoclear/Autocryl Clear (100 parts by volume) with 1,2,3 Hardener/ Autocryl Hardener (50 parts by volume) and Autocryl/Non-stop Reducer (200 parts by volume).
6. For a low gloss level, use Autocryl Non-Stop Reducer. Let the Autocryl set for 5 to 10 minutes, then use the Reducer to dissolve overspray.
7. At least 10 minutes after the last application of Autocryl, apply one coat of Autoclear/Autocryl Clear (100:50:200) on the overspray. Allow it to flash off for 2 to 3 minutes. Apply one or two single coats of the same mixture over the entire panel being repainted. Extend the spray well past the repainted area. The higher the gloss level desired, the more coats that should be applied.

Using Autocryl, other methods

Method 1:

This is the easiest application, with the best air drying capability.

1. Mix in the following proportions: Autocryl (100 parts by volume), 1,2,3 Hardener/Autocryl Hardener (50 parts by volume) and Autocryl Accelerator 885 (50 parts by volume).
2. Thinning with Autocryl Accelerator 885 slightly changes the nature of Autocryl, making it a refinish paint for spot repairs.
3. For solid colors, add an extra 100% Autocryl Non-Stop Reducer coat. Prior to the second and additional mist coats, add another 100% Autocryl Non-Stop Reducer.
4. For metallics, before the mist coat, add 30% Autocryl Non-Stop Reducer. Mist coat until fade-out is complete. Dissolve edge of Autocryl Non-Stop Reducer or wait at least 10 minutes and dissolve edge with Autoclear/ Autocryl Clear (100:50:200).

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Method 2:

This gives the best hardening for air drying or baking.

1. Mix in the following proportions: Autocryl (100 parts by volume), 1,2,3 Hardener/Autocryl Hardener (50 parts by volume) and Autocryl Temp-o-actif (30 parts by volume).
2. Reducing with Temp-o-actif results in faster hardening.

NOTE
Never add extra Temp-o-actif. Dissolve edge with Autocryl Non-Stop Reducer.

3. For solid colors, add an extra 100% Autocryl Non-Stop Reducer before the mist coat. Before applying the second and further mist coats, add another 100% Autocryl Non-Stop Reducer.
4. For metallics, do not add extra Reducer. Dissolve overspray with Autocryl Non-Stop Reducer.

Method 3:

This is for baking or for air drying.

1. Mix in the following proportions: Autocryl (100 parts by volume); 1,2,3 Hardener/Autocryl Hardener (50 parts by volume) and 1,2,3 Reducer Slow (30 parts by volume).
2. For solid colors, add an extra coat of 100% AC Non-Stop Reducer. Add another coat of 100% AC Non-Stop Reducer before the second and additional mist coats.
3. For metallics, do not add extra amount of Reducer. Dissolve overspray with Autocryl Non-Stop Reducer.

NOTE
The extra amounts of reducer to be added for fading out should be based on the amount of paint already mixed for the spraying application.

<u>Using Autobase metallic, standard process</u>

Use the following procedure to repaint 2-step metallic paints:

1. Sand the area with #600 grit paper, using a wet sanding technique.
2. Degrease the area with M600. Use Scotch Brite Grey #7448 or a similar product to roughen the area. DO NOT USE A COMPOUND. Then degrease the area again.
3. To lay down the base coat, spray one medium coat of Autobase Metallic. Allow 2 to 5 minutes for flash off.
4. Spray the area until sufficient paint has been applied.
5. Lower air pressure to 15 to 20 psi and fade out the new paint.
6. Remove dry overspray between the coats, using a tack rag.
7. After the paint has dried, the fade out area may be polished with Commandant #7.

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Using Autobase Metallic, alternative process

1. Sand the area with #600 grit paper, using a wet sanding technique.
2. Degrease the area with M600. Use Scotch Brite Grey #7448 or a similar product to roughen the area. DO NOT USE A COMPOUND. Then degrease the area again.
3. Prior to applying Autobase Metallic, spray a medium coat of Basefix mixed with 200% Autocryl Non-Stop Reducer (no hardener).
4. Allow at least 5 minutes for flash off. To lay down the base coat, spray one medium coat of Autobase Metallic. Allow 2 to 5 minutes for flash off.
5. Spray the area until sufficient paint has been applied.
6. Lower air pressure to 15 to 20 psi and fade out the new paint.
7. The fade out area may be polished with Commandant #7 after the paint has dried.

Using Autobase Metallic, clear coat

1. After 15 to 20 minutes, tack the entire repainted area.
2. Mix Autocryl Clear (100:50:30). Apply 3 medium coats. Allow 5 to 10 minutes for flash off after each coat.
3. If possible, spray the entire panel. If not, fade out the Autocryl Clear by adding extra amounts of Autocryl Non-Stop Reducer.
4. If necessary, use a kitchen cleaning compound such as Cornet, on a wet sponge or use Scotch Brite #98, to prepare the area surrounding the painted surface.

To polish

Minor repair or removal of dirt and scratches can be accomplished through polishing.

NOTE
The system can be used 24 hours after baking or 72 hours after air drying.

1. Wet sand with 3M #1500 Imperial micro wet or dry paper.
   Polish the sanded area using 3M #6031 micro finishing compound (the recommended polishing pad is 3M #5700 super buff pad).

3. Using the oppositie side of the super buff pad, remove swirl marks and produce a high luster with 3M #5928 Finesse-It-2.

4. Final polish with 3M #5705 polishing pad and 3M #5939 liquid polish.

APPEARANCE CARE

COACH EXTERIOR

General washing

1. To keep the lacquer finish in the best condition, pre-wash with lots of water and a soft synthetic brush. This will remove any sand or rough particles that might damage the finish during the complete wash.

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2. Give the coach a complete wash with a mild liquid soap, using a sponge or brush. Do not use alkaline or powdered soaps.
3. Rinse thoroughly to remove all soap residue. Soap residue can damage the finish over time.
4. Dry the vehicle with a chamois.

To clean / remove tar

Use denatured alcohol and a soft rag. Rub lightly to prevent scratching the finish with any abrasive particles that may be stuck to the coach. Always wash and dry the coach after tar removal.

Underneath the coach

Clean the underside every spring to remove the build-up of mud and salt from winter. Use a high-pressure washing facility.

!!! CAUTION !!!
USE COLD WATER AND NO DETERGENT. HOT WATER AND/OR DETERGENTS CAN HARM THE PROTECTIVE OIL COAT ON THE BOTTOM OF THE COACH. THE PROTECTIVE OIL COAT SHOULD BE RENEWED EVERY TWO YEARS. USE VALVOLINE OR SIMILAR PRODUCTS.

Aluminium trim

Clean the anodized aluminium trim with synthetic non-abrasive neutral products. Do not use sodium, ammonia, chlorohydric acid or phosphoric acid. To remove stubborn particles, use a non-abrasive scrub pad like the 3M Scotch Brite. Do not use steel wool.

Persplex (plastic)

Persplex products can be cleaned and then dried with a chamois. Do not use solvents like paint thinner on persplex. Light scratches can be removed with household polish.

Rust prevention

1. Wash the vehicle frequently. Check for chips in the paint.
2. Touch-up any problem immediately.
3. Repair all damage due to accidents as quickly as possible.

Automatic washing facility

To remove mirrors

NOTE
Before washing the coach in an automated washing facility, remove the outside mirrors, close the ventilation flaps and switch off the HVAC system.

1. Disconnect power plug.
2. Pull up and remove mirror and arm.
3. To remove mirror alone, loosen set screws and back of mirror.

To wash coach

1. Pre-wash with lots of water and a soft synthetic brush. This will remove any sand or rough particles that might damage the lacquer during the complete wash.

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2. Center the coach so that all brushes will press equally during the wash.

3. Make certain the brushes are in good shape and keep the brushes moving in relation to the coach so that no coach surface gets excessive brushing.

4. Use liquid soap as needed.

5. Move the coach as necessary to make certain the brushes reach all areas.

6. Rinse thoroughly to remove all soap residue. Soap residue can damage the lacquer finish.

7. Dry vehicle with a chamois.

!!! CAUTION !!!
WHEN USING A HIGH-PRESSURE CLENAING FACILITY, KEEP THE TEMPERATURE BELOW 158°F AND THE WATER PRESSURE BELOW 711 PSI

COACH INTERIOR

Seats

Brush or vacuum seats weekly. Remove stains as quickly as possible. Use carpet or upholstery cleaner for normal stains and spot remover for difficult stains. Fabric can be cleaned with lukewarm water and mild soap. Use light sponge or brush movements to remove soil. Remove the soap and dirt with a clean damp sponge or cloth, and rub the surface several times with a dry towel. Brush the damp fabric with a fairly hard brush. Then brush it again when the fabric is dry. Always clean, dry and brush the fabric with the grain of the fabric, never rub across the grain.

The look of the fabric seats can be revitalized with steam. Spread a wet linen, such as a sheet or hand towel, on the seat and iron with a hot steam iron. The steam will penetrate the fibers and make them stand upright. While the fabric is wet, rub it with a hard brush. Then brush it again when the fabric is dry. Do not use hot water, colored gasoline solutions or decolorized solutions like chloride of lime, cloric water or oxide water on fabric.

Synthetic covering (vinyl)

Clean synthetic covering from time to time with mild soap and water. Rinse with vinegar and water. Stubborn stains can be removed with alcohol. Before starting, always test a small area with any cleaning solution to check for discoloration.

To keep the synthetic material supple, sponge it with a mixture of 1 gallon of water, a handful of salt and 1 1/2 cups of milk. Do not rinse. Dry with a chamois.

Crepe headrest covers

Hand or machine wash in warm water (below 90°F) with a mild detergent. Rinse well and drip dry. Do not wring or spin dry. Do not use bleach or fabric softener.

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Arm rest

To adjust arm rest

Use the hexagonal tool provided or an appropriate hex driver.

1. To loosen the armrest, turn screws clockwise.

2. To tighten arm rest, turn screws counterclockwise.

To replace arm rest

1. Remove screws by turning clockwise until the armrest comes off.

2. Remove arm rest. Replace with new armrest.

3. Reinstall by turning screws counterclockwise.

FABRIC CARE RECOMMENDATIONS

!!! CAUTION !!!

THESE ARE RECOMMENDATIONS ONLY. ALWAYS TEST THE CLEANING METHOD ON SCRAP FABRIC OR AN INCONSPICUOUS SPOT FIRST.

TYPE OF STAIN	CLEAN-UP
Beer, wine, chocolate, soft drinks, sauce	Lukewarm detergent for delicate fabrics, applied with a damp cloth and sponged up.
Blood, eggs, other proteins	Use cold water, first trying to dab it up, then drenching the fabric, if necessary.
Paint/fat products	Lukewarm detergent for delicate fabric, applied with damp cloth. Use turpentine or gasoline, soak cloth in cleaner, then wipe off stain. Rinse with water.
Coffee, tea	Use household soap or plain water. Gently wipe with damp cloth, then rinse.
Chewing gum	Use a chewing gum remover. Spray it on, then carefully scrape the gum off.
Ink	Use a gasoline-soaked cloth. Dab gently on stain.
Lipstick, shoe polish, soup	Use detergent for delicate fabrics, applied with a damp cloth. Soak and rinse.
Urine	Try baking soda in lukewarm water. Use a damp cloth and rinse thoroughly.

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PASSENGER DOOR

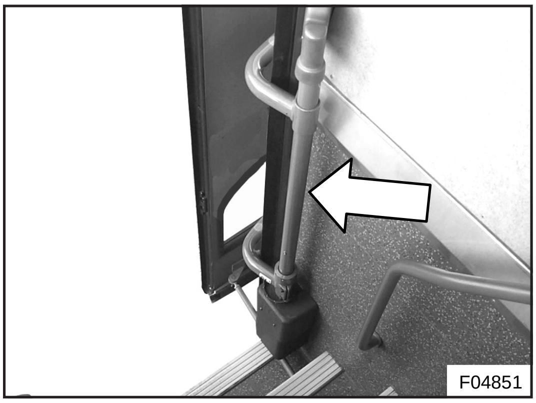

Figure 1: Passenger door mechanism

OPERATION OF DOOR MECHANISM - Figure 2

The passenger door is an one-panel, outward swinging type door. The door is powered by a double acting air cylinder which drives spiral grooved shaft (4) within spiral grooved door-pillar tube (10). This design converts the straight-line motion of air cylinder piston (1) into a rotary motion of door-pillar tube (10). Ball bearing cage assembly (5) insures a smooth rotating operation.

The lower part of the spiral grooved shaft (4) is cut in a straight spline which mates with the straight spline within bearing hub (3). This insures the shaft will run straight up and down, and safeguards against the torsion of the rotating action.

Once the door reaches the fully closed position, the rotary motion of the door-pillar tube is converted into a lifting motion. As the door panel is lifted, wedge type cam locks are wedged together, locking the door into place. The reverse operation takes place when the door is opened.

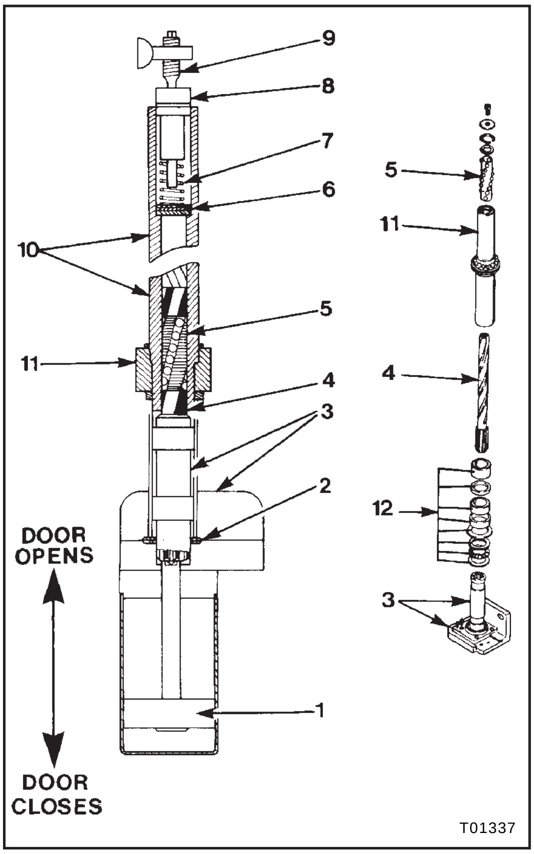

Figure 2: Door opening mechanism

1. **Piston**
2. **Needle bearing assembly**
3. **Bearing hub**
4. **Shaft (spiral grooved)**
5. **Ball bearing cage assembly**
6. **Space washers**
7. **Tension spring**
8. **Pressure plug**
9. **Pivot pin (adjustable)**
10. **Upper door pillar**
11. **Coupler nut**
12. **Bushings, seal, washers**

The lifting action of the door will also take place any time the door is blocked during the closing or opening cycle. A safety re-open switch will be activated during this lifting action and will cycle the door solenoid valve.

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DOOR CONTROLS

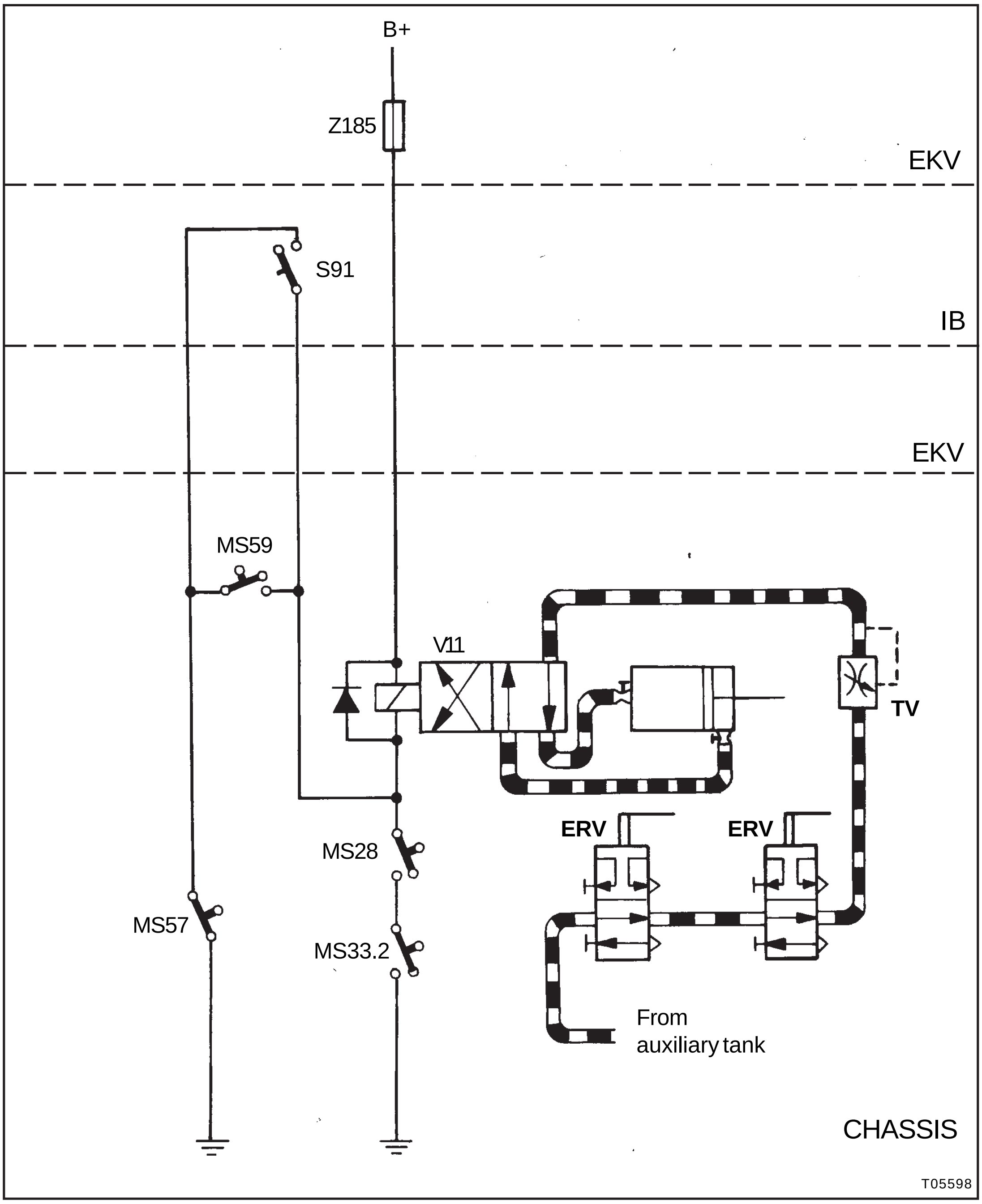

Figure 3: Door controls

EKV : Main junction box

IB : Instrument panel

B+ : Power supplied directly from battery

ERV : Emergency release valve

MS28 : Safety re-open switch

MS33.2 : Safety off switch

MS57 : Bolt lock switch

MS59 : Door open/close switch (on door handle)

S91 : Door open/close switch (on instrument panel)

TV : Throttle valve

V11 : Door solenoid valve

Z185 : Circuit breaker

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DOOR SWITCHES

The door is operated from inside the coach by a momentary push-button located on the right-hand instrument panel (see Figure 4). Operation of the door from outside is accomplished with the momentary push-button on the door control panel (see Figure 5).

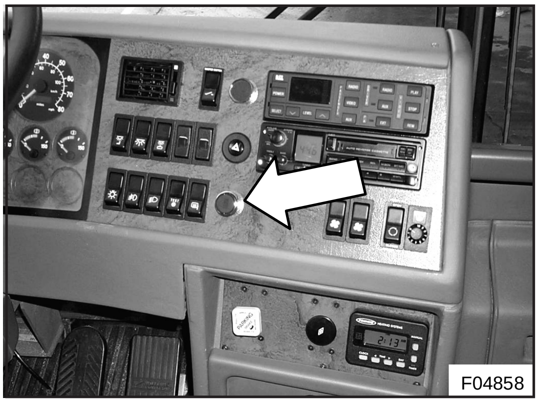

Figure 4: Door open/close push-button on the instrument panel

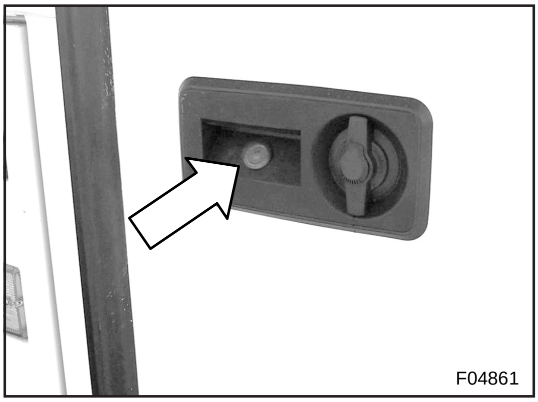

Figure 5: Door open/close push-button on the door leaf (at the outside of the coach)

DOOR SOLENOID VALVE

The door solenoid valve is located under the right-hand dash. To gain access to the door solenoid valve:

1. Remove the four screws of the central dash panel (see Figure 6). Take away the central dash panel.

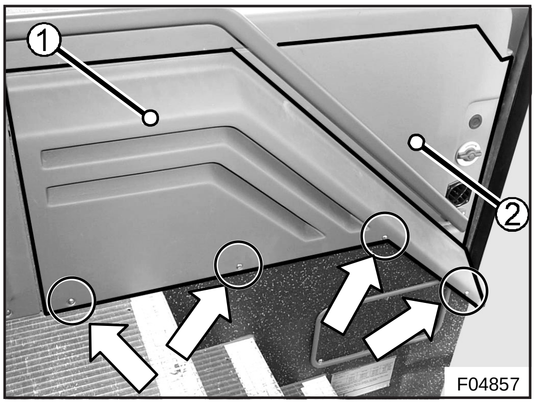

Figure 6: Dash panels at righ-hand side of entrance

1. **Central dash panel (arrows show mounting screws of central dash panel)**
2. **Right-hand dash panel**

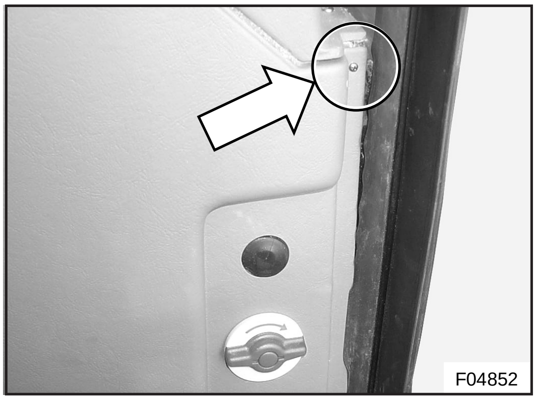

Figure 7: Screw at the upper right corner of the right-hand dash panel

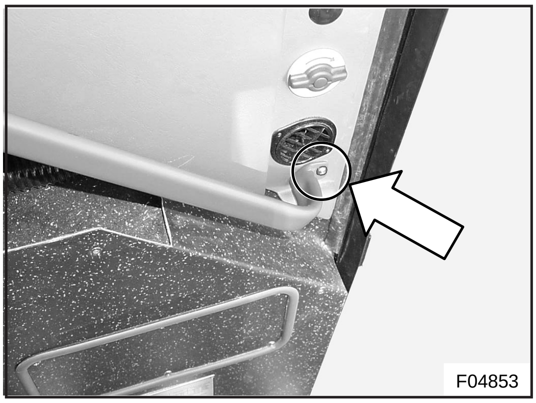

Figure 8: Mounting screw of grip bar

2. Remove the screw of Figure 7 and the screw securing the grip bar to the dashboard (see Figure 8).

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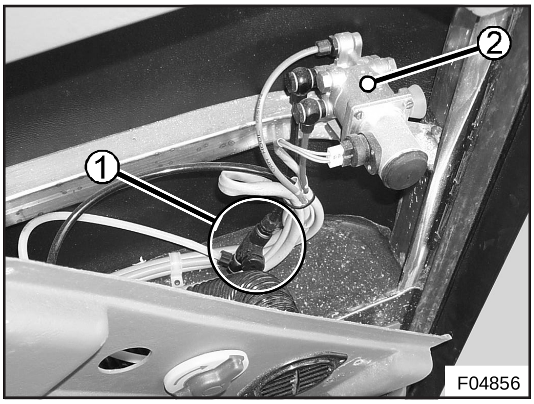

Figure 9: Door control components behind right-hand dash panel

1. Throttle valve
2. Door solenoid valve

3. Pull the grip bar away from the dash panel and slide the panel aside. The door solenoid valve and the throttle valve are now accessible.

The purpose of the solenoid valve is to alternately pressurize and exhaust door cylinder.

NOTE
The solenoid valve is designed for momentary switching only. A constantly closed electrical circuit can damage solenoid.

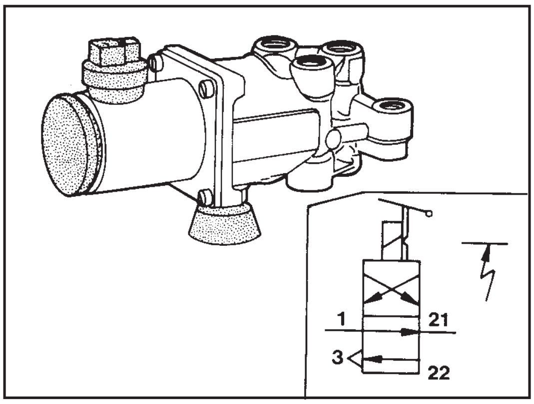

Figure 10: Door solenoid valve

Operation - Figure 11

Compressed air flows from the auxiliary tank through port (1) into the solenoid valve. The compressed air then flows through open inlet valve (11) and port (22) to the door cylinder. The door is closed in this valve position.

When current is supplied to solenoid (3), armature (2) moves downward and pushes plunger (4) onto rocker (5). Rocker (5) tilts onto tappet (6), which causes inlet valve (8) to open. The release of tappet (9) opens outlet valve (10). The supply air flows through port (21) to the door cylinder. Simultaneously, port (22) is exhausted through opened outlet valve (10) into the atmosphere. Thus the force acting upon the door cylinder piston is reversed, opening the closed door. Interruption of the current supply to solenoid (3) causes a spring to push armature (2) upward again to its neutral position.

To close the door, current is supplied again to solenoid (3). This causes armature (2) to move downward and plunger (4) pushes rocker (5) into its original position. Tappet (9) closes outlet valve (10) and opens inlet valve (11). Compressed air passes through port (22) to the door cylinder. Simultaneously, port (21) is exhausted through opened outlet valve (7) into the atmosphere. Thus the force acting upon the door cylinder piston has been reversed again, closing the open door.

If the current supply is interrupted, the solenoid valve can also be hand operated by pressing down on armature (2).

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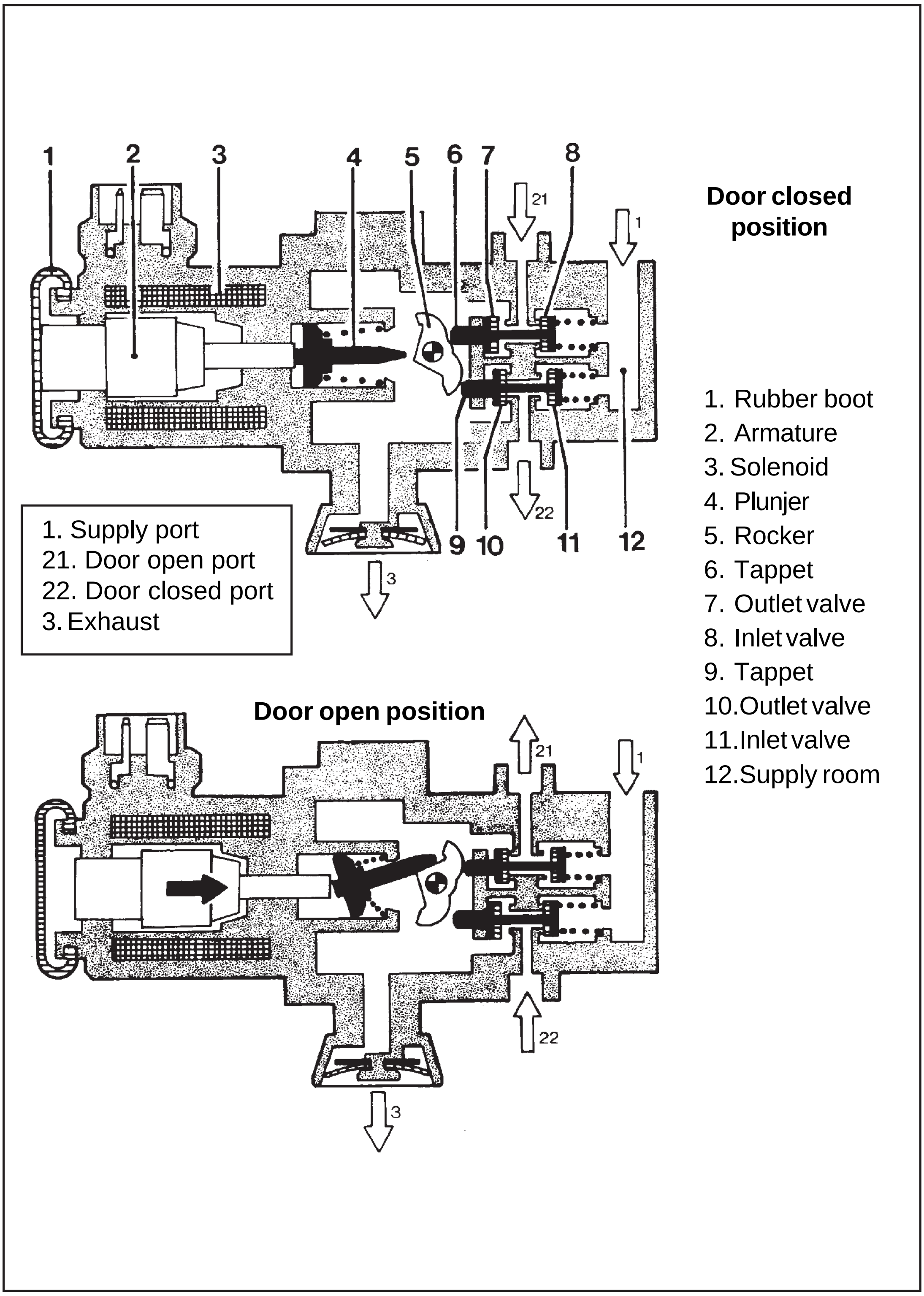

Figure 11: Section through door solenoid valve

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MICROSWITCHES

On door cylinder- Figure12

Anytime the door is blocked during its movement, the lifting action will take place. The safety re-open switch (MS28) will then be activated and will cycle the door solenoid valve.

As the door is near the fully closed position, the safety re-open function is turned off by the safety off switch (MS33.2).

On door handle- Figure 13

When bolt locks are in the lock position, door lock safety switch (MS57) opens the circuit so that the door cannot be operated.
The door open/close switch(MS59) makes contact each time the push button is pushed. This cycles the door solenoid valve to open and close the door.

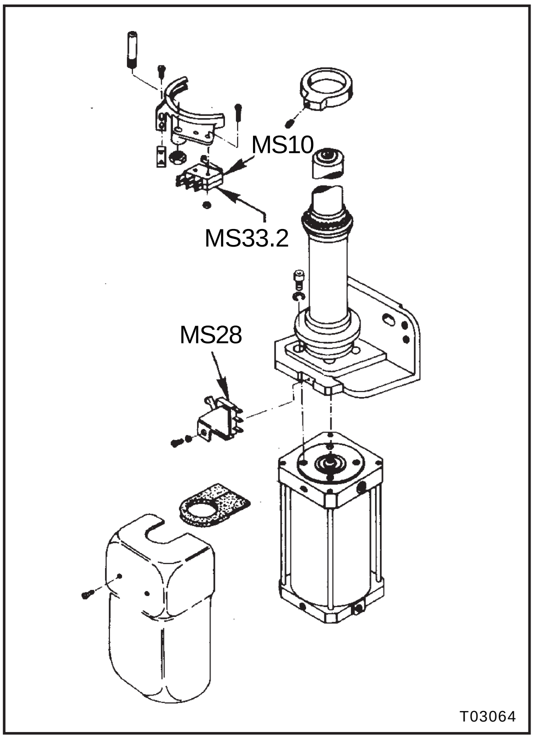

Figure 12: Microswitches on door cylinder

MS10 : Step light switch
MS33.2 : Safety off switch
MS28 : Safety re-open switch

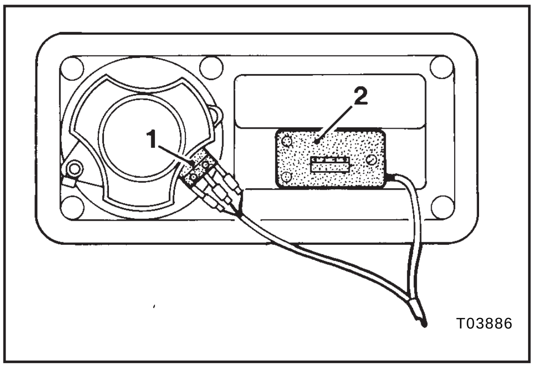

Figure 13 : Microswitches on door handle

1. Door lock safety switch (MS57)
2. Door open/close switch (MS59)

THROTTLE VALVE

The throttle valve is a differential pressure regulator. Its purpose is to prevent door slamming, when the air system is recharged with the emergency release valve.
Settings have been determined by the manufacturer. However, adjustments can be made by removing the plastic cap and turning the adjusting screw. Clockwise will increase the time needed for repressurization and counter-clockwise will decrease the time. The throttle valve is located in the

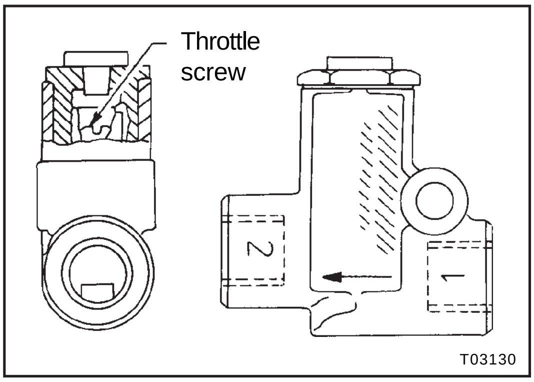

Figure 14 : Throttle valve

1. **Supply**
2. **Delivery**

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air supply line near the door solenoid valve and is accessible as explained under "Solenoid valve" heading.

EMERGENCY RELEASE VALVES

The purpose of the emergency release valves is to depressurize the door system, in case of electrical malfunction, so that the door can be opened or closed by hand. Inside and outside valves are plumbed in series in supply line for door solenoid valve.

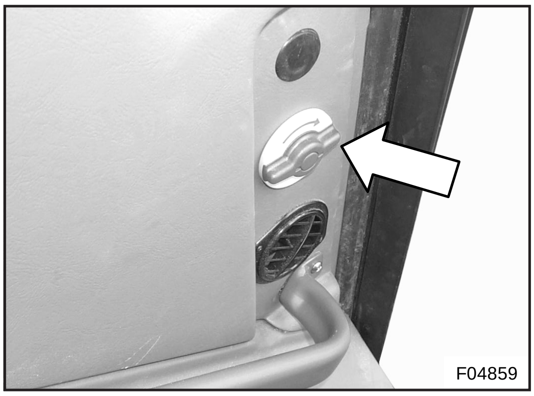

Figure 15 : Emergency release valve at the inside

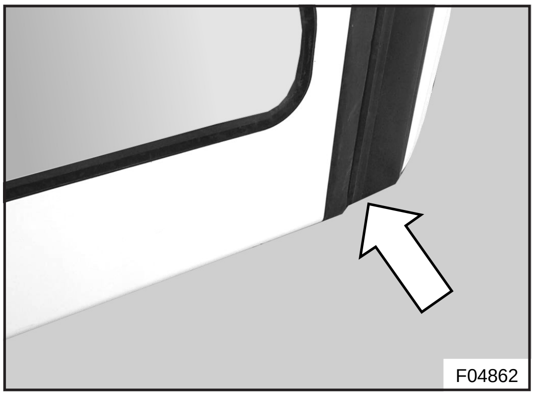

Figure 16 : Emergency release valve at the outside

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DOOR STEP LIGHT CIRCUIT

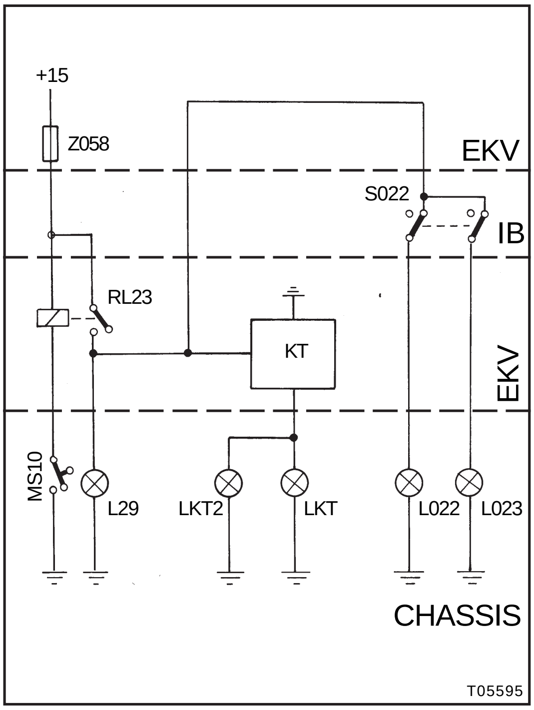

Figure 17 : Step light electrical circuit on early vehicles

+15	**:**	**Power supplied with ignition on**
EKV	**:**	**Main junction box**
IB	**:**	**Instrument panel**
KT	**:**	**Flasher unit**
L22	**:**	**Spotlight in roof**
L23	**:**	**Spotlight in roof**
L29	**:**	**Light below entrance**
LKT	**:**	**Red flashing stair light**
LKT2	**:**	**Red flashing "Watch your step"**
MS10	**:**	**Step light switch**
RL23	**:**	**Step light relay**
S022	**:**	**Driver's light switch**
Z058	**:**	**Circuit breaker**

MICROSWITCH (MS10)

Refer to Figure 12 for location of step light switch (MS10).

FLASHING UNIT (KT)

The flashing unit is located in the main junction box.

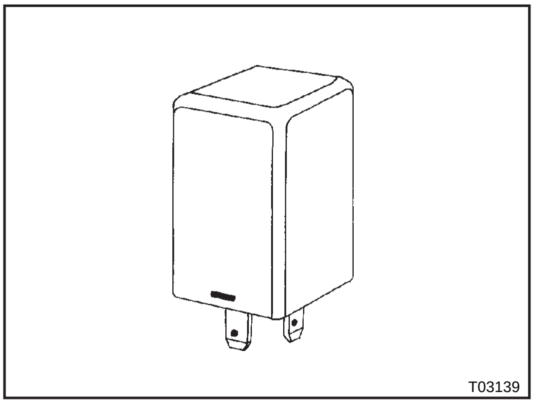

Figure 18 : Flashing unit

LOCATION OF STEP LIGHTS

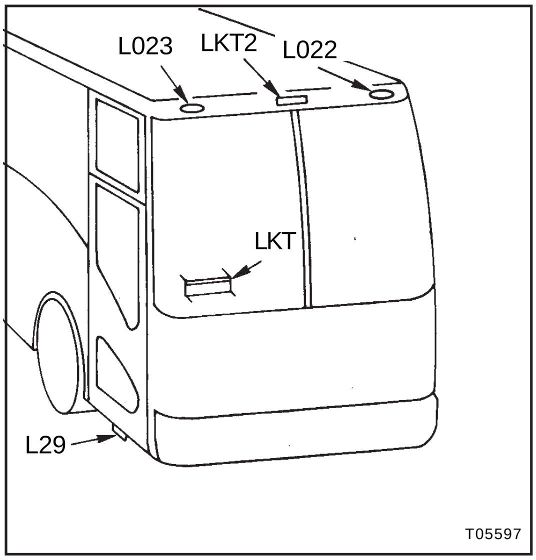

Figure 19 : Location of step lights

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MAINTENANCE

TO CHECK SAFETY RE-OPENING SYSTEM

At approximately halfway through the closing cycle, carefully block the door by hand. Within about two seconds, the door should re-open automatically. If it does not, check the safety re-open switch adjustment as described further in this section.

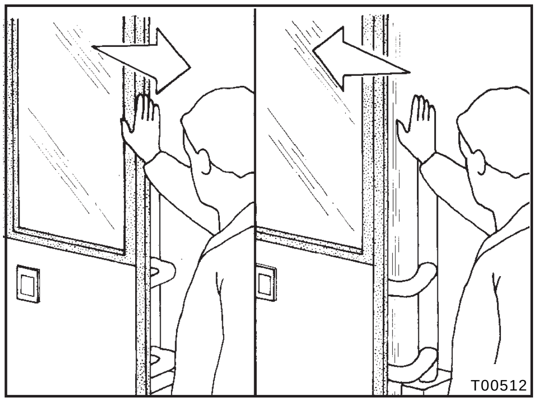

Figure 20 : To check safety re-opening system

TO APPLY VASELINE TO LOCKING CAMS- Figure 21

Apply a light film of vaseline to the sliding surfaces of the locking cams on the door posts and leaf.

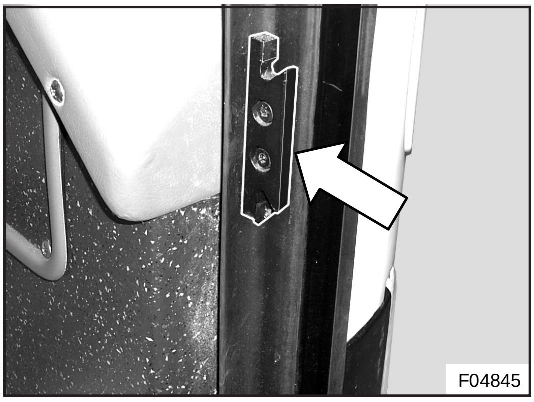

Figure 21 : Locking cam on door post

TO LUBRICATE

See chapter 12 for recommended grease.

Door pillar

Lubricate the "pin type" grease nipple located on the door pillar tube, 3 to 5 strokes with a hand grease gun. A pin-type grease gun adaptor (Van Hool Part No. 639901610) or similar tool is required. Do not use other grease than the prescribed type.

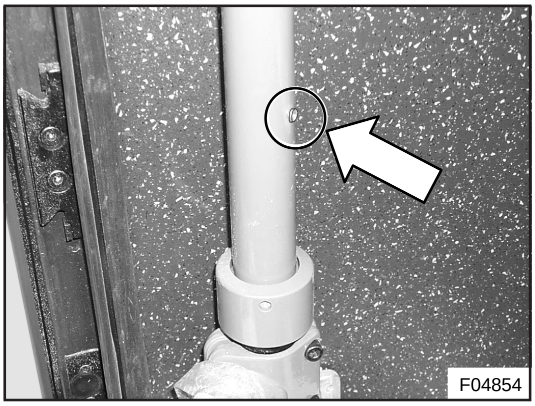

Figure 22: Grease nipple on door pillar

Guide rod end

The guide rod end is fitted with a grease nipple.

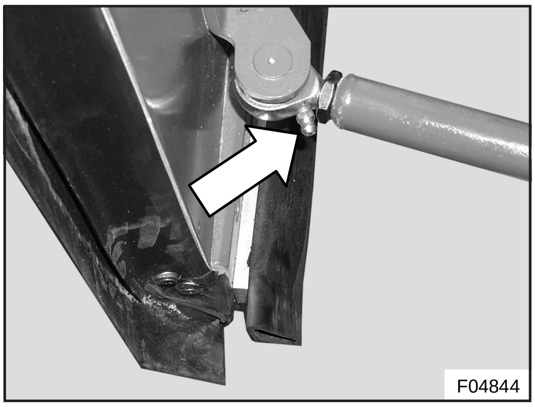

Figure 23: Grease nipple on guide rod end

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TO PRESERVE RUBBER DOOR SEALS

The rubber seals will not harden as easily if you treat them with a silicone spray at monthly intervals. Do not forget the inside of the seals on the door leaf: the inside must be able to slide smoothly along the door posts while the door leaf moves upwards. Do not use Vaseline, as this product will freeze in winter, causing the rubber seals to rupture.

TO CHECK DOOR OPENING/ CLOSING TIME

While checking, maximum pressure of 115 to 130 psi must be maintained in the air tanks. Measure the duration of the door movement with a stop watch. Door opening/closing time should be 4 to 5 seconds.

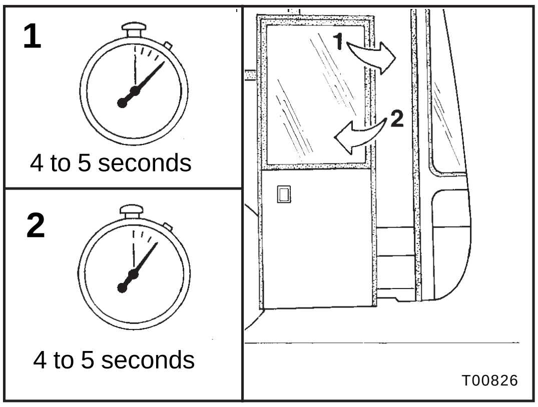

Figure 24 : To check door opening/closing time

ADJUSTMENTS

DOOR OPENING/CLOSING TIME

The door cylinder has four adjustment screws: one pair is for adjusting the door leaf movement speed, the other pair for adjusting end damping (slowing down the door leaf towards the end of the movement to avoid door slamming). To have access to the adjustment screws, first remove the plastic protection cover from the door cylinder. While adjusting maximum pressure (115 to 130 psi) must be maintained in the air tanks.

First, rotate counterclockwise both end-damping adjustment screws 1/8 to 1/4 turn at the most and adjust the door movement speed as follows.

- The door leaf moves too slow: rotate the door speed adjustment screw counterclockwise 1/4 turn at a time until the door movement speed is correct.
- The door leaf moves too fast: rotate clockwise the door speed

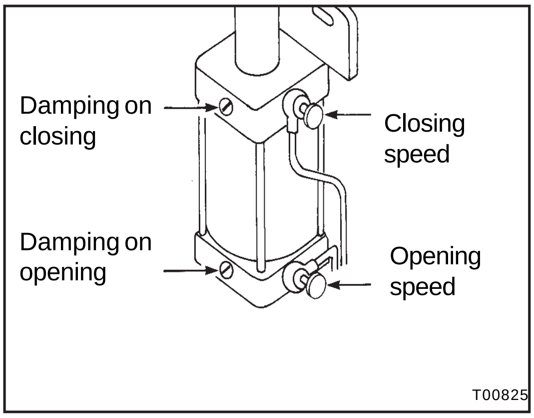

Figure 25 : Adjustment screws on door cylinder (Protective cover of cylinder removed)

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adjustment screw 1/4 turn at a time until the door movement speed is correct.

To increase damping: turn screw clockwise.

To decrease damping: turn screw counterclockwise.

MICROSWITCHES ON DOOR CYLINDER

Safety re-open switch - Figure 26

The switch is activated by adjustable plastic cam (2).

Adjusting the cam consists of loosening two screws (1) and sliding the cam up or down to the proper position. The switch should be activated when the door pillar has lifted to a maximum of 1/4".

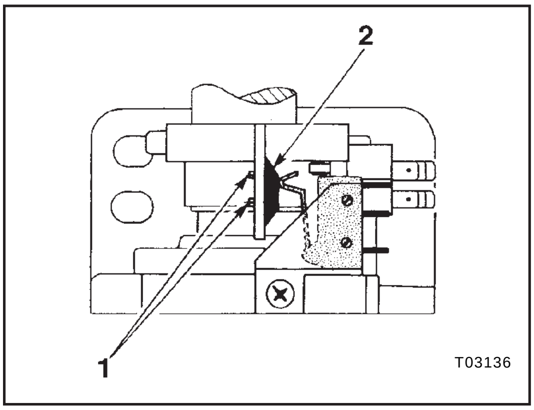

Figure 26 : Safety re-open switch adjustment

Safety off switch and step light switch - Figure 27

The safety off switch and the step light switch are activated simultaneously.

The switches are activated by adjustable cam (1). The switches should be activated when the front edge of the door just meets the door frame.

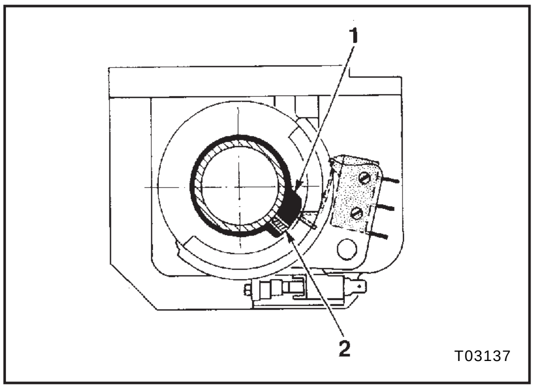

Figure 27 : Safety off switch and step light switch adjustment

MICROSWITCHES ON DOOR HANDLE

No position adjustment can be done. For location of switches, see figure 13.

DOOR PILLAR TENSION SPRING

Proper spring tension exists when circular groove (A) is flush with the top edge of the door pillar tube when the door is open. To adjust the spring pressure use pivot pin(1).
Increase spring tension by screwing clockwise. Decrease spring tension by screwing counterclockwise.

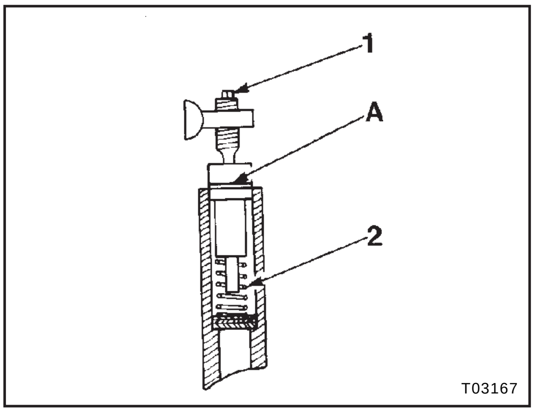

Figure 28 : Door pillar tension spring adjustment

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LOCKING CAMS

Check cam positions by exhausting air pressure from the system with the emergency release valve. Then close the door manually.
With the door closed, but not yet lifted, there should be a vertical clearance of 0.04 to 0.08 " between the cams (2 and 4) on the door leaf and catches (1 and 3) on the door posts.
(See Figure 30 for number reference.)
To adjust the cam position, loosen the holding screws of cams (2 and 4) and move the cam until the clearance is within the limits. Retighten the holding screws to a torque of 16 to 17 ft.lbf.

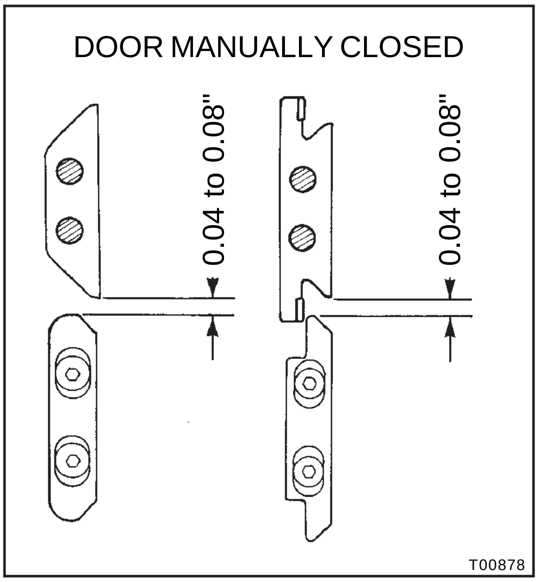

Figure 29 : Locking cams adjustment

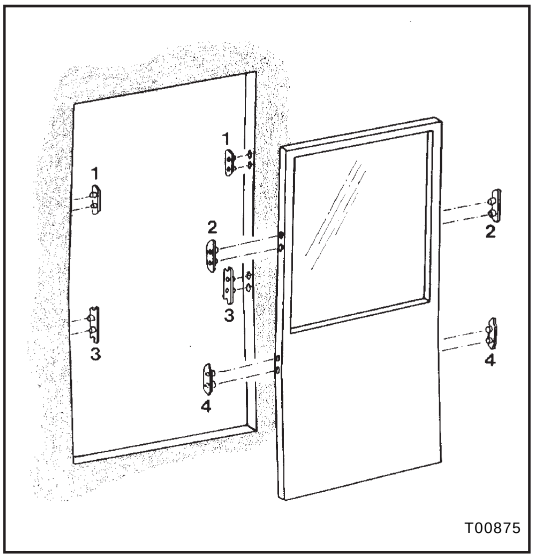

Figure 30 : Locking cams on door posts and leaf

It is very important to make sure all four wedge cam locks are adjusted equally. If one lock is out of adjustment, the door will rattle.

Close the emergency release valve and operate the door. The door should lift 0.23 to 0.39" at the end of the door closing movement.

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DOOR LEAF

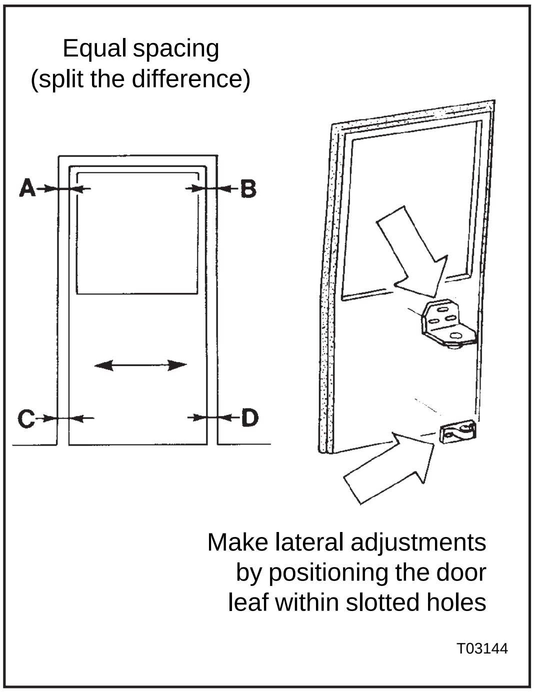

Figure 31: Lateral adjustment

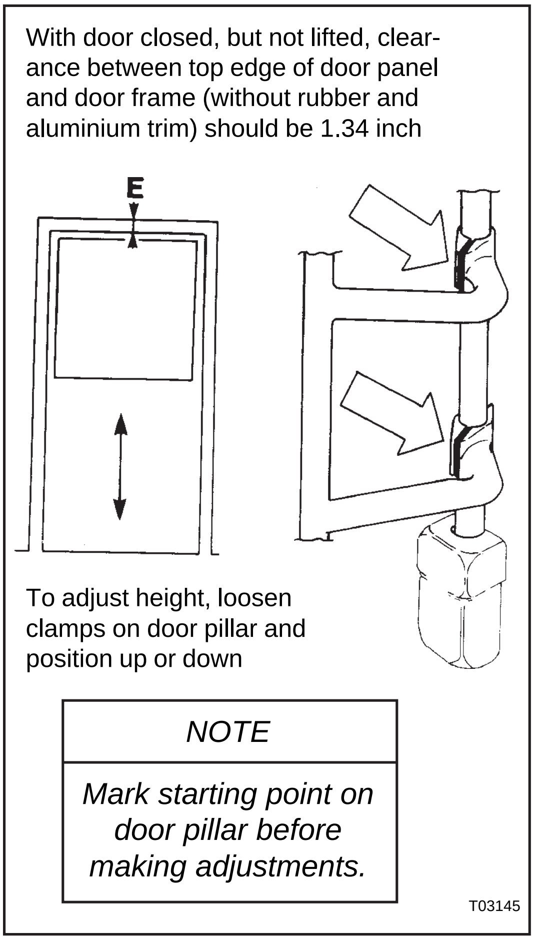

Figure 32 : Height adjustment

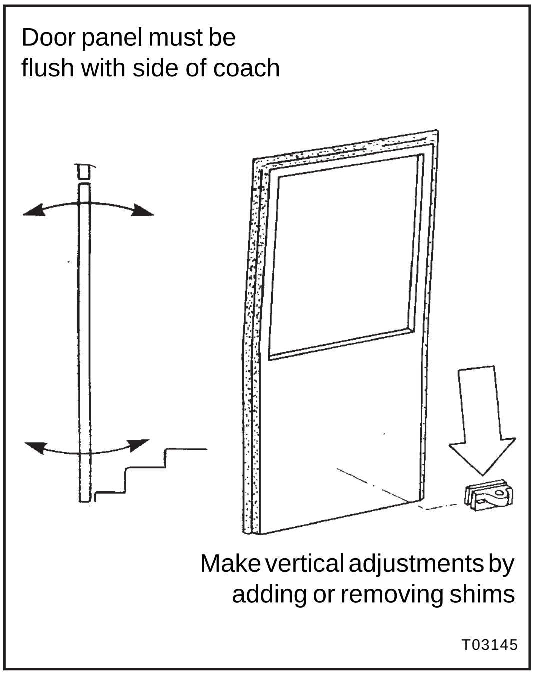

Figure 33 : Vertical adjustment

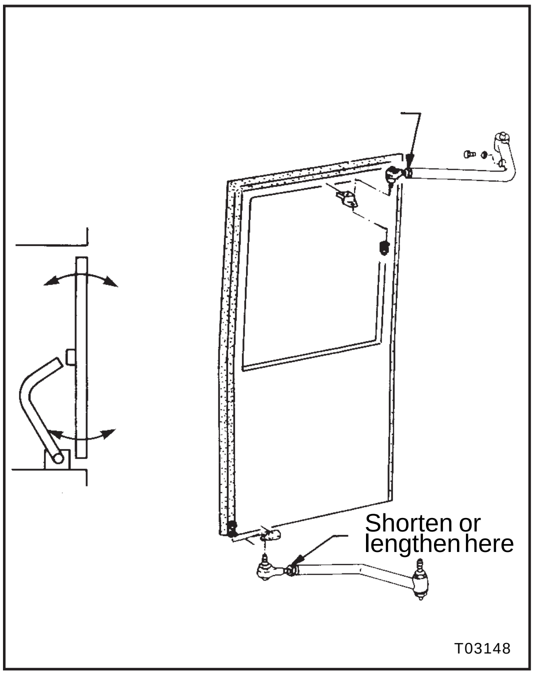

Figure 34 : Horizontal adjustment

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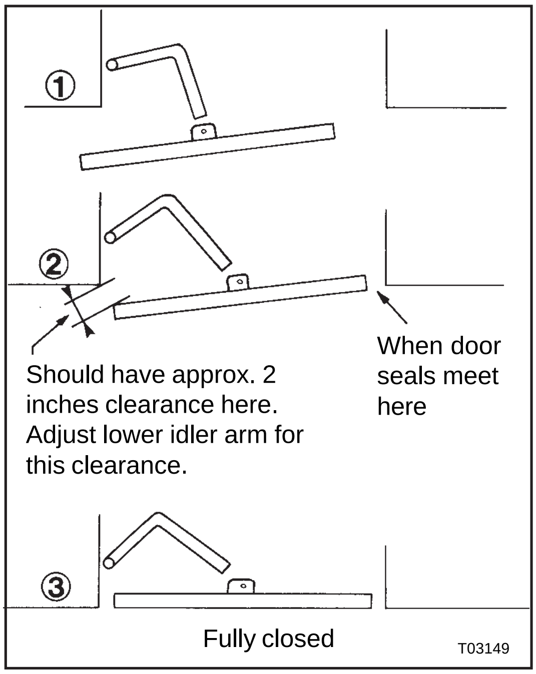

Figure 35: Closing cycle

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SEATS

PASSENGER SEATS

TO CHECK SEAT MOUNTING

Check at regular intervals the tightening torque of the seat mounting nuts.
Tightening torque: 15 to 16 ft.lbf.

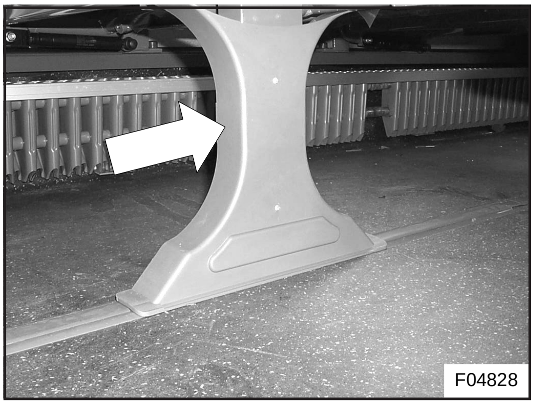

Figure 1: Protection cover around pedestal

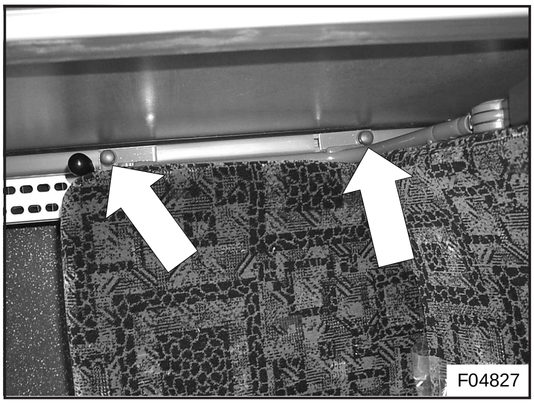

Figure 2: Mounting nuts at the window side

To gain access to the seat mounting nuts at the aisle side, remove the protection cover of the pedestal (see figure 1).

To gain access to the mounting nuts at the window side, remove the nut protection caps (see figure 2).

TO REMOVE/INSTALL THE PRESSURE CYLINDER

To remove the pressure cylinder

To gain access to the pressure cylinder at the aisle side, remove its protection cover (see Figure 3). The pressure cylinder at the window side is accessible through the bottom of the seat (see Figure 4).

1. Remove pressure cylinder pivoting bolt.
2. Unscrew nut (1, Figure 5) and remove pressure cylinder.

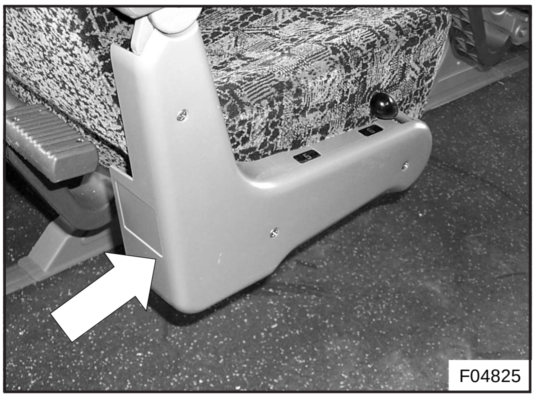

Figure 3: Protection cover

Figure 4: Pressure cylinder mounting at window side

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To install pressure cylinder - Figure 5

Install by reversing the removal steps. The distance between pin (4) and handle (5) should be at least 0.04 inch. Adjust the distance by changing the position of nut (2).

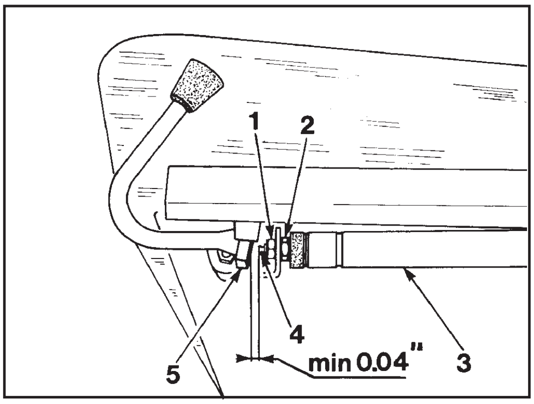

Figure 5: Pressure cylinder mounting

1. Nut
2. Nut
3. Pressure cylinder
4. Valve pin
5. Handle

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GLASS / GLAZING

!!! CAUTION !!!

REPLACING WINDSHIELDS AND SIDE WINDOWS REQUIRES SKILL AND EXPERIENCE. IF POSSIBLE, BRING THE COACH TO AN AUTHORIZED VAN HOOL SERVICE CENTER FOR REPAIR. IF AN EMERGENCY REPAIR IS NECESSARY, USE EXTREME CARE TO AVOID DAMAGING THE NEW GLASS DURING INSTALLATION.

WHEN HANDLING GLASS, ALWAYS WEAR GLOVES AND PROTECTIVE GOGGLES. USE SUCTION CUP HANDLING DEVICES DURING INSTALLATION.

NOTE

Removal and installation must be performed by more than one person. Use a scaffold that extends the width of the windshield rather than individual ladders.

WINDSHIELDS

The windshields are held in place by insert-type rubber retainers. No adhesive is used.

TO REMOVE WINDSHIELDS

1. Remove the wiper arms.
2. Cover the paint surrounding the windshields with paper.
3. Remove the rubber inserts (5 and 6, Figure 1) from the seals. Raise one end of rubber insert out with pointed tool, then pull insert out by hand.
4. Break the seal away from the glass with a putty knife, at the inside and outside.

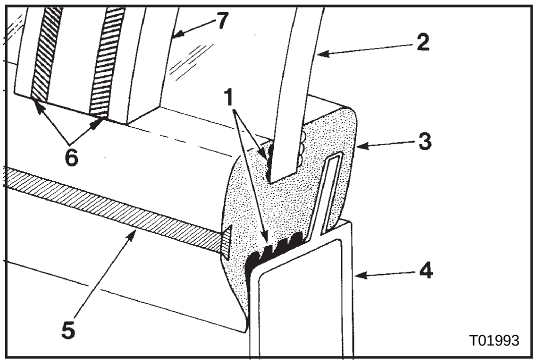

Figure 1: Section through windshield lower edge

1. **Sealer**
2. **Glass**
3. **Circumferential retainer seal**
4. **Frame opening**
5. **Seal insert of seal 3**
6. **Seal insert of seal 7**
7. **Wide central retainer seal**

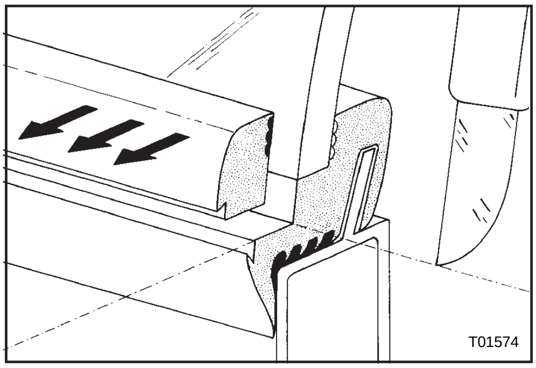

Figure 2: Incisions to be made in the rubber seal to allow glass removal

5. Make two deep cuts in the circumferential seals with a sharp knife, one perpendicular to the other (see Figure 2). Remove the part that has been cut.
6. Push each windshield out from the inside, starting at a corner. Two other persons on the outside then lift the windshield up and out of the opening.
7. Remove the remainder of the rubber seals with a knife and keep it for reference. Scrape off sealer

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remainder until flanges around the opening are smooth. Repair damaged or rusted flanges. Clean the windshield opening with SIKAFLEX 205.

TO PREPARE NEW WINDSHIELD

NOTE
Neatness is the key word when installing windows. Mounting flanges must be clear of glass, sealant or any other debris. Always use new seals when installing windshields.

1. Check that windshield surface and edges are smooth.
2. Place the windshield (both halves of the windshield) on wooden blocks on a table.The edges of the windshield must remain free of the work surface (see Figure 3).
3. Clean and degrease the windshield edges, using SIKAFLEX 205 (VH No. 660193035).
4. Put both windshield halves at a distance of approx. 3/4 inch.
5. Connect the two windshield halves crosswise with two rows of adhesive tape. Three strips of 1 1/2 inch wide tape, approx. 15 inches long, for each row will do. Leave room at the edges for the wide rubber seal.

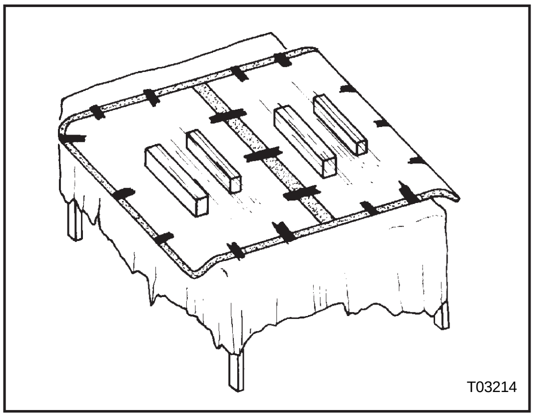

Figure 3: Completely prepared lower windshield halves on table

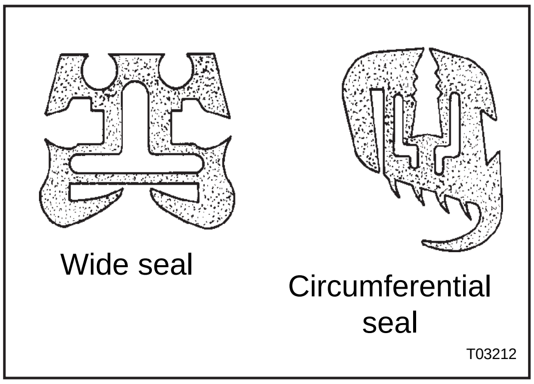

Figure 4: Insert-type rubber retainer seals

6. Cut the wide rubber seal (VH No. 66006451) so it comes 19/32 inch short of both the upper and lower edge of the windshield halves. Crosscuts should be V-shaped to fit the outer seals.
7. Brush both grooves of the wide rubber seal with a light soap solution.
8. Slide the wide rubber seal between the windshields and under the tape.
9. Cut four lengths of circumferential seal, using the old seals as reference. Cut ends of seals at an angle of 45°. Join the four lengths with Loctite 424 to form a rectangle. Make sure the right length is in the right place.
10. Fit the rectangle to (both) windshield(s) starting at a corner and secure it with adhesive tape.
11. Opposite the wide rubber seal, make two liberal T-shaped cuts in the back of the circumferential

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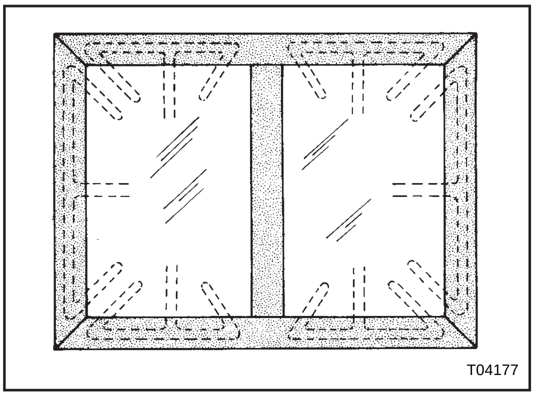

Figure 5: To install nylon strings in the circumferential rubber seals of the lower windshields

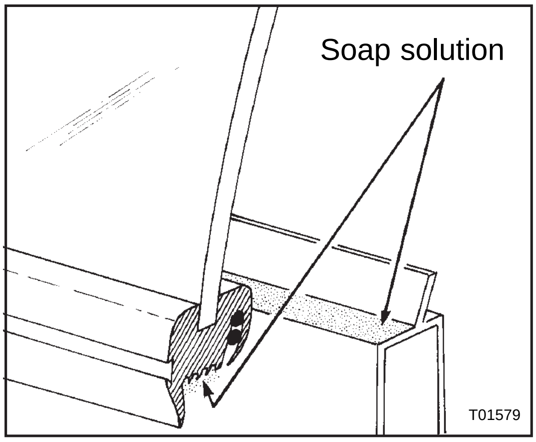

Figure 6: Brush the bottom of the circumferential rubber seal and the frame with a soap solution

seals to fit the T-shaped central post.

12. Fit six lengths of 1/8 inch thick nylon string in the groove of the circumferential seals, using figure 5 as a guideline. Stick the ends of the strings on the inside of the windshield.

13. Brush the bottom of the circumferential rubber seal and the frame of the windshield opening with a light soap solution.

TO INSTALL WINDSHIELDS

1. Hold the assembled windshield upright, lift it and lower it onto the bottom flange of the windshield opening. Make sure the rubber seals and nylon strings are seating properly and the string ends are inside the coach. Center the windshield assembly.

2. Now one person works from inside the coach while two other persons help from the outside. They should work simultaneously. Fit the bottom seal first, then the side seals and last the upper seal.

3. The person inside:

   a. holds a corner loop firmly with one hand.

   b. pulls the matching string end towards that corner with the other hand.

   at the same time one person outside:

   c. pushes and slaps with the flat of one hand along the edge of the windshield in the direction the string is moving.

   d. the other person holds the windshield upright with both hands.

4. Repeat this procedure until the entire windshield assembly seats correctly on the mounting flanges.

!!! CAUTION !!!
BE CAREFUL HOW HARD AND WHERE YOU STRIKE THE WINDSHIELD. AT THIS STAGE THE GLASS EASILY CRACKS. NEVER USE A HAMMER OR ANOTHER HEAVY OBJECT.

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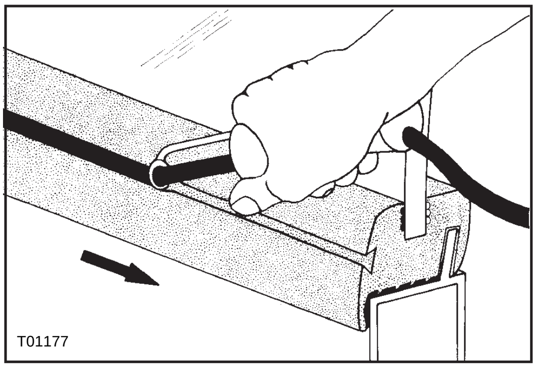

Figure 7: To insert the seal-insert (VH tool no. 313630051)

5. Fit the wide vertical rubber seal to the T-shaped post with a pointed tool. Remove the masking paper.
6. Brush the paint surrounding the circumferential rubber seal with linseed oil.
7. Apply SIKAFLEX 221 sealer around the entire circumference between the windshield and seal, and body and seal.
8. Place the seal inserts with VH tool no. 313630051.
9. Remove excess sealant. Clean windshield.
10. Refit the wiper arms.

TO REMOVE/INSTALL SINGLE PANE OF LOWER WINDSHIELDS

Refer to remove/install complete lower windshields earlier in this section. Take note of following differences:

1. Make a deep crosscut in the bottom and upper circumferential seal 10 inch from the wide rubber seal.
2. Leave the wide central rubber seal in place and thoroughly clean the groove holding the windshield.
3. At installation, lower the windshield onto the flange of the windshield opening then push the windshield into the groove of the central rubber seal.

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LAVATORY

Figure 1: Lavatory compartment

The lavatory compartment is located at the right rear of the coach. It is standard equipped with a chemical toilet, wet napkin dispenser, waste paper container and mirror.

The compartment flood light will illuminate with the master/ignition switch in the second position. With the engine running the ventilation fan will start to run at low speed. Locking the door from inside will turn the ventilation fan to high speed, illuminate the compartment roof lights and illuminate the occupied light.

This warning light illuminates when a passenger pushes the emergency switch in the lavatory compartment. At the same time a buzzer will sound.

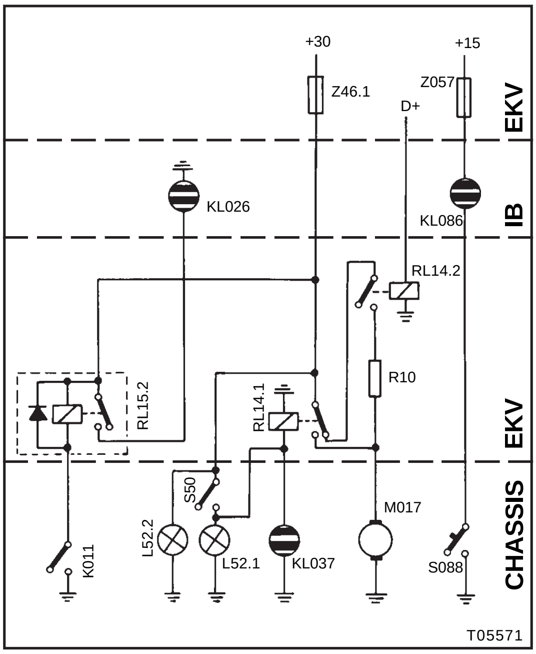

Figure 2: Lavatory compartment electrical circuit (non-multiplexed vehicles)

+30	:	**power supplied with "batteries connected"**
+15	:	**power supplied with "ignition on"**
D+	:	**power supplied with engine running**
EKV	:	**Main junction box**
IB	:	**Instrument panel**
K011	:	**Waste holding tank full switch**
KL026	:	**"Waste holding tank full" indication light**
KL037	:	**Toilet occupied light**
KL086	:	**Emergency switch indication light**
L52.1	:	**Lavatory compartment flood light**
L52.2	:	**Lavatory compartment roof lights**
M017	:	**Fan motor**
R10	:	**Resistance**
RL...	:	**Relay**
S50	:	**Door locked switch**
S088	:	**Emergency switch in lavatory compartment**
Z...	:	**Circuit breaker**

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TOILET

MAINTENANCE

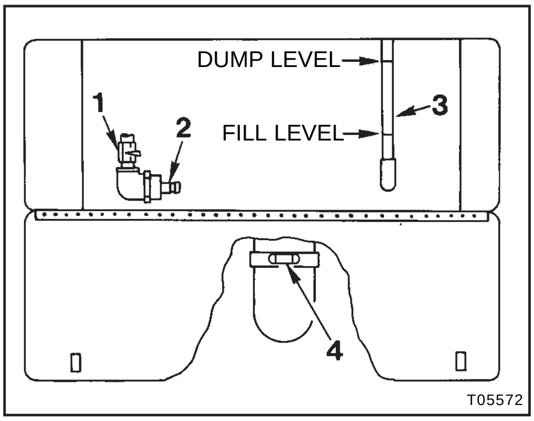

Figure 3: Lavatory service compartment located at the right in the engine compartment

1. **"TOILET TANK RINSING + FILLING" cock**
2. **Exterior water source coupling**
3. **Gauge glass**
4. **Toilet dump valve handle**

To drain the toilet- Figure 3

The toilet must be drained when the liquid level reaches the "DUMP LEVEL" on gauge glass (3).

A manually operated slide dump valve is provided at the bottom of the toilet to drain the toilet. The dump valve is accessible through the engine compartment.

Procedure:

1. Unlock dump valve handle (4).
2. Pull dump valve handle (4). This dumps contents of toilet in waste holding tank.
3. To rinse toilet tank: connect a external water source to coupling (2) and open "TOILET TANK RINSING + FILLING" cock (1). Close cock (1) when toilet tank is rinsed.
4. Close the dump valve, by pushing its handle completely, if toilet is empty. Relock valve (4).

To fill the toilet -Figure 3

1. Connect a external water source to coupling (2).
2. Open "TOILET TANK RINSING + FILLING" cock (1) until water reaches the "FILL LEVEL" on gauge glass(3).
3. Press the flush button and add 120 ml (7.32 in³) Aqua Kem (toilet chemical of Thetford) through the bowl.

To flush

Depress flush button located above the toilet (see Figure 4).

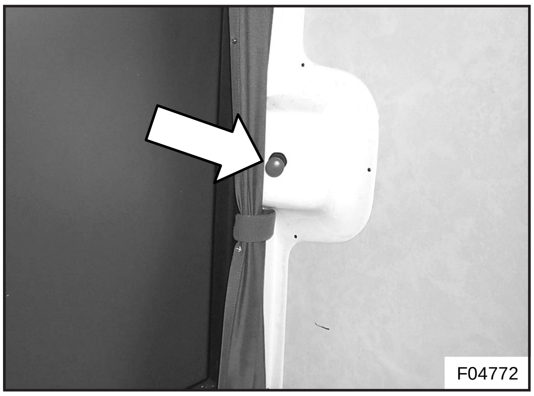

Figure 4: Flush button

To operate the toilet in cold weather

In cold weather protect the toilet from freezing so as to avoid damage to certain toilet parts.

The toilet chemical will freeze below 30°F.

The first way to protect the toilet assembly in cold weather is to use an anti-freeze solution such as Calcium Chloride ($CaCl_2$) in the toilet tank.

Depending upon the expected average low temperature and the expected accumulation of waste in the toilet tank between draining, charge the toilet according to table 1. The quantity of

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Table 1

Tank volume	Weight (in lbs.) of $CaCl_2$ required in tank to protect to temperature of			
Gallons	30°F	20°F	10°F	0°F
3	0.6	2.8	4	5
4	0.8	3.5	5.3	6.5
6	1.3	5.5	8	10
8	1.8	7.5	10.5	13.5
10	2.2	9	13	17
12	2.5	11	16	20
16	3.5	15	21	27
20	4.2	18	27	33

Calcium Chloride should never exceed 20 percent by weight. Therefore, the tank contents cannot be kept from freezing below 0°F. Further, the Calcium Chloride must be added in amounts proportional to the amount of waste in the tank to avoid exceeding a 20 percent concentration in the lower temperature protection range.
Another way to protect the toilet assembly, should it be exposed to extremely cold temperatures; is to use Ethylene Glycol as an anti-freeze solution in the toilet tank.

Based on the expected average low temperature and the quantity of waste in the toilet tank, charge the toilet assembly according to table 2.

!!! CAUTION !!!

ETHYLENE AND PROPYLENE GLYCOL ARE TOXIC SUBSTANCES. DO NOT SWALLOW OR INHALE. THEY CAN IRRITATE THE EYES. IF THE SUBSTANCE HAS BEEN SWALLOWED, HAVE A FIRST-AID ASSISTANT MAKE THE VICTIM VOMIT (PROVIDED HE/SHE IS CONSCIOUS). IN CASE OF INHALATION, BRING THE VICTIM INTO THE OPEN AIR. CALL A DOCTOR IN BOTH CASES. IF EYES HAVE BEEN AFFECTED, RINSE THEM

Table 2

Required % of antifreeze in tank	25%	33%	40%	50%
Protects to	+10°F	0°F	-12°F	-34°F

THOROUGHLY WITH PLENTY OF WATER. CONSULT A PHYSICIAN IN CASE OF EYE IRRITATION.

To clean the interior of the lavatory compartment

To avoid unintentionally drainage of waste water when cleaning the lavatory with water, a shut-off valve with a red handle is installed in the lavatory floor drain hose. The valve is located in the luggage compartment behind the right tag wheel and is labeled "Restroom floor drain" (see Figure 5).

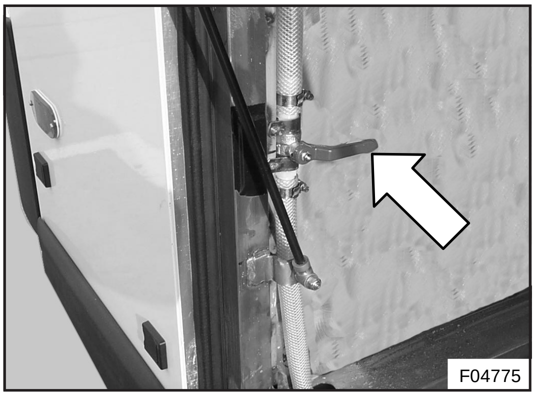

Figure 5: Restroom floor drain shut-off valve

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LAVATORY COMPARTMENT DOOR MICROSWITCH

The lavatory compartment door microswitch, which is located in the door post at the end of the front partition, is activated by the door lock mechanism. When the door is being locked, the microswitch turns on the roof lights in the lavatory compartment, the occupied light, and the toilet ventilation fan at high speed.

TO REMOVE AND INSTALL THE LAVATORY COMPARTMENT DOOR MICROSWITCH- Figure 6

To remove

1. Remove the two screws securing the striker plate to the door post.
2. Remove the bolts securing the microswitch to the striker plate. Remove the washers and the spacers.

To install

1. Place a bolt in the lower hole of the striker plate and slide a large spacer onto the bolt.
2. Align the holes in the shutter with the spacer. Position the microswitch in the shutter (lower hole aligned with bolt).
3. Push the bolt through the hole in the microswitch.
4. Slide the smaller spacer and the washer onto the bolt. Fix nut.

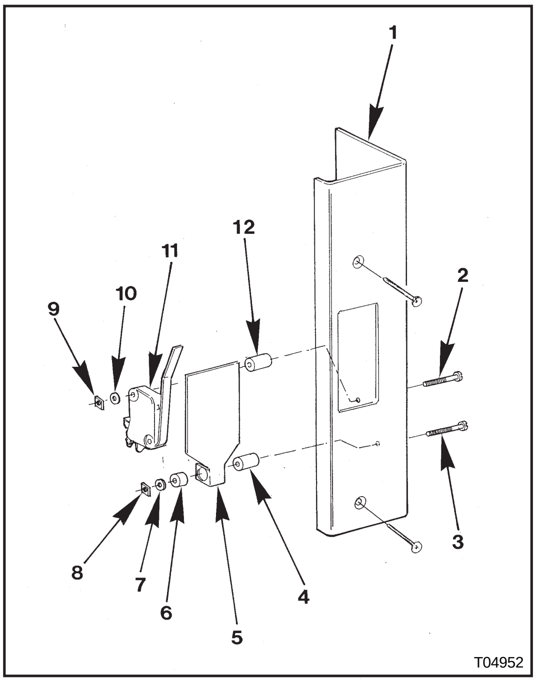

Figure 6: Lavatory compartment door microswitch assembly

1. Striker plate	**7. Washer**
2. Bolt	**8. Nut**
3. Bolt	**9. Nut**
4. Large spacer	**10. Washer**
5. Shutter	**11. Microswitch**
6. Small spacer	**12. Large spacer**

5. Place the other bolt in the upper hole and slide a large spacer onto the bolt.
6. Push the bolt in the hole of the microswitch.
7. Fit the washer and the nut.
8. Hand-tighten both nuts.
9. Secure striker plate to the door post with the two screws.

US1150AG

WASTE HOLDING TANK

The waste holding tank is located behind the engine compartment side-door, at the right of the coach.

This light (KL026) will come on when the waste holding tank is nearly full.

A manually operated slide dump valve is provided at the bottom of the tank to drain the tank.

To drain the tank:

1. Position the coach so that the waste holding tank outlet is over a receptable or sewer inlet or other facilities to comply with local health regulations.
2. Unlock dump valve handle.
3. Pull dump valve handle.
4. Return the handle to its original position when the waste holding tank is empty. Relock dump valve.

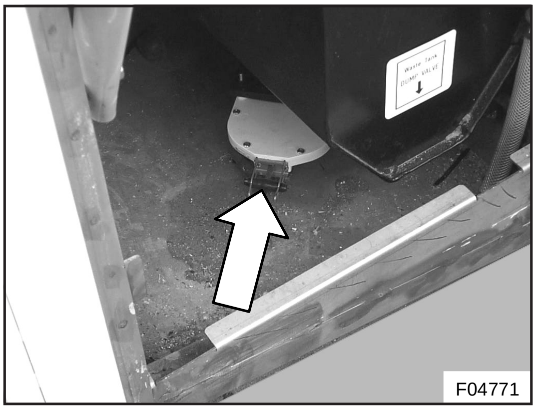

Figure 7: Waste holding tank dump valve (located behind the engine compartment side door, at the RHS of the coach)

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HATCHES AND ACCESS DOORS

LUGGAGE COMPARTMENT DOORS CENTRAL LOCKING SYSTEM

DESCRIPTION

The luggage compartment doors are locked by spring pressure of the single acting air cylinder mounted in each door handle, and require air pressure to be released. They will be locked automatically when the parking brake is released. To unlock the doors, first apply the parking brake. Actuation of the control button on the instrument panel will lock or unlock.

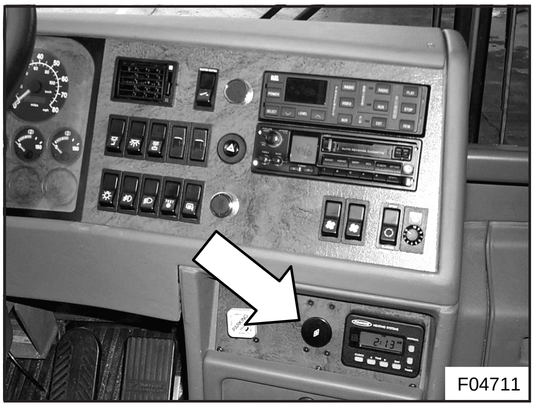

Figure 1: Control button of luggage compartment doors central locking system

To unlock the doors:

1. Apply parking brake.
2. Push the control button located on the instrument panel to unlock the doors.

To lock the doors:

Pull the control button located on the instrument panel to lock the doors. Note that the doors will be locked automatically when you release the parking brake, regardless of the position of the control button on the instrument panel.

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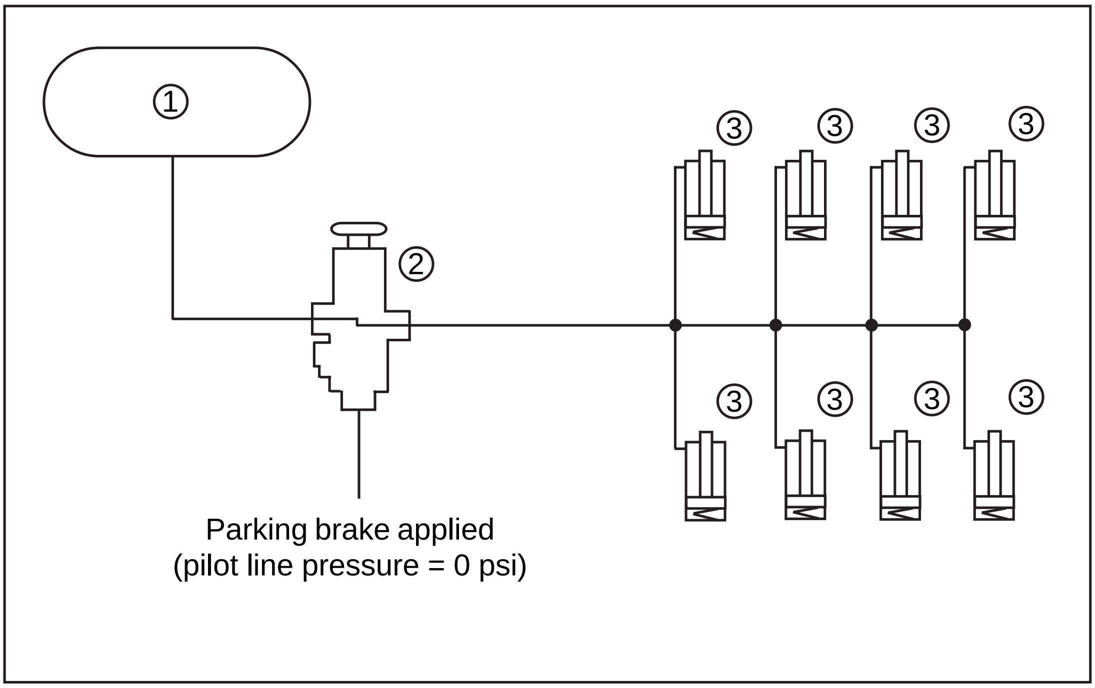

Figure 2: Pneumatic diagram of luggage compartment doors central locking system. Diagram shows luggage compartment doors unlocked (Push-pull valve (2) pushed and parking brake applied)

1. Auxiliary tank
2. Push-pull valve on instrument panel
3. Locking cylinder in door handle

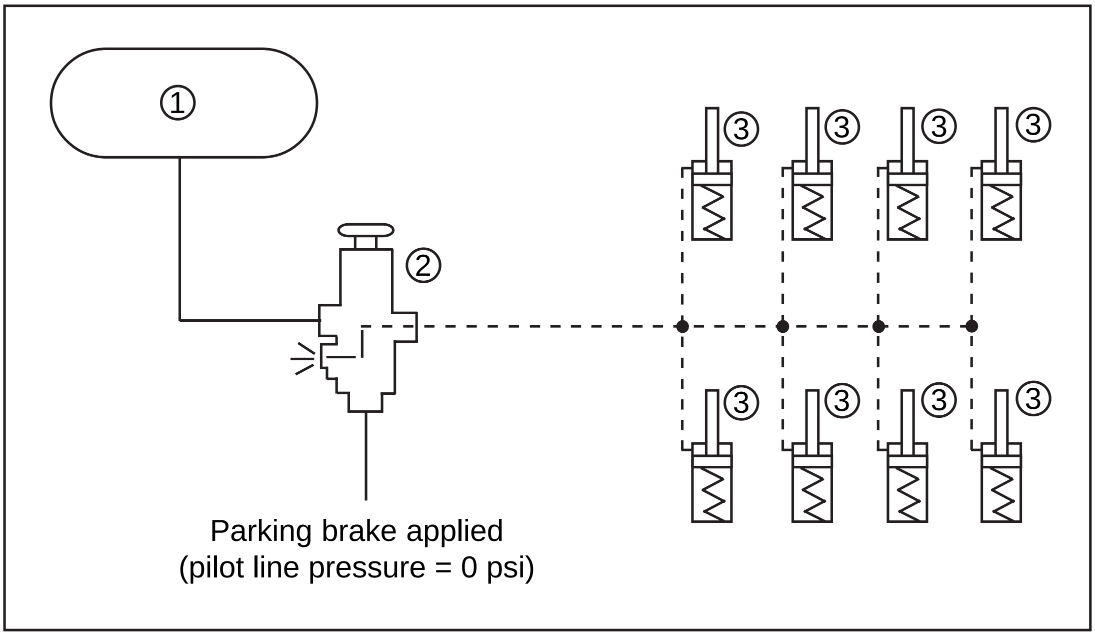

Figure 3: Pneumatic diagram of luggage compartment doors central locking system. Diagram shows luggage compartment doors locked (Push-pull valve (2) pulled and parking brake applied)

1. Auxiliary tank
2. Push-pull valve on instrument panel
3. Locking cylinder in door handle

US1160AF

ROOF ESCAPE HATCH

NOTE
Use of the escape hatches as ventilation aids upset proper functioning of the HVAC-system.

MAINTENANCE CAUTIONS

The hatches are designed to provide years of reliable service with a minimum of maintenance. All components are rust proof with lifetime finishes, and moving parts are Teflon coated to eliminate need for lubrication.

NOTE
Use of lubricants, paints, or other coatings -such as graffiti deterring sprays- is not recommended.

Suggested maintenance includes periodic inspection of attaching fasteners for evidence of loosening due to tampering, and regular cleaning with mild soap and water.

Although there are other cleaning solutions available, some of them contain solvents and other chemicals that can attack the high strength materials used in the production of the hatch.

It is the customer's responsibility to ensure that cleaning solutions are compatible with the materials used on hatches.

Graffiti removing cleaners often contain acetone, ether, lacquer thinner, or other solvents known to destroy the high strength properties of many engineering plastics and use of these cleaners must be avoided.

Graffiti resistant 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. Use of these coatings on hatches is at considerable risk and should be avoided.

REPAIR

All components used in the production of hatches are available as service parts, except for one hinge that represents a possible hazard when improperly reattached to a hidden tapping plate that is often damaged whenever the hinge is damaged. The tapping plate is permanently laminated between the inner and outer cover assemblies and can neither be inspected nor replaced. It is therefore necessary to replace the entire cover assembly following damage to the hinge.

!!! 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.

Should water enter the coach from the hatch, the following steps can be taken:

1. Open the hatch cover.

2. Apply rubber adhesive in the gap between the seal ends and join the two ends of the rubber seal.

NOTE:
Seal joint should face rear of coach.

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3. Apply liquid sealant between the edge of the escape hatch and the roof of the coach.

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SPECIAL SERVICE TOOLS

TOOL11AC

TOOL11AC

SERVICE BULLETINS

Service Bulletins are issued to supplement or supersede information in the Van Hool manuals. Note below number, date and subject of Bulletins pertaining to this chapter. File Bulletins separately by number for future reference.

Number	Date	Subject

CHAPTER 12

MAINTENANCE SCHEDULE AND APPENDICES

PAGE

MAIN12AD

MAINTENANCE SCHEDULE

VALID FOR COACHES WITH
CUMMINS ISM OR
DETROIT DIESEL SERIES 60 DDEC IV OR
DETROIT DIESEL SERIES 60 DDEC IV WITH EGR ENGINE,
ALLISON WTB500(R) OR ZF ASTRONIC TRANSMISSION,
DANA DRIVE AXLE AND
LUCAS D-ELSA DISC BRAKES ON ALL AXLES

For maintenance intervals of HVAC system (including combustion heater), refer to Section 10.9 "Periodic Service Guide".

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MAINTENANCE

HOSES

Inspection

The vehicle performance is directly related, among other things, to the ability of flexible hoses to supply lubricating oil, air, coolant and fuel. Maintenance of hoses is an important step to ensure efficient, economical and safe operation of the vehicle.

Check hoses daily as part of the pre-starting checks. Examine hoses 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 hazardous areas. Since all machinery vibrates and moves to a certain extent, clamps and ties can loosen and wear with age. To ensure continued proper support, inspect fasteners frequently and tighten or replace them as necessary.

Investigate leaks immediately to determine if fittings have loosened or cracked and also if hoses have ruptured or worn through. Take corrective action immediately.

!!! 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

A hose has a limited service life, determined by the temperature and pressure of the gas or fluid within it, time in service, mounting, ambient temperatures, amount of flexing, and the vibration it is subject to. The service life of a hose may also be reduced by exposure to road salt. Some types of hoses with wire braid reinforcement are subject to oxidation damage and a subsequent reduction in hose strength.

Van Hool recommends that all hoses be thoroughly inspected at least every 24,000 miles and/or annualy. Look for cover damage or indications of damaged, twisted, worn crimped, brittle, cracked or leaking lines. Hoses having the outer cover worn through or damaged metal reinforcement should be considered unfit for service. Van Hool further recommends that all hoses be replaced during major overhaul and/or after a maximum of five years service. by hoses of equal or superior quality, compared with the original.

ALLISON WTB500 TRANSMISSION

Transmission fluid

From transmission unit # 6610092269 the transmission is factory filled with TranSynd fluid instead of mineral based Dexron.
Transmissions filled with TranSynd fluid can be identified by a warning tag secured to the transmission fill tube.

This transmission uses **TranSynd™** synthetic automatic transmission fluid.

To maintain optimum transmission performance refill with TranSynd™

SA 3316EN

Figure 1: TranSynd warning tag

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Mixture of TranSynd and Non-TranSynd fluid

When you use TranSynd fluid in a transmission which was previously filled with mineral based Dexron fluid, initially follow the intervals in the maintenance schedule valid for Non-TranSynd fluid due to the mixture of Dexron and TranSynd. After the recommended mileage or time have elapsed, you may follow the intervals in the maintenance schedule for TranSynd fluid.

NOTE
TRANSYND FLUID IS 100 PERCENT COMPATIBLE WITH DEXRON AND C4 FLUIDS.

"Gold Series" filters

From transmission unit #6610092269 the current filters are changed by the new "Gold Series" main and lube oil filters. The "Gold Series" filters have increased filtration capacity that will allow you extended time between oil filter replacements. The Gold Series filters can be identified by the words "Gold Series" printed on the end caps.

NOTE
ONLY WHEN THE "GOLD SERIES" FILTERS ARE USED WITH TRANSYND, CAN THE OIL AND FILTER CHANGE INTERVALS BE EXTENDED.

Fluid loss at filter change

When changing main and lube oil filters at recommended intervals, approximate fluid loss for each filter is as follows:

- main filter: 2 quarts
- lube filter: 8 quarts

Oil analysis

Local conditions, severity of operation or duty cycle may require more or less frequent fluid change intervals that differ from the published recommended fluid change intervals. Transmission protection and fluid change intervals can be optimized by the use of oil analysis. Oil analysis requires that periodic samples be taken from the operating transmissions and sent to a reputable oil analysis laboratory for testing.Oil analysis may be used to set oil change intervals; however it is important to remember that oil analysis must be monitored regulary and results must be analyzed consistently to determine trends for best results.

PREVENTIVE MAINTENANCE SCHEDULE

The following preventive maintenance schedule is a compilation of suggested maintenance operations contained in this maintenance manual. Some intervals must be determined by shop personnel based on operating conditions, component failure history and previous experience. In cases when both miles and time are given for a particular operation, maintenance should be performed at whichever interval first occurs.

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BREAK-IN PERIOD

AFTER THE FIRST 1,000 MILES

Check:
- ❒ Drive belts tension (with gauge)
- ❒ Engine air intake piping for loose clamps, cracked hoses, etc.
- ❒ Tire inflation (with gauge)
- ❒ Suspension ride height (with gauge)
- ❒ Check that emergency exits (windows and roof hatches) open, close and latch properly

Torque:
- ❒ Wheel nuts (with torque wrench)

AFTER THE FIRST 3,000 MILES

Perform:
- ❒ Break-in period maintenance "After the first 1,000 miles"

Fluid check:
- ❒ Batteries electrolyte level

Check:
- ❒ Dashboard gauges and warning lights operation
- ❒ Brake chambers, valves, lines and fittings for air leaks
- ❒ Air suspension leaks
- ❒ Drive axle breather for freedom of obstruction

Change:
- ❒ Engine lube oil and filter
- ❒ Allison WTB500 transmission: main fluid filter
- ❒ Drive axle oil

Lubricate:
- ❒ Steering king-pins(1)
- ❒ Intermediate lever of steering system
- ❒ Propeller shaft universal joints
- ❒ HVAC compressor pivot bushings

Torque check:
- ❒ Security of engine and transmission
- ❒ Security of propeller shaft
- ❒ Security of all steering components
- ❒ Security of axles and suspension components
- ❒ Security of air tanks

(1) Van Hool have introduced a new steering knuckle type. This type of steering knuckle should not be lubricated periodically. Refer to chapter 4.1 "Front axle" to identify the steering knuckle type used on your vehicle.

DATE:	**VEHICLE NO:**
R.O. NO:	**MILEAGE:**
NOTES:	
SUPERVISOR'S SIGNATURE:	

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VEHICLE MAINTENANCE INTERVAL A
DAILY

Fluid check:
- ❒ Engine lube oil level
- ❒ Engine coolant level
- ❒ WTB500 transmission fluid level
- ❒ Power steering fluid level

Check:
- ❒ Engine air intake piping for loose clamps, cracked hoses, etc.(visually)
- ❒ Drive belts condition and tension (visually)
- ❒ Pipes and hoses for security, damage and chaffing
- ❒ Fluid leaks in engine compartment, wheel hubs etc.
- ❒ Tire inflation, use "tire thumper"
- ❒ Tire condition
- ❒ Wheel nuts for tightness (visually)
- ❒ Wheel rims for cracks and deformation
- ❒ Suspension ride height (visually)
- ❒ Check that emergency windows are closed and locked
- ❒ Air cleaner restriction indicator
- ❒ Cummins engine: crankcase breather tube (visually)

Drain:
- ❒ Cummins engine: fuel filter

DATE:	**VEHICLE NO:**
R.O. NO:	**MILEAGE:**
NOTES:	
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VEHICLE MAINTENANCE INTERVAL B
EVERY 6,000 MILES

Fluid check:
- ❒ Drive axle oil level
- ❒ Batteries electrolyte level
- ❒ Windshield washer liquid level

Check:
- ❒ Tire pressure (with gauge)
- ❒ Dashboard gauges and warning lights operation
- ❒ Drive belts wear and tension
- ❒ Suspension ride height (measure)
- ❒ Screen in air intake for radiator
- ❒ Engine rear mounts adjustment
- ❒ Check that emergency exits (windows and roof hatches) open, close and latch properly

Drain:
- ❒ Air tanks
- ❒ Detroit Diesel engine: fuel water separator
- ❒ Detroit Diesel engine with EGR (Exhaust Gas Recirculation): PuraGuard filter(1)

Lubricate:
- ❒ Steering king pins (2)
- ❒ Intermediate lever of steering system
- ❒ HVAC compressor pivot bushings

Torque check:
- ❒ Security of axles and suspension components
- ❒ Wheel nuts (with torque wrench)

(1) At least every month.

(2) Van Hool have introduced a new steering knuckle type. This type of steering knuckle should not be lubricated periodically. Refer to chapter 4.1 "Front axle" to identify the steering knuckle type used on your vehicle.

DATE:	**VEHICLE No:**
R.O. NO:	**MILEAGE:**
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VEHICLE MAINTENANCE INTERVAL C
EVERY 12,000 MILES

Fluid check:
- ❒ ZF Astronic transmission: fluid level

Check:
- ❒ Engine coolant SCA (supplemental coolant additives) concentration level
- ❒ Engine coolant antifreeze concentration level
- ❒ Engine air cleaner restriction indicator operation
- ❒ Steering ball-joints for excessive play
- ❒ Electric cable connections for corrosion and tightness
- ❒ General condition of the brake assemblies for damage and corrosion
- ❒ Brake lining wear
- ❒ Brake chamber condition and leaks
- ❒ Brake system valves, lines and fittings for leaks
- ❒ Suspension air bellows external condition/leaks
- ❒ Shock absorbers for external damage and leakage
- ❒ Air dryer operation
- ❒ All lights, interior and exterior
- ❒ Headlight beam settings
- ❒ Windshield wiper and washer condition and operation
- ❒ Automatic passenger door: operation and adjustment
- ❒ Lavatory operation, toilet, sink etc.
- ❒ Detroit Diesel engine: water pump drain hole to be sure it is open
- ❒ Detroit Diesel engine: crankshaft vibration damper
- ❒ Foot brake valve operating mechanism (refer to Section 5.0)

Change:
- ❒ Engine fuel filter
- ❒ Detroit Diesel engine: fuel water separator
- ❒ Detroit Diesel engine: lube oil
- ❒ Detroit Diesel engine: lube oil filter
- ❒ Allison WTB500 transmission: fluid(1)
- ❒ Allison WTB500 transmission: fluid filters (main and lube)(1)

Lubricate:
- ❒ All body components such as door locks, latches and linkages (with oil)
- ❒ Windshield wiper linkage pivot points (with oil)

Torque check:
- ❒ Security of all steering components
- ❒ All coolant hose clamps

(1) At least every 6 months. Valid for:
- transmissions with hydraulic retarder filled with Non-TranSynd fluid
- transmissions without hydraulic retarder filled with Non-TranSynd fluid: when the vehicle exceeds an average of one stop per mile, including traffic and scheduled stops.

DATE:	**VEHICLE NO:**
R.O. NO:	**MILEAGE:**
NOTES:	
SUPERVISOR'S SIGNATURE:	

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VEHICLE MAINTENANCE INTERVAL D
EVERY 24,000 MILES

Perform:
- ❒ Air brake system functional check (refer to Section 5.0)

Check:
- ❒ Throttle control
- ❒ Toe of front wheels
- ❒ Drive axle breather for freedom of obstruction
- ❒ Air suspension leveling valves for wear and damage
- ❒ Emergency window release tension (20 lbs)
- ❒ All hoses (thoroughly)

Clean:
- ❒ Cooling radiator and intercooler

Change:
- ❒ Cummins engine: lube oil
- ❒ Cummins engine: lube oil filter
- ❒ Allison WTB500 transmission: fluid(1)
- ❒ Allison WTB500 transmission: fluid filters (main and lube)(1)

Lubricate:
- ❒ Propeller shaft universal joints
- ❒ Throttle control pivot points (with oil)
- ❒ Automatic passenger door: pillar (requires needle tip grease gun adapter)
- ❒ Automatic passenger door: guide rod end
- ❒ Automatic passenger door: locking cams with vaseline
- ❒ Passenger door(s): rubber seals with silicone spray
- ❒ Emergency window release handle, cable and latches

Torque check:
- ❒ Security of engine
- ❒ Security of transmission
- ❒ Security of air compressor

(1) At least every year. Valid for transmissions without hydraulic retarder filled with Non-Transynd fluid. An extra condition is that the vehicle does not exceed an average of one stop per mile, including traffic and scheduled stops. If it makes more stops, the fluid and fluid filters should be changed every 12,000 miles/6 months.

DATE:	**VEHICLE NO:**
R.O. NO:	**MILEAGE:**
NOTES:	
SUPERVISOR'S SIGNATURE:	

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VEHICLE MAINTENANCE INTERVAL E
EVERY 48,000 MILES

Change:
- ❒ Allison WTB500 transmission: fluid(1)
- ❒ Allison WTB500 transmission: fluid filters (main and lube)(2)
- ❒ ZF Astronic transmission without ZF-Intarder: fluid(3)

(1) At least every 2 years. Valid for:
- transmissions with hydraulic retarder filled with TranSynd fluid and use of Gold Series filters.
- transmissions without hydraulic retarder filled with TranSynd fluid and use of Gold Series filters: when the vehicle exceeds an average of one stop per mile, including traffic and scheduled stops.

(2) At least every 2 years. Valid for transmissions filled with TranSynd fluid and use of Gold Series filters.

(3) At least every year. The 48,000 miles interval is valid for class 02A oil of ZF lubricants list TE-ML 02. The interval can be increased to 100,000 miles if class 02H oil is used. The interval can be increased to 180,000 miles or 2 years if class 02L oil is used.

DATE:	VEHICLE NO:
R.O. NO:	MILEAGE:
NOTES:	
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VEHICLE MAINTENANCE INTERVAL F
EVERY 60,000 MILES

Perform:
- ❒ Minor inspection of propeller shaft (refer to Section 3.4)

Check:
- ❒ Alternator: voltage regulator brushes
- ❒ Air system pressure protection valve settings
- ❒ Automatic passenger door: locking cams for wear

Adjust:
- ❒ Engine valves and injectors

Change:
- ❒ Drive axle oil
- ❒ Power steering filter
- ❒ Air suspension line filters
- ❒ Air dryer cartridge[1]

Clean:
- ❒ Pressure wash engine compartment
- ❒ Crankcase breather assembly

Torque check:
- ❒ Security of turbocharger and exhaust system

[1] At least every year.

DATE:	**VEHICLE NO:**
R.O. NO:	**MILEAGE:**
NOTES:	
SUPERVISOR'S SIGNATURE:	

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VEHICLE MAINTENANCE INTERVAL G
EVERY 96,000 MILES

Change:
- ❒ Drive axle oil (1)
- ❒ ZF Astronic transmission with ZF-Intarder: fluid(2)
- ❒ Detroit Diesel engine with EGR (Exhaust Gas Recirculation): PuraGuard filter element(3)

(1) This interval can be increased to 240,000 miles when Dana approved synthetic lubricant is used.

(2) At least every year. The 96,000 miles interval is valid for class 02H oil of ZF lubricants list TE-ML 02. The interval can be increased to 180,000 miles or 2 years if class 02L oil is used. Change the filter of the ZF-Intarder at each transmission oil change interval.

(3) At least every year.

DATE:	VEHICLE NO:
R.O. NO:	MILEAGE:
NOTES:	
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VEHICLE MAINTENANCE INTERVAL H
EVERY 120,000 MILES

Check:
- ❐ Wheel bearings end play
- ❐ Wheel brakes: condition of guide pin and tappet rubber boots. Ensure they are undamaged and securely located[(1)]
- ❐ Wheel brakes: housing assembly for easy sliding on the guide pins[(1)]
- ❐ Wheel brakes: brake disc for signs of heavy grooving, cracking or corrosion[(1)]
- ❐ Wheel brakes: brake disc thickness[(1)]
- ❐ Wheel brakes: brake disc run-out[(1)]

Change:
- ❐ Allison WTB500 transmission: fluid[(2)]

[(1)] At least every year.

[(2)] At least every 4 years. Valid for transmissions without hydraulic retarder filled with Transynd fluid and use of Gold Series filters. An extra condition is that the vehicle does not exceed an average of one stop per mile, including traffic and scheduled stops. If it makes more stops, the fluid should be changed every 48,000 miles/2 years. The fluid filters (main and lube) should be changed at 48,000 miles/2 years.

DATE:	**VEHICLE NO:**
R.O. NO:	**MILEAGE:**
NOTES:	
SUPERVISOR'S SIGNATURE:	

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VEHICLE MAINTENANCE INTERVAL I
EVERY 180,000 MILES

Perform:
- ❒ Major inspection of propeller shaft (refer to Section 3.4)

Check:
- ❒ Power steering system: operation and condition
- ❒ Vehicle undercoating, touch up if necessary
- ❒ Air compressor unloader valves condition
- ❒ Air compressor discharge line for carbon build-up
- ❒ Cummins engine: crankshaft vibration damper

Clean:
- ❒ Vehicle understructure

Change:
- ❒ Cooling and heating system coolant (clean the system before filling)
- ❒ Surge tank filler and pressure caps
- ❒ Air system governor
- ❒ Brake chamber diaphragms
- ❒ Detroit Diesel engine: thermostats and seals

Drain:
- ❒ Fuel tank

DATE:	VEHICLE NO:
R.O. NO:	MILEAGE:
NOTES:	
SUPERVISOR'S SIGNATURE:	

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MAINTENANCE FILE

NOTE
This maintenance file assists service technicians in keeping track of maintenance work accomplished or required. After each required maintenance, a copy of the sheet detailing work performed should be placed in a file.   *Van Hool reserves the right to deny warranty coverage on claims due to lack of maintenance or neglect. Claims in question must be supported by maintenance records which are in accordance with the contractual agreement.*

Maintenance is set up according to an alphabetical schedule:

LEVELS	
A.	Daily
B.	Every 6,000 miles
C.	Every 12,000 miles
D.	Every 24,000 miles
E.	Every 48,000 miles
F.	Every 60,000 miles
G.	Every 96,000 miles
H.	Every 120,000 miles
I.	Every 180,000 miles

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DATE	MILEAGE	SERVICE INTERVAL	MAINTENANCE LEVEL									REMARKS
			A	B	C	D	E	F	G	H	I	
		6,000	•	•								
		12,000	•	•	•							
		18,000	•	•								
		24,000	•	•	•	•						
		30,000	•	•								
		36,000	•	•	•							
		42,000	•	•								
		48,000	•	•	•	•	•					
		54,000	•	•								
		60,000	•	•	•			•				
		66,000	•	•								
		72,000	•	•	•	•						
		78,000	•	•								
		84,000	•	•	•							
		90,000	•	•								
		96,000	•	•	•	•	•		•			
		102,000	•	•								
		108,000	•	•	•							
		114,000	•	•								
		120,000	•	•	•	•		•		•		
		126,000	•	•								
		132,000	•	•	•							
		138,000	•	•								
		144,000	•	•	•	•	•					
		150,000	•	•								
		156,000	•	•	•							
		162,000	•	•								
		168,000	•	•	•	•						
		174,000	•	•								
		180,000	•	•	•			•			•	
		186,000	•	•								
		192,000	•	•	•	•	•		•			
		198,000	•	•								
		204,000	•	•	•							
		210,000	•	•								
		216,000	•	•	•	•						

SEE NEXT PAGE

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DATE	MILEAGE	SERVICE INTERVAL	MAINTENANCE LEVEL									REMARKS
			A	B	C	D	E	F	G	H	I	
		222,000	•	•								
		228,000	•	•	•							
		234,000	•	•								
		240,000	•	•	•	•	•	•		•		
		246,000	•	•								
		252,000	•	•	•							
		258,000	•	•								
		264,000	•	•	•	•						
		270,000	•	•								
		276,000	•	•	•							
		282,000	•	•								
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		336,000	•	•	•	•	•					
		342,000	•	•								
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		366,000	•	•								
		372,000	•	•	•							
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		414,000	•	•								
		420,000	•	•	•			•				
		426,000	•	•								
		432,000	•	•	•	•	•					

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DATE	MILEAGE	SERVICE INTERVAL	MAINTENANCE LEVEL									REMARKS
			A	B	C	D	E	F	G	H	I	
		438,000	•	•								
		444,000	•	•	•							
		450,000	•	•								
		456,000	•	•	•	•						
		462,000	•	•								
		468,000	•	•	•							
		474,000	•	•								
		480,000	•	•	•	•	•	•	•	•		
		486,000	•	•								
		492,000	•	•	•							
		498,000	•	•								
		504,000	•	•	•	•						
		510,000	•	•								
		516,000	•	•	•							
		522,000	•	•								
		528,000	•	•	•	•	•					
		534,000	•	•								
		540,000	•	•	•			•			•	
		546,000	•	•								
		552,000	•	•	•	•						
		558,000	•	•								
		564,000	•	•	•							
		570,000	•	•								
		576,000	•	•	•	•	•		•			
		582,000	•	•								
		588,000	•	•	•							
		594,000	•	•								
		600,000	•	•	•	•		•		•		
		606,000	•	•								
		612,000	•	•	•							
		618,000	•	•								
		624,000	•	•	•	•	•					
		630,000	•	•								
		636,000	•	•	•							
		642,000	•	•								
		648,000	•	•	•	•						

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DATE	MILEAGE	SERVICE INTERVAL	MAINTENANCE LEVEL									REMARKS
			A	B	C	D	E	F	G	H	I	
		654,000	•	•								
		660,000	•	•	•			•				
		666,000	•	•								
		672,000	•	•	•	•	•		•			
		678,000	•	•								
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		714,000	•	•								
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		726,000	•	•								
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		816,000	•	•	•	•	•					
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		852,000	•	•	•							
		858,000	•	•								
		864,000	•	•	•	•	•		•			

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DATE	MILEAGE	SERVICE INTERVAL	MAINTENANCE LEVEL									REMARKS
			A	B	C	D	E	F	G	H	I	
		870,000	•	•								
		876,000	•	•	•							
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		924,000	•	•	•							
		930,000	•	•								
		936,000	•	•	•	•						
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		978,000	•	•								
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		990,000	•	•								
		996,000	•	•	•							
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RECOMMENDED LUBRICANTS, FLUIDS AND GREASE

LUBRICANTS AND FLUIDS

LUBRICATING OIL

Cummins recommendations

Engine sump capacity:

Max. level .... 9 U.S. gallons
Min. level .... 7 U.S. gallons

The use of quality engine lubricating oils, combined with appropriate oil drain and filter change intervals, is a critical factor in maintaining engine performance and durability.

Cummins Engine Company, Inc. recommends the use of a high quality, American Petroleum Institute (API) licensed CH-4 or CES20071, 15W-40 multiviscosity oil or premium oil.

A sulfated ash content of 1.0 mass percent will yield optimal control of valve and piston deposit and will minimize oil consumption.

The sulfated ash *must not* exceed 1.85 mass percent.

For further details and discussion of engine lubricating oils for Cummins engines, refer to Cummins Engine Oil Recommendations, Bulletin No.3810340.

The use of low viscosity oils, such as 10W or 10W-30 can be used to aid in starting the engine and in providing

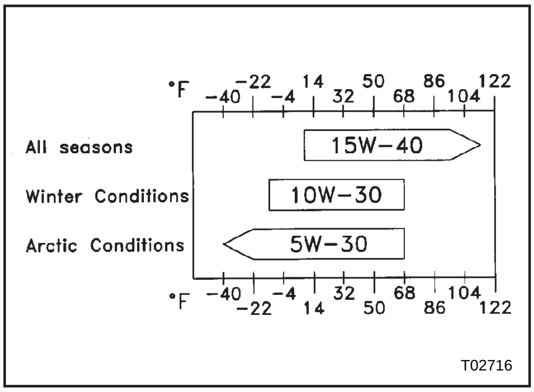

Figure 1: Lubricating oil viscosity recommendations table (Cummins)

sufficient oil flow at ambient temperatures below 23°F. However, continuous use of low viscosity lubricating oils may decrease engine life due to wear.

Arctic operation

!!! CAUTION !!!
THE USE OF A SYNTHETIC BASE OIL DOES NOT JUSTIFY EXTENDED OIL CHANGE INTERVALS. EXTENDED OIL CHANGE INTERVALS CAN DECREASE ENGINE LIFE DUE TO FACTORS SUCH AS CORROSION, DEPOSITS AND WEAR.

If an engine is operated in ambient temperatures consistently below -10°F and there are no provisions to keep the engine warm when it is *not* in operation, use a synthetic CE/SF engine oil with adequate low temperature properties, such as 5W-20 or 5W-30.

The oil supplier *must* be responsible for meeting the performance service specifications.

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Detroit Diesel recommendations

Engine oil pan capacity (without oil filters):

- Full mark .... 32 U.S. Qts
- Low mark .... 26 U.S. Qts

Total oil capacity of the engine:
40 U.S. Qts to the full mark (with oil filters installed and filters and oil galleries charged).

SAE viscosity grade: 15W-40
API classification: CH-4

T04825

Figure 2: Engine lubricating oil recommendations (Detroit Diesel without Exhaust Gas Recirculation)

Detroit Diesel recommend the use of a high quality SAE 15W-40 oil meeting API performance classification:

- CH-4 or equivalent for engines without Exhaust Gas Recirculation

- CI-4 or equivalent for engines with Exhaust Gas Recirculation (Engine model: 6067MK...)

FUEL

!!! CAUTION !!!
DO NOT MIX GASOLINE, ALCOHOL, OR GASOHOL WITH DIESEL FUEL. THIS MIXTURE CAN CAUSE AN EXPLOSION. DUE TO THE PRECISE TOLERANCES OF DIESEL INJECTION SYSTEMS, IT IS EXTREMELY IMPORTANT THAT THE FUEL BE KEPT CLEAN AND FREE OF DIRT OR WATER. DIRT OR WATER IN THE SYSTEM MAY CAUSE SEVERE DAMAGE TO BOTH THE FUEL INJECTION PUMP AND THE FUEL INJECTORS.

Fuel tank capacity:
120 or 245 U.S. gallons.

Cummins recommendations

Cummins Engine Company, Inc., recommends the use of ASTM No. 2D diesel fuel. The use of No. 2D diesel fuel will result in optimum engine performance. At operating temperatures below 32°F, acceptable performance can be obtained by using blends of No. 2D diesel and No. 1D diesel.

NOTE
LIGHTER FUELS CAN REDUCE FUEL ECONOMY.

The viscocity of the fuel must be kept above 1.3 cST at 104°F to provide adequate fuel system lubrication.

Detroit Diesel recommendations

Fuel must meet ASTM designation D975(grades 1-D and 2-D).

NOTE
THE USE OF 1-D FUEL IS RECOMMENDED AT COLD WEATHER CONDITIONS BELOW 32°F.

COOLANT

Engine cooling and heating system capacity: approx. 26 U.S. gallons.

Cummins recommendations

Engine cooling and heating system capacity: approx. 26 U.S. gallons.

Cummins Engine company, Inc., recommends the use of fully formulated

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antifreeze or coolant containing a precharge of Supplemental Coolant Additives (SCA). The antifreeze must meet the specifications outlined in The Maintenance Council (TMC) Recommended Practice RP 329. The use of fully formulated antifreeze or coolant significantly simplifies cooling system maintenance. Copies of TMC specifications can be obtained through Cummins Engine Company.

Fully formulated *antifreeze* contains balanced amounts of antifreeze, SCA, and buffering compounds, but does NOT contain 50% water. Fully formulated coolant contains balanced amounts of antifreeze, SCA, and buffering compounds already premixed 50/50 with deionized water.
Cummins Engine Company recommended fully formulated coolant: Fleetguard Compleat (ethelyne glycol form).

Good quality water

Fully formulated antifreeze must be mixed with good quality water at a 50/50 ratio (40 to 60 percent working range). Good quality water is important for cooling system performance. Excessive levels of calcium and magnesium contribute to scaling problems, and excessive levels of chlorides and sulfates cause cooling system corrosion. Water added to the fully formulated antifreeze must meet specifications given in the chart below.

Mineral	Max. Limit
Calcium Magnesium	170 ppm
Chloride	40 ppm
Sulfate	100 ppm

Supplemental coolant additive (SCA)

Fully formulated products contain SCA and are required to protect the cooling system from fouling, solder blooming, and general corrosion.

Detroit Diesel recommendations

Water requirements

Distilled or de-ionized water which eliminates the adverse effects of minerals in tap water is preferred. High levels of dissolved chlorides, sulfates, magnesium, and calcium in some tap water causes scale deposits, sludge deposits and/or corrosion. These deposits have been shown to result in water pump failures and poor heat transfer, resulting in over-heating. If tap water is used, the mineral content in the water must be below the maximum allowable limits shown in the table.

Maximum allowable limits for minerals in water		
	Parts per million	Grains per gallon
•Chlorides	40	2.5
•Sulfates	100	5.8
•Total dissolved solids	340	20
•Total hardness magnesium &calcium	170	10

Antifreeze

Use genuine Detroit Diesel "Power Cool". Detroit Diesel part number 23512138.

Antifreeze must be used in any climate for both freeze and boiling point protection. Detroit Diesel recommend a 50 % "Power Cool" antifreeze / water solution in most climates. Concentrations over 67 % are not

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recommended because of the poor heat transfer, reduced freeze protection and possible silicate dropout. An antifreeze concentration below 33 % offers too little freeze and/or corrosion protection and is not recommended.

Supplemental Coolant Additives (SCA)

Nitrite concentration is an indication of the SCA concentration in the coolant. Nitrite test kits and test strips are available from authorized Detroit Diesel service outlets. The coolant must be tested for required inhibitor levels at the intervals shown in the Maintenance Manual. SCA levels must be within the ranges shown in the table.

SCA concentration limitations		
	Min. PPM	Max. PPM
Boron (B)	125	500
Nitrite (NO_2)	800	2,400
Nitrates (NO_3)	200	750
Silicon (Si)	50	250
Phosphorous (P)	0	0
pH	8.0	10.5

Maintenance dosage of SCA must only be added if nitrite concentration is less than 800 PPM. If nitrite concentration is higher than 800 PPM, do not add additional SCA. Penray NALCOOL® 3000 is the recommended SCA for all Detroit Diesel engines.

TRANSMISSION FLUID RECOMMENDATIONS

Allison WTB500(R)

Capacity:

- Initial fill .... approx. 47 U.S. Qts
- Refill after oil change .... approx. 37 U.S. Qts

Recommended fluids:

- Mineral based DEXRON-III or C-4 fluids, or...
- TranSynd synthetic transmission fluid.

NOTE
FROM JANUARY 2002 ONWARDS, THE TRANSMISSION IS FACTORY FILLED WITH "TRANSYND™ SYNTHETIC AUTOMATIC TRANSMISSION FLUID. THESE TRANSMISSIONS HAVE A PLASTIC WARNING TAG TO THE FILL TUBE OR DIPSTICK.

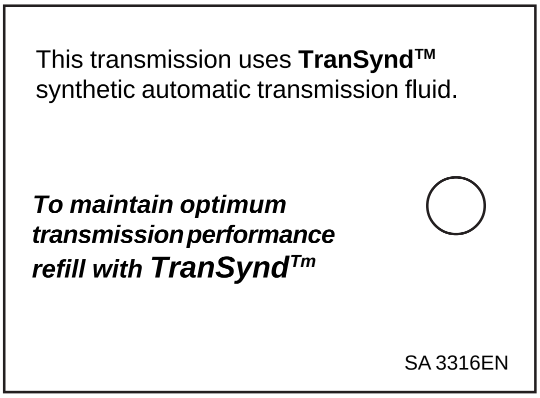

Figure 3: TranSynd warning tag

ZF Astronic

Capacity: approx. 11 U.S.Qts

Fluids to ZF lubricant list TE-ML 02. This list can be found on the internet at "www.zf.com".

DRIVE AXLE OIL RECOMMENDATIONS

Capacity: 20 U.S. Quarts

Multigrade gear lubricants meeting the requirements of military specification MIL-L-2105D.

Oil viscosity recommendations

Oil viscosity should be selected on the basis of the ambient temperature range

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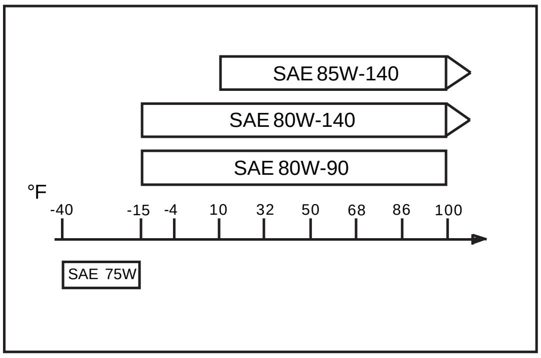

Figure 4: Drive axle oil viscosity recommendations table

the vehicle normally operates in. Refer to figure 4 for right oil viscosity.

POWER STEERING FLUID RECOMMENDATIONS

Capacity: approx. 9.3 U.S. Qts. DEXRON-IID, -IIE, -III fluids are recommended.

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GREASE

APPLICATION	GREASE SPECIFICATIONS
All chassis and body lubricators (unless otherwise stated)	Approved multi-purpose greases: • Energrease LS EP 9346 of BP; • LM grease of Castrol; • Multipurpose of Veedol.
Propeller shaft	Special high temperature greases: • Retinax LX 2 of Shell; • Renolith Dutraplex GWB of Fuchs; • Norplex LKP 2 of Rhenus.
Steering gear: pitman shaft protection cap	Special grease: TEXACO Texando F0 20
Automatic passenger door: pillar	High temperature grease HT/2 with molybdenum disulphide (MoS_2)

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SERVICE BULLETINS

Service Bulletins are issued to supplement or supersede information in the Van Hool manuals. Note below number, date and subject of Bulletins pertaining to this chapter. File Bulletins separately by number for future reference.

Number	Date	Subject