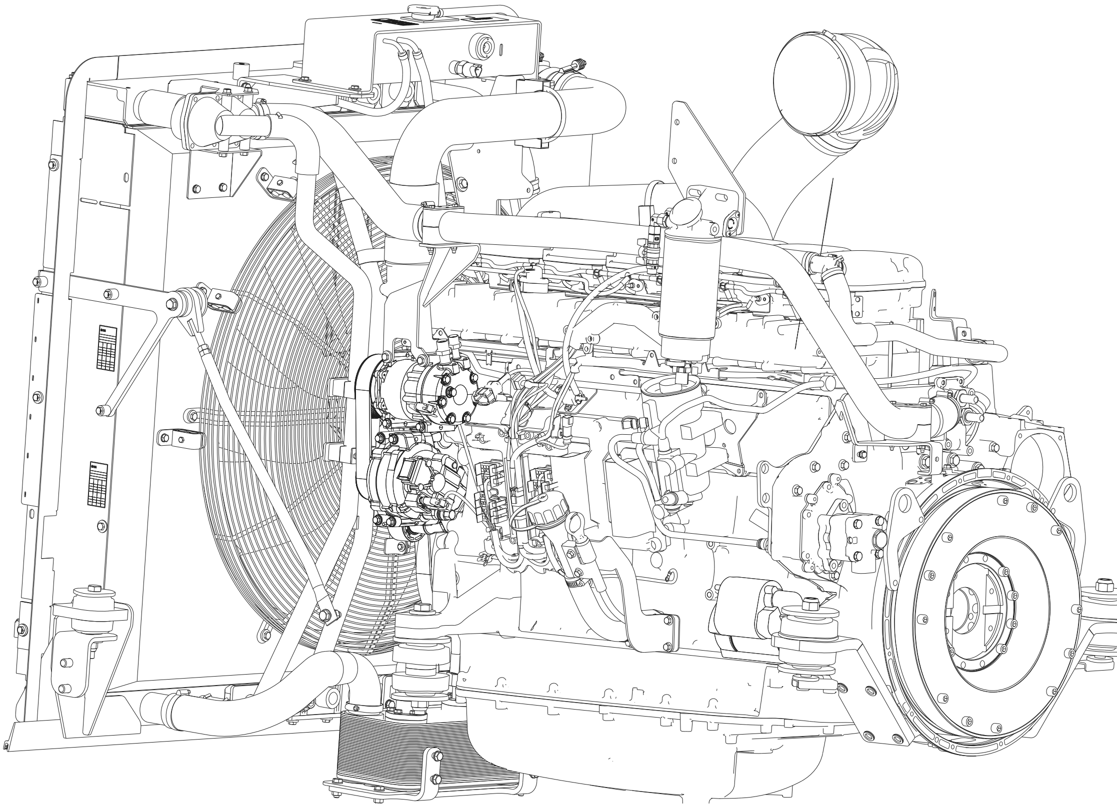
Chapter 1

Engine

PDE



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Structure of the Repair Manual

Important information on industrial safety

Generally, the persons repairing Hyundai product-sets are responsible on their own for the industrial safety.

The observation of all valid safety regulations and legal impositions is the pre-condition for avoiding damage to persons and to the product during maintenance and repair works.
Persons performing repair works must familiarize themselves with these regulations.

The proper repair of these Hyundai-products requires the employment of suitably trained and skilled staff.
The repairer is obliged to perform the training.

The following safety references are used in the present Repair Manual:

Serves as **reference** to special working procedures, methods, information, the use of auxiliaries etc..

NOTE — **This word is used for precautions that must be taken to avoid actions which could shorten the life of the dump truck.**

CAUTION — This word denotes safety messages for hazards which could result in minor or moderate injury if the hazard is not avoided. This word might also be used for hazards where the only result could be damage to the dump truck.
Illustrations, drawings and parts do not always represent the original; the working procedure is shown. The illustrations, drawings, and parts are not drawn to scale; conclusions regarding size and weight must not be drawn (not even within one representation).
The works must be performed according to the description.

REFERENCE: Prior to starting the checks and repair works, thoroughly study the present instructions.

DANGER — This word denotes safety messages where there is a high probability of serious injury or death if the hazard is not avoided. These safety messages usually describe precautions that must be taken to avoid the hazard. Failure to avoid this hazard may result in serious damage to the dump truck.
Is used, if lacking care can lead to **personal injury or danger to life.**

REFERENCE: **After the repair works and the checks, the expert staff must convince itself that the product is properly functioning again.**

Engine identification

The engine designation indicates, in the form of a code, the type of engine, its size and applications, etc.

The type designation and engine serial number are indicated on a type plate affixed to the right-hand side of the engine.
The engine number is also stamped on the engine block

Refer to the “Figure 1”.

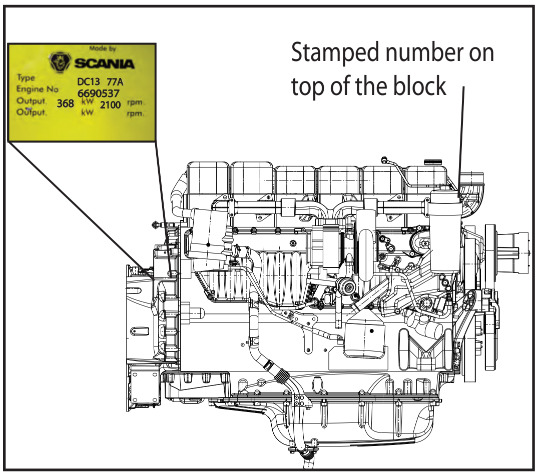


Figure 1

DC 13 368kW 083 A 00

Type

DC Supercharged diesel engine with air-cooled charge air cooler.

Displacement in whole dm^3

Performance and certification code

Indicates, together with the application code, the normal gross engine output
The actual output setting of the engine is indicated on the engine card.

Application

A For general industrial use

Variant 00 -99

Figure 2

NOTE

Because of the different engine variants the parts and images which are contained in this book can be different from the current model of engine or dump truck. For the spare parts please use the parts catalogue for current model.

NOTE

This chapter explains injection systems across each other due to components do not differ, but are common to both. The components or functions which mainly distinguishes these systems from each other is advertised clearly.

PREPARING THE ENGINE FOR STORAGE

If the engine is not to be used for an extended period, then its cooling system, fuel system and combustion chamber must be protected against rust. This also applies to the external shell of the engine. An alternative to preparing the engine for long-term storage is to start the engine and warm it up every 6 months.

Handling the Engine

The engine can normally stand idle for up to six months without preparation for storage. For longer periods of downtime, the following measures should be taken. These measures provide protection for approximately 4 years.
Preparations for storage:

- Thoroughly clean the engine.
- Run the engine for a specific period using special preservative fuel, oil and coolant.
- Also prepare other aspects of the engine for storage (filter renewal, lubrication, etc.).

Preservative Coolant

If the engine is to be stored with a full cooling system, use coolant containing 50 percent glycol by volume. Glycol without nitrite based inhibitor should be used.

WARNING

Ethylene glycol is highly dangerous if imbibed. Avoid contact with the skin.

Preservative oil

Suitable preservative oils are supplied by most oil companies.

Preparations for Storage

NOTE

Use a container to avoid spills when draining the oil and coolant. Dispose of used fluids through an authorized waste disposal contractor.

1. Drain and flush the cooling system. Top up with preservative coolant.

2. Warm up the engine on regular fuel. Stop the engine and drain the oil.

3. Renew the fuel filter.

4. Fill the engine with preservative oil up to the minimum level on the dipstick.

5. Mix preservative fuel in a can. Detach the fuel pipe at the feed pump suction line and connect a hose from the can.

6. Detach the fuel pipe at the overflow valve and connect the return hose to the can.

7. Start the engine and run it at about 1,000 rpm for 20-25 minutes.

8. Stop the engine, remove the hoses and connect the normal fuel pipes.

9. Remove the rocker covers and lubricate the valve mechanisms with plenty of preservative oil. Refit the rockercovers.

NOTE

Do not remove the injectors.

10. Drain the preservative oil from the engine. Fill with new engine oil immediately or when the engine is to be reused. (For fluid type and specifications, refer to the Hyundai Operating & Maintenance Manual Chapter 6)

11. Drain the coolant if the engine is not to be stored with coolant in the system. Plug and tape all coolant connections if the engine is to be stored without a coolingsystem.

12. Air cleaner: clean or renew the filter element.

13. Cover air intakes and exhaust pipes.

14. Alternator and starter motor: Spray with water-repellent anticorrosive oil.

15. Spray the outside of bright engine parts, first with penetrating preservative oil such as Dinitrol 25B and then with Dinitrol 112 or the equivalent.

Clearly mark the engine with the storage preparation date, and state that the engine must not be started or cranked.

Batteries

Remove the batteries for trickle charging at a charging station (this does not apply to batteries which are maintenance-free according to the manufacturer).
The same applies to short-term storage, even if the engine has not been prepared for storage as above.

WARNING

Wear gloves and protective goggles when charging and handling batteries. The batteries contain a highly corrosive acid.

Storage

After the preparations, the engine should be stored in a dry and warm place (room temperature).
When the engine is to be taken into operation again

- Remove plugs and tape from coolant connections, air intakes and exhaust pipes.
- Fill the cooling system with coolant. For more information refer to Inspections.
- Check the oil level in the engine or top up with fresh engine oil.
- Lubricate the valve mechanisms and their pushrods and valve tappets as well as the injector mechanisms with plenty of oil.
- Drain the preservative fuel from the fuel manifold and fuel filter.
- Connect and bleed the fuel system. For more information refer to the section headed Inspection.
- Wash off any preservative oil on the outside using white spirit.

Checks After Long-term Parking

- All oil and fluid levels.
- Tension of all belts.
- Air pressure.
- Air cleaner.
- Batteries and electrical connections.
- Lubricate all greasing points.
- Wipe off grease from piston rods.
- Inspect for signs of nests (i.e. birds, rodents, etc.)

Removal of engine assembly

- Place the dump truck on level ground and apply parking brake.
- Apply articulation lock.
- Raise the dump body and lock it with the safety support.
- Turn off main switch in battery case.
- Raise the tiltable cab and lock it with the safety support.
- Drain engine coolant.

  Look in OPERATION & MAINTENANCE MANUAL chapter 2 for instructions.

WARNING

Never turn off battery main switch when engine is running
Never turn off battery main switch when ignition is on
Leave battery main switch on for atleast 5 minutes after engine has completely stopped

DANGER

Place wheel chocks to the front wheel

Take away the cab bolt, left and right hand side.

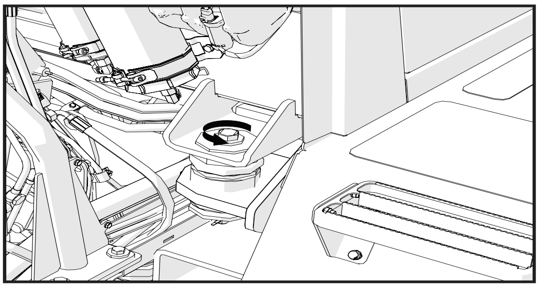


Figure 3

Turn the direction valve on the pump in lifting up position.

Using the handle, pump and raise the cab.

Figure 4

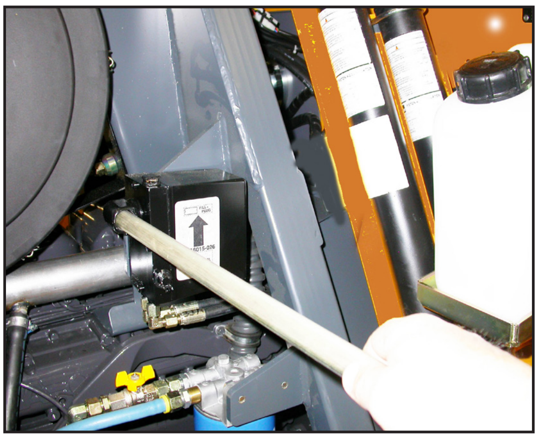


Figure 5

Left side:

1. Disassemble the cab pump and diesel filter from the air filter stand.

2. Remove the fuel hoses from engine (2 pcs).

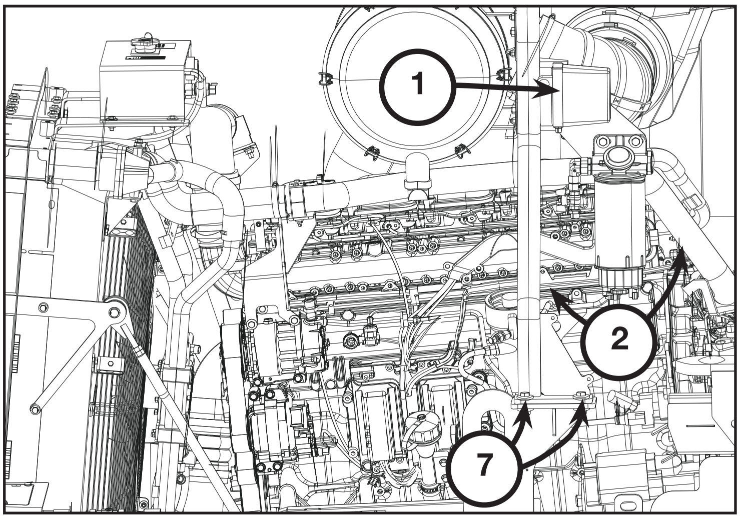


Figure 6

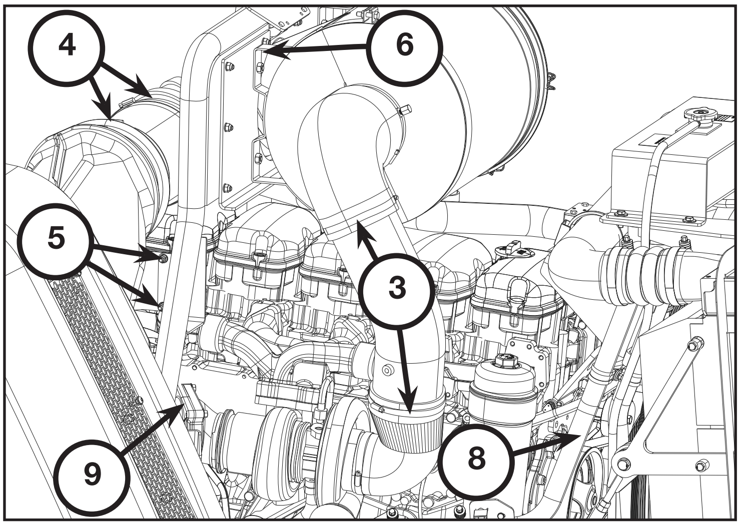


Figure 8

Right side:

1. Unscrew the hose clamps and remove the pipe bend, filter - turbo.

2. Disassemble inlet pipe and hose before air filter.

3. Disassemble air guide plate.

4. Hoop up the filter stand in lifting device.

5. Unscrew the fastening bolts for filter stand and lift off filter stand.

6. Unmount hoses attached to cooling water expansion tank.

7. Disconnect the exaust pipe from the turbo pipe bend.

8. Unmount hoses attached to cooling water expansion tank.

9. Disconnect the exhaust pipe from the turbo pope bend.

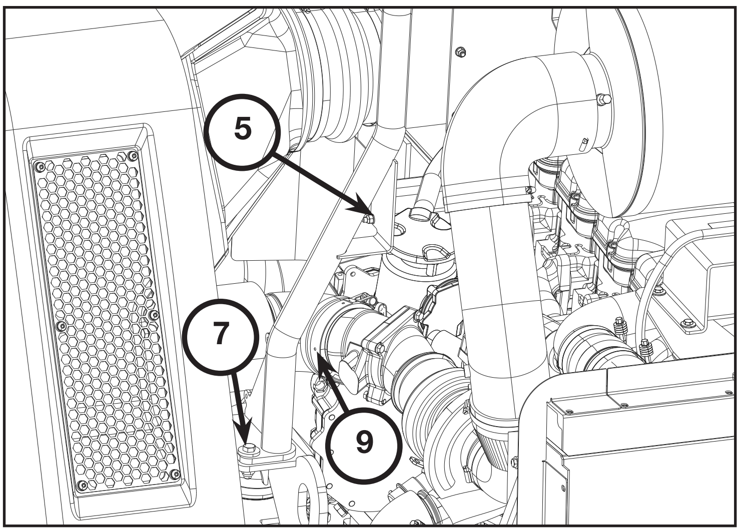


Figure 7

Slack the transmission belt.

Detach the air cond. compressor with the hoses on, from the engine. Check that all of the clamps are undone.

Place the air condition compressor on the left side while the
engine is dismounted.

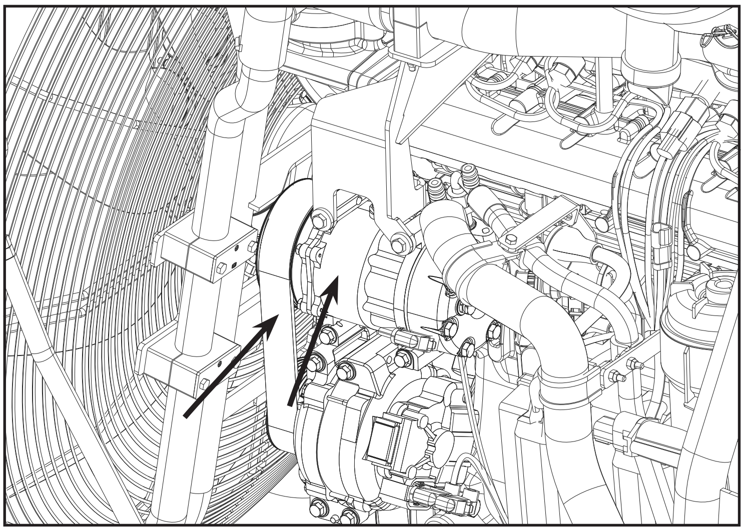


Figure 9

Disconnect the hose from the thermostat housing and the pipe between the air cooler and engine air inlet.

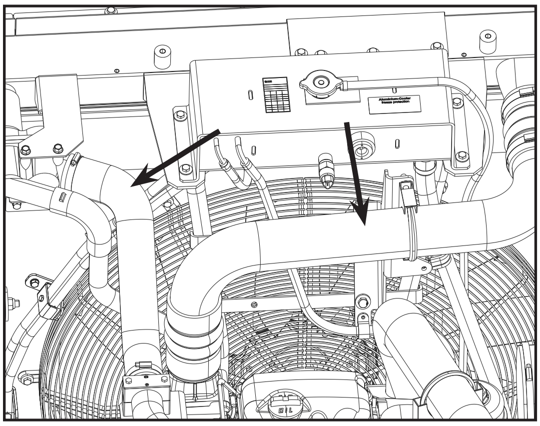


Figure 10

Disconnect the outlet pipe bend from turbo, and the inlet water hose from the transmission cooler.

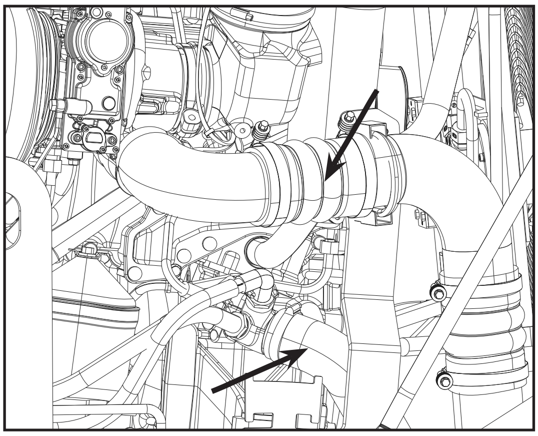


Figure 11

Disconnect the return hose. (Engine - expansion tank)

(Quick release coupling)

(Front of the engine, view from the right hand side)

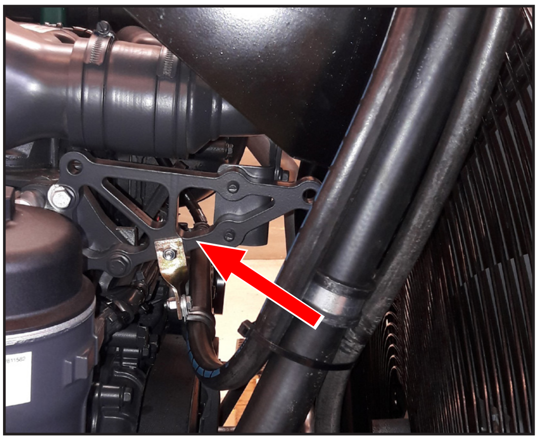


Figure 12

Disconnect the cables between starter motor and the frame.

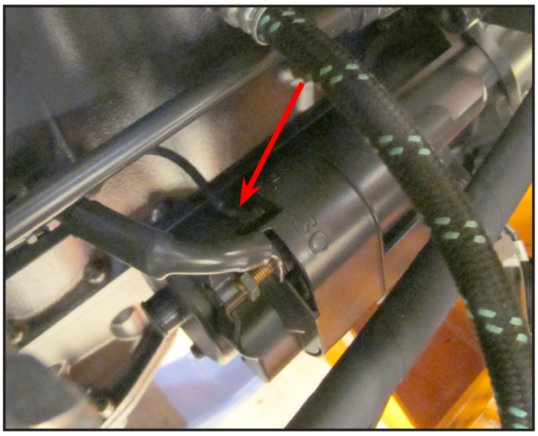


Figure 13

Disassemble grounding cable attached to bracket underneath the engine starter.

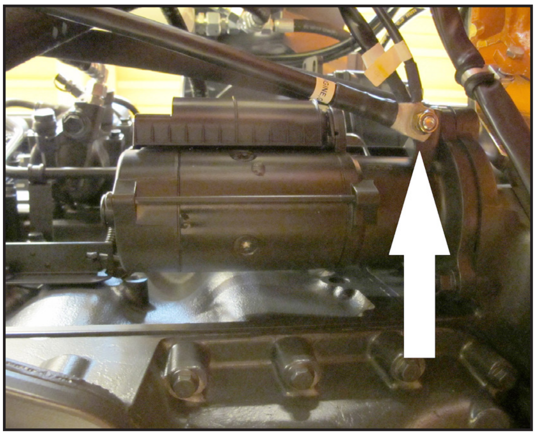


Figure 14

Disconnect contact on the dynamo.

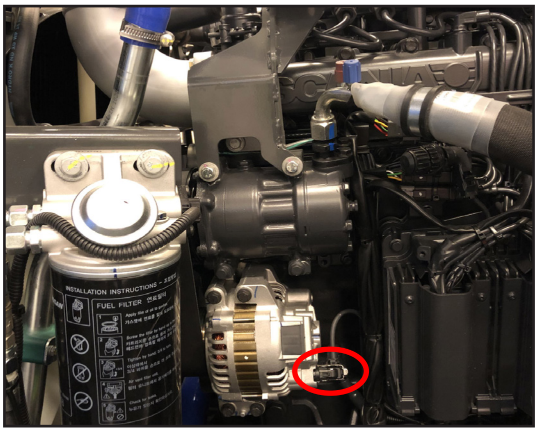


Figure 15

Remove the cover and disconnect the electrical contact from the engine ECU -S6 control unit.

Unwind wires from engine to frame.

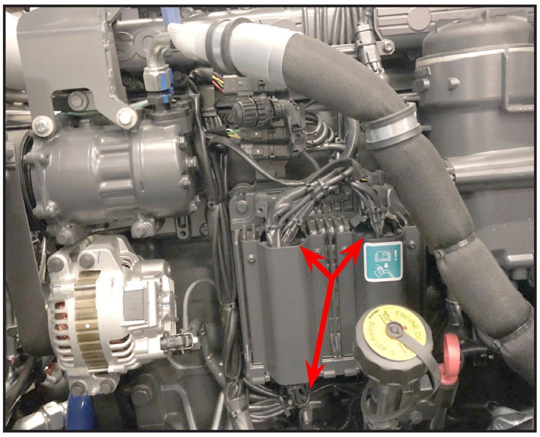


Figure 16

Drive shaft
Remove safety archer.
Remove driveshaft between transmission and engine coupling,

1 Assembly torque: 114 Nm

2 Assembly torque: 141 Nm

3 Assembly torque: 141 Nm

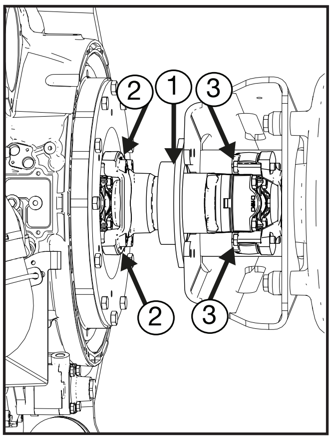


Figure 17

Front- Left and right hand side, disassemble screw on the engine mounting bracket.

Assembly torque: 560 Nm (M20 10.9)

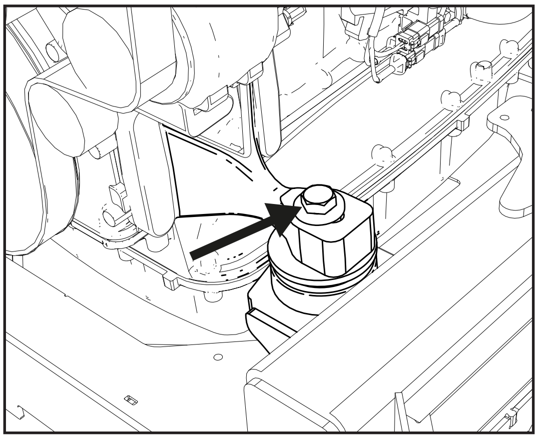


Figure 18

1. Disassemble the hose clamp bracket.
   Remount the bolts of lifting eye.

2. Unscrew the engine bracket bolt left and right hand side.

Assembly torque: 560 Nm (M20 10.9)
Use lock washer on bolts when reassembling.

Remove clamps and dissasemble hoses connected to hydraulic block.

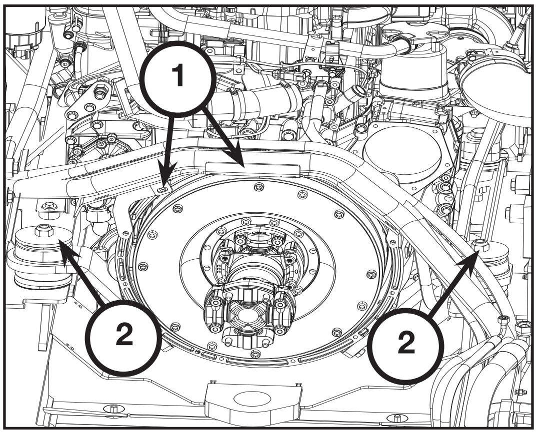


Figure 19

Disassemble front brake oil cooler hose from the brake cooler circulate pump. Plug open ports.

Torques for assembly:

1. 110 Nm

2. 37 Nm

3. Hand tighten

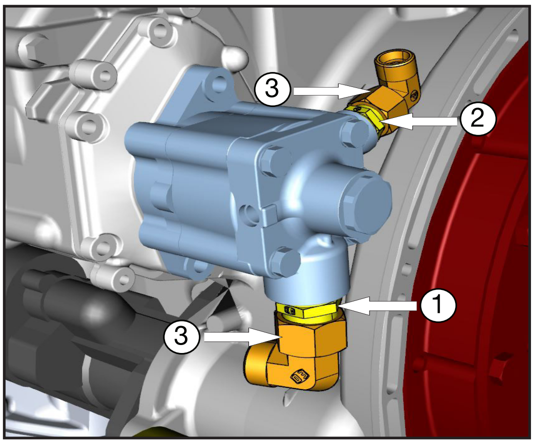
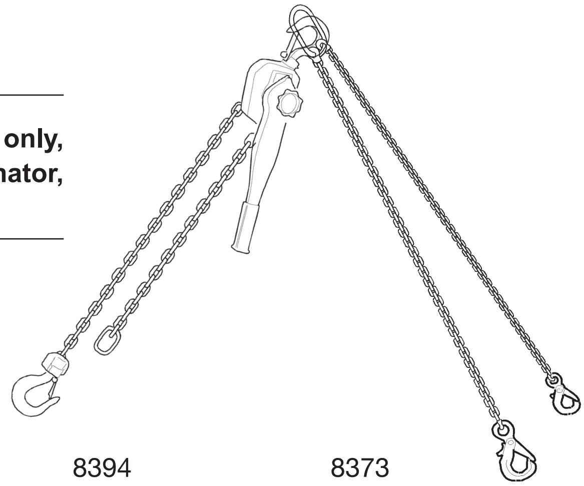


Figure 20

Lifting the engine

NOTE

The engine lifting eyes are designed for lifting the engine only, not the engine together with its ancillary equipment (alternator, gearbox etc.) or frame.



8394
Lever block

8373
Lifting chain

Figure 21

- Mount the lifting chain to the rear lifting eyes.
- Mount the lever block to the front lifting eye.

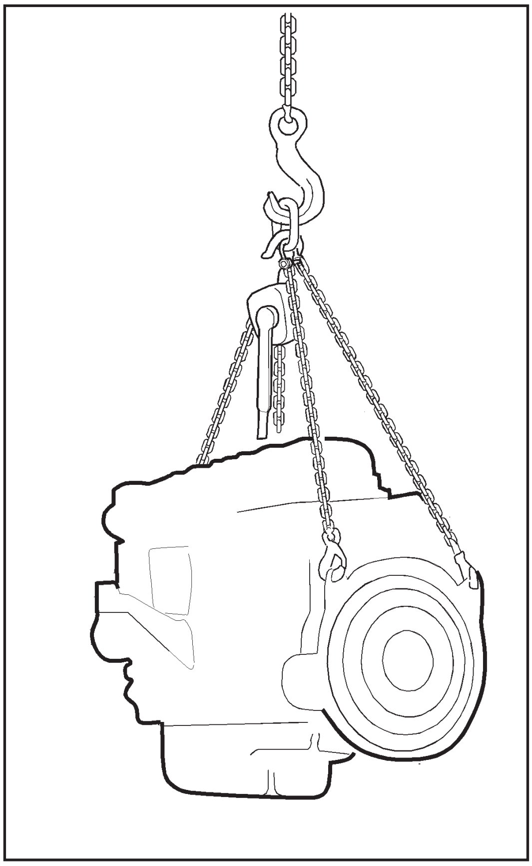


Figure 22

With caution, lift the engine out from the frame

NOTE

The lifting eyes are sized to cope with a maximum angle of 30°.

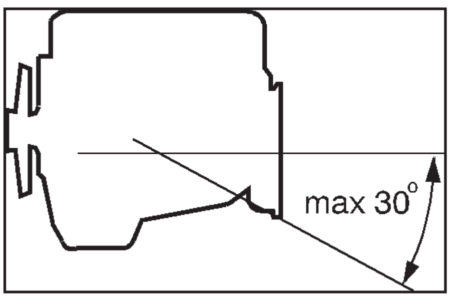


Figure 23

Starting the engine

For environmental reasons the Scania engine has been developed to be started with a low fuel feed. Using unnecessarily large amounts of fuel when starting the engine always results in emissions of unburnt fuel.

- Open the fuel cock if fitted.
- Disengage the engine.
- If the engine has a battery master switch: switch on the power by means of the battery master switch.
- Start the engine.

If the fuel tank has been run dry or if the engine has not been used for a long time, bleed the fuel system.

WARNING

Never use starter gas or similar agents to help start the engine. An explosion may occur in the intake manifold with a risk of personal injury. Only start the engine in a well ventilated area. When the engine is run in an enclosed space, there must be effective devices to extract exhaust gases and crankcase gases.

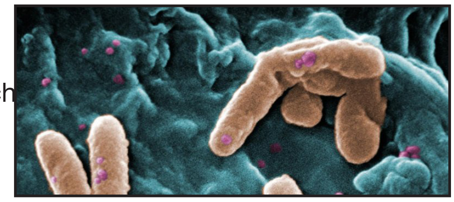
NOTE

The starter motor must only be cranked twice for 30 seconds at a time. After that, it must rest for at least 5 minutes before the next attempt to start it.

Starting at low temperatures
Take the local environmental requirements into account. Use a fuel heater and engine heater to avoid starting problems and white smoke.
A low engine speed and a moderate load on a cold engine limits white smoke, gives better combustion and warms up the engine more quickly than warming it up with no load.
Avoid running it longer than necessary at idling speed.

Important information about the fuel

Fuel initially contains a reduced quantity of water rom the manufacturing process. The water content may increase, e.g. as a result of condensation, during prolonged and unsuitable storage.
Small quantities of water in the fuel do not affect the engine operation. However, micro-organisms grow in the water. The microbes obtain nourishment from the oil and their growth is therefore greatest in the boundary layer between the water and oil. In an emulsion the boundary layer is very large and emulsification therefore encourages growth.



The cause of breakdowns can generally be attributed to badly maintained supply tanks. Water, dirt, fungi and/or **bacteria** have collected in tanks which are rarely cleaned or drained. They form a mass which can block filters. There are additives which counteract this, but we would warn against their use since they are hazardous environmental toxins which affect the microflora. In our experience the established oil companies maintain their tanks in such a way that contamination of this kind does not occur. Where problems have occurred, the tank has not been maintained correctly. The oil companies do not use toxic substances, but rely entirely on regular cleaning and drainage of water from the tanks. The latter should, however, be carried out only some days after the tank has been filled, so that the water has sunk to the bottom. Drainage is carried out at all stages of the distribution, both in depots and at filling stations. Heat is applied to larger, cooled tanks to reduce the fuel iscosity, resulting in internal
circulation to accelerate the precipitation before draining the water.

De-contamination
Tanks:
- Clean large supply tanks carefully inside and dry them before filling them with new fuel.
- Drain the water a few days after filling and at regular intervals from then on in accordance with the oil supplier's instructions.

Engines installed in vehicles, boats etc.:
- Clean the entire fuel system, otherwise the microbial flora will spread again.
- Rinse the fuel lines and blow them dry.

Replace fuel filters.
- Clean the fuel tank.
- If the contamination was very serious, it may be necessary to inspect the injectors and injection pump and remove any deposits that may have formed. Experience has shown that biological tissue can penetrate the fuel filter
and may create deposits in those parts of the system beyond the filter.
- Biocides may be used as a last resort. The individual tank owner should refrain from handling such substances. Any such use should take place with the assistance of the fuel supplier.

Summer and winter fuels
(Available on markets with cold climates)
Fuel can be adjusted to the seasons by adding lighter components and removing components which can crystallise out at low temperatures. It is mainly the higher paraffinic hydrocarbons which crystallise out and these help to increase the ignition value.

The winter fuel has a lower density and lower viscosity. This results in a reduction in engine output.

Environmental fuel
Environmental fuel with markedly reduced sulphur contents and therefore emissions is available on various markets. Normally the density and viscosity is also lower for these fuels.
By using output correction curves (formulae), the outputs can be corrected for the effect of density and viscosity.

Fuel system Tier2 (PDE)

Schematic diagram of the fuel system Tier2

A = Pressurised fuel
B = Return pipe
C = Leak-off fuel

The feed pump (1) draws fuel from the fuel tank and presses it through the fuel filter (2) and into the fuel manifold (3).

On the feed pump there is a hand pump, which is used when bleeding the fuel system.

The fuel manifold distributes the fuel through ports in the cylinder head and into the unit injectors (4) in each cylinder head. The engine control unit controls when the unit injectors should inject fuel into the cylinders.

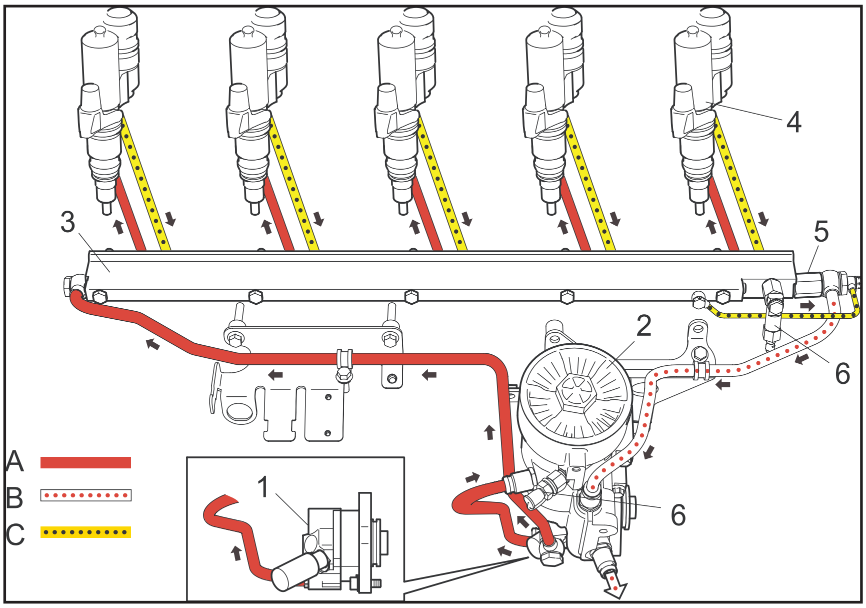


Figure 24

Surplus fuel in the unit injector after combustion remains in the fuel duct. Any leak-off fuel from the unit injector goes out into the leak-off fuel duct in the fuel manifold. After the overflow valve (5) the leak-off fuel flows into the return fuel pipe, returning to the fuel tank.
The overflow valve opens when the pressure becomes too high and the surplus fuel can then return to the fuel tank.
At the overflow valve there is a connection for a bleed nipple, which is used during maintenance (6).

Overflow valve

The purpose of the overflow valve is to limit the pressure in the fuel system and continuously vent it. The overflow valve ensures that the fuel circulates round the system and that there is always fuel in the injection pump for cooling, lubrication and injection.

Lowest permitted fuel pressure at 1,900 rpm	5.5 bar
Lowest permitted fuel pressure at 720 rpm	4.5 bar
Lowest permitted fuel pressure	4.5 bar
Highest permitted fuel pressure	7.5 bar

Opening pressure is **4,5 bar**.
Working pressure is approx. **6 bar**.

1. Fuel rail
2. Drain nipple (for bleeding)
3. Fuel filter
4. Overflow valve

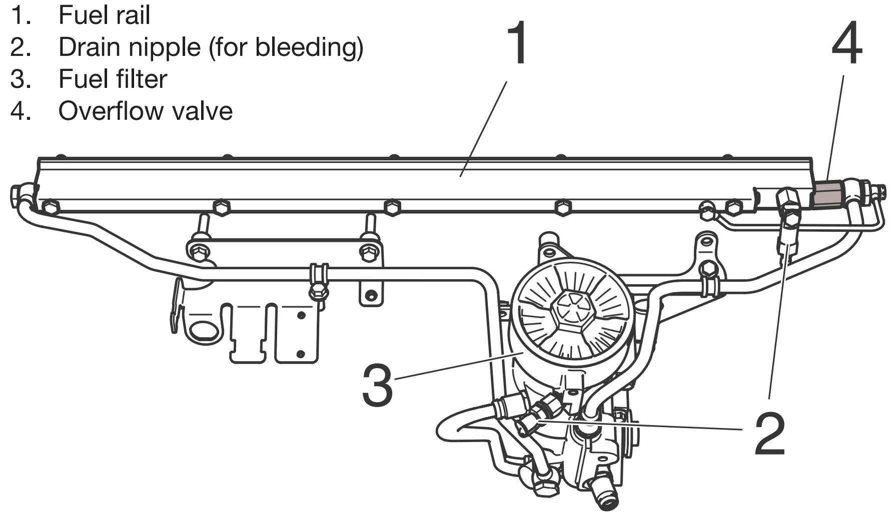


Figure 25

The pressure must be at least 4.5 bar before the overflow valve opens. If the overflow valve opens at a lower pressure, it is faulty and must be renewed.

Start the engine and increase the speed to 1,500 rpm. If the pressure then exceeds 7.5 bar, the overflow valve is blocked and must be cleaned or renewed.

General

Apart from fuel lines and a fuel tank, a PDE (Pumpe-Nozzle-unit) fuel system with unit injectors consists of the following items:
• a feed pump
• a hand pump
• a fuel filter
• one fuel rail.
• a pressure relief valve
• One PDE type unit injector per cylinder.
The fuel system also includes an electronic control system. The control system includes an electronic control unit, the unit injector solenoid valves and sensors.

PDE

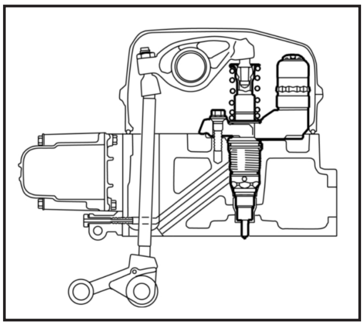


Figure 26

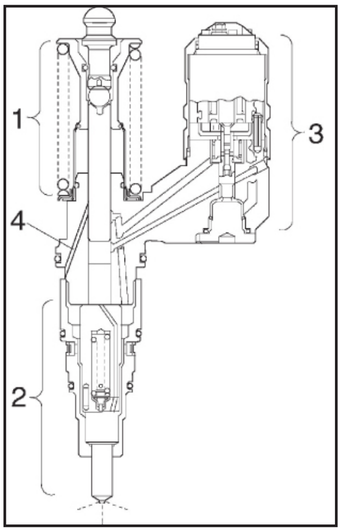


Figure 27

Fuel

Diesel fuel oil

The composition of the diesel fuel oil has a great influence on the functioning and the service life of the engine and the injection system.
The engine output and exhaust emissions are also dependent on the fuel quality.
The diesel fuel must meet European standard EN 590.
The table below shows the requirements for some of the most important properties:

Property	Requirement
Viscosity at 40°C	2.0 - 4.5 mm^2/s (cSt)
Density at 15°C	0.82 - 0.86 kg/dm^3
Sulphur (concentration by mass)	max. 0.3%
Ignitability (CET rating)	min. 49
Flashpoint	56°C

Figure 28

Temperature dependency of the fuel

At temperatures lower than those specified for the fuel, paraf-
fin
wax may precipitate from the fuel and block filters and pipes.
The engine can then lose power or stop.
The fuel is adapted for use in the specific climate of each country. If a vehicle or an engine is to be operated in a temperature zone with a temperature lower than normal, first identify the temperature properties of that particular fuel.
The properties of the fuel when cold can be improved by adopting one of the following measures before the tempera-
ture
drops:

• Install an electric fuel heater if this particular fuel is not suitable for the expected temperature, and no fuel is available with the correct temperature properties.

• Add 0.5 - 2% alcohol (isopropanol) to prevent any water in the fuel from freezing and forming plugs of ice. Drain fuel tanks and drain or renew fuel filters regularly.

NOTE

Mixing kerosene or other paraffins with the fuel is prohibited. The injectors may be damaged.

Mixing petrol with the fuel is prohibited. In the long term petrol can cause wear in the injectors and engine.

Environmentally favourable fuels (low sulphur fuels)

There are three classes of so called environmentally favourable fuels (SS15 54 35).

Class 1 is sulphur-free and class 2 is low in sulphur. Compared with class 3 (normal fuel), these fuels are less dense and this reduces engine power output.

Fuel filter

Design
The fuel filter is of single-mounted type on a PDE system.
The filter consists of a container with a folded paper element.

The fuel filter has no bleed screw and is bled by undoing plug **4** in the free inlet passage.

Function
Fuel is pumped into the inlet by the fuel pump. It then continues through passages in the filter retainer to the upper part of the filter, down through the filter(s) and on to the outlet passage. From there, the fuel is piped to the injection pump.

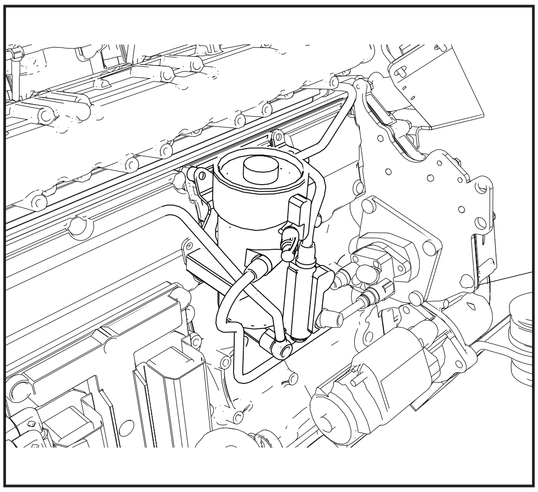


Figure 29

Fuel filter, constituent parts

Changing the fuel filter

NOTE

Avoid spillage and use a suitable container. Used fuel must be disposed of as specified in national and international law.

1. Unscrew the filter cover with a closed tool with hexagondriver, e.g. socket, so as not to damage the filter cover.

2. Lift out the filter cover and filter element. The filter housing will drain automatically. This applies only if the fuel tank is lower than the engine. Otherwise the fuel shut-off cock must be closed first.

3. Undo the removed filter element from the cover by carefully bending it to one side.

4. Renew the O-ring in the cover. Lubricate the O-ring with O-ring grease.

5. Check that the filter housing is drained of fuel. Contaminated fuel may enter the injectors if the drainage does not work.

6. Press a new filter element into the snap fastener in the cover.

7. Fit the filter element and cover in the filter housing. Tighten the cover to 25 Nm (18.4 lbf.ft).

8. Bleed the fuel system after renewing the water separating filter.

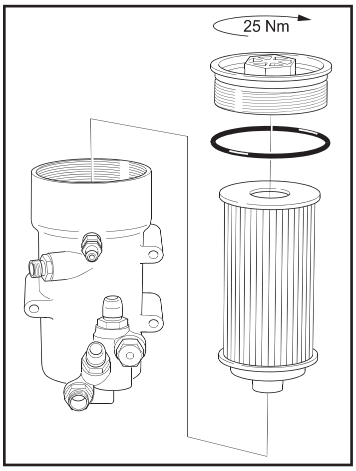


Figure 30

CAUTION

Fit the filter elements in the filter covers before placing them in the fuel filter housings or the filter elements may be damaged.

Water separating prefilter PDE

NOTE

The same intervals between changes apply as for those for an ordinary fuel filter.

Changing the water separating fuel filter

1. Close the shut-off cock (1) in the fuel pipe and position a container under the filter.
2. Open the drain tap (2) in the filter cover and let the fluid run down into the container. Unscrew the filter cover.
3. Unscrew the filter from the filter head.
4. Discard the old filter and use a new filter.
5. Lubricate the O-ring in the filter cover with engine oil.
6. Screw the filter cover onto the new filter by hand. Make sure that the drain tap is fully closed.
7. Lubricate the O-ring on the filter with engine oil.
8. Fill the width of the filter with clean fuel.
9. Screw the filter into position until the O-ring rests against the filter head. Tighten the filter another 1/2-3/4 turn by hand.
10. Open the shut-off cock and check the system for leaks.
11. Bleed the fuel system.

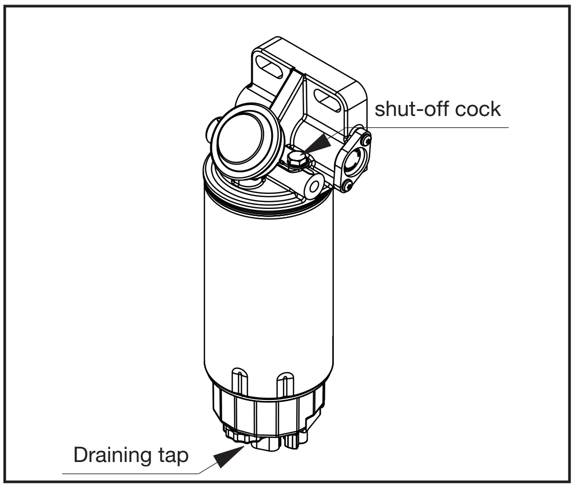


Figure 31

Bleeding the fuel system

1. Attach a clear plastic hose to the bleed nipple on the fuel filter housing. Place the end of the plastic hose in a container that holds at least 3 litres (1 US gallon).

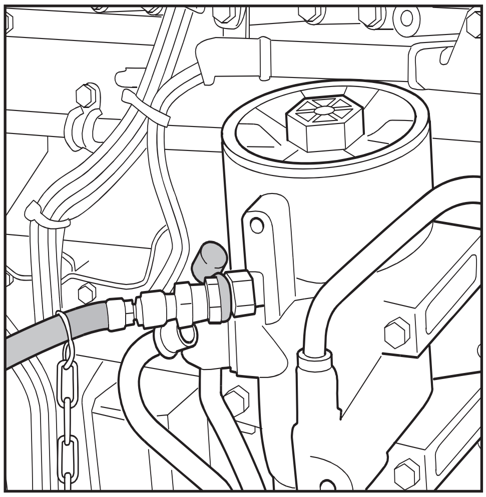


Figure 32

2. Connect the suction tool.

3. Connect compressed air to the suction tool. Turn the rotary control to create a vacuum.

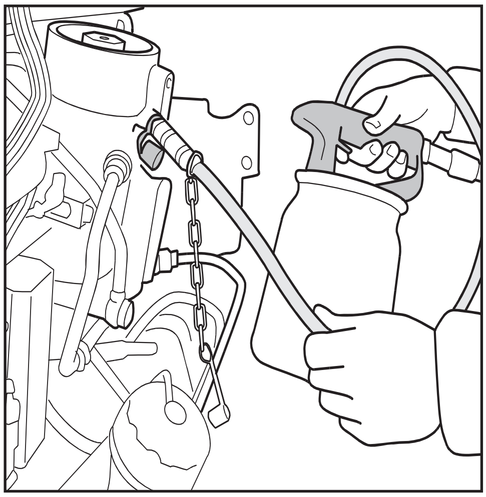


Figure 33

4. Open the bleed nipple. Hold the suction tool straight and draw out at least a full container of fuel. Once the fuel coming out of the hose is free of air bubbles, then bleeding is complete.

5. Close the bleed nipple. Remove the hose and suction tool.

6. Start the engine and check that there are no leaks.

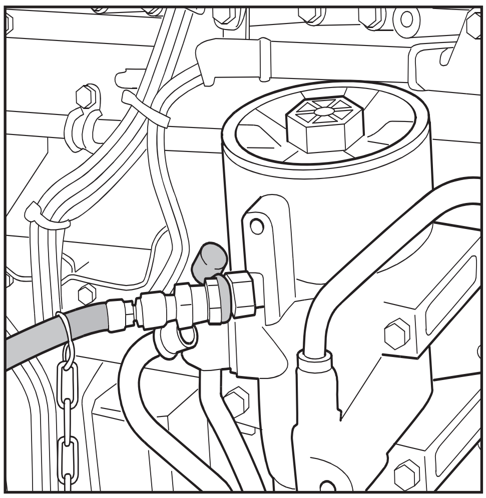


Figure 34

Temperature dependence of diesel fuel

At temperatures lower than those specified for the diesel fuel, paraffin wax may precipitate from the fuel and block filters and pipes. The engine can then loose power or stop.
The diesel fuel is adapted for use in the specific climate of each country. If a vehicle or an engine is to be operated in a temperature zone with lower temperature than normal, first identify the temperature properties of the fuel concerned.

The properties of the fuel when cold can be improved by adopting one of the following measures before the temperature drops:

- If the fuel concerned cannot cope with the expected temperatures, and diesel fuel is not available with the correct temperature properties, we recommend that an electric fuel heater is installed **as a preventative measure.**

- The low temperature properties of diesel fuel may be improved by adding kerosene **as a preventative measure.** A maximum of 20% may be added. When refuelling, the kerosene should be added first, so that it mixes thoroughly with the diesel fuel.

NOTE

It is prohibited to use kerosene in engine fuel in some countries.

- To prevent water in the fuel from freezing and forming ice, a maximum of 0.5-2% alcohol (isopropanol) may be added.

Drain fuel tanks and drain or change fuel filters regularly.

WARNING

It is not permitted to mix kerosene with diesel fuel that is already adapted for the climate concerned. This can damage the PDE injectors. All use of paraffin other than kerosene is forbidden, as it causes engine damage.

CAUTION

It is not permissible to mix petrol with diesel fuel. In the long term, petrol may cause wear to the PDE injectors and it may also cause damage to the engine.

Feed pump

The feed pump is of the gear pump type and is driven by the compressor crankshaft.
Its capacity is adjusted to deliver the right pressure and flow rate to all unit injectors.
On the underside of the feed pump is an overflow aperture that functions as a leakage indicator for both fuel and oil.

Feed pump renewal

1. Clean the outside of the feed pump. Remove the suction and pressure lines from the feed pump. Fit protective plugs.
2. Unscrew the bolts and remove the feed pump.
3. Place a new O-ring onto the feed pump and lubricate with O-ring grease.
4. Fit the feed pump.
5. Connect the suction and pressure pipes.
6. Bleed the fuel system; refer to Bleeding the fuel system.
7. Start the engine and check for leaks.

The feed pump (B) draws fuel from the fuel tank (6) and forces it through the fuel filter (4) and into the fuel rail (1). On the feed pump there is a hand pump (2) The hand pump is used to vent air from the fuel system.
On the fuel rail there is a pressure relief valve 5. The pressure relief valve constantly regulates the fuel pressure.

When the pressure is too high, the pressure relief valve opens, so that the excess fuel is returned to the fuel tank. The fuel rail distributes the fuel to the unit injectors in each cylinder head. The ECU control unit determines when the unit injectors must inject fuel into the cylinders.

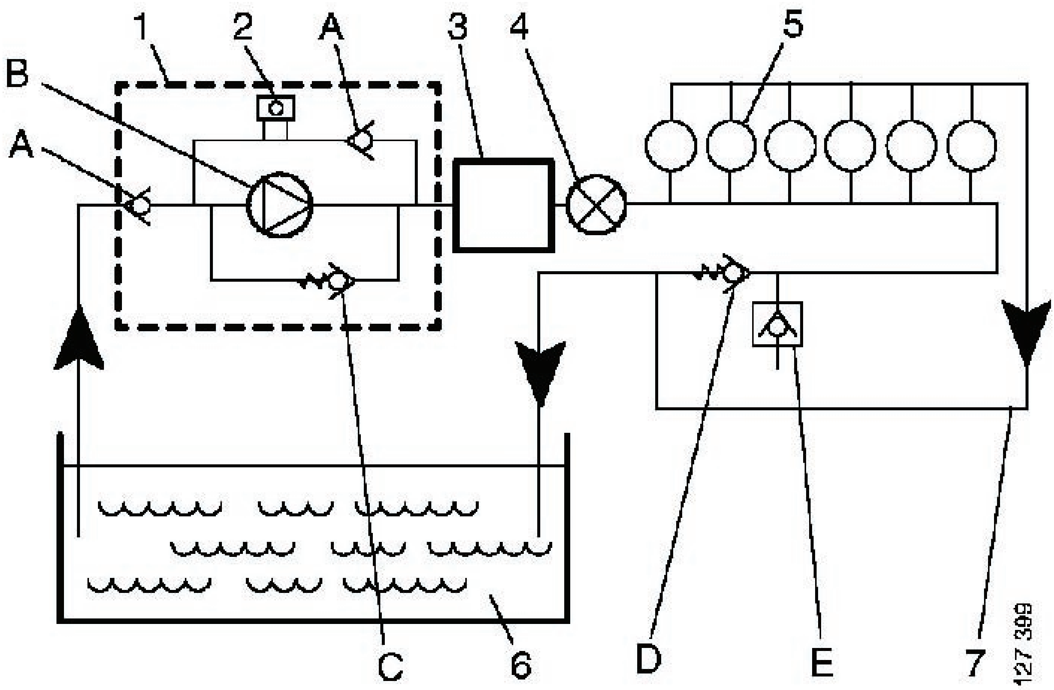


Figure 35

1. Feed pump
2. Hand pump
3. Control unit
4. Fuel filter
5. Cylinders
6. Fuel tank
7. Return pipe

A. Check valve
B. Feed pump (gear driven)
C. Safety valve
D. Overflow valve
E. Drain nipple

Renewing the control unit

Tightening torques

Control unit, screws	22 Nm

Work description

CAUTION

The control unit may suffer damage if it is powered when you unplug it. Before removing the control unit you must switch off the power with the starter key and wait for the EMS warning lamp to go out.

1. Remove the control unit cover
2. Remove the control unit connectors
3. Detach the fuel pipes to the control unit cooling coil from the control unit
4. Remove the fuel pipes to the control unit cooling coil from the feed pump and the fuel filter
5. Remove the control unit
6. Remove the control unit bracket

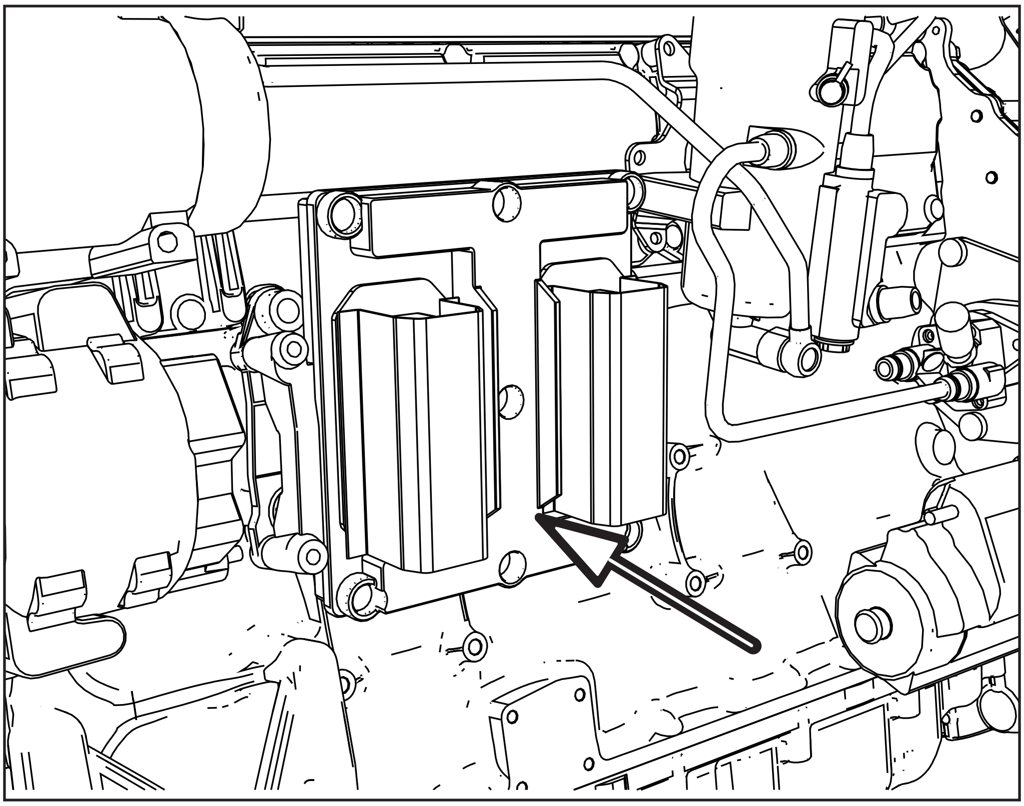


Figure 36

Cylinder head - PDE System Tier2

Cylinder head, parts view. PDE Tier2

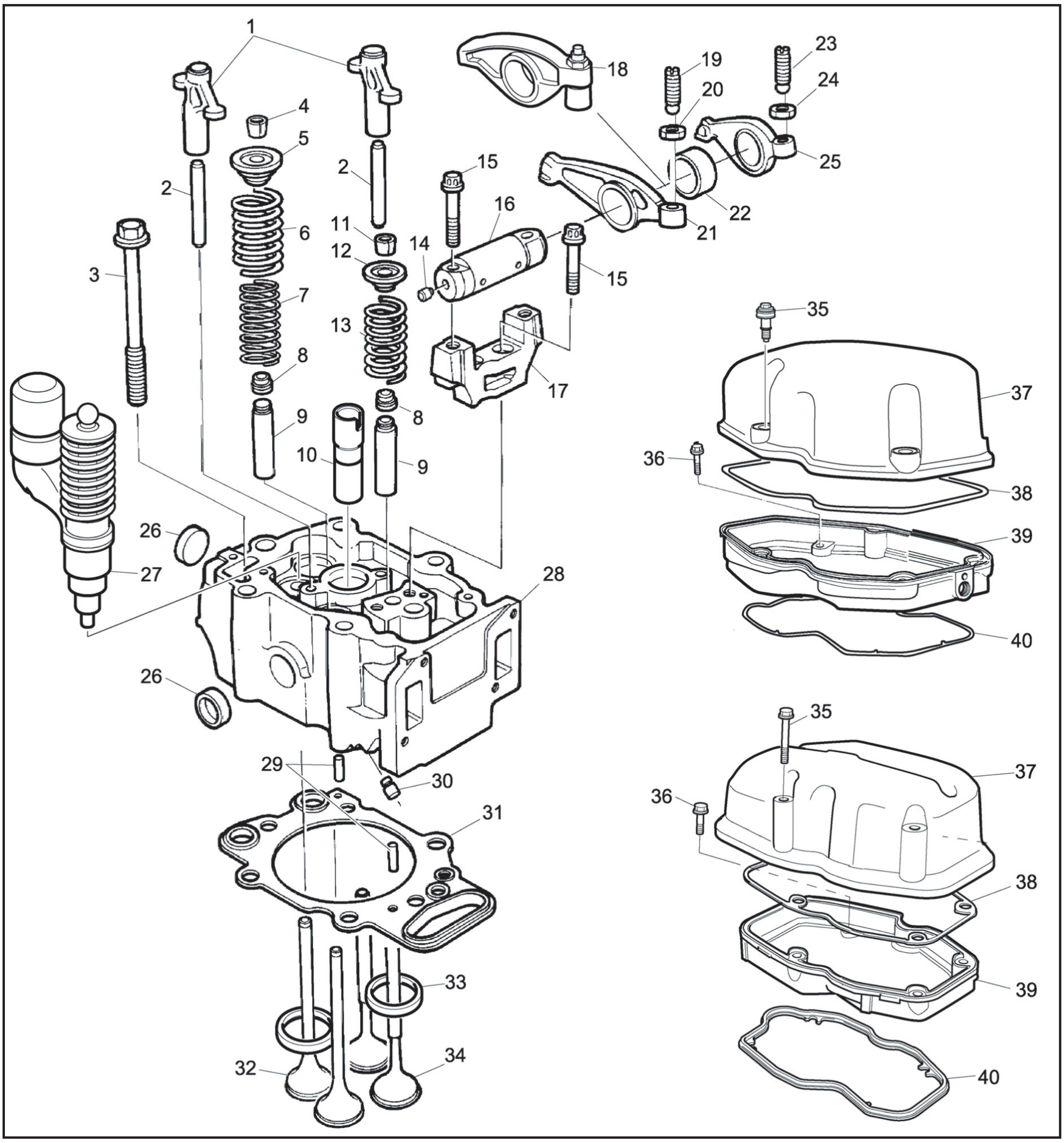


Figure 37

1. Valve bridge
2. Pin
3. Bolt
4. Collet
5. Valve spring collar
6. Valve spring
7. Valve spring
8. Valve stem seal
9. Valve guide
10. Socket
11. Collet
12. Valve spring collar
13. Valve spring
14. Rivet plug
15. Tight-fit screw
16. Shaft
17. Bearing bracket
18. Rocker arm for unit injector
19. Adjusting screw
20. Hexagon nut
21. Rocker arm
22. Spacing sleeve (injection pump)
23. Adjusting screw
24. Hexagon nut
25. Rocker arm
26. Core plug
27. Unit injector
28. Cylinder head
29. Pin
30. Rivet plug
31. Gasket
32. Exhaust valve
33. Valve seat insert
34. Intake valve
35. Flange bolt
36. Flange bolt
37. Rocker cover, upper section
38. Rocker cover gasket
39. Rocker cover, lower section
40. Rocker cover gasket

Special tools

850329-00335	Slide hammer
MX008049	Impact drift
MX008029	Extractor for injectors
MX008019	Compression tester
MX008386	Sleeve for injectors
850329-00174	Tool for turning flywheel
MX008387	Socket
850329-00302	Press drift
850329-00303	Assembly drift
MX512260	Drift
MX512261	Handle
MX512257	Drift
MX512266	Pilot tap
MX512259	Drift
MX512258	Drift
MX512262	Guide
850329-00368	Valve seat cutter
MX512263	Setting tool

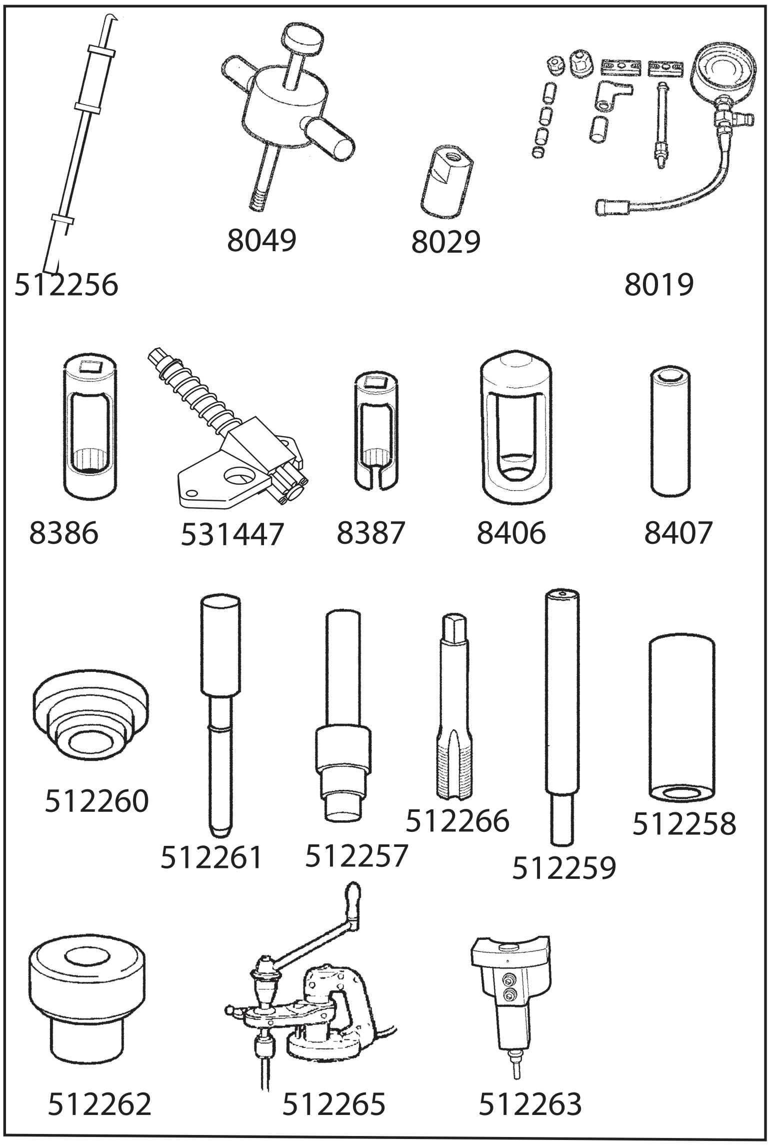


Figure 38

Valve mechanism

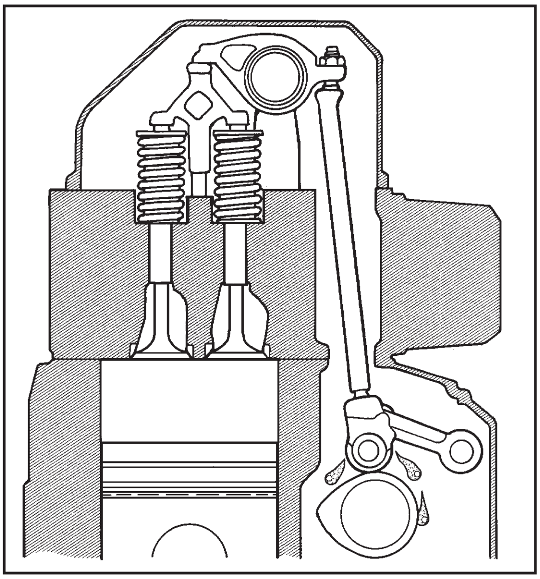


Figure 39

The purpose of the valve mechanism is to actuate the valves, causing them to open and close at the right times in relation to the position of the crankshaft and piston.

The camshaft is located high up and driven by the timing gears at the rear end of the engine so that it rotates at half the speed of the crankshaft.

The camshaft cams (lobes), two for each cylinder, actuate the valve tappets.

The pushrods have one end in the tappets and the other end, via the rocker arms, transfers the movement from the camshaft cam to the valves.

At one end of the rocker arm is an adjusting screw, the spherical lower end of which rests in the pushrod so that the tappet follows the camshaft at all times.

The correct clearance can be set with the adjusting screw to ensure that the valve will close properly during combustion.

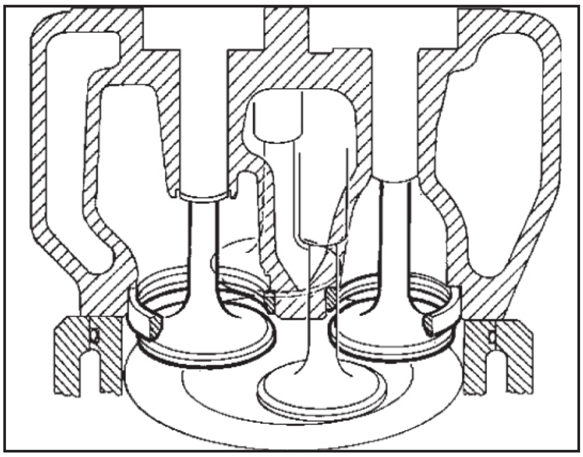


Figure 40

The valves seal against valve seat rings which are pressed into the cylinder head to make a tight fit.
The valve seat rings are made of extremely durable material to give them a long service life.
They can be replaced if necessary.

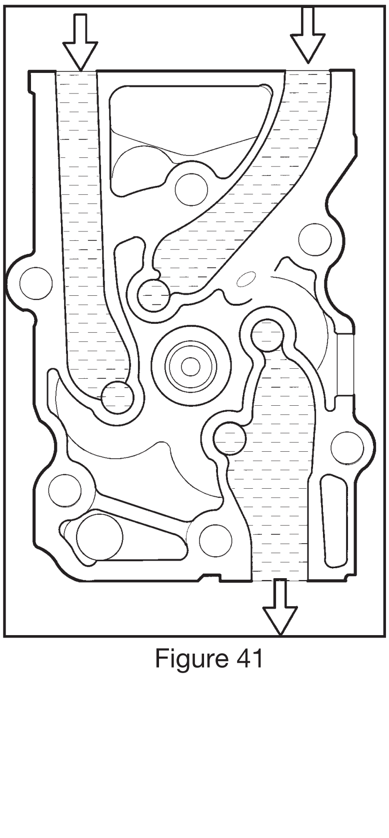


Figure 41

With four valves per cylinder, the total valve area becomes greater, making it easier to fill the cylinder with air. At the same time, less energy is consumed in forcing out the exhaust fumes.
The effort required for gas flow is reduced and engine efficiency is improved. This in turn leads to a reduction in fuel consumption.
The injector can be located centrally, which improves combustion and results in reduced emissions and lower fuel consumption.

1. Open the bleeder nipple and drain the fuel system by undoing the banjo screw on the back of the fuel manifold.

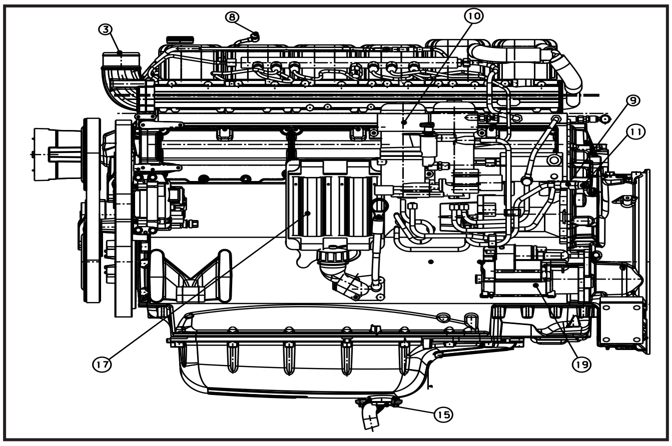


Figure 42

1. Bleeder nipple
2. Banjo screw

WARNING

The fuel system must be empty or fuel may run down into the cylinders, which will result in a great risk of liquid hammering. If fuel runs into the combustion chamber, it must be removed immediately using a pump.

2. Clean the rocker cover and the surrounding area.

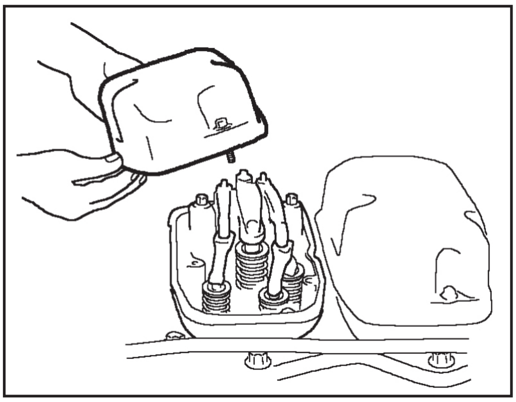


Figure 43

3. Remove the top part of the rocker cover.

4. Relieve the pressure on the valves by undoing the bolts on the rocker arm shaft alternately.

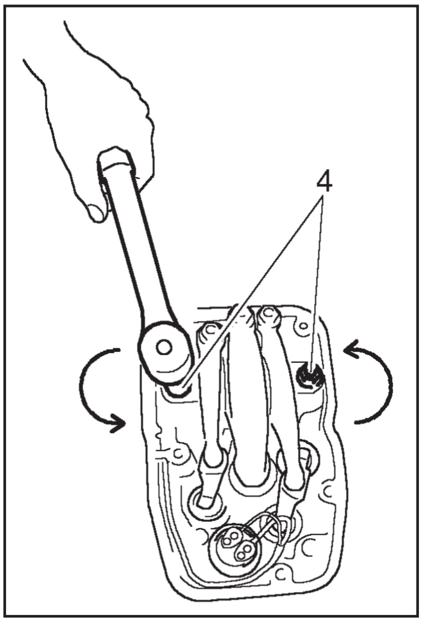


Figure 44

WARNING

Do not lean over the engine when removing the rocker arm shaft. The unit injector spring is pre-tensioned and can come loose, causing personal injury.

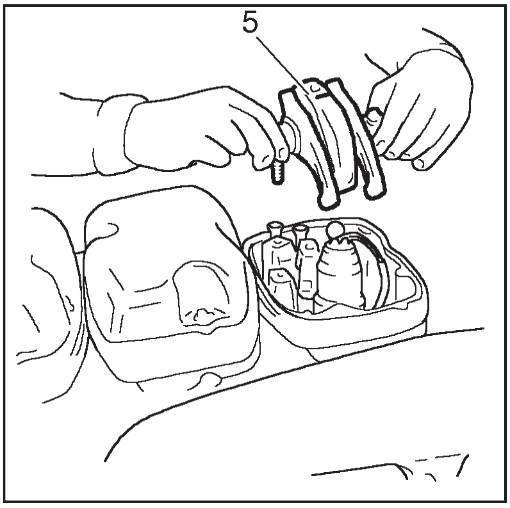


Figure 45

NOTE

If the spring comes loose from the unit injector, the unit injector must be renewed.

5. Remove the rocker arm shaft.

6. Remove the bearing bracket.

7. Remove the pushrods.
   Note: The pushrod for the unit injector is secured with a retaining ring. Jiggle and pull carefully on the pushrod to loosen it.

8. Remove the valve bridges.

9. Remove the lower rocker cover.

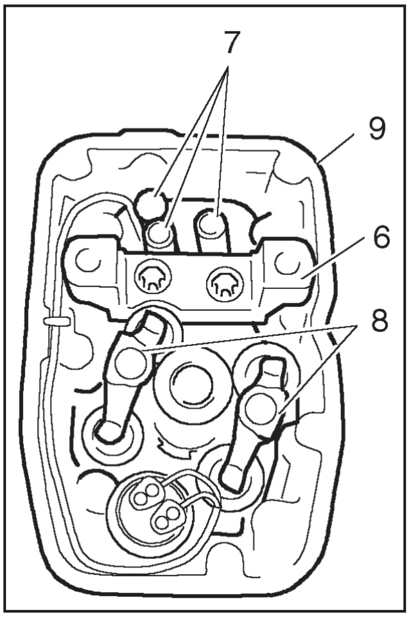


Figure 46

10. Remove the fork clamp bolt holding the unit injector in place.

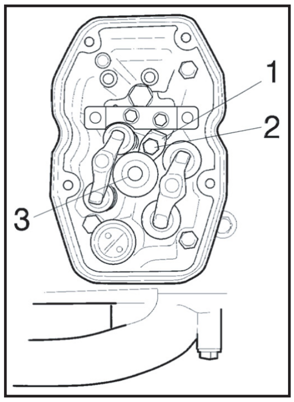


Figure 47

1. Fork clamp
2. Fork clamp bolt
3. Unit injector

11. Detach the cables on the unit injector. The screws can not be removed but undo them as far as possible.

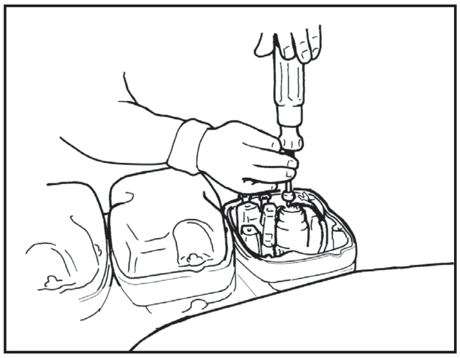


Figure 48

NOTE

Do not lift the unit injector by the spring. The spring can come loose.

12. Turn the unit injector anti-clockwise until it stops. Place the slide hammer 87 596 between the solenoid valve and the edge of the lower rocker cover as illustrated.

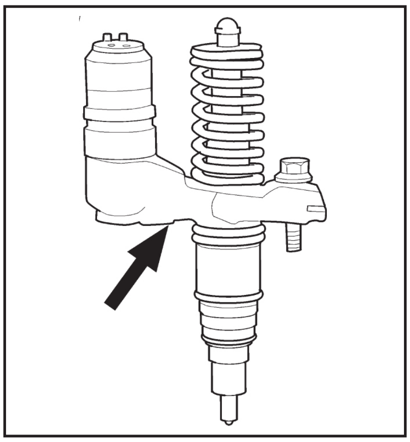


Figure 49

Place the slide hammer as indicated by the arrow.

NOTE

If the slide hammer is placed directly under the solenoid valve, there is a risk of breaking the solenoid valve.

13. It is easier to position the slide hammer if one of the lower rocker cover bolts is removed.

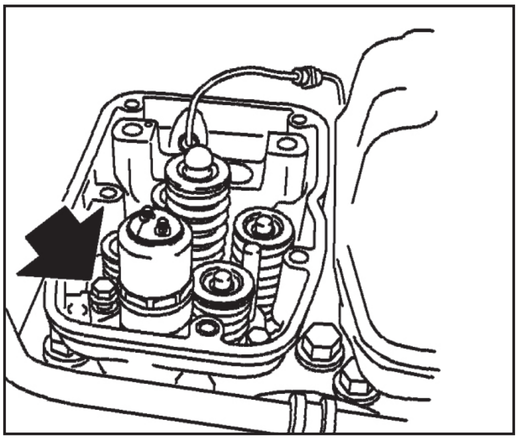


Figure 50

14. Withdraw the unit injector. If the unit injector is stuck, tap carefully with a rubber mallet on the solenoid valve housing.

NOTE

The unit injector is not to be dismantled. Renew the entire unit.

15. Remove the sealing washer from the bottom of the injector seat, (if it was left behind when the unit injector was removed).

16. Detach the intake manifold, fuel manifold, ventilation pipe for the cooling system and the exhaust manifold.

17. Remove the cylinder head. Mark the cylinder heads if more than one is being removed at the same time.

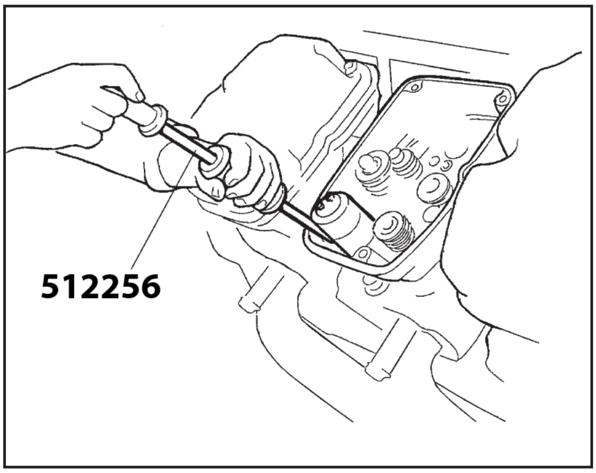


Figure 51

Dismantling

1. Remove collets, valve spring collars, springs and valves. Press the spring down using tool 850329-00302 in a press so that the collets can be removed.

2. Mark and place the valves in a rack so that they can be refitted in the same position in the cylinder head.

3. Mark the cylinder heads if more than one is removed at the same time.

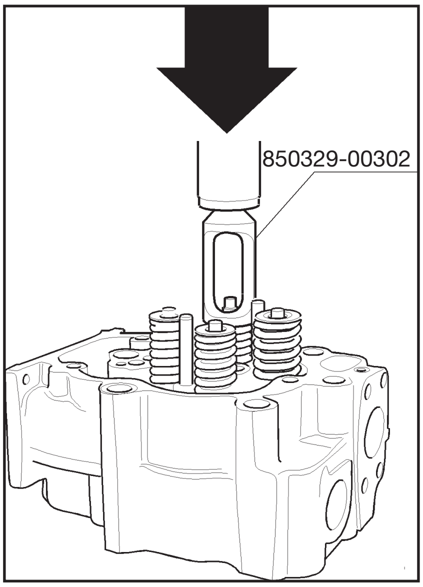


Figure 52

Renewing the valve stem seal

1. Remove the valve.

2. Remove the valve stem seal with a pair of pliers.

3. Fit the valve.

4. Tap in a new valve stem seal carefully using tool 850329-00303 and a hammer.

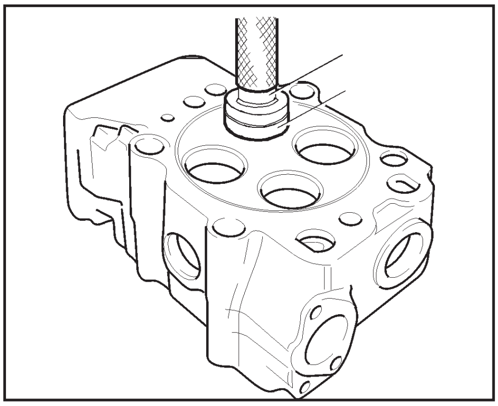


Figure 53

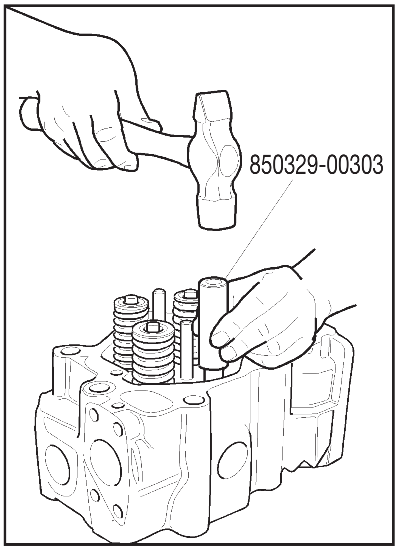


Figure 54

Replacement of valve seats

1. Remove the valve seat inserts. Use a discarded valve that has been ground so that the diameter of the disc is slightly smaller than the inside diameter of the seat.

2. Fit the valve and weld around it with an electric welder. Cool with water. Turn over the cylinder head and knock the valve stem so that the valve and seat insert fall out.

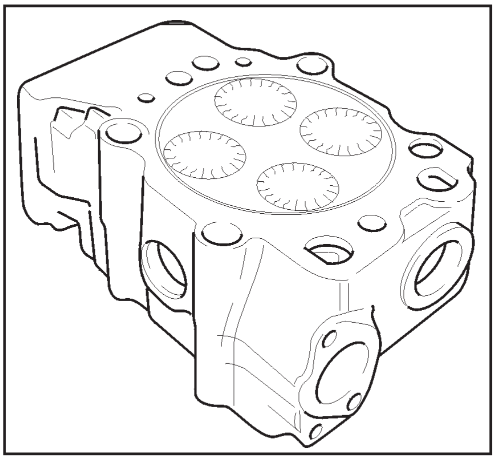


Figure 55

WARNING

Use protective goggles. Always turn the cylinder head around with the underside downwards when tapping out the valve seat ring. Otherwise there is a risk of loose splinters causing personal injury.

3. Press in new valve seat inserts. Use drift MX512260 and handle MX512261. Cool the drift and valve seat to approximately 80°C in dry ice or using liquid air. Pressing must be carried out rapidly.

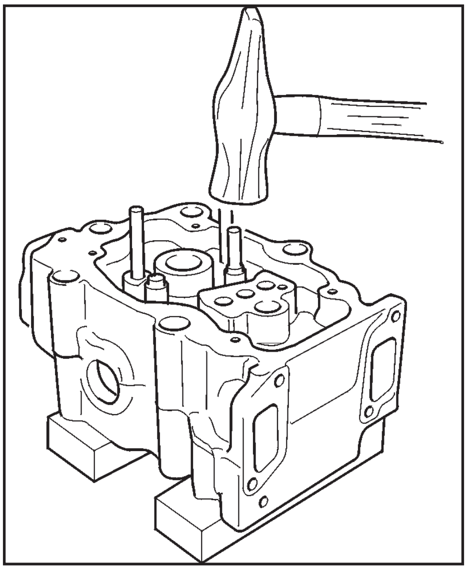


Figure 56

WARNING

Be careful with the above-mentioned coolants and cooled components. There is a risk of frost injuries.

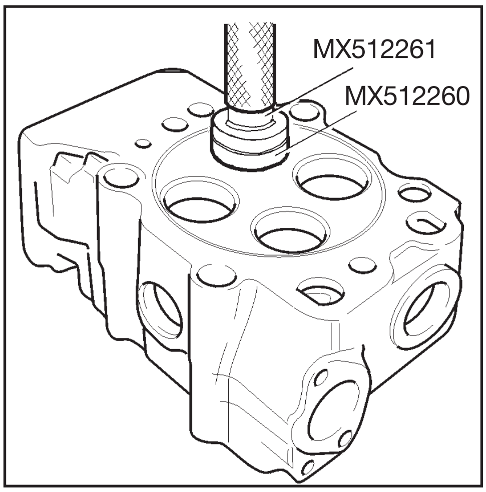


Figure 57

Oversize valve seat inserts can be fitted if the valve seat insert position has been damaged. If this is the case, the seat must be machined using valve seat cutter 850329-00368.

Machining the valve seats insert

Machining values

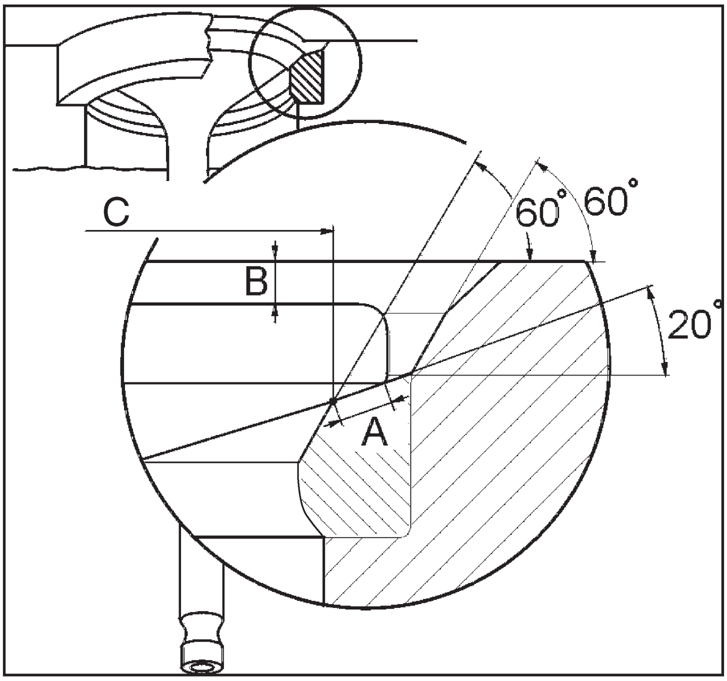


Figure 58

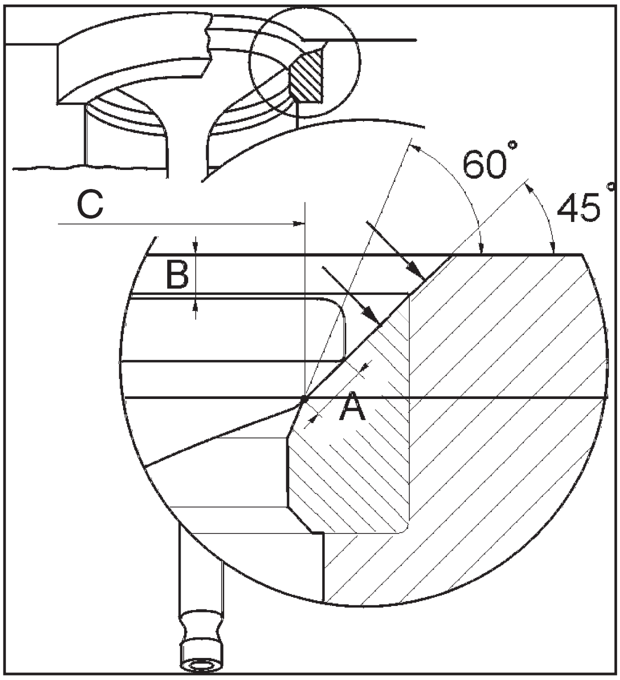


Figure 59

Inlet valve
A = 1,9 - 2,6 mm
B = 0,75 - 1,8 mm
C = diameter 39,8 +/- 0,5 mm
(setting value for machining tool)

Exhaust valve
A = 1,8 - 2,6 mm
B = 0,66 - 1,8 mm
C = diameter 37,9 +/- 0,5 mm
(setting value for machining tool)

Work description

The following description applies to valve seat cutter 850329-00368.
Machining values and over-sized valve seat inserts, see Specifications and above.

1. Check that the contact surface and the magnetic base are smooth and clean. Clean the valve bushings.

2. Select the largest spindle which slides easily into the valve guide.Insert the guide spindle and turn the feed screw to its uppermost position.

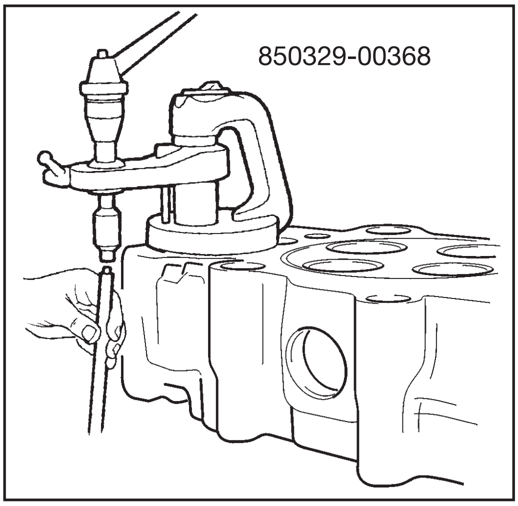


Figure 60

3. Select and fit the cutter.

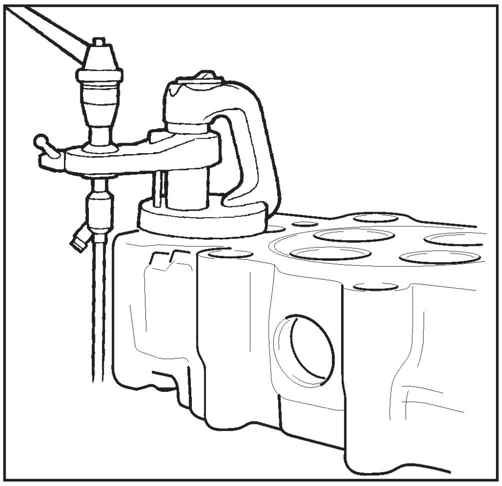
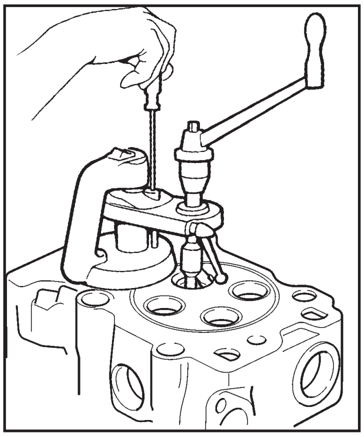


Figure 61

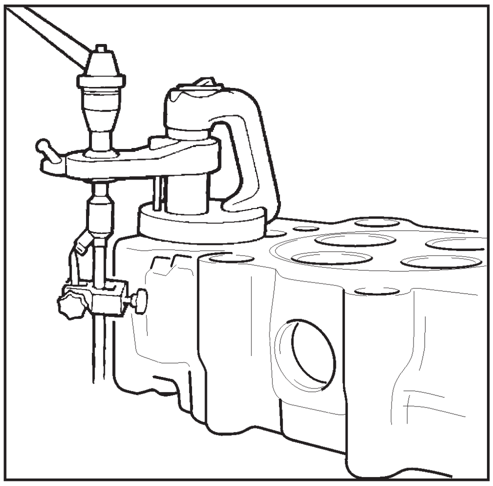
4. Release the quick-action lock and move the pivot plate to the upper position with the adjusting screw.



5. Set up the dial on the cutter adjuster using a valve.

6. Adjust the cutter. Diameter 37.9 mm or 39.8 mm, see Machining values.

Figure 62



7. Disconnect the magnetic base (position 2). Insert the guide spindle into the valve bushing. Adjust the pivot plate so that the distance between the cutter and the valve seat is approximately 1 mm.
Centre the tool precisely.

8. Connect the magnetic base (position 1).

Figure 63

9. Apply the quick-action lock. Make sure the crank can be turned easily. If not, redo the centering.

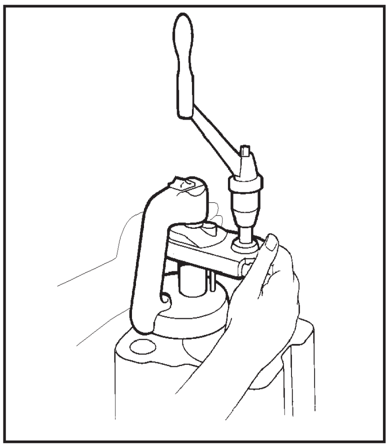


Figure 64

10. Machine the valve seat by cranking clockwise while turning the feed screw. Never crank counterclockwise, as this could damage the cutter. Lubricate with cutting oil during the procedure.

11. When the machining of the valve seat is completed, reduce the cutting pressure by turning the crank
23
turns without feeding. Then continue to turn the crank while turning the feed screw anti-clockwise. The valve seat cutter is now ready for the next valve seat.

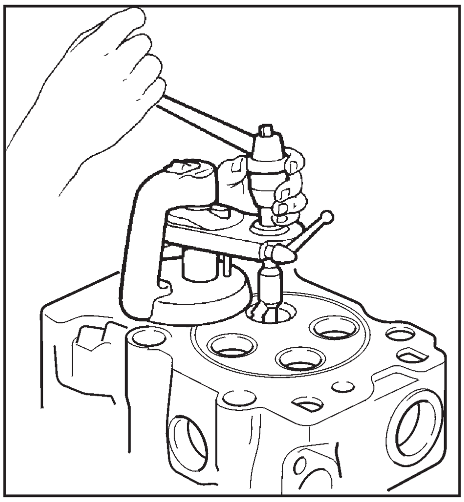


Figure 65

Renewing the valve guides

1. Press out the valve guides using drift MX512259.

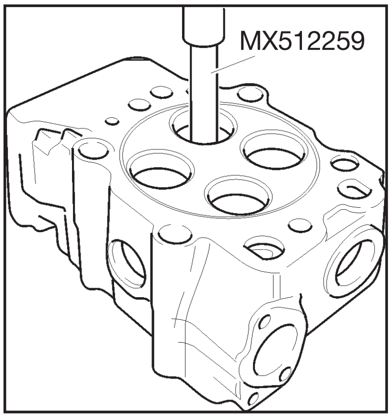


Figure 66

2. Press in the new valve guides using drift MX512258. Press the guide down as far as the drift allows, i.e. until it makes contact with the spring seat in the cylinder head.

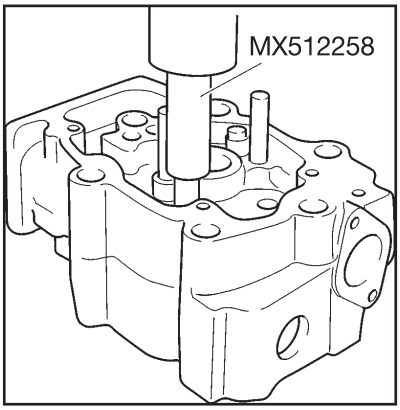


Figure 67

Renewing PDE unit injector sleeves

- The cylinder head must be removed when renewing the injector sleeve.
- The valves do not need to be removed.
- The illustration shows the cylinder head with valves removed to demonstrate clearly the work described.

1. Thread the bottom part of the sleeve with pilot tap MX512266 and guide MX512262.

2. Knock out the pilot tap and sleeve from underneath. Use a 100 mm metal rod with a 9 mm diameter.

3. Degrease and check the contact surfaces of the sleeve and cylinder head. Smooth off any burrs and irregularities that may score the sleeve.

4. Degrease the new injector sleeve and apply a thin film of sealing agent 351161 on the sleeve and cylinder head contact surfaces.

5. Press in the sleeve with drift 512561 and guide MX512262.

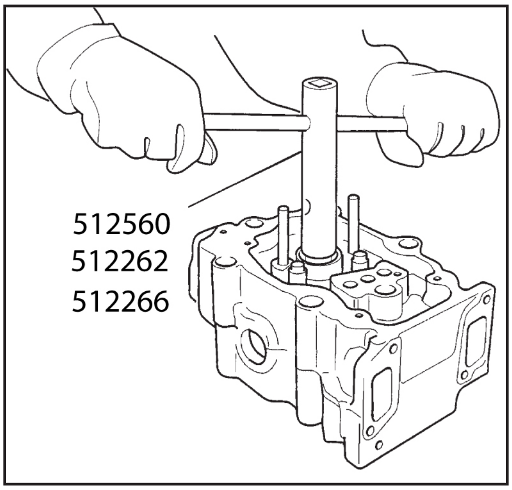


Figure 68

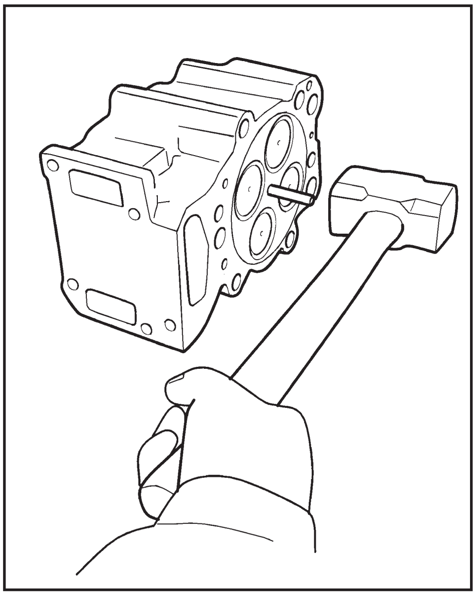


Figure 69

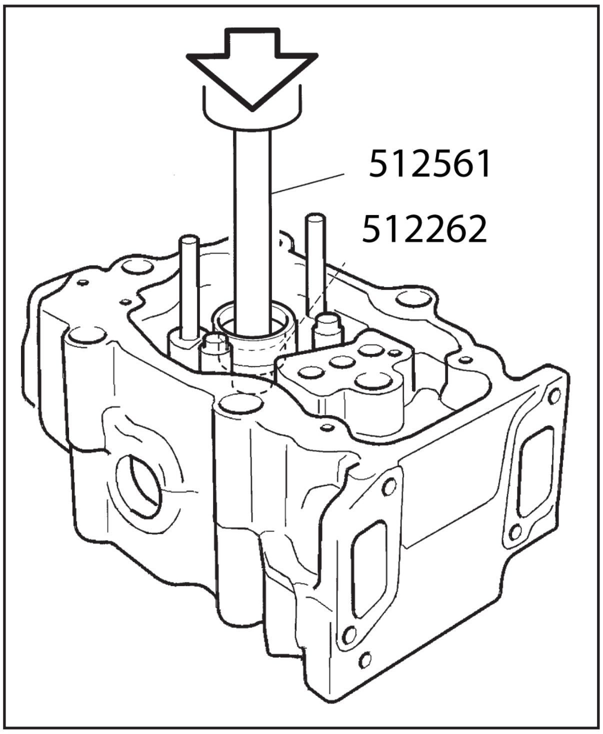


Figure 70

Assembly

NOTE

There are different versions of the combination valve - valve spring collar - split collet. Parts from the different versions must not be mixed on the same valve.

1. Lubricate all parts well with engine oil before assembly.
2. Fit the valves in the their guides and position the cylinder head in a press.
3. Fit the valve springs and the valve spring collars.
4. Compress the springs using tool 850329-00302 and fit the collets, making sure that they go into their correct positions.

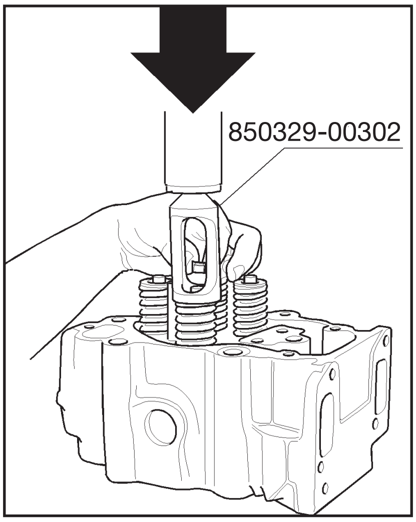


Figure 71

Fitting

1. Check liner height, refer to Measuring the cylinder liner height.
2. Fit a new cylinder head gasket.
3. Fit the cylinder head and ensure that the guide pins fit into the holes.
4. The cylinder head bolts can be reused up to 3 times. Therefore, make sure the bolts have no more than 2 punch marks on top of the bolt head. If any of the bolts has 3 marks, it must be replaced with a new one.
5. Lubricate the threads on the cylinder head bolts and the surface under the head.
6. Tighten the bolts in the order given in “Figure 72” and in three stages + 90° as follows:

- Tighten all bolts to 60 Nm
- Tighten all bolts to 150 Nm
- Tighten all bolts to 250 Nm
- Finally, tighten all bolts a further 90°
- Make a mark with a centre punch on the head of the bolt.

7. Fit the lower part of the rocker cover and tighten the bolts to 26 Nm.

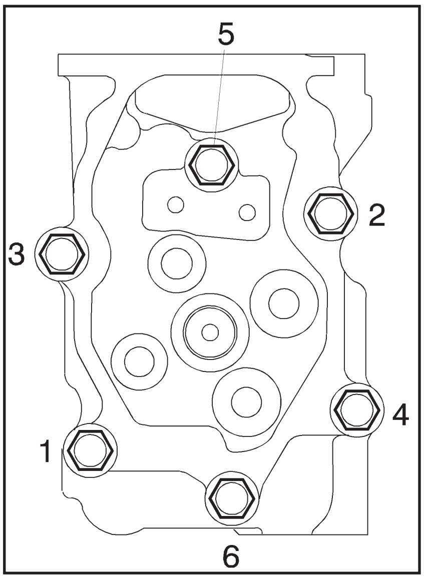


Figure 72

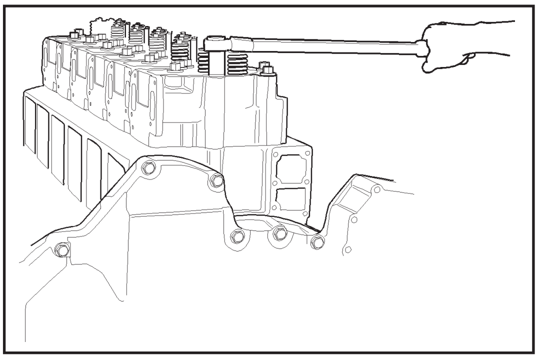


Figure 73

CAUTION

Use torque screwdriver 512562 to avoid the risk of shearing off the screws.

The entire unit injector must be renewed if the screws shear off.

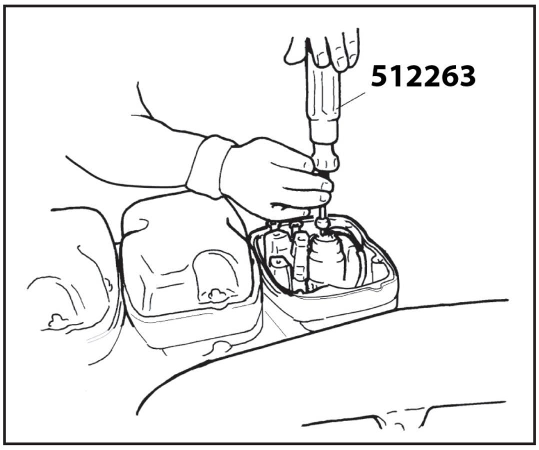


Figure 74

8. Refit the upper rocker cover and torque tighten the bolts to 18 Nm.

9. Close the bleed nipple and tighten the banjo screw.

10. Fill and bleed the fuel system. Refer to Bleeding the fuel system.

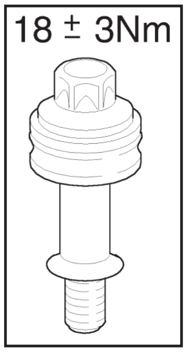


Figure 75

Valve adjustment DC9 / DC13 with XPI

Warning!

Block the starting device. If the engine starts unexpectedly, there is a serious risk of injury.

Special tools required

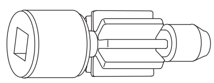
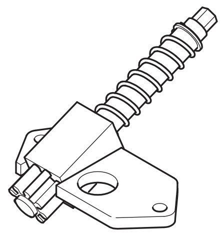
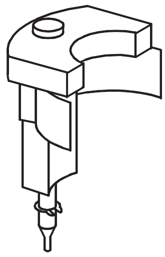
Hyundai part number	Designation	Illustration
850329-00175	Turning tool for rotating the flywheel from below	
850329-00529	Turning tool for rotating the flywheel from above	
850329-00347	Setting tool	

Figure 77

The reference information UP TDC,DOWN TDC and the angle indications listed in the table below are engraved on the flywheel. Depending on the engine installation, this information is visible in one of the windows, either furthest up or furthest down on the flywheel. See illustration.

Valve Clearance, specifications	
Intake valve	0.45 mm (0.018 in)
Exaust valve	0.70 mm (0.028 in)

Tightening torque	
Lock nut for valves	35 Nm (26 lb/ft)

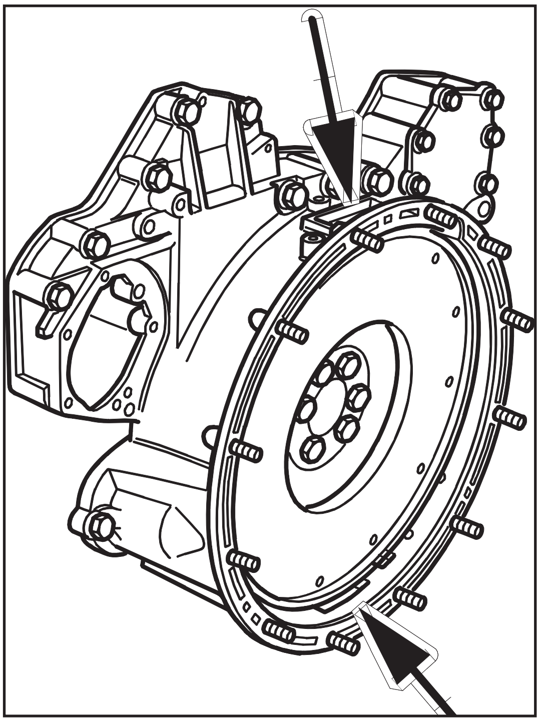


Figure 76

Adjustment tables DC9 / DC13

Adjust the valves according to the table below.
Follow the respective column depending on whether you are reading the engraving on the flywheel in the lower or the upper window. Start adjustment at the top of the table.

DC9:

Reading in the lower window	Rotation	Valve transition on cylinder	Adjust valves on cylin-der	Adjust injector on cylinder	Reading in the upper window
DOWN TDC	1		1	2	TDC Up
72/432	1	5			252/612
144/504	1		2	4	324/684
216/576	1	3			36/396
288/648	1		4	5	108/468
DOWN TDC	2	1			UP TDC
72/432	2		5	3	252/612
144/504	2	2			324/684
216/576	2		3	1	36/396
288/648	2	4			108/468

Figure 78

DC13:

Reading in the lower window	Valve transition	Valve adjust-ment	Adjust injec-tor on cylin-der	From above
DOWN TDC	6	1	2	TDC up
120/480	2	5	4	300/660
240/600	4	3	1	60/420
DOWN TDC	1	6	5	TDC up
120/480	5	2	3	300/600
240/600	3	4	6	60/420

Figure 79

NOTE

Valve change occurs when the cylinder goes from the outlet stroke to the inlet stroke. The exhaust valve is about to close at the same time that the intake valve is opening

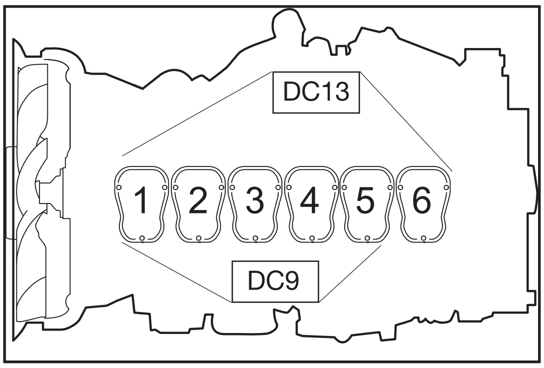


Figure 80

1. Clean the rocker covers and the area around them.

2. Remove the rocker covers.

3. Use the turning tool appropriate to the installation of the engine. Tool 99 309 is used to rotate the flywheel from the underside of the engine and tool 2 402 509 is used from the top side.

4. Start adjusting one cylinder according to the table. Rotate the flywheel until the correct engraving can be read on the flywheel. It may be necessary to rotate it more than 1 revolution. Rotate the flywheel in the rotational direction of the engine, which is clockwise viewed from the front of the engine, and anticlockwise viewed from the back of the engine. During a valve transition, the exhaust valve (the long arm) is closing at the same time as the intake valve is opening.

The UP TDC engraving on the flywheel is now visible in the window furthest up on the flywheel. The DOWN TDC engraving is visible in the lower window.

5. Read the table on the previous page to see which valve to adjust.

6. Stick the feeler gauge under the pressure pad of the rocker arm and check the valve clearance.

7. If necessary, adjust the valve clearance by
a) loosening the lock nut on the end of the rocker arm
b) adjusting the valve clearance with the adjusting screw
c) tightening the lock nut.

8. Mark the rocker arm with the felt-tip pen and then continue with the next cylinder according to the table.

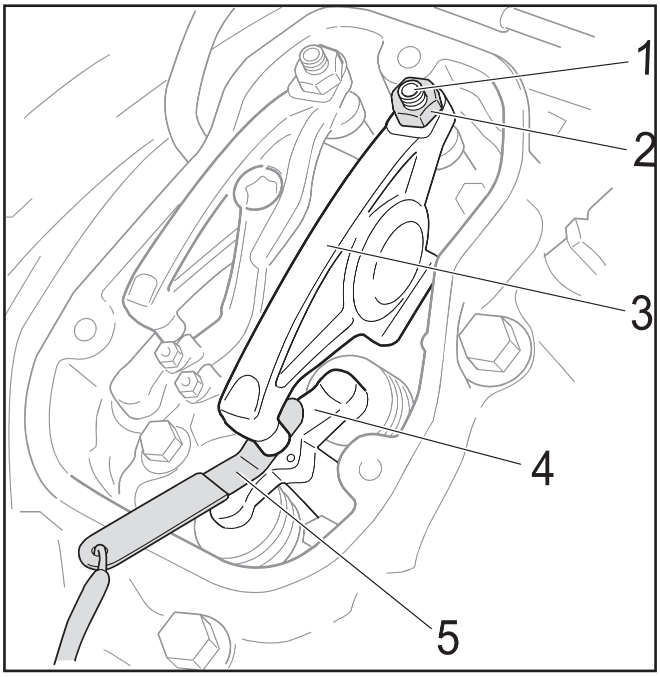


Figure 81

1. Adjusting screw
2. Lock nut
3. Rocker arm
4. Valve bridge
5. Feeler gauge

Checking and adjusting the unit injectors

Tightening torque	
Lock nut for unit injectors	39 Nm (29 lb/ft)

1. See the workflow table for details of the injectors to be adjusted.
2. Fit the setting tool with the metal plate.

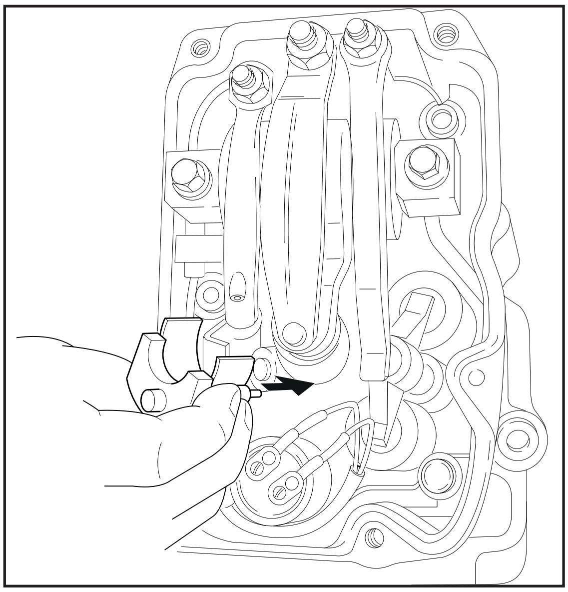


Figure 82

The unit injector is correctly set when the small piston (1) is level with the flat upper surface of the tool. Use a finger to check. You can feel very small differences. See also
the illustrations on the next page.

3. If necessary, adjust the unit injector by
a) loosening the lock nut (2)
b) adjusting the unit injector using the adjustingscrew (3)
c) tightening the lock nut.

IMPORTANT!

Remove the setting tool when the adjustment isdone.

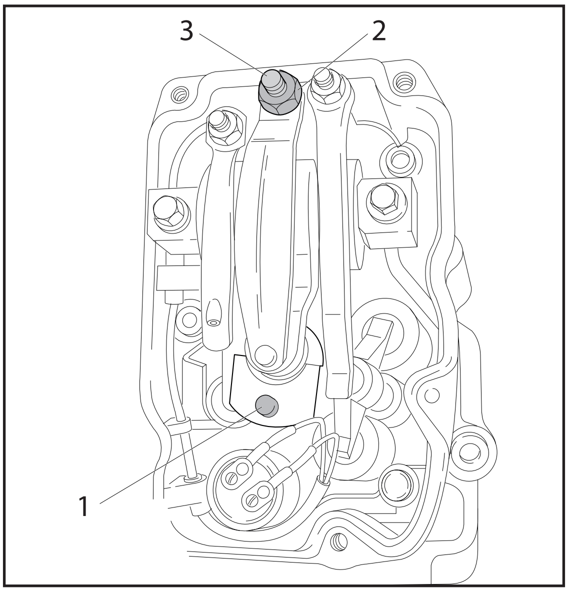


Figure 83

4. Mark the injector with the felt-tip pen and continue adjustment according to the table.

The setting tool piston is above or below the flat upper surface of the tool. Adjust the unit injector until the piston is completely level.

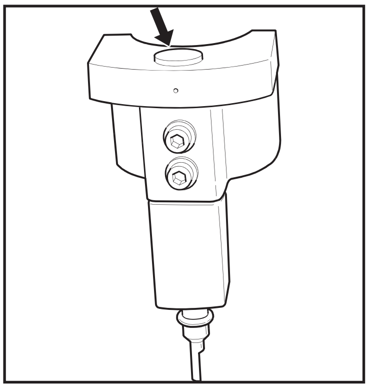


Figure 84

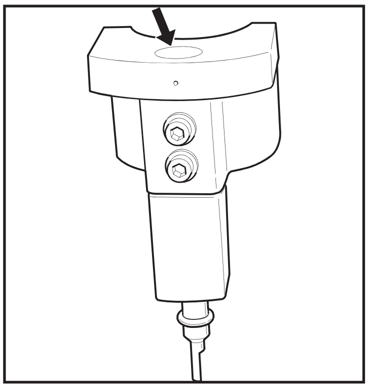


Figure 85

Turbocharger

The purpose of the turbocharger is to increase the volume of air entering the engine's cylinders. With more air the engine can burn more fuel and so develop more power and achieve cleaner combustion than a corresponding engine without supercharging.

The turbocharger is driven by the engine's exhaust gases and consists of a turbine part and a compressor part. The compressor part compresses the engine's intake air.

The compressor wheel is mounted on the same shaft as the turbine wheel. This shaft runs in a bearing housing between the compressor and turbine.

Higher power output from the engine gives more exhaust fumes and the increased exhaust means that the turbine wheel and therefore the compressor wheel rotate faster. In this way, the quantity of air is adapted to engine requirements without any special control devices.

The turbocharger wheel rotates extremely fast. At full power, speed is about 100,000 rpm. At the same time, the temperature on the exhaust side of the turbine wheel is above 600°C.

This makes big demands on the rotating parts in regard to balance, cooling and lubrication.

The shaft is mounted in two bushings which rotate freely in the bearing housing. The bearing housing seals for the turbine and compressor consist of seals which are similar to piston rings.

The turbo is equiped with a wastegate valve, the function of the wastegate valve is to limit the flow to the turbine so that the engine receives the correct amount of air.

The turbo wastegate pressure should not exceed recommended pressure:

Normal: 2.4 bar
Max: 2.7 bar

If there is an electrical fault on the wastegate valve control, fault codes will be generated and the engine will not perform correctly.

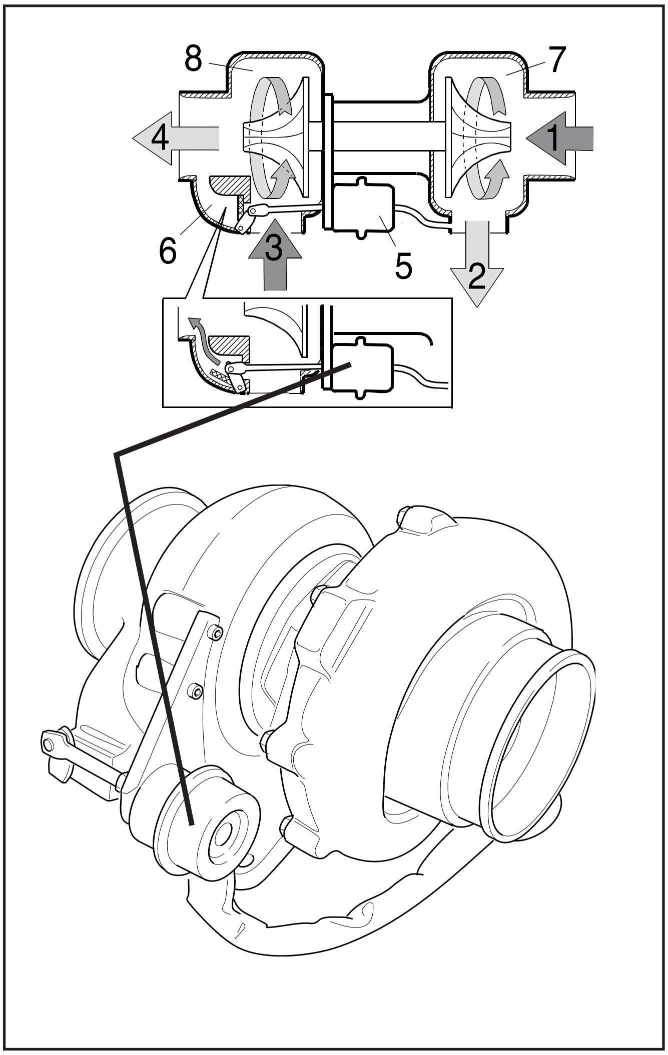


Figure 86

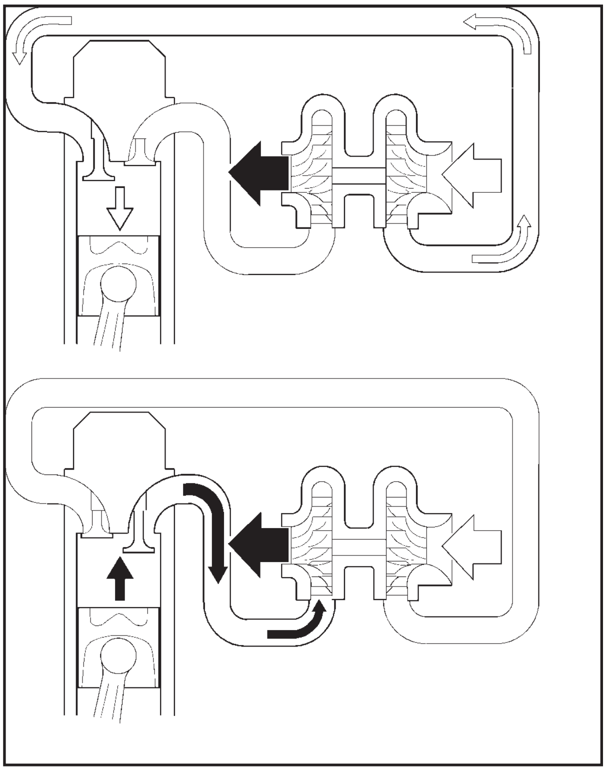


Figure 87

Measuring radial clearance and axial clearance

1. Lubrication oil pipe
2. Ferrule
3. Union nut
4. Straight union
5. Seal
6. Straight union
7. Gasket
8. Lubrication oil return pipe
9. Hose
10. Hose clamp
11. Bolt
12. Bracket
13. Bolt
14. Clamp
15. Clamp
16. Bolt
17. Gasket
18. Turbocharger

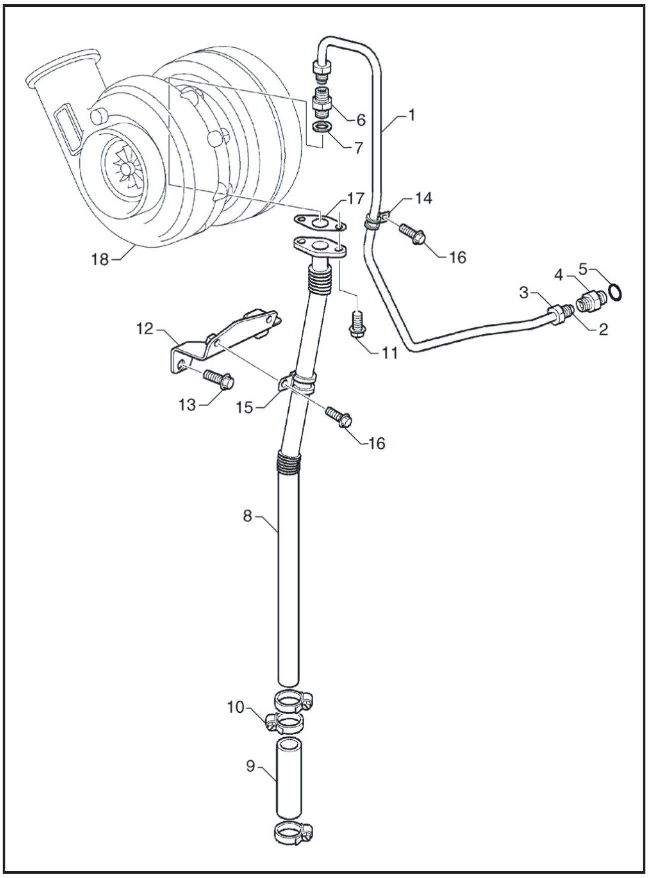


Figure 88

Measuring radial clearance and axial clearance does no usually give any indication of the remaining service life of the turbocharger.

When the turbocharger is not working correctly or sounds abnormal, measuring charge pressure or measuring radial clearance or axial clearance can show that the turbocharger is defective.

To measure axial and radial clearances it is advisable to remove the turbocharger and bolt it to a steel plate, which will also serve as a base for the magnetic stand holding the dial gauge.

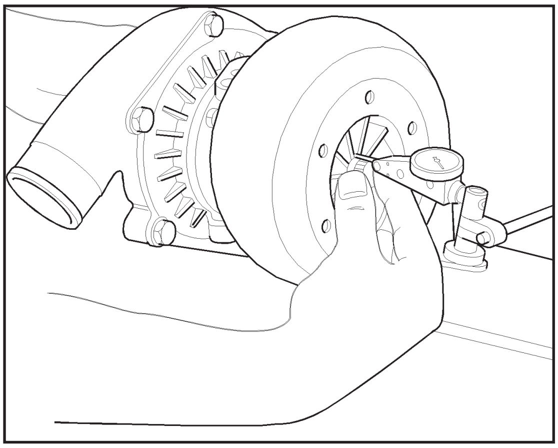


Figure 89

Measuring turbine wheel radial clearance with deflection gauge 8222 and measuring stand 8209

Radial clearance
Take readings on both turbine wheel and compressor wheel.

1. Place the tip of the deflection gauge against the turbine wheel and compressor wheel.
2. Pull both ends of the shaft up. Take a reading.
3. Press both ends of the shaft down. Take a reading. The difference between readings is radial clearance.
4. Repeat measurements three times on each side.
5. If any wheel rubs against the housing, despite radial clearance being within tolerance, the turbocharger should be changed.

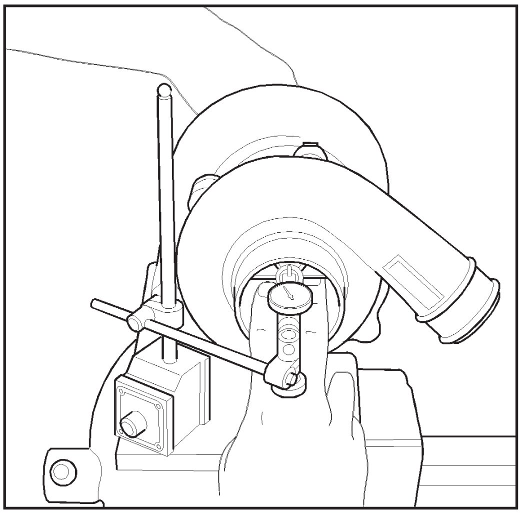


Figure 90
Measuring compressor wheel radial clearance with deflection gauge 8222 and measuring stand 8209

Axial clearance
1. Place the tip of the dial gauge **800109-00288** against the end of the shaft.
2. Press the shaft forwards and backwards and read the dial at the end positions. The difference between readings is axial clearance.
3. Repeat measurements three times.

Wear limits for Holset:

Radial clearance	**0.198-0.564 mm**
Axial clearance (after running in)	**0.025-0.106 mm**

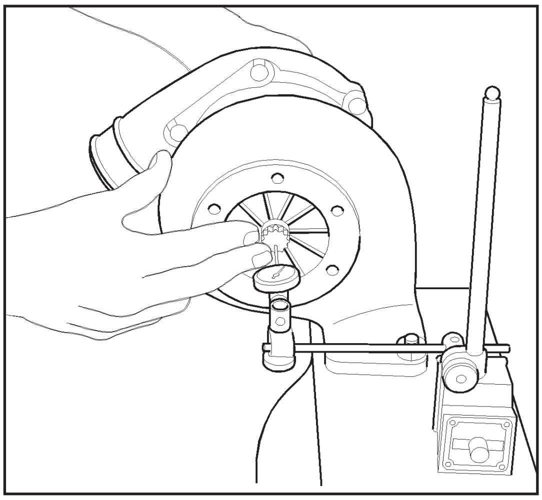


Figure 91
Measuring axial clearance with dial gauge 800109-00288 and measuring stand 850329-00319

If the turbocharger does not work:

1. Check that there is no leakage or loose objects in the line between the air cleaner and turbocharger.
2. Check that there are no loose particles in the exhaust manifold or intake manifold.
3. Check that all valves are intact.
4. Check the lubrication oil return pipe from the turbocharger for blockage or deformation.
5. Check the oil delivery pipe to the turbocharger for any blockage, deformation and leakage under pressure.
6. Check the condition and part number of the oil filter.
7. Check that the air filter is not blocked and that there are no other reasons for the abnormal increase of vacuum in the intake system.
8. Check that engine output is correct. Excessively high output reduces the life of the turbo.

Renewing the turbocharger

NOTE

When renewing the turbocharger, all gaskets and the oil filter must be changed and the centrifugal cleaner must be cleaned.

Removal

1. Detach the delivery and return oil lines from the turbocharger.

2. Detach the exhaust pipe, induction pipe and charge air cooler pipe from the turbocharger.

3. Undo bolts in the turbocharger base and remove turbocharge.

Fitting

1. Check the connecting flange on the exhaust manifold to ensure that there are no remnants of the old gasket.

2. Fit a new gasket and bolt on a new turbocharger. Lubricate the exhaust manifold bolts with high-temperature resistant lubricant, part No. 561 205. Tighten the turbocharger to 50 Nm and the exhaust manifold to 59 Nm.

3. Connect the oil supply and return lines.

4. Connect the charge air pipe, induction pipe and exhaust pipe.

5. Disconnect the fuel valve’s power supply (fuel shut-off) and turn the engine over with the starter motor for at least 30 seconds so that the lubricating oil will reach the turbocharger.

6. Start the engine and check that there is no leakage.

General

NOTE

Whenever working on the turbocharger, observe utmost cleanliness. The oil intake and outlet connections must never be left open. A foreign body in the bearing housing can quickly cause total breakdown.

Oil leakage
With a clogged air cleaner, the vacuum in the intake pipe will be excessive. There is then a risk that oil mist will be sucked out of the turbocharger's bearing housing.

If the seal on the turbine side is worn, exhaust gas is blue when idling.

If the oil outlet pipe from the turbocharger is damaged, there is a risk of oil leaking out through the seals due to lubrication oil pressure.

Oil filter
The turbocharger rotates at high speed, sometimes above 100.000 rpm.

The oil lubricates and cools the turbocharger. Efficient lubrication is extremely important. There is no separate turbo filter and the oil passes through the engine oil filter. For this reason, change the oil filter and clean the oil filter assembly in accordance with our instructions.

Use filter wrench **850329-00421** when removing the oil filter.

If the oil filter assembly is not cleaned, the oil filter will soon become clogged and its resistance to the flow of oil will increase.

A valve in the filter holder then opens and allows the oil to pass through the filter without being cleaned (filtered). Unfiltered oil is consequently supplied to the turbocharger with heavy bearing wear as a result.

The valve is designed for genuine filters and only these should be used.

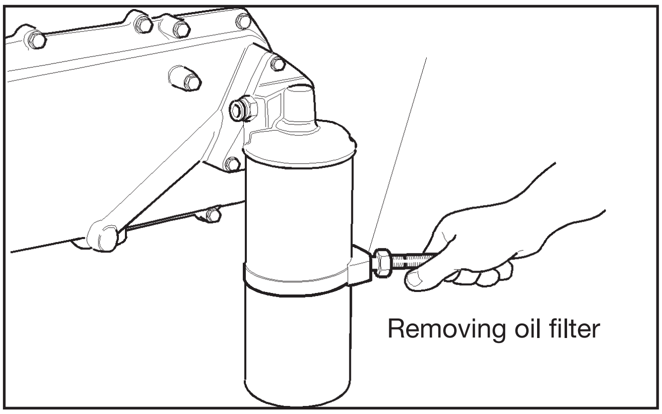

Removing oil filter

Figure 92

Foreign bodies
Foreign bodies, such as grains of sand or metal filings, in the turbine or compressor will damage their blades.

This leads to imbalance and bearing wear. Engine output falls off and continued operation could give rise to overheating damage on account of a decrease in the supply of air.

This type of overheating cannot be observed on the coolant temperature gauge.

NOTE

Never attempt to straighten a damaged impeller. It will usually break in operation causing the turbocharger to break down and may also cause enginedamage. Change the entire turbocharger.

Air and exhaust leakage
Even small leaks in the line between the air cleaner and turbocharger cause dirt deposits on the compressor wheel.

Charge pressure decreases with increased exhaust temperature, causing smoke. In addition, the engine is worn unnecessarily.

Exhaust leakage between cylinder head and turbocharger also results in lower charge pressure.

Cleaning the compressor wheel
Low charge pressure can be caused by a dirty compressor wheel, for example.

- Remove the compressor housing.

- Wash the compressor wheel using white spirit and a brush.

- Fit the compressor housing and measure charge pressure again.

NOTE

The compressor wheel must not be removed from the shaft. Imbalance may occur when it is refited.

Changing oil filter

NOTE

Use only SCANIA oil filter.

NOTE

Clean the centrifugal oil cleaner when renewing the oil filter. Otherwise, the oil filter will be blocked and resistance in the filter will increase. If this happens, an overflow valve in the filter holder opens and lets the oil pass without being filtered.

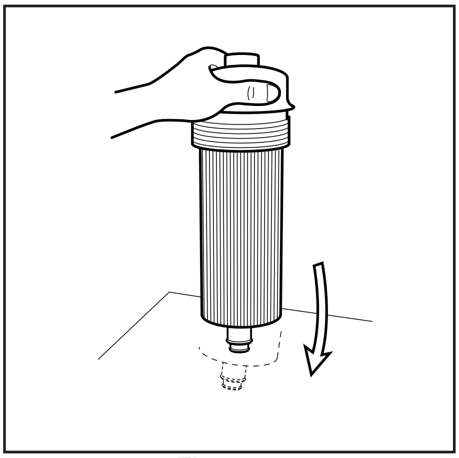


Figure 93

1. Unscrew the filter cover with a closed tool with 36 mm (1/2’’) socket.
2. Lift out the filter housing cover with filter. The filter housing will drain automatically once the filter has been removed.
3. Remove old filter from the cover.
4. Assemble new filter and tighten filter cover to 25 Nm.

CAUTION

Avoid spillage when handling oil.

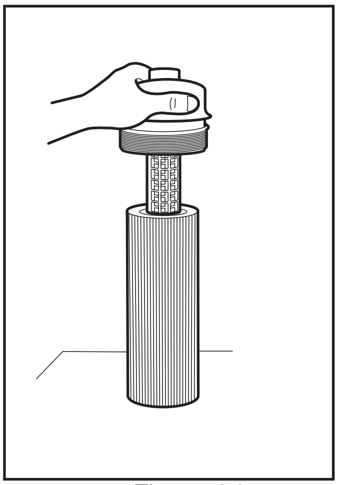


Figure 94

NOTE

Do not use an adjustable wrench or other open tool as there is risk of damaging the filter cover.

Oil analysis

Oil analysis may be necessary to determine a different oil change interval from that recommended here.

Oil companies can offer analysis of the engine oil.

Such analysis measures the oil's TBN (Total Base Number), TAN (Total Acid Number), fuel dilution, water content, viscosity and the quantity of particles and soot in the oil.

The result of a series of analyses is used as the basis for establishing a suitable oil change interval.

If the conditions are changed, a new oil analysis programme must be carried out to establish new change intervals.

Checking oil level

Checking the Oil Level with the Engine Switched Off

NOTE

Leave the engine off for at least 1 minute before checking the oil level.

1. Remove oil dipstick (1 LHS of engine) and check the oil level. The correct level is between the minimum and maximum marks on the oil dipstick.

2. Top up with oil when the oil level is at or below the minimum mark.

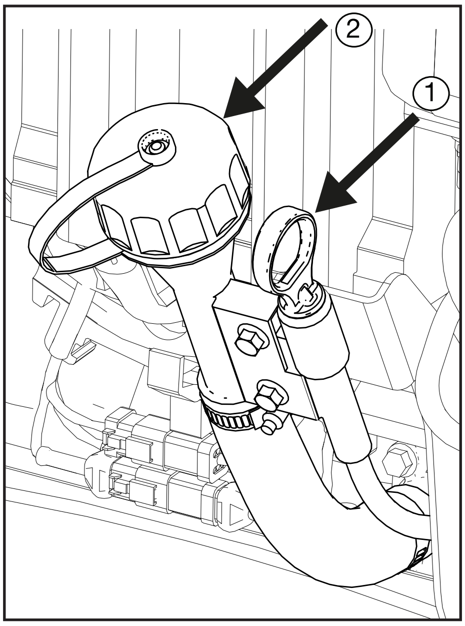


Figure 95

Changing the oil

NOTE

Renew the oil filter and clean the centrifugal oil cleaner when changing oil.

WARNING

AVOID DEATH OR SERIOUS INJURY

• Hot oil can cause burns and skin irritation. Wear protective gloves and goggles when changing hot oil.
• Make sure that there is no pressure in the lubrication system before starting work on it.
• The oil filler cap must always be in place when starting and running the engine to prevent oil being ejected.

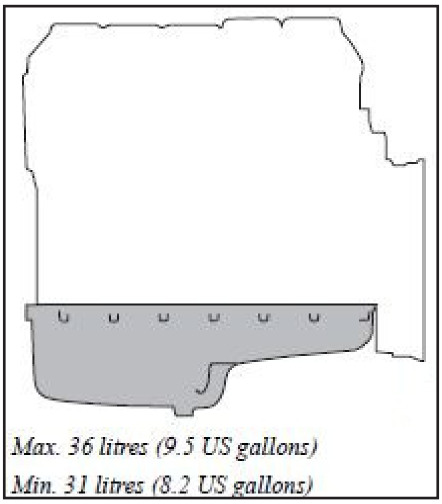


Figure 96

NOTE

Use a container to avoid spillage. Used oil must be disposed of as specified in national and international law.

NOTE

Change oil more often if the engine is subjected to particularly demanding operation, such as a dusty environment, or if deposits in the centrifugal oil cleaner are thicker than 28 mm.

1. Unscrew the oil plug and drain the oil when the engine is hot. In certain engines the oil is pumped out by means of a bilge pump.
2. Clean the magnet on the oil plug.
3. Refit the oil plug.
4. Fill up with oil.
5. Check the level on the dipstick.

Maximum angles of inclination during operation.

Maximum permissible angles during operation vary, depending on the type of oil sump; see “Figure 97”.

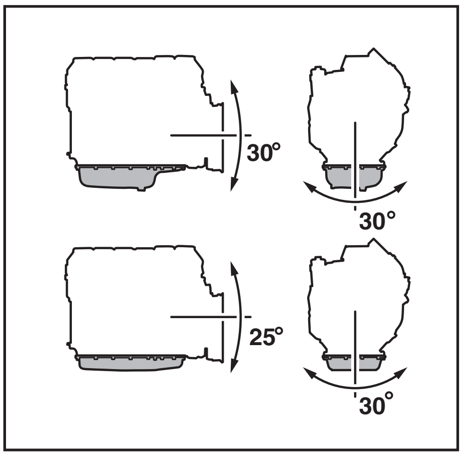


Figure 97

Special tools

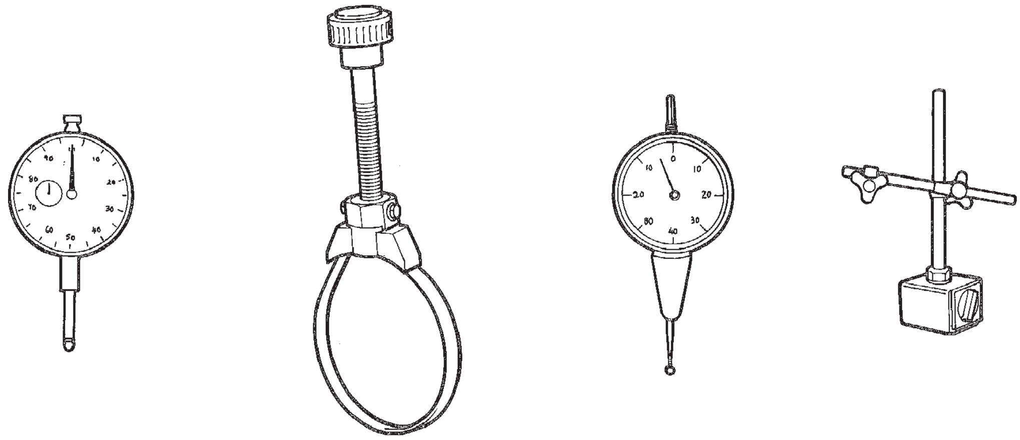


Figure 98

800109-0028	Dial gauge
850329-00421	Filter wrench
(1)	Deflection gauge
850329-00319	Stand

Pistons and cylinder liners

1. O-ring
3. Cylinder liner for steel piston
5. O-ring
6. Compression ring
7. Compression ring
8. Oil scraper ring
9. Circlip
10. Steel piston
12. Gudgeon pin
13. Circlip
14. Bearing bushing
15. Connecting rod
16. Crankshaft
17. Bearing shell
18. Bearing cap
19. Flange bolt

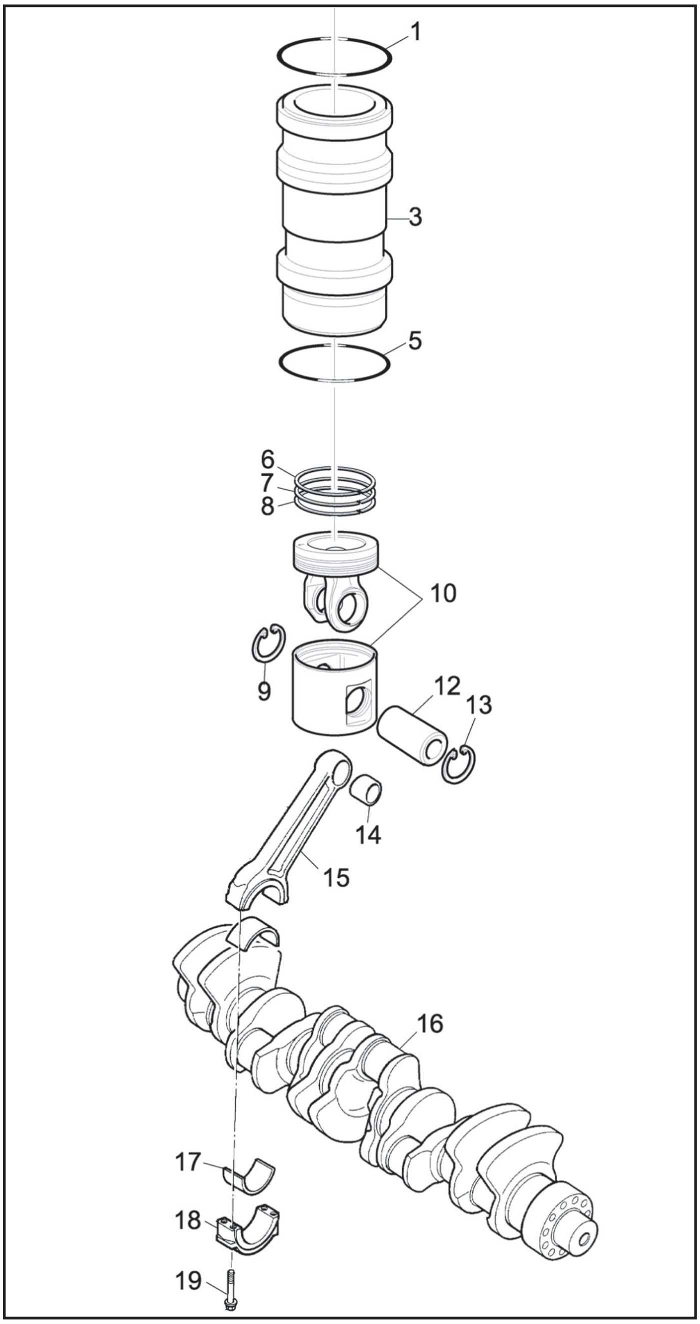


Figure 99

Special tools

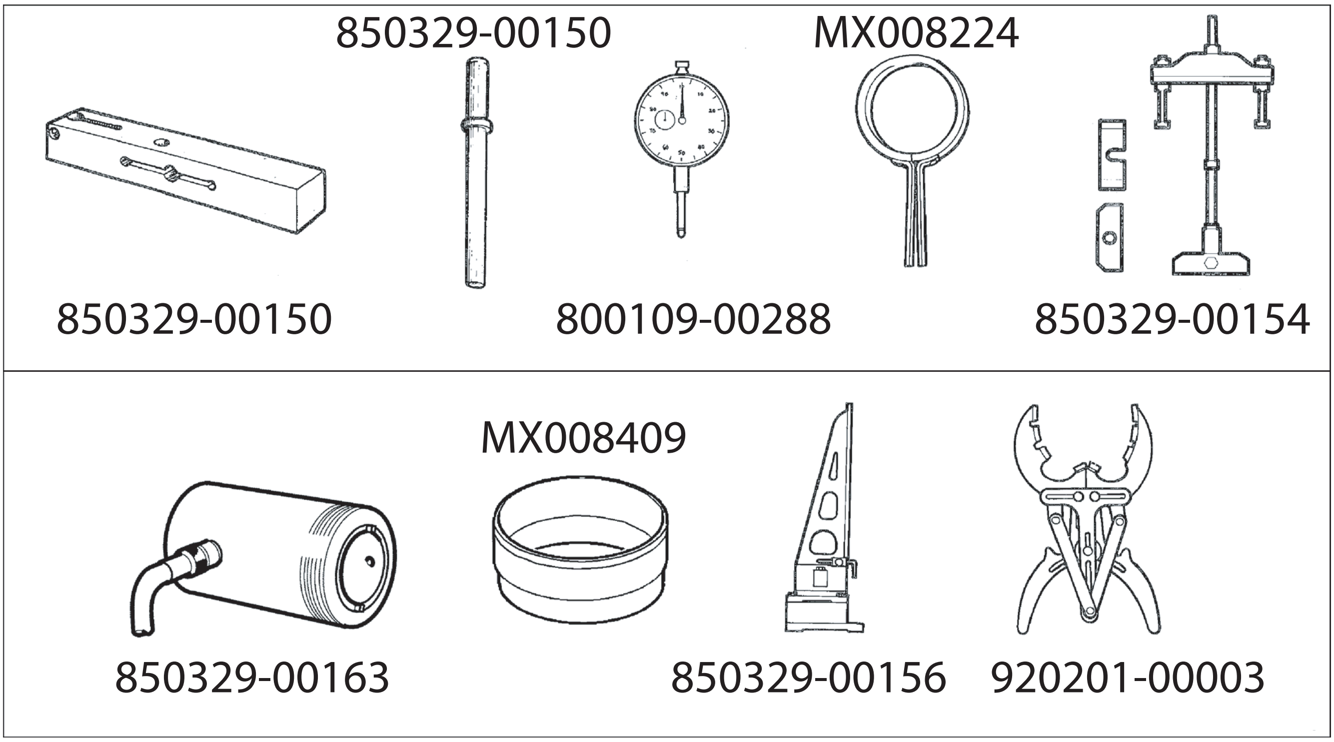


Figure 100

850329-00150	Rule for dial gauge
850329-00150	Drift
800109-00288	Dial gauge
MX008224	Piston ring compressor
850329-00154	Pressing tool
850329-00163	Hydraulic cylinder
850329-00154	Puller for cylinder liner
MX008049	Impact drift
850329-00155	Dismantling tool
MX008409	Assembly tool
850329-00156	Test apparatus for connecting rods
920201-00003	Piston ring expander

Connecting rods

The connecting rod and big-end cap consist of a single casting which is split during the machining operation.

To prevent the big-end cap from being displaced in relation to the connecting rod, the contact surfaces are provided with grooves and guide pins. The surfaces are machined together to ensure a precise and accurate fit. The parts are also marked so that they can always be fitted in the same position.

The connecting rod and big-end cap are split obliquely, partly so that the con rod bolts will not be subjected to excessive loads and partly to enable the piston and con rod to be withdrawn through the cylinder.

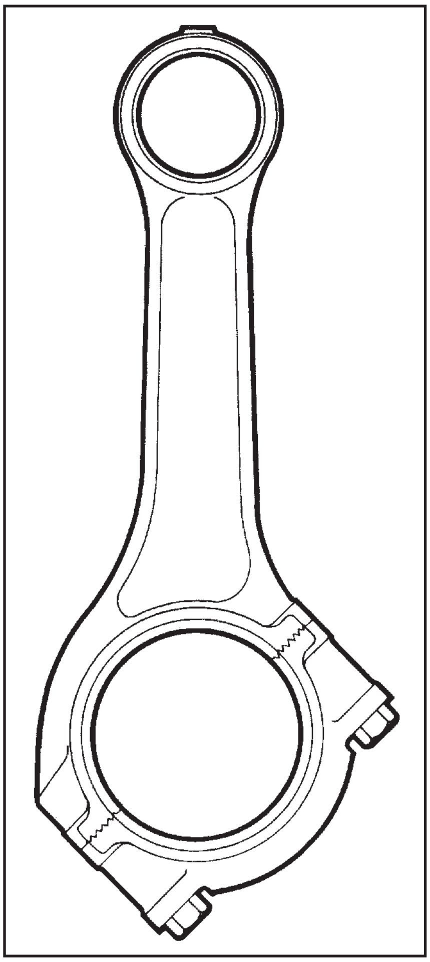


Figure 101

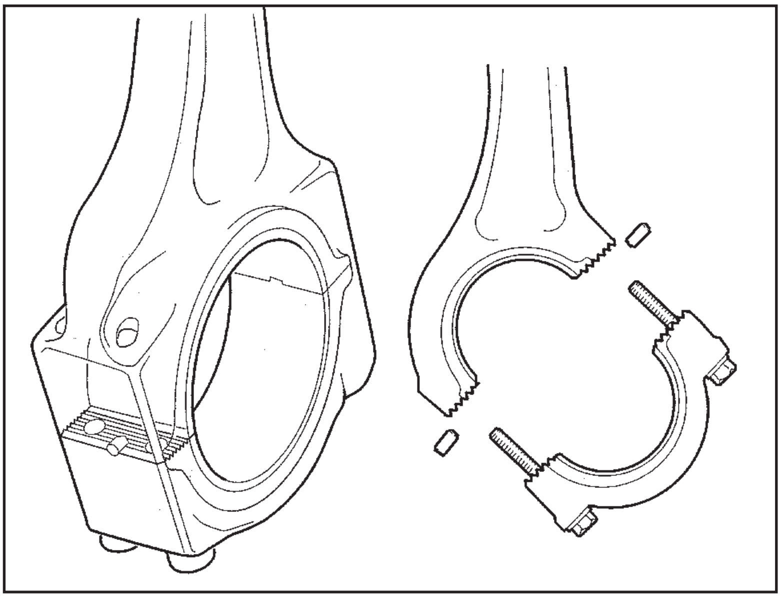


Figure 102

Connecting rod cap: Torx 50Nm + 90°

The upper part of the connecting rod is wedge shaped. This allows a larger journal surface on the underside of the gudgeon pin where load is greatest during combustion.

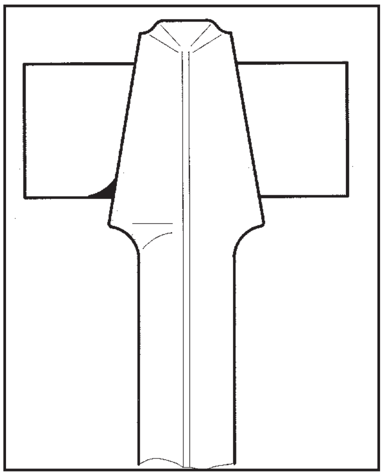


Figure 103

Removing and dismantling connecting rods and pistons

1. Remove the cylinder head and oil sump.

2. Remove the piston cooling nozzle in the cylinder block.

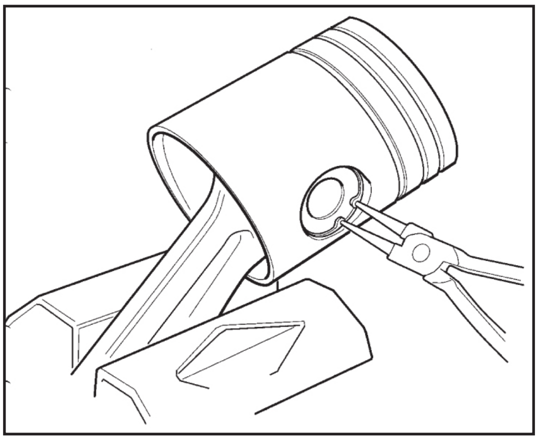


Figure 104

NOTE

The piston cooling nozzle must not be damaged. The oil jet must hit the piston precisely. If it does not, the piston will become too warm resulting in engine breakdown. Damaged nozzles must not be straightened. They must be renewed.

3. Remove the bearing cap and bearing shells. Protect the oil way in the crankcase using, e.g. adhesive tape, applied with the sticky side out.

4. Mark the piston and connecting rod before removing them. They must be refitted in the same place and in the same way.

5. Lift out the piston and connecting rod.

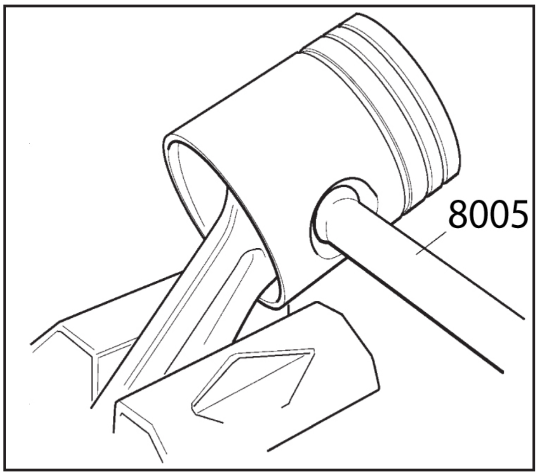


Figure 105

6. Place the connecting rod in a vice with soft jaws. Remove the retaining rings for the gudgeon pin.

7. Push out the gudgeon pin using drift 850329-00150.

8. Remove the piston rings using tool 920201-00003, taking care to avoid scratching the surface of the piston skirt with the piston rings.

9. When cleaning graphited pistons in a machine, the graphiting may disappear. This does not matter after they have been in use for a while. However, new pistons should be washed carefully using white spirit or the like.

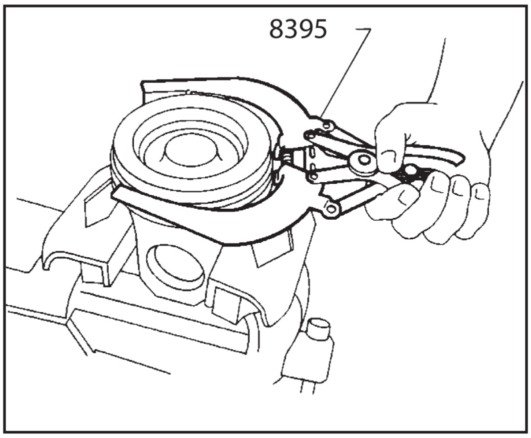


Figure 106

NOTE

Always inspect the connecting rod in cylinders which have seized, been filled with water or where the valve has broken. Bent connecting rods must not be straightened.

Checking connecting rods

Check the connecting rods using tool 587 110.
Proceed as follows:

1. When the gudgeon pin bushing has been checked, insert the bearing cap as marked and tighten the bolts to full torque.

2. Mount the connecting rod in the tool using the expander and place the gudgeon pin in its bushing. Then place indicator studs on the gudgeon pin.

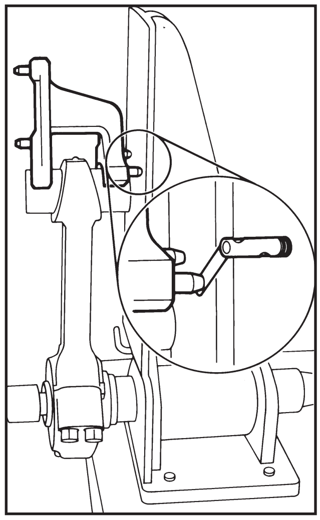


Figure 107
Checking if connecting rod is twisted

- Check whether the connecting rod is twisted with the indicator studs horizontal.

- Check whether the connecting rod is bent with the indicator studs vertical.

- The distance between the indicator studs on the tool illustrated here is 75 mm.

- The distance between one of the indicator studs and the measuring surface must be max. 0.1 mm when measured using this tool.

- Check with a feeler gauge.

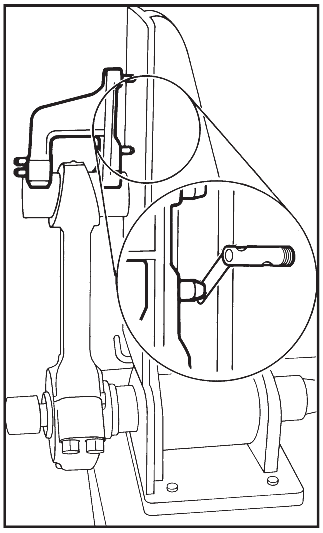


Figure 108
Checking if connecting rod is bent

NOTE

The difference must not exceed 0.6 mm.

- Also check whether the connecting rod is bent into an S-shape. This is done by measuring the distance between the outside of the connecting rod bushing and the level surface of the tool.

- Turn the connecting rod around and measure the corresponding distance.

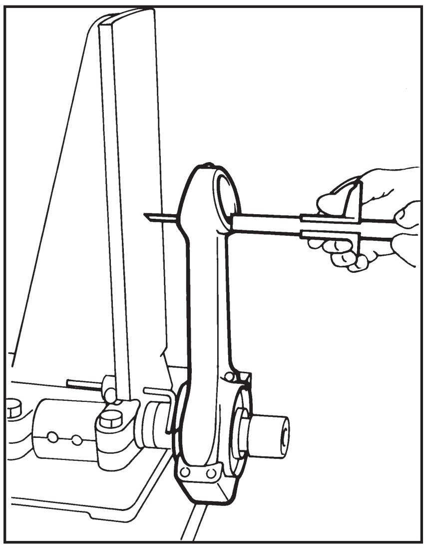


Figure 109
Checking whether the connecting rod is bent into an S-shape

Renewal of bearing bushing in connecting rod

Use tool 512564 when renewing the bearing bushing.

The tool comprises three parts:

1. Pressplate with guide pin.

2. Press drift.

3. Supports.

There are different supports, depending on the engine type.

The support marked with a D should be used for the 12 engine.

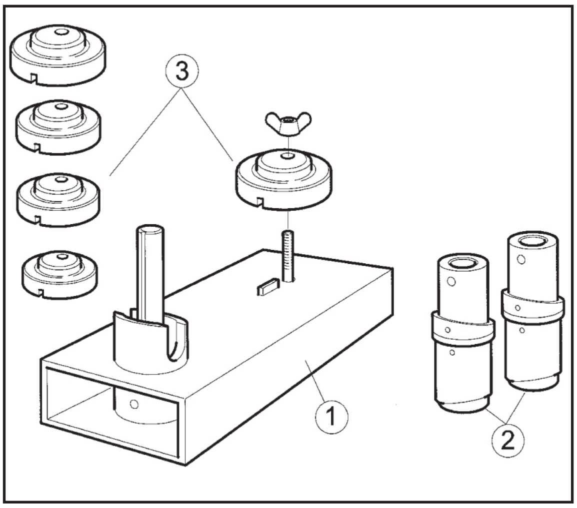


Figure 110

NOTE

Before carrying out this procedure, the connecting rod should be checked for straightness in accordance with Checking connecting rods.

Work description

1. Fit the correct support on the pressplate and place the connecting rod so that the wide end of the connecting rod is resting against the support. Turn the press drift with the smaller diameter against the bearing bushing and press it out.

2. Turn over the press drift and mount a new bearing bushing onto it. Press in the bearing bushing.

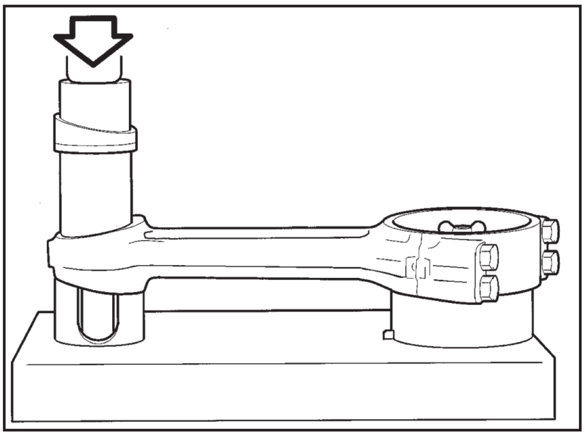


Figure 111

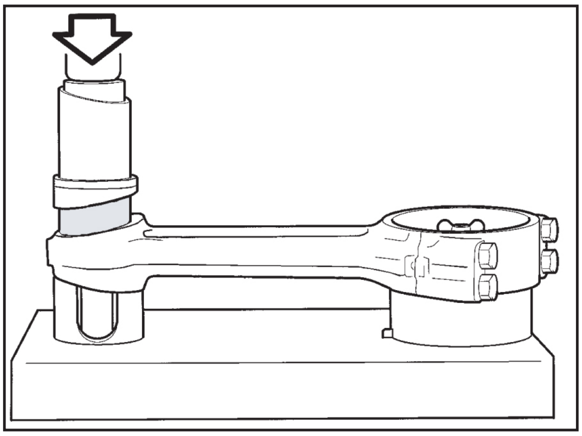


Figure 112

3. After pressing in a new bearing bushing, it must be finish-turned. This requires special equipment.

Refer to “Figure 113” for the dimen-
sions
required.

Diameter, d = 54.030 - 54.043 mm
Surface quality = 0.6 Ra

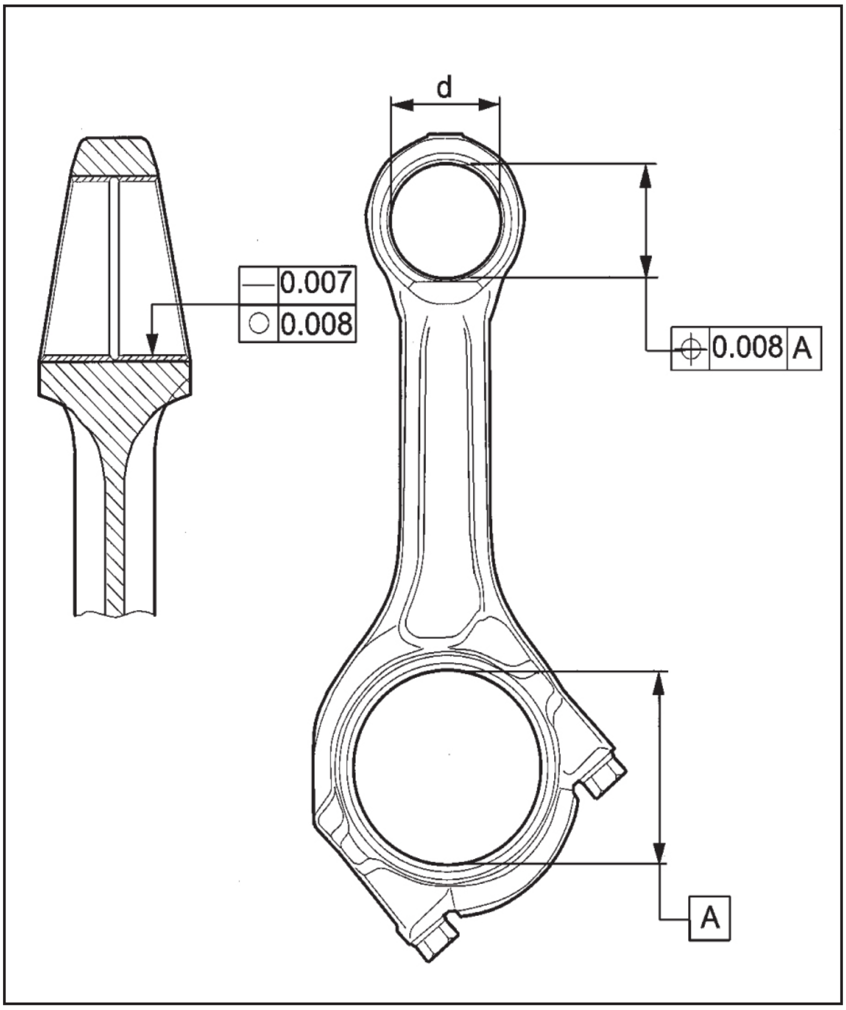


Figure 113

Pistons

The pistons which are used in DA40 engine is of type; articulated pistons.
Articulated pistons are split and have an aluminium skirt and a steel crown.

(For the aluminium piston to resist the high pressure and high temperature prevailing in the combustion chamber, the material is thicker at the piston crown and piston ring grooves than in the remainder of the piston.)

One of the advantages of articulated pistons is that they can tolerate higher loads than conventional pistons completely made of aluminium.

As the piston crown is made of steel it can withstand higher temperatures and pressure in the combustion chamber.

This enables more power to be extracted from engines with articulated pistons.

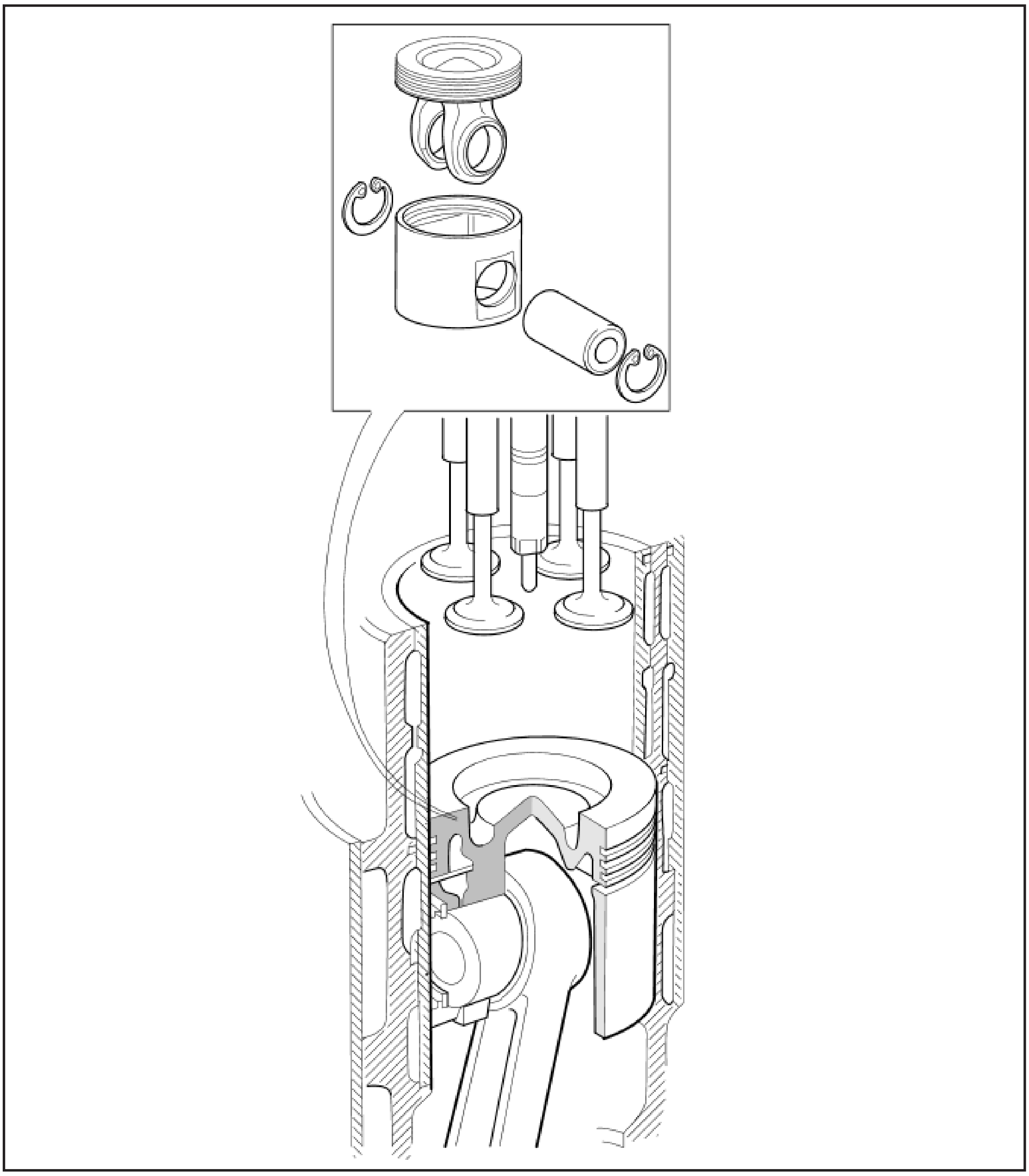


Figure 114

The bowl-shaped combustion chamber in the piston crown has a protuberance in the centre. The design of this protuberance ensures that the fuel injected at the end of the compression stroke is quickly mixed with the air in the combustion chamber.

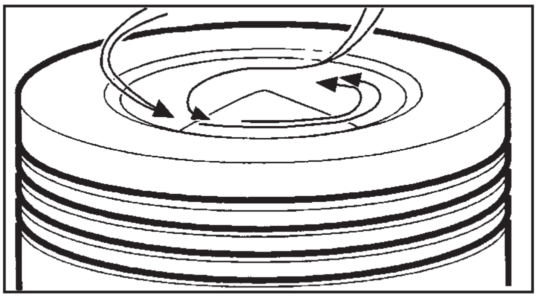


Figure 115

Piston rings
For the piston to travel freely, a gap is required between the piston and cylinder liner.

The piston therefore has two compression rings which seal this gap and conduct the heat from the piston.

The upper of these rings is exposed to higher pressure than the intermediate ring and is therefore wedge-shaped, a “key-stone” ring, which increases the force pressing it against the cylinder wall.

Since the greatest stress is on the upper piston ring groove, and also to reduce wear, a reinforcement of cast iron is incorporated in the piston.

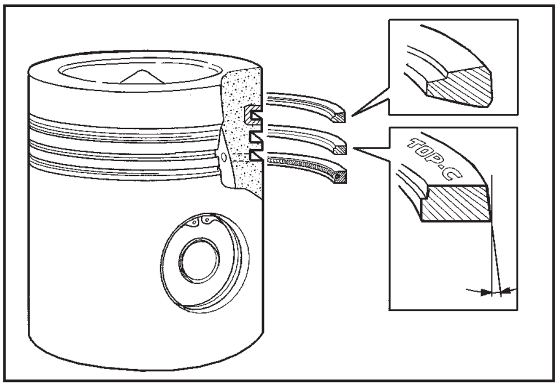


Figure 116

The bottom piston ring, the oil scraper ring, prevents oil from the crankcase from finding its way up to the combustion chamber.

In the oil scraper ring is a coil spring which presses it against the cylinder wall.

The design and quality of the pistons and piston rings are extremely important for the reliability and lubrication of the engine as well as oil and fuel consumption.

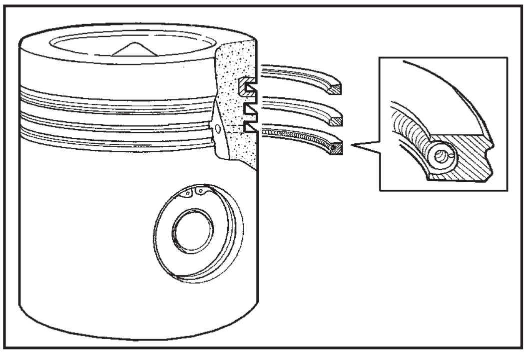


Figure 117

Turn the piston rings so that the gaps are distributed around the piston.

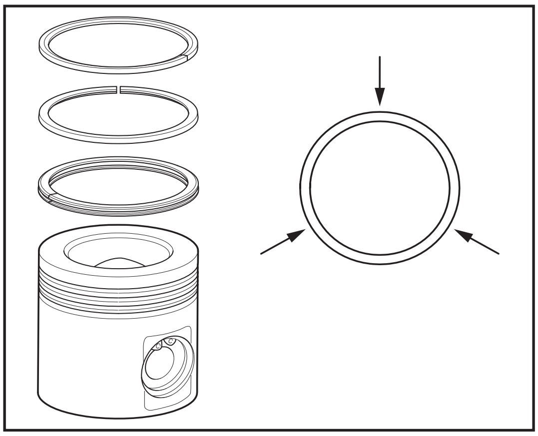


Figure 118

Assembling piston and connecting rod

1. Clean the piston and its rings thoroughly without scratching the sides of the ring grooves. The oil holes in the piston should be cleaned using a suitable drill.

2. Make sure the piston ring gaps do not exceed the permitted limit. Place the piston rings in the cylinder liner and measure the gap using a feeler gauge.
   For permitted gap, see section entitled Specifications, piston rings.

   Maximum piston ring gap for 9 and 13 litre engines with PDE:

Compression ring 1 (upper)	0.9 mm
Compression ring 2 (lower)	1.8 mm
Oil scraper ring	0.8 mm

3. Fit the piston rings using tool 920201-00003. The oil scraper ring has an expander. Pistons rings marked with TOP must be turned with TOP face up.

4. Oil all the bushings, the gudgeon pin hole and the gudgeon pin before assembling.

5. Place one of the retaining rings in the piston.

6. Turn the piston and connecting rod as illustrated. The arrow mark should point forward on the engine.

7. Insert the gudgeon pin using tool 850329-00150 and fit the second retaining ring for the gudgeon pin.

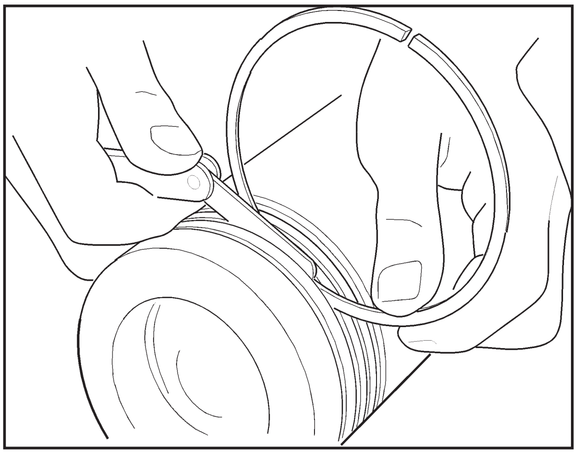


Figure 119

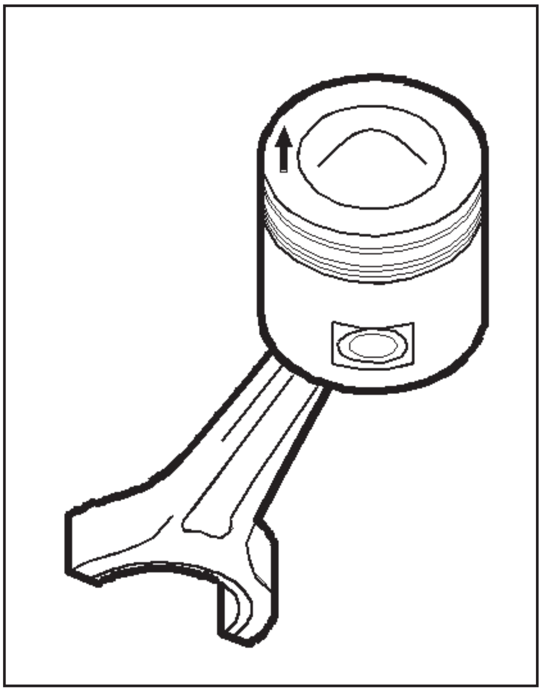


Figure 120

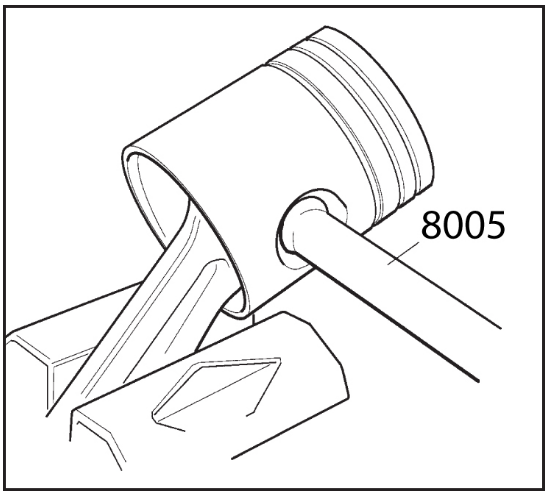


Figure 121

Cylinderblock

The cylinder block is a one-piece casting. It has 6 cylinder bores. There is a separate cylinder head for each cylinder.

The seal between cylinder block and cylinder head consists of a steel/elastomer gasket. Seals are bonded in place at the oil and coolant passages.

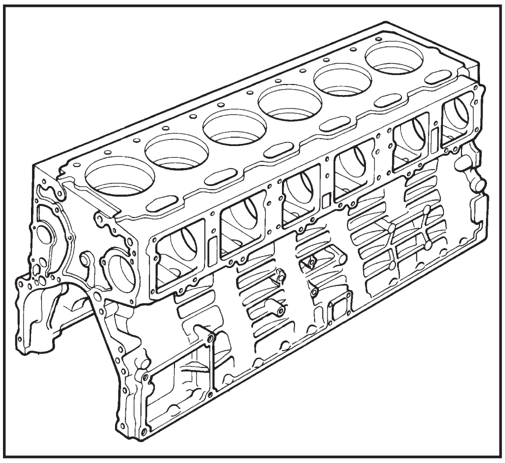


Figure 122

Cylinder liner

The cylinder liners are of the “wet” type, i.e. they are surrounded by coolant.

To ensure a good seal, the edge of the cylinder liner protrudes slightly above the surface of the cylinder block. This ensures that the cylinder head gasket is pressed against the cylinder head.

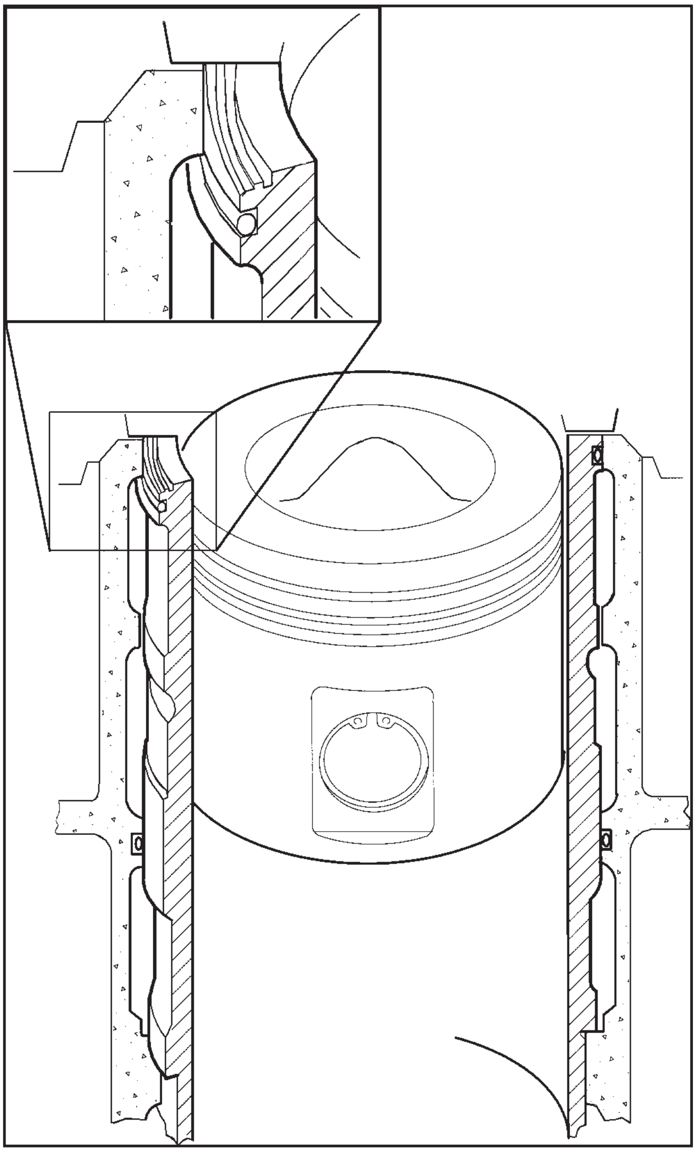


Figure 123

The inside of the cylinder liner is machined by what is known as plateau honing. This type of machining leaves a fine pattern of grooves which ensures that the oil needed for lubrication between piston rings and liner remains on the wall of the liner.

The design of the pattern is of major importance for ensuring low oil consumption in the engine.
Two sealing rings, one in the block and one in the liner, seal off the coolant jacket. The surface of the liner in contact with the liner shelf seals off the lubricating oil.

In the space between liner shelf and sealing ring in the block is an overflow hole which discharges in the side of the cylinder block under the side covers.

Leakage at any of the sealing surfaces will result in oil or coolant coming out of the overflow hole.

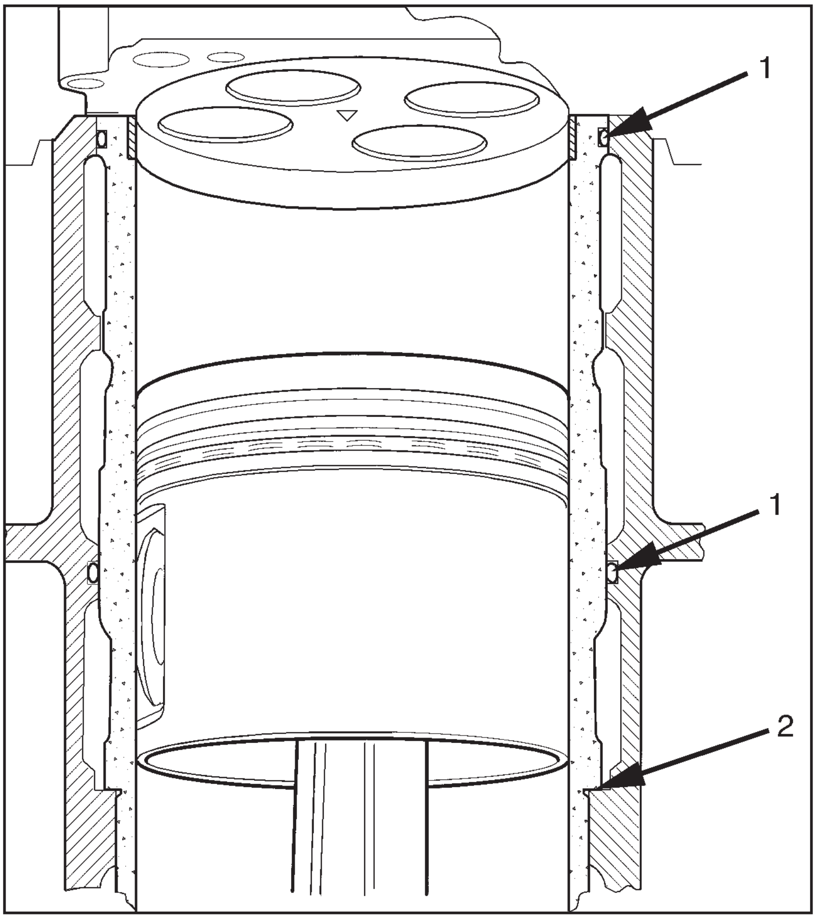


Figure 124

1. Seal for coolant
2. Support point for liner

Removing the cylinder liners

1. Mark the liners with the numbers 1- 6. The mark is necessary so that the liners can be refitted in the same place and position as previously.

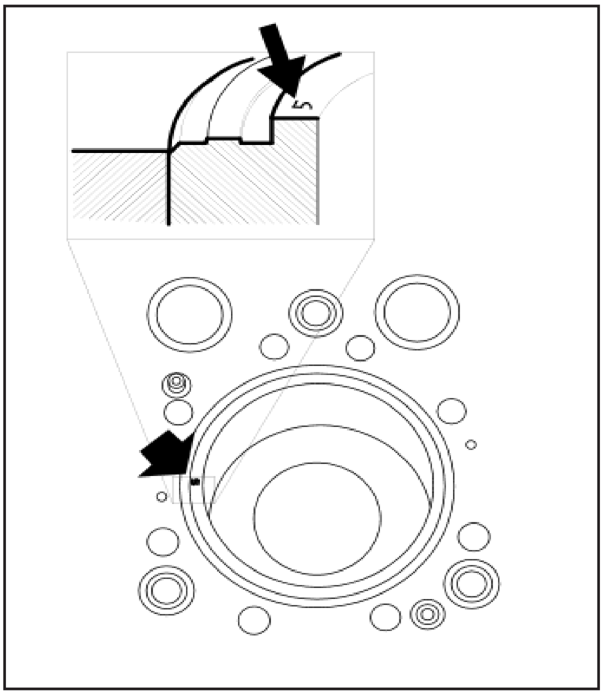


Figure 125

NOTE

The mark must be made only on the surface indicated in “Figure 125“. Other surfaces are for sealing, If you use a marker, you can mark anywhere.

2. Withdraw the cylinder liner using puller 850329-00154 and hydraulic cylinder 850329-00163. Fit spacers under the support lugs to avoid damaging the surface of the block.
3. Remove the sealing ring in the cylinder block.

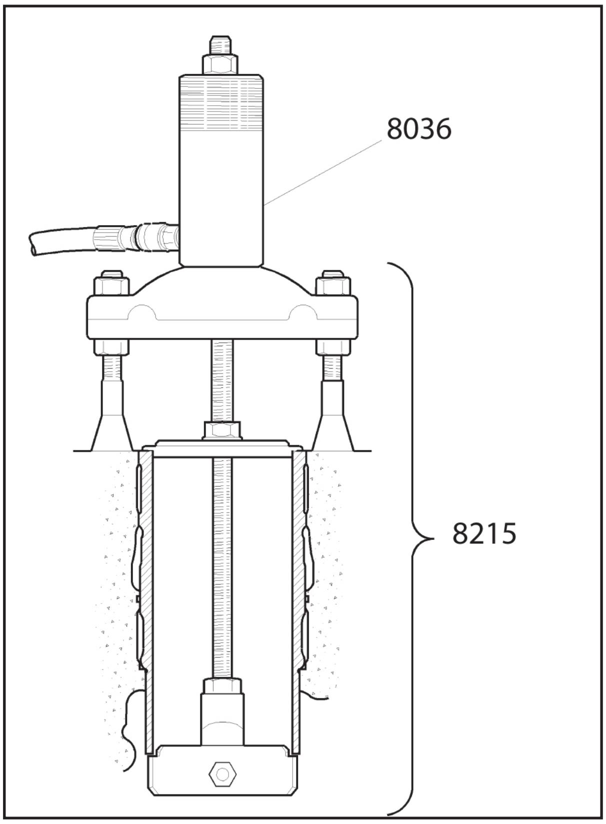


Figure 126
Cylinder liner extractor with hydraulic cylinder

Measuring the cylinder liner height

1. Thoroughly clean the cylinder block liner shelf, the face around the cylinder, the cylinder liner shelf and the upper face of the cylinder liner.

2. Fit the cylinder liner without O-rings and twist down by hand into position.

3. Lift out the liner and wipe the liner shelf in the cylinder block and the cylinder liner shelf.

4. Insert the cylinder liner without O-rings and twist it down into position again by hand.

5. Place straight edge 87 198 with dial gauge 98 075 on the liner and zero the dial gauge to the liner (A). Slide the tip of the dial gauge over to the cylinder block (B) and measure the height of the liner (A-B) as illustrated.

6. Measure each liner at two diametrically opposite points transversely across the engine.

   - The cylinder liner must be slightly above the face of the cylinder block.

   - The difference between the two measurements on the same liner must not exceed 0.02 mm.

   - The height of the cylinder liner D (=A-B) above the block should be 0.20 – 0.30 mm.

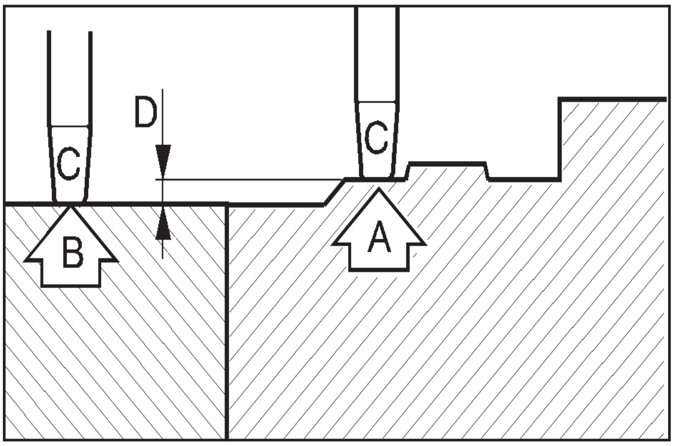


Figure 127

A = Measuring surface on cylinder liner
B = Measuring surface on cylinder block
C = Tip of dial gauge
D = Cylinder liner height D = A-B

Measuring cylinder liner height

Measuring the cylinder wear ridge and cylinder bore

C Measure the diameter of the cylinder wear ridge 2-8 mm down the cylinder bore.

D Measure the diameter of the cylinder bore 10-12 mm down the cylinder bore.

2. Cylinder liner type A

The difference between the diameter of cylinder wear ridge C and the diameter of cylinder bore D must not exceed 0.06 mm

Cylinder liner type B

The difference between the diameter of cylinder wear ridge C and the diameter of cylinder bore D must not exceed 0.06 mm

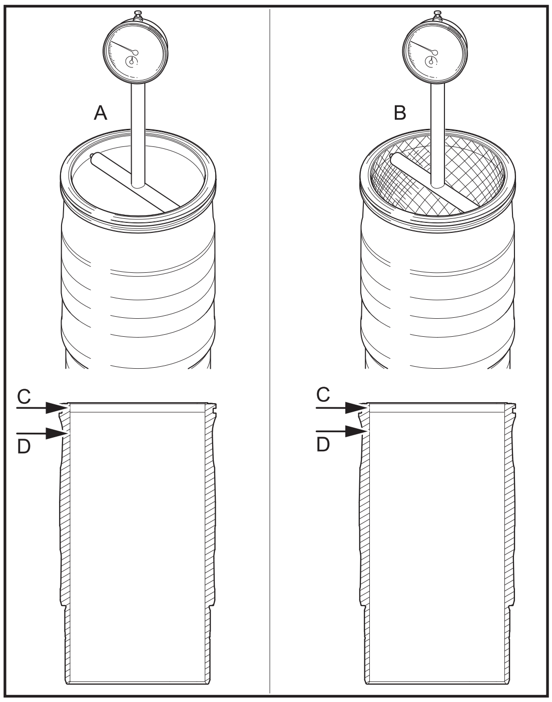


Figure 128

Fitting the cylinder liners

1. Check cylinder liner height as described in the section entitled Measuring the cylinder liner height.
2. Make sure the interior of the cylinder block is clean. Clean the O-ring surfaces.
3. Check that the holes for coolant going to the cylinder head and cylinder liner are not clogged.
4. Carefully check the cylinder liners, both new and old, for cracks which might have arisen during transport or careless handling.
5. Tap the liner carefully with a metal object. It should give a clear metallic ring if it is intact. If it sounds cracked, renew it.

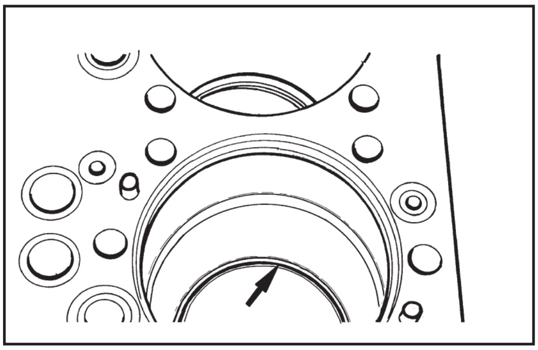


Figure 129

NOTE

Use only glycerol to lubricate the cylinder block, cylinder liner and O-rings. Other lubricants may cause the O-rings to swell.

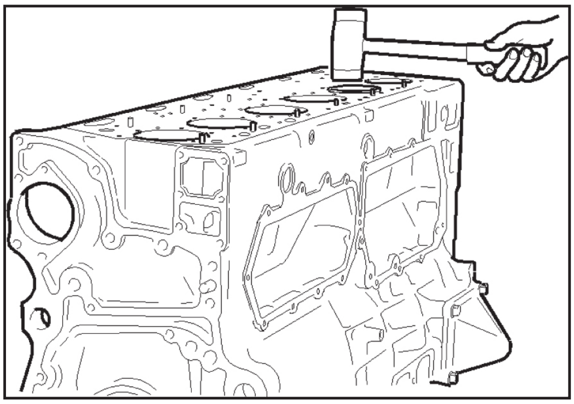


Figure 130

6. Lubricate the sealing ring to be fitted in the cylinder block with engine oil and fit it in place.
7. Lubricate the sealing ring to be fitted in the cylinder liner with engine oil and fit it in place.
8. Turn the liner with the stamped cylinder number facing forward and carefully tap it down with a rubber mallet.
9. Fit the scraper ring in place after the piston has been fitted.
10. Check that the liner goes down completely.

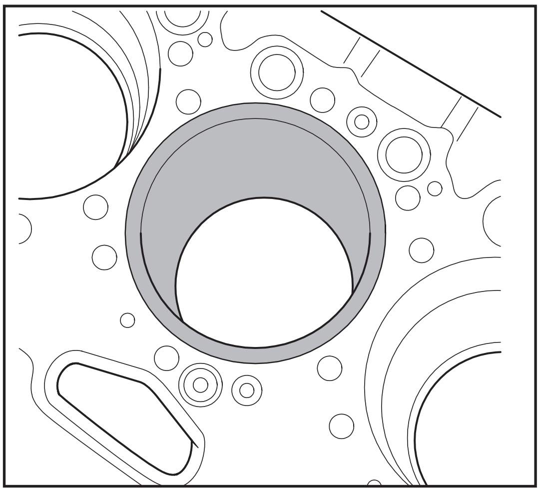


Figure 131

Fitting the piston and connecting rod

1. Lubricate the piston, piston-rings, cylinder liner and piston ring compressor with engine oil.
2. Remove the protection on the connecting rod journal and lubricate the journal.
3. Turn the piston rings so that the ring gaps are evenly distributed round the piston.
4. Fit the upper connecting rod bearing shell to the connecting rod and lubricate the bearing surface.
5. For engines with a scraper ring in the liner: Fit assembly tool MX008409 instead of the scraper ring in the liner.
6. Carefully insert the connecting rod and piston so that the arrow mark on the piston points forward.
7. Clamp piston ring compressor MX008224 round the piston and push the piston down into the cylinder past the assembly tool.
8. Remove the assembly tool and press in the scraper ring. Be careful to press it in straight so that it does not tilt.
9. For engines without a scraper ring in the liner: Insert the connecting rod and piston. On aluminium pistons the arrow mark on the piston should point forward.
10. Clamp piston ring compressor 98 212 round the piston and push the piston down into the cylinder.

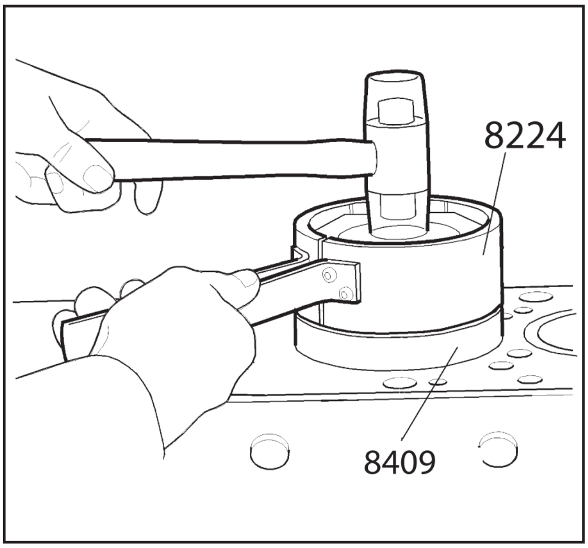


Figure 132

11. Fit the lower connecting rod bearing shell into the cap and lubricate the bearing surface. Fit the cap. Check that the connecting rod and cap have the same marking and that they are opposite each other.

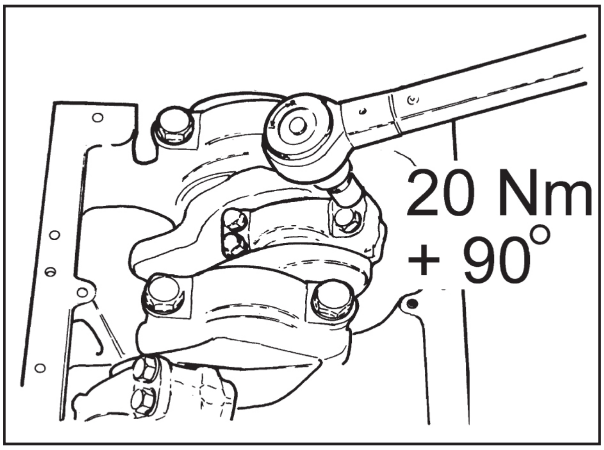


Figure 133

12. Lubricate the bolts, fit them and tighten to 20 Nm + 90°. Check that the pistons nozzles are in perfect condition and fully open. If necessary, blow clean with compressed air.

13. Fit the piston cooling nozzle and tighten the banjo bolts to 23 Nm.

NOTE

The piston cooling nozzle must not be damaged. The oil jet must hit the piston precisely. If it does not, the piston will become too warm resulting in engine breakdown. Damaged nozzles must not be re-aligned, renew them instead.

14. Fit the oil sump and tighten the bolts to 30 Nm.

15. Fit the cylinder head. Tighten the cylinder head bolts as described in the section Cylinder head.

Flywheel and flywheel housing

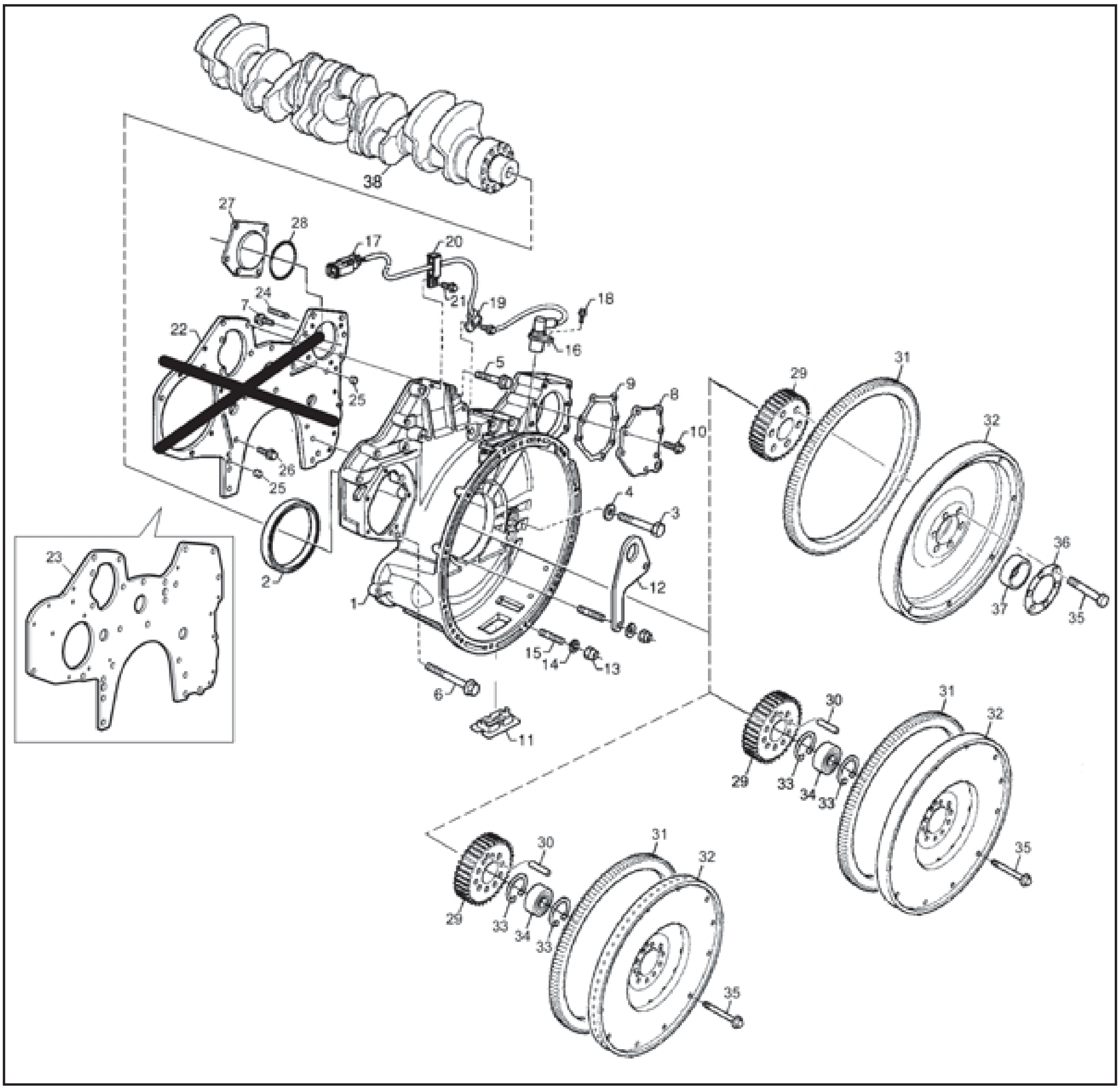


Figure 134

NOTE

23.Timing gear plate, engines with PDE unit injectors

1. Flywheel housing
2. Seal
3. Bolt
4. Washer
5. Flange bolt
6. Flange bolt
7. Flange bolt
8. Cover
9. Gasket
10. Flange bolt
11. Cover
12. Lifting eye
13. Hexagon nut
14. Washer
15. Stud
16. Rotation speed sensor
17. Contact housing
18. Flange bolt
19. Clamp
20. Clamp
21. Bolt
22. Timing gear plate,
    engines with injection pump
23. Timing gear plate,
    engines with PDE unit injectors
24. Stud
25. Pin
26. Flange bolt
27. Cover
28. O-ring
29. Crankshaft gear PF
30. Pin
31. Ring gear
32. Flywheel
33. Circlip
34. Ball bearing
35. Bolt
36. Washer
37. Guide sleeve
38. Crankshaft

Special tools

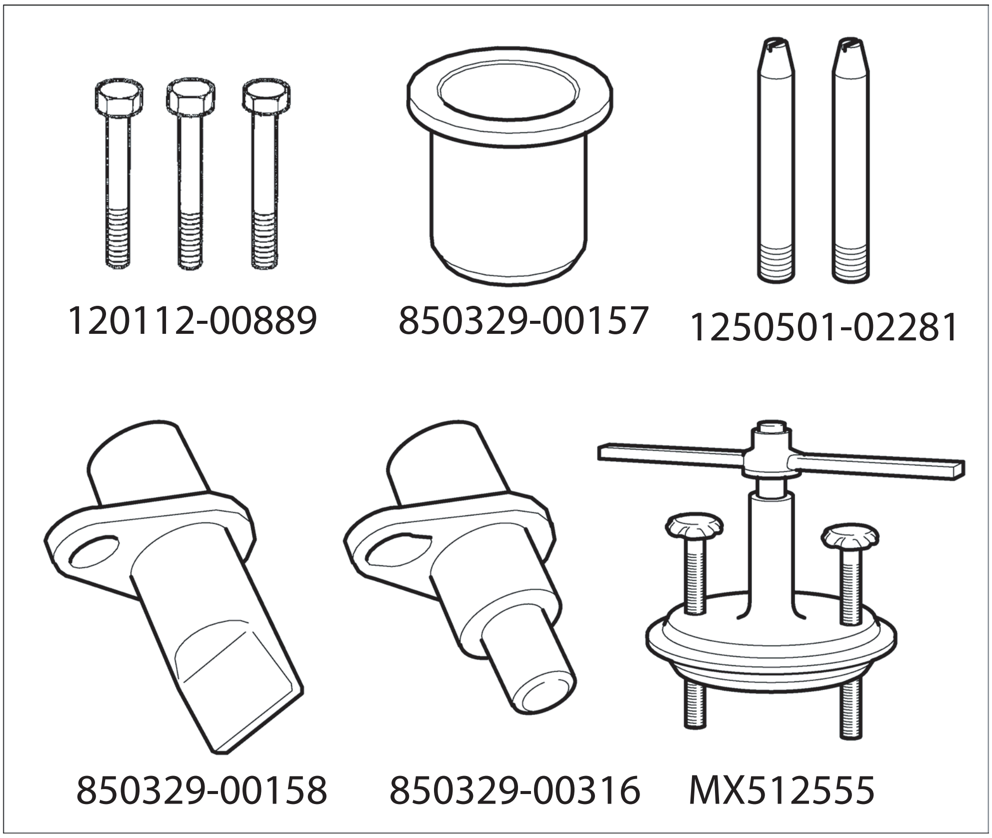


Figure 135

120112-00889	Puller bolts	Not illustrated:	
850329-00157	Drift		
1250501-02281	Guide pins	850329-00446	Air powered sprayer
850329-00158	Assembly tool	MX512557	Cartridge adapter
850329-00316	Assembly tool	MX512558	Nozzle
MX512555	Assembly tool		

Removing the flywheel

1. Remove the rotational engine speed sensor(s) in the flywheel housing.
2. Remove the bolts for the flywheel. 14” flywheel: Also remove the washer.
3. Pull off the flywheel from the crankshaft using puller bolts 120112-00889.

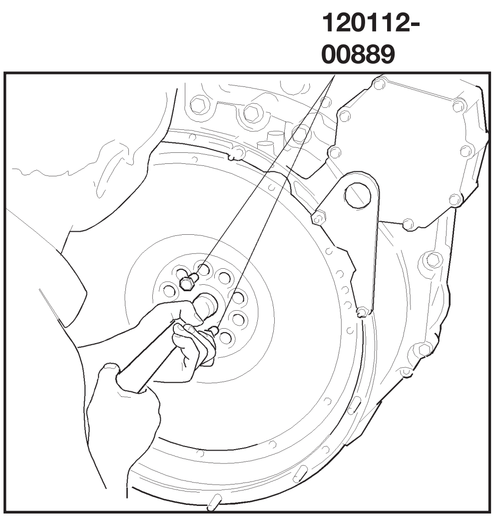


Figure 136

Renewing support bearing

1. Remove the retaining rings on both sides of the support bearing.

2. Knock out the support bearing from the flywheel using drift 850329-00157.

3. Fit the inner retaining ring and fit the new support bearing with drift 850329-00157.

4. Fit the outer retaining ring.

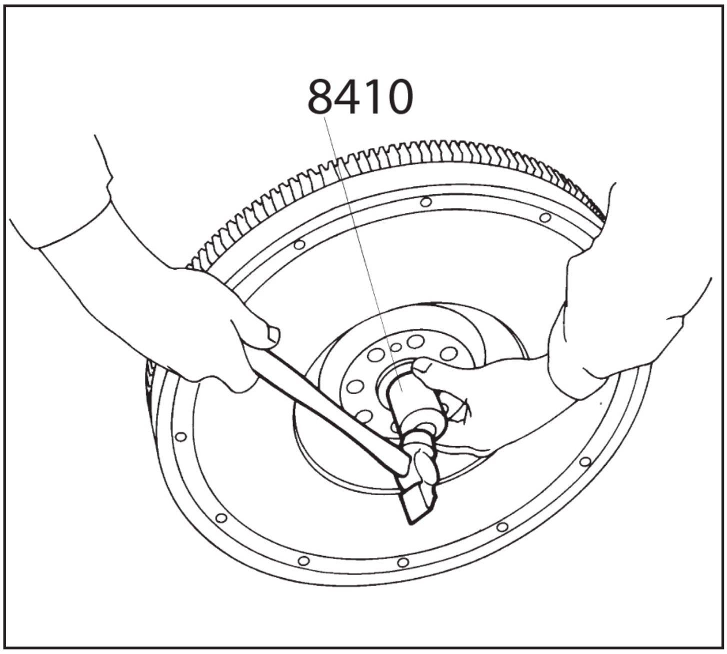


Figure 137

Renewing ring gear

Renew the flywheel ring gear if the gear teeth have become so worn that the starter motor pinion will not engage.

1. Grind a groove as deep as possible in the ring gear and crack it open with a chisel. Remove the ring gear from the flywheel.

WARNING

Use protective goggles due to the risk of metal shivers.

2. Clean the contact surfaces on the flywheel with a wire brush.

3. Heat the new ring gear evenly around its circumference to 100 - 150°C.

4. Place the heated ring gear on the flywheel so that the marking with the part number is facing the engine when fitting the flywheel. Make sure the ring gear is securely against the flywheel. If necessary, knock down the ring gear with a plastic hammer.

5. The ring gear must not be cooled rapidly but be left to cool in the open air.

Renewing the rear crankshaft seal

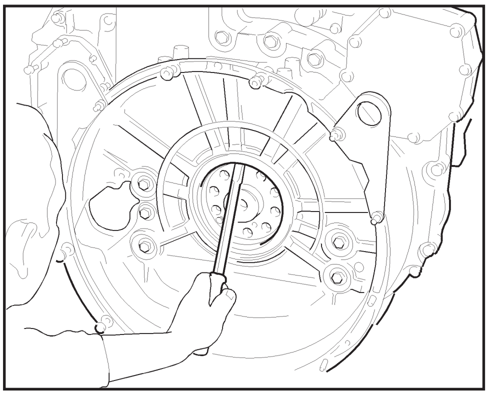


Figure 138

1. Remove the crankshaft seal using a screwdriver. Take care not to scratch the sealing surfaces on the crankshaft and the flywheel housing.

NOTE

The crankshaft seal must be fitted dry and must not be lubricated. The sleeve in the seal should be left in place until the seal is fitted. The crankshaft should be degreased before the new seal is fitted.

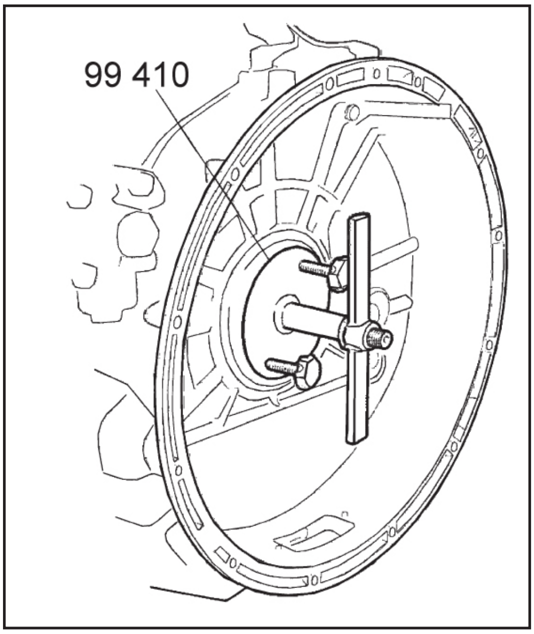


Figure 139

2. Fit the new crankshaft seal using tool MX512555. Place the crankshaft seal on the tool and fasten the tool with the bolts.

3. Turn the tool clockwise until i stops in order to attain the correct crankshaft seal position.

Removing the flywheel housing

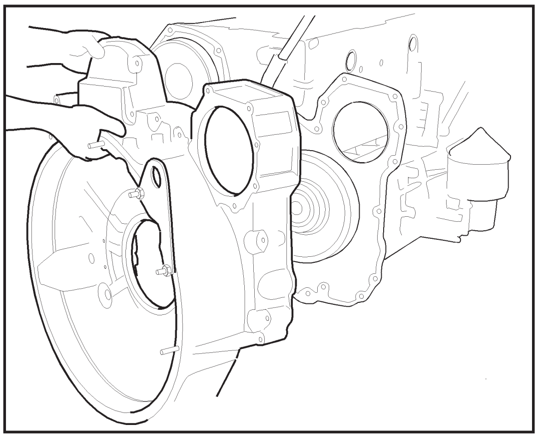


Figure 140

1. Remove the starter motor.

2. Remove flywheel housing.

Fitting flywheel housing

1. Remove all old sealing compound on the sealing surfaces of the timing gear casing and timing gear plate. Clean off any oil and grease using an alcohol based cleaning agent.

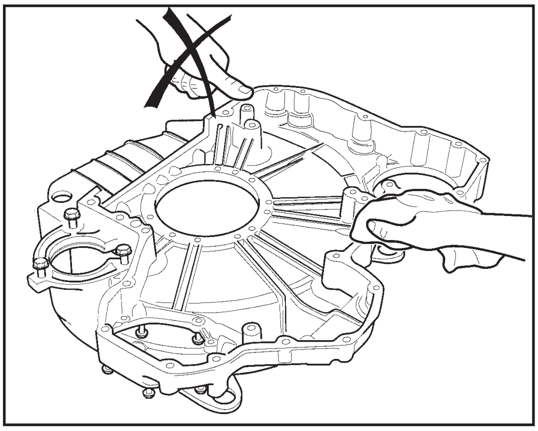


Figure 141

NOTE

The sealing surfaces must be absolutely clean and free from grease. Do not touch the surfaces after degreasing.

2. Apply the sealing agent (512565) on the timing gear hous ing with the air powered sprayer (850329-00446), cartridge adapter (512565) and nozzle (MX512558). The width of the bead should be between 0.8 and 1.2 mm. Follow the patern as illustrated.

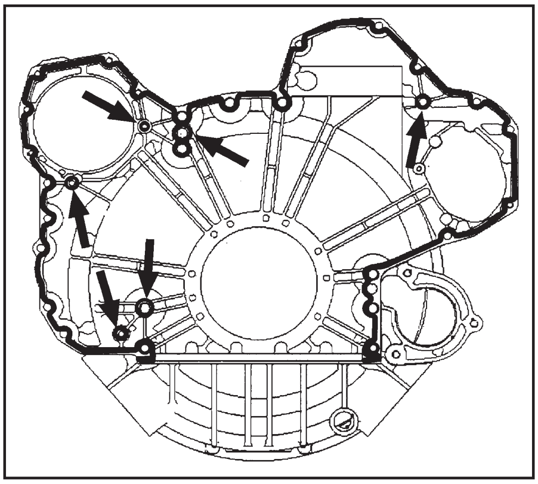


Figure 142

CAUTION

Ensure that you apply sealing agent inside the screwholes, but without allowing sealing agent into the crankcase. The sealing agent may block channels and nozzles. This is particularly important to bear in mind around oil ways, where the flow of oil to the air compressor or injection pump can be blocked.

NOTE

Assembly must be completed within 25 minutes of starting to apply the sealing agent. The bolts are of various sizes and lengths. Ensure that they are fitted in the correct places. See also the illustrations on the next page.

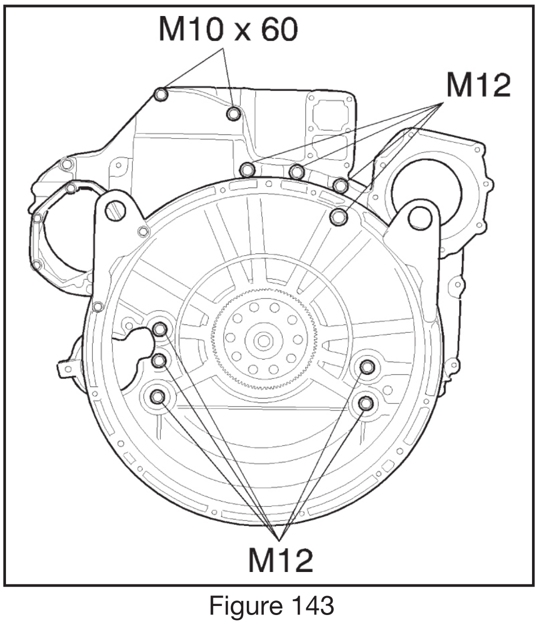


Figure 143

3. Torque tighten the M12 bolts to 90 Nm and the M10 bolts to 50 Nm.

4. Fit the starter motor. Apply the sealing agent on the timing gear housing side against the transmission plate. Apply the sealing agent around the screw holes marked with arrows.

5. Torque tighten the M12 bolts to 90 Nm and the M10 bolts to 50 Nm.

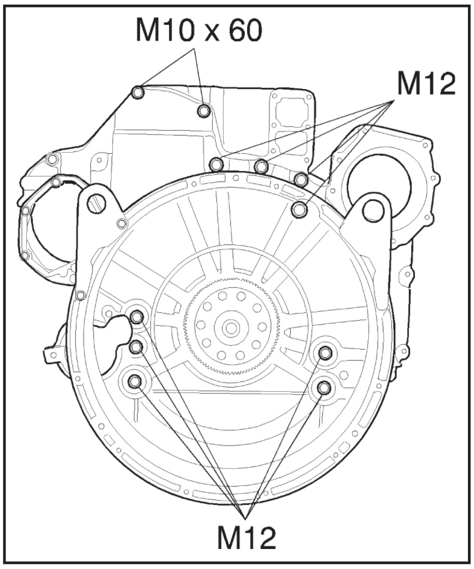


Figure 144

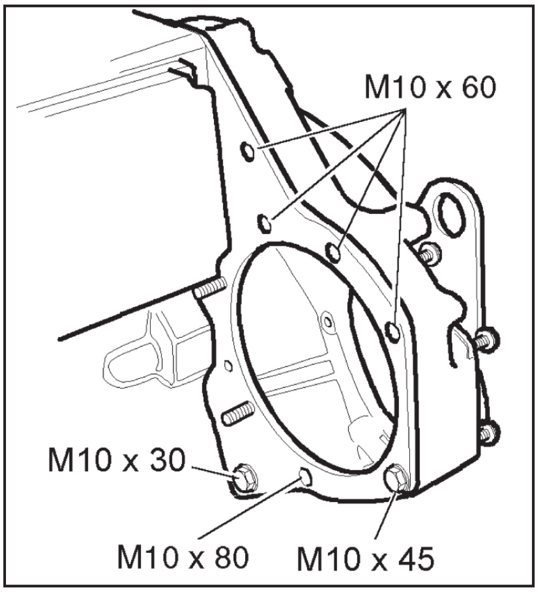


Figure 145

6. Fit the power steering pump.

7. Fit the starter motor.

8. Fit the flywheel, see Fitting of flywheel.

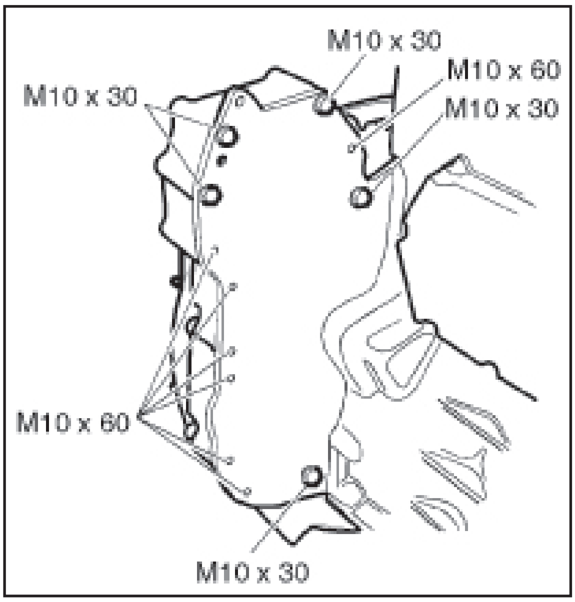


Figure 146

Fitting the flywheel

1. Fit two guide pins **1250501-02281** in the crankshaft flange.

2. Fit the flywheel on the crankshaft.

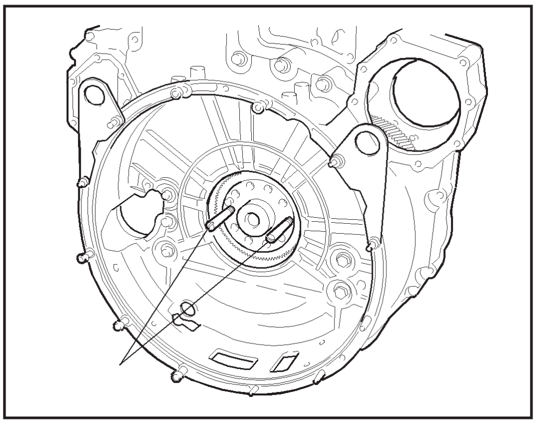


Figure 147

NOTE

Always use new bolts and washer.

3. Lock the flywheel using tool: - 512563 for engines with unit injector.

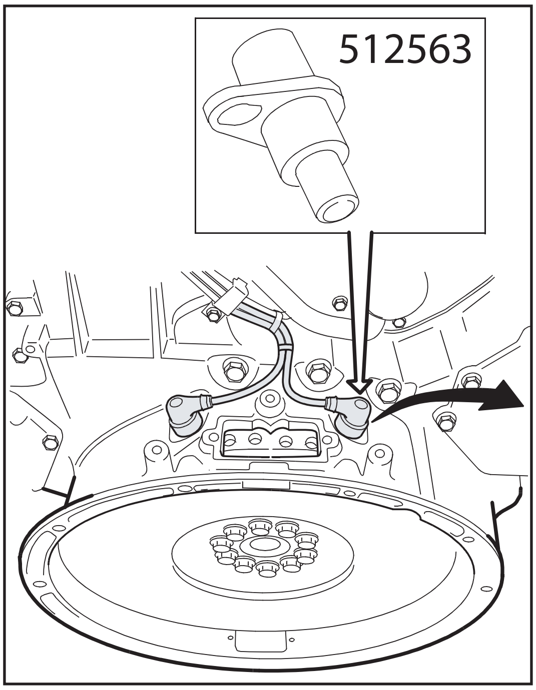


Figure 148

4. Torque tighten the bolts alternately to 130 Nm and then a further 90°.

5. Refit the engine speed sensors.

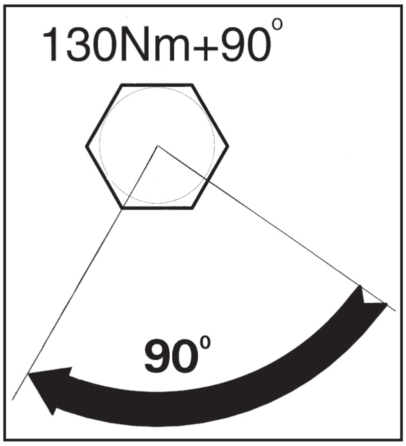


Figure 149

Flexible coupling

Safety instructions

For all work on the coupling it must be ensured that both the drive engine and the driven machine are at a standstill and cannot be started up under any circumstances.
Work should only be begun when the coupling has cooled down to below 30°C.

Rotating parts such as the coupling itself and exposed shaft components are to be fitted with a guard to prevent injuries. However, this must not impair ventilation.
The coupling contains flammable materials. This must be taken into account when operating the coupling.

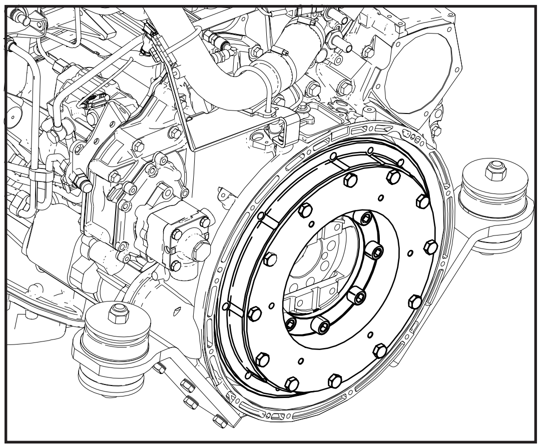


Figure 150

Functional description

The flexible coupling is an industrial torsional vibration damper, which both displaces resonance frequencies and dampens torque peaks.

For this purpose, the drive line is coordinated with the aid of the coupling by arranging mass inertias, torsion spring strengths and dampings in such a way that the permitted torsional vibration or load surge levels are not exceeded.

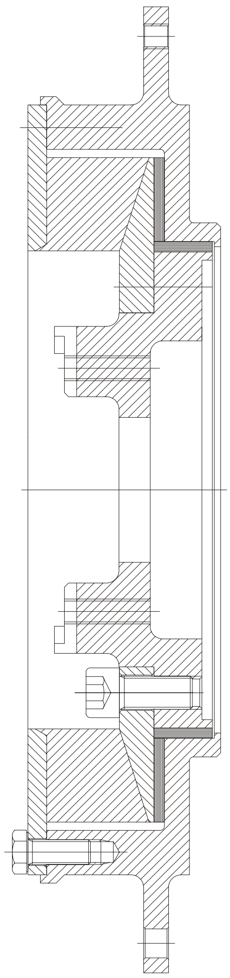


Figure 151

Disassembly and dismantling the coupling

To disassemble the coupling, the cardan shaft bolted onto the universal shaft coupling is unbolted and removed.
Then the flywheel connection bolts are undone so that the coupling can be completely removed.

After undoing the bolts (7) and the inner bolted connection (6), the coupling can be dismantled into its individual components.
This applies only up to →7x1126;→8x1128

NOTE

All parts should be cleaned after dismantling the coupling. After the technical change the new coupling is available only as a complete unit

NOTE

All bolted connections should generally be replaced

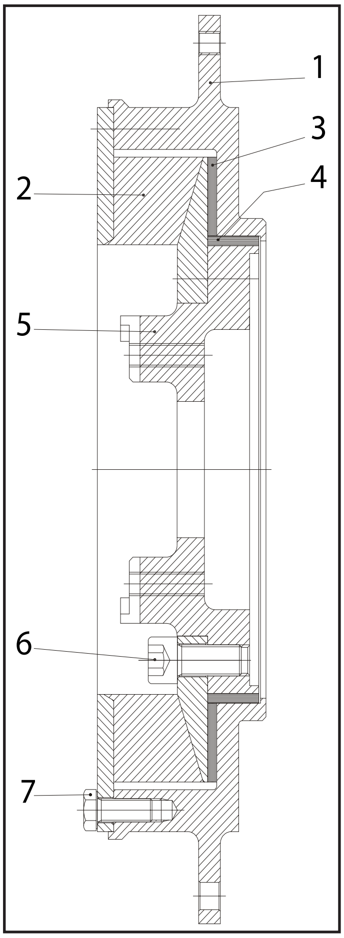


Figure 152

Assembling the coupling →7x1126;→8x1128.

When assembling the coupling, the bolt tightening torques must be observed.

Assembly is begun by inserting the friction ring (4) and the friction disk (4) into the flange casing (1). When reusing the friction disk (3) and the friction ring (4), the surfaces should be brushed lightly with mineral oil.

No other lubricants or auxiliary materials may be used, in particular no greases with metallic soaps or dry-film lubricants.

Then the hub (5) is pushed in and the coupling element (2) inserted. The coupling is bolted tight with the inner (6 [Torque: 390Nm]) and outer fixing bolts (7 [Torque: 125Nm]).

Installation instructions

Before installation, the corrosion protection on the contact surfaces of the coupling must be removed with a conventional solvent. The coupling is attached in assembled state to the engine flywheel with the flywheel bolted connection.

M12x20 8pcs	M12x90 8pcs
Torque: 136Nm.	Torque: 86Nm.
Use Loctite® 245	Use Loctite® 245

No washers are to be used.

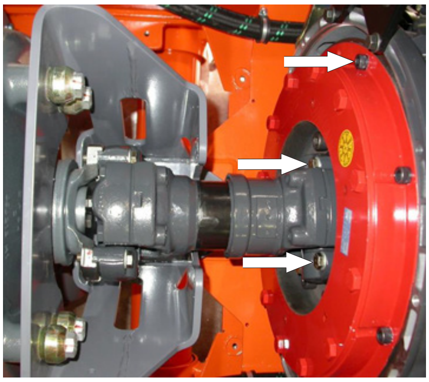


Figure 153

The cardan shaft can now be mounted and assembled.
Mount shaft with dust sealing forward (log on driving side). Enter two screws and tighten until there is a 3mm gap. Then enter the two remaining screws (same side) all the way and then the first ones. Same procedure on both sides.

Torque: 141Nm. Use Threebond® 1374 on screws.

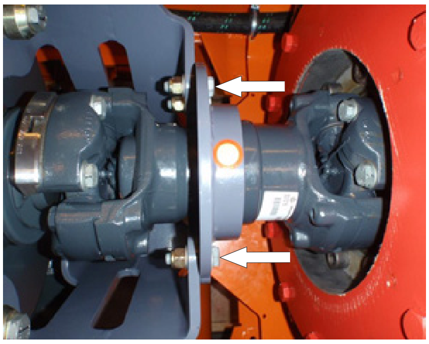


Figure 154

Mount lower flange-half all the way down and equal clearance on both sides of shaft.
Mount upper flange-half all the way up and equal clearance on both sides of shaft.

Torque: 114Nm

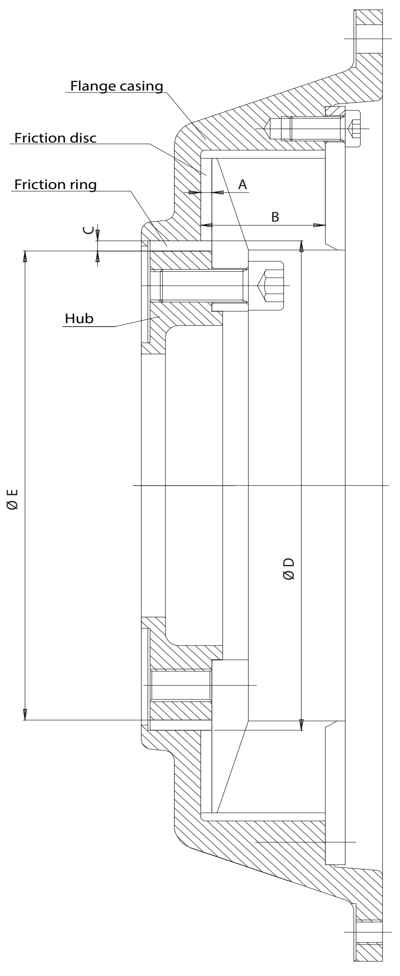
WARNING

If unusual torsional vibrations (high noise level) occur after the engine or drive unit is switched on, the system is to be shut down immediately.

Friction disk, friction ring

The friction disk and friction ring are components which due to their design are subject to a certain degree of wear. The opposite steel surfaces of these components may also be subject to a small degree of wear.

The wear threshold values for the friction disk, the friction ring, the housing bore and the hub diameter are given in the following table.



Manufactured size	055	
Friction disk thickness "A"	5,0	mm
Wear threshold value	4,5	mm
Flange casing depth element seat on outer ring up yo striking surface "B"	63,1	mm
Wear threshold value	63,4	mm
Friction ring thickness "C"	5,0	mm
Wear threshold value	4,5	mm
Flange casing diameter bearing seat "D"	266,0	mm
Wear threshold value	266 ,3	mm
Hub diameter on bearing seat "E"	256,0	mm
Wear threshold value	255,7	mm

Figure 155

If these wear threshold values are exceeded on the housing (dimensions B and D) or values are below these limits for the friction ring, friction disk or hub, the parts must be replaced or reworked. In the event of grooves, ripples and burn marks, the housing must always be replaced. When replacing the coupling element, the friction disk and friction ring should also be replaced.

NOTE

Not applies to the new type of coupling . Refer to Parts Catalogue for parts identification.

Timing gear - 13 and 9 liter

Gear drive

The crankshaft gear drives two intermediate gears and the oil pump gear. One intermediate gear drives the camshaft, air compressor and hydraulic pump. The other intermediate gear drives the power take-off and on buses it also drives a hydraulic pump which in turn drives the fan motor.

Engine with unit injector

1. Oil pump gear
2. Crankshaft gear
3. Intermediate gear
4. Hydraulic pump gear
5. Compressor gear (compressed air)
6. Camshaft gear
7. Power take-off

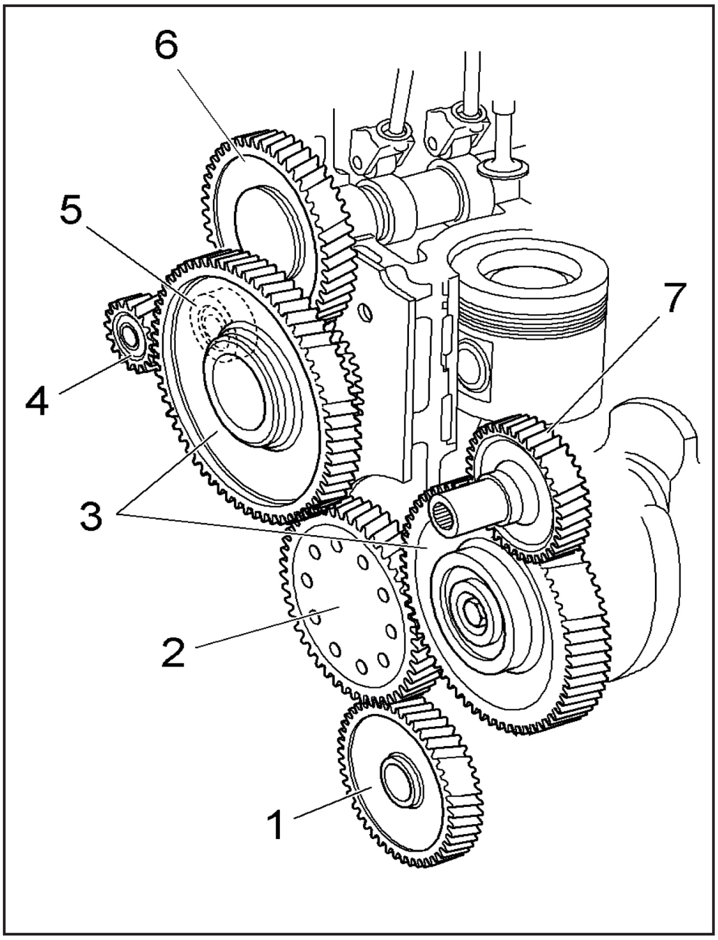


Figure 156

To facilitate assembly the gears have markings, either on a tooth or in a toothgap.

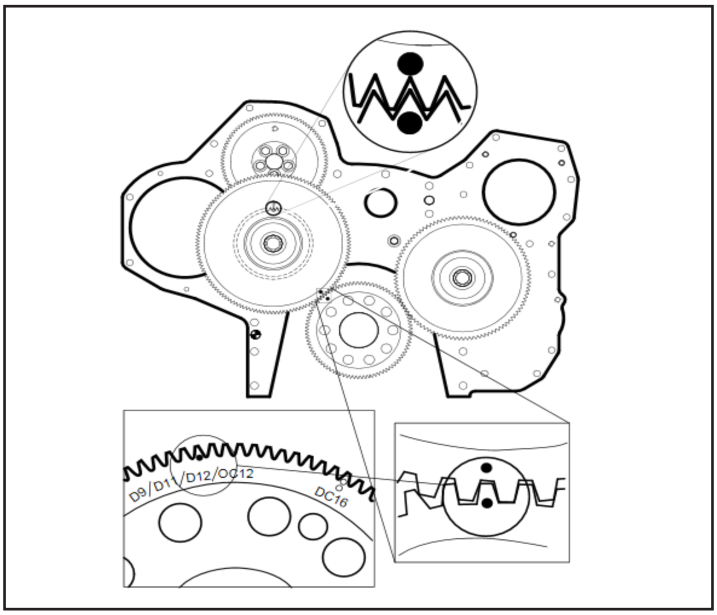


Figure 157

Belt drive collant pump, generator and AC compressor

The coolant pump and alternator are driven by the belt drive, as also is the A/C compressor.

The fan is mounted on a special bracket and is driven by the hydraulic system. (See in chapter 5 Hydraulic system)

The drive belt is a “Multigroove V-belt”, i.e. the belt has numerous V-shaped grooves on the drive side. The pulleys are of corresponding design and the belt therefore has an extremely large contact surface for its width. A large contact surface reduces the risk of belt slippage.

Included in the belt circuit are also jockey pulleys, the purpose of which is to give the belt a good arc of contact round the pulleys.

An automatic belt tensioner is used to obtain the correct belt tension.

1 Spacing sleeve
2 Roller
3 Roller
5 Roller
7 Belt tensioner
9 Poly V belt
10 Alternator
11 Coolant pump
12 A/C compressor
13 Pulley

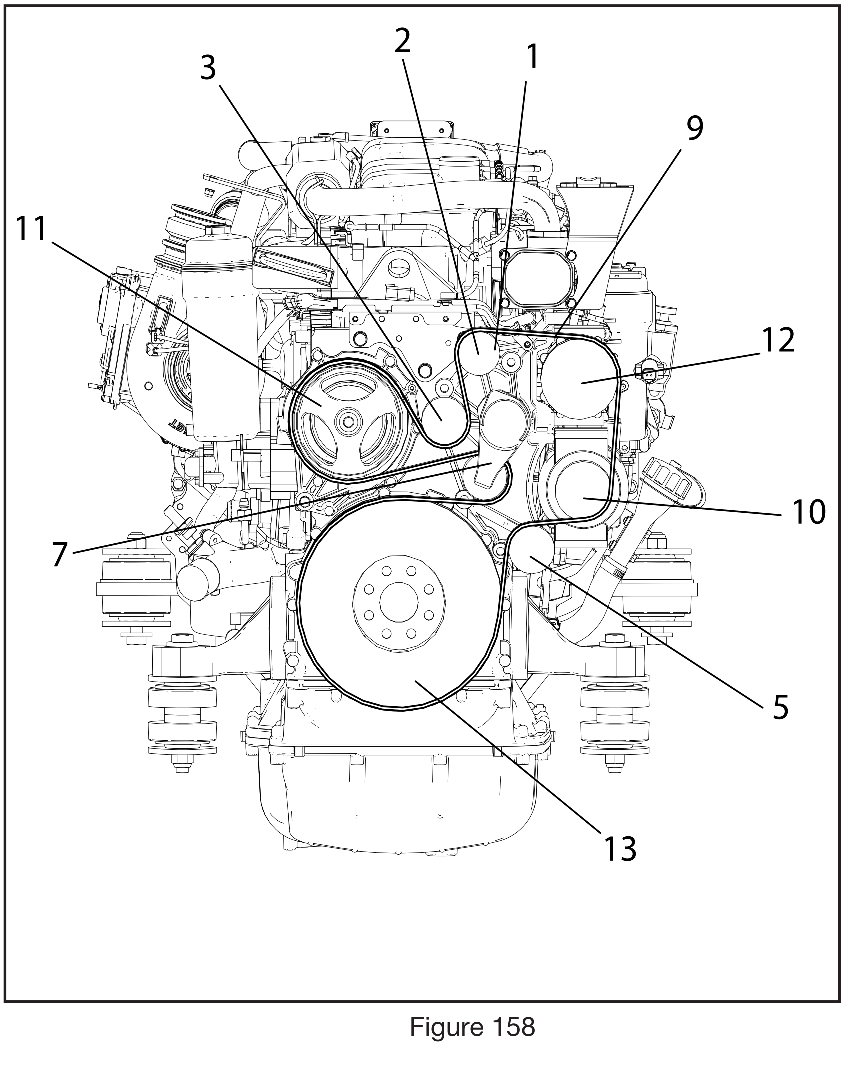


Figure 158

Checking the drive belt

CAUTION

Disconnect the cable terminal prior to charging to prevent control unit damage. Avoid boost charging as this damages the battery over time.

Check the drive belt thoroughly, particularly at the idler rollers.

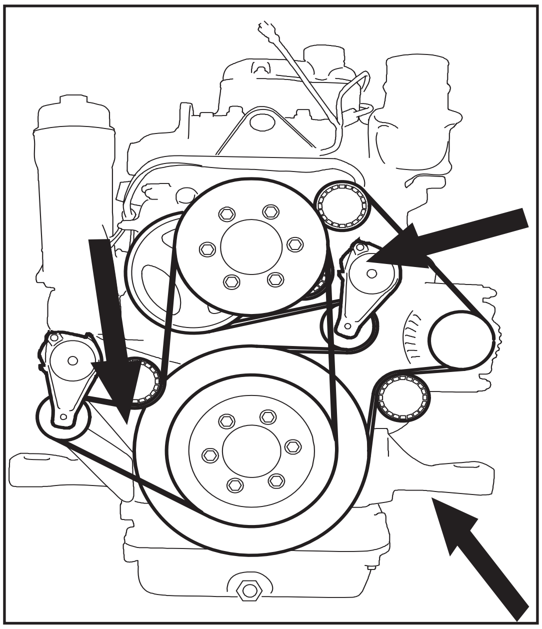


Figure 159

Check the drive belt for cracks.

NOTE

Example of a minor crack in the drive belt. The drive belt can be refitted.

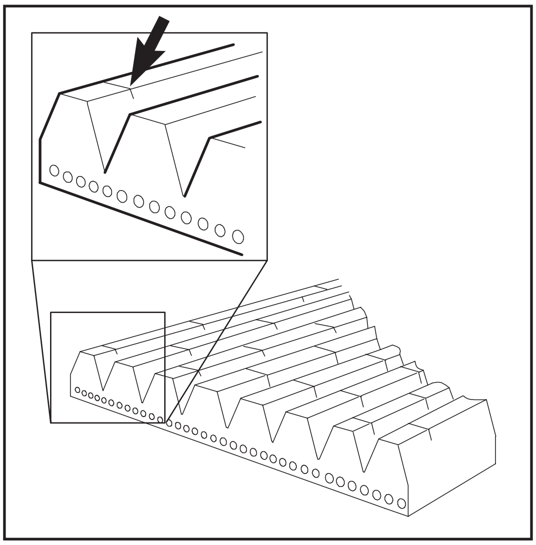


Figure 160

NOTE

The drive belt has deep cracks and must be renewed.

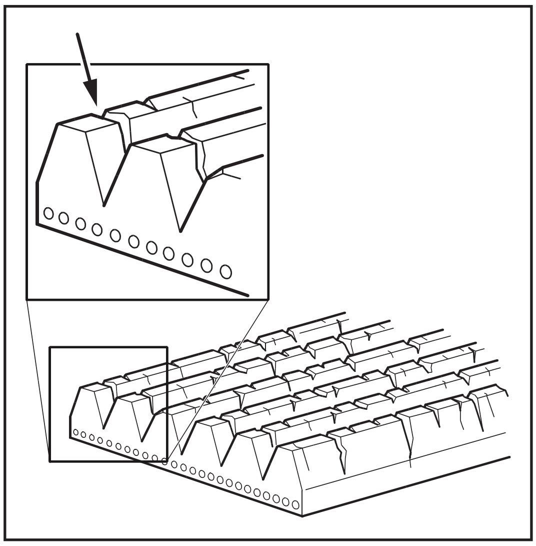


Figure 161

Check drive belt wear.

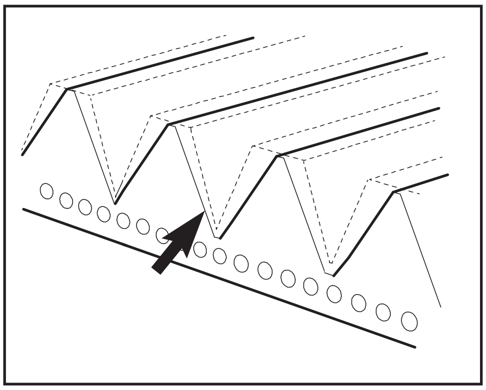


Figure 162

NOTE

The drive belt is starting to become worn, but can be refitted.

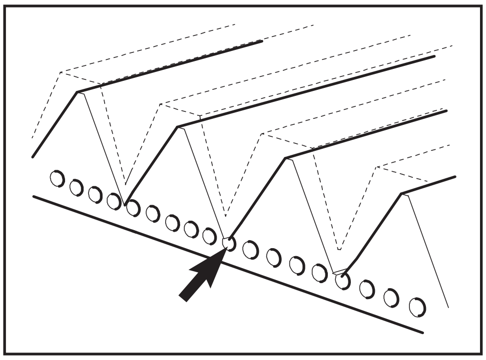


Figure 163

NOTE

The belt is worn down to the cord. The drive belt must be renewed.

Check for leaks

- Start the engine.
- Check for oil, coolant, fuel, air or exhaust leaks.
- Tighten or renew leaking connections. Check the overflow holes which show whether the O-rings between the cylinder liners and crankcase are leaking.
- Check whether the drain hole on the coolant pump is blocked. If there is a leak, renew the seal in the pump or the complete coolant pump.

NOTE

If serious leakage occurs, contact your nearest Hyundai workshop.

Renewing the seal in the front cover

1. Remove the fan ring and the fan.
2. Thermostatic fan: store it upright (vertical).
3. Remove the belt(s), crankshaft damper and belt pulley.
4. Remove the driver bolts and withdraw the driver. Mind the sealing surface.
5. Pull or prise off the seal in the cover. Take care to avoid damaging the sealing surface in the cover.
6. Wipe the sealing surface in the cover clean.

NOTE

The crankshaft seal must be fitted dry and must not be lubricated. The sleeve in the seal should be left in place until the seal is fitted.

7. Place the new seal on tool 8421 and press it in place by tightening the diametrically opposite bolts alternately. The seal is correctly fitted when the tool comes up against the cover.
8. Remove the tool by screwing the bolts into the threaded holes.
9. Wipe the driver sealing surface clean. Fit a new seal on the end surface of the driver and push the driver onto the spacing sleeve on the end of the crankshaft.
10. Bolt the driver to the crankshaft flange and tighten the flange bolts to 135 Nm.
11. Bolt the crankshaft damper and possibly the belt pulley to the hub and tighten to 110 Nm.
12. Fit the belt(s), fan ring and fan.

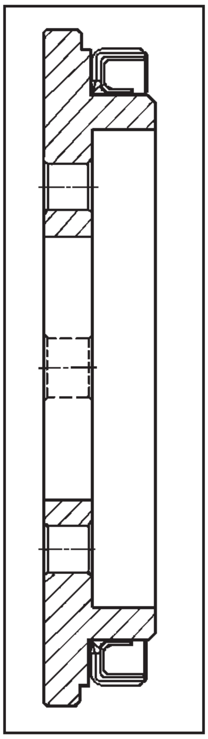


Figure 164

Tool 524615 with crankshaft seal

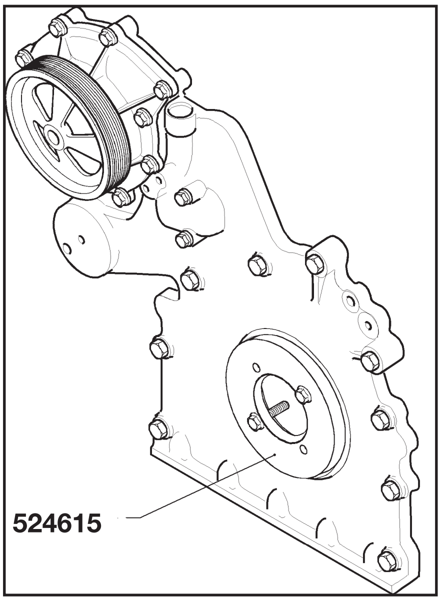


Figure 165

Crankshaft damper

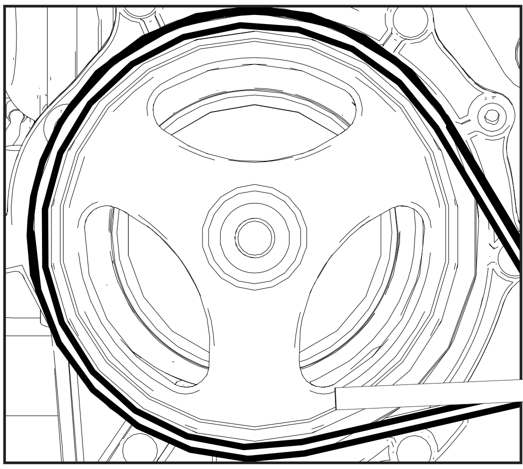


Figure 166

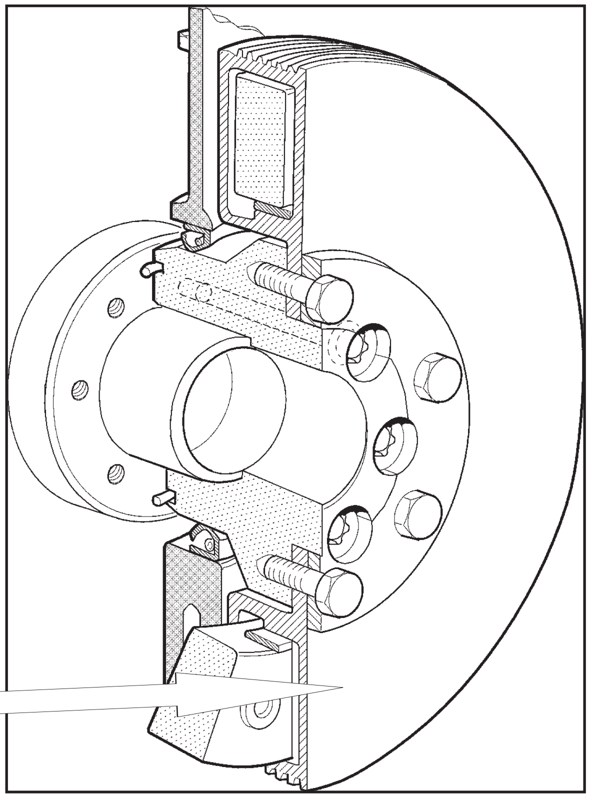


Figure 167

The power impulses from the connecting rods give rise to torsional oscillation in the crankshaft. These oscillations are severest at certain engine speeds which vary with the design of the engine, how it is loaded, etc.

Torsional oscillation is characterised as follows:

The flywheel (at the “rear” end of the crankshaft) rotates at an almost constant speed throughout each revolution of the crankshaft. Relative to the flywheel, the rotational speed of the front end of the crankshaft will increase and decrease several times during each revolution.
To reduce the amplitude of the oscillation, a crankshaft damper is attached to the front end of the crankshaft.

A ring of steel is incorporated in the circular and completely enclosed housing of the crankshaft damper. The housing is bolted onto the crankshaft.

There is a heavy oil between the housing and ring which damps the relative movement between the two. The oscillation at the front of the crankshaft is damped by the ring striving to rotate with even speed.

The crankshaft damper has numerous belt grooves for a “Multigroove V-belt”.

Timing gear, exploded view

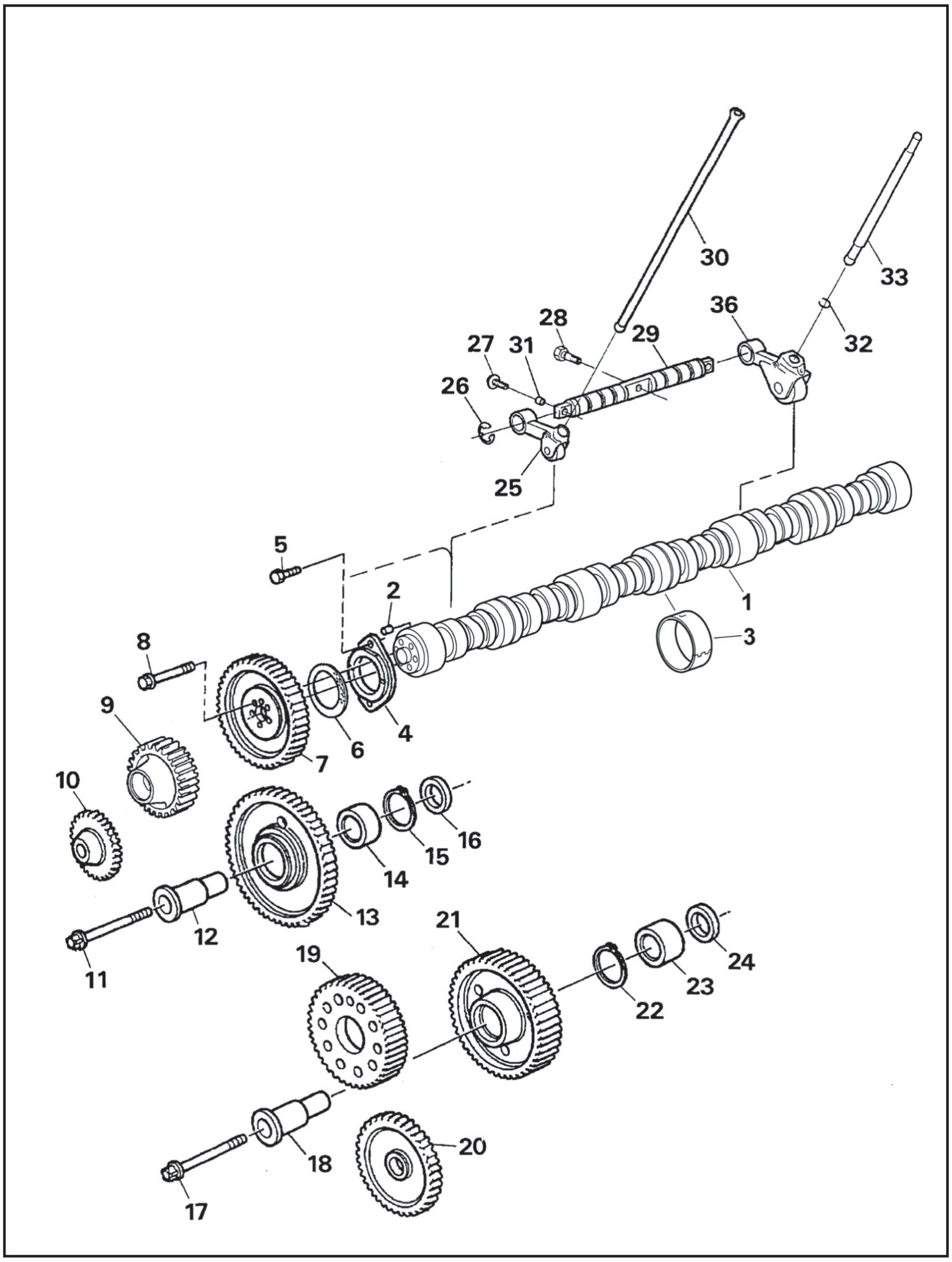


Figure 168

1. Camshaft
2. Pin
3. Camshaft bearing
4. Guide flange
5. Flange bolt
6. Thrust washer
7. Camshaft gear
8. Flange bolt
9. Compressor gear
10. Hydraulic pump wheel
11. Flange bolt
12. Shaft
13. Intermediate gear
14. Ball bearing
15. Snap ring
16. Spacing sleeve
17. Bolt
18. Shaft
19. Crankshaft gear
20. Oil pump gear
21. Intermediate gear
22. Snap ring
23. Shaft
24. Spacing sleeve
25. Roller tappet
26. Circlip
27. Flange bolt
28. Banjo screw
29. Shaft
30. Pushrod
31. Slide ring
32. Snap ring
33. Pushrod
34.
35.
36. Roller tappet

Special tools

Special tools, gear

850329-00159 Drift
850329-00160 Drift
MX008049 Impact drift
850329-00161 Support drift
850329-00174 Flywheel turning tool

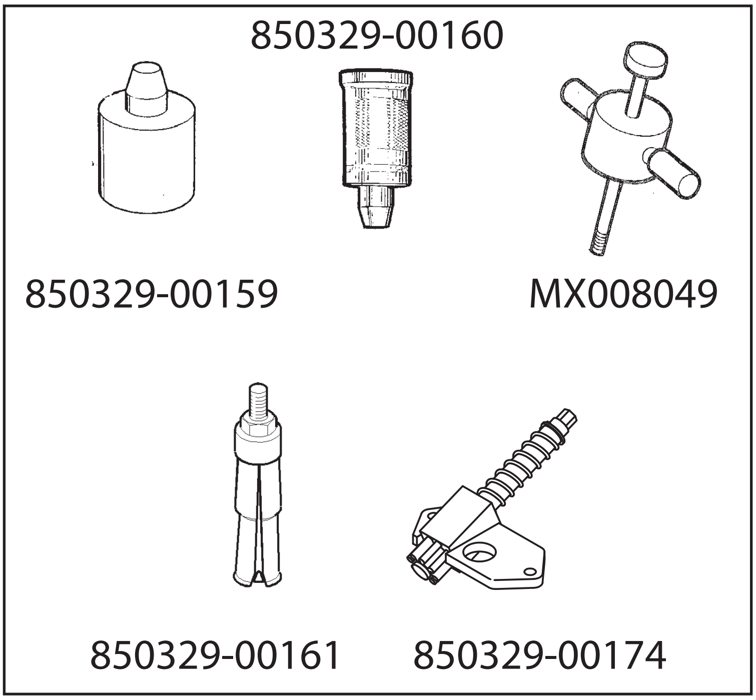


Figure 169

Special tools, replacement of camshaft bearing

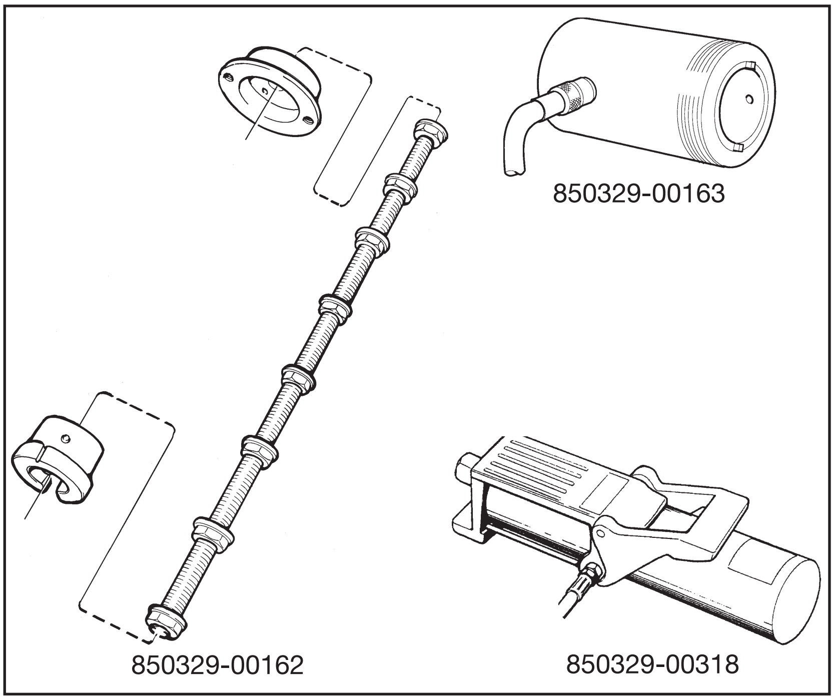


Figure 170

850329-00162 Tool for replacing camshaft bearing
850329-00163 Hydraulic hole cylinder
850329-00318 Compressed air powered hydraulic pump

Intermediate gear

Intermediate gear

Removal

- The timing gear has two intermediate gears.

- One for the camshaft and pump drive and one for driving the compressor.

- Both these gears should be removed in the same manner.

1. Turn the crankshaft so that cylinder number 1 is close to TDC. Use tool 850329-00174 on the flywheel.

2. Remove the flywheel as described in the section Removing the flywheel.

3. Remove the flywheel housing as described in Removing the flywheel housing.

4. Manufacture a thread block according to the sketch.

5. The shaft on which the gear is located has a groove. Fit puller 850329-00161, slide hammer MX008049 and the thread block. Loosen the gear and shaft.

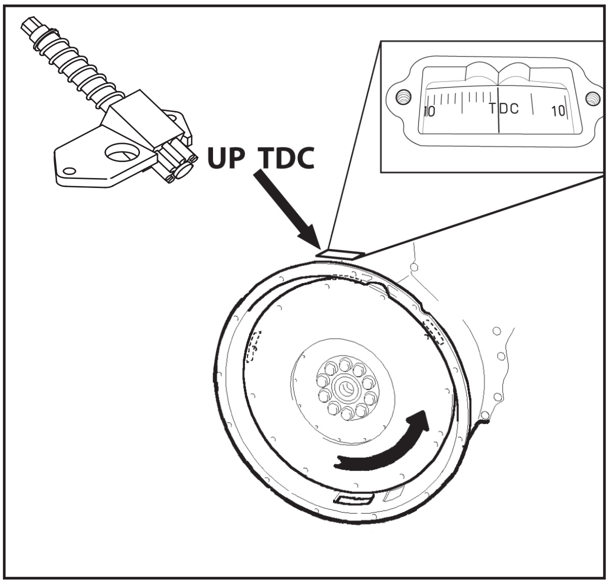


Figure 171

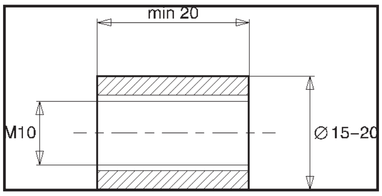


Figure 172

NOTE

After removing the intermediate gear, neither the camshaft or the crankshaft must be rotated. This may cause pistons and valves to collide and be damaged.

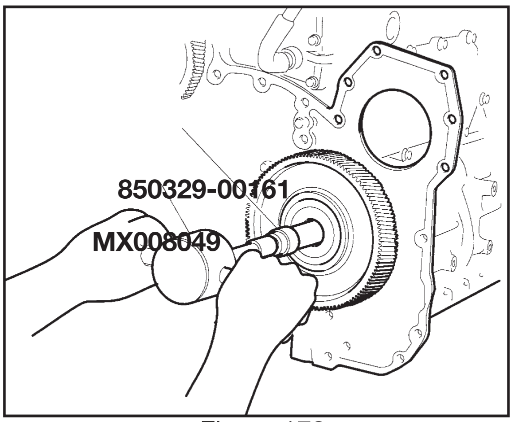


Figure 173

Renewal of bearing in intermediate gear for the camshaft

1. Press the shaft out of the bearing.
2. Press the bearing inner race shell from the shaft and remove the retaining ring.
3. Place the removed bearing inner race in the bearing and press out the bearing using drift 850329-00159.
4. Press a new bearing onto the shaft journal using drift 850329-00159.

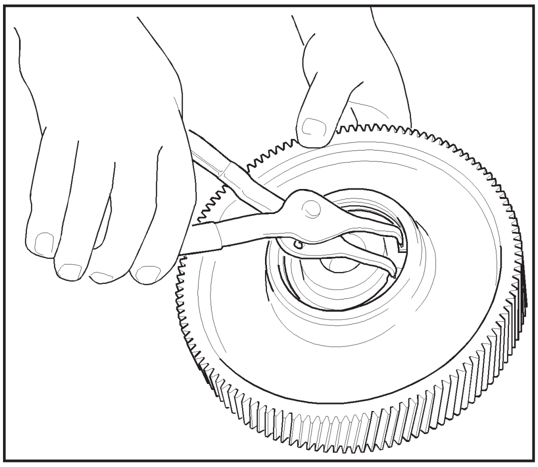


Figure 174

NOTE

Do not press on the outer race.

5. Press the bearing and shaft journal into the intermediate gear using drift 850329-00160.
6. Fit the snap ring.
7. Press the spacing ring onto the shaft journal. Ensure that the shaft journal is on the press table.

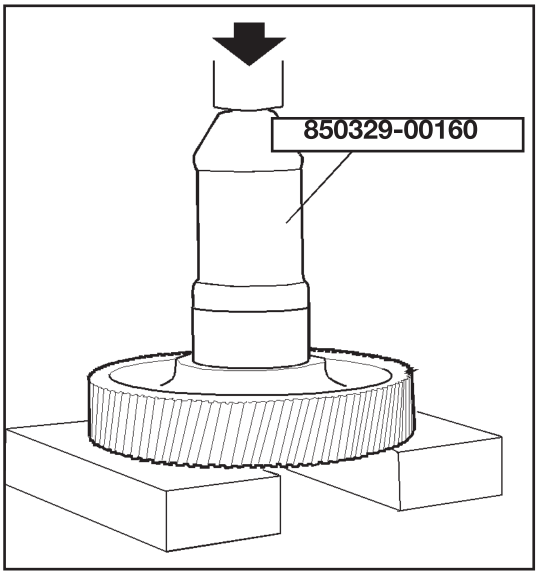


Figure 175

Fitting

1. Check that cylinder number 1 is close to TDC. The markings on the camshaft gear and crankshaft gear must point towards the centre of the intermediate gear.

2. Lubricate the bearing surfaces.

3. Fit the intermediate gear against the camshaft gear and the crankshaft gear so that the markings point towards each other.

4. Fit the second intermediate gear.

5. Tighten the bolts on the intermediate gears to 50 Nm + 60°.

6. Fit the flywheel housing as described in the section Fitting the flywheel housing.

7. Fit the flywheel as described in the section Fitting the fly-wheel.

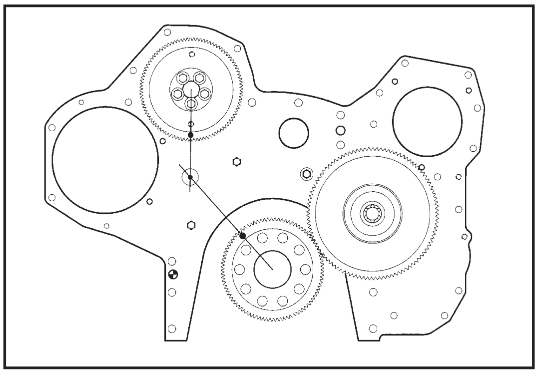


Figure 176

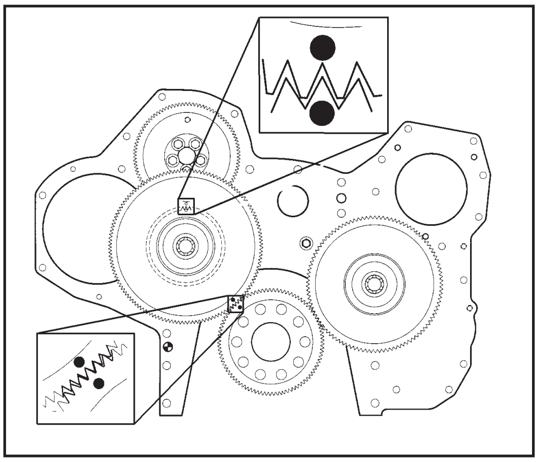


Figure 177

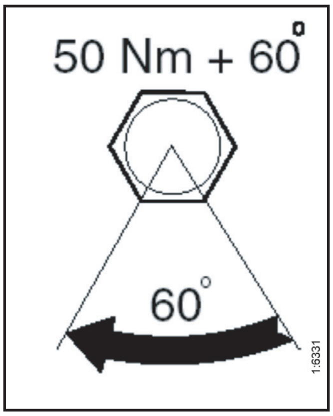


Figure 178

Camshaft gear

Removal

1. Turn the crankshaft so that cylinder number 1 is

   close to TDC. Use tool 850329-00174 on the fly wheel.

2. Remove the flywheel as described in the section Removing the flywheel.
3. Remove the flywheel housing as described in the section Removing the flywheel housing.
4. Remove the intermediate gear.

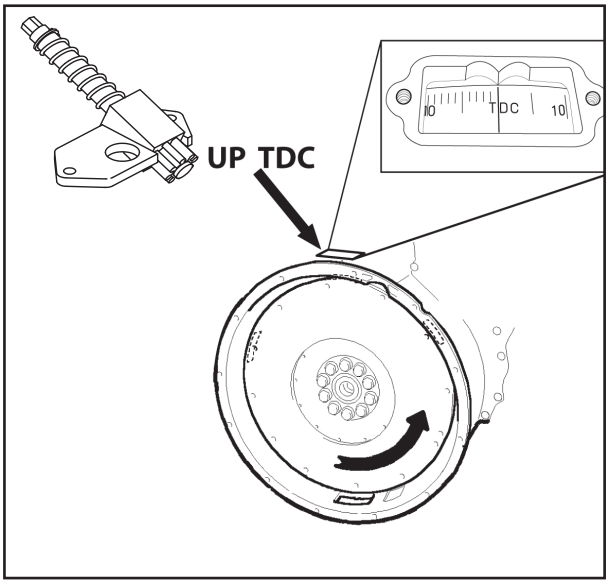


Figure 179

NOTE

After removing the intermediate gear, neither the camshaft nor the crankshaft must be rotated. This may cause pistons and valves to collide and be damaged.

5. Remove the camshaft gear.

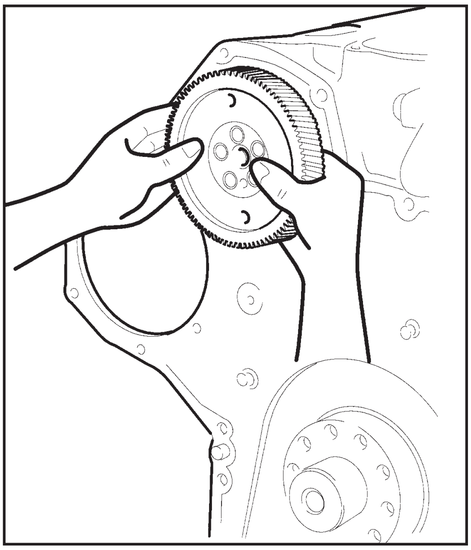


Figure 180

Fitting

1. Fit the camshaft gear and torque tighten the bolts to 63 Nm.
2. Fit the intermediate gear as described in Intermediate gear, fitting.
3. Fit the flywheel housing as described in the section Fitting the flywheel housing.
4. Fit the flywheel as described in the section Fitting the flywheel.

Camshaft gear	20 Nm + 40°

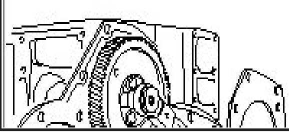


Figure 181

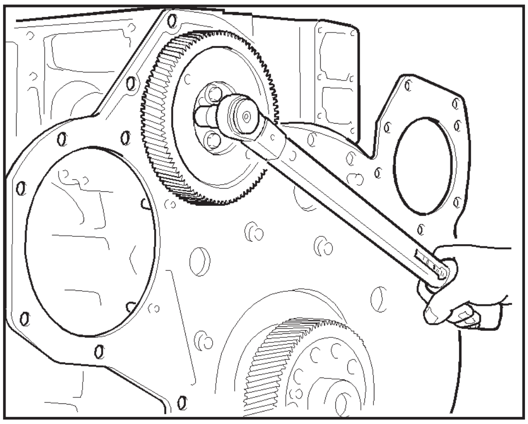


Figure 182

Crankshaft gear

Removal

1. Turn the crankshaft so that cylinder number 1 is close to TDC. Use tool 850329-00174 on flywheel.
2. Remove the flywheel as described in the section Removing the flywheel.
3. Remove the flywheel housing as described in the section Removing the flywheel housing.
4. Remove the intermediate gear.

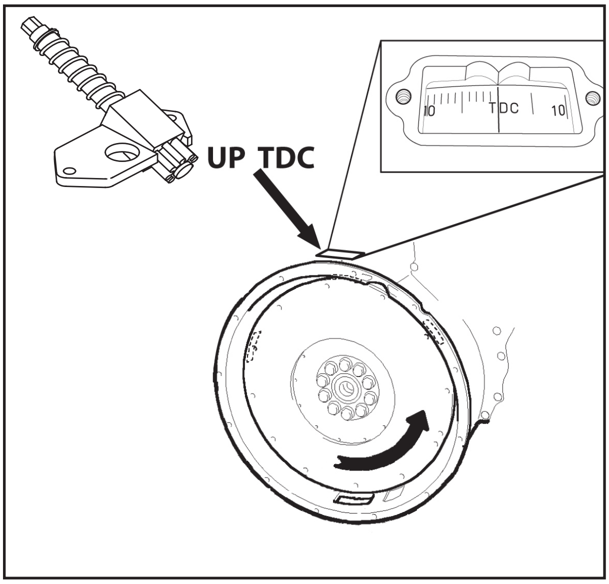


Figure 183

NOTE

After removing the intermediate gear, neither the camshaft nor the crankshaft must be rotated. This may cause pistons and valves to collide and be damaged.

5. Remove the crankshaft gear.

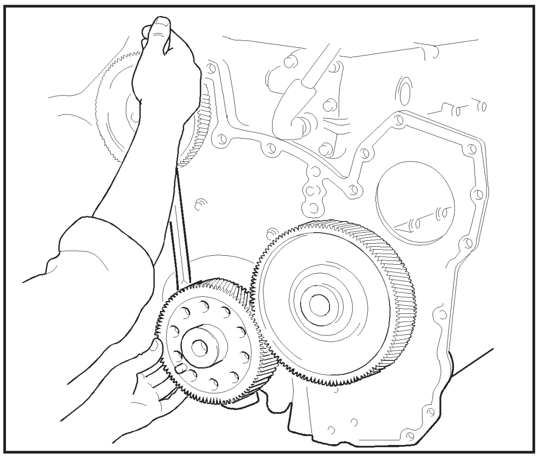


Figure 184

Fitting

1. Fit the crankshaft gear and guide pin.
2. Fit the intermediate gear as described in Intermediate gear, fitting.
3. Fit the flywheel housing as described in the section Fitting the flywheel housing.
4. Fit the flywheel as described in the section Fitting the flywheel.

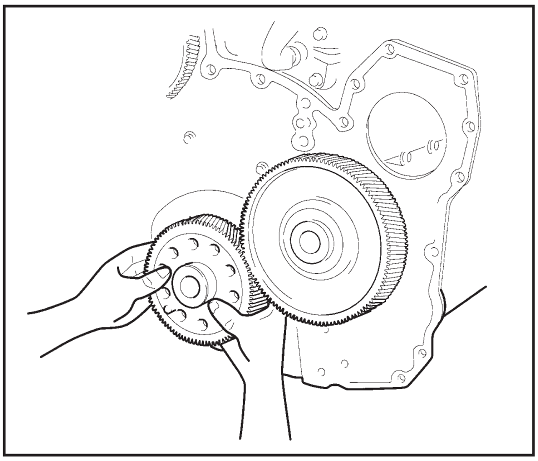


Figure 185

Camshaft

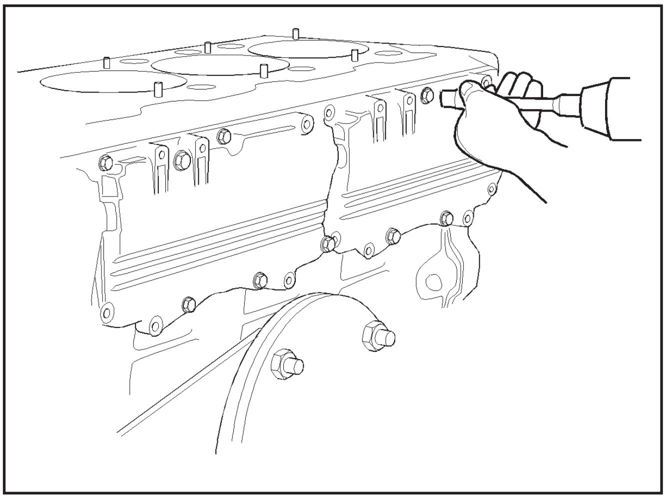


Figure 186

Removal

1. Remove the flywheel as described in Removing the flywheel.
2. Remove the flywheel housing as described in Removing the flywheel housing.

NOTE

Check the condition of the rocker arms, valve bridges and push rods. Replace damaged parts. Mark the parts that are undamaged because they must be refitted in their original positions.

3. Remove rocker arms, pushrods and valve bridges.
4. Remove the camshaft gear.
5. Remove the intermediate gear and the guide flange bolts.
6. Remove the timing gear plate.
7. Remove the camshaft covers.
8. Remove the valve tappets.

NOTE

Mark the valve tappets because they must be refitted in the same places.

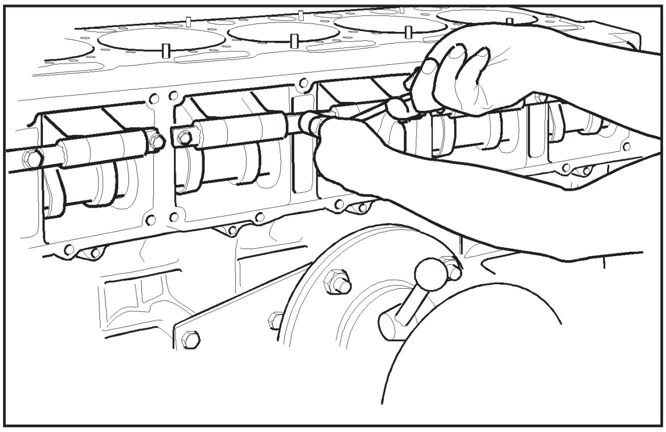


Figure 187

9. Pull the camshaft backwards. Take care not to damage the cams and bearings.

Replacement of camshaft bearing

Work description

1. Remove the camshaft according to the section Camshaft, removal.

2. Remove the camshaft cover at the front end of the engine.

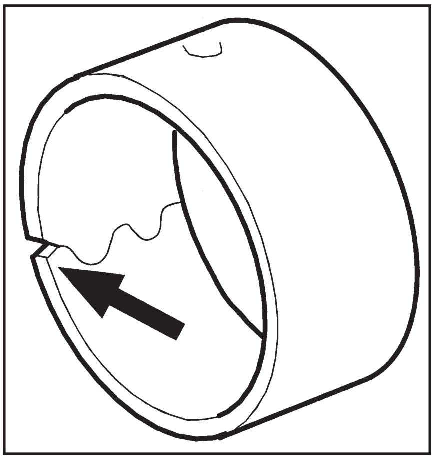


Figure 188

NOTE

Wipe around the edges and the bearing seat surfaces around the old bearings to avoid damaging the contact surfaces when fitting the new bearings.

3. Wipe the bearing seat surfaces clean around the old bearings.

NOTE

The recess in the bearing joint must be turned towards the front of the engine.

4. Place the new bearings in the space between the bearing seats for the camshaft.

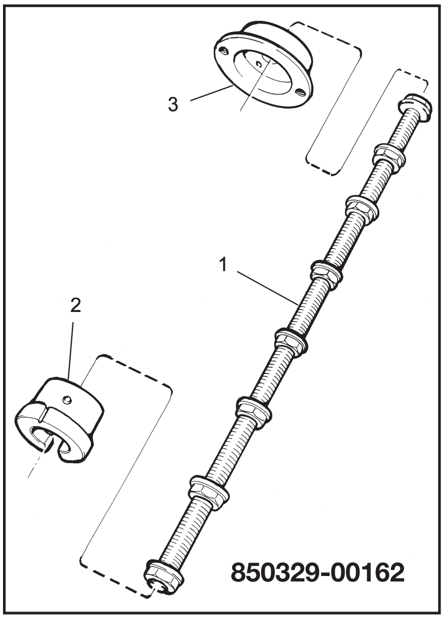


Figure 189

1. Threaded stem with eight flange nuts
2. Press drift
3. Flange

5. Place the flange nuts on the threaded stem, included in tool 850329-00162, as illustrated.

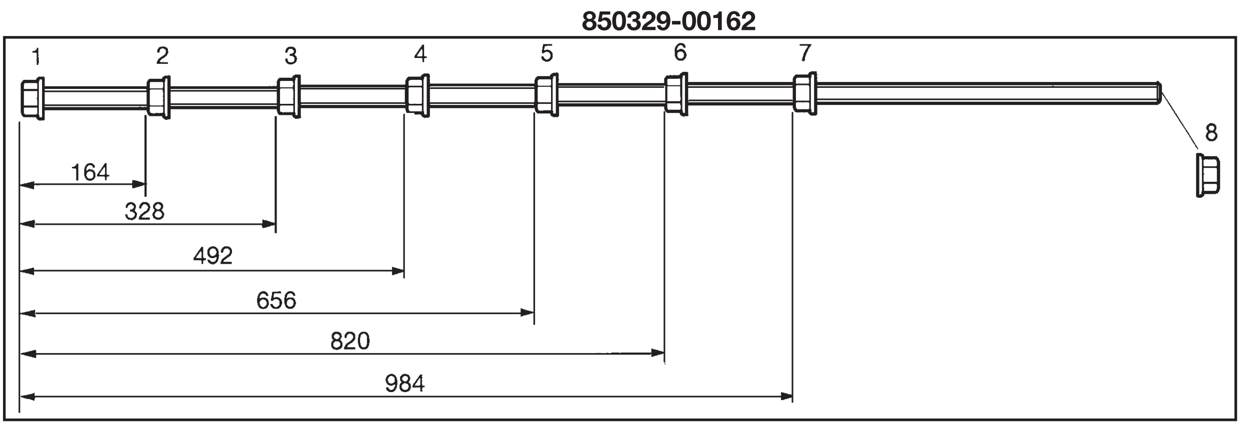


Figure 190

6. Take the threaded stem and insert the end with flange nut number 1 from the rear edge of the engine past the rear most bearing seat. Insert it further through the bearing seats and the new bearings until flange nut 1 protrudes from the front of the engine.

7. Screw the flange part of tool 850329-00162 securely onto hydraulic cylinder 850329-00163 with two M6x12 bolts. Press together cylinder 850329-00163 if not already in neutral position.

8. Screw the flange securely to the hydraulic cylinder at the rear of the engine with two of M10x25.

9. Screw on flange nut 8, from tool 850329-00162, onto the threaded stem.

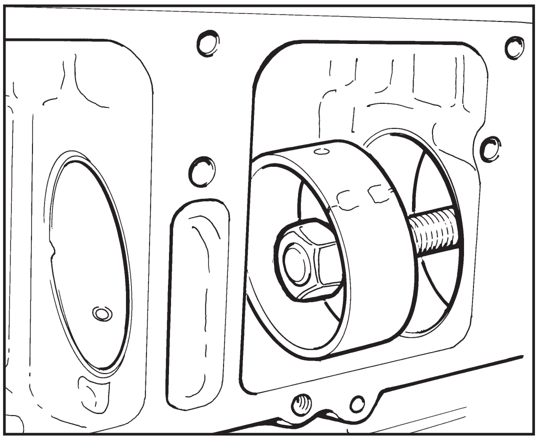


Figure 191

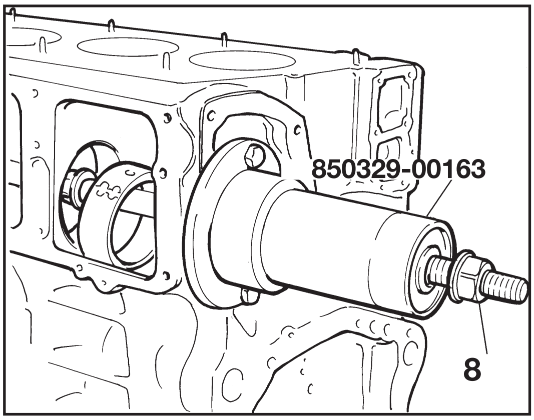


Figure 192

10. Hang a new bearing on the stem at the front of the engine.

11. Place the press drift on the threaded stem and place the bearing on the drift.

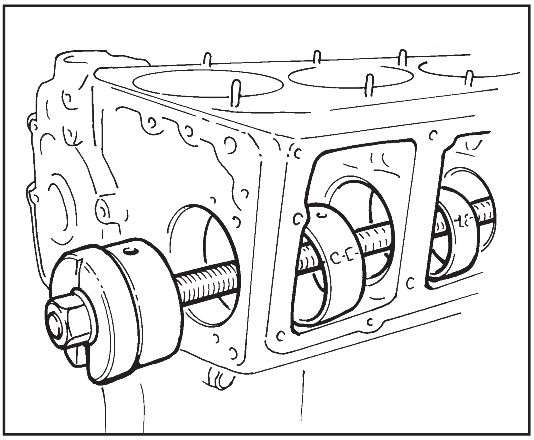


Figure 193

NOTE

The recess in the bearing joint must be turned towards the flange on the press drifts. Secure the bearing on the drift by placing the spring-loaded ball in an oil way. The bearing is correctly located on the drift when the ball and a marking hole are centred on the bearing oil hole.

12. Clean around the bearing contact surface.

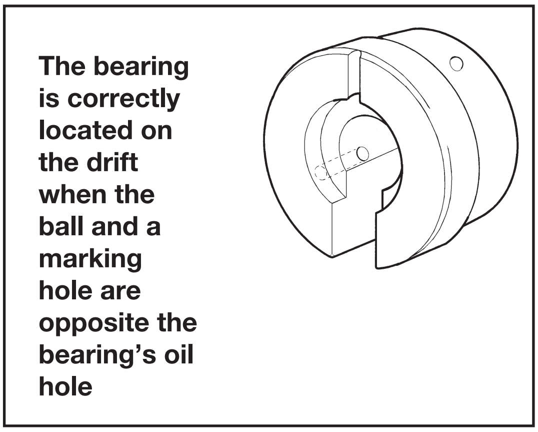


Figure 194

NOTE

The marking on the drift must be uppermost and vertical so that the oil hole in the bearing will be central to the oil ways.

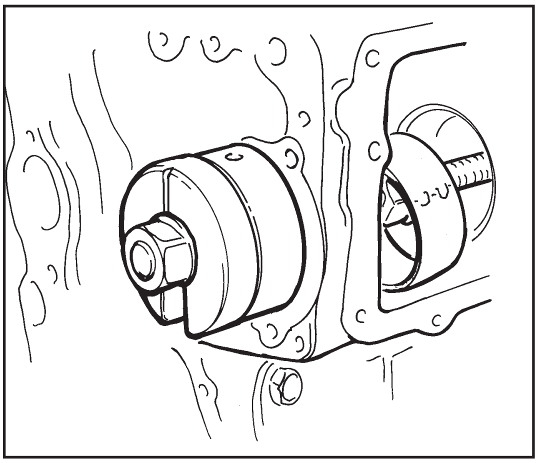


Figure 195

13. Hold the press drift with the new bearing against the old.

Secure the threaded stem between the press drift and hydraulic cylinder 850329-00163 by tightening flange nut 8 on the stem.

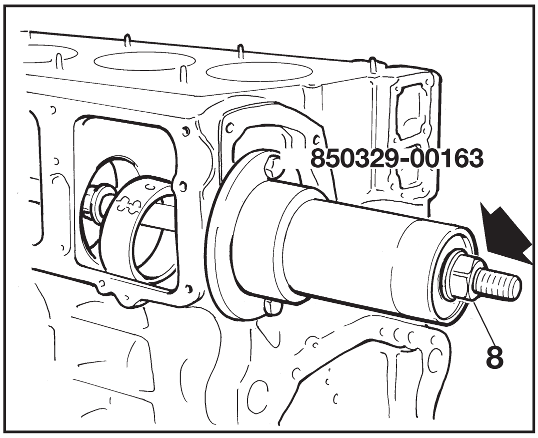


Figure 196

NOTE

The new bearing is in the correct position before the old bearing is completely released. The new bearing has the correct position when the distance from the front edge of the cylinder block to the front edge of the press drift has a permitted value according to the table.

By -12 mm it means that the drift should protrude 12 mm out of the block.

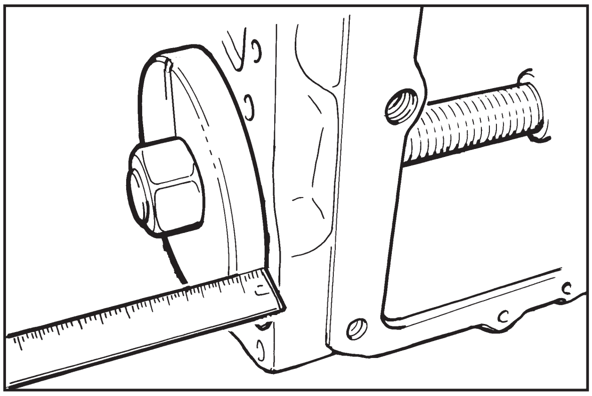


Figure 197

Control measurement of bearing number 1

Table for correctly located camshaft bearing

Camshaft bearing no.	Distance (mm)
1	-12 to -14
2	150 to 152
3	314 to 316
4	478 to 480
5	642 to 644
6	806 to 808
7	970 to 972

14. Press in the new bearing at the same time as pressing out the old bearing with hydraulic cylinder 850329-00163 and hydraulic pump 850329-00318. Check that the bearing is correctly positioned by measuring.

15. Remove the press drift by detaching flange nut 8 and pushing in the threaded stem.

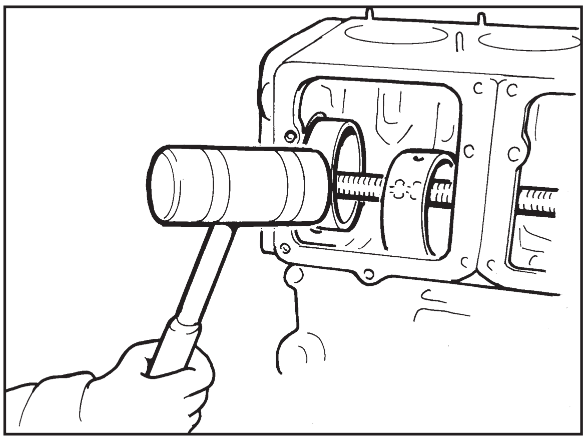


Figure 198

16. Check that the bearing oil hole is opposite the cylinder block oil ducts.

NOTE

The seats for camshaft bearings 2, 4 and 6 have two oil ducts. The others only have the lower one.

17. Repeat the procedure for the remaining bearings.

18. Carefully knock with a plastic hammer to release the old bearings.

19. Clean the sealing surface, take a new gasket and fit the cover for the camshaft at the front of the engine.

20. Refit the camshaft according to the section Fitting the Camshaft. Then perform a check on the camshaft setting.

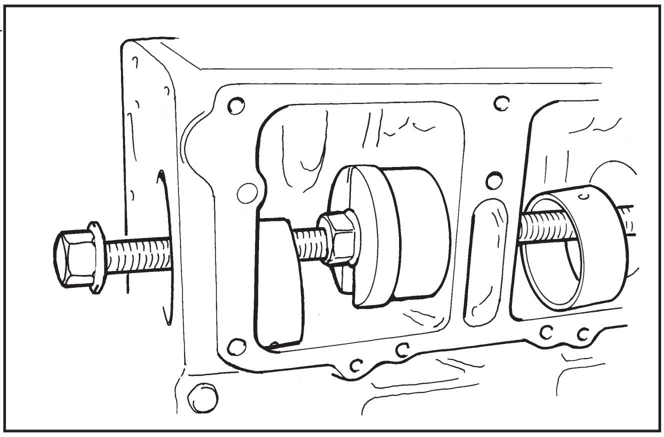


Figure 199
Extraction and pressing of bearing number 2.

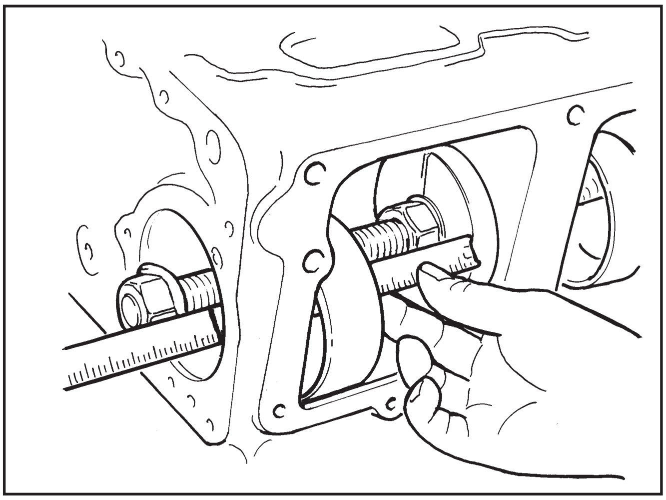


Figure 200
Check measurement of bearing number 2

Fitting

1. Fit the camshaft. Take care not to damage the cams and bearings.

2. Lubricate with engine oil and fit the valve tappets in the same places as they were before removal. Tighten the banjo bolts to 32 Nm.

3. Fit the camshaft covers. Fit the guide flange bolts.

4. Install the control flange with thrust washers in the camshaft rear end. Now you can check camshaft end play: Fit the camshaft gear temporarily Measure the camshaft end play with a dial indicator. End float should be between 0.05 to 0.35 mm. If the game is outside allowable value, replace the thrust washers. Remove the camshaft gear wheel again.

5. Remove all old sealing compound on the sealing surfaces of the timing gear casing and timing gear plate. Clean off any oil and grease using an alcohol based cleaning agent.

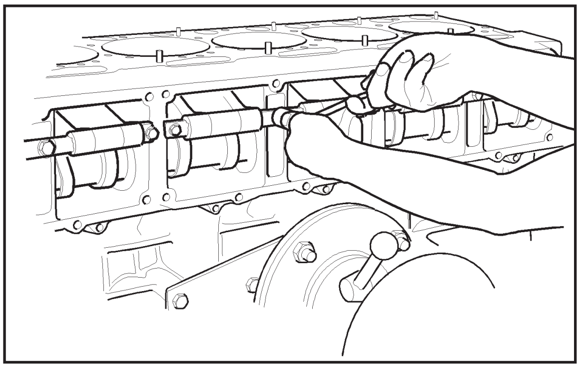


Figure 201

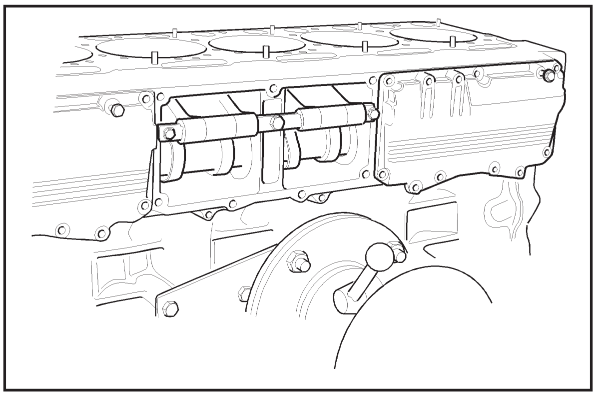


Figure 202

NOTE

The sealing surfaces must be absolutely clean and free from grease. Do not touch the surfaces after degreasing.

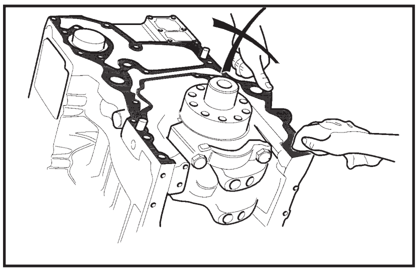


Figure 203

6. Apply the sealing agent (512565) to the timing gear casing with the special nozzle. The width of the bead should be approximately 4 mm

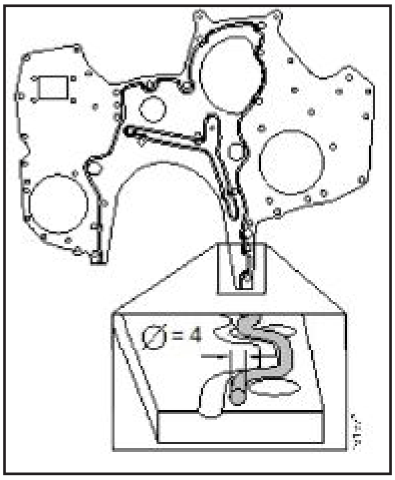


Figure 204

NOTE

Ensure that you apply sealing agent inside the screwholes, but without allowing sealing agent into the crankcase. The sealing agent may block channels and nozzles. This is particularly important to bear in mind around oil ways, where the flow of oil to the air compressor or injection pump can be blocked. Important! Assembly must be completed within 25 minutes of starting to apply the sealing agent.

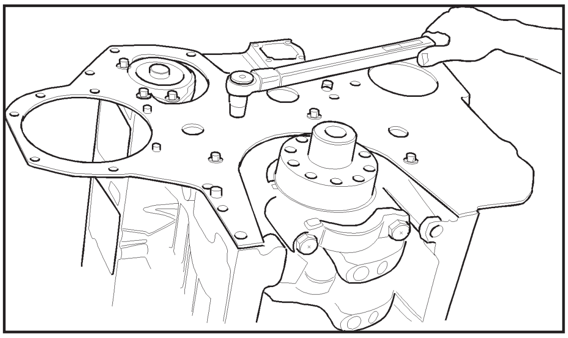


Figure 205

7. Fit the timing gear plate on the engine block. Tighten the bolts to 63 Nm.

8. Fit the intermediate gear as described in Intermediate gear, fitting.

9. Ensure that the markings on the camshaft gear point towards the centre of the intermediate gear.

10. Fit the camshaft gear and torque tighten the bolts to 63 Nm.

11. Fit the flywheel housing as described in Fitting the flywheel housing.

12. Fit the flywheel as described in Fitting the flywheel.

Checking camshaft setting

1. Set the crankshaft to TDC after the compression stroke on cylinder number one.

2. Put two dial gauges against the valve spring thrust washers.

3. Adjust the rocker arms to remove the free play and then adjust them further so that both valves are open 0.1 mm.

4. Zero both the dial gauges.

5. Turn the crankshaft one revolution in its direction of rotation until TDC position is again achieved.

6. Read off both dial gauges and compare with the values given below:

- Intake valve lifting height 0.37-1.47
- Exhaust valve lifting height 0.16-1.16

Crankshaft

Each compression stroke ”brakes” the crankshaft and each combustion stroke attempts to increase the speed of rotation of the crankshaft.

The pistons and connecting rods change their direction of travel twice during each rotation of the crankshaft. This exposes the crankshaft to numerous power pulses during each revolution.

The material is of major importance for the useful life of the crankshaft. Its design and surface treatment also help to extend its life - for instance, the surface quality of the shaft journals is an important factor in providing protection against fatigue failure.

The bearing surfaces on the crankshaft are hardened to a depth which allows them to be ground several times.

Only the bearing surfaces are hardened as it is important to retain the toughness of the material in other parts.

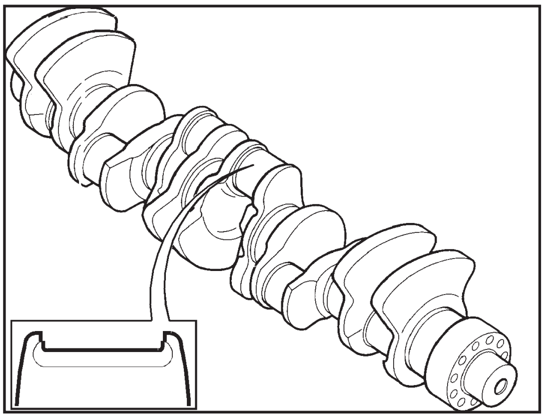


Figure 206

The bearing shells of the main and big-end bearings consist of three layers. An outer layer or backing of steel, an interlayer of lead-bronze and, nearest the crankshaft, an overlay consisting of a mixture of lead and indium or lead, tin and copper. The innermost layer is usually worn away during the course of egine utilization.

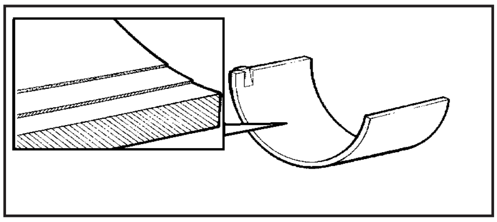


Figure 207

Thrust washers are used for endways location of the crankshaft at the rear main bearing. These thrust washers are available in different thicknesses so that the crankshaft can be adjusted to the correct clearance. The thrust washers have the same types of layer as the big-end bearing shells.

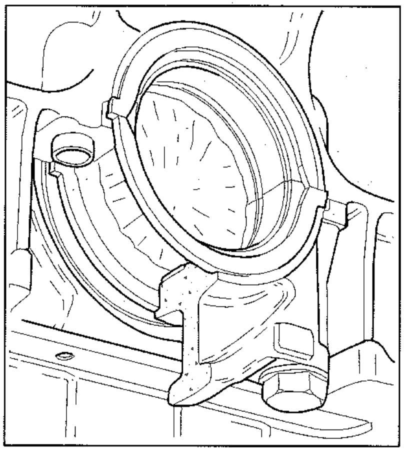


Figure 208

Removal

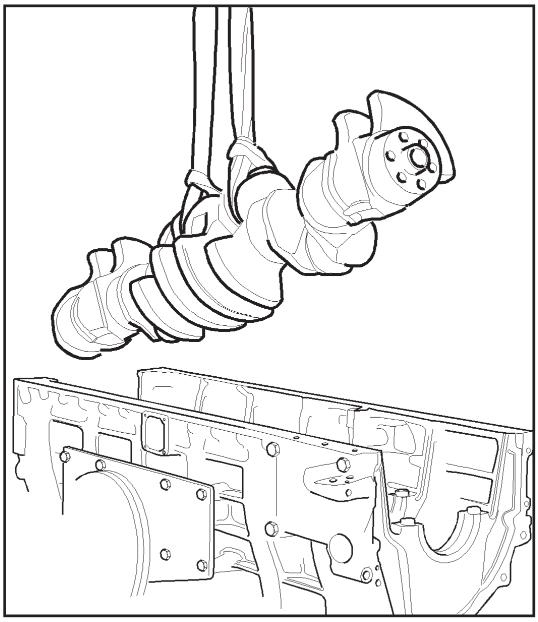


Figure 209

1. Remove the crankshaft gear as described in Removing the crankshaft gear.
2. Remove the crankshaft pulley as described in the work description Removing the pulley.
3. Remove the oil sump, oil suction pipe with strainer and the oil pump.
4. Remove the pistons and connecting rods as described in Removing connecting rods and pistons.
5. Remove the crankshaft bearing caps and main bearings.

NOTE

The main bearings and bearing caps are marked and must be refitted in the same place.

6. Lift out the crankshaft.

Checking and grinding

- Measure the crankshaft journals. Use a micrometer to measure two diameters at right angles to each other.
- If either of these diameters is lower than the minimum indicated limit, regrinding of the crankshaft should be considered.
- Consideration must also be given to oil pressure, which is in turn affected by such things as main bearing and crankshaft bearing wear.

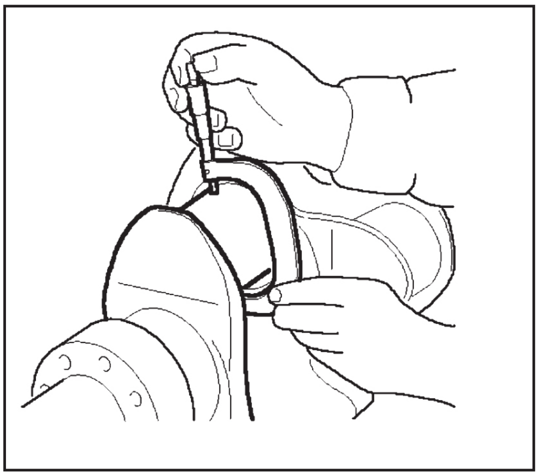


Figure 210

- When regrinding, stated undersizes must be complied with. Suitable bearings are available for these sizes.

- Refer to the next page for the diameters required for different undersizes.

- It is important that the fillet radius of the journals is correct.

- After grinding the journals, the oil hole connections to the bearing surfaces should be rounded off and polished.

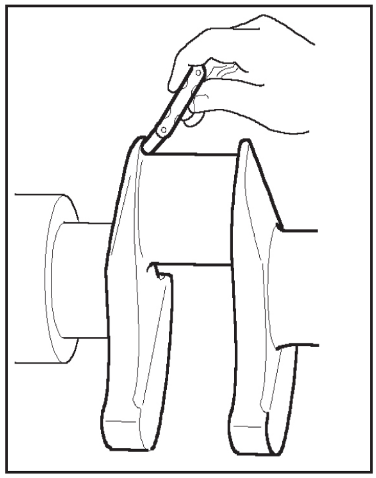


Figure 211

Cylinder block

Reconditioning

Heat arising from the main bearings seizing and rotating in the cylinder block will change the properties of the material in the cylinder block. These cylinder blocks must be discarded.

If the main bearing seizes but does not rotate in the cylinder block, the cylinder block can be overhauled. The main bearing seats must comply with the demands on roundness given in the table. Machining out-of-round main bearing seats is something we do not recommend.

1. Measure the diameter at four different positions as illustrated. The diameter must be measured with the main bearing caps tightened and without main bearings.

2. Check the dimensions with those in the table.

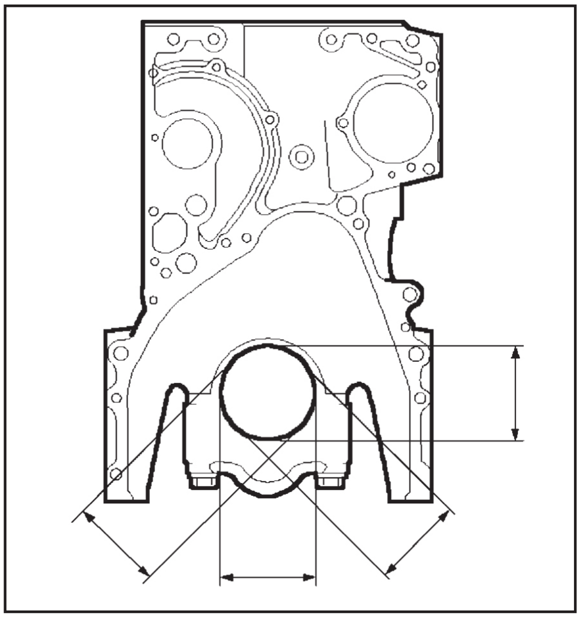


Figure 212

Minimum permitted diameter	Maximum permitted diameter	Maximum permitted difference*
112.200 mm	112.222 mm	0.016 mm

* Maximum permitted difference between the largest and smallest diameter on the same main bearing seat.

Dimensions when regrinding

Main bearing journals

Standard, diameter	107.978-108.000 mm
Undersize 1, diameter	107.728-107.750 mm
Undersize 2, diameter	107.428-108.500 mm
Undersize 3, diameter	107.228-107.250 mm
Undersize 4, diameter	106.978-107.000 mm
Hole recess radius	4.75-4.85 mm
Surface quality	0.25 Ra

Connecting rod journals

Standard, diameter	86.978-87.000 mm
Undersize 1, diameter	86.728-86.750 mm
Undersize 2, diameter	86.478-86.500 mm
Undersize 3, diameter	86.228-86.250 mm
Undersize 4, diameter	85.978-86.000 mm
Hole recess radius	4.8-5.2 mm
Surface quality	0.25 Ra
Width, max.	56.05
Radial clearance	0.20-0.35 mm

Thrust washers

Standard, thickness	46.70-46.78 mm
Oversize 1, thickness	46.86-46.94 mm
Oversize 2, thickness	46.96-47.04 mm
Oversize 3, thickness	47.22-47.30 mm
Oversize 4, thickness	47.72-48.80 mm
Axial clearance	0.18-0.37 mm

Fitting

1. Place the bearing shells in the main bearing seats in the cylinder block and in the main bearing caps. Then lubricate the bearing surfaces with engine oil.

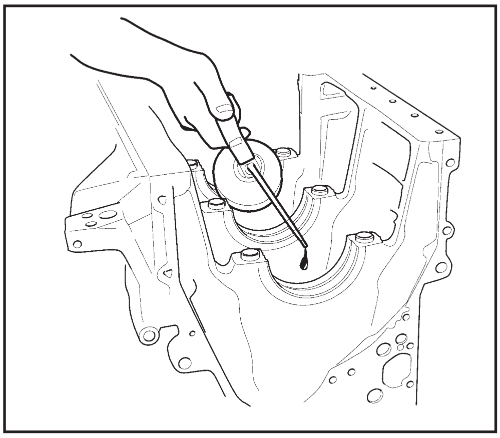


Figure 213

2. Lift in the crankshaft.

NOTE

The outside of the bearing shells must not be lubricated.

3. Lubricate the bolt thread and the surface of the main bearing cap where the bolt is tightened, see illustration. Scania engine oil can be used.

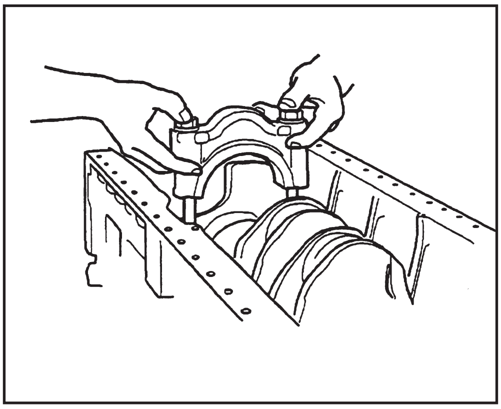


Figure 214

4. Insert the main bearings in the crankshaft bearing caps and fit them.

Main bearing cap: 110Nm + 90°

NOTE

Fit the main bearings and caps in the same place as before removal.

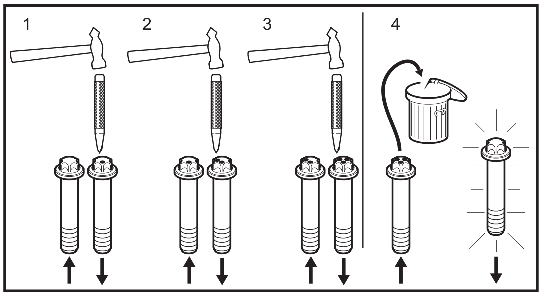


Figure 215

CAUTION

The bolts can only be reused three times. Check the number of punch marks on the head, if a screw has three punch marks it must be replaced.

NOTE the machine serial number!

5.
Machine 810001 - 810108
Tighten the bearing cap bolts to 50 Nm + 90°.

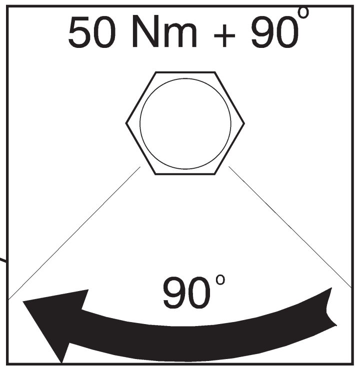


Figure 216

5.
Machine 810109 (Tier3) -
Tighten the bearing cap bolts to 200 Nm + 90°.

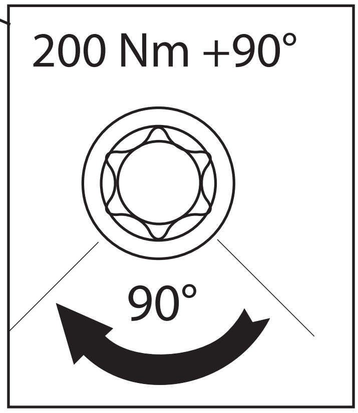


Figure 217

6. Fit the pistons with connecting rods as described in Fitting the connecting rod and piston.

7. Fit the oil pump, oil suction pipe with strainer and the oil sump.

8. Renew the seal in the front cover. Fit the spacing sleeve on the crankshaft journal. Fit the driver and crankshaft damper. See Belt transmission, Renewing the seal in the front cover.

9. Fit the crankshaft gear as described in Crankshaft gear, fitting.

Adjust - Machining the crankshaft

1. Measure the diameter of the crankshaft bearing journal using a micrometer. Measure at several points around the bearing journal.

   If any of these diameters are lower than the minimum indicated limit, regrinding of the crankshaft should be considered. Refer to the dimensions under the tab “Specification”.

   Oil pressure should also be checked, as it is affected by such factors as wear in the main bearings and connecting rod bearings.

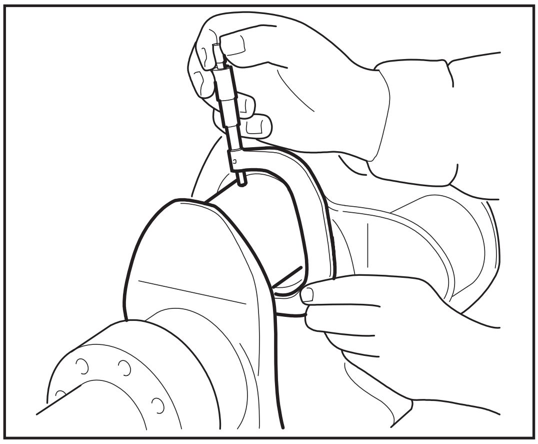


Figure 218

2. When regrinding, keep to the undersizes indicated in the “Specification” tab. Suitable bearings are available for these sizes. It is important that the fillet radius of the bearing journals is correct. Use a template to check fillet radius.

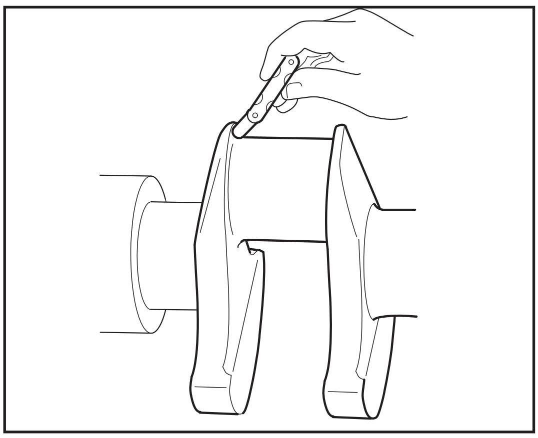


Figure 219

Lubrication system

General

Lubricating oil consumption refers to the lubricating oil that is consumed through combustion in the engine.

Take into account the fuel consumption when assessing the lubricating oil consumption. Both lubricating oil and fuel consumption is affected by driving style and operating conditions.

Lubricating oil consumption is usually higher when the engine is new. Only when the engine has been run in, i.e. after 600 operating hours, can lubricating oil consumption be considered to be constant. Normally, lubricating oil consumption in Scania engines will then fall under 0.3% of fuel consumption.

Prolonged driving at high engine speeds with low power output, however, will increase lubrication oil consumption slightly in relation to fuel consumption.

In such conditions, the lubrication oil consumption can be considered as acceptable even if it exceeds 0,3 % of fuel consumption.

Checking lubricating oil consumption

In order to avoid having to take premature measures, lubricating oil consumption should be carefully monitored for at least 300-500 operating hours after the running-in period mentioned above.

If the follow-up shows that the lubrication oil consumption is really abnormally high, the engine must be inspected and repaired.

Directions and follow-up documentation

Fuel consumption and lubricating oil consumption calculations must be based on information that is as accurate as possible.

Start with the fuel tank full and the lubricating oil topped up to the maximum mark on the dipstick.

Read the oil dipstick when all the lubricating oil in the engine has collected in the oil sump. The vehicle must be level.

With an engine at operating temperature, the oil dipstick can be read 7 minutes after shutdown. Wait for at least 30 minutes between the shutdown and the readout if the engine has been started but not attained operating temperature.

Copy the form Driver’s log-book for measuring oil consumption on next page and use it to note when fuel and lubrication oil has been filled, as well as operating hours and type of driving during the follow-up period.

Driver's logbook

Example of driver's log-book

Engine serial number	5 555 555	Make of oil	Shell
Oil change interval	400 h	Designation	Myrina
Responsible	Sven Svensson	Viscosity	15W/40

Date	Odometer reading (h)	Filled fuel (l)	Full tank	Lubrication oil consumption (l)	Main type of driving
01/04/15	600		Yes		
03/04/15	625	1,200		7	Driving on road
...	...	...	...	...	
...	...	...	...	...	
...	...	...	...	...	
...	...	...	...	...	
...	...	...	...	...	
01/06/15	1,100	800	Yes	5	
	Total	20,000		100	

Fuel consumed = 20,000 litres
Oil consumed = 100 litres
Oil consumption as a % of fuel consumption =
100/20,000 x 100 = 0.5%

Driver's log-book for measuring oil consumption

Engine serial number ____________________ Make of oil ____________________

Oil change interval ____________________ Designation ____________________

Responsible ____________________ Viscosity ____________________

Date	Odometer reading (h)	Filled fuel (l)	Full tank	Lubrication oil consumption (l)	Main type of driving

Oil pump

An oil pump, driven by the crankshaft gear, generates the circulation required to provide lubrication oil to all lubrication points so that it flows through the oil cleaner and oil cooler.

The lubricating oil is sucked from the sump through a strainer in the oil pump.

The oil pressure must be so high as to ensure that each lubrication point receives the amount of oil needed for its lubrication and cooling.

Too high oil pressure could cause excessive stress to components in the lubrication system.

Particularly when the oil is cold there is a risk that the pressure will be high and for this reason a safety valve is incorporated in the oil pump. If the pressure is too high the oil pressure valve will allow oil to escape (and run back to the sump) so that the pressure will not be so high as to cause any damage.

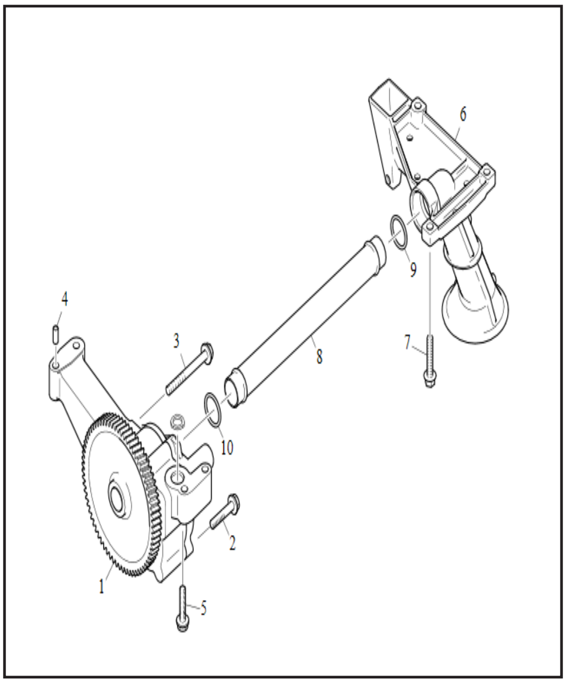


Figure 220
Oil pump

1	Oil pump
2	Flange screw
3	Screw
4	Guide sleeve
5	Flange screw
6	Suction pipe
7	Flange screw
8	Pipe
9	O-ring
10	O-ring

NOTE

In the case of leakage or fault in the oil pump, it should not be recondtioned but should be renewed as a unit.

Lubrication oilways

The lubrication oil reaches the camshaft bearings, crankshaft main bearing and balancer shaft assembly via ducts in the cylinder block.

Ducts in the crankshaft lead the lubrication oil to the connecting rod bearings. A duct leading from the main duct takes lubrication oil to the rocker arms.

The channel is constantly pressurised. The oil is fed to the roller tappet shafts via grooves in the camshaft bearing. The roller tappet shafts have drilled ducts for lubricating the roller tappets.

1	Oil strainer
2	Oil pump
3	Safety valve
4	Oil cooler
5	Centrifugal oil cleaner
6	Relief valve
7	Oil filter
8	Piston cooling valve
9	Oil pressure sensor

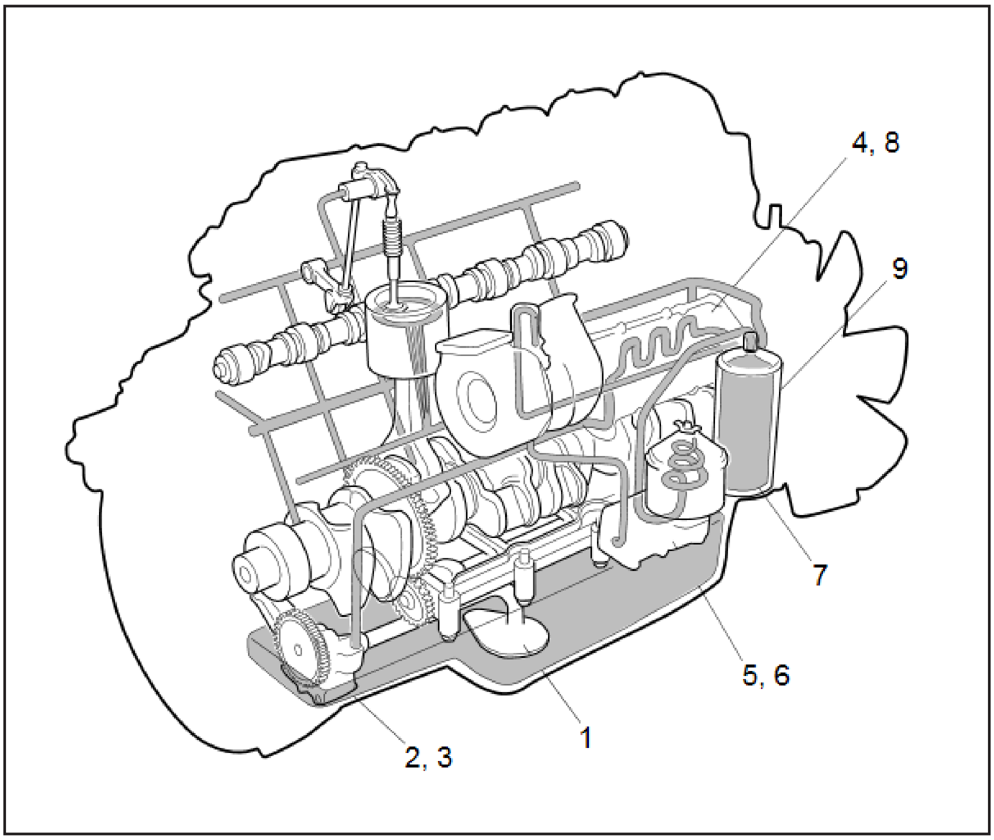


Figure 221

Oil pressure

NOTE

High lubricating oil pressure (above 6 bar) is normal when starting a cold engine.

Max. oil pressure:
Warm engine running at a speed above 800 rpm 6 bar

Normal oil pressure:
Warm engine running at an operating speed of 3 - 6 bar

Min. oil pressure:
warm engine running at a speed of 1000 rpm 1.0 bar

The control system has the following alarm levels:
- at a speed of less than 1000 rpm and an oil pressure of less than 1.0 bar
- at a speed of more than 1000 rpm and an oil pressure of less than 2.3 bar for longer than 5 seconds.

The following functions are available if there is an alarm:
- Alarm which only switches on the warning lamp and diagnostics lamp.

A fault code is generated in the control unit.

After an alarm, approved values should be registered for more than 1 second to reset the alarm.

The pistons are cooled by the lubrication oil. Oil is sprayed up under the piston crown through special nozzles, one for each cylinder. Since piston cooling is not needed at low engine rpm, an oil pressure valve in the oil cooler housing opens at 3 bar.

See the next page.

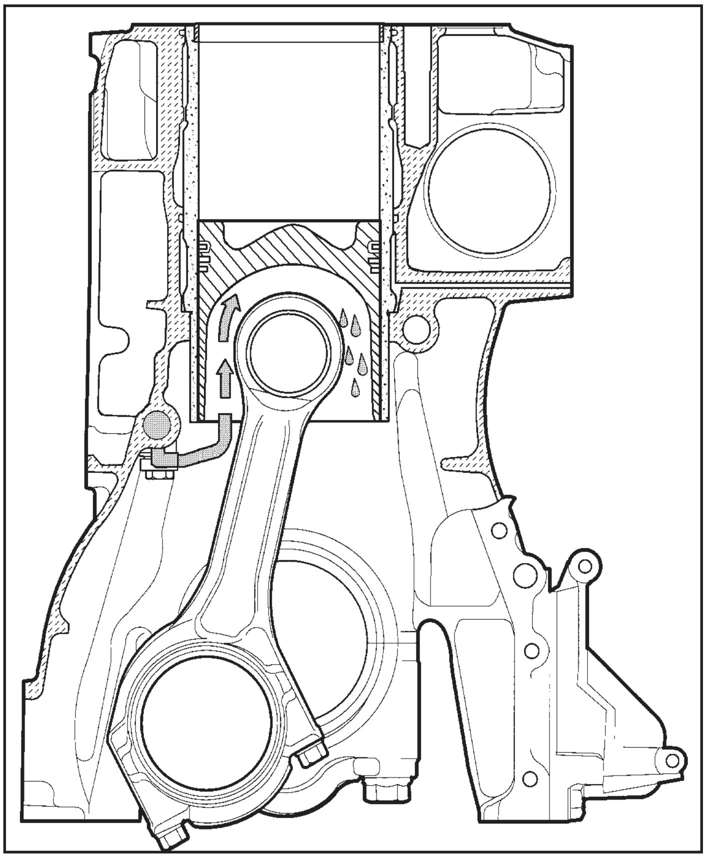


Figure 222

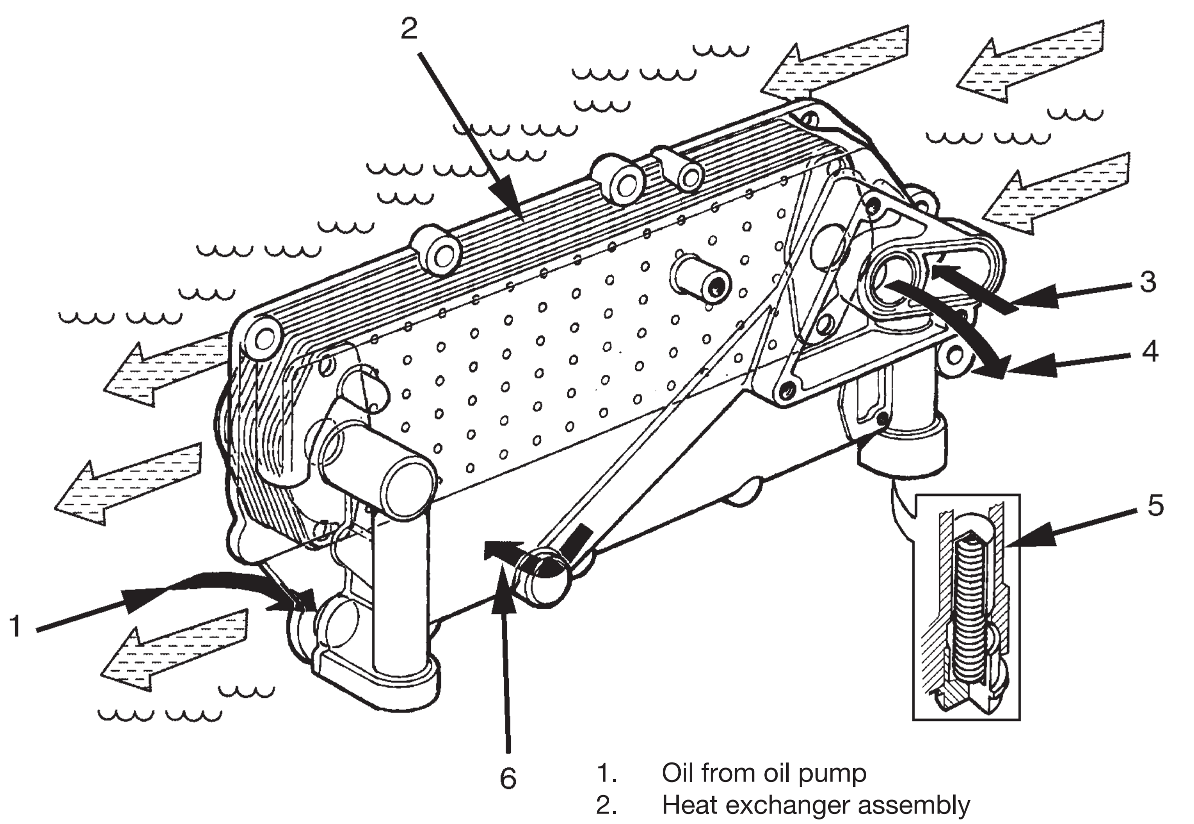
Oil cooler, engine

From the oil pump, the lubricating oil flows via passages in the block to the oil cooler located inside the front side cover on the right-hand side of the block.

The oil cooler is a plate heat exchanger.

All the oil flows through the cooler where it is cooled by the coolant from the cooling system.

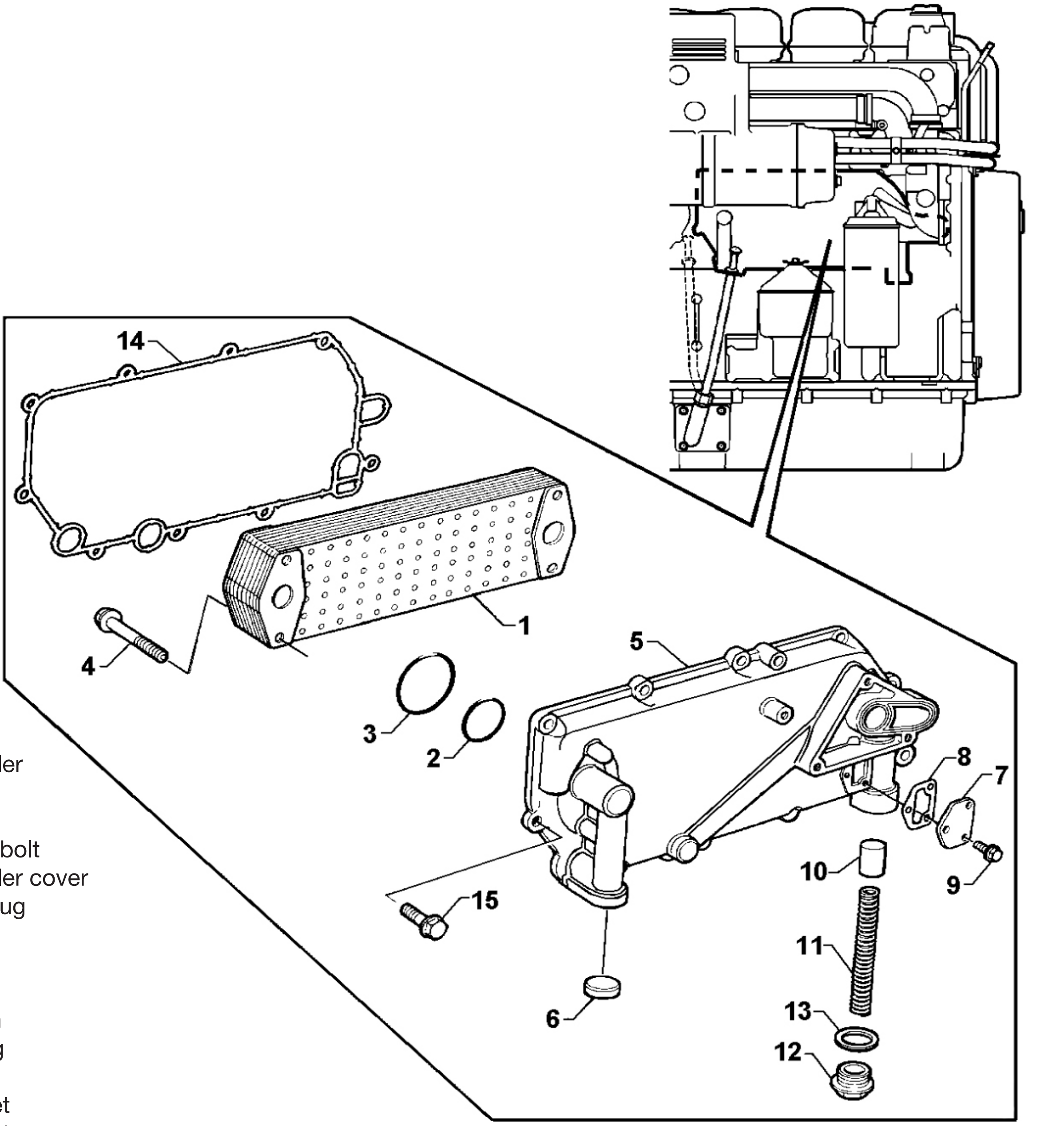
An oil pressure valve (5) is located in the coil cooler housing for cooling the pistons.
It has an opening pressure of 3 bar. No piston cooling therefore takes place at low engine speeds (idling).
See also under **Lubrication oilways**.



1. Oil from oil pump
2. Heat exchanger assembly
3. Oil from filter into engine
4. Cooled oil to paper filter
5. Delivery valve for piston cooling
6. Partial flow to centrifugal cleaner

Figure 223

Oil cooler view See 010009



1. Oil cooler
2. O-ring
3. O-ring
4. Flange bolt
5. Oil cooler cover
6. Core plug
7. Cover
8. Gasket
9. Bolt
10. Piston
11. Spring
12. Plug
13. Gasket
14. Gasket
15. Flange bolt

Figure 224

Important !
Oil cooler core tightening torques: 26 Nm

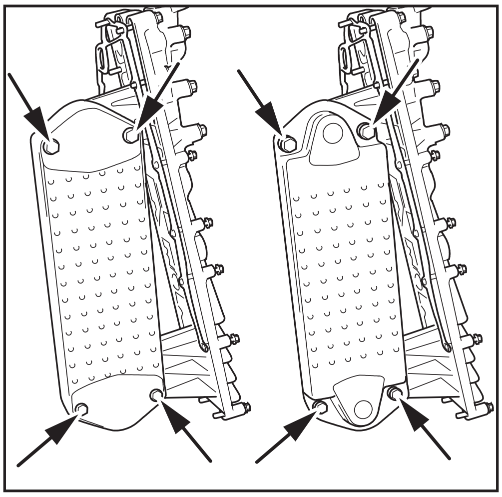


Figure 225

Renewing seals and leakage testing

1. Remove the side cover and oil cooler from the block.

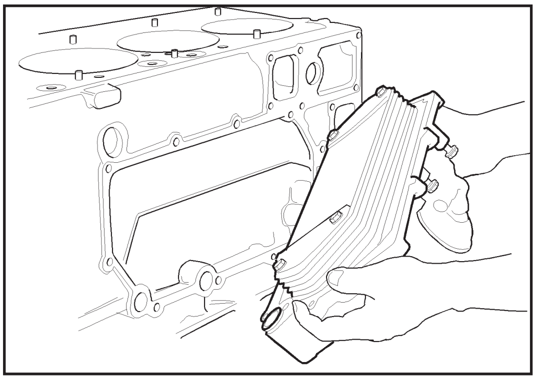


Figure 226

2. Remove the 4 bolts securing the oil cooler to the side cover.

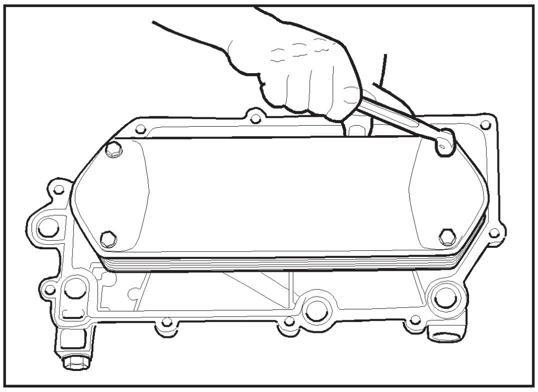


Figure 227

3. Remove the oil cooler.

4. Renew the 4 O-rings.

5. Fit the oil cooler insert and bolt securely to the side cover using 26 Nm torque.

6. Bolt the side cover to the block.

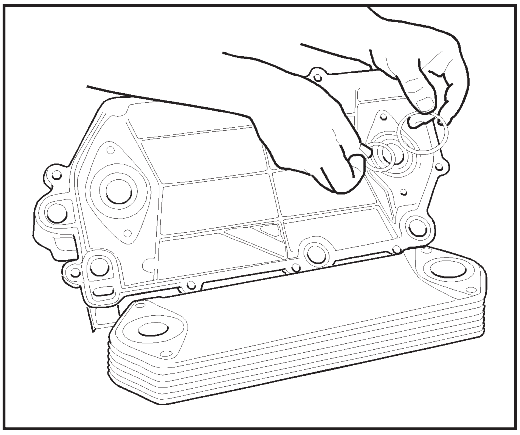


Figure 228

Leakage testing (12 Litre engine)

Connect tool 532335 and 532336
Lower the oil cooler complete with the housing into a water bath.
Raise the pressure to 2 bars using the handle.

Maintain the pressure for at least one minute.

Where there is leakage, renew the parts which leak and carry out the pressure test one more tim

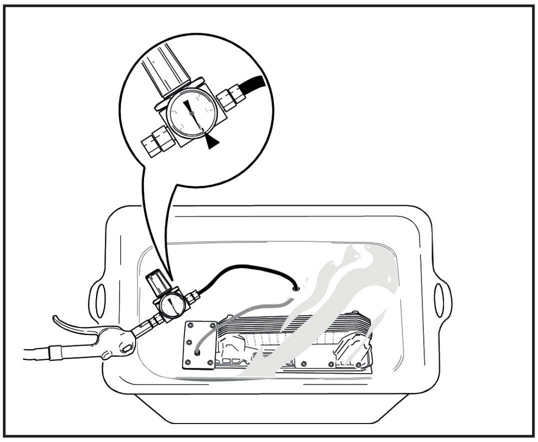


Figure 229

Oil filter

From the oil cooler, the oil passes through a large-capacity full-flow filter of paper.

This filter also cleans the oil to the turbocharger.

The oil filter has an overflow valve which opens if the filter becomes clogged. Unfiltered oil than continues to the engine and only some of the oil is cleaned in the centrifugal cleaner.

It is therefore especially important to change the filter at the intervals recommended in the **Operating & Maintenance Manual**.

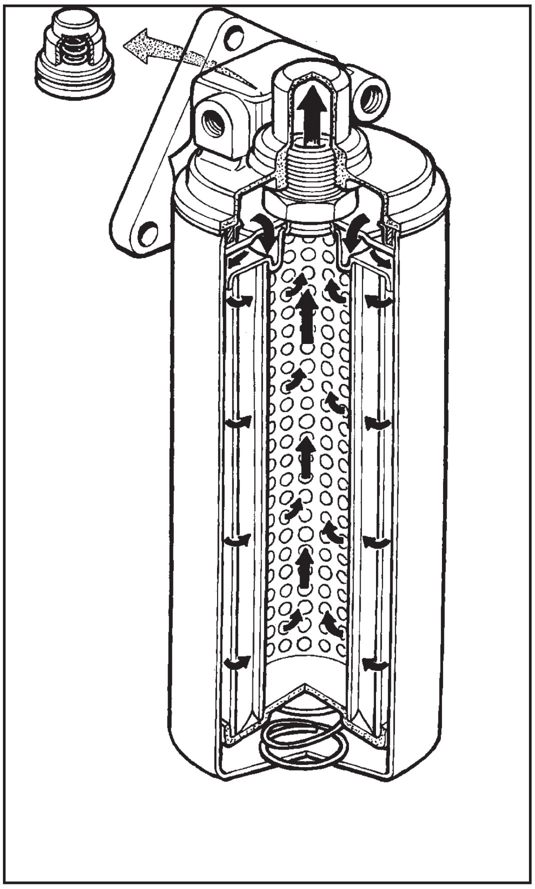
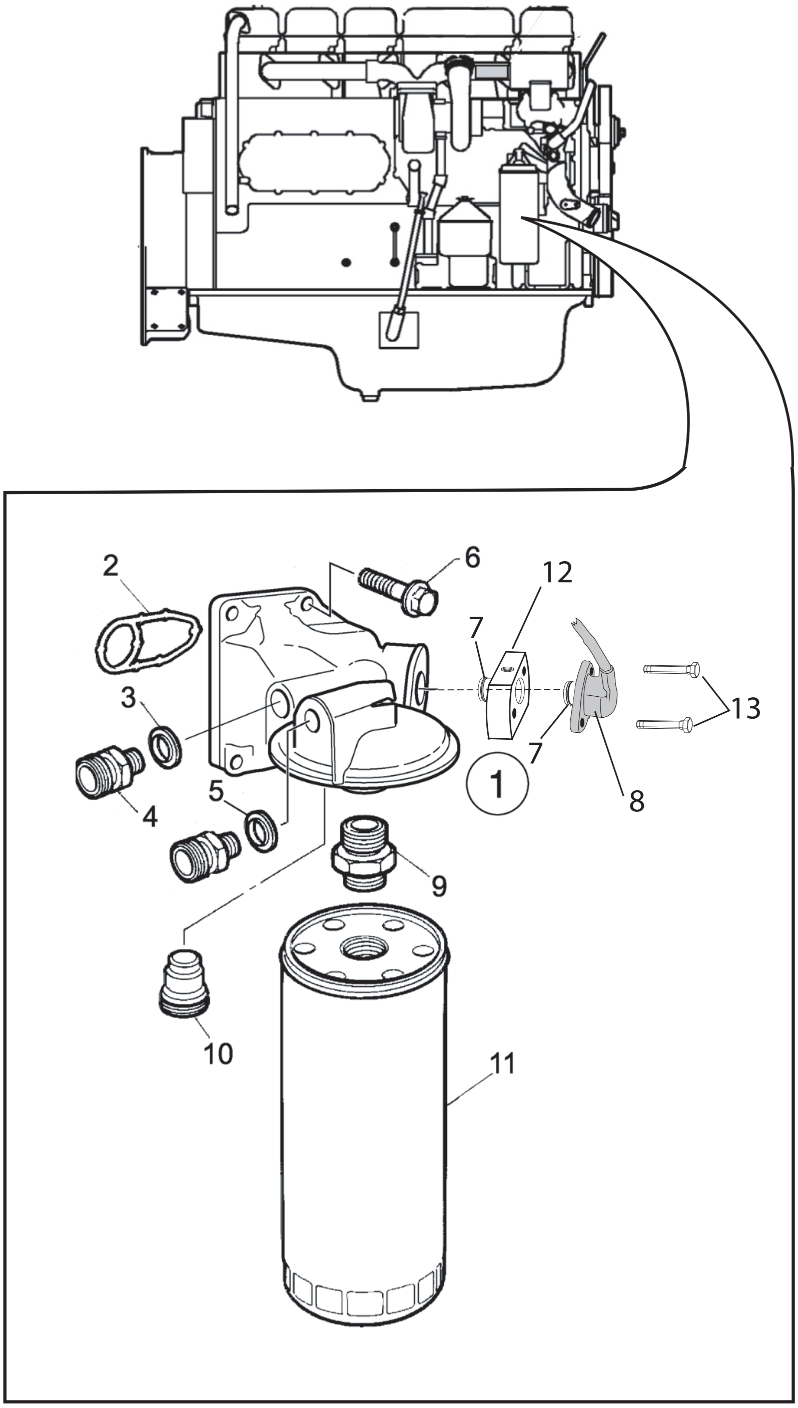


Figure 230



1. Filter head
2. Gasket
3. Seal
4. Straight union
5. Gasket
6. Flange bolt
7. O-ring
8. Pressure censor
9. Union
10. Overflow valve
11. Oil filter
12. Adapter
13. Screw

Figure 231

Centrifugal oil cleaner

Some of the oil passes from the main passage in the oil cooler cover to the centrifugal cleaner and then, after cleaning, flows back to the sump.

Surplus oil is drained back to the sump via an overflow valve. This ensures that the pressure in the oil system is not too high.

The centrifugal cleaner's rotor is caused to spin by the force of the oil which squirts out through two nozzles at the bottom of the rotor.

Dirt particles are slung against the wall of the rotor by centrifugal force and fasten there as a coating.

The rotor should be dismantled and cleaned at definite intervals according to the inspection programme included in the operator's manual.

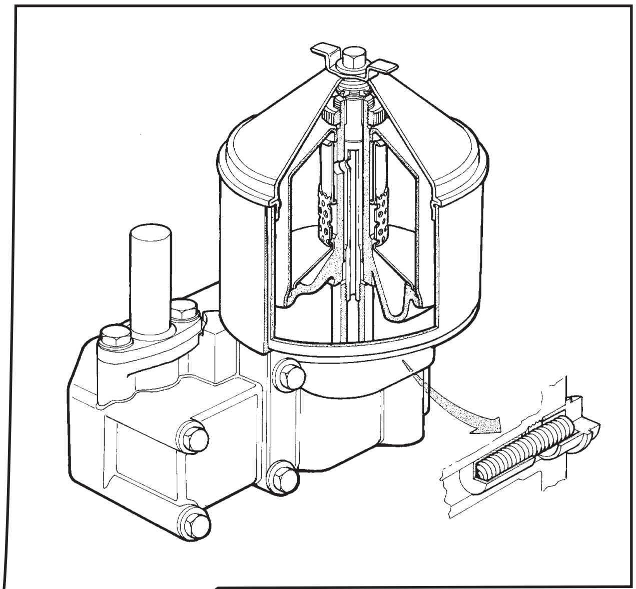
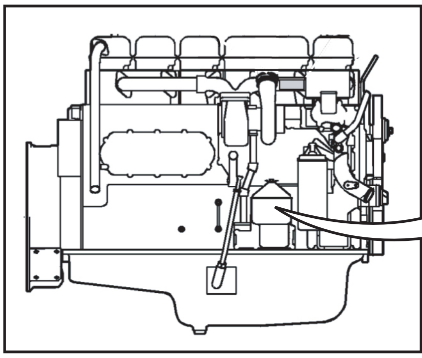


Figure 232



1. Housing
2. Plug
3. Gasket
4. Spring
5. Piston
6. Plug
7. Washer
8.Shaft
9. Nozzle
10. Rotor
11. Strainer
12. O-ring (change when cleaning)
13. Rotorbowl
14. Nut
15. Snap ring
16. O-ring (change when cleaning)
17. Cover
18. Lifting eye
19. O-ring
20. Lock nut
21. Nipple
22. Gasket

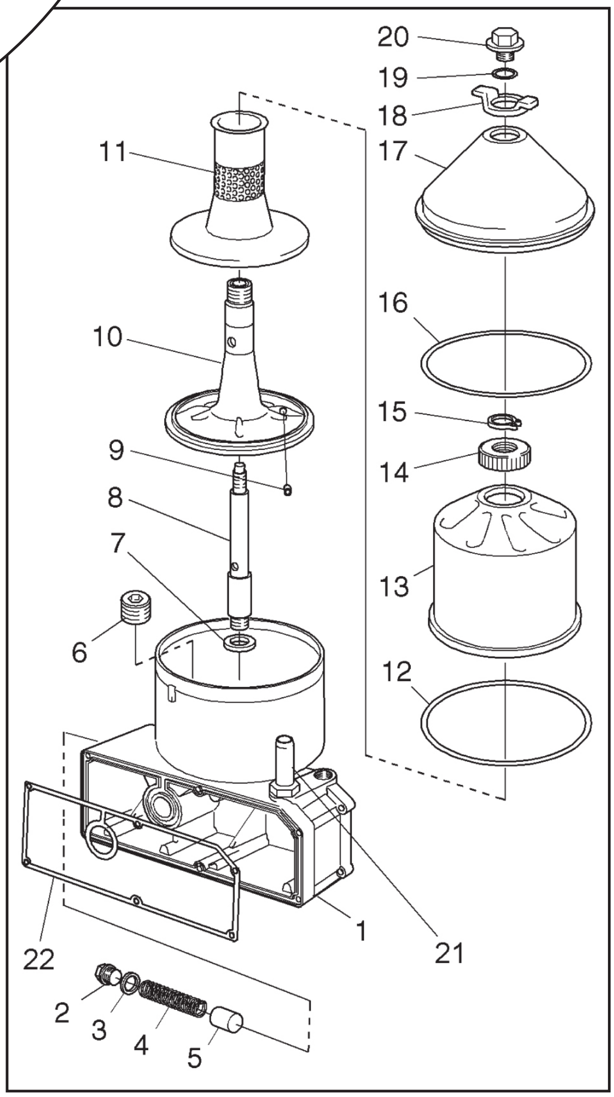


Figure 233

Dismantling and assembly

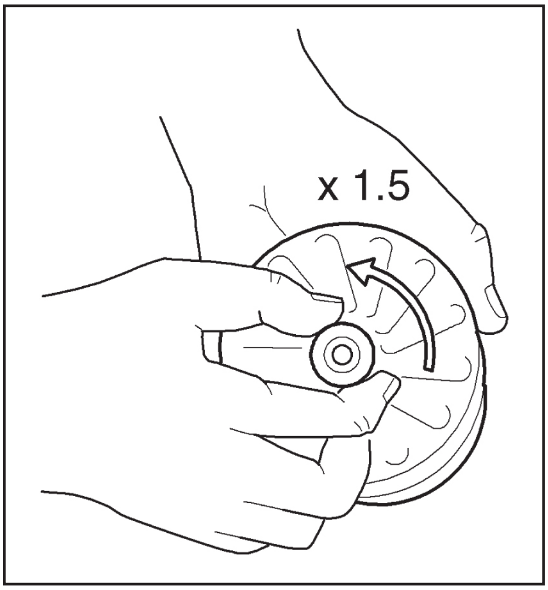


Figure 234

- During routine cleaning of the oil cleaner, there should be a certain amount of dirt deposits in the rotor bowl.

- If this is not the case, it indicates that the rotor is not spinning. The cause of this must be immediately investigated.

- If the dirt deposit exceeds 28 mm at the recommended inter-vals, the rotor bowl should be cleaned more often.

1. Clean the cover.
2. Unscrew the nut securing the outer cover.
3. Let the oil run out from the rotor.
4. Lift out the rotor. Wipe off the outside.
5. Loosen the rotor nut and unscrew it about turns.

NOTE

The rotor must not be put in a vice. Never strike the rotor bowl. This may cause damage resulting in imbalance.

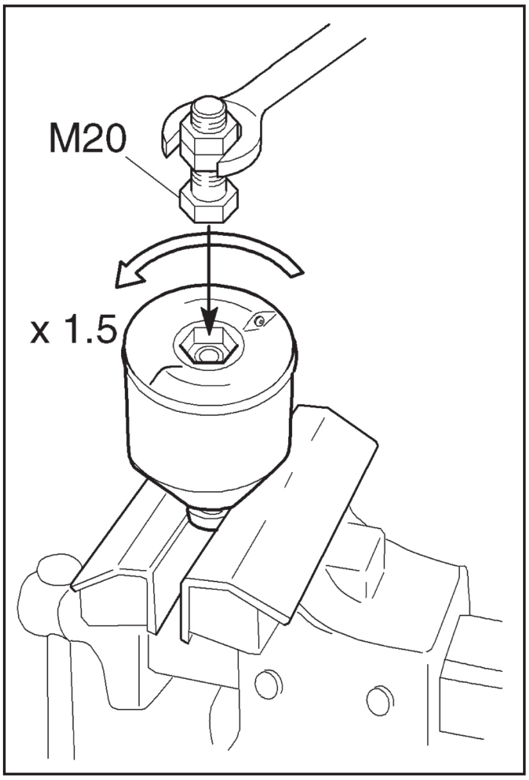


Figure 235

6. If the rotor nut is jammed: Turn the rotor upside down and fasten the rotor nut in a vice. See illustration.
7. Use protective jaws so as not to damage the grooves of the rotor nut.
8. Turn the rotor 1.5 turns anti-clockwise by hand.
9. If this does not work: Screw two nuts together with an M20 screw.
10. Position the screw head at the bottom of therotor.
11. Position a ring spanner on the lower nut and turn the rotor 1.5 turns anti-clockwise."Figure 235".

IMPORTANT!

Do not attach the rotor directly to the vice. Never strike the rotor cover.

12. Remove the rotor cover by holding the rotor in both hands and tapping the rotor nut against the table. Never strike the rotor directly as this may damage its bearings.

13. Remove the strainer from the rotor cover. If the strainer is stuck, insert a screwdriver between the rotor cover and strainer and carefully prise them apart.

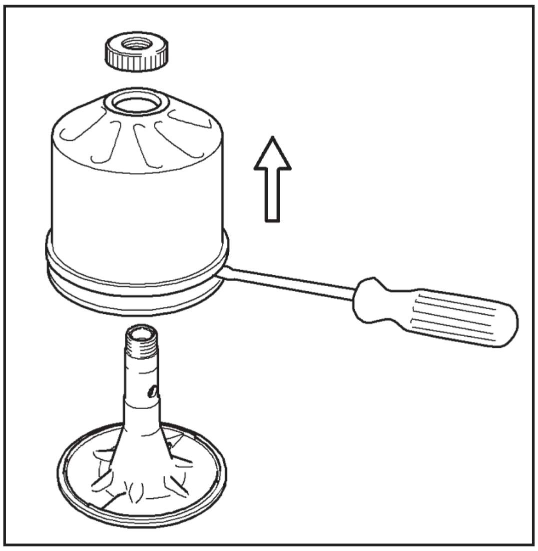


Figure 238

14. Remove the paper insert.

15. Scrape off any remaining dirt deposits from the inside of the rotor cover. If the deposits on the paper are thicker than 28 mm (1.1 in), the centrifugal oil cleaner must be cleanedmore often.

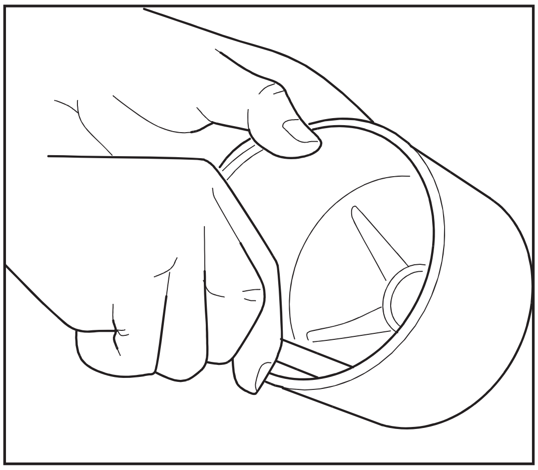


Figure 236

16. Wash the parts according to the applicable industrial method.

17. Check the 2 nozzles on the rotor. Ensure that they are not blocked or damaged. Renew any damaged nozzles.

18. Check that the bearings are undamaged. Renew damaged bearings.

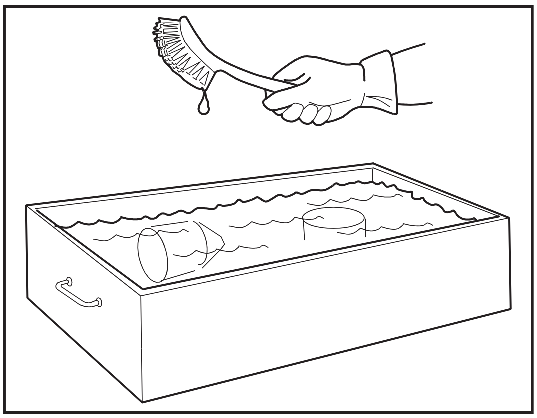


Figure 237

19. Fold and fit a new paper insert on the inside of the rotor cover as illustrated.

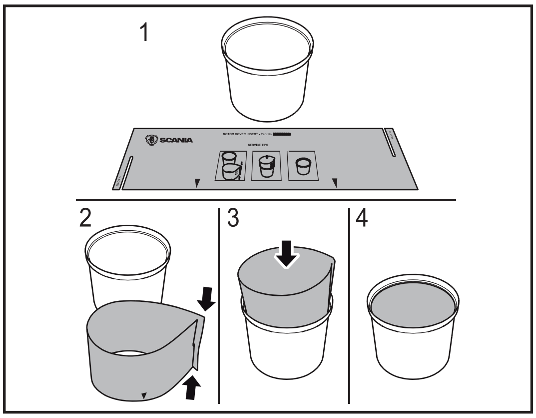


Figure 241

20. Fit the strainer onto the rotor.

21. Fit a new O-ring to the foot of the centrifugal oil cleaner.
22. Refit the rotor cover. Ensure that the O-ring is not outside the edges, but is in the groove.

23. Screw the rotor nut back on by hand.

24. Check that the shaft is not damaged or loose. Contact a Scania workshop if the rotor shaft needs renewing.

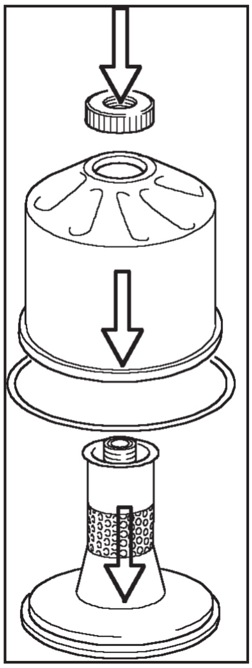


Figure 239

NOTE

Take care not to damage the rotor shaft

25. Refit the rotor and rotate it by hand to makesure it rotates easily.

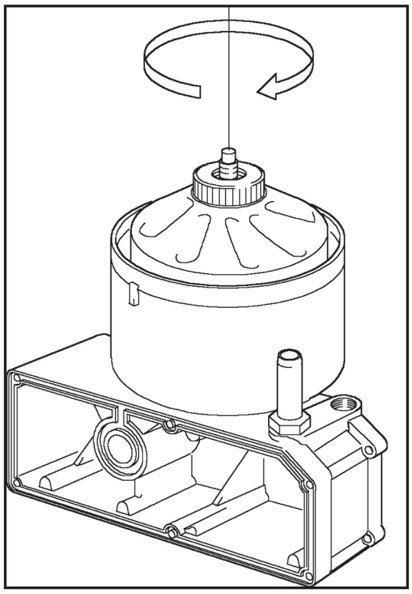


Figure 240

26. Fit a new O-ring in the cover.

27. Refit the cover and tighten the lock nut. Tightening torque 20 Nm (15 lb/ft).

IMPORTANT!

To reduce the risk of oil leakage it is important to tighten the cover to the correct tightening torque.

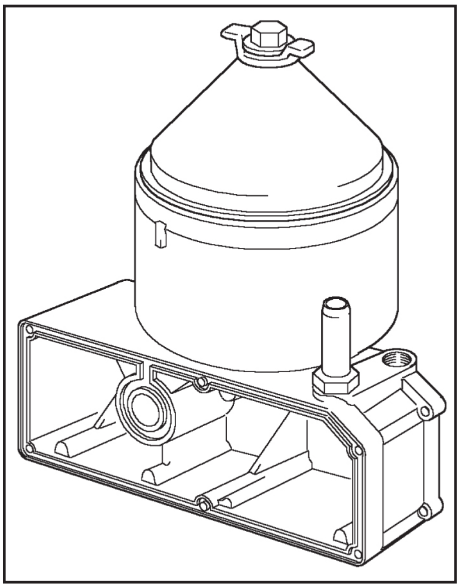


Figure 242

Operational testing of the centrifugal oil cleaner

Operational testing need only be carried out if it is suspected that the centrifugal oil cleaner is malfunctioning. For example, if the dirt deposit is abnormally small given the distance driven.

The rotor rotates very fast and should continue to turn when the engine has stopped.

1. Run the engine until it reaches normal operating temperature.

2. Turn off the engine and listen for the sound from the rotor. Use your hand to feel if the filter housing is vibrating.

3. If the filter housing is not vibrating, dismantle and check the centrifugal oil cleaner.

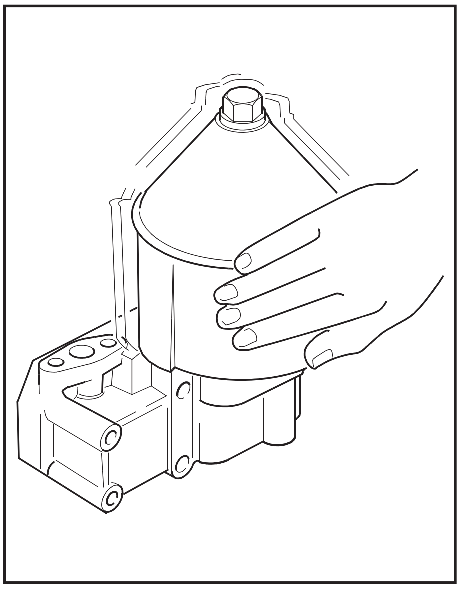


Figure 243

Oil mist separator

General

A certain amount of oil is always found in the crankcase gases, and this is normal. The amount of oil mist increases with the engine's operating time.
The closed crankcase ventilation system is very sensitive to changes in the flow of crankcase gases in the engine.
If the flow of crankcase gases increases, the amount of oil which passes through the crankcase ventilation also increases. The crankcase gases can then take with them small drops of oil from the crankcase.
The causes of too high a flow of crankcase gases can be difficult to determine, and troubleshooting must therefore be carried out methodically.
When the flow of crankcase gases is too high, the primary symptom is an increased amount of oil mist.
If the engine's oil sump is filled with too much oil, or if the oil cannot be separated, oil will be sucked up with the crankcase gases.
Faults which can arise in the engine and which are caused by the oil mist separator fall into 3 different categories:

- Too high a flow of crankcase gases
- Increased crankcase pressure
- Increased amouts of oil carryover

High levels of oil carryover

High levels of oil carryover mean large amounts of oil coming from the crankcase ventilation. High levels of oil carryover are often due to excessive amounts of oil entering the crankcase ventilation, and the oil can therefore not be separated quickly enough in the oil mist separator. There may also be a blockage in the return pipe for the separated oil.

Common causes of levels of oil carryover being too high:

- Worn rocker arm shafts on cylinder 6 (cylinder 5 on five cylinder engines).
- Too much oil in the oil sump.
- Gas leakage at valve guides, particularly during exhaust braking.
- Internal oil leakage.
- Blockage in the return pipe for the separated oil.

Fault causes,
The most common faults when there are problems with crankcase gases. See table next page.

Component	Cause	Affects
Air filter	Blocked filter	The vacuum in the engine increases, but this does not result in increased crankcase gases.
Turbocharger, exhaust brake	Internal exhaust leakage in turbocharger.	Increased flow of crankcase gases, which also leads to increased amounts of oil carryover, particularly during exhaust braking.
Charge air cooler	Blocked charge air cooler.	Can be caused by too high a level of oil carryover or a frozen charge air cooler.
Cylinder liners/piston rings	Leakage between liners and pistons.	Increased flow of crankcase gases.
Rocker arm shaft/cylinder head	Worn valve guides, worn rocker arm shafts.	Increased flow of crankcase gases, particularly during exhaust braking.
		Can also result in increased amounts of oil carryover.
Oil sump	Oil level too high.	Increased amounts of oil carryover.
Oil dipstick	Defective oil dipstick	Can result in too high an oil level in the engine.
	Air leakage at oil dipstick/oil filler.	Flow of crankcase gases through the engine is increased if the air filter is blocked.
Oil mist F	Defective centrifuge	Can result in increased vacuum in the engine if the air filter is blocked.
	Blocked return pipe for oil separated from the crankcase gases.	Increased amounts of oil carryover.
	Broken O-ring.	Increased amounts of oil carryover.
Air compressor	Worn seals	Increased flow of crankcase gases through the engine and the oil mist separator.
	Blocked outlet valves.	Increased flow of crankcase gases.
Cylinder head	Cracks	High crankcase pressure, increased flow of crankcase gases.

NOTE

The vehicle's operating profile and area of usage also affect the crankcase gases and oil mist in the engine.
Operating profiles which affect this include crane operation, exhaust braking, acceleration, and rapid throttle actuation.

Crankcase pressure measurement

The measurement should be carried out with a laden vehicle.

To check the engine crankcase pressure, a manometer shoud be used together with an adater which replaces the oil filler cap.

Measurement:

The measurement should be carried out with a laden vehicle. Note the readings on the form.

1. Connect a hose between the adapter and manometer which is long enough for the manometer to be taken into the cab.
2. Take the manometer into the cab and carry out the test as described below.

   Measuring with throttle

3. Note the crankcase pressure when the vehicle is stationary, no throttle.
4. Drive the vehicle and rev the engine up to 1,900 rpm and note the crankcase pressure.
5. Repeat the procedure 3 times.

   Measuring with exhaust brake (If installed)

6. Activate the exhaust brake on a downhill stretch.
7. Repeat the procedure 3 times.

Oil mist separator exploded view

The oil mist separator is driven by oil from the lubrication system. The oil flows into the oil mist separator and is sprayed onto the turbine located on the rotor shaft. The oil then flows out and back to the oil sump.

The rotor consists of a number of tapered plastic plates which are located on top of one another. There is a space for the crankcase gases and oil particles between each plate.

The crankcase gases and oil particles flow into the oil mist separator through the union in the top of the oil mist separator housing. The oil particles stick to the rotating plates and the centrifugal force causes the oil particles to be thrown against the wall of the oil mist separator housing. The oil which has been separated from the crankcase gases runs down along the walls of the oil mist separator housing and then flows out of the oil mist separator via the centrifugal oil cleaner to the oil sump. The centrifugal oil cleaner contains an oil trap. The oil trap is there so that oil from the oil sump is not drawn in the wrong direction.

The cleaned crankcase gases flow out of the oil mist separator via a diaphragm which acts as a pressure regulator. When the vacuum downstream of the oil mist separator is too great, the diaphragm will close the opening until the pressure has risen again.
The oil mist separator does not normally need to be dismantled for cleaning.

NOTE

Remove the oil mist separator from the engine before it is dismantled.

1 Oil mist separator housing (different version for closed crankcase ventilation)
2 O-ring
3 Nipple
4 Heat shield
5 Screw
6 Diaphragm (not used on oil mist separator for closed crankcase ventilation)
7 Diaphragm spring (not used on oil mist separator for closed crankcase ventilation)
8 Cover (different version for closed crankcase ventilation)
9 O-ring
10 Nipple (not used on oil mist separator for closed crankcase ventilation)
11 Screw
12 Screw (not used on oil mist separator for closed crankcase ventilation)
13 Upper bearing retainer
14 Screw
15 Retaining ring
16 Spring
17 Separator
18 Washer
19 Retaining ring
20 O-ring
21 Insert
22 Lower bearing retainer
23 Turbine
24 Retaining ring
25 O-ring
26 O-ring
27 Turbine housing
28 Washer
29 Straight nipple

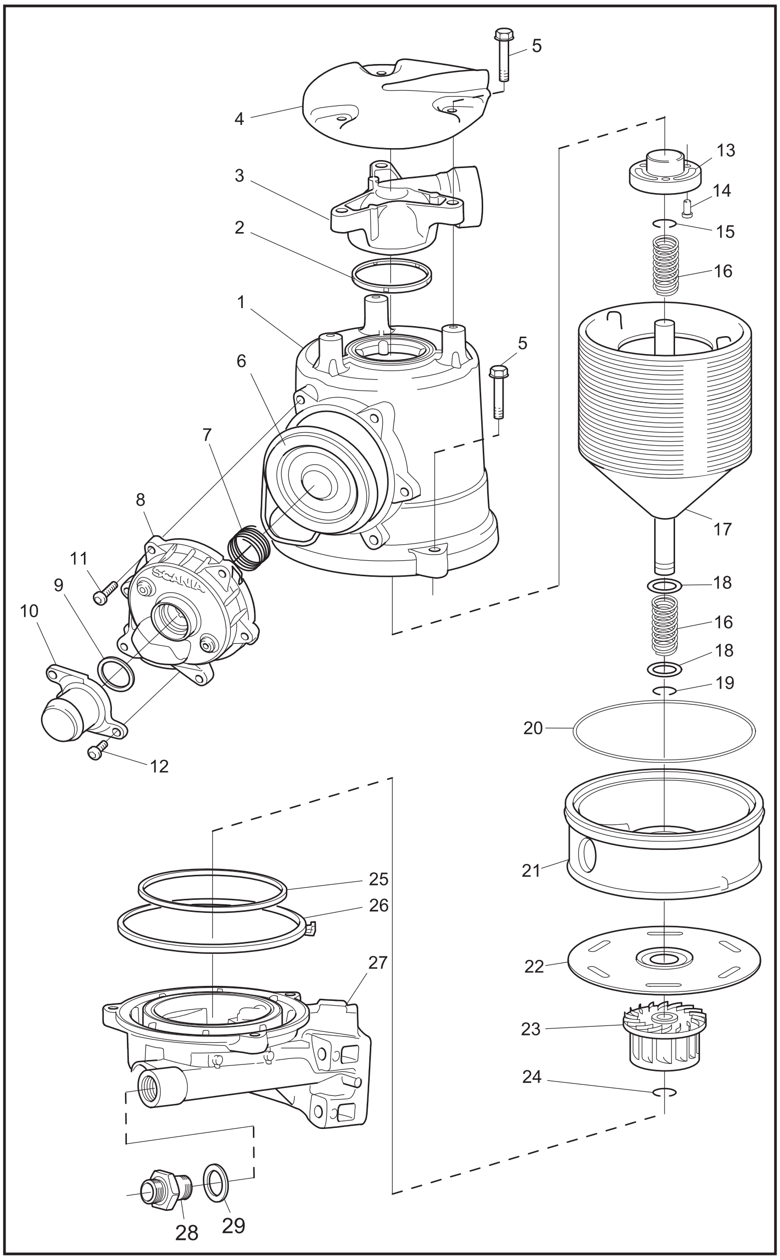


Figure 244

Oil mist separator disassemble

Remove the oil mist separator from the engine before it is dismantled.

1. If the engine has an exhaust brake:
- Remove the exhaust pipe between the exhaust brake and silencer.
- Undo the V-clamp between the turbocharg er and exhaust brake. Lift up the exhaust brake and undo the compressed air hose. Remove the exhaust brake.

2. Remove the outlet pipe and inlet pipe from the compressor.

NOTE

Cover all inlets and outlets.

3. Undo the hose clamps for the lubrication oil return pipe and remove the hose

4. Remove the pressure pipe for the oil mist separator.

5. Undo the inlet pipe for the oil mist separator.

6. Remove the oil mist separator outlet pipe.

7. Remove the oil mist separator.

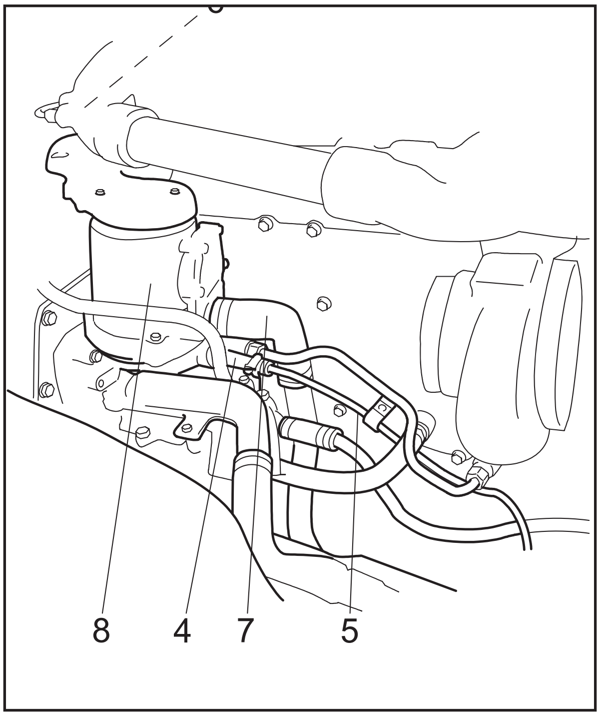


Figure 245

In accordance with the previous page parts view:

1. Remove the gasket (26) between the turbine housing (27) and oil mist separator housing (1).

2. Lift the rotor assembly out of the oil mist separator housing. If the rotor assembly is difficult to remove, use a rubber mallet to carefully tap alternately on the three brackets.

3. Remove the turbine (23) from the rotor unit shaft. Press the turbine downwards and release the retaining ring(24).

4. Detach the rotor discs by removing the retaining ring (19). The magnets fitted in the uppermost rotor disc can easily be detached when the rotor discs are dismantled.

5. Remove the diaphragm cover (8).

6. Remove the diaphragm spring (7) and diaphragm (6).

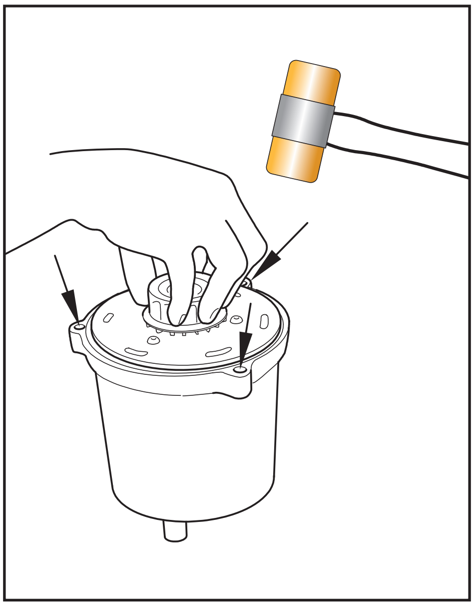


Figure 246

1 Oil mist separator housing (different version for closed crankcase ventilation)
2 O-ring
3 Nipple
4 Heat shield
5 Screw
6 Diaphragm (not used on oil mist separator for closed crankcase ventilation)
7 Diaphragm spring (not used on oil mist separator for closed crankcase ventilation)
8 Cover (different version for closed crankcase ventilation)
9 O-ring
10 Nipple (not used on oil mist separator for closed crankcase ventilation)
11 Screw
12 Screw (not used on oil mist separator for closed crankcase ventilation)
13 Upper bearing retainer
14 Screw
15 Retaining ring
16 Spring
17 Separator
18 Washer
19 Retaining ring
20 O-ring
21 Insert
22 Lower bearing retainer
23 Turbine
24 Retaining ring
25 O-ring
26 O-ring
27 Turbine housing
28 Washer
29 Straight nipple

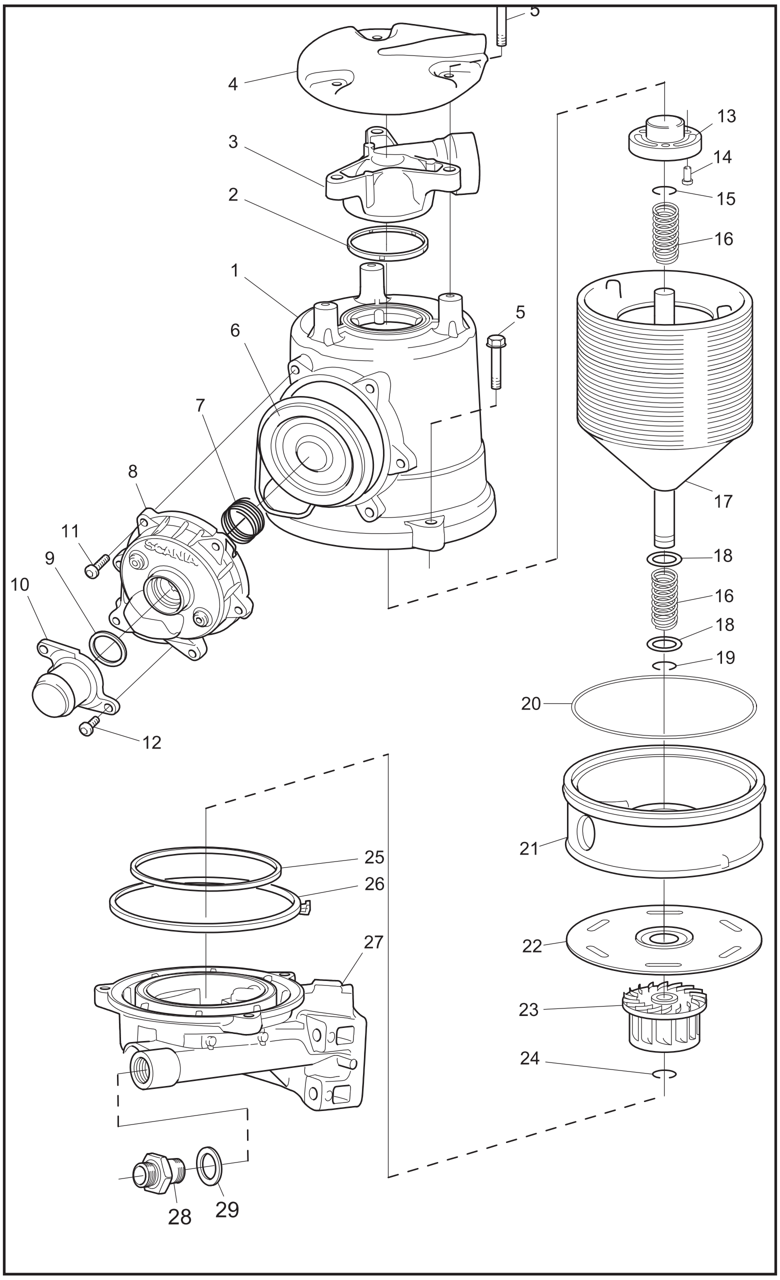


Figure 247

1. Fit the rotor discs (17) on the rotor shaft and fit the retaining ring (19).

2. Fit the rotor in the insert (21).

3. Fit the turbine (23) on the rotor shaft and press on the retaining ring (24).

4. Fit a new O-ring (20).

5. Press the rotor assembly down into the oil mist separator housing (1).

6. Fit the diaphragm (6) and diaphragm spring (7).

7. Fit the diaphragm cover (8).

Check - Rotational speed on oil mist separator

An angled ABS sensor should be used to measure the rotational speed on the oil mist separator. Cut the electrical cables and fit 2 switches suitable for a multimeter which can measure Hz, see “Figure 248”.

Cold engine at idling speed, oil temperature of 20–50°C
120 +/-50 Hz

Warm engine at engine speed of 1,000 rpm
150–220 Hz

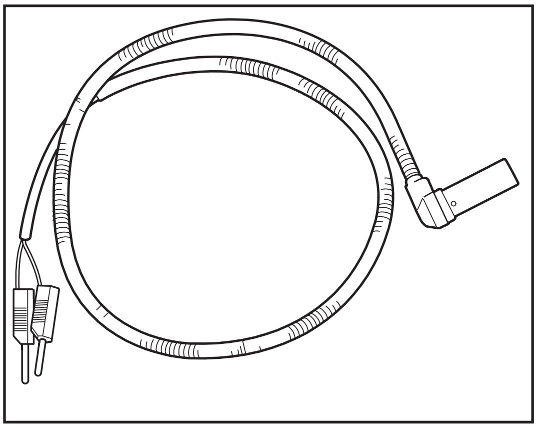


Figure 248

1. Start the engine and rev it up to 1,000 rpm.
2. Hold the sensor against the oil mist separator and read the multimeter. The value should be at least 150 Hz at an engine speed of 1,000 rpm.

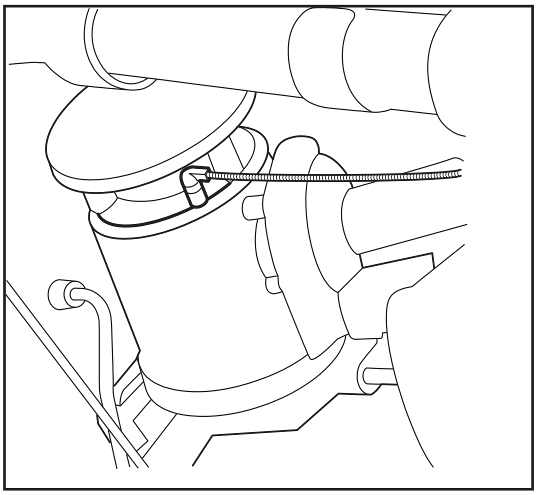


Figure 249

Alternator 100 A

Check

CAUTION

Make sure that you never run an alternator without the batteries connected! This may cause the rectifiers and/or charge regulator to be overloaded and damaged.

NOTE

To obtain a correct result, the alternator should be kept at a temperature of 20-25°C. A higher temperature may give a lower current.

When the engine control unit has generated fault codes for the alternator, the following tests can be carried out.

- Output test.
- Control voltage test.
- Phase measurement.
- Length of brushes.
- Slip rings, rotor resistance and overcharging.

Test	Test values	Mea-sured values	Acceptable value	Incorrect value
1. Output test	Bosch 100A: >40A and 28V		Carry out voltage test	Carry out phase measurement
Control voltage test	28 +/- 1.0V at 20°C		Alternator OK	Check the brush length
Phase measurement	<250 mV		Check the brush length	Renew alternator
Brush length[1]	Bosch 100A: >1.0 mm		Check slip rings	Renew alternator
Slip rings[1]	The surface should be smooth and bright		Check the rotor resistance	Renew alternator
Rotor resistance between the slip rings (at 20°C)[1]	Bosch 100A: 8.5 +/-0.5 ohms		Carry out overcharging test	Renew alternator
Measuring overcharg-ing between slip rings and framework[1]	> 10 MOhm		Renew regulator	Renew alternator

Figure 250

Output test

1. Connect an ammeter and a voltmeter to the batteries as illustrated.

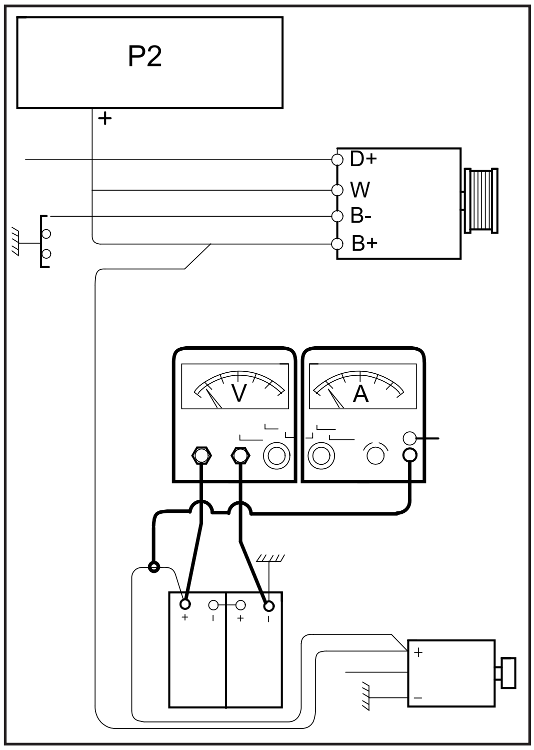


Figure 251

Connection to batteries

2. Start the engine and run it at idling speed for a few minutes. Then note how much current is supplied from the alternator to the batteries. Check at the same time that the voltmeter does not fall below 27 V. Run the engine at approximately 500 rpm.

3. Connect the same equipment as before to the central electric unit as illustrated.

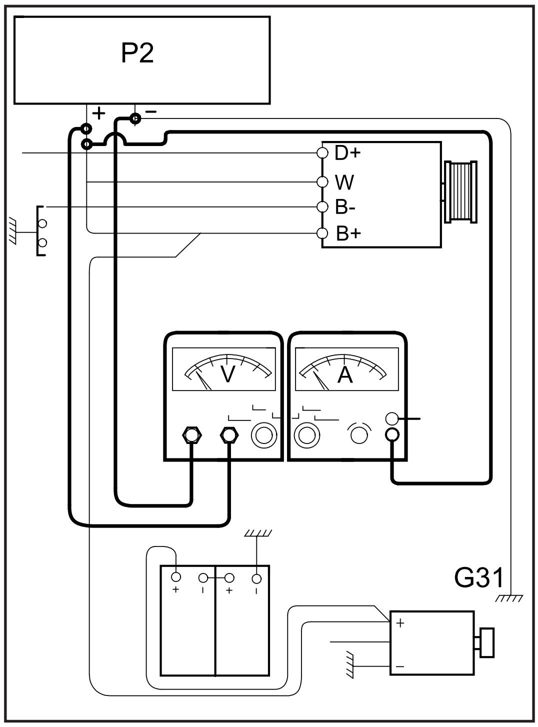


Figure 252

Connection to central electric unit

4. Hold the engine speed at 500 rpm and apply loads to the system by using the vehicle's current consumers in accordance with the test report, column Check value. See below for examples of current consumers.

Add the current you read at the batteries to the sum of the loads you are applying.

Example using 80 A Bosch alternator: If you obtained a value of 10 A at the batteries, you only need to apply a load of 25 A to the alternator instead of 35 A. 10 A + 25 A = 35 A

5. Run the engine for a time while you are applying the load. Read the voltmeter again. It should still not show less than 27 V.

Examples of current consumers:

Cab fan at maximum	approx. 10 A
Main beam	approx. 6 A
Two auxiliary lamps	approx. 6 A
Seat heater	approx. 2.5 A/seat
Electrically heated mirrors	approx. 2.5 A/mirror
Coolant-operated cab heater	approx. 6 A
Radio	approx. 1.5 A

Voltage test

Carry out this test especially if you suspect there is overcharging.

NOTE

The batteries should be fully charged to give good results, i.e. maximum consumption at 10A.

1. Connect the ammeter and voltmeter to the central electric unit as illustrated. Run the engine at approximately 500 rpm.

Connection to batteries

2. Load the system with approximately 10-20A by using various current consumers.

3. Allow the engine to run for a while. The voltage on the voltmeter should be 28V +/- 0.5V at 20°C.

Phase measurement

Keep the voltmeter connected as it was for the voltage test, but reset it to the AC voltage position.

The voltmeter should be stable around 100 mV and at most 250 mV. If this performance is not achieved, the alternator is defective and must be renewed.

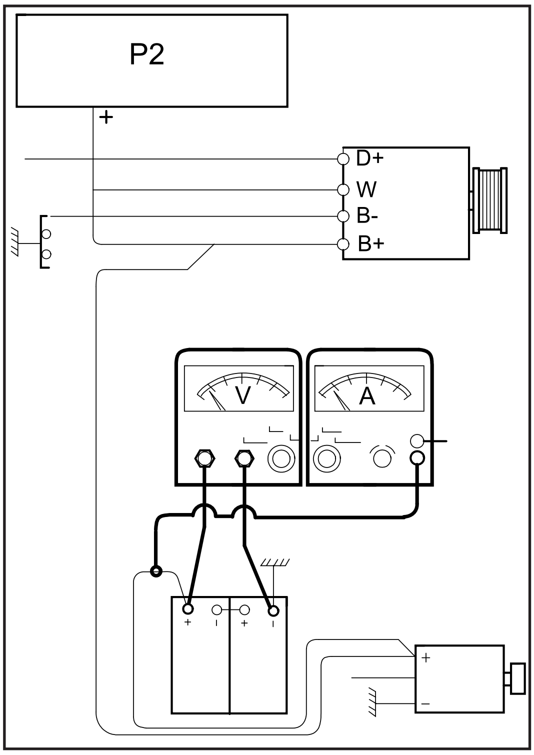


Figure 253

Length of brushes

Check that the length of the carbon brushes does not fall below the permitted length, see specification.

Slip rings/rotor resistance/overcharging

The charge regulator must be removed in order to check the slip rings.

1. Check that the surfaces of the slip rings are smooth and bright. If the surfaces are not bright, this indicates poor contact with the carbon brushes.

2. Measure the rotor resistance, see measurement specification. Refer to “Figure 254”

3. Measure the insulation resistance between the slip rings and alternator core (chassis earth). The ohmmeter must show infinite resistance (at least 10 MOhm).

If one of the checks is not satisfactory, the alternator must be renewed.

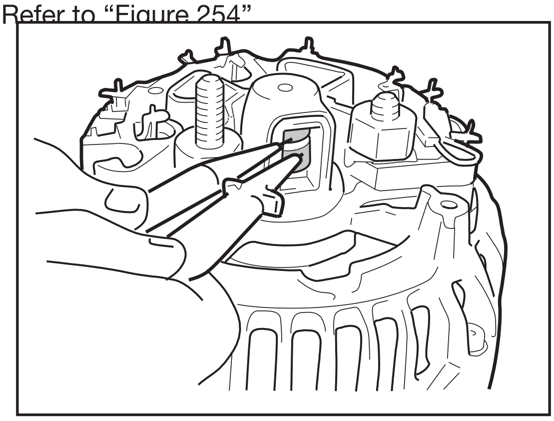


Figure 254

Renewal - Bearing and carbon brushes

Specification Bosch 100 A

Designation	NCB2 28V 40/100A
Output power at 6000 rpm	2800 W
Resistance in rotor	8.5 ohm +/- 5%
Brush length	>1 mm

Engine speed (rpm):	Bosh 100A
500	40
600	60
800	80
1500	100

Max alternator current at an alternator temperature of 20-25 °C

1. Remove the cover washers for the carbon brushes.

Remove the screws holding the carbon brushes.

Important!

Mark the front housing against the rear housing to make it easier when assembly the housings.

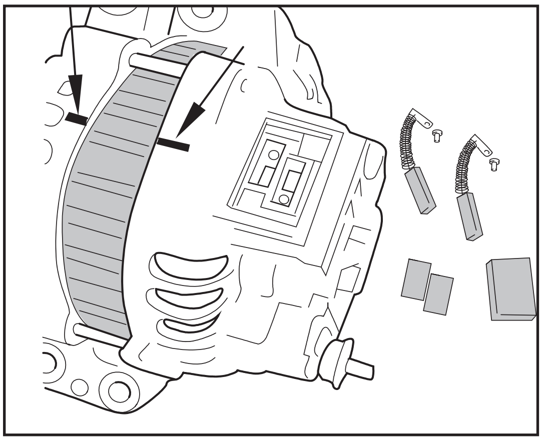


Figure 255

2. Remove the nut and pulley. The nut should be tightened with a force of 139 Nm on assembly.

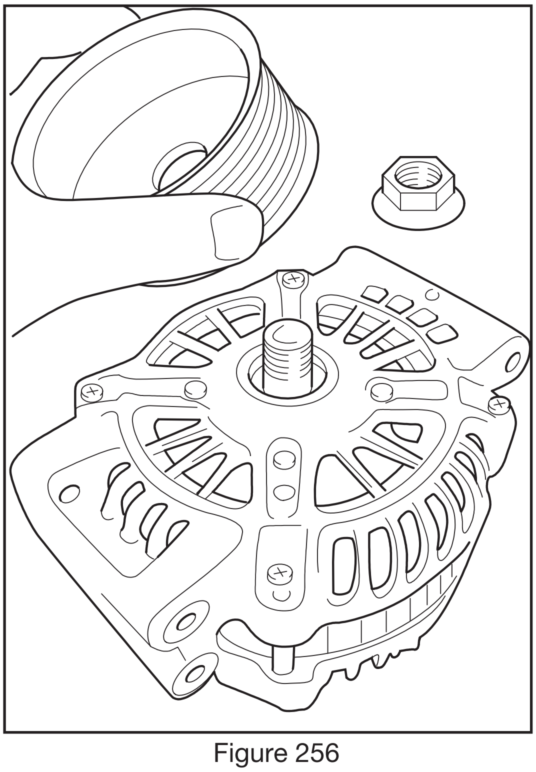


Figure 256

3. Remove the 4 screws which hold the alternator together.

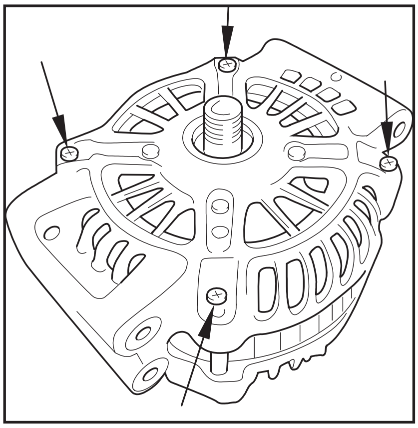


Figure 257

4. Separate the alternator. The stator winding should remain in the rear housing.

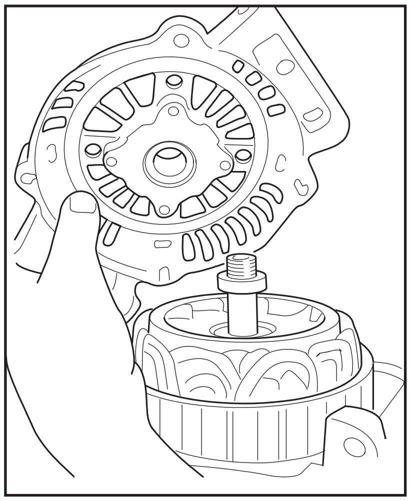


Figure 258

5. Remove the rotor from the rear housing as follows: refit the nut on the rotor shaft. Hold the rotor in the nut and gently tap all around the housing until the rotor comes loose.

CAUTION

Make sure that you do not damage the stator winding and rotor.

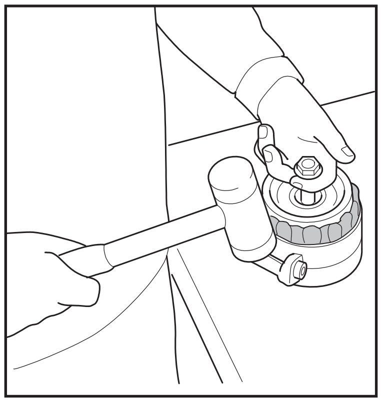


Figure 259

6. Clamp the rotor in the vice.

NOTE

Use soft jaws on the vice so as not to damage the rotor.

Remove the bearing on the rotor using puller plate 587 517 and bearing puller 587 518.

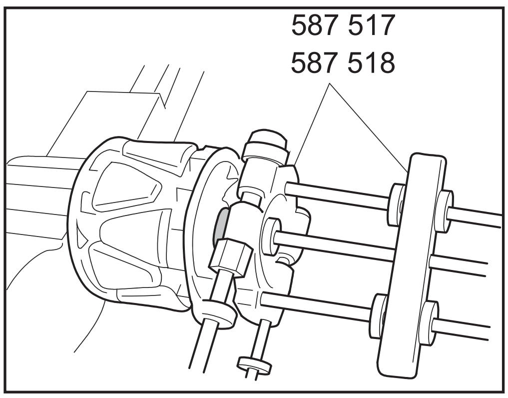


Figure 260

7. Press on the new bearing.

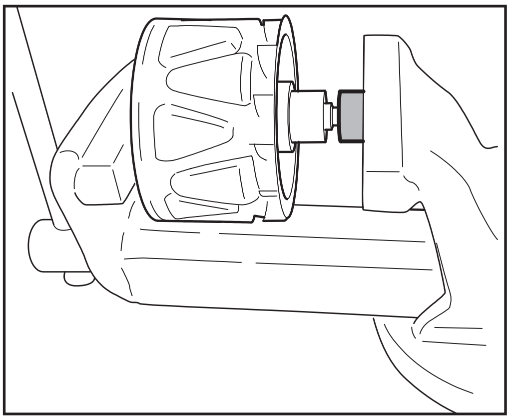


Figure 261

8. Remove the screws and the washer securing the bearing in the front housing.

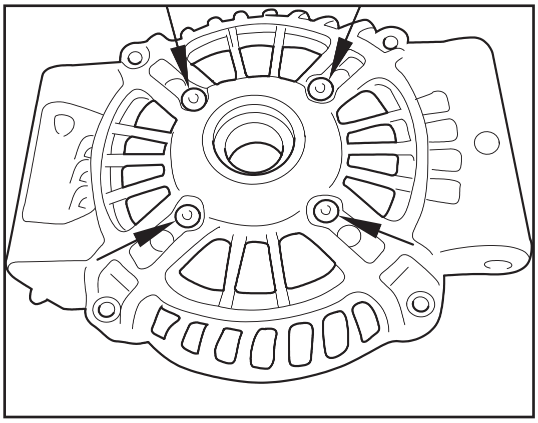


Figure 262

9. Put a sleeve on the bearing and tap out the old bearing from the front housing.

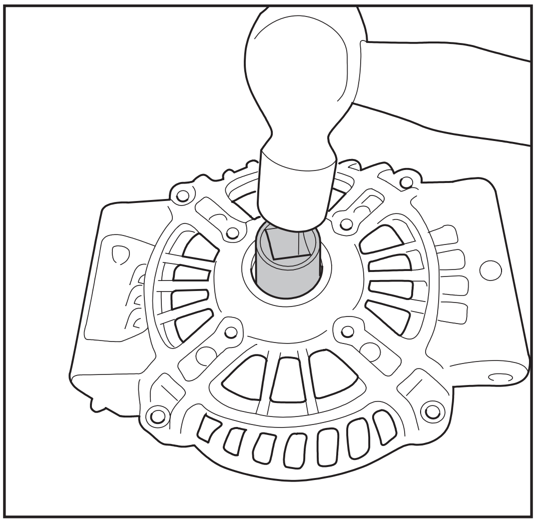


Figure 263

10. Fit a new bearing. Fit the front housing in the vice and press it into position using a sleeve on the outer race.

Then, refit the washer and tighten the 4 screws.

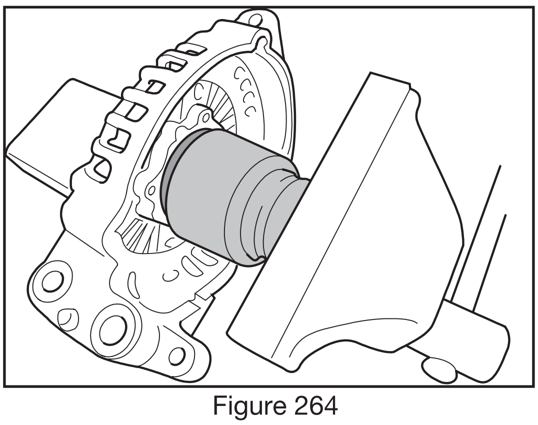


Figure 264

11. Assembly: fit the rotor in the rear housing. Remember to fit the spacing washer between the rotor and bearing in the front housing.

Fit the front housing.

Important!

Check that the marks on the housings are aligned.

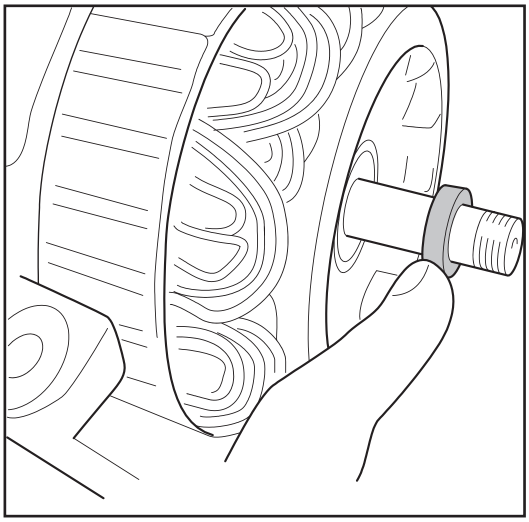


Figure 265

12. Screw on the housing and fit the carbon brushes.

13. Fit the nut and the pulley.

CAUTION

The pulley nut must be tightened to the correct torque, otherwise there is a risk that it will come loose.

Oil pump, brake cooling

Exploded view

1 Pump housing
2 Bolt, 4 off
3 Washer, 4 off
4 O-ring, 2 off
5 Support ring, 2 off
6 Plug
7 O-ring
8 Compression spring
9 Control valve
10 Pressure plate
11 Rotor housing
12 Rotor
13 Vanes
14 Wear plate
15 O-ring
16 Guide pin, 2 off
17 O-ring
18 End plate
19 Spacing ring
20 Sealing ring
21 Washer
22 Axle
23 Retaining ring
24 Bearing
25 Retaining ring
26 Gear
27 Nut
28 Flange
29 Gasket
30 Stud, 2 off
31 Bolt, 5 off

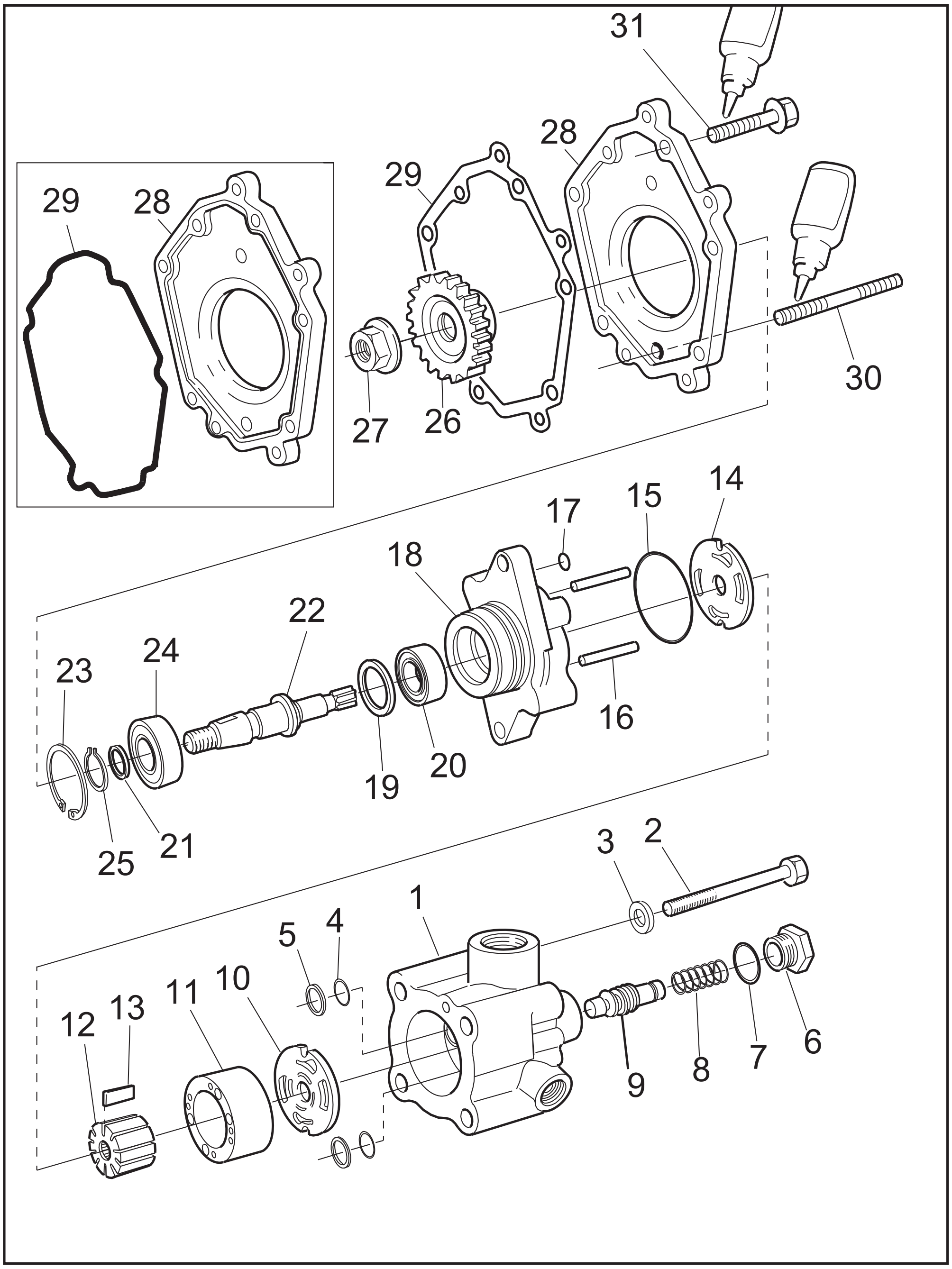


Figure 266

Disassemble and overhaul the oil pump

Brake oil pump is located on the engine's flywheel house on the left.

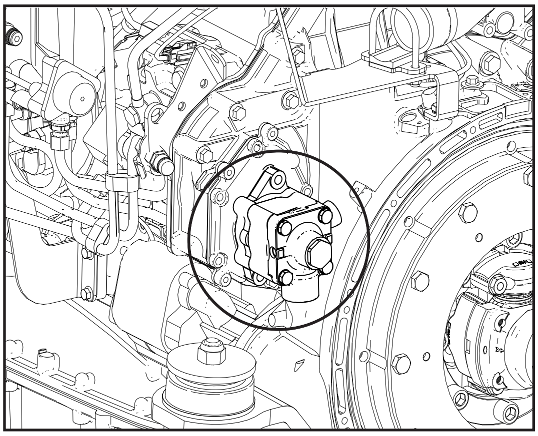


Figure 267

1. Lift the cab and secure with safety device.
2. Drain the oil from the steering system. Place a receptacle under the fluid reservoir. Disconnect the suction pipe first from the fluid reservoir and then from the hydraulic pump.
3. Clean and remove the connections to the hydraulic pump.
4. Detach and remove the hydraulic pump.
5. Screw the new hydraulic pump into place on the engine.
6. Screw the two oil hoses of the hydraulic pump into place.
7. Fill with oil and bleed the steering system as described in Workshop Manual main group 13, steering, checking and troubleshooting.
8. Lower the cab into drive position.
9. Check the function.

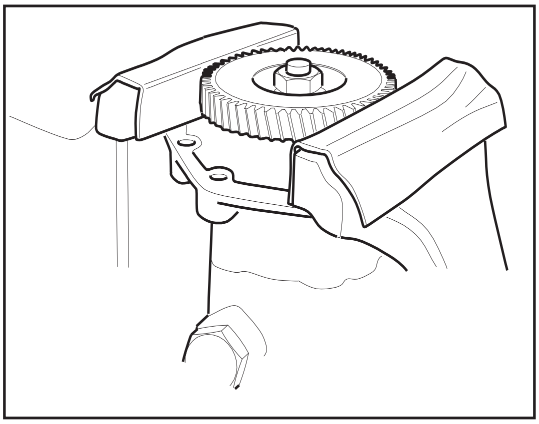


Figure 268

1. Drain all oil from the pump and clean it on the outside.
2. Clamp the gear 26 in a vice with protective jaws. Remove the nut 27.

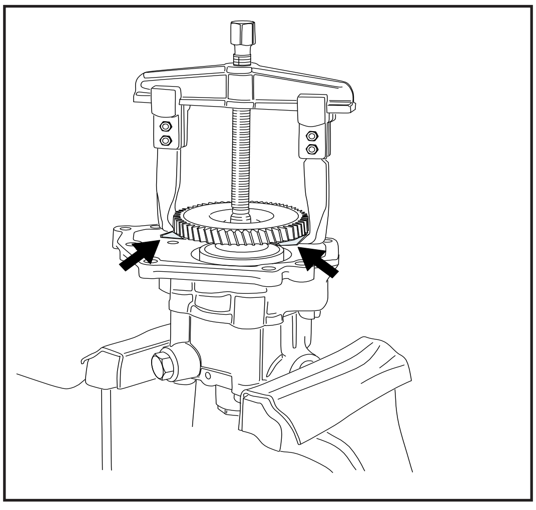


Figure 269

3. Clamp the pump in the vice. Remove the gear 26 using puller 587 315 as illustrated.

NOTE

Use soft jaws on the puller to protect the gear from damage.

4. Remove the plug 6, compression spring 8 and control valve 9.

NOTE

The plug is spring loaded and might fly off.

5. Remove the bolts 2 holding together the pump housing and end plate. Remove the end plate.

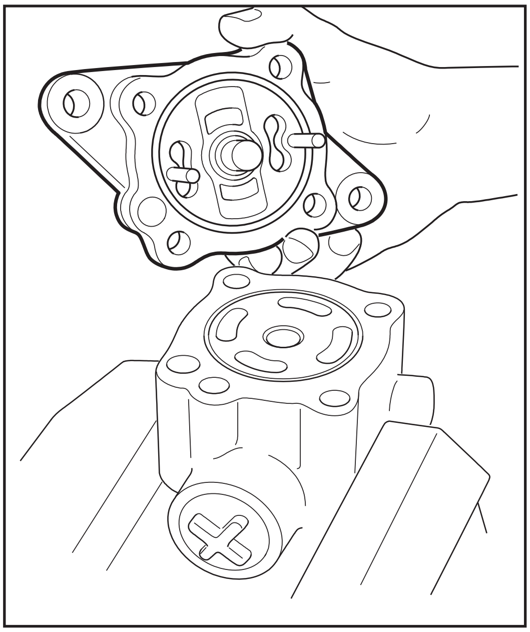


Figure 270

6. Remove the wear plate 14 and the rotor housing 11 with rotor 12 and vanes 13.

7. Remove the pressure plate 10 and guide pins 16.

8. Remove the retaining ring 23 from the end plate 18.

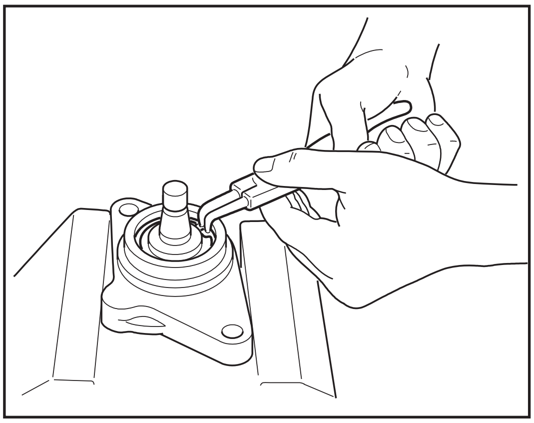


Figure 271

9. Tap out the shaft with a rubber mallet.

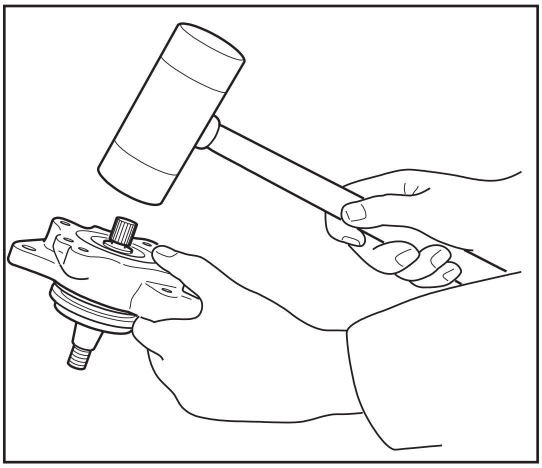


Figure 272

10. Remove the spacing ring 19.

Remove the sealing ring 20 using tool 850329-00335.

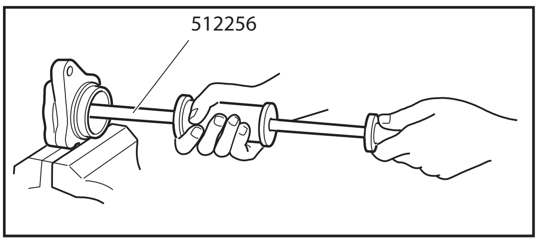


Figure 273

Checking and renewing parts

Clean and check the following parts:
Half shaft 22. Especially check the sealing surface of the sealing ring 20 and the bearing surface of the slide bearing. Slide bearing in end plate.
Plunger 9 in the control valve. The plunger must not jam in the housing.
Blow all channels in the pump housing clean. Ball bearing 24.

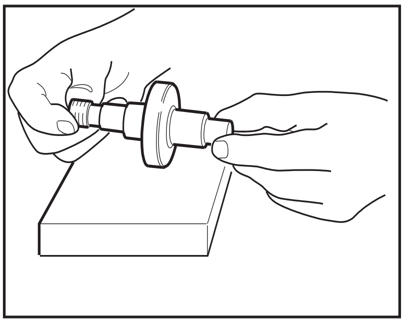


Figure 274

NOTE

If any of these parts are damaged or visually worn, the complete pump must be replaced.

Checking and renewing rotor assembly:
Check the rotor housing 11 with rotor 12 and vanes 13 for wear. The vanes must rotate easily in the rotor.
Check the wear plate 14 and pressure plate 10 for discolouring, wear and scratches. Especially check the surfaces contacting the rotor.

NOTE

If any of these parts are damaged or visually worn, the rotor assembly must be renewed. Renew the following parts:
O-rings 4, 7, 15 and 17
Support rings 5
Sealing ring 20
Retaining ring 23

1	Pump housing
2	Bolt, 4 off
3	Washer, 4 off
4	O-ring, 2 off
5	Support ring, 2 off
6	Plug
7	O-ring
8	Compression spring
9	Control valve
10	Pressure plate
11	Rotor housing
12	Rotor
13	Vanes
14	Wear plate
15	O-ring
16	Guide pin, 2 off
17	O-ring
18	End plate
19	Spacing ring
20	Sealing ring
21	Washer
22	Axle
23	Retaining ring
24	Bearing
25	Retaining ring
26	Gear
27	Nut
28	Flange
29	Gasket
30	Stud, 2 off
31	Bolt, 5 off

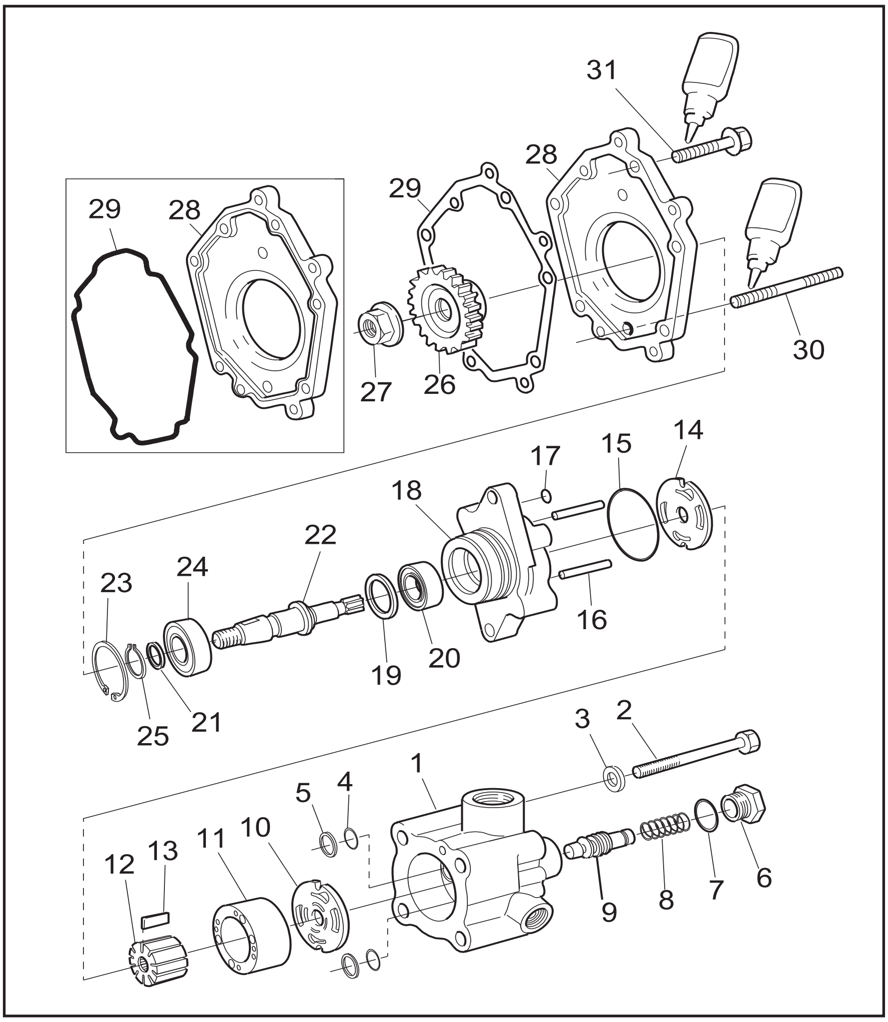


Figure 275

Oil circulate pump assemble.

1. Lubricate the component parts with automatic transmission fluid.

2. Turn the sealing ring as illustrated.

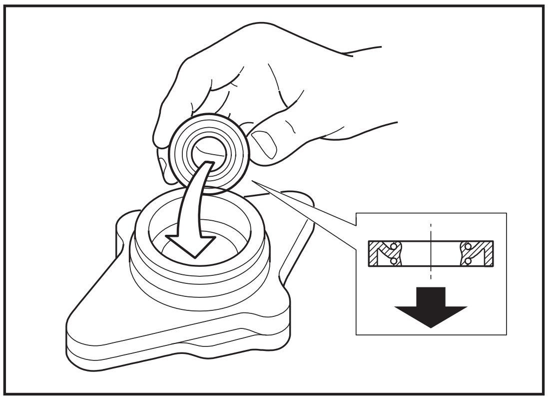


Figure 276

3. Press on the sealing ring using drift 532339 and shank 532340.

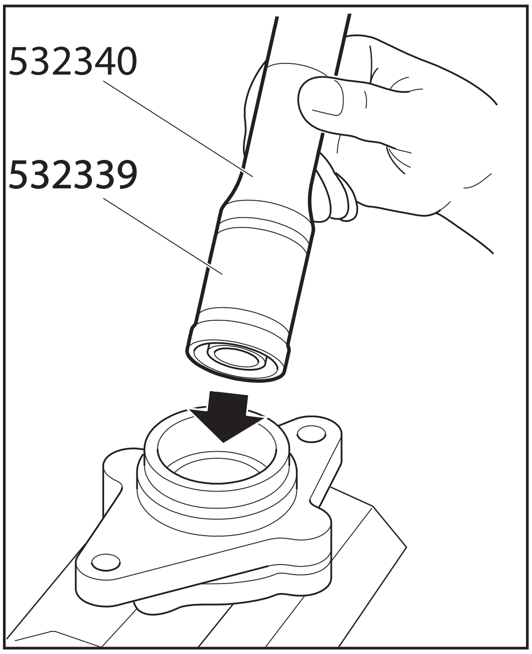


Figure 277

4. Fit the spacing ring 19.

5. Tap the shaft into the end plate with a rubber mallet.

6. Fit retaining ring 23.

7. Fit two new O-rings, 15 and 17, in the mating face. Fit the guide pins 16.

8. Fit the wear plate 14. Turn the wear plate so that the groove faces the rotor housing.

9. Fit the rotor housing 11.

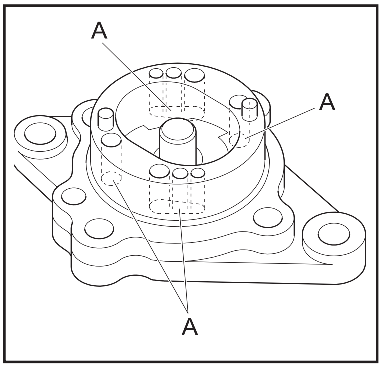


Figure 278

NOTE

Turn the rotor housing so that the oil channels A will not be blocked.

10. Fit the rotor 12 with the chamfered side facing the flange. Make sure that the rounded part of the vanes 13 is facing outwards.

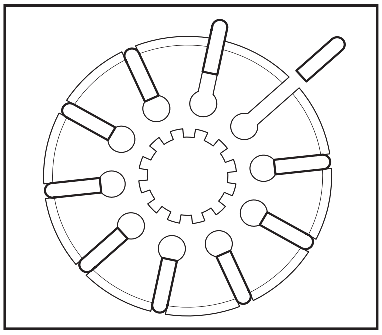


Figure 279

11. Fit the pressure plate 10 with oil channel C facing the rotor housing.

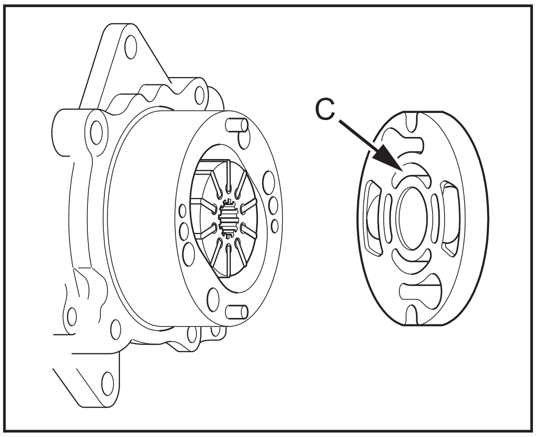


Figure 280

12. Fit new O-rings 4 and oil channel support rings in the pump housing.

13. Assemble the housing and the end plate. Make sure that the oil channels and the O-rings are lined up. Fit the bolts 2.

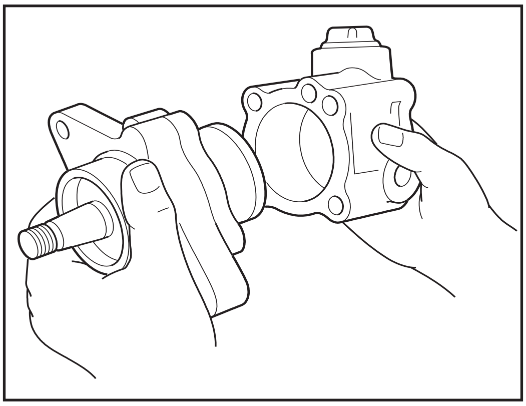


Figure 281

1 Pump housing
2 Bolt, 4 off
3 Washer, 4 off
4 O-ring, 2 off
5 Support ring, 2 off
6 Plug
7 O-ring
8 Compression spring
9 Control valve
10 Pressure plate
11 Rotor housing
12 Rotor
13 Vanes
14 Wear plate
15 O-ring
16 Guide pin, 2 off
17 O-ring
18 End plate
19 Spacing ring
20 Sealing ring
21 Washer
22 Axle
23 Retaining ring
24 Bearing
25 Retaining ring
26 Gear
27 Nut
28 Flange
29 Gasket
30 Stud, 2 off
31 Bolt, 5 off

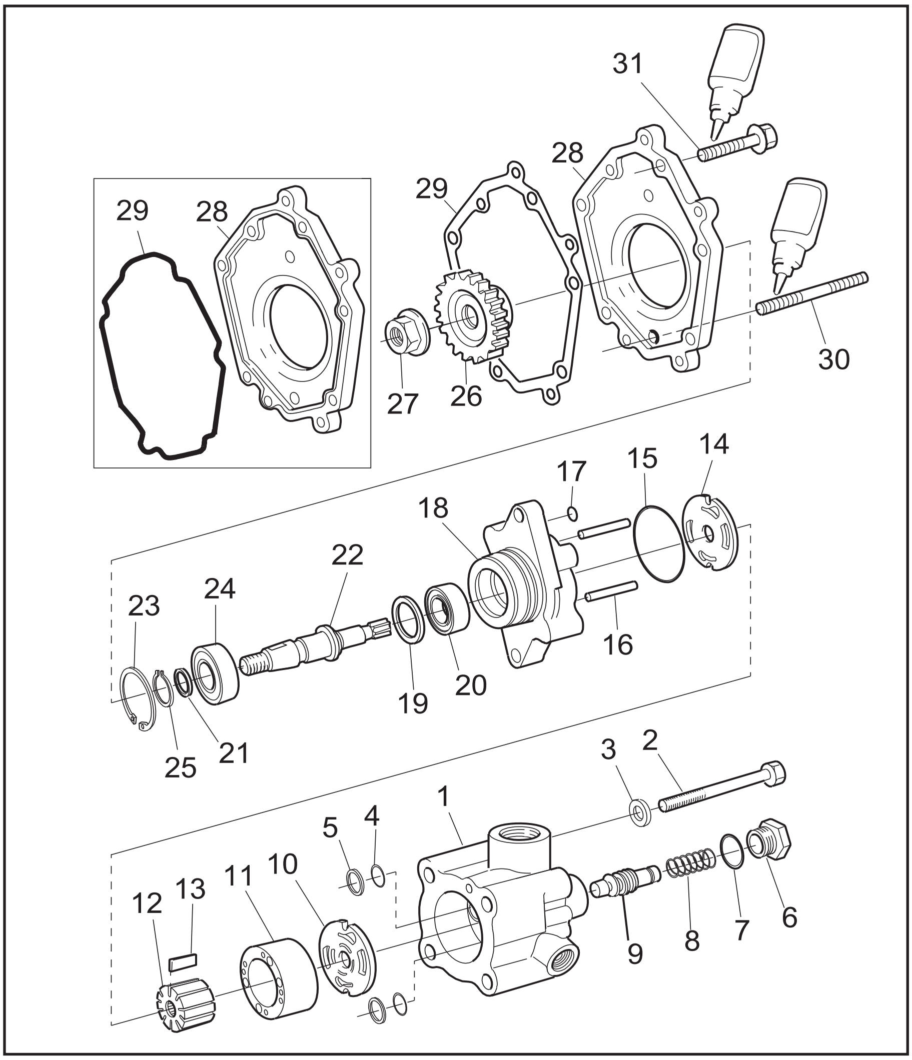


Figure 282

14. Renew the O-ring 7 on the hexagonal plug. Fit the valve insert and spring and screw in the plug.

NOTE

Make sure the control valve is turned as illustrated.

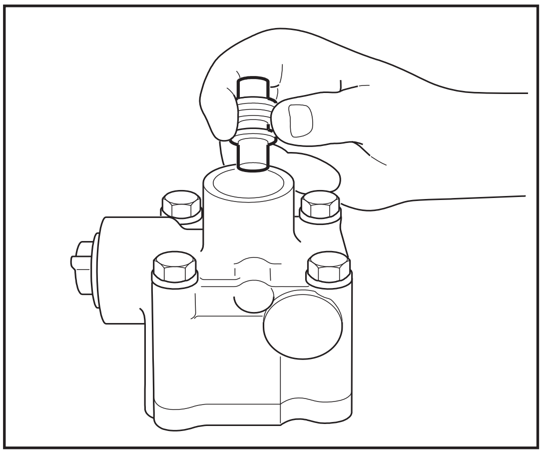


Figure 283

Important!

The shaft end and the gear must be degreased and free of oil and grease before fitting.

15. Fit the gear (26) and the nut (27) as follows:

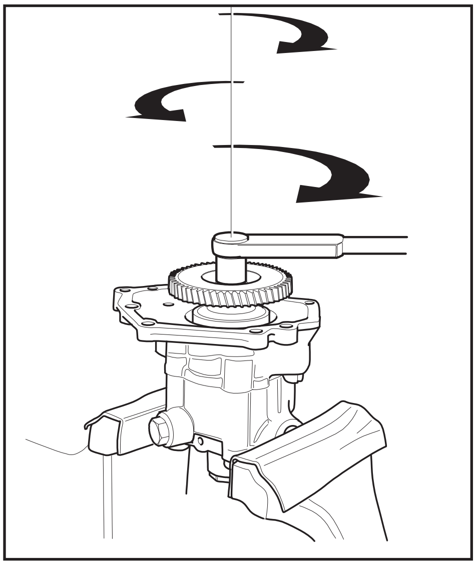


Figure 284

16. Check the pressure and flow after assembly and fitting. See: Workshop Manual main group 13, Testing the hydraulic system.

Renewing the gasket

Important !
Use only Loctite® 406 when fitting the gasket. Loctite 406 does not contain any solvents that will damage the gasket

NOTE

Cleanliness when fitting the gasket is essential for the flange to be tight. Keep the surfaces around and on the flange clean and free from dirt.

1 Remove the gasket from the paper.

2 Fit the gasket on the flange.

3 Apply a thin layer (drops) of Loctite 406.

4 Refit the flange. Use existing bolts with sealing agent or new bolts coated with sealing agent.

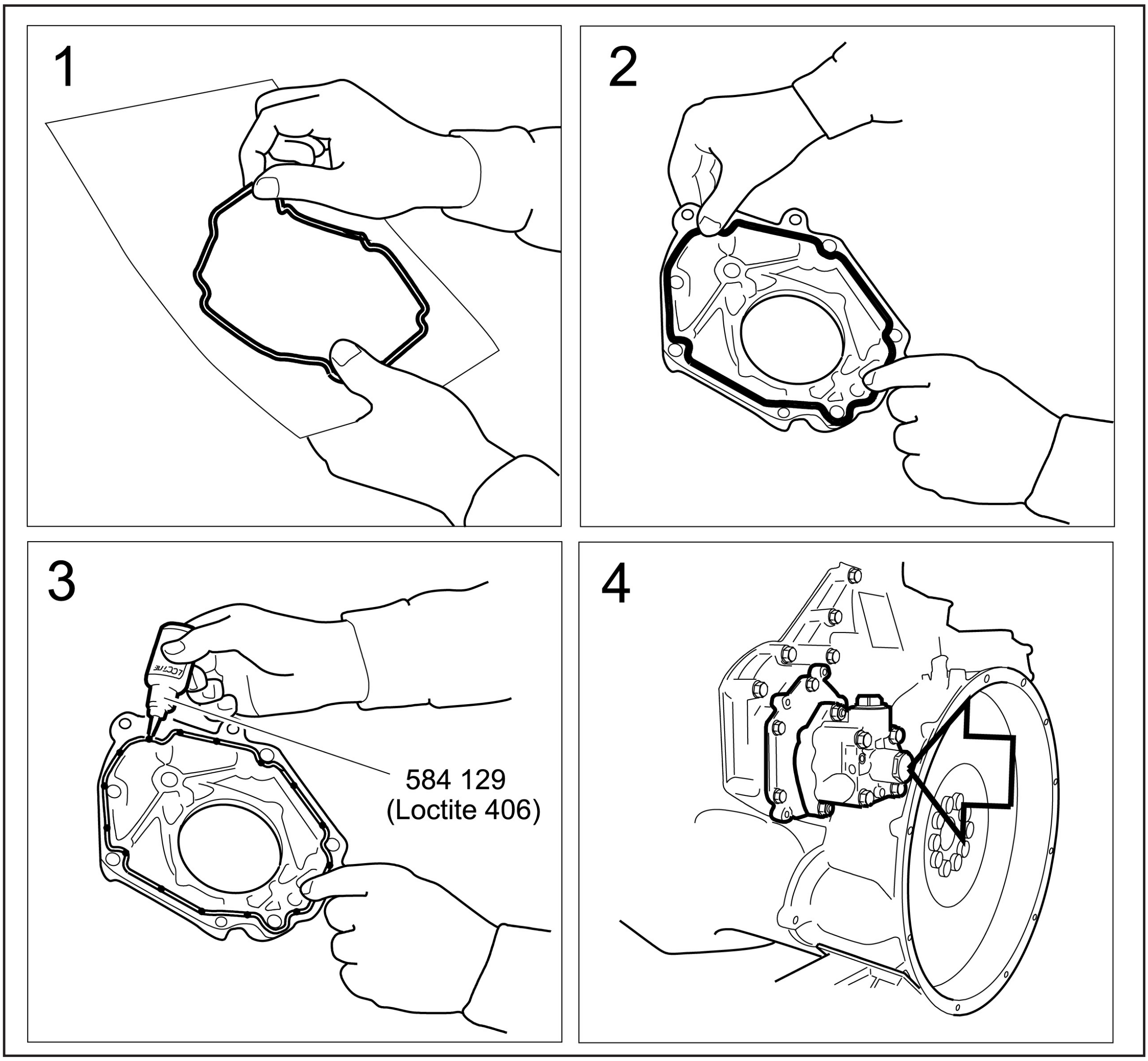


Figure 285

Cooling fan

The fan is driven by the hydraulic system and is moved to the hydraulic chapter.

Look in the Hydraulic chapter 5.

View of the radiator system

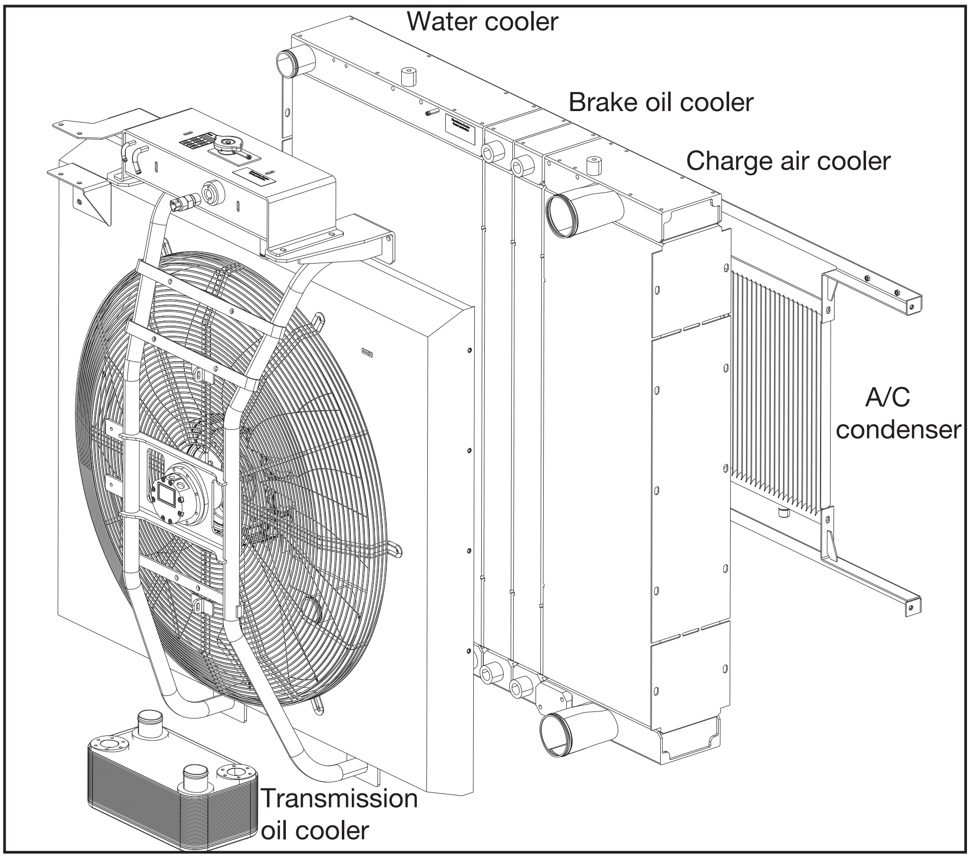


Figure 286

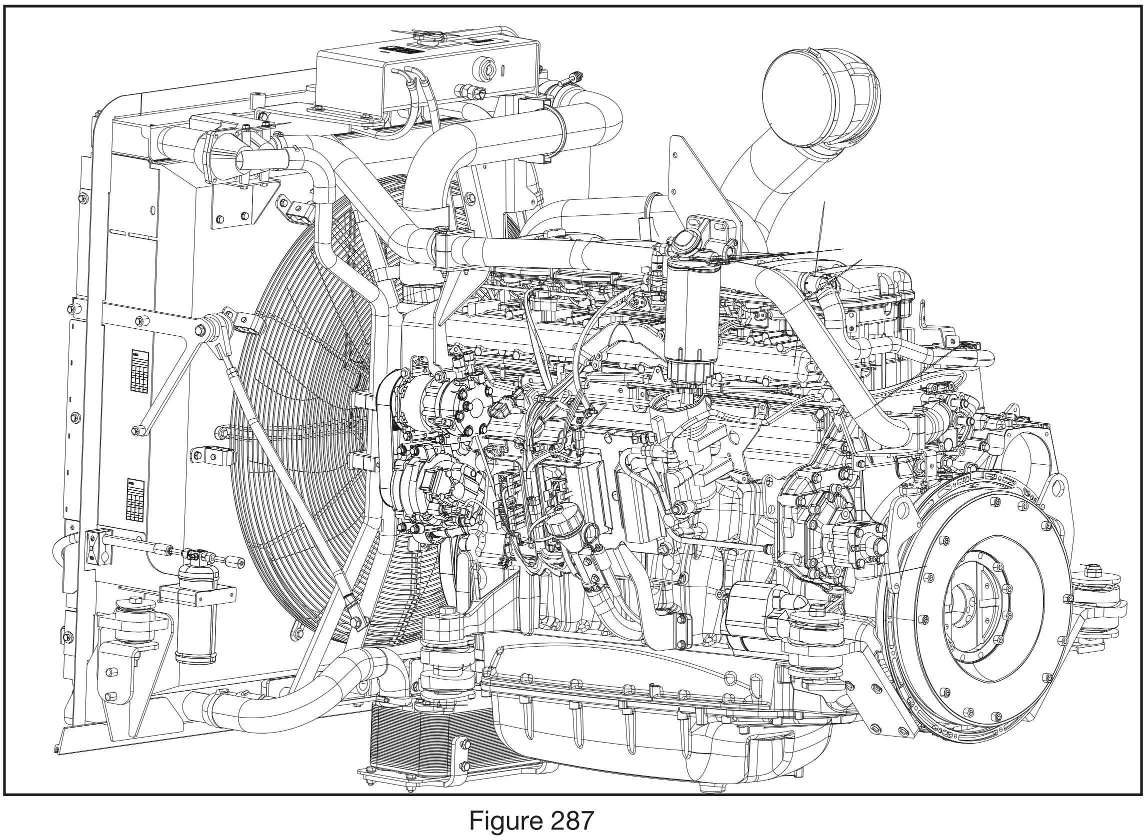


Figure 287

Cooling system

Principal view of the cooling system

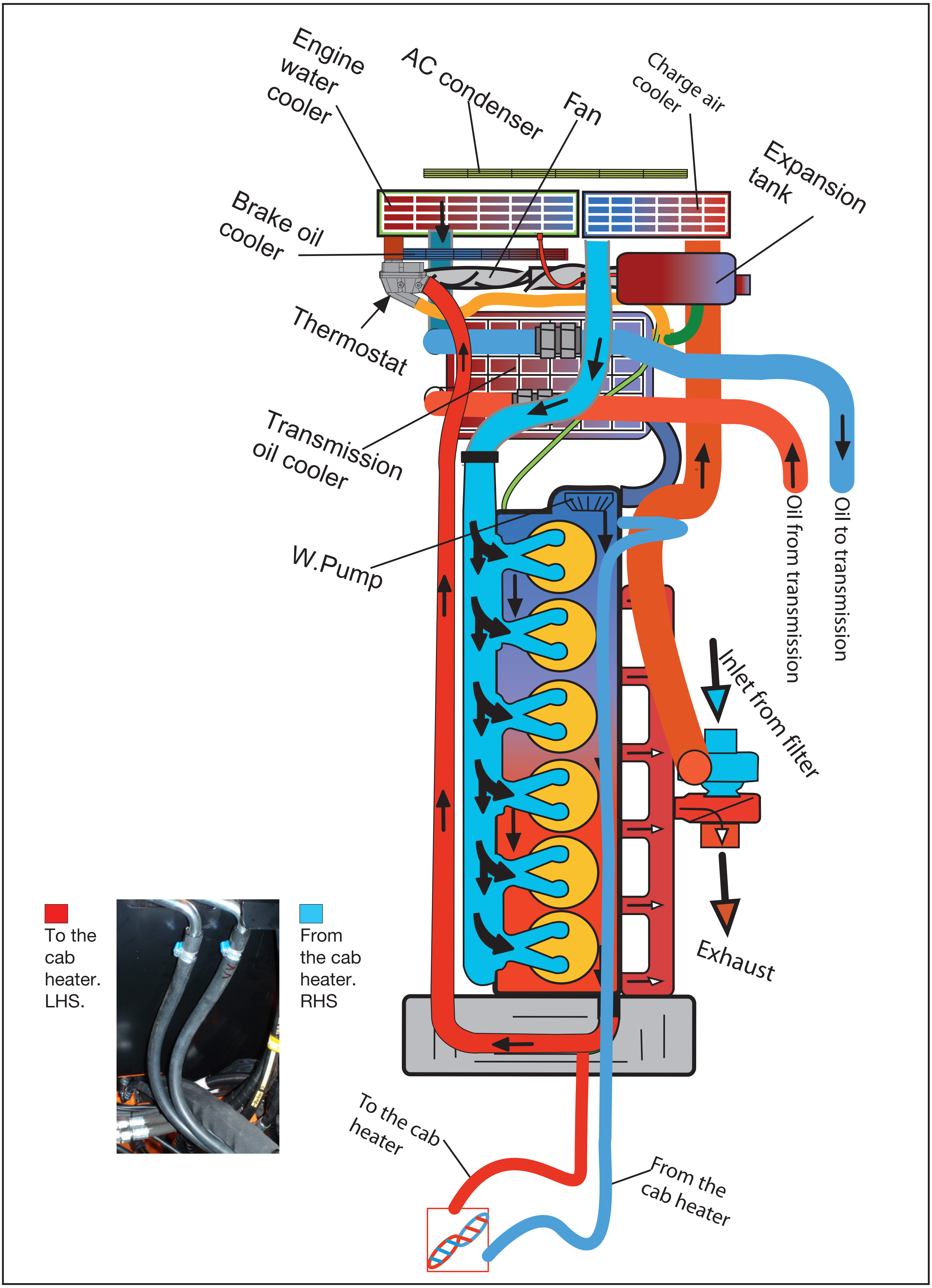


Figure 288

Circulation

From the pump, the coolant is carried into the cylinder block's longitudinal distribution ducting and then through holes in the cylinder block, washes round the cylinder liners and flows up to the cylinder heads.

The coolant is also forced directly up into the cylinder heads from the distribution ducting via passages which leads to the injectors and exhaust valves.

From the engine's rear cylinder head the coolant flows forward through the pipe directly into the thermostat housing, which is located on the left-hand side of the radiator shield.
The by pass in the thermostat housing forwards the coolant which is under the temperature limit for the thermostat, back to the engine through the transmission cooler. The coolant which needs to be cooled, are going through the open thermostat and to the radiator cooler system, through the transmission cooler and back to the engine, where the coolant pump is circulating the coolant in the system.

The cab heater takes the heat coolant from the pipe line on the backside of the engine, and after heating the cab, the returned coolant is going to the right-hand side of the engine where the coolant pump is located.

The turbo sucks air through a filter and then pushes the charge air through the charge air cooler. The hot charge air, on the inside of the CAC, is cooled by the cooling air - going through the CAC on the outside. The cooling air on the outside is sucked through all the coolers (in the cooling package) by a hydraulic fan. The pressure of the air, in the air charge system, to the cylinders is approx 1 - 2 bar (gauge), depend on the engine's rpm.

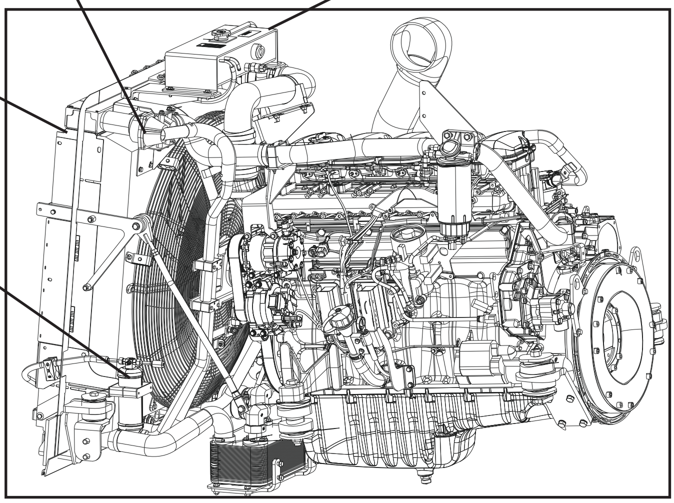


Figure 290

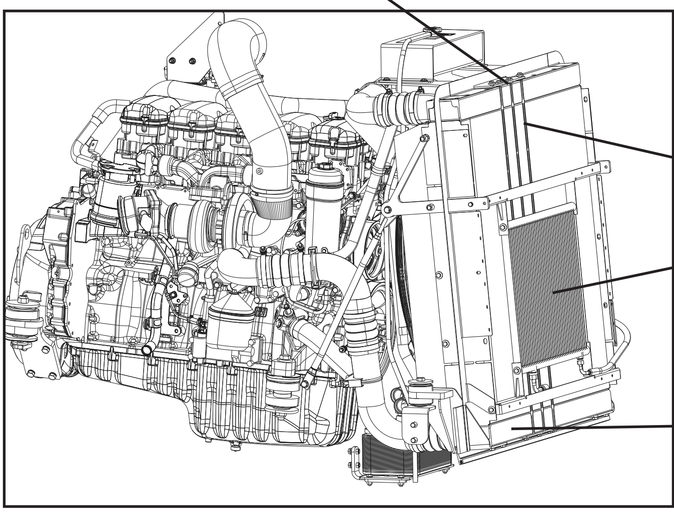


Figure 289

Coolant

NOTE

Coolant additives must be as follows:

• An antifreeze content of minimum 35 and maximum 60 percent by volume when there is a risk of freezing

NOTE

The coolant should be changed when the cooling system is cleaned: every 6,000 hours or at least every 5 years.

Coolant, resistance to cold

The following example shows coolant properties with 30 percent by volume of antifreeze:

• Ice slush starts to form at -16°C (3°F).

• At -30°C (-22°F), there is a risk of cooling system malfunction.

• There is no risk of damage by freezing with a minimum antifreeze content of 35 percent by volume.

The diagram depicts coolant properties at different percentages of antifreeze concentration by volume.

A	Ice formation starts (ice slush)
B	Damage by freezing occurs
1	Safe area
2	Malfunctions may occur (ice slush)
3	Risk of damage by freezing

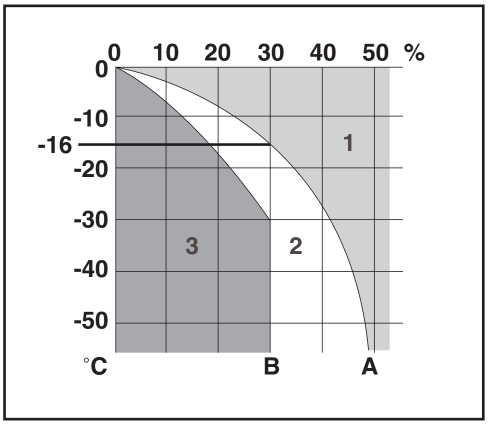


Figure 291

NOTE

Only pour pre-mixed coolant into the cooling system.

Checking coolant level

WARNING

Never open the coolant filler cap when the engine is hot. Hot coolant and steam may spray out and cause burns. If the cap has to be opened do it slowly and carefully to release the pressure before removing the cap. Wear gloves as the coolant is still very hot.

1. Check coolant level in level glass on the expansion tank. (See the black arrow on figure 292 and 293).

2. Top up with coolant as necessary.

Up to 7X1761 / 8X1730

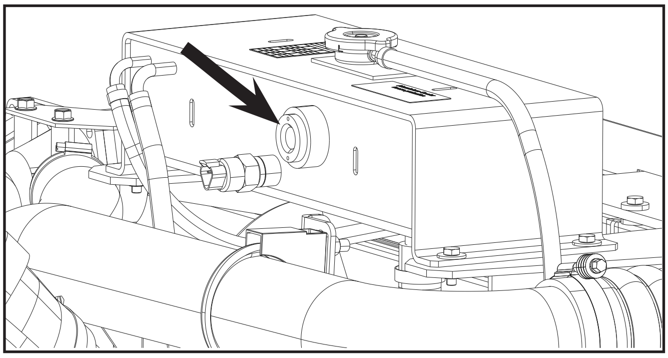


Figure 292

From 7X1762 / 8X1731

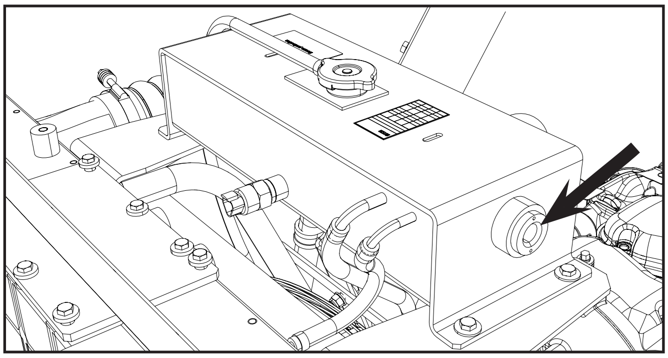


Figure 293

NOTE

It is not advisable to fill large amounts of coolant through the expansion tank. Fill according to the instructions in the section on changing the coolant.

NOTE

Never fill a large amount of cold coolant in a hot engine. There is great risk of cracks forming in the cylinder block and cylinder heads.

External leakage

External leakage is indicated by coolant leaking out onto the ground. First check all hose and pipe connections, including those for the bus heating system.

Internal leakage

Internal leakage in the engine can produce white exhaust gases and coolant in the engine oil. Then engine conditioning is the only solution.
Internal leakage in one of the bus oil coolers can lead to oil in the cooling system or coolant in the oil. Renew the defective oil cooler and clean the cooling system.

Checking the antifreeze level

NOTE

Use only pure fresh water that is free from particles, sludge and other impurities

1. Pour a small amount of coolant into a container and check that the coolant is pure and clear.
2. Change the coolant if it is contaminated or cloudy.
3. Measure the antifreeze content with one of the following instruments:

The following rules apply to ethylene glycol-based coolant:

- The antifreeze content must be minimum 35 percent by volume for corrosion protection to be sufficient.
- Fill with antifreeze if the antifreeze content is below 35 percent by volume.
- Antifreeze content greater than 60 percent by volume impairs the ability to protect against frost.
- If ice forms in the coolant, there are disruptions initially, but there is no immediate risk of damage. The engine should not be subjected to heavy loads when ice starts to form.

Changing coolant

NOTE

Avoid spillage and use a suitable container. Used coolant must be disposed of as specified in national and international law.

1. Pour a small amount of coolant into a container and check tha the coolant is pure and clear.
2. Change the coolant if it is contaminated or cloudy.
3. Measure the antifreeze content with one of the following instruments: The following rules apply to ethylene glycol-based coolant:

- The antifreeze content must be minimum 35 percent by volume for corrosion protection to be sufficient.
- Fill with antifreeze if the antifreeze content is below 35 percent by volume.
- Antifreeze content greater than 60 percent by volume impairs the ability to protect against frost.

If ice forms in the coolant, there are disruptions initially, but there is no immediate risk of damage. The engine should not be subjected to heavy loads when ice starts to form.

NOTE

Mix the coolant as specified under the section Coolant.

1. Remove the expansion tank cap.
2. Drain the coolant at the following two locations:
   - Lowest point of the cylinder block.
   - The lowest point of the cooling system.
3. Close the taps.

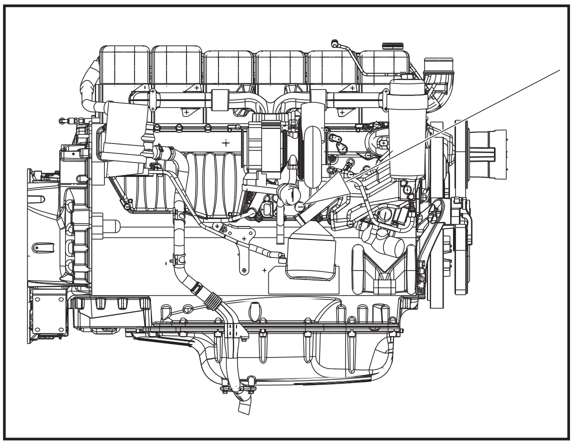


Figure 294

Filling coolant

1. Remove the filler cap from the expansion tank.
2. Close the cocks.
3. Fill with correct mixture, pre-mixed coolant through the expansion tank filler hole.
4. Set the heating control to maximum heating and start the engine. Idling speed must not exceed the normal rpm. Leave the engine idling for 15 minutes.
5. Stop the engine and top up with coolant to the maximum level through the expansion tank.
6. A small amount of air may still be left in pockets of the cooling system which will disappear when the vehicle is back on the road. This means that it will need some topping up to start with.

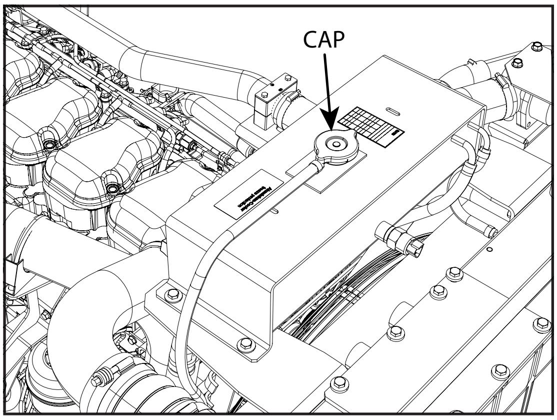


Figure 295

Cleaning the cooling system

NOTE

Clean the cooling system more often if necessary.

NOTE

Do not use caustic soda or other alkaline cleaning agent as this could damage the aluminium.

Cleaning the Radiator and Charge Air cooler (Outer)

1. Check that the radiator and the charge air cooler are not clogged on the air side and that the cooling fins are not damaged.

2. Carefully scrape away any deposits from the radiator cooling fins. Use a paraffin-based engine cleaner if necessary.

3. Carefully straighten bent cooling fins using a steel brush or similar.

WARNING

To ensure proper handling of cooling system detergent, study the warning text on the package

Removing Oil and Grease (Inner)

1. Run the engine until it has reached operating temperature and then drain the cooling system.

2. Remove the thermostats.

3. Fill the system with clean, hot water mixed with liquid dishwasher detergent intended for household appliances. Concentration 1%.

4. Run the engine until it has reached operating temperature for approximately 20-30 minutes. Remember to switch on the cab heating system, if one is installed.

5. Drain the cooling system.

6. Refill the system with clean hot water and run the engine for about 20-30 minutes.

7. Drain the water from the system.

8. Refit the thermostats.

9. Fill the system with new coolant following the specification under Coolants earlier in the document.

NOTE

Avoid spillage and use a suitable container. Used coolant must be disposed of as specified in national and international law.

Disassemble the cooling unit

1. Drain the coolant. First, remove the cover on the front left underside.

Connect drain hose with Rölex connection to radiator and drain the coolant

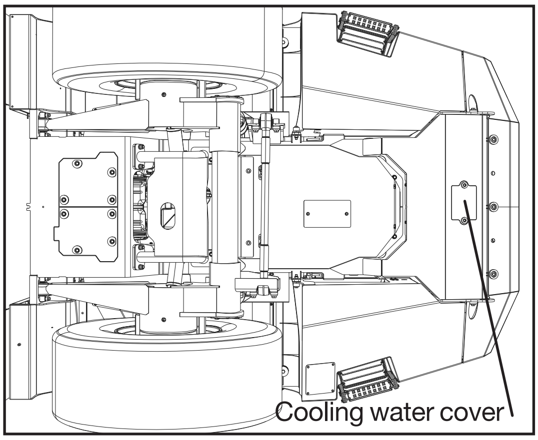


Figure 296

NOTE

Use a clean drum or similar if the cooling water should be reused. It is recommended to supply with new oil when refilling oil to the transmission.

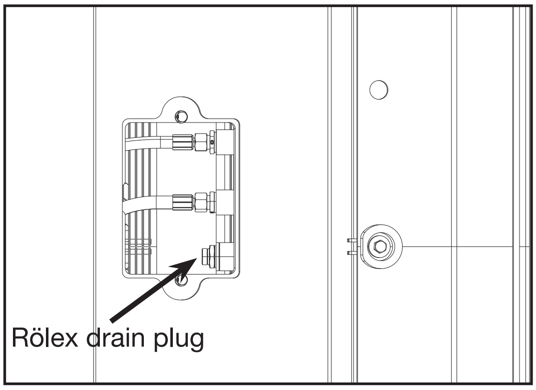


Figure 297

2. Disassemble the wiring and hoses, remove the wiring strips and clamps from the brackets.
3. Disconnect the cooling hoses from the thermostat housing and transmission oil cooler.
4. Disassemble the charge air hose.
5. Disconnect hoses between the expansion tank and the engine. Remove clamps.
6. Disassemble oil hoses from fan motor, hydraulic oil cooler and brake oil cooler. Remove clamps, there are two clamps on HA30, while on HA45 there is three clamps.

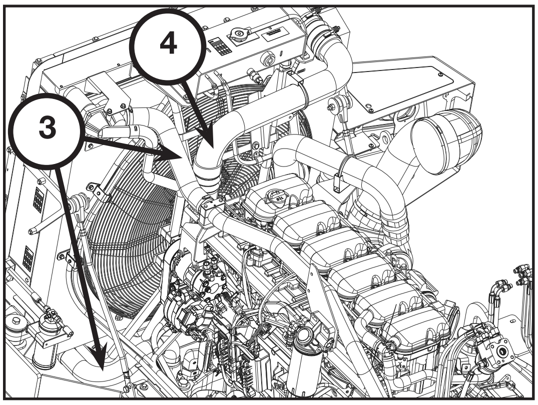


Figure 298

NOTE

Oil under hydraulic pressure !

The oil system for the fan motor is in the same oil system as the brake, therefore it is recommended when disassembling hoses or units from this system, always to eliminate pressure in the accumulator, located on the right side, under the cab. This can be done by operating the brake pedal several times. (Approx 15-20 times)

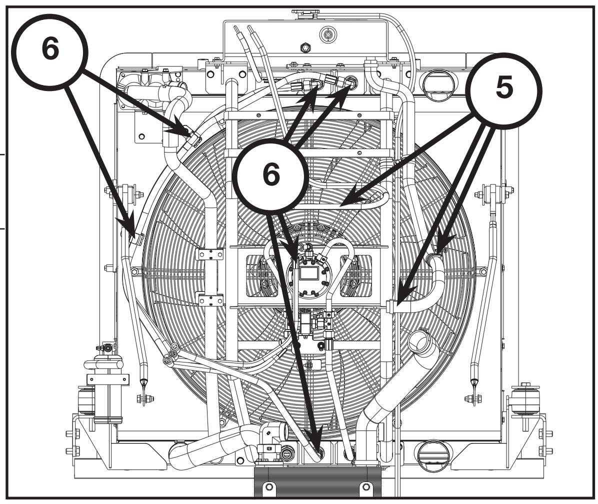


Figure 299

7A. Disassemble the sealing plate on the left side.

7B. Disassemble the drying filter, incl bracket.

7C. Disassemble the condenser, leaving the top frame.

Place the condenser and the dryer filter on the left side of the engine.

NOTE

Do not disassemble the air condition hoses from the condenser filter or the compressor.

Up to 7X1761 / 8X1730

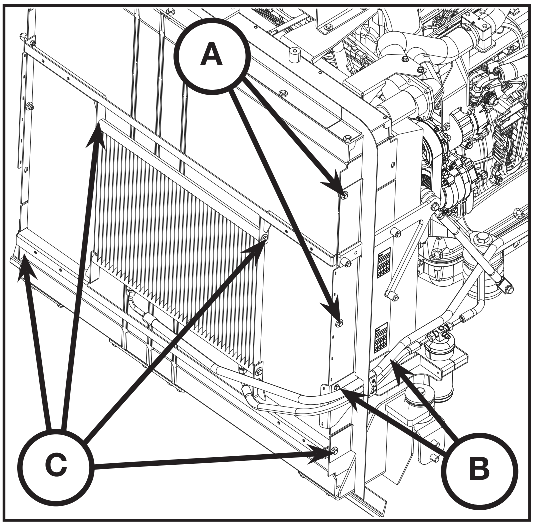
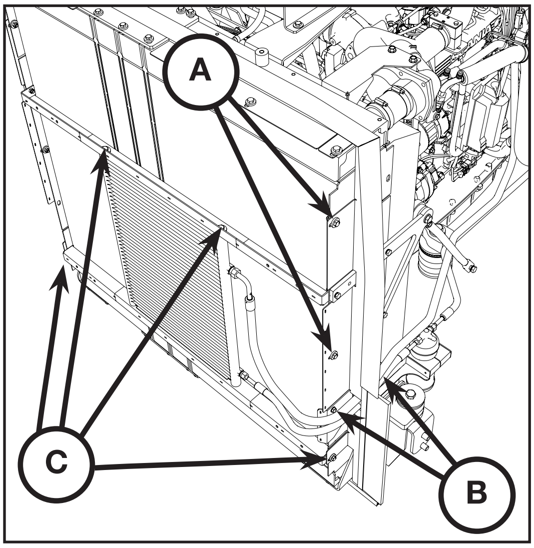


Figure 300

From 7X1762 / 8X1731



8. Fasten 2 pcs M10 lifting eyes on top of the cooling unit, and attach the lifting device to these.

Check that all cooling pipes and hoses are disassembled

9. Disassemble the stay bars from the frame (both sides).

10. Disassemble lower fastening 2 screws (left and right hand side).

11. Check again that all wiring and hoses are disassembled.

Carefully lift the cooler unit out from the frame.

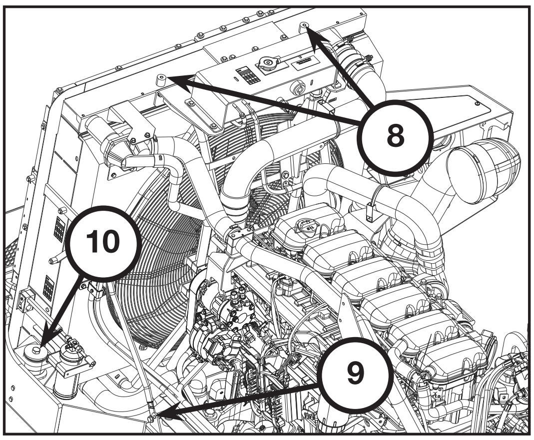


Figure 301

Disassemble the cooling unit

1. Drain the coolant from the cooling system (See chapter on disassembly of cooling pack)
2. Drain the transmission oil.

   Removeright side cover under transmission.

   Connect drain hose with Rölex connection and drain oil.

   Beware that some amount of oil may be left in hoses and cooler.

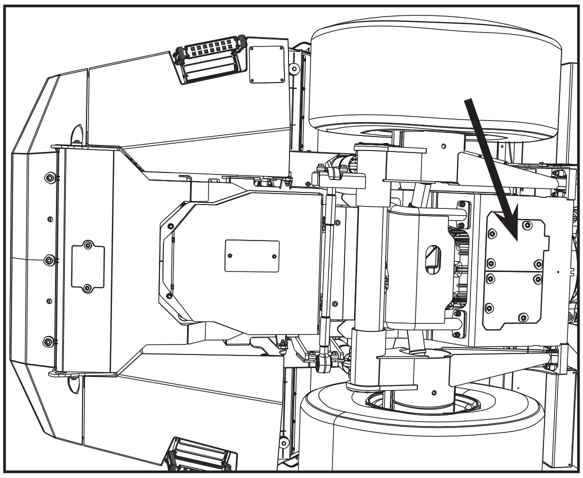


Figure 302

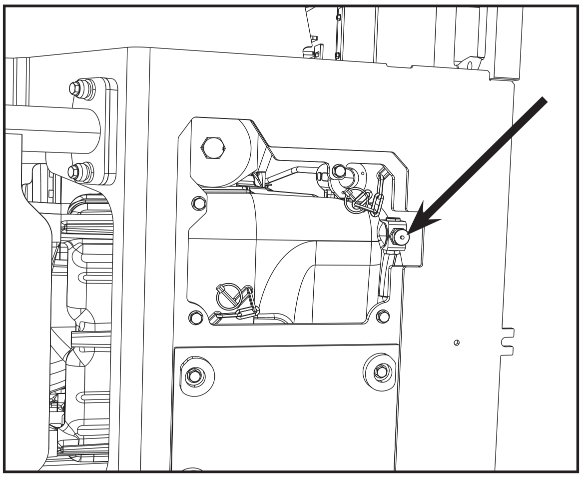


Figure 303

3. Disconnect water hoses.
4. Disconnect oil hoses.
5. Disconnect oil cooler.

   Carefully lift the oil cooler out from the frame.

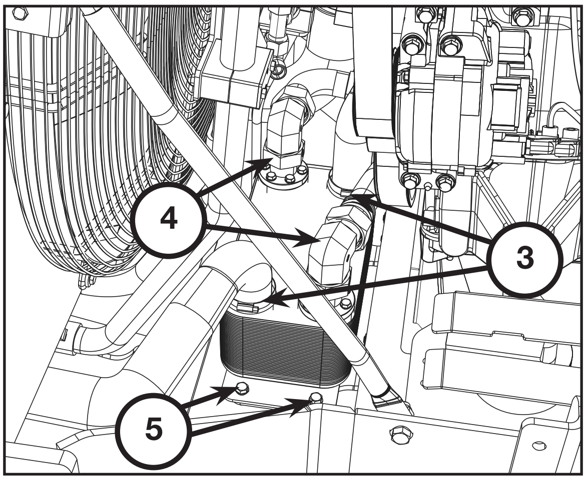


Figure 304

Thermostat and thermostat housing

The engine have a double thermostat.

When a double thermostat are used they have the same opening temperature as standard.

The thermostats use wax as the temperature-sensitive medium.

At coolant temperatures below the opening temperature of the thermostats, nearly all the coolant circulates between the engine's coolant passages and the coolant pump without passing through the radiator.

When the coolant temperature in the engine is higher than the temperature for fully open thermostat, the by-pass channel is closed and all coolant flows through the thermostats and on to the radiator.

If temperature equilibrium occurs within the operating range of the thermostats, i.e. between the temperature limits for fully closed and fully open thermostat, the thermostat valves will assume a corresponding intermediate position.
Some of the coolant will then be directed to the coolant pump without being cooled and the remainder directed to the radiator.

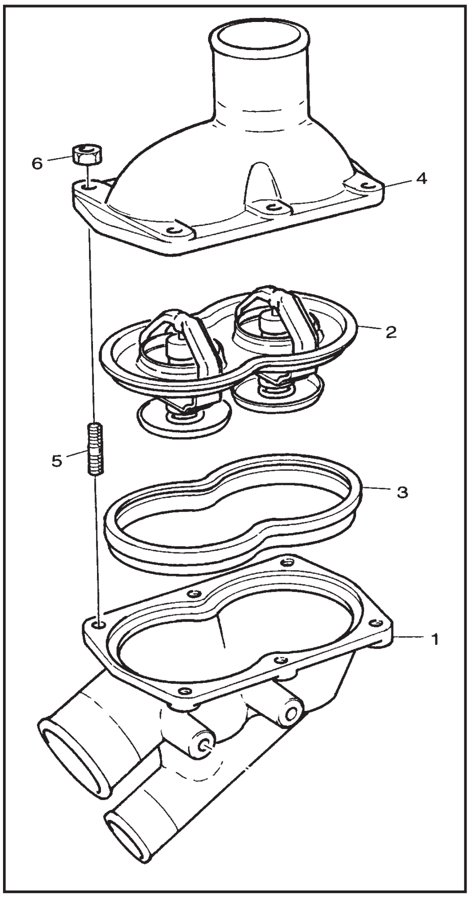


Figure 305

1. Termostat housing
2. Thermostat
3. Gasket
4. Cover
5. Stud
6. Flange nut

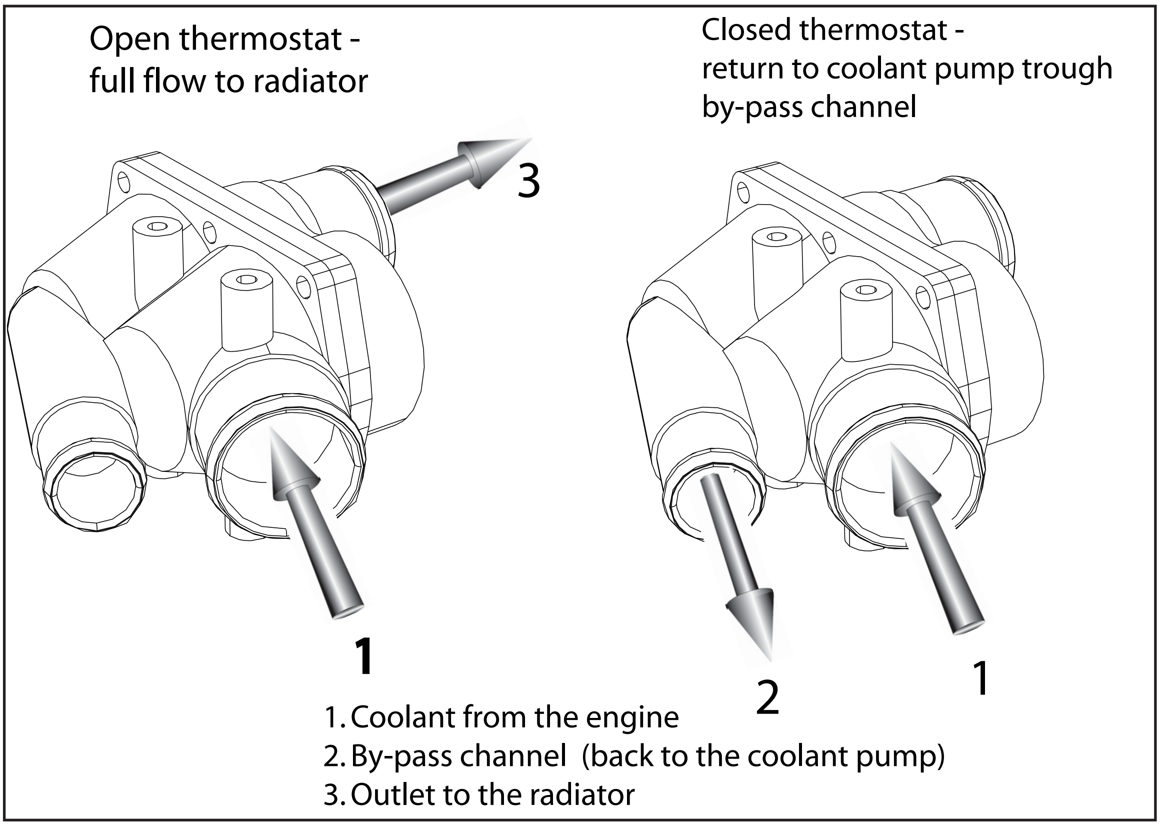


Figure 306

Thermostat

Removing

1. Remove the expansion tank filler cap.

   Drain a sufficient amount of coolant from the system.

2. Remove the hose from the thermostat housing cover.

   Detach the thermostat housing cover and remove the thermostat (double thermostat).

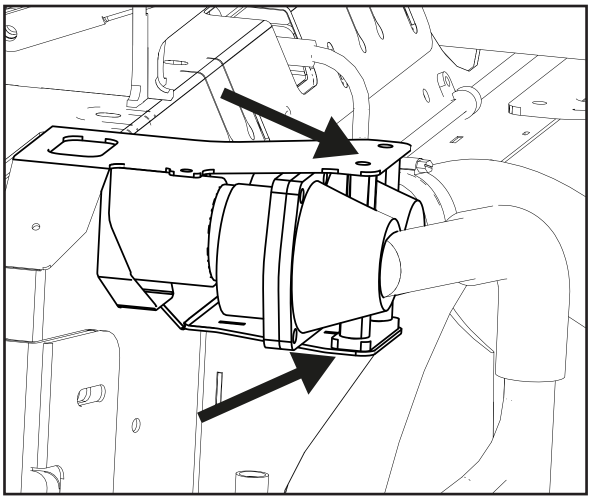


Figure 307

Fitting

1. Clean the thermostat housing and check that nothing obstructs the function of the thermostat.

2. Insert the thermostat in the housing. Fit new gaskets and screw the thermostat housing together.

3. Fill the system with coolant. See **OPERATING & MAINTENANCE MANUAL** chapter 7 for the composition of the coolant.

4. Start the engine and check that there are no leaks. Check the coolant level and top up as necessary.

Apply Loctite No. 510
Part No. 516204

Assemble cover;
Screw No. 051735 M8 x 38 - 8.8
Nut No. 502975 M8

Torque with 24 Nm

Figure 308

Coolant pump

The coolant pump is located at the front side of the front cover on the right-hand side of the engine.

The coolant pump is driven by a multigroove belt directly from the crankshaft damper.

The pump is of centrifugal type and consists of a spiral shaped pump housing with an impeller directly mounted on the driveshaft. The shaft is mounted in the housing and by means of two permanently lubricated ball bearings.

The pump shaft bearing is sealed against the ingress of coolant by an elastic axial seal.

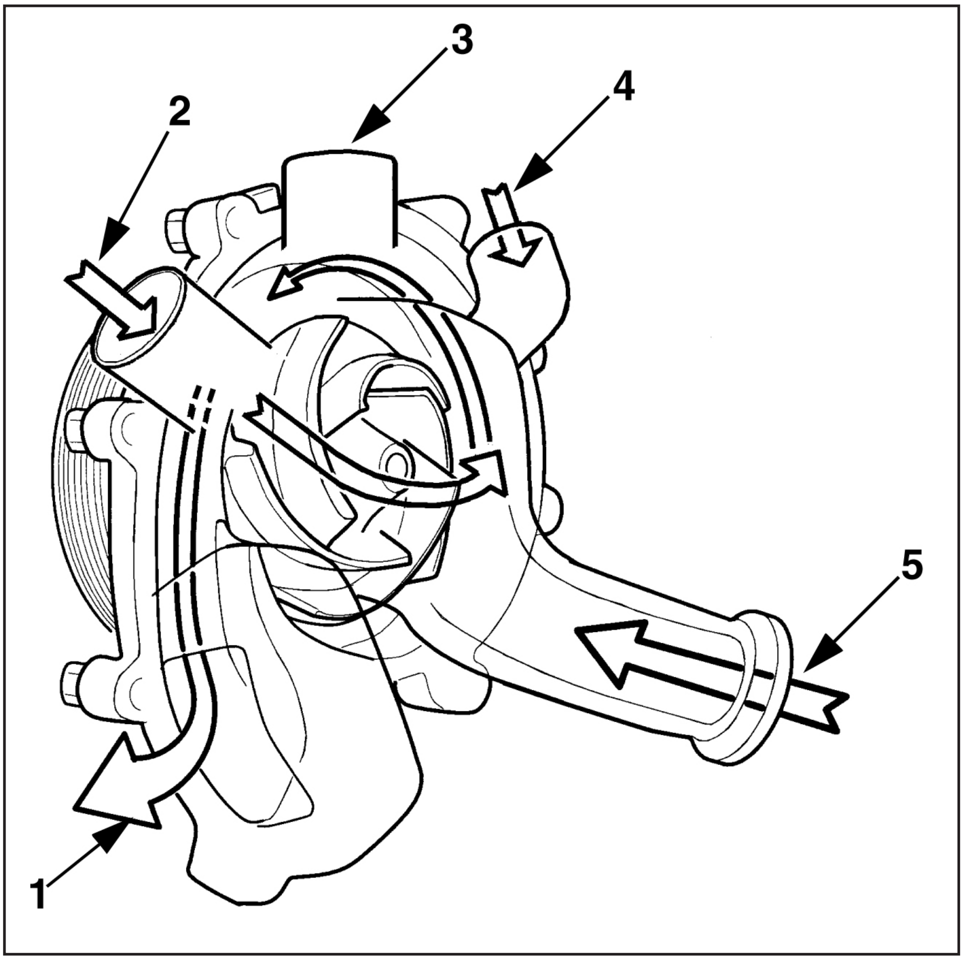


Figure 309
Circulation through coolant pump

1. Outlet to engine
2. By-pass channel
3. Static line
4. Return from charge air cooler
5. Coolant from radiator

Removing

1. Drain the cooling system through the drain taps in the block and in the pipe from the outlet on the radiator.
2. Remove any protection meshes and fan ring with sealing ring to gain access to the fan.
3. Remove the fan.
4. Turn the automatic belt tensioner and prise the poly-V-belt off the coolant pump pulley.
5. Remove the coolant pump assembly. Fitting the pump.
6. Clean old gasket debris from the sealing surfaces.
7. Fit the pump without damaging the seal(s).
8. Fit the automatic belt tensioner.
9. Fit the (poly-V) drive belt and any protection mesh and fan ring with sealing ring.
10. Fit the fan.
11. Fill the cooling system. See booklet 00:03-01 for the composition of the coolant.
12. Start the engine and check that no leakage occurs. Check the level of the coolant and top up as necessary.

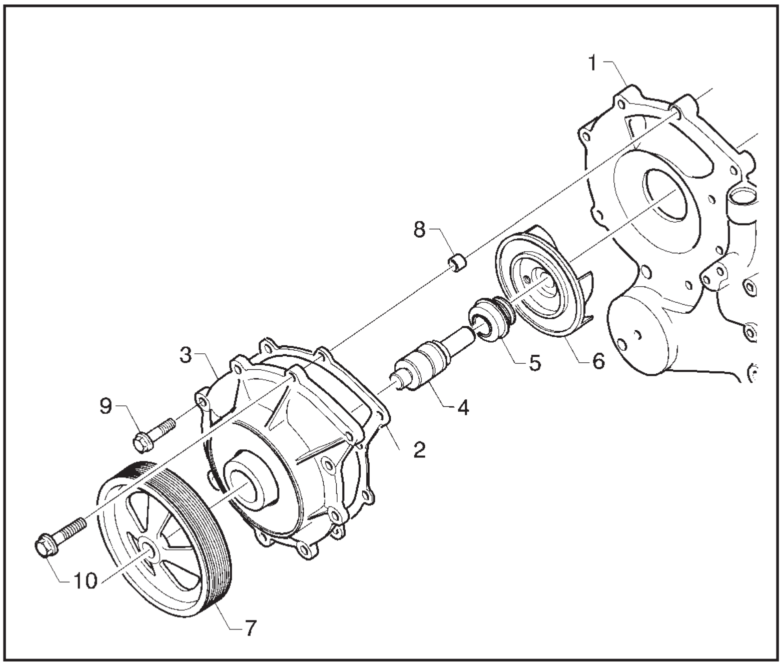


Figure 310

1. Front cover
2. Gasket
3. Pump cover
4. Shaft with bearing
5. Sealing ring
6. Impeller
7. Pulley
8. Guide sleeve
9. Flange screw
10. Flange screw

Changing the pulley

1. Remove the pulley using puller 501348 and drift 501349.
2. Press the pulley on until it is flush with the shaft end face.

The pulley is removed

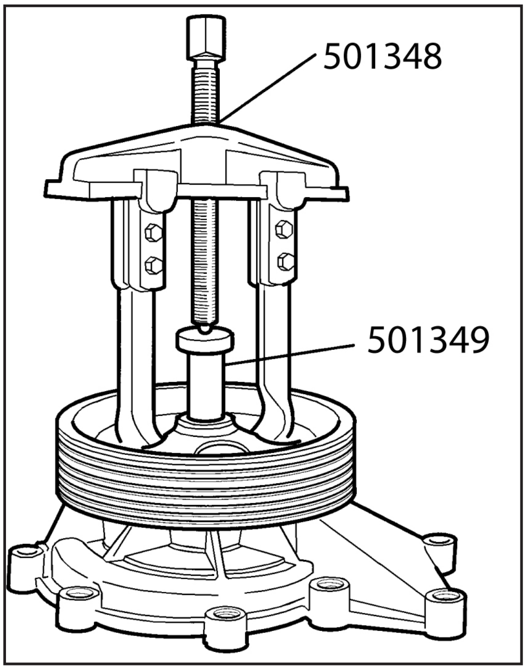


Figure 311

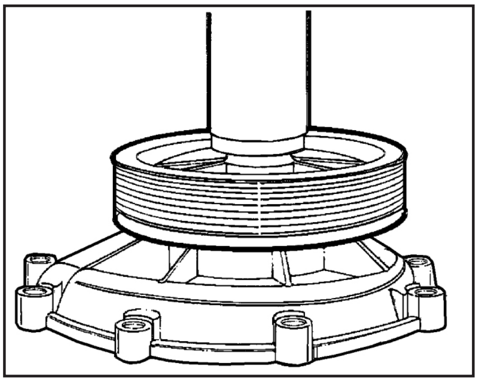


Figure 312

The pulley is pressed on

Changing the sealing ring

If coolant has leaked out inside the housing behind the pulley, the sealing ring can be changed.

1. Place the pump with pulley on a flat and level surface.
2. Fit puller 501354 using two M8 x 65 mm bolts and drift 501349. Pull off the impeller.
3. Split the carbon ring on the seal and remove the debris.

The impeller is removed

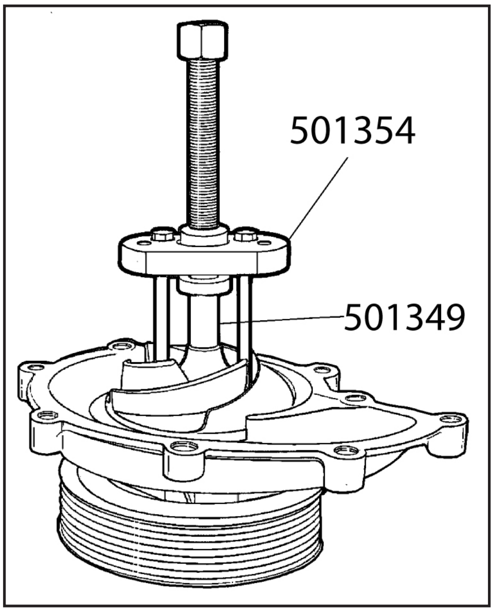


Figure 313

4. Prise off the seal using two screwdrivers and separator plates.

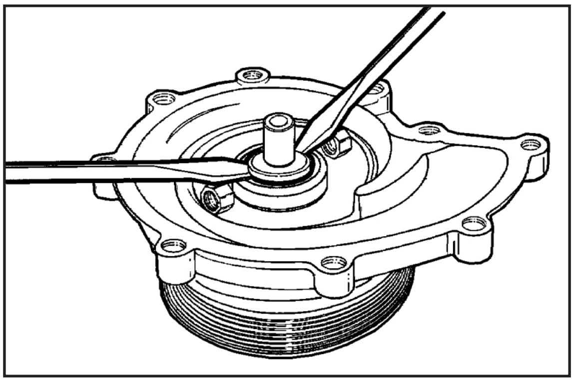


Figure 314
The seal ring is removed

NOTE

Do not damage the pump housing gasket surface.

5. Apply sealing agent (501350) to the inside and outside (brass sleeve) of the sealing ring. Make sure that no sealing agent gets onto other sealing surfaces.

Important!

Sealing agent (501350) should be used sparingly. There is a risk of the sliding surfaces being glued together.

6. Press in the new sealing ring with drift 501351 until the edge of the brass sleeve abuts against the pump housing. Keep it under pressure for about 10 seconds.

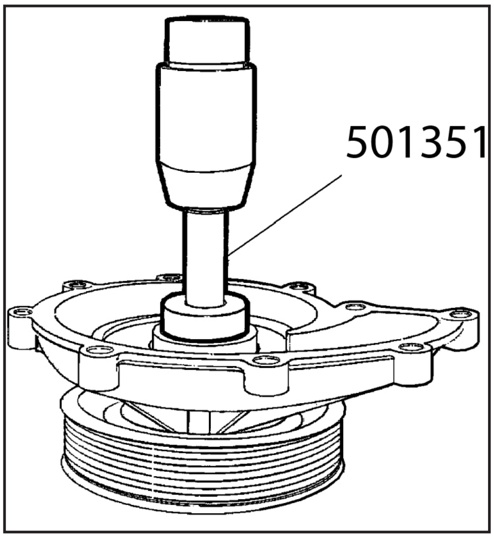


Figure 315
The new seal ring is pressed in

NOTE

It is very important that tool 501351 is used. It is designed to correctly preload the spring which holds the seal.

7. Press on the impeller using drift 501351 until the clearance between the gasket surface of the pump housing and the end of the impeller shaft is 13.3 - 13.7 mm.

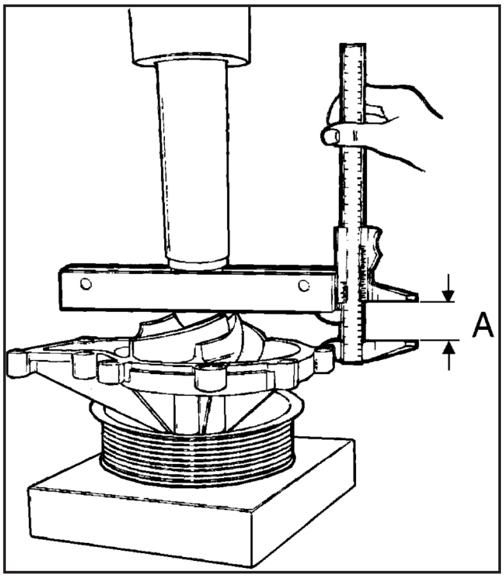


Figure 316

A = 13,3 - 13,7 mm
The clearance is measured

Important!

The shaft must not change position in the pump housing as there is a danger that the sealing ring would then also change its position.

Puller for pulley	501348
Drift for pulley	501349
Puller for impeller	501354
Drift for pressing in sealing ring and for impeller	501351

External cleaning

Radiator

- Check that the radiator is not clogged on the air side and that the cooling fins are not damaged.
- Carefully scrape the deposit off the radiator’s cooling fins. If necessary, a paraffin-based engine cleaner can be used.
- Bent fins can be straightened using a wire brush, for example, and exercising care.

Internal cleaning

Removing oil and grease

- If possible, run the engine until it has reached the operating temperature and then drain the cooling system.
- Remove the thermostat.
- Fill the system with clean, hot water mixed with liquid dishwasher detergent intended for household use. Concentration 1% (0.1/10 l).
- Run the engine until warm for about 20-30 minutes. Do not forget the cab heating system (if fitted).
- Drain the cooling system.
- Fill the system again using clean, hot water and run the engine for approximately 20-30 minutes.
- Drain the water from the system.
- Refit the thermostat.
- Fill up with new coolant.

WARNING

Handling cleaning agents for the cooling system: Read the warning label on the container.

Removing deposits

- If possible, run the engine until it has reached operating temperature and then drain the cooling system.
- Remove the thermostat.
- Fill the system with clean, hot water mixed with a commercially available radiator cleaner based on sulphamic acid and containing dispersing agents. Follow the manufacturer’s instructions for mixing proportions and cleaning times.
- Run the engine for the specified time and then drain the cooling system.
- Refill the system with hot water and run the engine for approximately 20-30 minutes.
- Drain the water from the system.
- Refit the thermostat.
- Fill up with new coolant.

Mind the environment!

Always collect fluid in a suitable container to avoid spillage when draining coolant.
Dispose of used coolant through an authorized waste disposal contractor.

Technical data DC13 with PDE

General data

Number of cylinders and configuration	6, straight
Working principle	4 stroke engine
Cylinder diameter (mm/in)	130/5,12
Cylinder diameter (mm/in)	140/5,56
Displacement (dm^3/in^3)	12,7/775,0
Firing sequence	1-5-3-6-2-4
Compression ratio	17,3:1
Engine direction of rotation, viewed from rear	Anticlockwise
Fan direction of rotation, viewed from front	Clockwise
Cooling	Coolant
Valve clearances, cold engine: intake valve (mm/in) outlet valve (mm/in)	 0,45/0,02 0,70/0,03
Number of teeth on the flywheel	158
Low idling speed (rpm)	600-750
Maximum full-load speed (rpm)	2 100
Fuel	Diesel
Weight, without coolant and oil (kg/lb)	1050/2315

Lubrication system

Oil volume	See Inspection
Oil cleaning	Centrifugal oil cleaning
Oil cooler	Coolant cooling, full flow
Oil filter	Paper filter from Scania
Interval between oil changes (h)	500
Oil pressure (kp/cm^2 (bar)/psi) normal with the engine at operating temperature, operating speed minimum permitted at idling speed	 3–6/43,4–87 0,7/10,2
Crankcase pressure with closed crankcase ventilation (mmH_2O/inH_2O)	-55–+20/-2,2–+0,8

Injection system

Type	PDE (unit injector)
Control system	EMS
Fuel filter	Paper filter from Scania
Fuel filter with water separator	Paper filter from Scania

Cooling system

Volume, excluding radiator (dm^3/US gallons)	16/4,2
Coolant temperature (°C/°F)	80–90/176–194
Number of thermostats	1
Thermostat, opening temperature (°C/°F)	80/176

Intake system

Permissible pressure drop in the system with cleaned or new filter (mmH_2O/inH_2O/mbar)	300/12/29
Permissible pressure drop in the system with a clogged (dirty) filter (mmH_2O/inH_2O/mbar)	500/20/49

Electrical system

Type	1-pin, 24 V, DC
Starter motor (standard equipment)	1-pin, 24 V, 5.5 kW
Alternator (standard equipment)	1-pin, 28 V, 100 A

Technical data DC9 with PDE

General data

Number of cylinders and configuration	5, straight
Working principle	4-stroke engine
Cylinder diameter (mm/in)	130/5.12
Piston stroke (mm/in)	140/5.51
Displacement (dm^3/in^3)	9.3/567.5
Firing sequence	1 - 2 - 4 - 5 - 3
Compression ratio	16:1[1]
Engine direction of rotation viewed from rear	Anti-clockwise
Fan direction of rotation viewed from front	Clockwise
Cooling	Coolant
Valve clearances, cold engine	
Intake valve (mm/in)	0.45/0.02
Outlet valve (mm/in)	0.70/0.03
Number of teeth on the flywheel	158
Low idling speed (rpm)	500-1,050
Maximum full-load speed (rpm)	2,100
Fuel	Diesel
Approximate weight, without coolant and oil (kg/lb)	950/2,094

1. For engines with performance and certification code 076, the compression ratio is 18:1.

Lubrication system

Oil volume	See Inspection
Oil cleaning	Centrifugal oil cleaning
Oil cooler	Coolant cooled, full flow
Oil filter	Paper filter from Scania
Interval between oil changes (h)	500
Oil pressure (bar)	
Normal with the engine at operating temperature, operating speed	3-6
Minimum permitted at idling speed	0.7
Crankcase pressure with closed crankcase ventilation (mbar)	-5.4 to 2.0

Injection system

Type	PDE (unit injector)
Control system	EMS
Fuel filter	Paper filter from Scania
Fuel filter with water separator	Paper filter from Scania

Cooling system

Volume, excluding radiator (dm^3/US gallons)	15/4.0
Coolant temperature (°C/°F)	90-95/194-203
Number of thermostats	1
Thermostat opening temperature (°C/°F)	80/176 and 87/189

Intake system

Permissible pressure drop in the intake system with cleaned or new filter (mbar)	30
Permissible pressure drop in the intake system with blocked (dirty) filter (mbar)	65

Electrical system

Type	1-pin, 24 V, DC
Starter motor, standard equipment	1-pin, 24 V, 5.5 kW
Alternator, standard equipment	1-pin, 28 V, 100 A

Troubleshooting SDP3 / Canbus

To do:

The troubleshooting manual is included in the machinery computer system.
Please connect Scania software system.

Troubleshooting - basic info

Troubleshooting in electronic control systems requires access to a multimeter and/or PC and SDP3.

Our electronic control systems store fault codes in their control units. The fault code can be read off using a PC and SDP3. It is generally possible to locate faults and test various components relatively easily using a PC and SDP3.

Control Area Network, CAN

Our electronic control systems operate in networks with other control units and components, CAN communication.
It is not possible to carry out troubleshooting with a test lamp in electronic control systems which use CAN communication. Troubleshooting is carried out on these control systems with a PC and SDP3. Cables which form part of CAN communication controlled circuits are marked with the letters CAN on their connections.

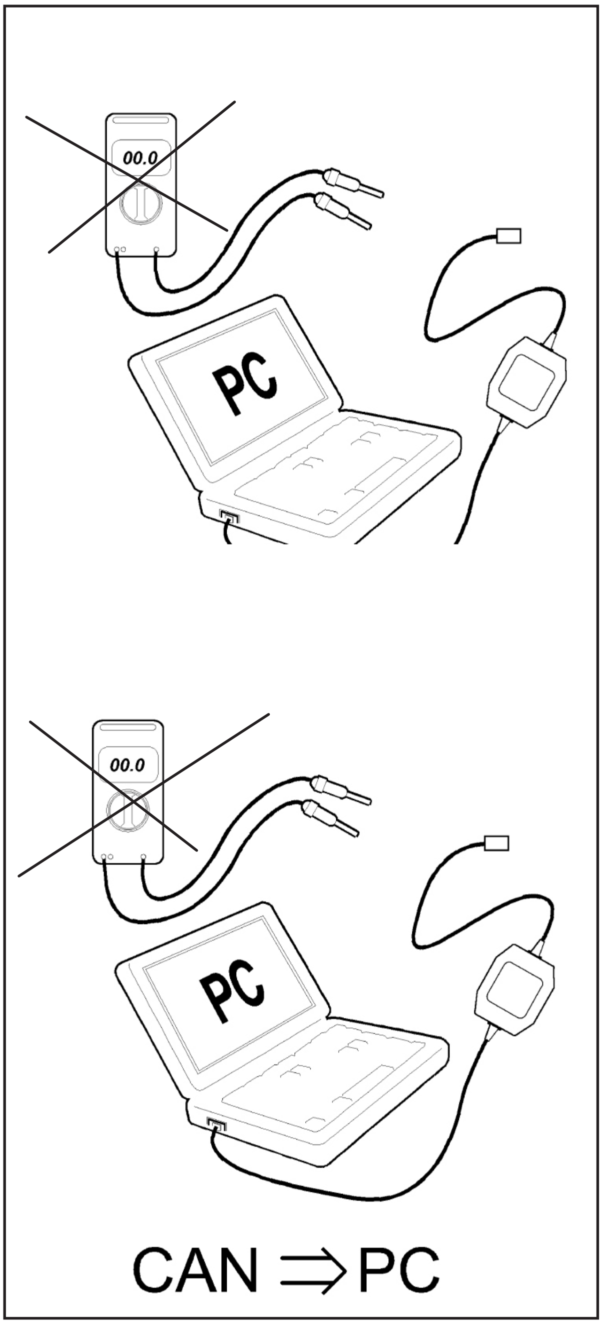


Figure 317

Diagnostic procedure

Use of diagnostic kit

1. Disassemble cover inside cab right side rear for connection point.

Figure 318

Connection point Canpc + OBDII conector

Connect diagnostic cable to laptop.

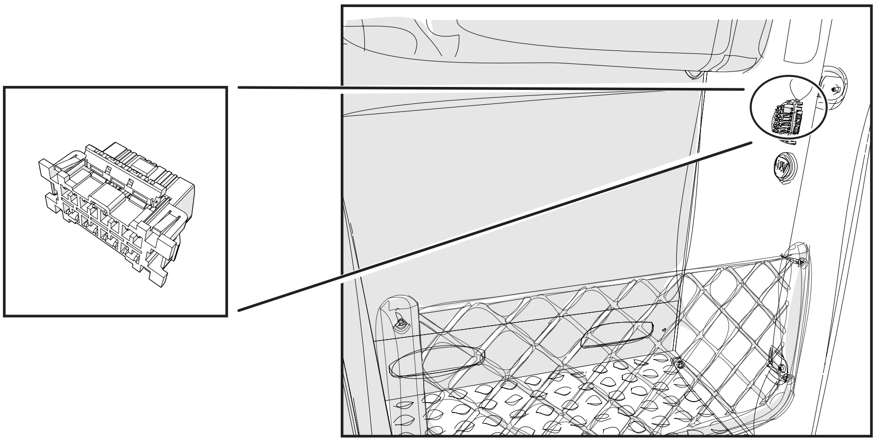


Figure 319

Can bus overview

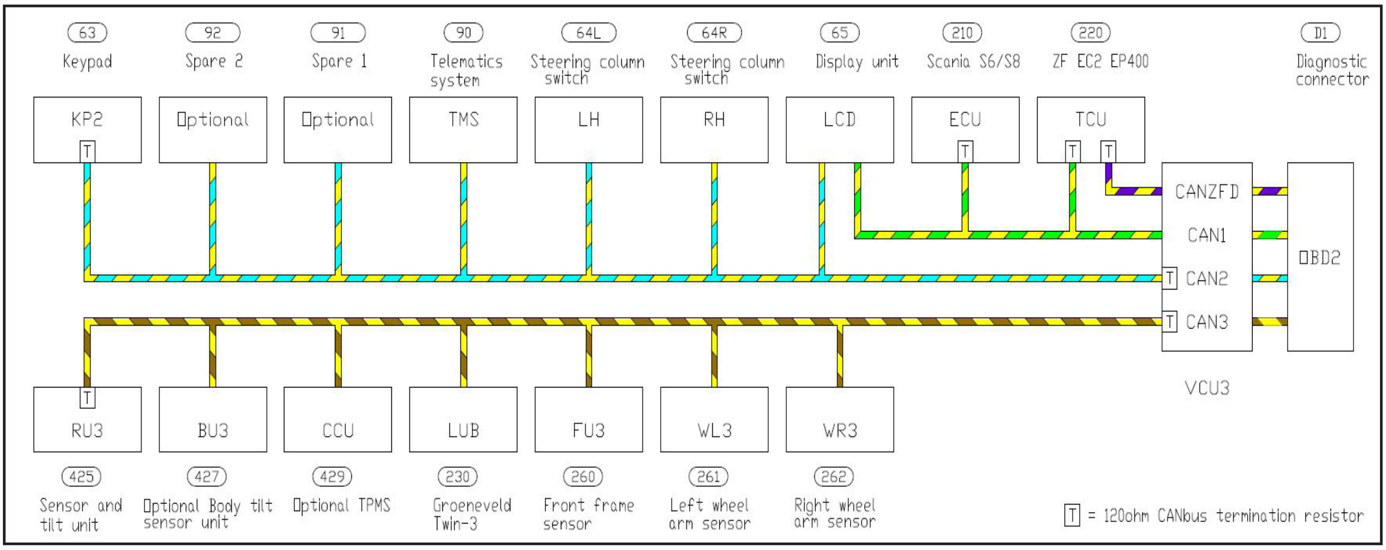


Figure 320

SDP3 Scania dagnostic

On left side of the engine there is the connection point for VCI (Scania diagnostic tool).

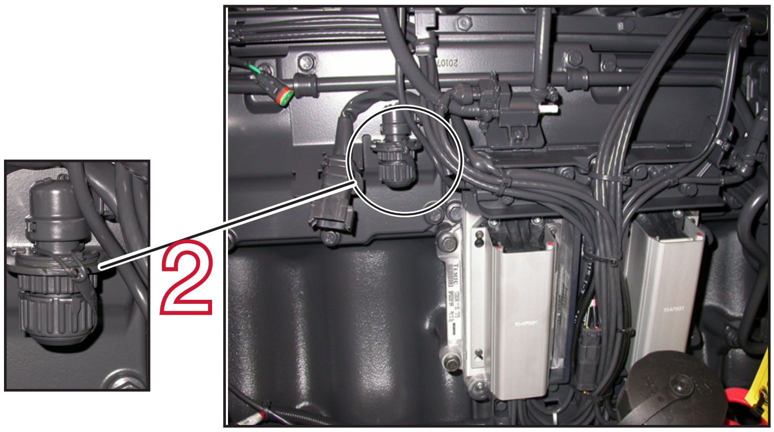


Figure 321

Connect the VCI :

1. Switch on the laptop.
2. Connect the end of the cabel (2) to the engine testport.
3. Connect the USB plug (3) to the laptop.
4. Put in the USB-licence key.
5. Switch on the ignition key (If read the setting parameters).
6. Start the engine SDP3 on the laptop.
7. Start the engine (If controlling of the parameters).

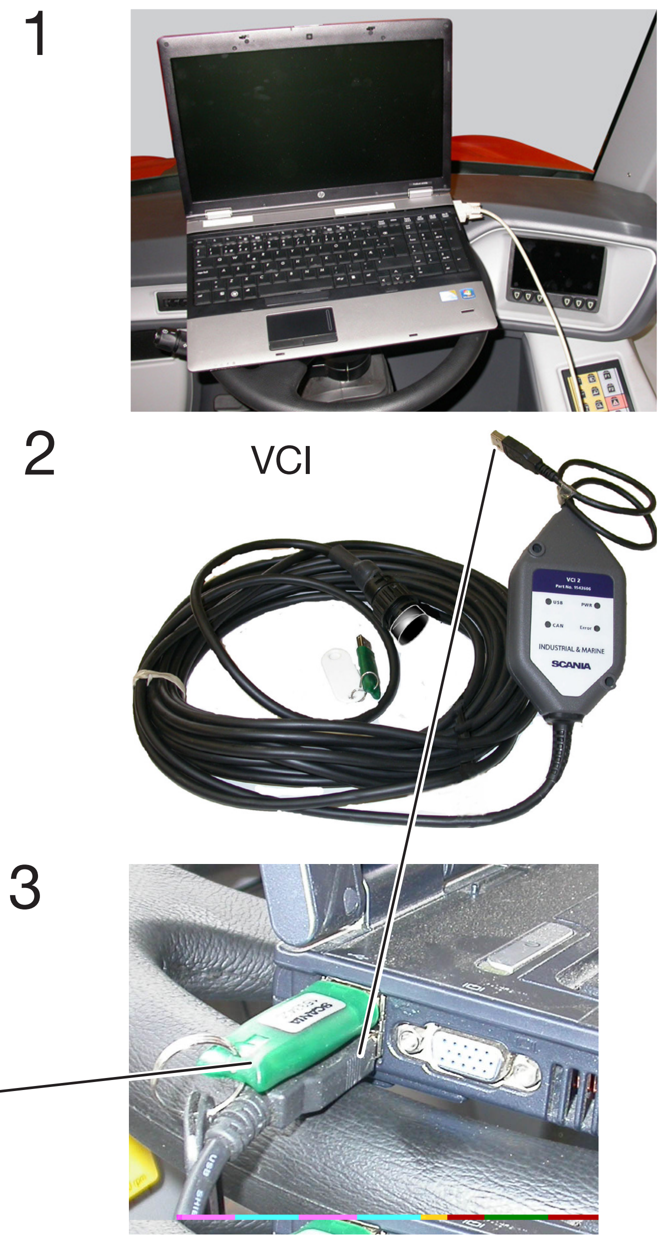


Figure 322

Troubleshooting Manual

The troubleshooting schedule is intended as a guide and source of ideas for practical troubleshooting carried out on the spot by experienced mechanics. The schedule contains the causes of faults which they the Scania have encountered over the years and it will be expanded with new causes of faults as they occur and as we gather knowledge about them.
If you like, use the form on the last page to report anything you think is missing from the troubleshooting schedule. That is the best way of keeping it up-to-date. The columns in the troubleshooting schedule headed “Troubleshooting” and “Action” describes such matters th at are not covered in other parts of the workshop manual. If these columns are empty, instructions can be found in other sections.

White smoke

Effect	Cause	Trouble shooting	Action
Incompletely burnt fuel	Cold engine	The white smoke starts to turn blue and disappears when the engine is warmed up	- If possible: reduce engine speed or put the engine under load - Install a white smoke limiting device (exhaust brake) - Install flame heater - Install an engine heater
Too much fuel in relation to air at low combustion temperatures	Injection timing too late		
	Inlet valve does not open properly. Valve adjustment disturbed		
	Broken delivery valve spring, uncontrolled injection	Disconnect one delivery pipe at a time and listen for changes in the engine sound. WARNING! Be careful when disconnecting the delivery pipes as the pressure is extremely high and could cause injury	
	Leaky injector, dripping?		

White smoke, water vapour

Effect	Cause	Trouble shooting	Action
Water in the combustion chamber	Leaky charge air cooler	Test pressure (air 0.5 bar, liquid 4 bar)	
	Leaky cylinder head gasket	The fault is also present when the engine is hot	
	Cracked water-cooled exhaust manifold		
	Cracked cylinder head (not cracks between valve seats).	If the fault is hard to trace: Change all cylinder heads for exchange cylinder heads. (Or test pressurize all cylinder heads. Heat the cylinder heads before pressurizing them.)	
	Crack in cylinder liner		

Effect	Cause	Trouble shooting	Action
Too much fuel in relation to air at high combustion temperatures	"Adjusted" injection pump, attempt to boost	Check the lead seal	- Test in test bench
	Injection timing too late		
	Inlet valve does not open properly. Valve adjustment disturbed		
	Broken delivery valve spring, uncontrolled injection	Disconnect one delivery pipe at a time and listen for changes in the engine sound. WARNING! Be careful when disconnecting the delivery pipes as the pressure is extremely high and could cause injury	
	Leaky injector, dripping?		
	Nozzle tip jams		
	Incorrect spray pattern from nozzle		
	More than 1 washer under injector		
	Fault in turbo	Check charge air pressure	
	Clogged air filter		
	High exhaust counter pressure	See trouble shooting for High exhaust temperature	
	Worn intake valves		
	Clogged intake port		

Black smoke on starting

Effect	Cause	Trouble shooting	Action
Engine difficult to start	Binding control rack	Open the cover (RQ/RQV) or hexagon (RSV) on the governor and check with a finger on the control rod that it goes to the maximum stop bracket. <u>(This applies to engines without a smoke limiter on the governor housing.)</u>	- Take the pump to a Bosch workshop for repair

Blue smoke

Effect	Cause	Trouble shooting	Action
	Oil coating past piston rings		
	Oil leakage in turbo-charger	Check for oil in the intake manifold after the turbocharger	
	Damaged piston cooling nozzles		- Change damaged nozzles
	Petrol in diesel oil		

Fuel in the oil

Effect	Cause	Trouble shooting	Action
Dilution of oil in sump	Unburnt fuel passes the piston		- Normally about 1% of fuel in the lubricating oil per 200 h
	Defective injector		
	Internal leakage in injection pump (worn pump element or crack in pump housing)		
	Worn/broken O-ring at feed pump pushrod		
	Frequent cold starts		
Dilution of oil in sump	Worn engine	Check "blow-by" in crankcase Correct value for new engine: 0 - +10 mm wc (flow rate 60 - 100 l/min.) Closed crankcase ventilation: -50 - +20 mm wc	
	Intake valve not opening		

Oil in coolant

Effect	Cause	Trouble shooting	Action
	Oil cooler leaks when engine is running	Test pressurize the oil cooler Note: classed oil cooler, test pressurized: 10 bar oil on the oil side, 0.5 bar air on the water side, immersed in water 25 - 27° C	
	Defective cylinder head gasket		
	Crack in cylinder head (not cracks between valve seats). (On 11-series engines: look for cracks between the water jacket and oil duct.)	If the fault is hard to trace: Change all cylinder heads for exchange cylinder heads. (Or test pressurize all cylinder heads. Heat the cylinder heads before pressurizing them.)	

Coolant/water in oil

Effect	Cause	Trouble shooting	Action
Dilution of oil in sump	Oil cooler leaks when engine is not running	Test pressurize the oil cooler, see above	
	Leaky O-rings at cylinder liner	Leakage in telltale hole?	- Change liner seals
	water is condensed in crankcase ventilation and runs down into the sump		
	14-series engine: Clogged drain hole in coolant pump in combination with leaking pump seal		
Dilution of oil in sump	Crack in cylinder head	Run the engine until warm. Remove the oil sump and all side covers. Test pressurize the cooling system. If coolant seeps out behind side covers or at the camshaft bearing there is probably a crack in one of the cylinder heads. As a rule it is possible to see which cylinder head or heads are leaking.	- Change the cylinder head for a exchange cylinder head - If no leakage can be found, change <u>all</u> cylinder heads for exchange cylinder heads
	Crack in water jacket on cylinder block/cylinder head. (Coolant runs down through the pushrod hole.)		
	Crack in water jacket on cylinder head. (Coolant runs down via the oil duct for rocker arm lubrication.)		
	Cracked water-cooled exhaust manifold		
	Leakage in charge air cooler core	Test pressure (air 0.5 bar, liquid 4 bar)	
	Water enters via the exhaust/intake system		- Install a self-closing cover on the exhaust pipe - Position the air cleaner so that water cannot run into it

Low oil pressure

Effect	Cause	Trouble shooting	Action
Gauge shows low pressure	Defective sensor/instrument	Take a reading of the oil pressure on warmed-up engine using a mechanical pressure gauge directly on the engine: Minimum 1 bar at 800 r/min. Maximum 6 bar > 800 r/min. Obs! Single-speed engines must not be tested at 800 r/min. Risk of damage to the flexible coupling	
	Incorrectly adjusted oil relief valve		- 1 shim = 0.2 bar (screw adjustment on 14-series engines)
	Broken spring in oil relief valve (14-series engines, earlier version)	Max. oil pressure 2 bar at 2000 r/min	- Check/remedy relief valve
	The piston in the oil relief valve has jammed in open position		
Gauge shows low pressure	Loosened guide plates in the oil cooler prevent passage of the oil		
	Worn/damaged oil pump		
	Plug in cylinder block under the relief valve has come loose (11-series engine)		
	Clogged oil cooler		
	Seized/worn bearings in compressed air compressor, see Compressed air sys.	Pressure varies when compressor charges/relieves	
	Loose screws in timing gear's intermediate gear		
	Crankshaft bearing/main bearing of wrong size has been fitted on reground crankshaft	Max. oil pressure 2 bar also when engine cold	- Change to bearings of the correct size. Check the bearing seats before assembly
	Excessive play in big-end and main bearings		
	Seizing in camshaft bearings	If the bushing slides all the way out of the bearing seat, the oil pressure warning lamp will come on. The engine throws out oil through the crank case ventilation	

Continuation next page

	Piston cooling nozzle has come loose		
	Seizing in the bearing on engine power take-off ED140 (14-series engine)	Oil pressure can be increased ~ 1 bar when the power take-off is under load	
	Loosened oil duct plugs at camshaft bearing seats, under the protection plate in the V (14-series engine)	Pressure drops to 0 bar	
	Suction pipe to oil pump has come loose, the pump sucks air		
	Engine too hot		
	Extremely low lubricating oil viscosity		- Choose a viscosity that is suitable for the ambient temperature
	Worn bushings or loose shaft in oil cleaner		- Change rotor if bushing is worn oval - Change worn/damaged shaft
	Broken O-ring on cyclone part of oil cleaner		
	Defective oil pump drive		
	Internal leakage in oil cleaner Loosened guide plates in the oil cooler prevent passage of the oil	Check that the oil cleaner is correctly assembled	
	Worn/damaged oil pump Plug in cylinder block under the relief valve has come loose (11-series engine)		
	Clogged oil cooler		
	Seized/worn bearings in compressed air compressor, see also page	Pressure varies when compressor charges/ relieves	
	Loose screws in timing gear's intermediate gear		
Gauge indicates low pressure at maximum speed but not at idling speed	The main oil duct (to piston cooling nozzles) plug in the rear of the engine has come loose (also at front of engine, 9-series engine)	Oil pressure at idling/ low engine speed is not affected since the delivery valve closes at 3 bar	
No oil pressure at idling speed (14-series engine)	Oil valve sleeve screwed out of oil pump housing (gives "by-pass" and disables the overflow valve)	Check that the oil valve sleeve is correctly fitted	- Tighten the oil valve sleeve - If damaged, change the sleeve

High oil pressure (engine warmed up)

Effect	Cause	Trouble shooting	Action
Gauge indicates high pressure	Defective sensor/instrument	Take a reading of the oil pressure on the warmed-up engine using a mechanical pressure gauge directly on the engine: Minimum 1 bar at 800 r/min. Maximum 6 bar > 800 r/min. Note! Single-speed engines must not be tested at 800 r/min. Risk of damage to the flexible coupling	
	Oil viscosity too high		- Choose a viscosity that is suitable for the ambient temperature
Gauge indicates high pressure	Incorrectly adjusted oil relief valve		- 1 shim = 0.2 bar (screw adjustment on 14-series engines)
	Piston in oil relief valve jammed in closed position		
	Valve in oil duct to piston cooling nozzles is binding		

Abnormal wear (liner, piston rings, etc.)

Effect	Cause	Trouble shooting	Action
Short service life	Unclean induction air due to inadequate filtering (wrongly dimensioned air filter)	Wear ridge (ring travel shoulder) at piston top dead centre	- Fit a more efficient air filter
	Unclean intake air due to leakage in intake piping		
	Wrong grade of oil, polishing damage		
	Changing of filters and oil has been neglected		
	Low coolant temperature (cold engine)		
	Excessive sulphur content in fuel		- Change the fuel - Change to oil with a higher base number - Shorter oil change intervals
	Defective injector (causes oil film to be washed off)		

Vibration, no driven components engaged

Effect	Cause	Trouble shooting	Action
	Wrong injection timing		
	Broken delivery valve spring	Disconnect one delivery pipe at a time and listen for changes in the engine sound.	
	Individual injectors not operating	WARNING! Be careful when disconnecting the delivery pipes as the pressure is extremely high and could cause injury	
	Fan imbalance		
	Flywheel has come loose		
	Crankshaft hub loosened		
	Abnormally worn main bearings		
Vibration or unusual noise at 1500 - 1700 r/min	Defective vibration damper		
Drive belts run off pulleys			
Only when compressed air compressor is charging, worst at about 1000 r/min, see Compressed air sys.	Compressor operates with excessive counterpressure (e.g. clogged piping/air dryer) or excessively high safety valve opening pressure		
	Alignment fault	Check engine alignment	
	Unsuitable rubber suspension and location of same		- Change to rubber elements of different hardness
	Weak engine bed	Movement at engine attachment points	- Reinforce the engine bed

Vibration when the clutch or reverse gear is engaged

Effect	Cause	Trouble shooting	Action
	Imbalance in driven unit		- Balance the unit
	Imbalance in clutch		
	Inadequate alignment between engine and driven unit	Check alignment	- Carry out alignment more accurately
	Unsuitable suspension of engine or driven unit		
	Weak engine bed	Movement at attachment points	- Reinforce the engine bed
	Defective flexible coupling between clutch/reverse gear and driven unit		- Change rubber element in flexible coupling (consumption item)
	Unsuitably mounted propeller shaft, e.g. excessive deflection angle or excessive deviation in parallelism between flanges		- Reposition the engine or driven unit so that the propeller shaft's working range is in accordance with recommendations
	Propeller shaft too long and weak		

Vibration when alternator is in operation

Effect	Cause	Trouble shooting	Action
	Imbalance in generator		
	Imbalance in coupling	Dismantle the coupling. Assemble the coupling halves rotated half a turn relative to each other	
	Bearing damage in alternator		
	Defective flexible coupling between engine and alternator		- Change the rubber element or type of coupling
	Fault in reduction gear		

Engine speed hunting - single-speed engines with RQ governor

Effect	Cause	Trouble shooting	Action
Hunting when engine is running under light load (15 - 20 kW) or no-load conditions	Play in flexible coupling between engine and alternator (worn coupling)	Apply a light load, at a load of about 20 kW the hunting disappears	- Change the rubber element/check the coupling hub and flange
	Play in new coupling		- Choose a coupling without play, e.g. Scania standard coupling
	Not enough flywheel mass in the driven unit, e.g. alternator		- Mount extra flywheel mass
	Skew engine brackets (engine suspension) could under unfavourable circumstances worsen engine speed hunting		- Change to harder rubber elements for the engine/alternator suspension
	Incorrect injection timing		
	Individual injectors not operating	Disconnect one delivery pipe at a time and listen for changes in the engine sound. WARNING! Be careful when disconnecting the delivery pipes as the pressure is extremely high and could cause injury	

Engine speed hunting - single-speed engines with RSV governor

Effect	Cause	Trouble shooting	Action
Engine speed hunting at 4-5% speed droop	The RSV governor should not nowadays be used for single-speed operation (except on 9-series engines)		- Change the injection pump delivery valves (1-hole or 2-hole) for 0-hole valves
Engine speed hunting at idling	Governor incorrectly adjusted		- Tighten the idling spring and adjust engine speed
	Below 700 r/min the standard starter spring, 282 544 (Bosch 1 424 650 006) is too strong		- Fit a weaker starter spring, part number 268 866 (Bosch 1 424 650 056)

Delivery pipe fractures

Effect	Cause	Trouble shooting	Action
	No clamping		
	Carelessly handled delivery pipe		
	Internal cavitation in delivery pipe Note: Single-pipe sys - tem is not permitted		Fit 0-hole delivery valves for single-speed operation

External corrosion on cylinder liner

Effect	Cause	Trouble shooting	Action
	Unsuitable corrosion protection agent, glycol or water in coolant		- Clean the cooling system and fill up with coolant as described in the maintenance instructions

Engine difficult to start

Effect	Cause	Trouble shooting	Action
Air in fuel system	Leakage in suction pipe		
	The highest fuel level in the tank is lower than the feed pump. A longer standstill (days) the fuel in the suction pipe may run back to the tank because of a leaky overflow valve		- Install a ”daily supply tank” at a higher location than the feed pump
	Leaky overflow valve		
	Low battery voltage		
	Ambient temperature too low		- Starting aids are not normally needed at temperatures above -15 ° C
	Oil viscosity too high		
	Paraffin precipitation in the fuel		
	Blocked intake or exhaust system		
	No fuel		
	Stop lever in stop position		- Check the stop solenoid and links
	Wrong injection timing		
	Faulty injector		
	Control rack/pump element will not go into the cold start position. Binding control rack/ pump element	Open the cover (RQ/ RQV) or hexagon (RSV) on the governor and check with a finger on the control rod that it goes to the maximum stop bracket. (This applies to engines without smoke limiter on the governor housing.)	- Take the pump to a Bosch workshop for repair
			- Preheat the engine combustion chambers by running the starter motor with the stop control in stop position for about 15 seconds. Then start in the usual way.

Fluid stroke

<table>
<tr><th>Effect</th><th>Cause</th><th>Trouble shooting</th><th>Action</th></tr>
<tr><td rowspan="4">Starter motor not powerful enough to pull the piston over the compression stroke (if the engine fires a connecting rod could be bent)</td><td>Leaky charge air cooler</td><td>Test pressure (air 0.5 bar, liquid 4 bar)</td><td rowspan="2"></td></tr>
<tr><td>Leaky cylinder head gasket</td><td></td></tr>
<tr><td>Crack in cylinder head</td><td colspan="2">If the fault is hard to trace:
Change all cylinder heads for exchange cylinder heads.
(Or test pressurize all cylinder heads. Heat the cylinder heads before pressurizing them.)</td></tr>
<tr><td>Crack in cylinder liner</td><td></td><td></td></tr>
<tr><td rowspan="3">Starter motor not powerful enough to pull the piston over the compression stroke (if the engine fires a connecting rod could be bent)</td><td>Water has entered the engine via the exhaust/ intake system</td><td></td><td>- Install a self-closing cover on the exhaust pipe
- Position the air cleaner so that water cannot run into it</td></tr>
<tr><td>Crack in water-cooled exhaust manifold</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Injector open</td></tr>
</table>

Knocking/noise

Effect	Cause	Trouble shooting	Action
Exhaust valves close too late and strike the piston crowns	Timing gears incorrectly meshed	Check the valve timing, see “Service data, engines”	
	The crankshaft gear has come loose		
	Valve mechanism not operating		
Rapidly increasing valve clearances	Disturbances in the supply of lubricant for the rocker arms		
The piston strikes the cylinder head	Loosened big end cap (wrong tightening torque after repair)		- Tighten to the torque specified in the Workshop manual
	Foreign objects in the piston crown		
	Piston seizure (may be caused by clogged piston cooling nozzles)		
	Wrong injection timing		
	Worn collets on exhaust valves		
Broken upper piston rings	Incorrectly adjusted injection pump	Disconnect one delivery pipe at a time and listen for changes in the engine sound. ⚠ WARNING! Be careful when disconnecting the delivery pipes as the pressure is extremely high and could cause injury	
	Broken delivery valve spring (after-injection)		
	Connecting rod bearing seizure		
	Faulty injector (seized, worn, incorrect or cracked tip, fatigued spring)		
	Incorrectly adjusted injector		
	More than 1 washer under injector		
	Fuel leakage in flame start	Check whether it leaks. (Take out the flame start and run the engine with fuel pipe connected)	
	Loosened big end cap		
Melting damage on piston crown	Injection timing extremely advanced, 30 ° BTDC or more	Check the injection timing	
	Incorrectly adjusted injector		

High oil consumption

Effect	Cause	Trouble shooting	Action
Blue smoke under load	Piston ring seizure		
	Piston seizure	Combustion temperature too high?	
	Cylinder seizure		
	Liner wear	Unclean intake air?	
	Carbon polishing (in patches)	Poor grade of oil?	
	Piston ring wear		
	Piston rings stuck		
	Tapered piston rings fitted wrong way		
	Broken piston rings	Individual piston rings broken = incorrectly fitted Several upper rings broken = start spray used wrongly, wrong injection timing (too early) Several intermediate rings broken = worn rings or grooves	
	Worn valve guides	Check the clearance between valve and guide. High exhaust temperature? Poor grade of oil?	
	Oil level too high?		
	Defective shaft seals in turbocharger	Check whether oil is present in the compressor or intake manifold	
	Clogged air filter		
	Excessive vacuum in the air intake before the turbocharger	Measure the vacuum (max. 500 mm wc) Check the air filter	
	Oil viscosity too low		
	Deformed/incorrectly directed piston cooling nozzles		
	External leakage		
	Leakage in seawater-cooled oil cooler (11-series marine engines)		

High fuel consumption

Effect	Cause	Trouble shooting	Action
	Faulty injector		
	Low charge air pressure		
	Adjusted injection pump	Check in a pump test bench that the amount (Q-mm^3/stroke) corresponds to specification	
	Manner of driving, operating/load conditions		

Low compression

Effect	Cause	Trouble shooting	Action
	Worn engine	Check the compression	
	Broken piston rings		
	Incorrectly adjusted/ defective valves		
	Hydrostatic lock/bent connecting rod		
	Readings not taken correctly	Take compression readings on a hot engine, with all injectors removed, at starter motor speed Check cylinders 1 - 6, then cylinder 1 again Check that starter motor speed does not drop Correct reading: 20 - 30 bar Max. 3 bar difference between cylinders	

Low engine output

Effect	Cause	Trouble shooting	Action
	Low fuel supply pressure (below 0.3 bar)	Check the feed pump and overflow valve for leakage as described in the workshop manual Look for leakage in the suction pipe between tank and feed pump Clogged fuel filter/Paraffin precipitation in fuel	
	Faulty injector		
	Fuel too hot		
	Incorrect fuel specification	Check density and viscosity	
	Low charge air pressure	Check charge air pressure	
	Abnormal pressure drop in intake piping	Check the vacuum before the turbocharger, max. 500 mm wc Check the air filter	
	Worn engine	Check "blow-by" in crankcase Correct value for new engine: 0 - +10 mm wc (flow rate 60 - 100 l/min.) Worn crankcase ventilation: -50 - +20 mm wc	
	Leaky valves	Take compression readings and compare those of the different cylinders	
	Wrong injection timing		
	Incorrectly adjusted governor/throttle control	Check that the governor starts deregulating at the intended speed Check that the throttle control goes to the maximum stop bracket	
	Intake air temperature too high	Check the temperature of the air before the engine. Above +25 ° C reduces engine power	
	Exhaust counterpressure too high	Take a reading, recommended counterpressure: 500 mm wc, max. 1000 mm wc	
	Intake counterpressure too high	See "Low charge air pressure", page"Low charge air pressure"	
	Incorrectly adjusted injection pump	Check in a pump test bench	
	Blocked fuel consumption gauge		
	Binding injector	Injector's nozzle nut tightened too hard	
	Exhaust brake/white smoke limiter throttle in closed position		

Hot engine

Effect	Cause	Trouble shooting	Action
Instrument shows high temperature	Defective sensor/instrument	Check that sensor and instrument suit each other (120 and 150 ° C) Check with a separate instrument	
	Low coolant level		
	Clogged seawater filter		
	Clogged freshwater/seawater cooling system		- Clean the cooling system internally and externally
	Pressure cap not operating	Test pressurize	
	Impeller on freshwater/seawater pump worn or damaged		
	Incorrect cam/worn cover on seawater pump		
	Restriction in coolant flow, e.g. pieces of rubber from seawater impeller		
	Cooling capacity too low	Take a reading of the cooling capacity	
	Gas leakage (causes loss of coolant)		
	Defective thermostats	Check opening temperature of thermostats	
Reduced coolant flow	Drive belts slip or pump wheel loose on pump shaft		
	Air pockets in engine's outer cooling circuit		- Vent at the cooling system's highest point - Check that the ventilation piping to the expansion tank is not clogged
	Excessive pressure drop in the external cooling system	Check with forcibly opened thermostats	
	Clogged radiator		
	Circulation of cooling air	Check by taking temperature readings	
	Cavitation damaged impeller in coolant pump		
	Leakage in charge air cooler		

Cold engine

Effect	Cause	Trouble shooting	Action
Instrument indi-cates low tempera - ture	Defective sensor/instru - ment	Check that sensor and instrument match each other (120 and 150 ° C) Check with a separate instrument	
	Thermostat jammed in open position	Check operation of ther-mostat	
	Low power output at low ambient temperature (large external cooling surface)	- Fit a thermostat fan - Fit a smaller fan - Install a KLAFFO radiator shutter NOTE: NOT A RADIATOR BLIND Risk of fan blade breakage - Reduce the air flow - Reduce fan/coolant pump gear ratio	
	Large leakage flow in thermostat housing (9- and 11-series marine engines)		

Coolant loss

Effect	Cause	Trouble shooting	Action
	Defective cylinder head gasket (external leakage)		
	External leakage		
Coolant pressed out of radiator on DSI engines	Turbocharging pressure enters cooling system via leaking charge air element	Test pressure (air 0.5 bar, liquid 4 bar)	
White smoke when engine hot indicates water vapour	Crack in cylinder head (not cracks between valve seats)	If the fault is hard to trace: Change all cylinder heads for exchange cylinder heads. (Or test pressurize all cylinder heads. Heat the cyl-inder heads before pressurizing them.)	
	Cracked cylinder liner	Grey oil = Coolant in oil Locate the leak by removing the oil sump and pres surizing the cooling system while turning the engine over by hand	

Polluted coolant

Effect	Cause	Trouble shooting	Action
	Faulty inhibitor		- Clean the cooling sys - tem and fill it with coolant as described in the maintenance instructions
	Overdosed corrosion inhibitor		

Effect	Cause	Trouble shooting	Action
Boiler scale on engine heater	Incorrect mixture or type of glycol and/or corro-sion inhibitor Anti-freeze with phos-phate-based inhibitor must not be used		- Clean the cooling sys-tem and fill it with coolant as described in the maintenance instructions
Short service life	The heater is not designed for continuous engagement. Suitable temperature for thermo-stat control = 40-60° C		

High oil temperature

Effect	Cause	Trouble shooting	Action
- Instrument indi-cates too high tem-perature	- Defective sensor/ instrument	Check with separate instrument	
	- Poor water flow in oil cooler		

High exhaust temperature

Effect	Cause	Trouble shooting	Action
	Adjusted injection pump	Check the lead seal, check CRO if necessary	- Test in test bench
	Wrong injection timing	Check the injection tim-ing	
	Nozzle drips	Check type, opening pressure and general condition	
	High exhaust counter pressure	Take a reading, recommended counterpressure: 500 mm wc, max. 1000 mm wc Check silencer, spark arrester, length and inside diameter of exhaust pipe	
	High inlet air tempera-ture		
	Low charge air pressure		
	Clogged air filter		

Low charge air pressure

Effect	Cause	Trouble shooting	Action
	Dirty/damaged turbine/ compressor wheel in turbocharger		- Check/clean
	Leakage between turbocharger and cylinder head		- Check/change gaskets
	Bearing seizure in turbocharger	Check bearing play	- Recondition/change turbocharger
	Clogged air filter	Check the vacuum before the turbocharger, max. 500 mm wc	
	High exhaust counterpressure	Take a reading, recommended counterpressure: 500 mm wc, max. 1000 mm wc Check silencer, spark arrester, length and inside diameter of exhaust pipe	
	High fuel temperature		

Low fuel pressure

Effect	Cause	Trouble shooting	Action
	Clogged fuel filter		
	Defective overflow valve		
	Defective feed pump		
	Air leakage in suction pipe		
	High pressure drop in suction pipe		

Low system voltage

Effect	Cause	Trouble shooting	Action
(Normal charging voltage: 27 - 28 V)	Broken alternator drive belt		
	Slipping alternator drive belt		
	Batteries in poor condition		
	Alternator fault		
	Voltage regulator fault		
	Battery charger fault		

High system voltage

Effect	Cause	Trouble shooting	Action
(Normal charging voltage: 27 - 28 V)	Voltage regulator fault		
	Battery charger fault		

External oil leakage

Effect	Cause	Trouble shooting	Action
	Crankcase pressure too high	Check “blow-by” in crankcase Correct value for new engine: 0 - +10 mm wc (flow rate 60 - 100 l/min.) Closed crankcase ventilation: -50 - +20 mm wc	
	Leaky crankshaft seal		
	Leakage at liner seal via overflow hole in cylin-der block		
	Defective cylinder head gasket		
Leakage in manifold joint	Low load		

External fuel leakage

Effect	Cause	Trouble shooting	Action
	Damaged injector and injection pump connec-tions/gaskets		
	Defective pulsation damper		
	Blocked overflow valve	Leakage at high engine speed and low power output	- Change to Bosch over-flow valve (with ball)

External coolant leakage

Effect	Cause	Trouble shooting	Action
	Leakage in cylinder liner seal		
	Cold leakage		- Change to hoses of better quality (preferably silicone hoses)
	Defective cylinder head gasket		
	Water pump leakage	Check at the water pump housing's telltale hole	
	Leakage at charge air cooler connection		
Loss of coolant in stationary installations with self-venting valves	Coolant pressed out of expansion tank	Check that the self-venting valve is not situated higher than the highest coolant level and that air is not drawn in through the valve	- Change the valve or fit a manual air screw

Oil pressed out via crankcase ventilation

Effect	Cause	Trouble shooting	Action
	Hole in piston crown	Increases when white smoke limiting device is engaged or exhaust brake applied	
	Bearing seizure in turbocharger		
	Oil seepage via pistons - liner		
	Oil seepage in air compressor		

Turbocharger breakdown

Effect	Cause	Trouble shooting	Action
Loss of power	Excessive bearing play in turbocharger		
	Lubrication piping between turbocharger and filter incorrectly connected		- Check the connections

Compressed air system

Effect	Cause	Trouble shooting	Action
Compressor does not maintain sufficient pressure in the system	Too much carbon in compressor cylinder head or discharge piping	Empty the compressed air tank, retain the air in connected compressed air components. Run the engine at 1200 r/min and note the time it takes for the compressor to discharge: 3 - 3.5 min. for 9/11-series engines with 90-110 dm^3 tank capacity 2.5 - 3 min. for 14-series engine with 90-110 dm^3 tank capacity	- If charging time exceeds specified values: - Rectify leakage, if any - Check/rectify pressure regulator - Check/rectify compressor
	Exhaust valves leak		
	Worn pistons and cylinders		
	Leaking/jammed intake valves		
	Defective pressure regulator		
	Leakage in compressed air piping		
Noise	Too much carbon in compressor cylinder head or discharge piping	Check/rectify compressor as described in the Workshop Manual	
	Worn big end/main bearings		
	Worn pistons and cylinders		
	Compressor gear loose on shaft, see also “Knocking/noise”, page“Knocking/noise”		
Compressor allows passage of oil, see also “High oil consumption”, page “High oil consumption”	Worn pistons and cylinders		
	Piston rings fitted wrongly		
	Overpressure in engine crankcase.		
Compressor does not discharge	Defective seals on discharge pistons		
	Discharge mechanism binding		
	Defective pressure regulator		
Moisture/oil in compressed air system	Air dryer not working properly	Check operation of air dryer, change desiccant. If desiccant is oily, see “Compressor allows passage of oil” above	

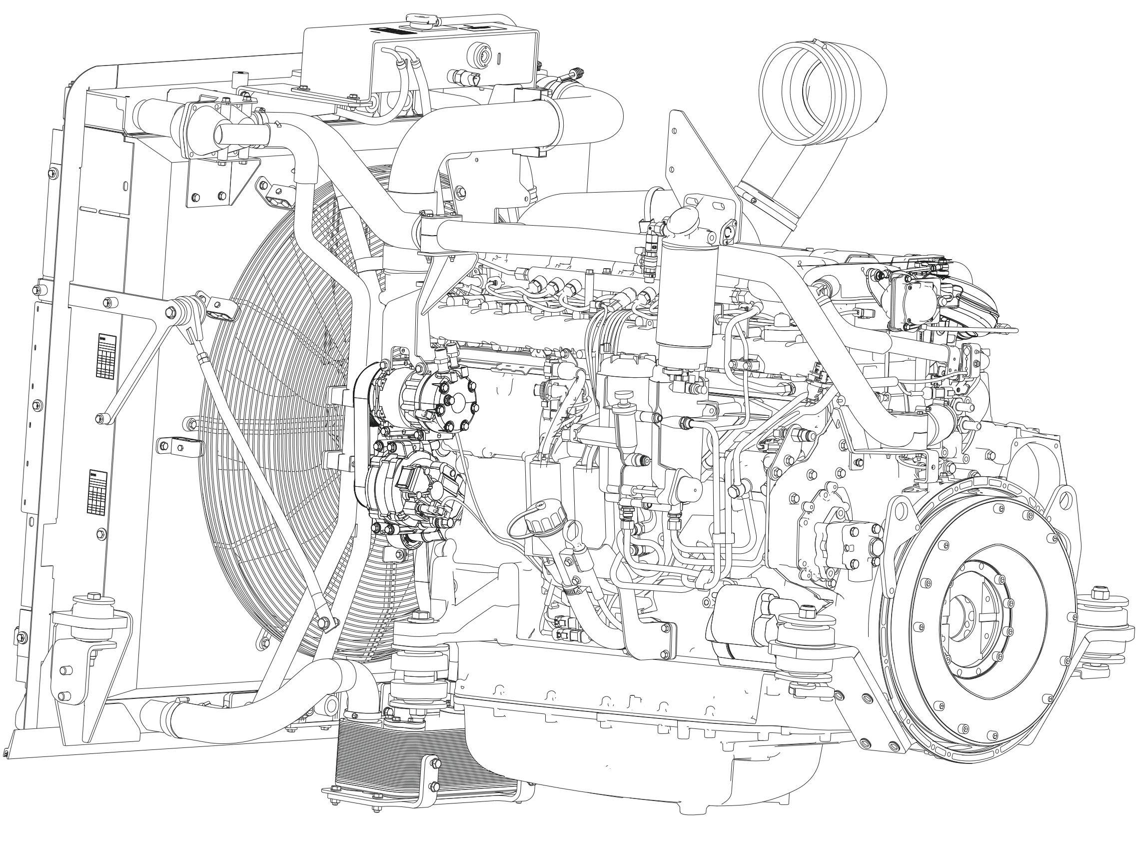
Note

Note

Chapter 1

Engine

XPI



Chapter 1
Engine
Index

Continuation next page

Continuation next page

Structure of the Repair Manual

Important information on industrial safety

Generally, the persons repairing Hyundai product-sets are responsible on their own for the industrial safety.

The observation of all valid safety regulations and legal impositions is the pre-condition for avoiding damage to persons and to the product during maintenance and repair works.
Persons performing repair works must familiarize themselves with these regulations.

The proper repair of these Hyundai-products requires the employment of suitably trained and skilled staff.
The repairer is obliged to perform the training.

The following safety references are used in the present Repair Manual:

Serves as **reference** to special working procedures, methods, information, the use of auxiliaries etc.

NOTE — **This word is used for precautions that must be taken to avoid actions which could shorten the life of the dump truck.**

CAUTION — This word denotes safety messages for hazards which could result in minor or moderate injury if the hazard is not avoided. This word might also be used for hazards where the only result could be damage to the dump truck.
Illustrations, drawings and parts do not always represent the original; the working procedure is shown. The illustrations, drawings, and parts are not drawn to scale; conclusions regarding size and weight must not be drawn (not even within one representation).
The works must be performed according to the description.

REFERENCE: Prior to starting the checks and repair works, thoroughly study the present instructions.

DANGER — This word denotes safety messages where there is a high probability of serious injury or death if the hazard is not avoided. These safety messages usually describe precautions that must be taken to avoid the hazard. Failure to avoid this hazard may result in serious damage to the dump truck.
Is used, if lacking care can lead to **personal injury or danger to life.**

REFERENCE: **After the repair works and the checks, the expert staff must convince itself that the product is properly functioning again.**

Engine identification

The engine designation indicates, in the form of a code, the type of engine, its size and applications, etc.

The type designation and engine serial number are indicated on a type plate affixed to the right-hand side of the engine.
The engine number is also stamped on the engine block

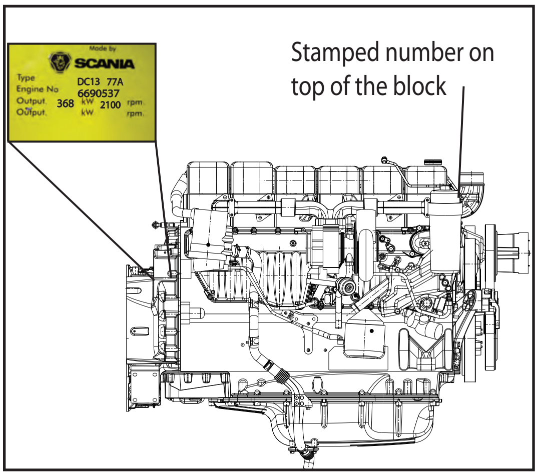


Figure 1

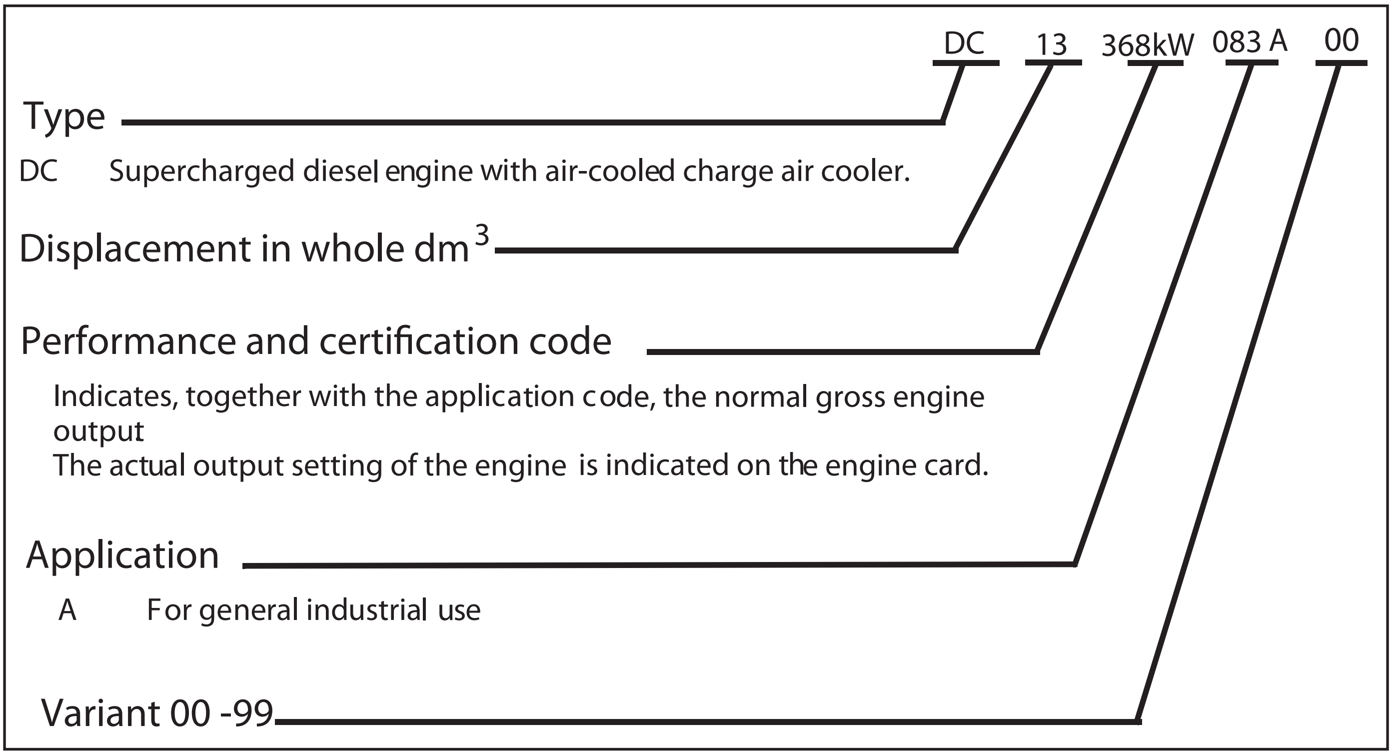


Figure 2

NOTE

Because of the different engine variants the parts and images which are contained in this book can be different from the current model of engine or dump truck . For the spare parts please used the parts catalogue for current model.

PREPARING THE ENGINE FOR STORAGE

If the engine is not to be used for an extended period its cooling system, fuel system and combustion chamber must be protected against rust. This also applies to the external shell of the engine. An alternative to preparing the engine for long-term storage is to start the engine and warm it up every 6 months.

Handling the Engine

The engine can normally stand idle for up to six months without preparation for storage. For longer periods of downtime, the following measures should be taken. These measures provide protection for approximately 4 years.
Preparations for storage:

- Thoroughly clean the engine.

- Run the engine for a specific period using special preservative fuel, oil and coolant.

- Also prepare other aspects of the engine for storage (filter renewal, lubrication, etc.).

Preservative Coolant

If the engine is to be stored with a full cooling system, use coolant containing 50 percent glycol by volume. Glycol without nitrite based inhibitor should be used.

WARNING

Ethylene glycol is highly dangerous if imbibed. Avoid contact with the skin.

Preservative Oil

Suitable preservative oils are supplied by most oil companies.

Preparations for Storage

NOTE

Use a container to avoid spills when draining the oil and coolant. Dispose of used fluids through an authorized waste disposal contractor.

1. Drain and flush the cooling system. Top up with preservative coolant.
2. Warm up the engine on regular fuel. Stop the engine and drain the oil.
3. Renew the fuel filter.
4. Fill the engine with preservative oil up to the minimum level on the dipstick.
5. Mix preservative fuel in a can. Detach the fuel pipe at the feed pump suction line and connect a hose from the can.
6. Detach the fuel pipe at the overflow valve and connect a return hose to the can.
7. Start the engine and run it at about 1,000 rpm for 20-25 minutes.
8. Stop the engine, remove the hoses and connect the normal fuel pipes.
9. Remove the rocker covers and lubricate the valve mechanisms with plenty of preservative oil. Refit the rocker covers.

NOTE

Do not remove the injectors.

10. Drain the preservative oil from the engine. Fill with new engine oil immediately or when the engine is to be reused. (For fluid type and specifications, refer to the Hyundai Operating & Maintenance Manual Chapter 6)
11. Drain the coolant if the engine is not to be stored with coolant in the system. Plug and tape all coolant connections if the engine is to be stored without a cooling system.
12. Air cleaner: clean or renew the filter element.
13. Cover air intakes and exhaust pipes.
14. Alternator and starter motor: Spray with water-repellent anticorrosive oil.
15. Spray the outside of bright engine parts, first with penetrating preservative oil such as Dinitrol 25B and then with Dinitrol 112 or the equivalent.

Clearly mark the engine with the storage preparation date, and state that the engine must not be started or cranked.

Batteries

Remove the batteries for trickle charging at a charging station (this does not apply to batteries which are maintenance-free according to the manufacturer).
The same applies to short-term storage, even if the engine has not been prepared for storage as above.

WARNING

Wear gloves and protective goggles when charging and handling batteries. The batteries contain a highly corrosive acid.

Storage

After the preparations, the engine should be stored in a dry and warm place (room temperature).
When the Engine is to be Taken Into Operation Again

- Remove plugs and tape from coolant connections, air intakes and exhaust pipes.
- Fill the cooling system with coolant. For more information refer to Inspections.
- Check the oil level in the engine or top up with fresh engine oil.
- Lubricate the valve mechanisms and their pushrods and valve tappets as well as the injector mechanisms with plenty of oil.
- Drain the preservative fuel from the fuel manifold and fuel filter.
- Connect and bleed the fuel system. For more information refer to the section headed Inspection.
- Wash off any preservative oil on the outside using white spirit.

Checks After Long-term Parking

- All oil and fluid levels.
- Tension of all belts.
- Air pressure.
- Air cleaner.
- Batteries and electrical connections.
- Lubricate all greasing points.
- Wipe off grease from piston rods.
- Inspect for signs of nests (i.e. birds, rodents, etc.)

Removal of engine assembly

Place the dump truck on level ground and apply parking brake
Apply articulation lock.
Raise the dump body and lock it with the safety support.
Turn off main switch in battery case.
Raise the tiltable cab and lock it with the safety support
Drain engine coolant
Look in OPERATION & MAINTENANCE MANUAL chapter 2 for instructions.

WARNING

Never turn off battery main switch when engine is running
Never turn off battery main switch when ignition is on
Leave battery main switch on for at least 5 minutes after engine has completely stopped

DANGER

Place wheel chocks to the front wheel

Take away the cab bolt, left and right hand side.

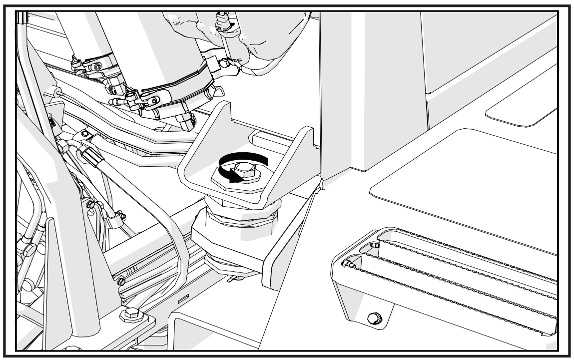


Figure 3

Turn the direction valve on the pump in lifting up position.

With the handle, pump and raise the cab.

Figure 4

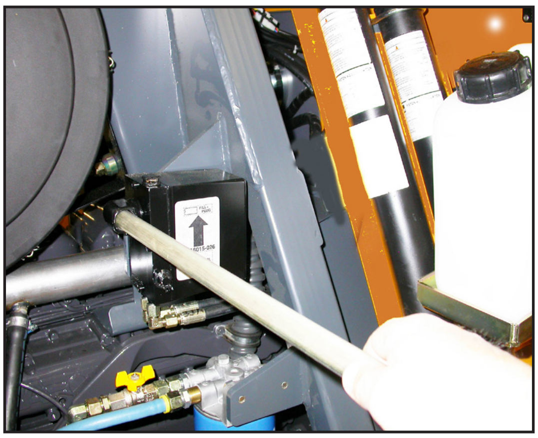


Figure 5

Left side:

1. Disassemble the cab pump and diesel filter from the air filter stand.

2. Remove the fuel hoses from engine (2 pcs).

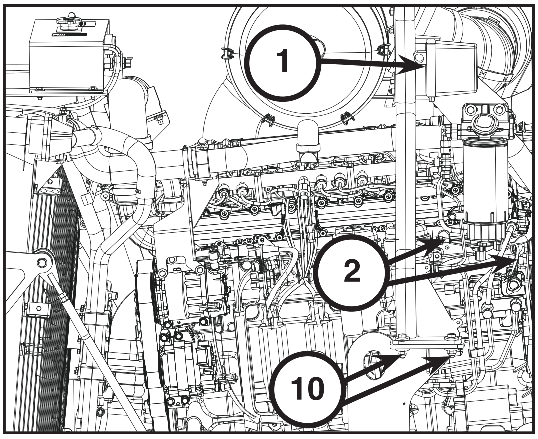


Figure 6

Right side:

3. Unscrew the hose clamps and remove the pipe bend, filter - turbo.

4. Disassemble inlet pipe and hose before air filter.

5. Disassemble air guide plate.

6. Disassemble the NOX sensor in turbo. Loosen cable from fitler stand.

7. Disconnect the cable to the air mass flow sensor. (Only T4F)

8. Disconnect air filter vacuum sensor.

9. Hook up the filter stand in lifting device.

10. Unscrew the fastening bolts for filter stand and lift off filter stand.

11. Unmount hoses attached to cooling water expansion tank.

12. Disconnect the exhaust pipe from the turbo pipe bend.

Make sure the cooling package is disconnected from engine.

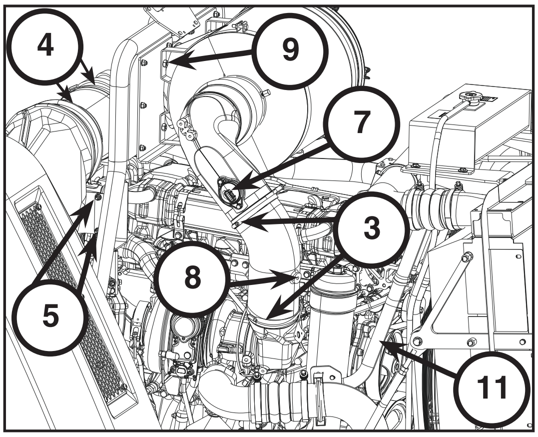


Figure 7

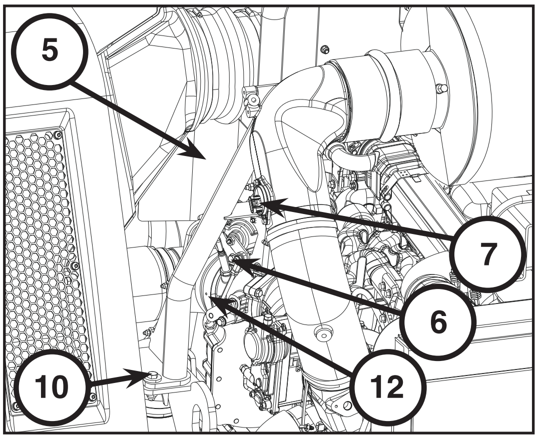


Figure 8

Slack the transmission belt.

Detach the Air Cond. Compressor with the hoses on, from the engine. Check that all of the clamps are undone.

WARNING

Empty AC before performing any work on it

Place the Air condition compressor on the left side while the engine is dismounted.

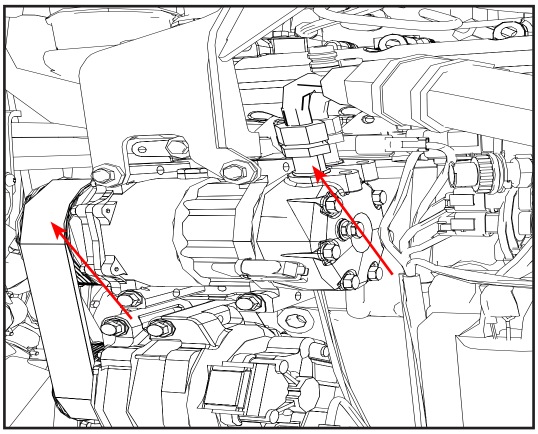


Figure 9

Disconnect the hose from the thermostat housing and the pipe between the air cooler and engine air inlet.

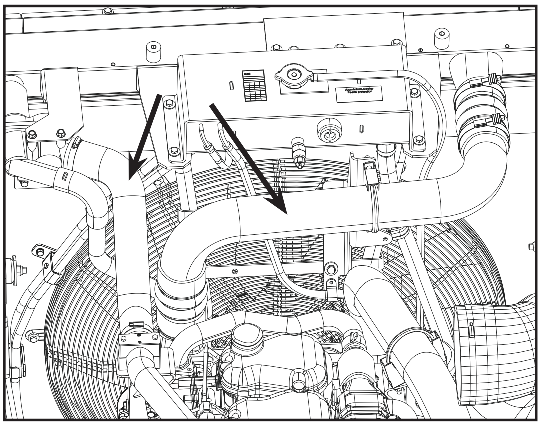


Figure 10

Disconnect the outlet pipe bend from turbo, and the inlet water hose from the transmission cooler.

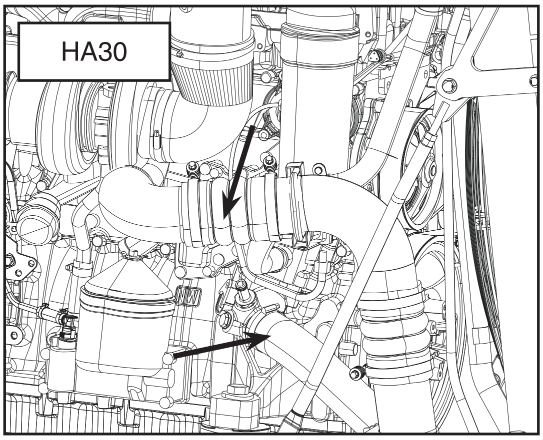


Figure 11

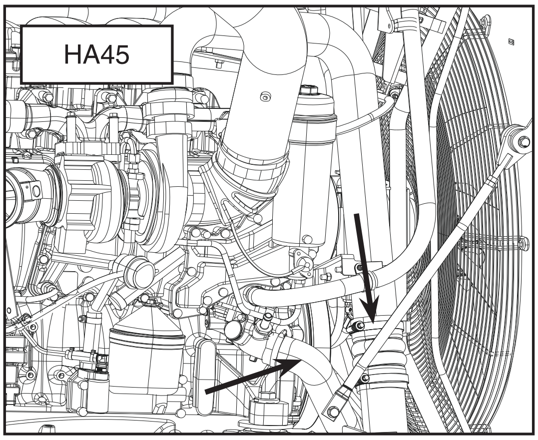


Figure 12

Disconnect the cables between starter motor and battery

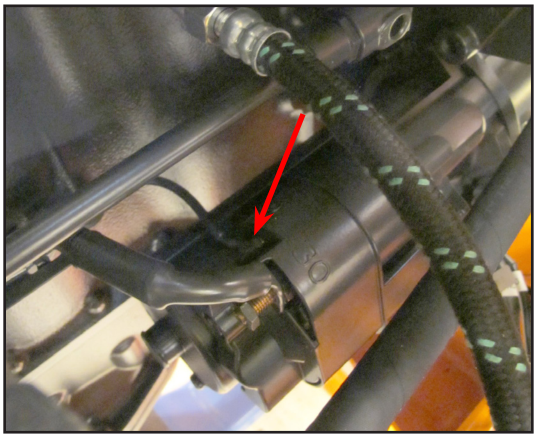


Figure 13

Disassemble grounding cable attached to bracket underneath the engine starter.

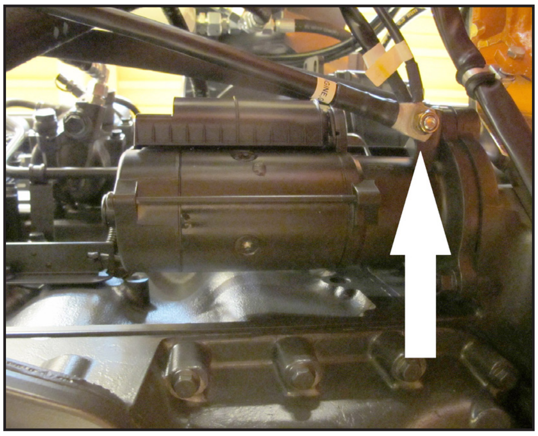


Figure 14

Disconnect contact on the dynamo.

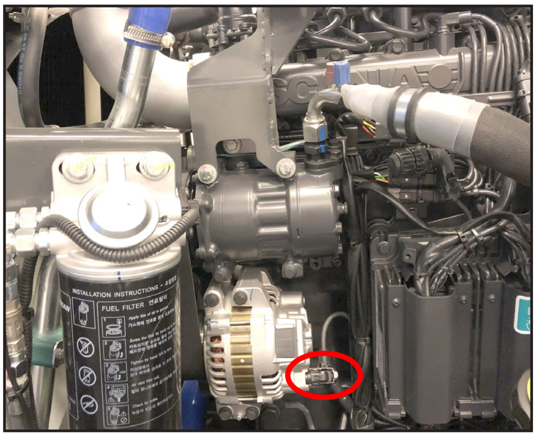


Figure 15

Disconnect the electrical contact from the engine ECU-S8 control unit.

Unwind wires connected to engine from the main wiring harness.

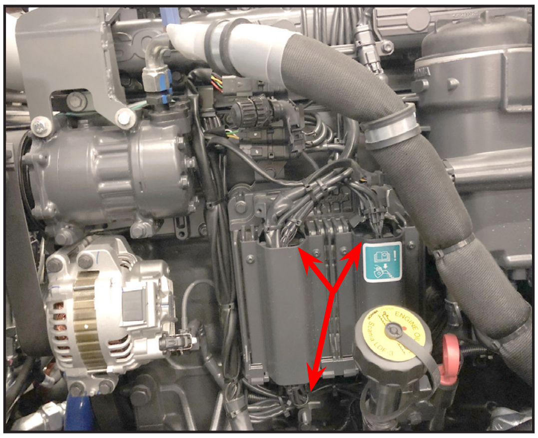


Figure 16

Drive shaft
Remove safety archer.
Remove driveshaft between transmission and engine coupling.

1 Assembly torque: 114 Nm

2 Assembly torque: 141 Nm

3 Assembly torque: 141 Nm

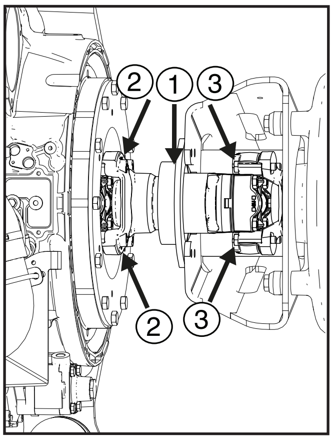


Figure 17

Front- left and right hand side, disassemble screw on the engine mounting bracket.

Assembly torque: 560 Nm (M20 10.9)

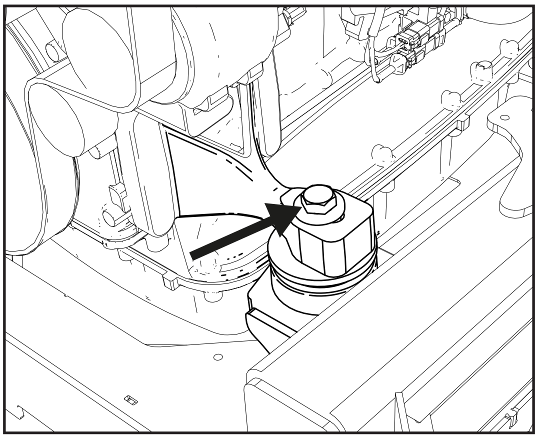


Figure 18

1. Disassemble the hose clamp bracket and hose routing to engine.

2. Unscrew the engine bracket bolt left and right hand side.

Assembly torque: 560 Nm (M20 10.9)
Use lock washer on bolts when reassembling.

Remove clamps and disassemble hoses connected to hydraulic block.

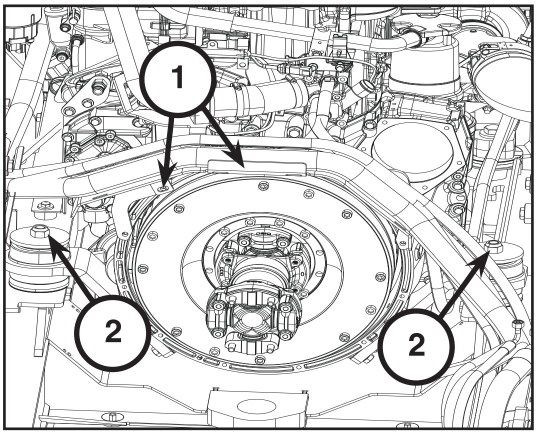


Figure 19

Disassemble front brake oil cooler hose from the brake cooler circulate pump. Plug open ports.

Torques for assembly:

1. 110 Nm

2. 37 Nm

3. Hand tighten

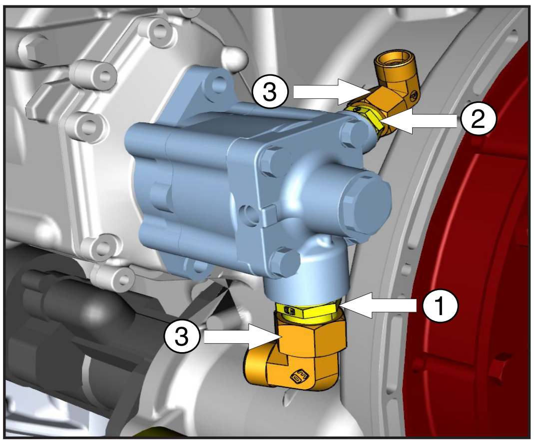
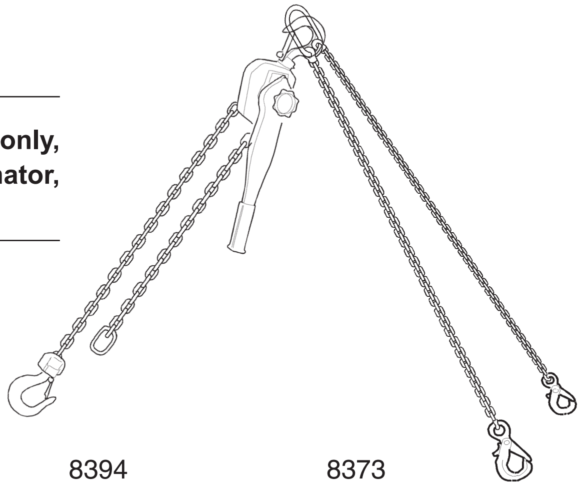


Figure 20

Lifting the engine

NOTE

The engine lifting eyes are designed for lifting the engine only, not the engine together with its ancillary equipment (alternator, gearbox etc.) or frame.



8394
Lever block

8373
Lifting chain

Figure 21

- Mount the lifting chain to the rear lifting eyes.
- Mount the lever block to the front lifting eye.

With attention, lift the engine out from the frame

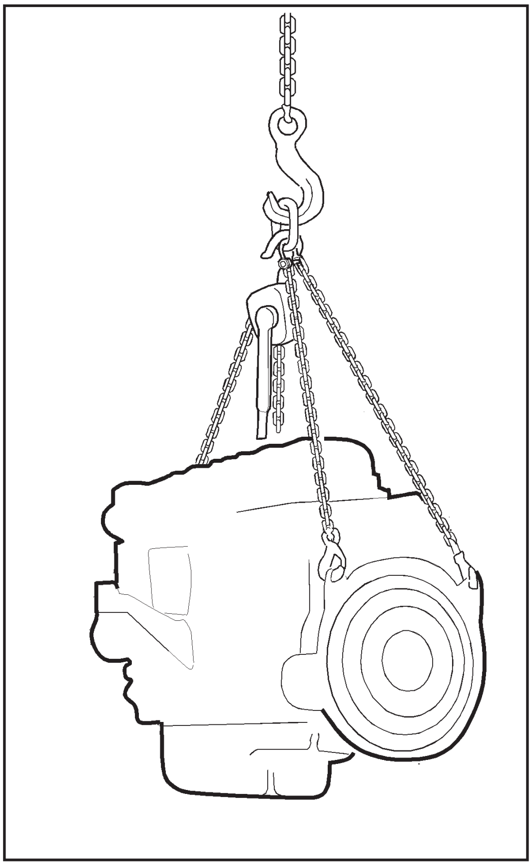


Figure 22

NOTE

The lifting eyes are sized to cope with a maximum angle of 30°.

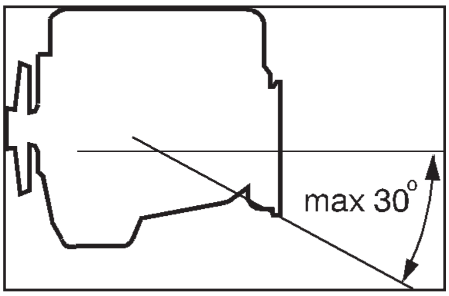


Figure 23

Starting the engine

For environmental reasons the Scania engine has been developed to be started with a low fuel feed. Using unnecessarily large amounts of fuel when starting the engine always results in emissions of unburned fuel.

- Open the fuel cock if fitted.
- Disengage the engine.
- If the engine has a battery master switch: Switch on the power by means of the battery master switch.
- Start the engine.
  If the fuel tank has been run dry or if the engine has not been used for a long time, bleed the fuel system.

WARNING

Never use starter gas or similar agents to help start the engine. An explosion may occur in the intake manifold with a risk of personal injury. Only start the engine in a well ventilated area. When the engine is run in an enclosed space, there must be effective devices to extract exhaust gases and crankcase gases.

NOTE

The starter motor must only be cranked twice for 30 seconds at a time. After that, it must rest for at least 5 minutes before the next attempt to start it.

Starting at low temperatures
Take the local environmental requirements into account. Use a fuel heater and engine heater to avoid starting problems and white smoke.
A low engine speed and a moderate load on a cold engine limits white smoke, gives better combustion and warms up the engine more quickly than warming it up with no load.
Avoid running it longer than necessary at idling speed.

XPI Fuel system HA30/45

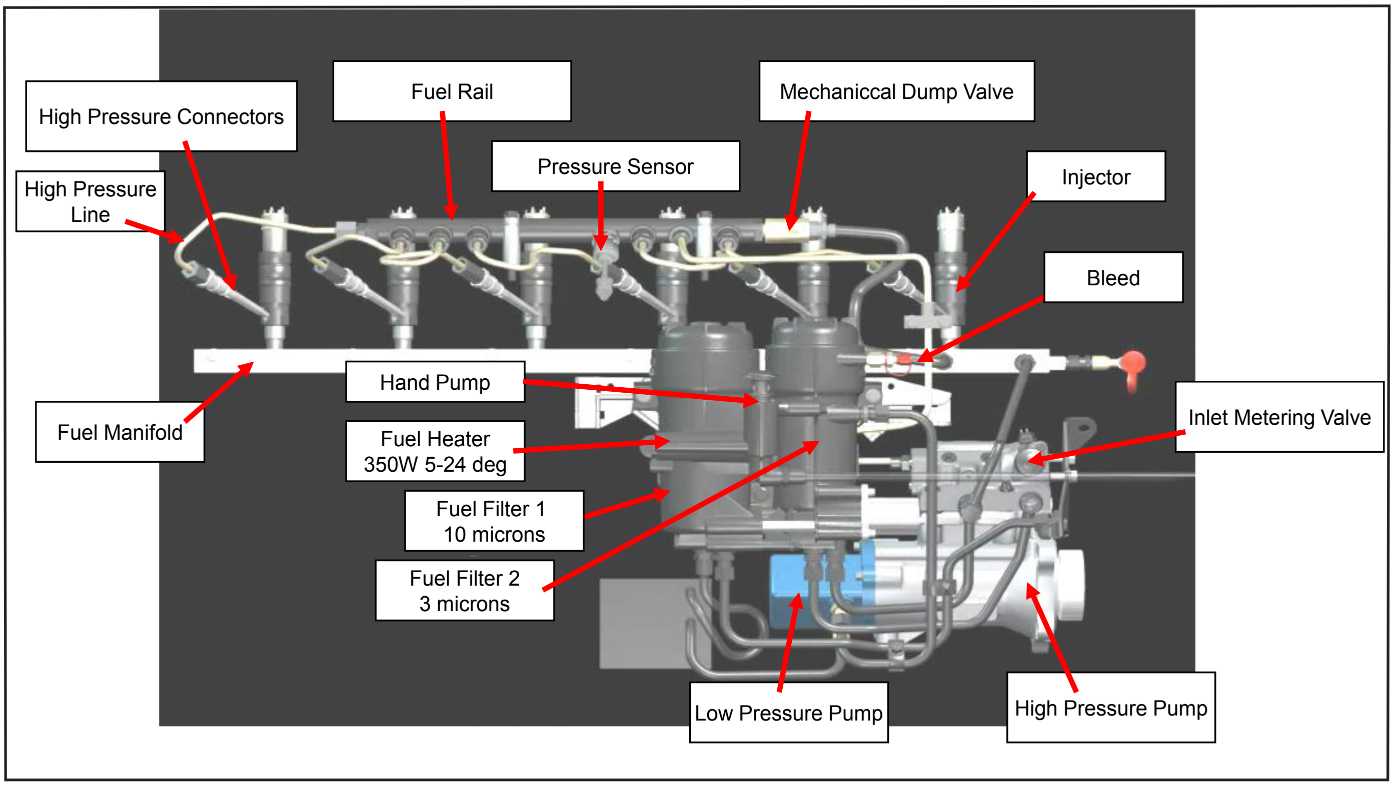


Figure 24

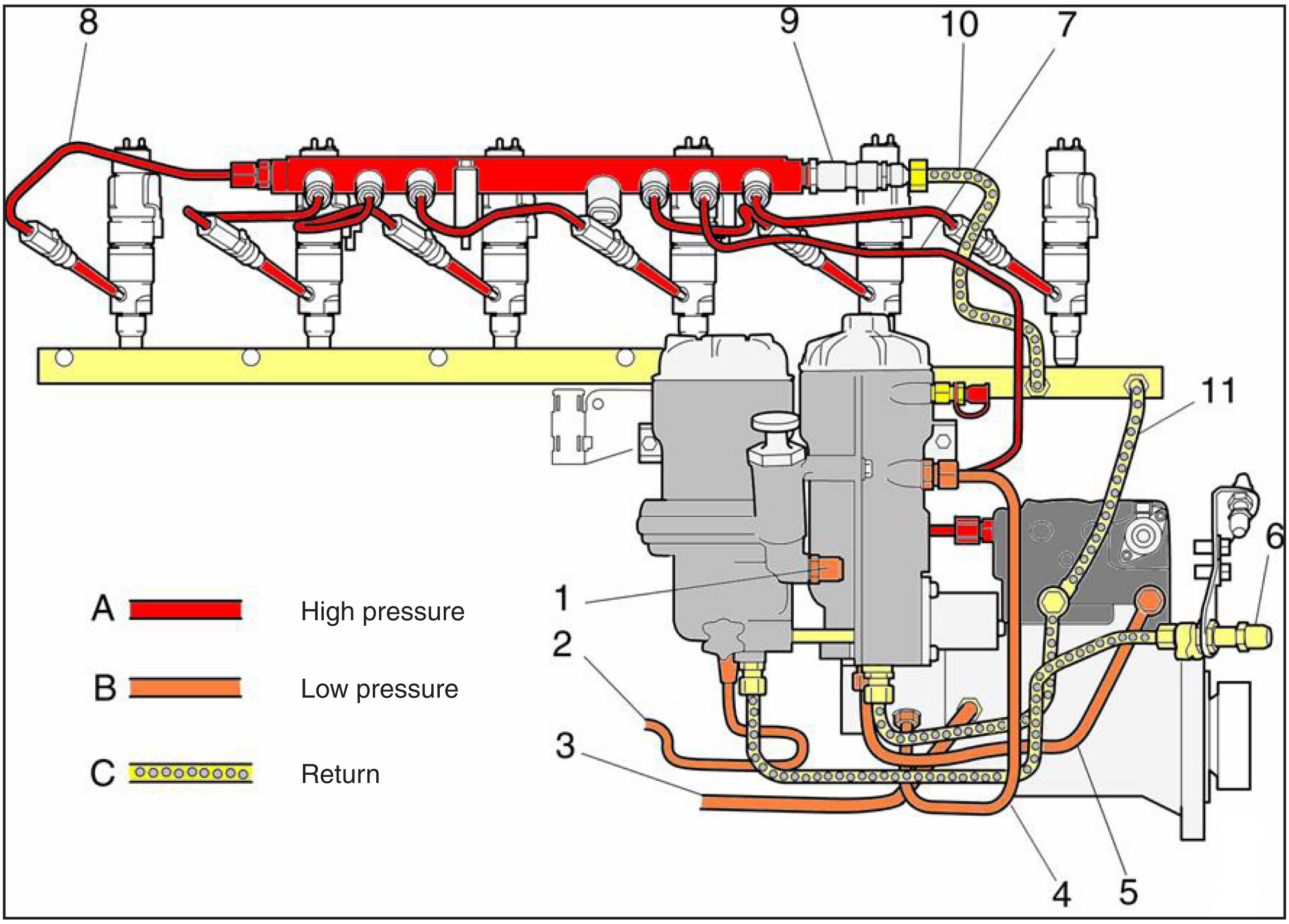


Figure 25

Route of the fuel on 9 and 13 liter engines

The feed pump draws fuel from the fuel tank. The fuel is taken into connection 1 and drawn through the suction filter. From the suction filter the fuel is drawn into the control unit cooler via the fuel hose 2 and then from the control unit cooler to the feed pump via the fuel hose 3.

The feed pump builds up the fuel pressure to between 9 and 12 bar and forces the fuel through the pressure filter via the fuel pipe 4. The fuel flows from the pressure filter via the fuel pipe 5 on to the fuel inlet metering valve fitted on the high pressure pump.

The fuel inlet metering valve controls how much fuel should be led into the high pressure pump when requested to do so by the engine control unit. The inlet metering valve is controlled electronically by the engine management system via a closed loop from a pressure sensor in the rail.

The high pressure pump builds up the fuel pressure to a maximum of 3,000 bar. The fuel is taken on to the accumulator via high pressure pipe 7.

A high pressure pipe 8 runs from the accumulator to each connection bringing fuel to the injectors. When the solenoid valve in the injector is supplied with voltage, the injector opens and fuel is injected into the cylinder.

The fuel system works under high fuel pressure and it is therefore important that there is no water in the fuel. Water causes corrosion of the fuel system components and the components will be damaged due to the system's tight tolerances. To prevent water from being present in the fuel, water is separated from the fuel at the suction filter and taken back to the fuel tank via the pipe 6.

There is a safety valve 9 on the accumulator that opens if there is a fault in the fuel system, which results in the fuel pressure becoming too high. The safety valve opens at a pressure of 3,000 bar and reduces the fuel pressure to 1,000 bar and then regulates the fuel pressure so that it remains at 1,000 ± 300 bar. When the safety valve opens, the fuel is returned via the pipe 10. Fuel which is taken out via the safety valve will heat up the pipe downstream of the safety valve.

Excess fuel from the injectors flows from the fuel manifold back to the fuel tank via the pipe 11.

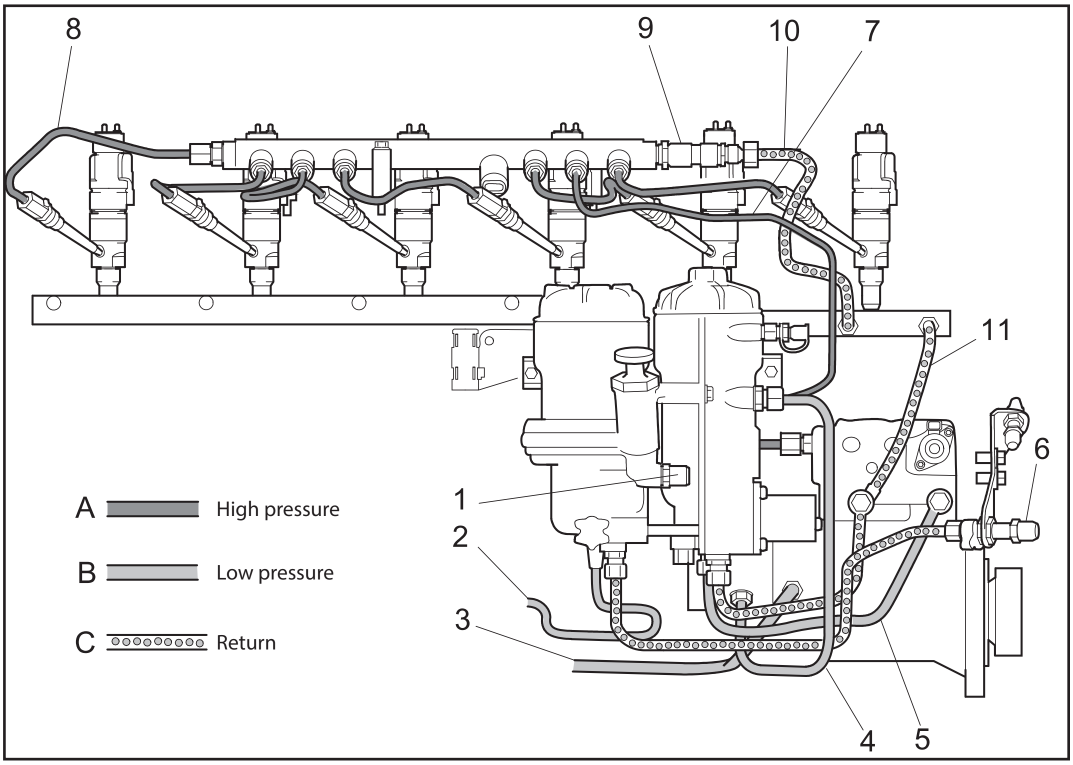


Figure 26

Fuel filter and water separation filter

The fuel system has two fuel filters because there are very high requirements on the purity of the fuel. Both fuel filters are filter elements.

Water separating suction filters.
The feed pump draws fuel from the fuel tank through the suction filter. A first filtering of fuel and a separation of water takes place in the suction filter. The fuel goes through a second water separating filter on the return to tank.

Pressure filter.
The pressure filter is located downstream of the feed pump and performs a finer filtration than the suction filter.

1. Water separating suction filter
2. Pressure filter
3. Inlet, fuel from the fuel tank
4. Fuel from the suction filter to the control unit cooler
5. Recirculation to fuel tank
6. Recirculation from the high pressure pump and injectors
7. Fuel from the pressure filter to the high pressure pump
8. Fuel from the feed pump to the pressure filter
9. Bleeder nipple

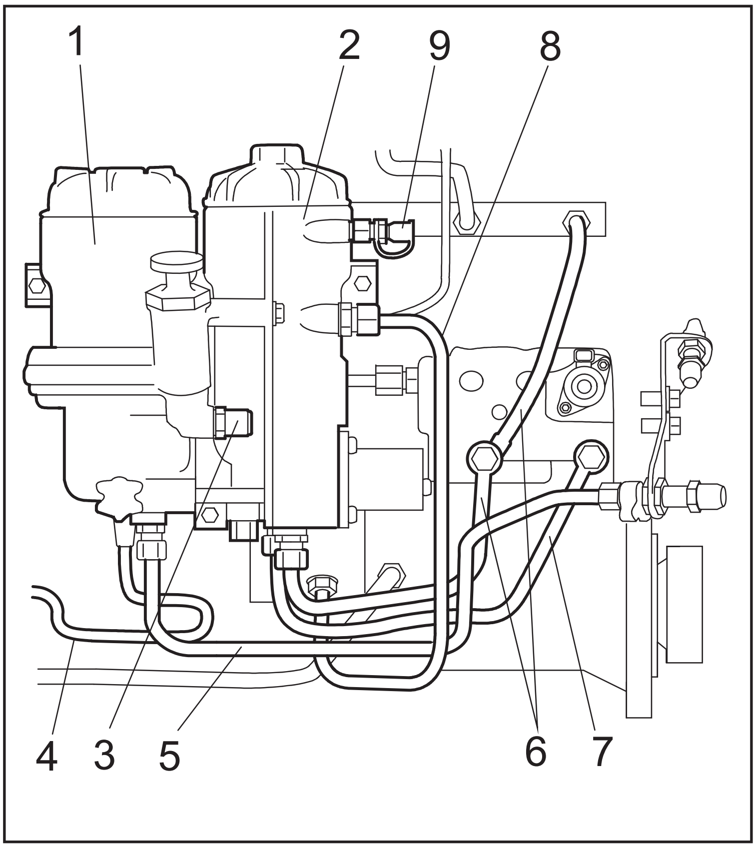


Figure 27

Water separation

The fuel system is sensitive to water. Water must therefore be separated from the fuel. Water is separated from the fuel in the water separating suction filter and is collected in the bottom of the fuel filter housing.

A proportion of the fuel from the pressure filter is led back to the fuel tank, and on its way back the fuel passes a venturi. The water is extracted from the water separating suction filter by means of the venturi and travels with the return fuel.

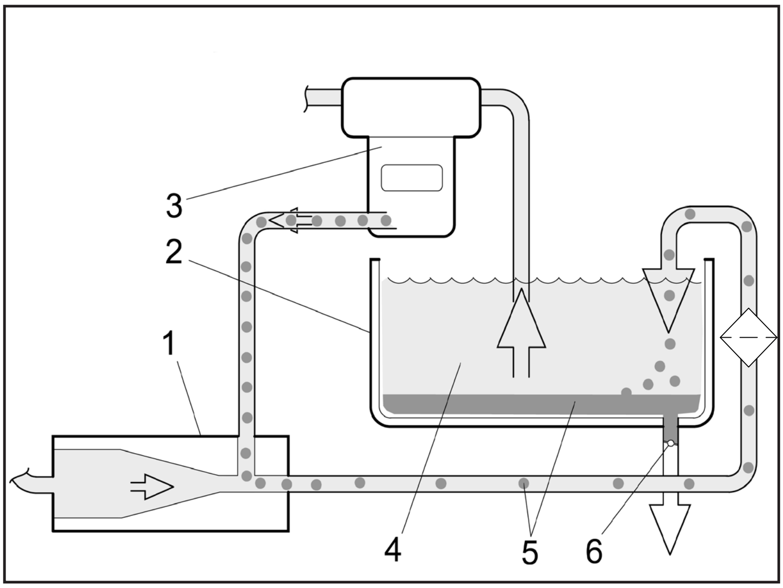


Figure 28

Design
The fuel filter is mounted alongside a water-separator filter on an XPI system.
The filter consists of a container with a folded paper element.

The fuel filter has no bleed screw and is bled by undoing plug **4** in the free inlet passage.

Function
Fuel is pumped into the inlet by the fuel pump. It then continues through passages in the filter retainer to the upper part of the filter, down through the filter or filters and on to the outlet passage. From there, the fuel is piped to the injection pump.

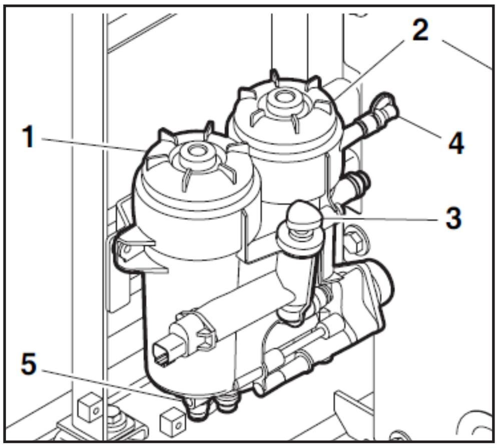


Figure 29

1. Water seperator
2. Pressure filter
3. Hand pump
4. Bleeder valve
5. Drain plug

Changing the fuel filter

NOTE

Avoid spillage and use a suitable container. Used fuel must be disposed of as specified in national and international law.

1. Unscrew the filter cover with a closed tool with hexagon driver, e.g. socket, so as not to damage the filter cover.

2. Lift out the filter cover and filter element. The filter housing will drain automatically. This applies only if the fuel tank is lower than the engine. Otherwise the fuel shut-off cock must be closed first.

3. Undo the removed filter element from the cover by carefully bending it to one side.

4. Renew the O-ring in the cover. Lubricate the O-ring with O-ring grease.

5. Check that the filter housing is drained of fuel. Contaminated fuel may enter the injectors if the drainage does not work.

6. Press a new filter element into the snap fastener in the cover.

7. Fit the filter element and cover in the filter housing. Tighten the cover to 25 N*m (18.4 lbf.ft).

8. Bleed the fuel system after renewing the water separating filter.

CAUTION

Fit the filter elements in the filter covers before placing them in the fuel filter housings or the filter elements may be damaged.

Water separating prefilter

NOTE

The same intervals between changes apply as for those for an ordinary fuel filter.

Changing the water separating fuel filter

1. Close the shut-off cock (1) in the fuel pipe and position a container under the filter.
2. Open the drain tap (2) in the filter cover and let the fluid run down into the container.
3. Unscrew the filter cover.
4. Unscrew the filter from the filter head.
5. Discard the old filter and use a new filter.
6. Lubricate the O-ring in the filter cover with engine oil.
7. Screw the filter cover onto the new filter by hand. Make sure that the drain tap is fully closed.
8. Lubricate the O-ring on the filter with engine oil.
9. Fill the width of the filter with clean fuel.
10. Screw the filter into position until the O-ring rests against the filter head. Tighten the filter another 1/2-3/4 turn by hand.
11. Open the shut-off cock and check the system for leaks.
12. Bleed the fuel system.

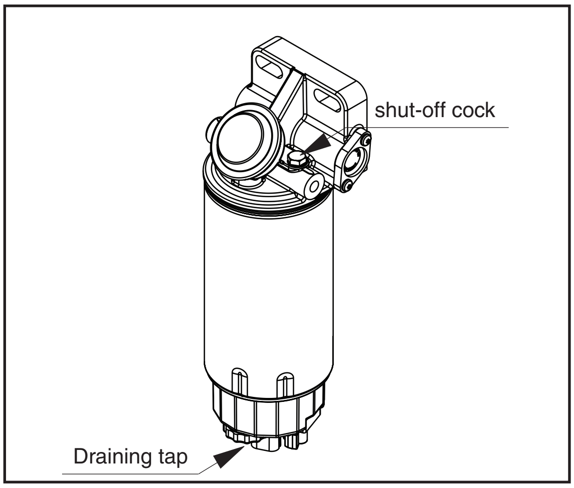


Figure 30

Bleeding the fuel system using a hand pump

1. Attach a clear plastic hose to the bleed nipple on the fuel filter housing. Let the plastic hose drop into a container that holds at least 5 litres (1.3 US gallons).
2. Unscrew the hand pump handle.
3. Open the bleed nipple on the fuel filter housing and pump until fuel runs out, which will take around 100 pump strokes. Close the bleed nipple.
4. Start the engine and open the bleed nipple carefully. Approximately 3 litres (0.8 US gallons) will run out into the container before the fuel coming out will be free of air.

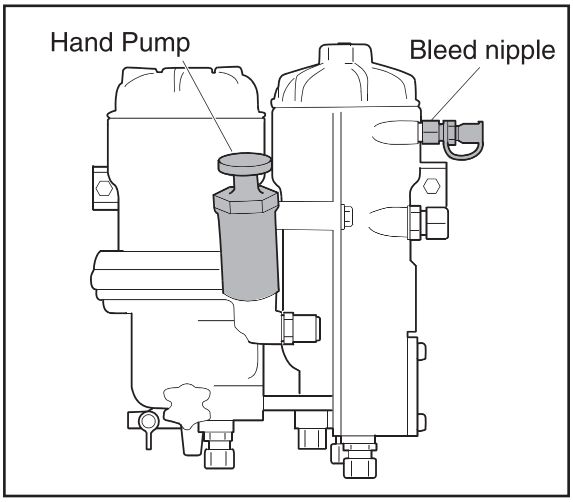


Figure 31

Overflow valve

Overflow valve in fuel manifold

The overflow valve controls the pressure downstream of the injector in the fuel system.
The normal operating pressure downstream of the injector is 0.7 bar.
The overflow valve uses a channel in the fuel manifold to recirculate return fuel to the fuel filter, which returns the fuel to the fuel tank via a channel.

Overflow valve in fuel filter housing

The overflow valve protects the fuel filter housing against too high a pressure.
Opening pressure is 14.4 bar.
Surplus fuel is recirculated to the fuel tank.

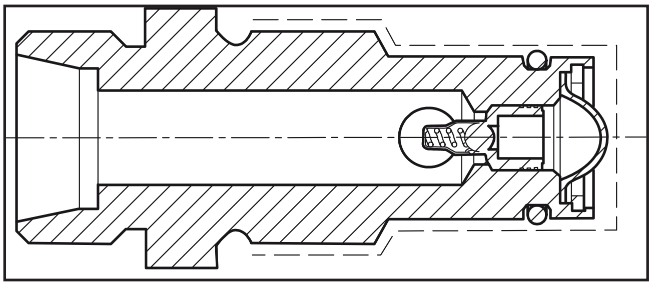


Figure 32

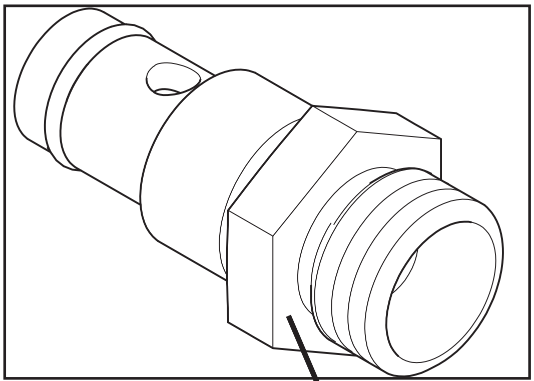


Figure 33

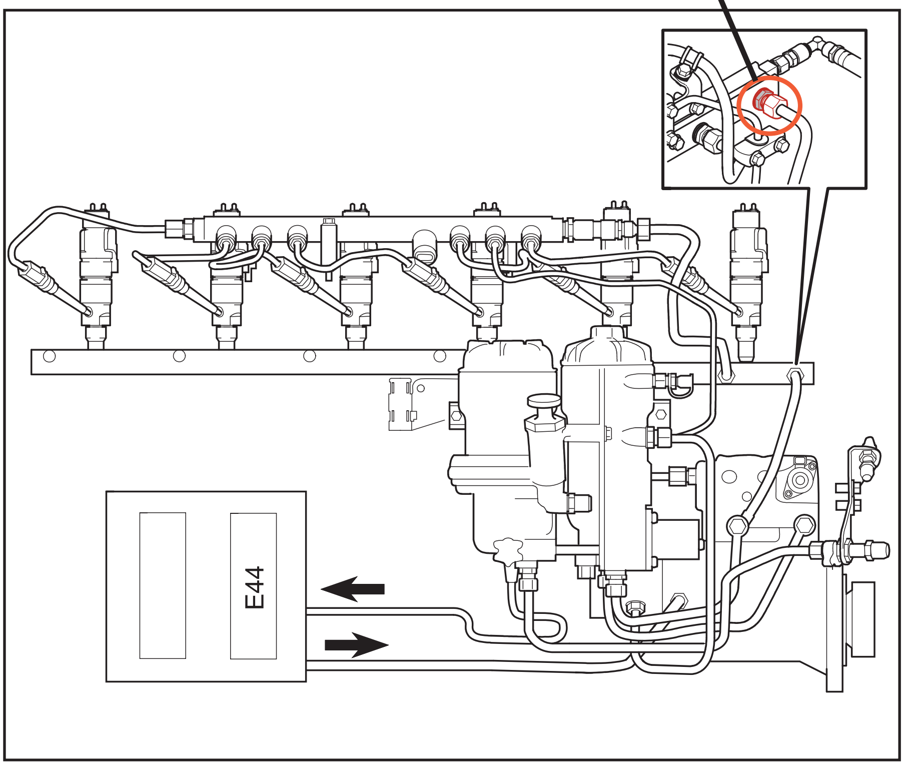


Figure 34

Fuel system components

1. Connection
2. Injectors
3. Accumulator
4. Fuel pressure sensor
5. Safety valve
6. Bleed nipple
7. High pressure pump
8. Fuel inlet metering valve
9. Feed pump
10. Hand pump
11. Fuel filter, 2 off
12. Fuel manifold for return fuel
13. Engine control unit with control unit cooler
14. Overflow valve

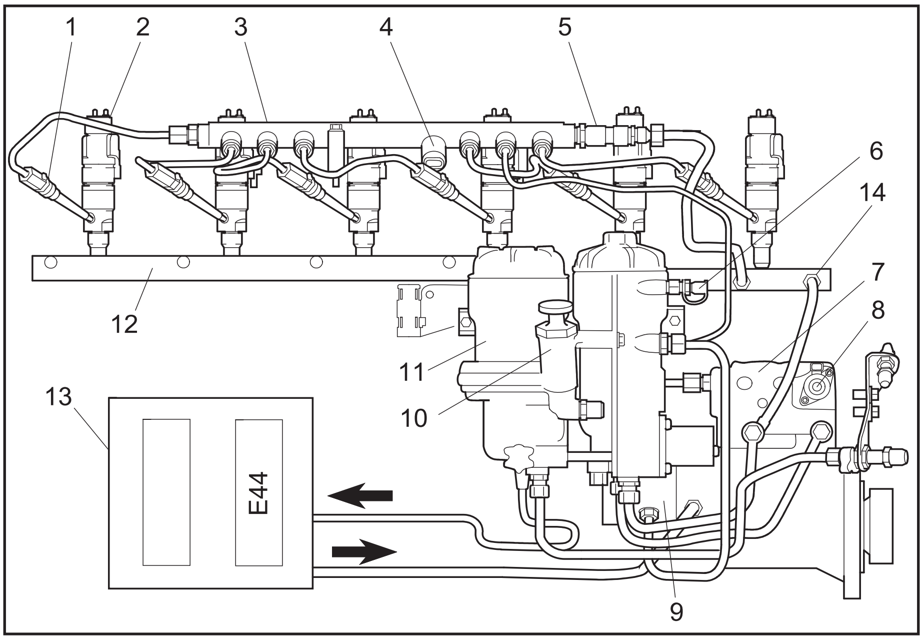


Figure 35

Schematic diagram of the fuel system:

1. Fuel tank
2. Hand pump with check valves
3. Fuel filter, water separat ing suction filter
4. Control unit cooler
5. Feed pump
6. Pressure filter
7. Fuel inlet metering valve
8. Check valve
9. High pressure pump
10. Check valve
11. Venturi
12. Accumulator
13. Connection
14. Injectors
15. Fuel pressure sensor
16. Safety valve
17. Fuel manifold for return fuel
18. Return pipe with pressure regulator
19. Venturi for draining water

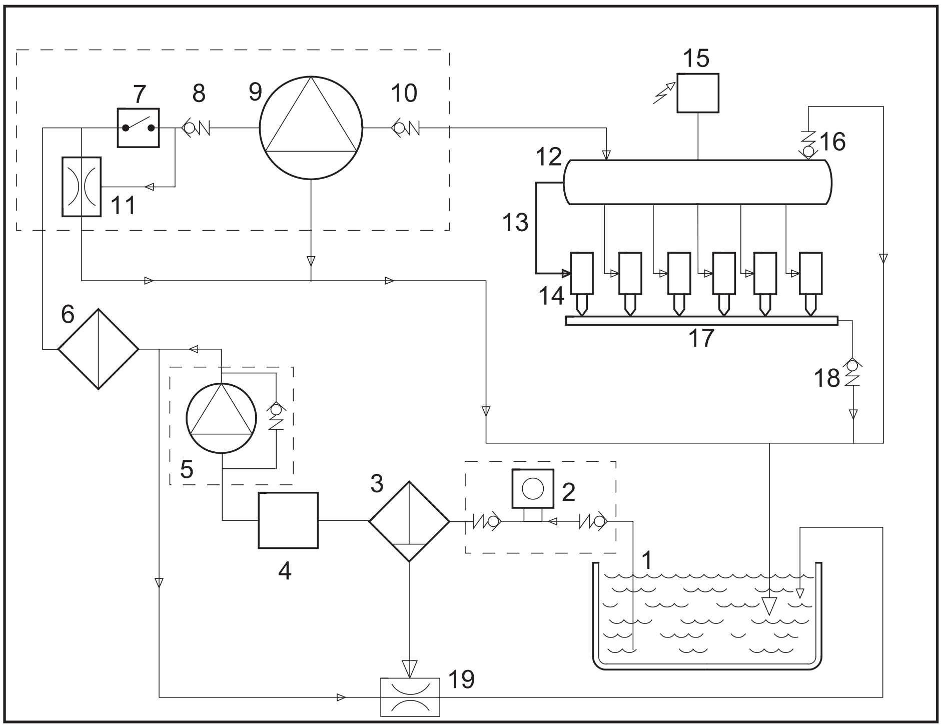
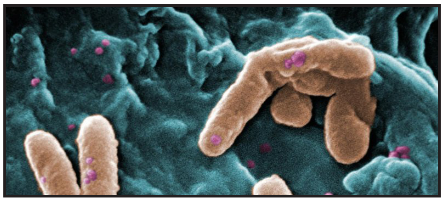


Figure 36

Important information about the fuel

Fuel initially contains a reduced quantity of water rom the manufacturing process. The water content may increase, e.g. as a result of condensation, during prolonged and unsuitable storage.
Small quantities of water in the fuel do not affect the engine operation. However, micro-organisms grow in the water. The microbes obtain nourishment from the oil and their growth is therefore greatest in the boundary layer between the water and oil. In an emulsion the boundary layer is very large and emulsification therefore encourages growth.



The cause of breakdowns can generally be attributed to badly maintained supply tanks. Water, dirt, fungi and/or **bacteria** have collected in tanks which are rarely cleaned or drained. They form a mass which can block filters. There are additives which counteract this, but we would warn against their use since they are hazardous
environmental toxins which affect the microflora.
In our experience the established oil companies maintain their tanks in such a way that contamination of this kind does not occur. Where problems have occurred, the tank has not been maintained correctly.
The oil companies do not use toxic substances, but rely entirely on regular cleaning and drainage of water from the tanks. The latter should, however, be carried out only some days after the tank has been filled, so that the water has sunk to the bottom.
Drainage is carried out at all stages of the distribution, both in depots and at filling stations. Heat is applied to larger, cooled tanks to reduce the fuel iscosity, resulting in internal circulation to accelerate the precipitation before draining the water.

De-contamination
Tanks:
- Clean large supply tanks carefully inside and dry them before filling them with new fuel.
- Drain the water a few days after filling and at regular intervals from then on in accordance with the oil supplier's instructions.

Engines installed in vehicles, boats etc.:
- Clean the entire fuel system, otherwise the microbial flora will spread again.
- Rinse the fuel lines and blow them dry.

Replace fuel filters.
- Clean the fuel tank.
- If the contamination was very serious, it may be necessary to inspect the injectors and injection pump and remove any deposits that may have formed. Experience has shown that biological tissue can penetrate the fuel filter
and may create deposits in those parts of the system beyond the filter.
- Biocides may be used as a last resort. The individual tank owner should refrain from handling such substances. Any such use should take place with the assistance of the fuel supplier.

Summer and winter fuels
(Available on markets with cold climates)
Fuel can be adjusted to the seasons by adding lighter components and removing components which can crystallize out at low temperatures. It is mainly the higher paraffinic hydrocarbons which crystallize out and these help to increase the ignition value.

The winter fuel has a lower density and lower viscosity. This results in a reduction in engine output.

Environmental fuel
Environmental fuel with markedly reduced sulphur contents and therefore emissions is available on various markets. Normally the density and viscosity is also lower for these fuels.
By using output correction curves (formulae), the outputs can be corrected for the effect of density and viscosity.

Exhaust system XPI T4F

Introduction system overview

To meet the new requirements for exhaust emissions, a technology will be used which is known as SCR, Selective Catalytic Reduction. This technology involves aftertreatment of the exhaust gases using reductant and catalytic converters in order to reduce the amount of nitrogen oxide in the exhaust gases.

Selective catalytic reduction and controlled fuel injection with an XPI fuel injection system are used to effectively clean the exhaust gases and remove harmful substances in them.

1	Evaporator	8	Coolant hose, return from tank and pump heating
2	Pressure line for reductant	9	NOx sensor with control unit
3	Coolant hose for tank and pump heating	10	Oxidation catalytic converter
4	Coolant valve	11	Exhaust gas temperature sensor
5	Reductant tank	12	SCR catalytic converter
6	Reductant pump and control unit	13	NOx sensor with control unit
7	Reductant pump and control unit	14	Reductant doser

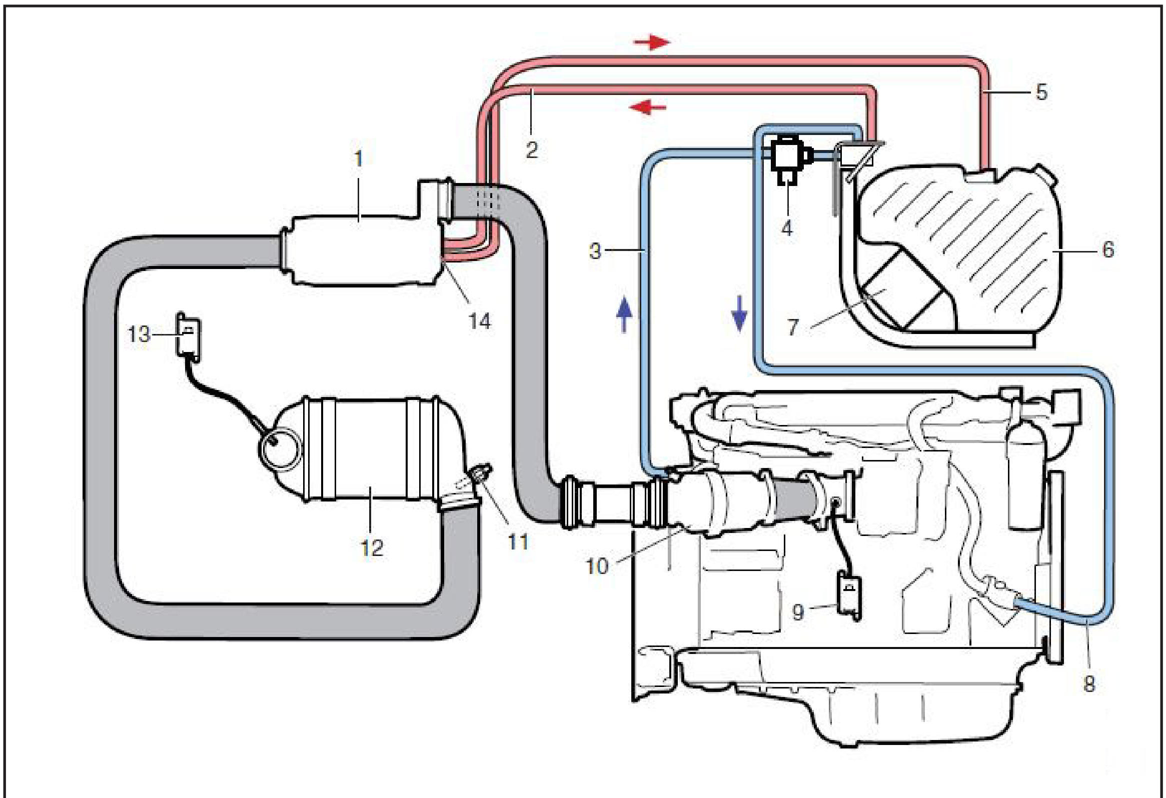


Figure 37

Overview - Control system for exhaust gas aftertreatment

The control system for exhaust gas aftertreatment consists of a control unit (EEC3), NOx sensor, temperature and pressure sensor, level and temperature sensor in the reductant tank, reductant pump, reductant doser, coolant valve and electrically heated reductant hoses. The 9 litre engine is also equipped with a valve block (2) and injection valve (3) for fuel injection.

1. Control unit EEC3
2. Valve block (fitted on 9 litre engine)
3. Injection valve (fitted on 9 litre engine)
4. Coolant valve
5. Temperature sensor
6. Level and temperature sensors in reductant tank
7. Electrically heated reductant hoses
8. Reductant pump
9. Reductant doser
10. NOx sensor
11. Pressure sensor

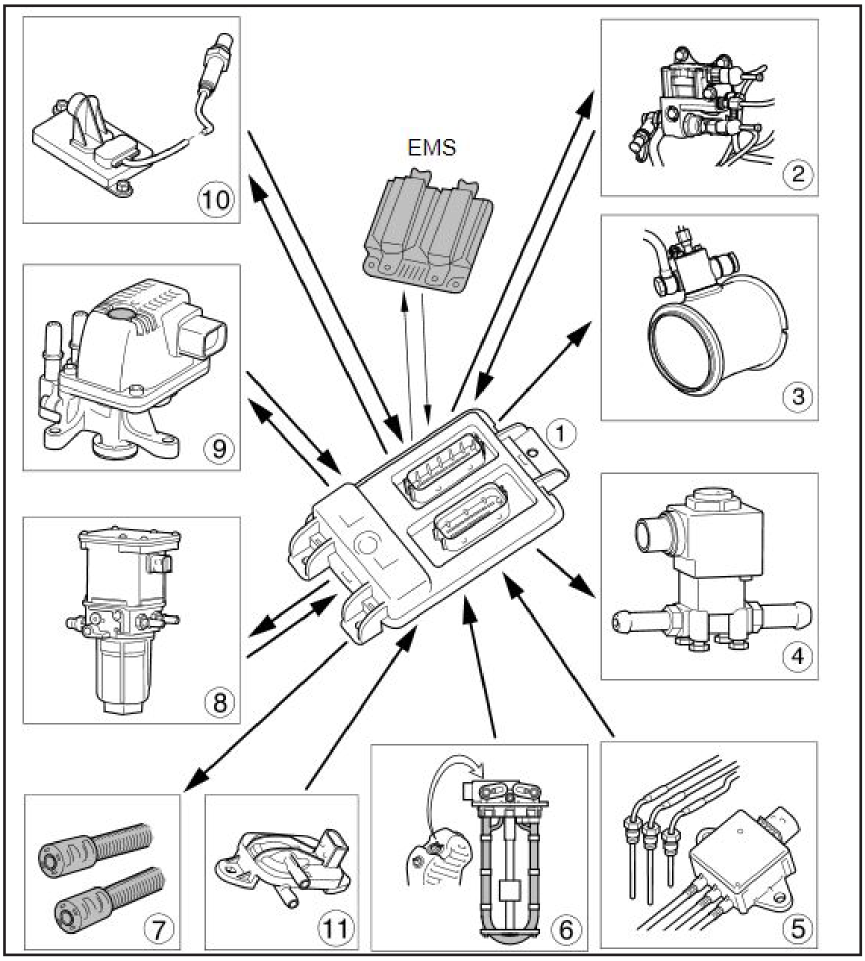


Figure 38

EEC3 control unit:

- Based on instructions from EMS, prepares and activates reductant dosing during starting and operation.
- Monitors and activates components that participate in reductant dosing during different operating conditions.
- Activates warnings and fault codes for components that participate in reductant dosing.
- Monitors other sensors in the exhaust gas aftertreatment system that send values to EMS via CAN.
- Participates in component and sensor diagnostics

- The EEC3 control unit transfers warnings and fault codes that trigger torque reduction to EMS, which activates the measure.

- If there is a risk that system components will be damaged.

- If the fault makes it impossible to run exhaust gas aftertreatment with full functionality.

The relationship between EMS and EEC3 data for exhaust gas aftertreatment is shown below:

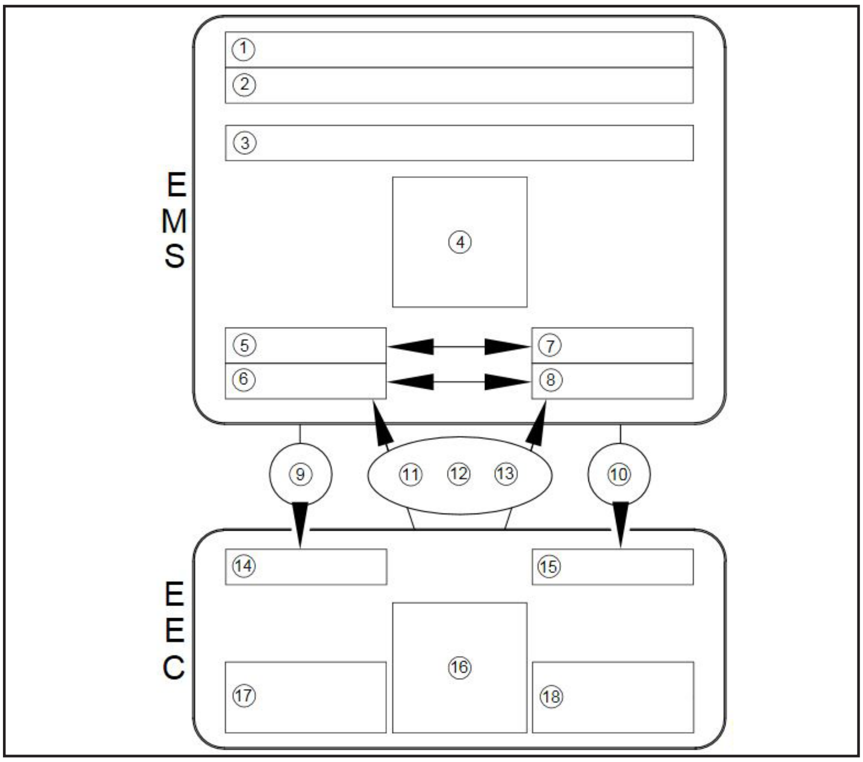


Figure 39

1	Engine control	10	Required dosing of fuel to the exhaust gases during regeneration of the particulate filter
2	Combustion control	11	Temperature sensor values
3	Exhaust gas monitoring	12	NOx sensor values
4	Diagnostic system for EMS	13	Fault messages that trigger torque reduction
5	Regulation for work of oxidation catalytic converter	14	Checking and activation of reductant dosing
6	Checking reductant dosing	15	Checks and activates dosing og fuel to the exhaust gases during regeneration of the particulate filter
7	Regulation for work of particulate filter	16	Diagnostic system for EEC
8	Checking soot particle regeneration	17	Diagnosis of reductant dosing and SCR catalytic converter
9	Required reductant dosing	18	Diagnosis of particulate filter.

Selective catalytic reduction (SCR), recirculation of exhaust gases (EGR) and controlled fuel injection with an XPI fuel injection system are used to effectively clean the exhaust gases and remove harmful substances in them

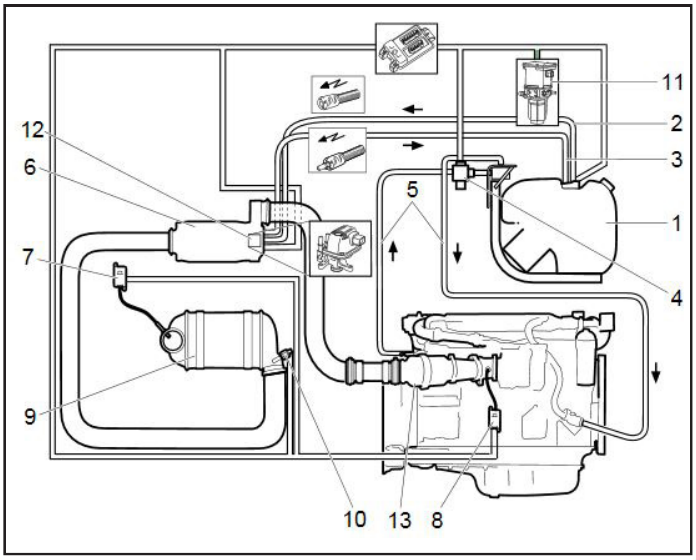


Figure 40

1. Reductant tank
2. Electrically heated pressure hose for reductant
3. Electrically heated return hose for reductant
4. Coolant valve
5. Coolant hoses
6. Evaporator with reductant doser
7. NOx sensors in the exhaust outlet or the SCR catalytic converter
8. NOx sensor in the exhaust brake housing
9. SCR catalytic converter
10. Temperature snesor
11. Reductant pump
12. Reductant doser
13. Oxidation catalytic converter

Working principle

The working principle for exhaust gas aftertreatment is divided into three different operations:

- Starting
- Operation and reductant metering
- Shutdown

Starting

The reductant pump starts when the following has taken place: the engine has started, the EEC3 control unit has carried out a system check, the catalytic converters have started to heat up and have reached the correct operating temperature (200 - 250°C) and any heating of the reductant is finished. The reductant pressure is built up to approximately 9 bar and is then injected into the evaporator by the reductant doser.

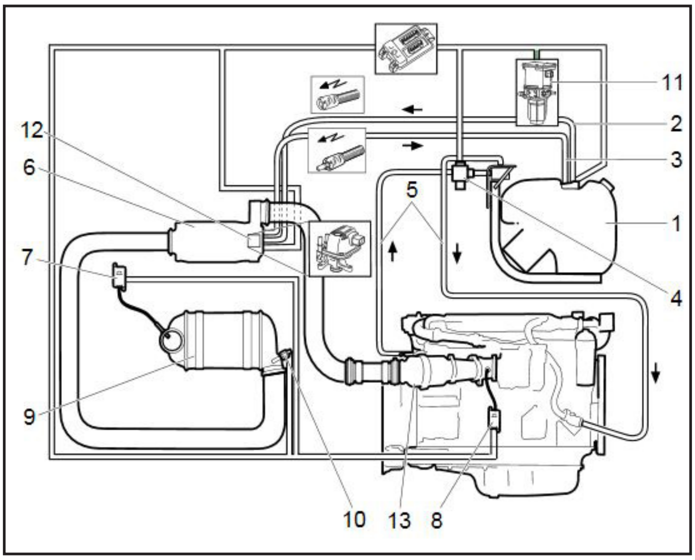


Figure 41

- The EEC3 control unit monitors the values and functions of all sensors.
- The engine is started
- The reductant pump (11) starts and builds up the reductant pressure to approximately 9 bar.
- When the temperature sensor (10) indicates that the temperature of the exhaust gases has reached 200 - 250°C, the EEC3 control unit activates the reductant doser (12), which starts injecting reductant to the evaporator (6). The dose is determined by the engine control unit EMS based on the value from the NOx sensor (8) and the combustion control mode in the engine currently being operated by the engine control unit.
- The process to reduce the quantity of NOx starts in the SCR catalytic converter (9).

Starting when heating frozen reductant

- The EEC3 control unit monitors the value and functions of all sensors.
- The engine is started.
- The EEC3 control unit opens the coolant valve (4) so that the coolant can heat the reductant tank (1) and reductant pump (11). The EEC3 control unit also activates electrical heating of the reductant hoses (2 and 3) and the electric heating in the reductant doser (12).
- The EEC3 control unit registers, via the temperature sensor in the reductant tank (1) and the reductant doser (12), when the reductant is at a temperature above -5°C, at which the reductant pump (11) starts.
- When the temperature sensor (10) shows that the temperature of the exhaust gases has reached 200 - 250°C and the value at the NOx sensor (8) has been reported to the engine control unit, the EEC3 control unit activates the reductant doser (12). The reductant doser then starts reductant injection into the evaporator (6). The dose is determined by the engine control unit on the basis of the combustion control in the engine which is currently being operated by the engine control unit.

Operation and reductant metering

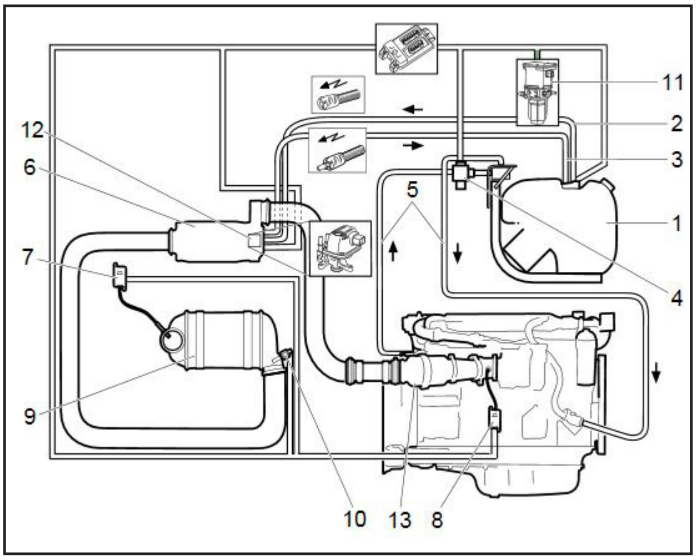


Figure 42

- The exhaust gases are treated in a number of steps before being released via the tailpipe. These steps are based on the combustion control mode of the engine control unit.
- Through engine control unit (EMS) regulation, the exhaust gases are monitored and treated in a number of steps before being released via the end pipe. The concentration of the NOx is measured by the NOx sensor (8) and the EEC3 control unit transmits the value to the engine control unit. The exhaust gases then pass the oxidation catalytic converter (13) where the NO_2 rate of the exhaust gases increases and any surplus diesel is burnt.

- The exhaust gases pass the evaporator (6), where reductant is injected. In order for the process to work, the exhaust gas temperature must have reached 200 - 250°C. The exhaust gas temperature is measured by the temperature sensor (10). The value is read off by the EEC3 control unit and transmitted to the engine control unit. If the temperature is too low or too high the engine control unit adjusts its combustion control mode.

- The EEC3 control unit controls the amount of reductant from the reductant tank (1) by activating and indicating the pump speed to the reductant pump (11) and the dose to the reductant doser (12). The values from the NOx sensors, exhaust gas temperature sensor and the combustion control mode of the engine control unit form the basis of the volume of reductant to be metered.

- When reductant has been mixed with the exhaust gases (evaporation), the exhaust gases pass the SCR catalytic converter (9), where the NOx is converted into water and nitrogen. In a last step the exhaust gases pass an ammonia slip catalystic converter (positioned in the SCR catalytic converter) that reduces any ammonia slip.

- Before the exhaust gases are released the NOx concentration is measured by NOx sensor (7). The value is read off by the EEC3 control unit and transmitted to the engine control unit. The value is compared to the NOx concentration from NOx sensor (8) and forms the basis of the combustion control mode of the engine control unit and any adjustment of the exhaust temperature or reductant doser.

Shutdown

- When the engine is switched off after being subject to heavy loading and heat release, the reductant pump (11) continues for a set period to deliver reductant to the reductant doser (12). However, reductant is not injected into the evaporator (6) but is returned to the reductant tank (1) and has the purpose of cooling the -reductant doser (12). Do not switch off the battery master switch during cooling, otherwise the reductant doser may be damaged by the radiated heat from the exhasut system

NOTE

The SCR system may need up to 30 minutes to cool the reductant doser in extreme conditions. The battery master switch must not be switched off until then

Control unit EEC3

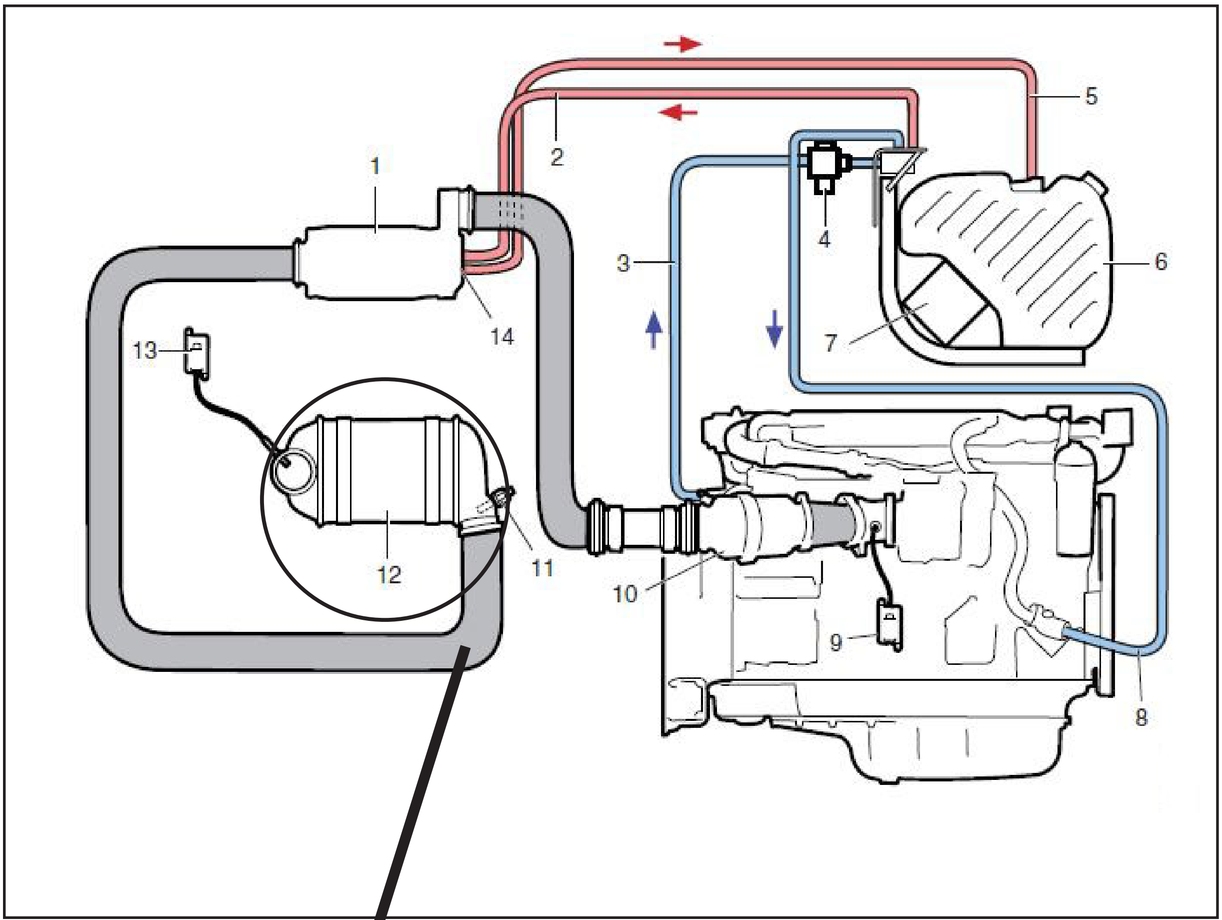


Figure 43

11. Exhaust gas temperature sensor
12. SCR catalytic converter
13. NOx sensor with control unit

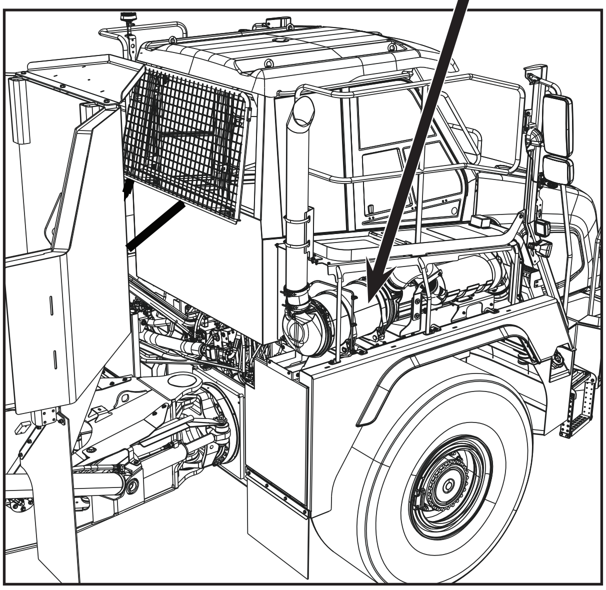


Figure 45

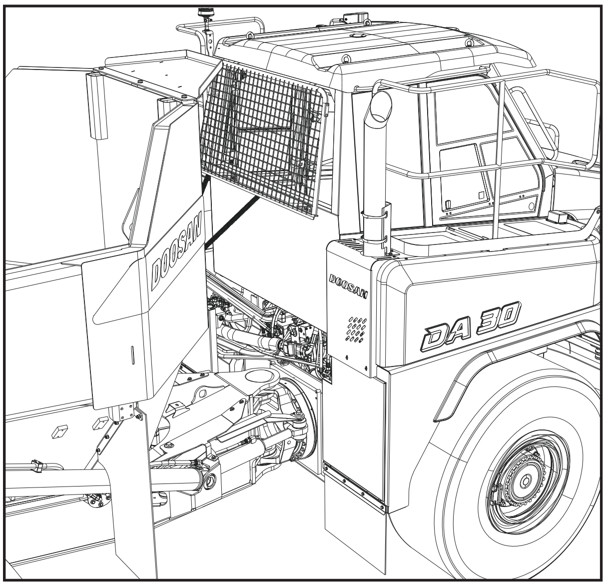


Figure 44

System overview for mechanics

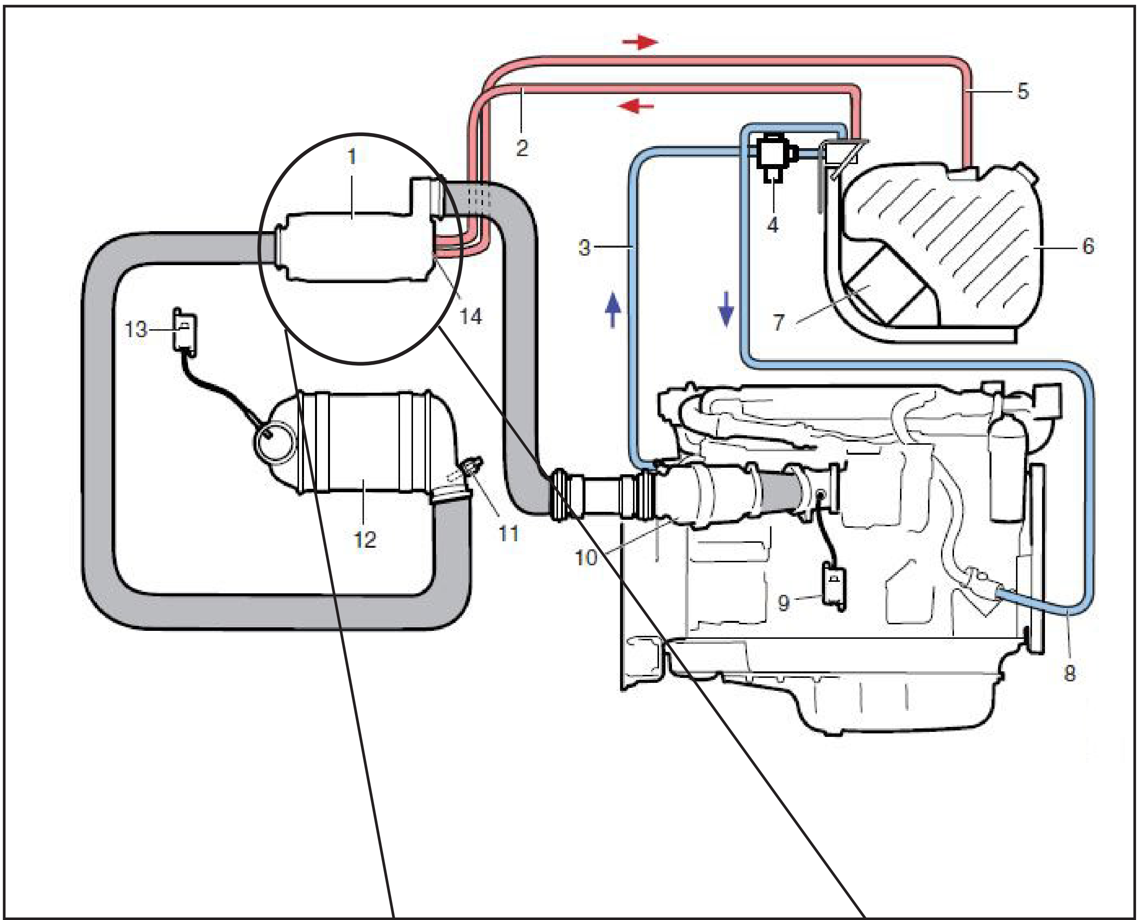


Figure 46

1. Evaporator

14. Reductant doser

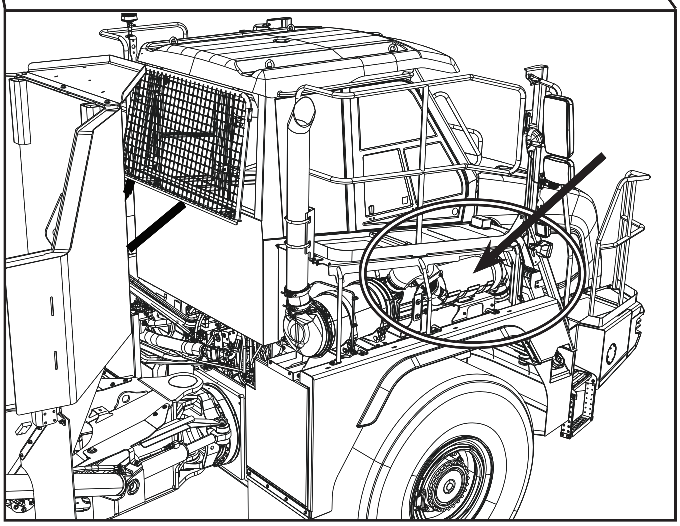


Figure 47

System overview for electronics

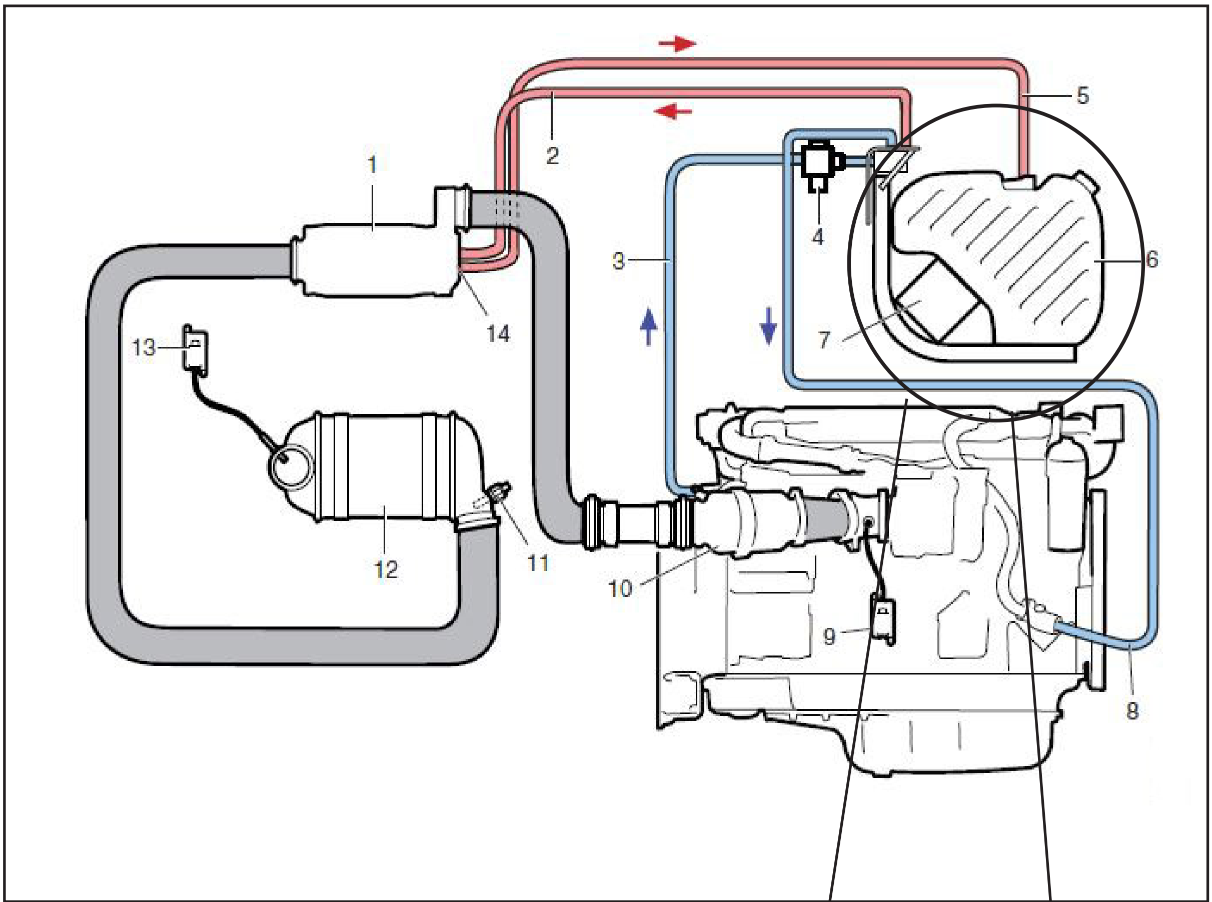


Figure 48

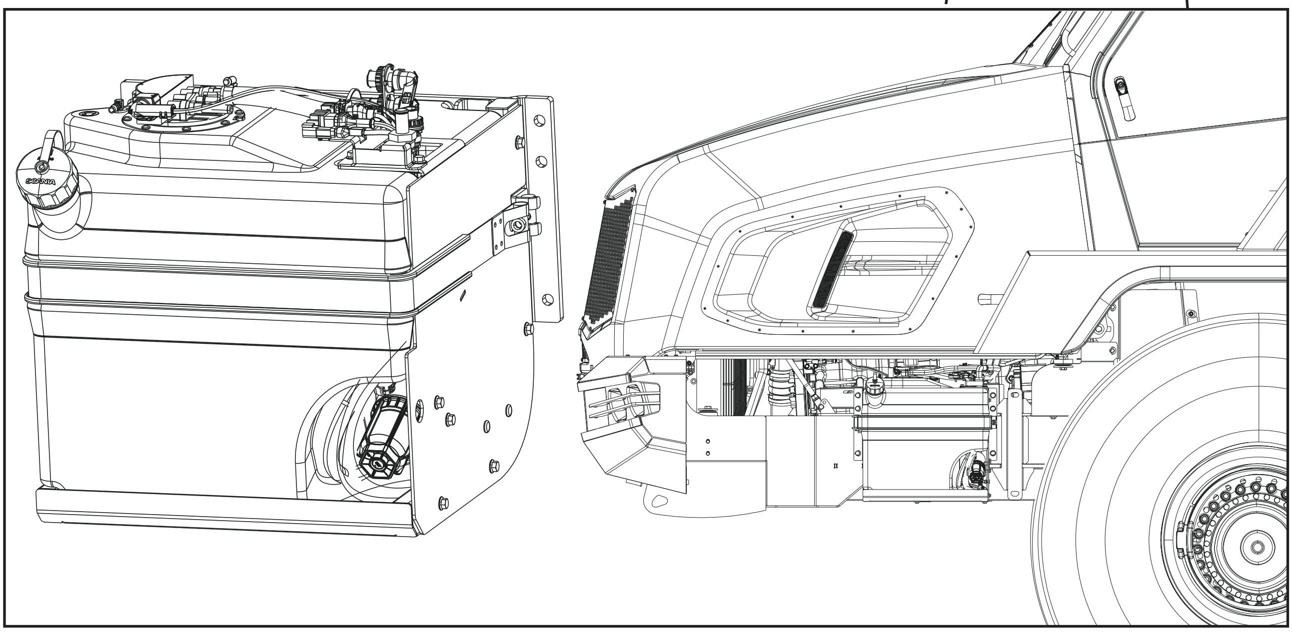


Figure 49

6. Reductant pump and controlunit

Ad blue filter change

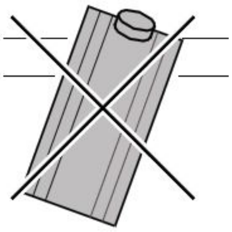
Renewing the reductant filter

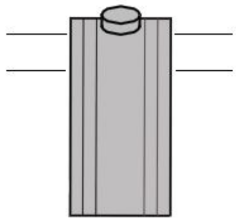
Every 1,000 hours:

Disassemble guard plate

1. Place a suitable container underneath.
2. Lift out filter element.
3. Renew the filter element and check the O-ring and insulation.
4. Wipe clean with lukewarm water and remove any crystals.
5. Fit guard plate under the fender.

The reductant tank must not be twisted or tipped in relation to the lode line.





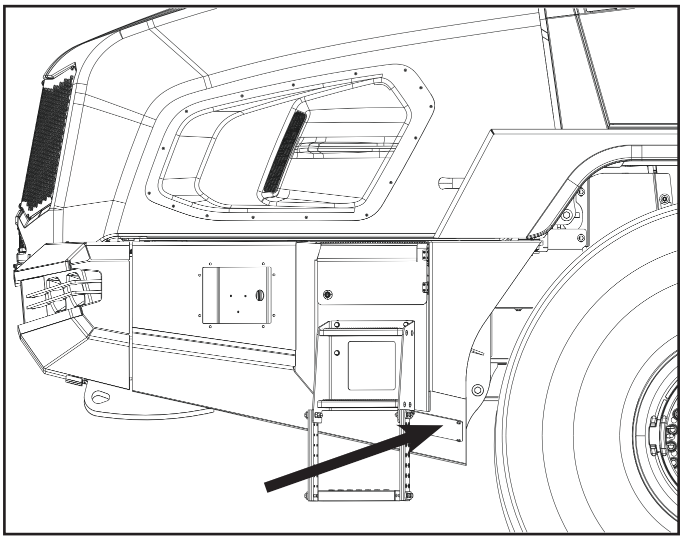


Figure 50

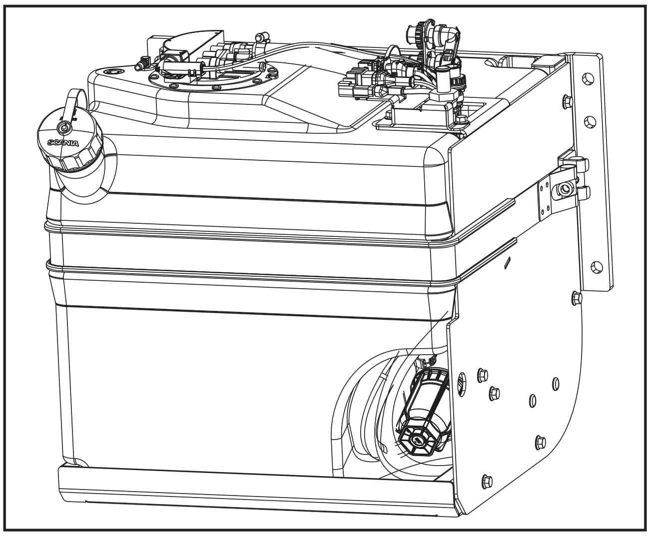


Figure 51

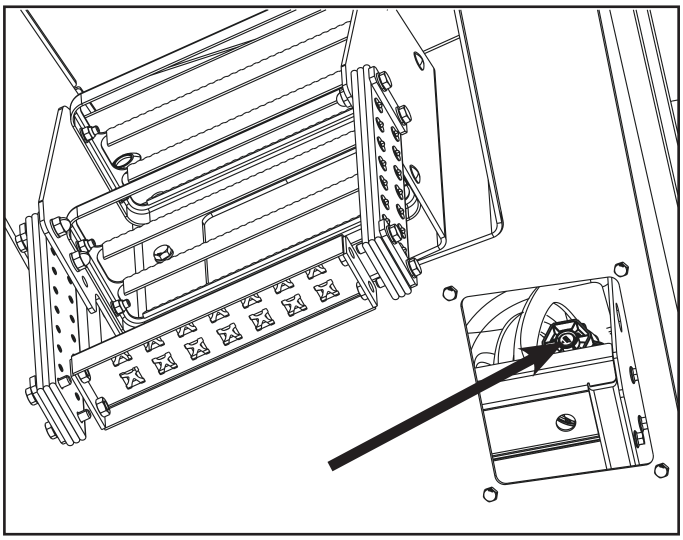


Figure 53

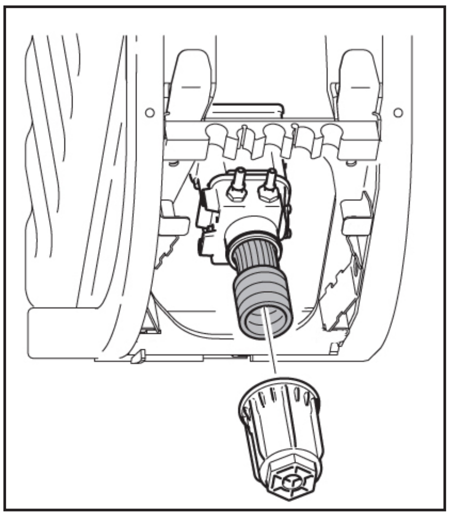
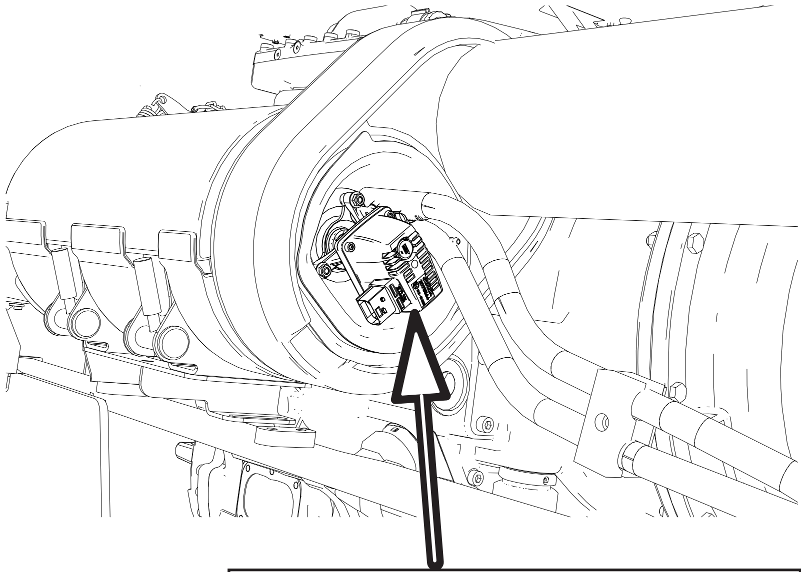


Figure 52

Reductant doser



Located on the evaporator.

The reductant doser meters out the quantity of reductant, which the engine control unit indicates, to the evaporator in the silencer. On industrial and marine engines the reductant is metered out to the hydrolysis catalytic converter

1. Connection for electrical connector
2. Reductant inlet
3. Reductant outlet
4. Nozzle
5. Ventilation

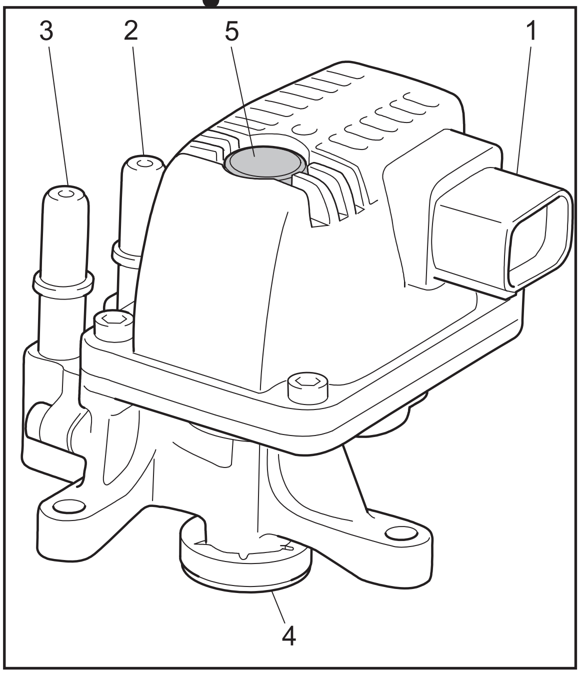


Figure 54

The reductant doser is electrically heated to prevent the reductant from freezing when the outdoor temperatures are low. The reductant doser is also equipped with a reductant temperature and pressure sensor and the measurements are transmitted to the exhaust gas aftertreatment system.

1. Restriction valve
2. Prefilter
3. Pressure and temperature sensor
4. Nozzle
5. Solenoid valve
6. Heater element

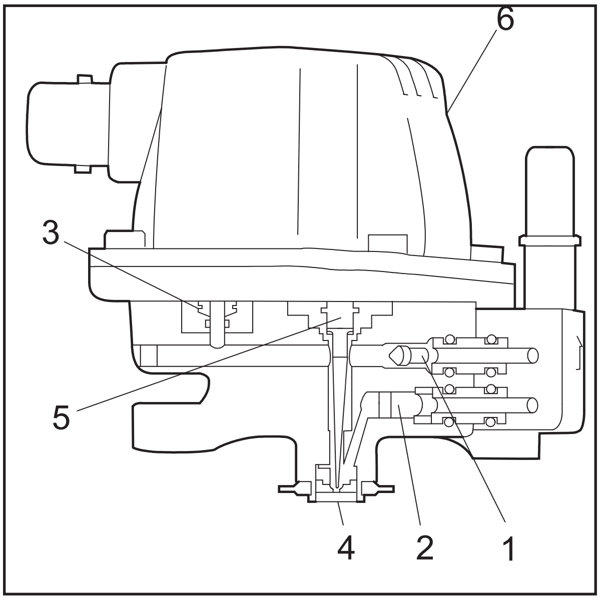


Figure 55

The reductant flows from the inlet at a pressure of about 9–10 bar and first passes the prefilter (2), fills the ducts after which the sensor (3) reads the pressure and temperature.

The dosage quantity is determined by the opening time of the solenoid valve (5). It opens once per second and the amount of time that the solenoid valve is open during that second determines the dosage quantity. The opening time can vary from 5–95% of 1 second. The reductant is metered to the exhaust gases via the nozzle (4).

After the engine has been switched off, the reductant pump continues to pump reductant to the reductant doser to cool it, otherwise the reductant doser can be damaged by the heat in the silencer. No metering takes place but the reductant flows out to the reductant tank via the restriction valve (1) and the outlet. Cooling stops when the temperature is not critical in the reductant doser.

CAUTION

Do not switch off the main switch until cooling of the reductant doser has finished. The reductant doser can be damaged by too high a temperature.

A graphite gasket (1) is fitted on the reductant doser which seals against the evaporator in the silencer (against the hydrolysis catalytic converter in industrial and marine software applications). It should be renewed if the reductant doser has been removed from the evaporator in the silencer or the hydrolysis catalytic converter. Also check the nozzle (2).

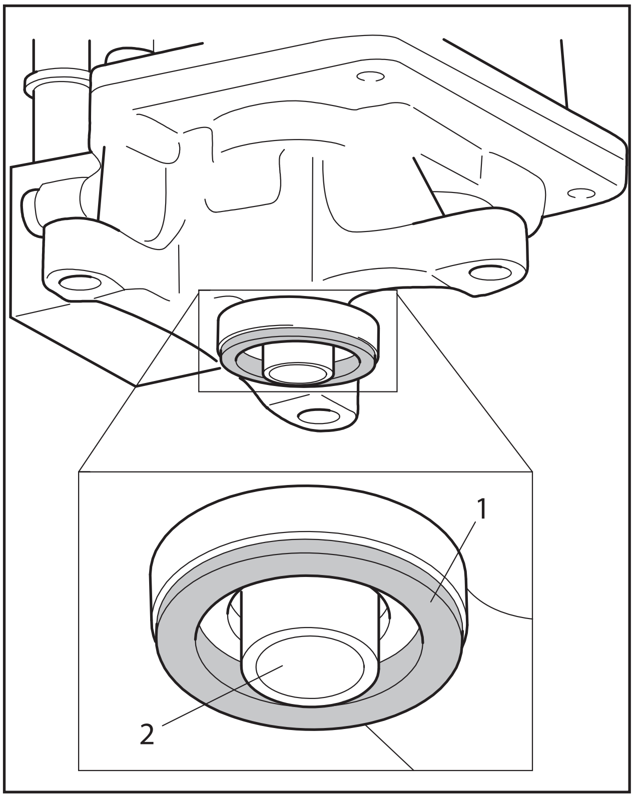


Figure 56

Start-up instruction for new SCR Pump

If an SCR pump has not been used for a long period of time, the check valves could seize and become jammed due to crystallized urea in the valves resulting in lack of system pressure. This could also be a problem on new spare part pumps that have spent a long time in stock.
Nowadays reductant with an extremely low concentration is used when testing these pumps in production. Reductant with low concentration reduces the risk of this problem occurring.
Nonetheless, local stocks may still have the old pumps.

NOTE

Use soap water! It is strictly forbidden to use SILICONE or VASELINE in any parts of the UREA system.

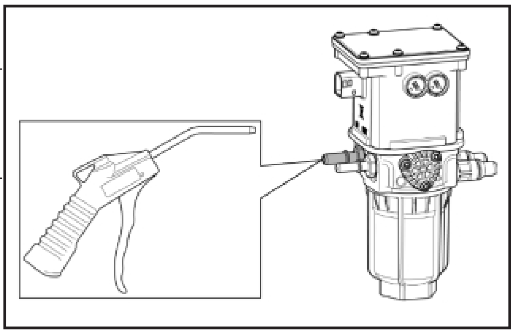


Figure 57

Pressurize the intake (suction side) of the SCR pump for 3 seconds with compressed air 6-10 bar.
The suction side of the pump is marked "IN". Always carry out this procedure before fitting a spare part pump.

NOTE

This action may also be needed after long time without using the machine


Figure 58

To locate pump inlet, follow hose marked in Figure 58.

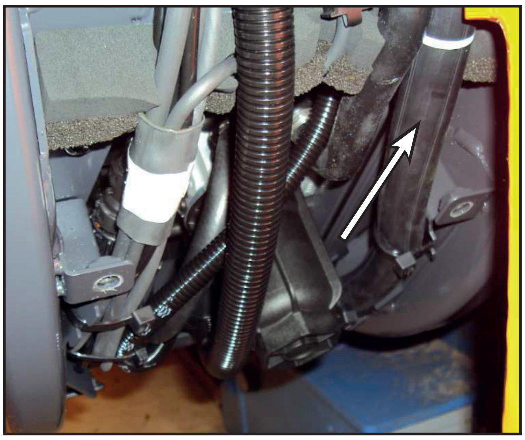


Figure 59

Folow line on “Figure 58” to locate pumpe inlet.

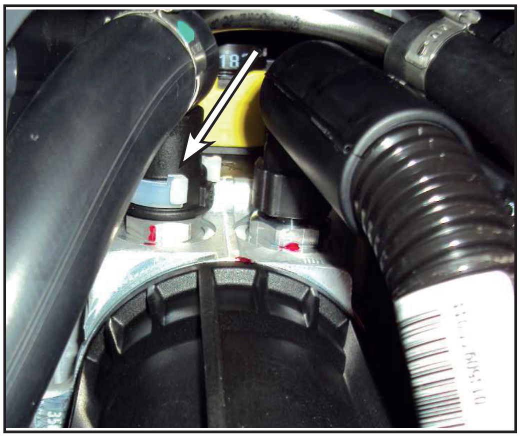


Figure 60

Suction line inlet on SCR pump

Reductant pump, function

NOTE

When carrying out repair work on the pump and control unit, the reductant tank should be removed

The reductant pump sucks reductant from the reductant tank, filters and builds up pressure for the reductant which is then fed to the reductant doser.

The reductant pump is an electrically driven diaphragm pump with a filter for cleaning the reductant. The reductant pump is heated using the engine's coolant at low outdoor temperatures in order to thaw frozen reductant or prevent it freezing.

1. Pump unit
2. Valve block
3. Reductant filter
4. Cover
5. Connections for coolant
6. Ventilation
7. Internal hexagon bolt
8. Connection for electrical connector
9. Connections for reductant
10. Electric motor for diaphragm pump

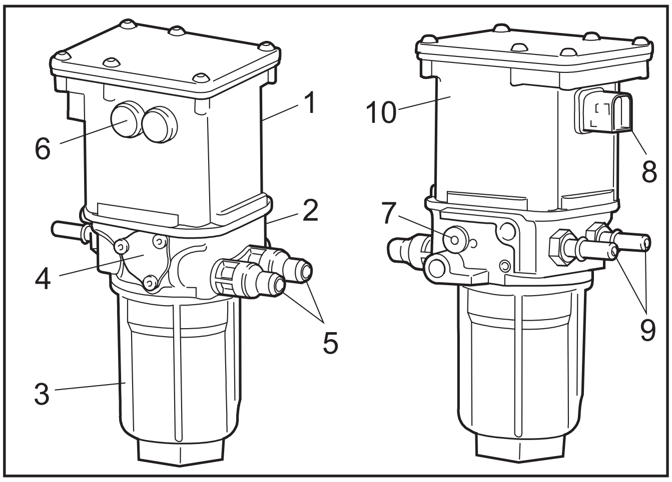


Figure 61

The illustration (Figure 62) shows a section through the valve block viewed from below.

Reductant is sucked through the intake (1) and reductant filter in the valve block (3) and then through a port (6) to the pump chamber, where reductant pressure is built up. If the reductant pressure exceeds 13 bar in the pump, the overflow valve (5) and check valve (7) open, reducing the reductant pressure in the pump. The amount of reductant pumped to the reductant doser can be varied by regulating the speed of the electric motor between 800 and 3500 revolutions per minute.

If the reductant freezes in the reductant pump at low outdoor
temperatures when it is non-operational, which takes place at
approx. -11°C, there is a damping element (4) in the valve block
that is compressed when the reductant expands during freezing.

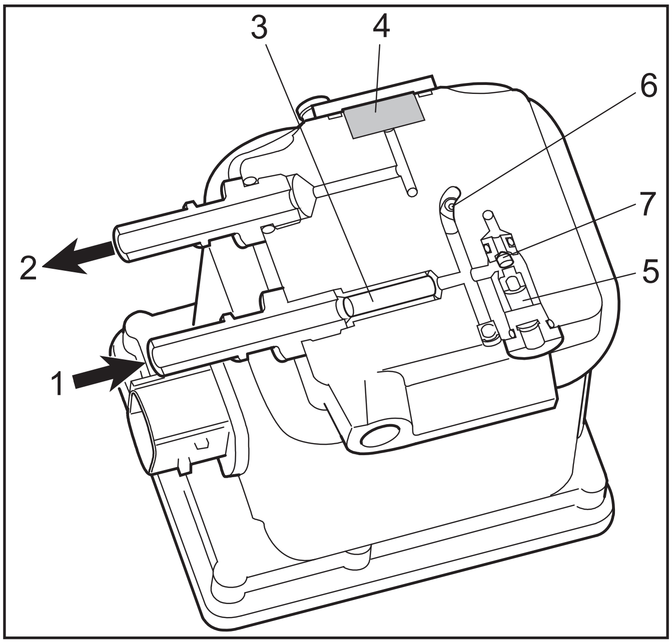


Figure 62

1. Intake, reductant
2. Outlet, reductant
3. Reductant filter
4. Damping element
5. Overflow valve
6. Port to pump chamber
7. Check valve

Figure 63 shows a section through the valve block viewed from the side.

Reductant is sucked in through the intake port (1) and via an intake valve (2) to the pump chamber, where reductant pressure is built up by means of the pump diaphragm (3). Pressurised reductant passes through the outlet valve (4) and via the port (5) to the reductant filter, which is located under the valve block. If the pressure exceeds 13 bar, the overflow valve opens via the port (6). Once the reductant has passed the reductant filter, it is pumped out via the port (7) and outlet (8). The reductant pressure has been reduced and is approx. 10 bar.

1. Port from the reductant filter in the valve block
2. Intake valve
3. Pump diaphragm
4. Outlet valve
5. Port to the reductant filter under the valve block
6. Port to overflow valve
7. Port from the reductant filter under the valve block
8. Connection, outlet for reductant
9. Reductant filter retainer under the valve block

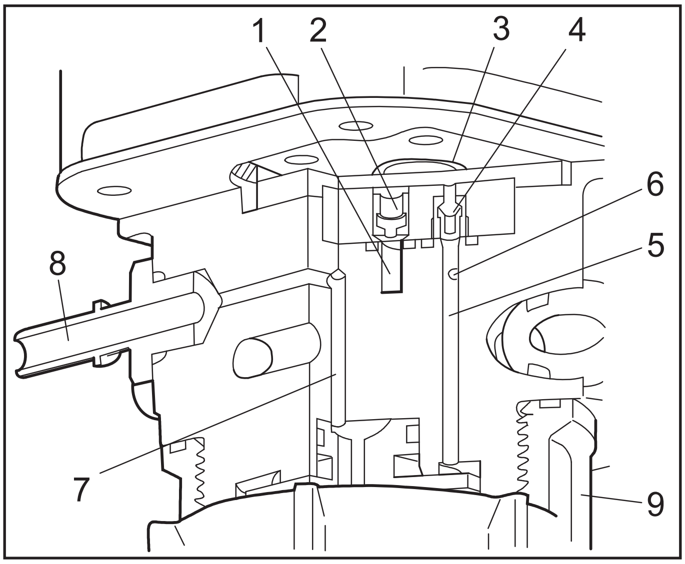


Figure 63

The reductant filter (1), which is located under the valve block, must be renewed in accordance with the specified inspection interval. If the reductant freezes in the reductant pump at low outdoor temperatures when it is non-operational, which takes place at approx. -11°C, there is a damping element (3) in the filter retainer that is compressed when the reductant expands during freezing. A sealing bladder (2) protects the damping element from coming into contact with the reductant. The damping element and the area around it are ventilated via a diaphragm valve (4).

1. Reductant filter
2. Sealing bladder
3. Damping element
4. Diaphragm valve

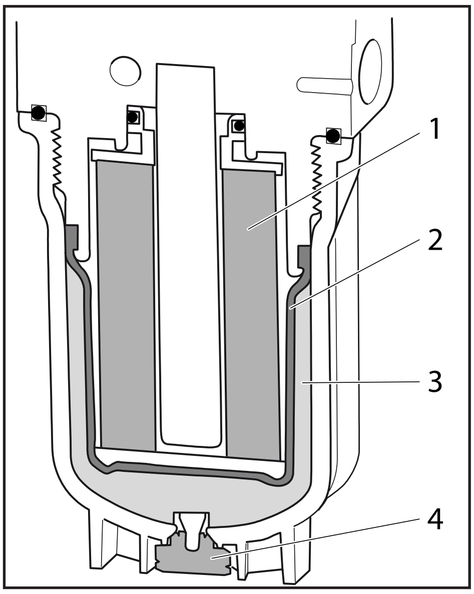


Figure 64

EGR SYSTEM

Page 43 - 47: T4F only

The engine is equiped with an EGR (exhaust gas resirculation) system. The EGR system returns part of the exhaust gases back to the engine. When the exhaust gases are returned to the intake air, it reduces the oxygen level. This results to a reduction in the combustion temperature and less NOx emission.

The EGR system is active between approximately 900 and the highest engine rotation with a positive torque.

The EGR system is active when the coolant temperature exceeds 50°C.

Controlling the flow

The engine control unit controls the flow of exhaust gases. The control unit regulates EGR content, i.e. the volume of exhaust gases that are returned to the engine. The level is measured in percent, e.g. 10% EGR content means that 10% of the total flow into the engine is exhaust gas and 90% is air.

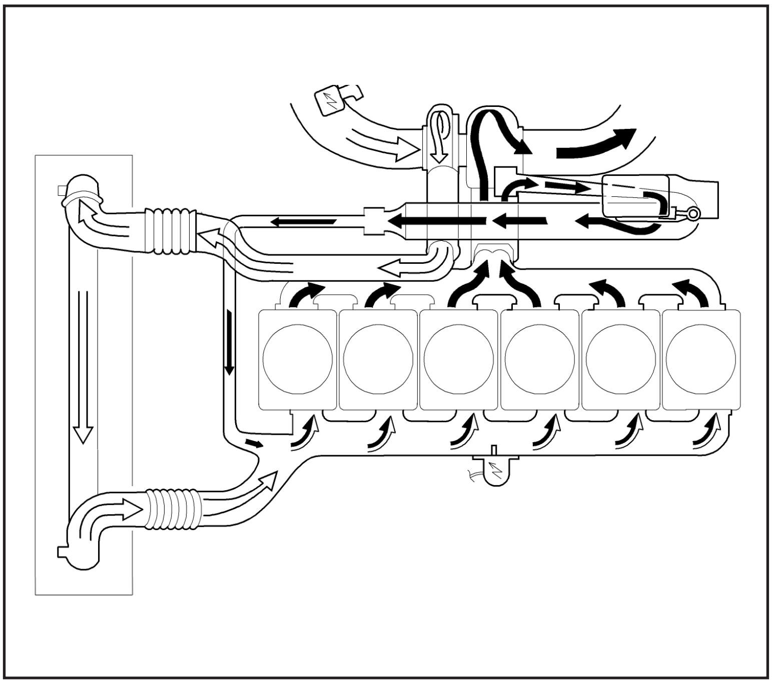


Figure 65

Principle drawing of the flow in a 6 cylinder engine

Cold engine

The engine control unit receives information from the coolant temperature sensor. If the coolant temperature is below 60°C, the control unit will not send a signal to the actuator to open the EGR valve. This also happens when the intake air is colder than 10°C due to the risk of condensation. No exhaust gases are then circulated.

Warm engine

When the coolant temperature has reached the required temperature, the engine control unit sends a signal to the actuator to open the EGR valve. The exhaust gases flow via the EGR valve through the EGR cooler, where they are cooled and then re-enter the engine.

When the throttle is rapidly opened, the engine control unit reduces the EGR content. This is intended to compensate for the shortage of induction air that occurs before the turbocharger begins to charge.

Shut-off conditions

The controll unit shuts down the EGR system if:

- The charge air temperature falls below a specific value. There is then a risk of freezing in the intake manifold.
- The engine is at such a high altitude that the air pressure affects its performance.
- Coolant temperature is too high. At very high coolant temperature, the control unit closes the EGR valve to avoid loading the engine with additional heat from the EGR cooler.
- The white smoke limiter is active.
- There is a risk of the EGR system freezing if the ambient temperature is very low.

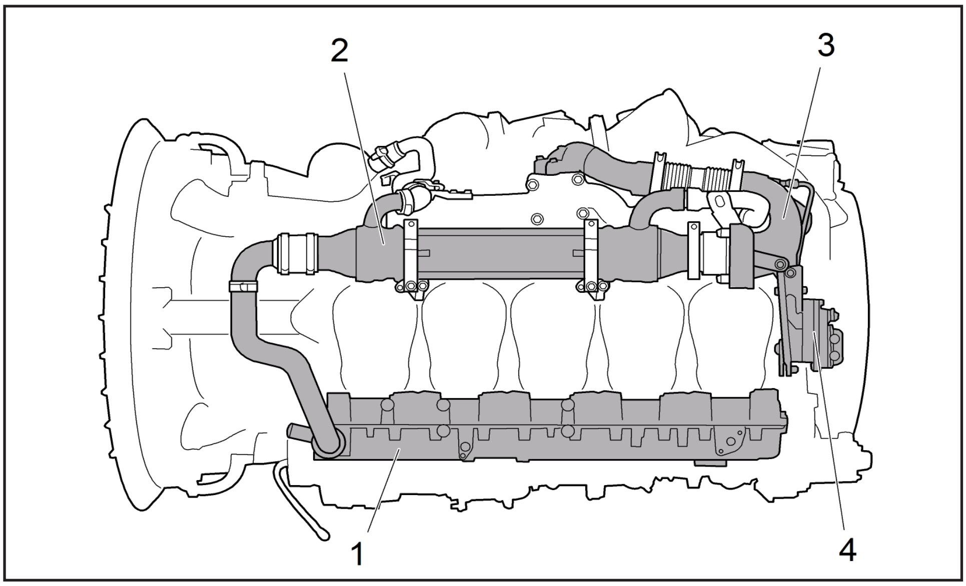


Figure 66

1. Inlet pipe
2. Liquid-cooled EGR cooler
3. EGR valve
4. Electric actuator

EGR valve and actuator removal

1. Turn off battery main switch.

WARNING

Never turn off battery main switch when engine is running
Never turn off battery mainSwitch when ignition is on
Leave battery main switch on for atleast 5 minutes after engine has completely stopped.

WARNING

Risk of crush injuries. The actuator can be activated automatically when supplied with voltage.

2. Drain the coolant.

3. Remove cable bracket (A).

4. Remove the contact housing (B).

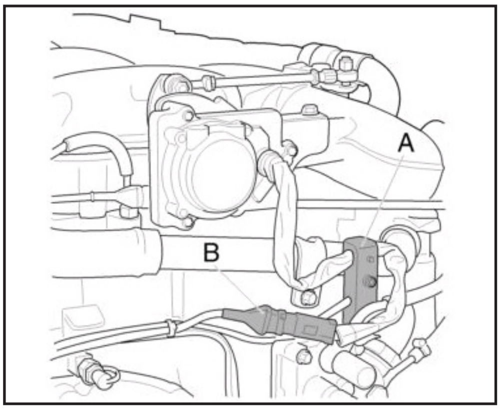


Figure 67

6. Remove the nut on the rear to detach the link arm from the actuator.

7. Remove the actuator.

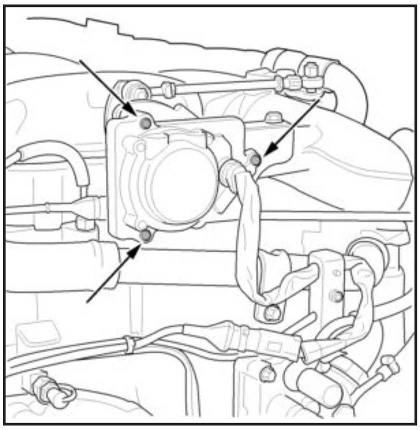


Figure 68

8. Release the clamp securing the by-pass valve controll line.

9. Remove the screws on the holder for the rear coolant pipe of the EGR cooler.

10. Remove coolant pipe.

11. Loosen the screws holding the EGR valve to the cylinder head.

12. Remove EGR valve.

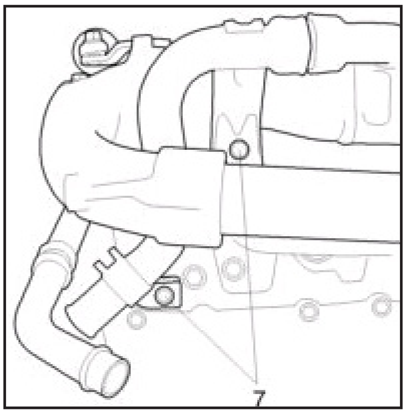


Figure 69

Leak test and functional inspection of the EGR system components

Component	How
Pulse convertor	Search for heavy soot accumulation.
Transition point between pulse converter and the EGR valve.	Search for heavy soot accumulation.
EGR valve	Search for heavy soot accumulation. Check that the EGR valve is properly closed.
The pipe between the EGR valve and the EGR cooler.	Search for heavy soot accumulation.
The pipe between the cooler and the inlet pipe	Search for heavy soot accumulation.
EGR cooler	Searching for leakage in the EGR cooler; see Leak testing the EGR cooler.
Venturi	On engines with venturi, search for heavy soot accumulation.
EGR valve actuator.	Manually check that the EGR valve can open and close without jamming.

Checking the control cylinder

- Connect Scania SDP3.

  Activate the control for the EGR valve control cylinder.
- Check that the control cylinder moves unhindered between the closed and open positions.

  Check the valve in the closed position.
- Make sure there is no play at the control cylinder.

  Check the valve in the open position.
- Check the integrity of the cylinder and that the valve opens fully. In the fully open position, the rear end of the valve shaft should lie against the mechanical stop.

Leak testing the EGR cooler

- Remove the EGR cooler from the vehicle. See sub group 01-65, EGR system.
- Seal the EGR cooler's coolant inlet and outlet.
  Plug the hose connection with a rubber plug or similar and with a plate on the end with a flange.

WARNING

It is important that the seals are securely fitted when the EGR cooler is pressurised. There is otherwise a risk of them coming loose.

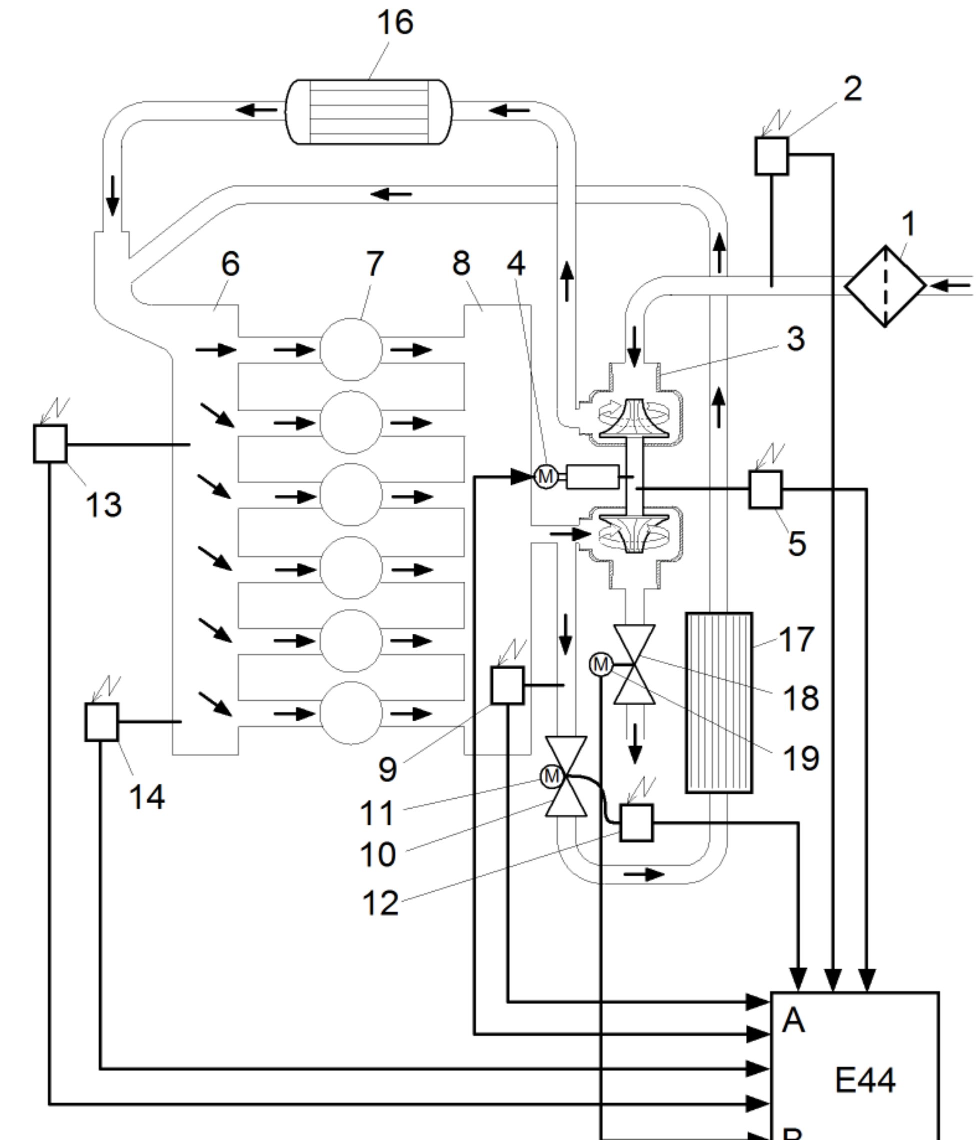
- Pressurise the EGR cooler via the bleed connection to 1.5 bar and lower it into a water bath. Use tool 99 405.
- Leave the EGR cooler submerged for approximately 30 minutes to make sure that this really is leakage.
- Once the leak test is complete, make sure that the EGR cooler is depressurised before removing the seals.

EGR system overview

1. Air filter
2. Mass flow sensor
3. Turbocharger
4. Electrical actuator for the turbocharger
5. Turbocharger rotational speed sensor
6. Inlet pipe
7. Cylinders
8. Exhaust manifold
9. Exhaust back pressure sensor
10. EGR valve
11. Electric actuator for EGR valve
12. Position sensor for EGR valve
13. Charge air temperature sensor
14. Charge air pressure sensor
15. Engine control unit
16. Charge air cooler
17. Liquid-cooled EGR cooler
18. Electronic exhaust brake
19. Electric actuator for exhaust brake

NOTE

This is a priciple drawing of the system, installed components may vary.



Principle drawing of the flow in a 6-cylinder engine.
The principle is the same for a 5-cylinder engine.

Figure 70

Renewing the control unit

Tightening torques

Control unit, screws	22 Nm

Work description

CAUTION

The control unit may suffer damage if it is powered when you unplug it. Before removing the control unit you must switch off the power with the starter key and wait for the EMS warning lamp to go out.

1. Remove the control unit cover
2. Remove the control unit connectors
3. Detach the fuel pipes to the control unit cooling coil from the control unit
4. Remove the fuel pipes to the control unit cooling coil from the feed pump and the fuel filter
5. Remove the control unit
6. Remove the control unit bracket

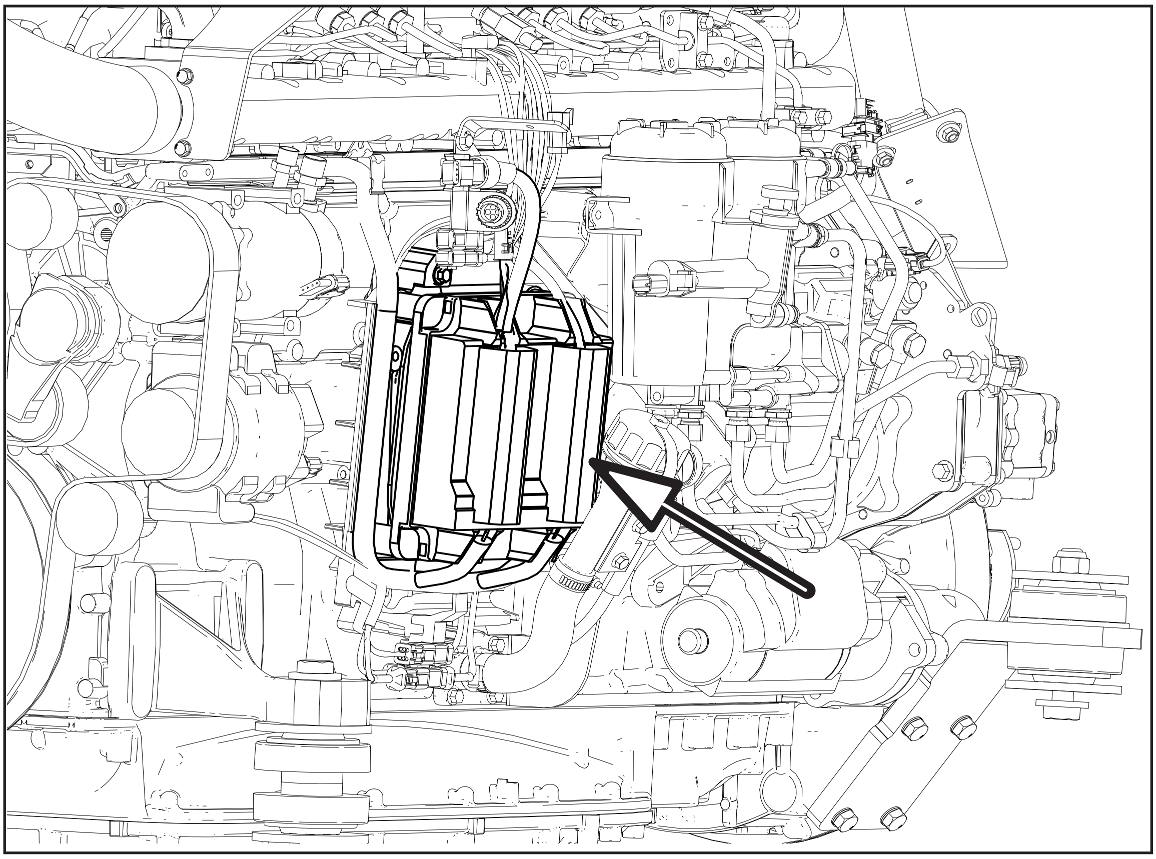


Figure 71

Common rail injectors Tier4/XPI

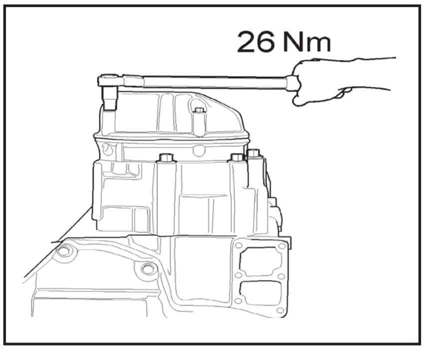


Figure 72

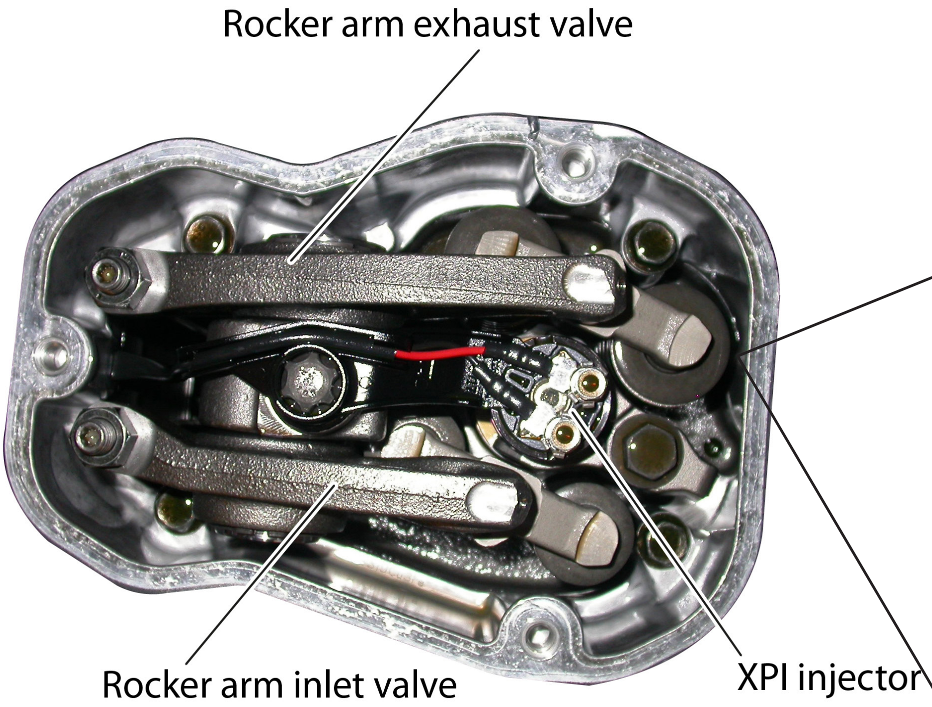


Figure 73

1. Low-pressure pump
2. Fuel filters with water separator
3. Inlet metering valve
4. High pressure pump
5. Rail (accumulator)
6. Rail Pressure sensor
7. Machanical dump valve
8. Return rail
9. Electronically controlled fuel injector

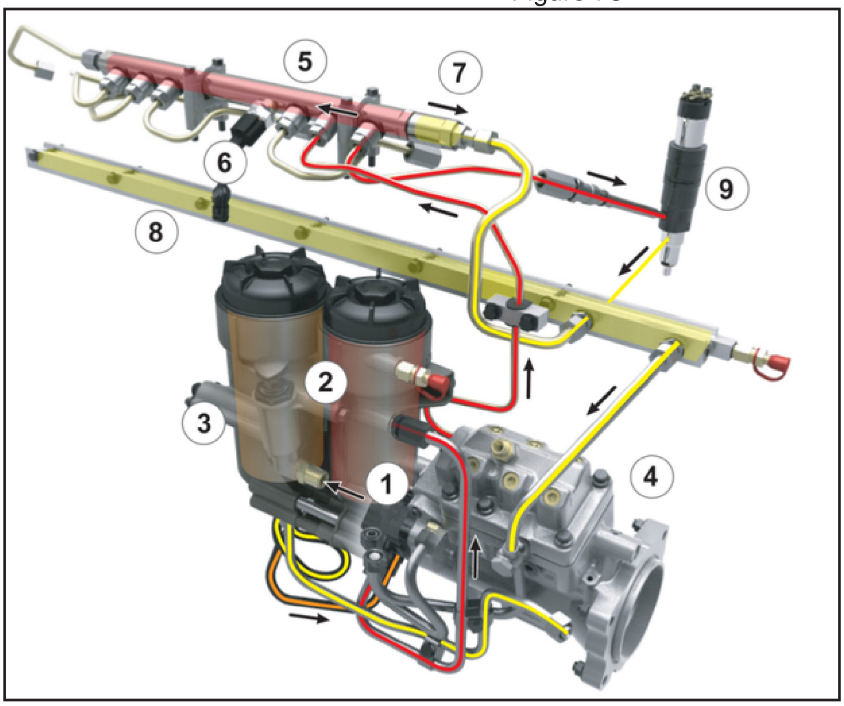


Figure 74

Cylinder head - XPI system Tier4

Cylinder head, parts view. XPI system Tier4

1. Cylinder head
2. Sleeve
3. Core plug
4. Rivet
5. Valve guide
6. Valve seat insert
7. Valve seat insert
8. Pin
9. Pin
10. Cylinder head gasket
11. Seal
12. Intake valve
13. Valve spring
14. Valve spring collar
15. Exhaust valve
16. Valve spring
17. Valve spring
18. Valve spring collar
19. Collet
20. Valve bridge
21. Bolt
22. Bearing bracket
23. Rivet plug
24. Bolt
25. Rocker arm
26. Adjusting screw
27. Hexagon nut
28. Bushing
29. Rivet plug
30. Snap ring
31. Rocker arm
32. Adjusting screw
33. Hexagon nut
34. Bushing
35. Rivet plug
36. Snap ring

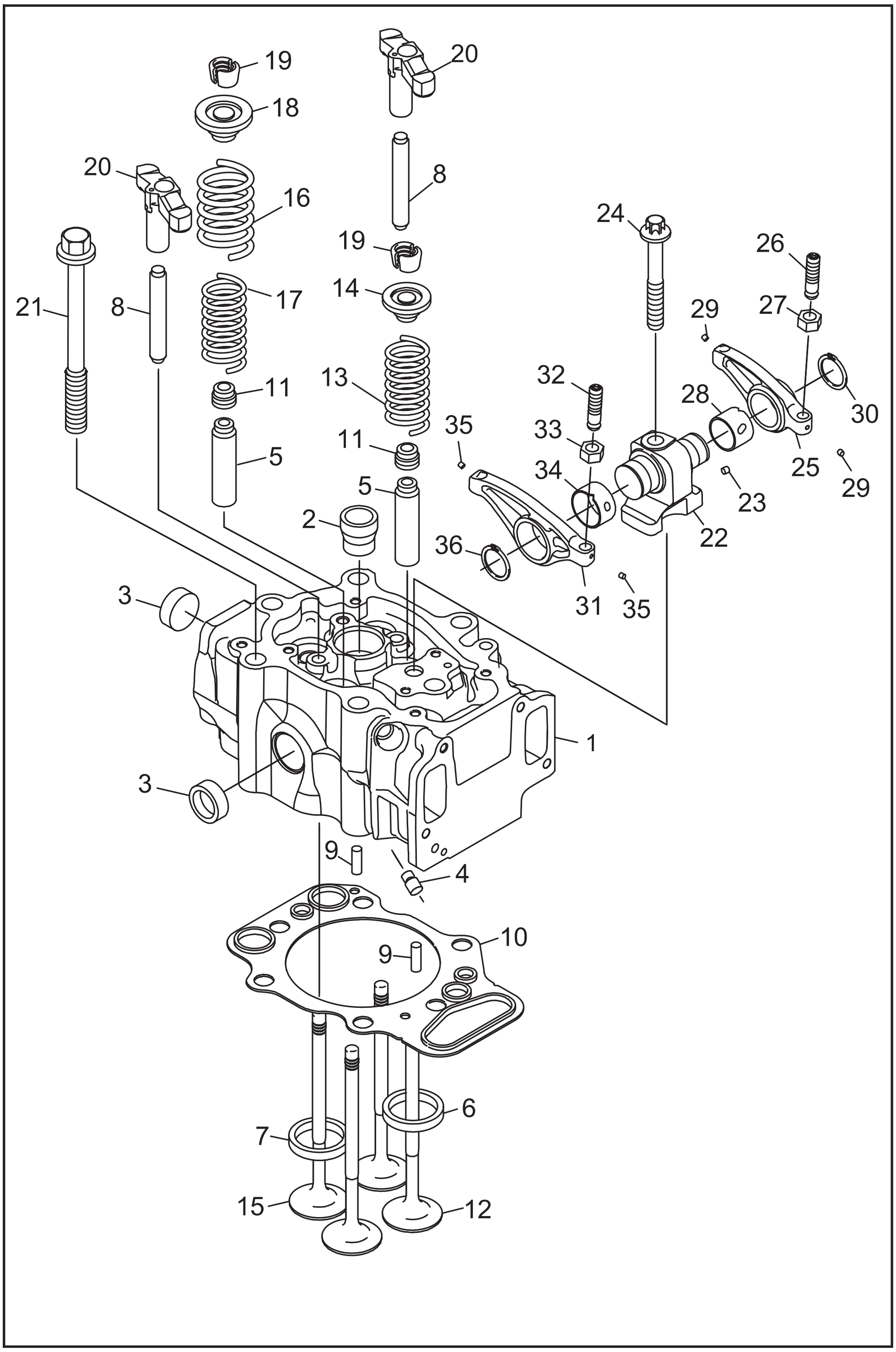


Figure 75

Injector Scania XPI

There is one injector for each cylinder. The injector is controlled electrically by the engine control unit.

The injector operates in two phases. One phase is when no power is supplied to the injector and it is closed. The other phase is when power is supplied to the injector and it is open.

The injector consists of a piston, nozzle needle, spring and an electromagnetically controlled fuel valve.

The fuel enters the injector via the connection. The injector is continuously pressurised to a maximum of 2400 bar. When the solenoid valve is supplied with power and opens, fuel is injected into the cylinder.

Injection timing and the amount of fuel to be injected is determined by the engine control unit. Injection duration and the fuel pressure in the accumulator determine the amount of fuel which is injected into the cylinder.

Phase 1, no power to the solenoid valve in the injector

No power is supplied to the injector solenoid valve and the injector is closed.

NOTE

There is a fuel pressure of between 350 and a maximum of 2400 bar in the injector.

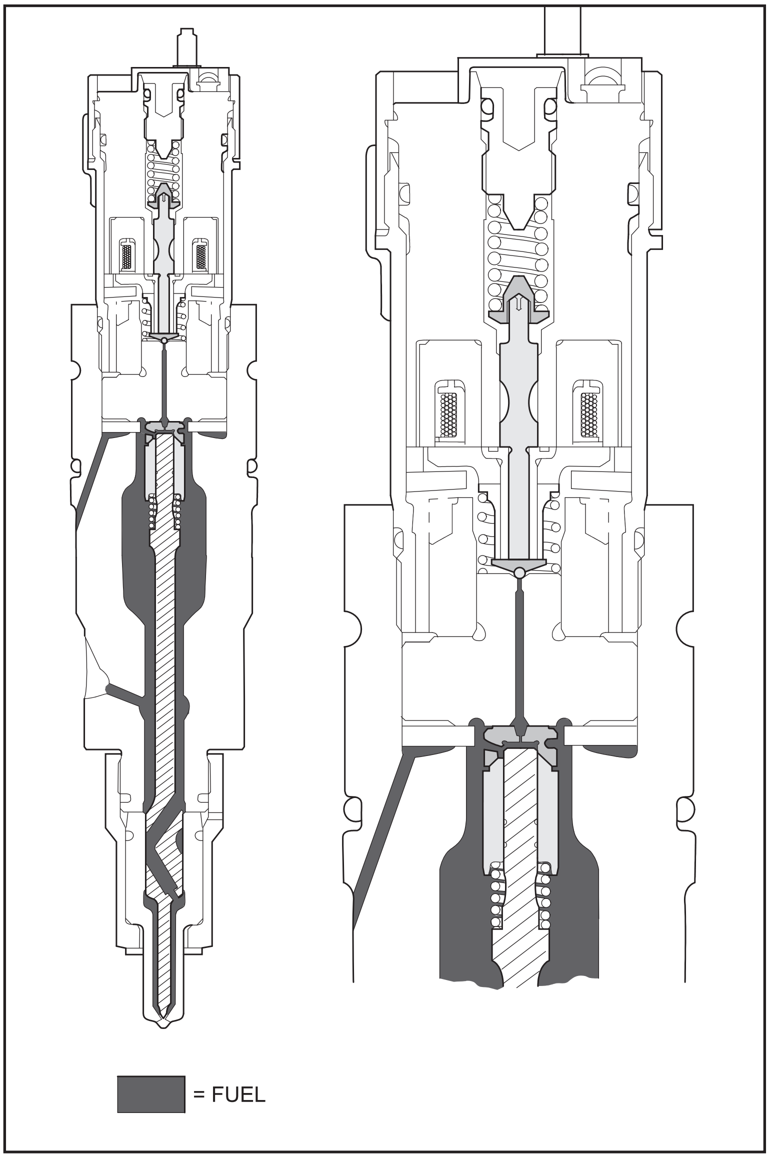


Figure 76

Phase 2, power to the solenoid valve in the injector

Power is supplied to the injector solenoid valve which then opens, so that the fuel flows up into the valve part. The pressure difference which arises in the injector means that the piston is drawn upwards and fuel is injected into the cylinders.

When power is switched off to the solenoid valve, the fuel pressure in the injector pushes the piston downwards and closes the injector.

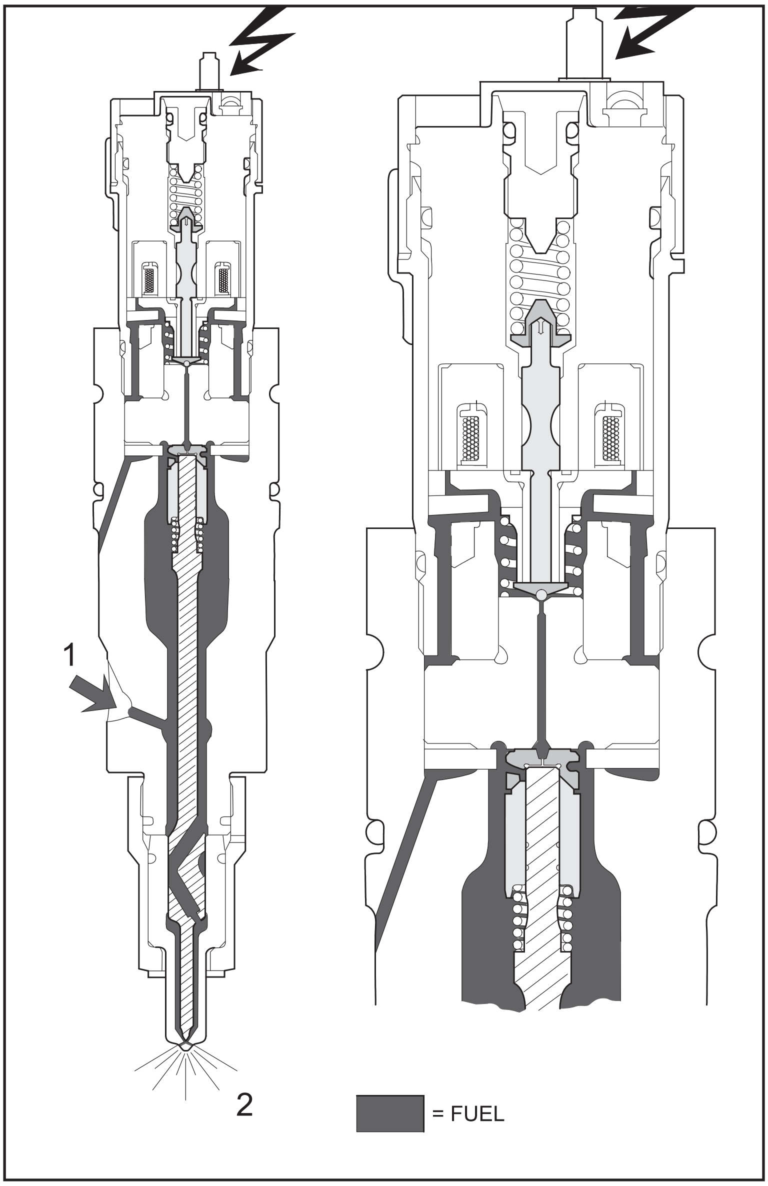


Figure 77

Valve adjustment DC9 / DC13 with XPI

Warning!

Block the starting device. If the engine starts unexpectedly, there is a serious risk of injury.

Special tools required

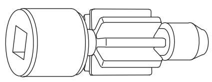
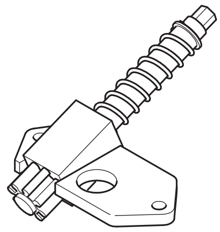
Hyundai part number	Designation	Illustration
850329-00175	Turning tool for rotating the flywheel from below	
850329-00529	Turning tool for rotating the flywheel from above	

Figure 80

The reference information UP TDC,DOWN TDC and the angle indications listed in the table below are engraved on the flywheel. Depending on the engine installation, this information is visible in one of the windows, either furthest up or furthest down on the flywheel. See illustration.

Valve Clearance, specifications	
Intake valve	0.45 mm (0.018 in)
Exaust valve	0.70 mm (0.028 in)

Tightening torque	
Lock nut for valves	35 Nm (26 lb/ft)

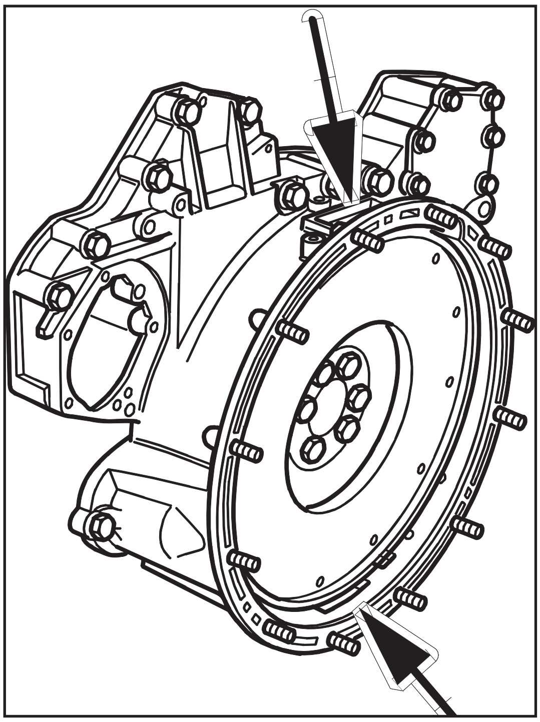


Figure 79

Figure 78

Adjustment tables DC9 / DC13

Adjust the valves according to the table below.
Follow the respective column depending on whether you are reading the engraving on the flywheel in the lower or the upper window. Start adjustment at the top of the table.

DC9:

Reading in the lower window	Rotation	Valve transition on cylinder	Adjust valves on cylinder	Reading in the upper window
DOWN TDC	1		1	TDC Up
72/432	1	5		252/612
144/504	1		2	324/684
216/576	1	3		36/396
288/648	1		4	108/468
DOWN TDC	2	1		UP TDC
72/432	2		5	252/612
144/504	2	2		324/684
216/576	2		3	36/396
288/648	2	4		108/468

Figure 82

DC13:

Reading in the lower window	Valve transition on cylinder	Adjust valves on cylinder	Reading in the upper window
DOWN TDC	6	1	TDC up
120/480	2	5	300/660
240/600	4	3	60/420
DOWN TDC	1	6	TDC up
120/480	5	2	300/600
240/600	3	4	60/420

Figure 83

NOTE

Valve change occurs when the cylinder goes from the outlet stroke to the inlet stroke. The exhaust valve is about to close at the same time that the intake valve is opening

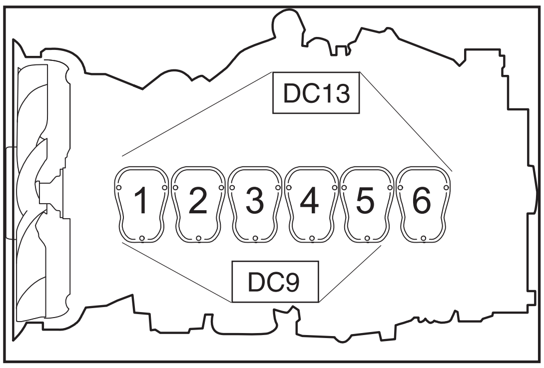


Figure 81

1. Clean the rocker covers and the area around them.

2. Remove the rocker covers.

3. Use the turning tool appropriate to the installation of the engine. Tool 99 309 is used to rotate the flywheel from the underside of the engine and tool 2 402 509 is used from the top side.

4. Start adjusting one cylinder according to the table. Rotate the flywheel until the correct engraving can be read on the flywheel. It may be necessary to rotate it more than 1 revolution. Rotate the flywheel in the rotational direction of the engine, which is clockwise viewed from the front of the engine, and anticlockwise viewed from the back of the engine. During a valve transition, the exhaust valve (the long arm) is closing at the same time as the intake valve is opening.

The UP TDC engraving on the flywheel is now visible in the window furthest up on the flywheel. The DOWN TDC engraving is visible in the lower window.

5. Read the table on the previous page to see which valve to adjust.

6. Stick the feeler gauge under the pressure pad of the rocker arm and check the valve clearance.

7. If necessary, adjust the valve clearance by
a) loosening the lock nut on the end of the rocker arm
b) adjusting the valve clearance with the adjusting screw
c) tightening the lock nut.

8. Mark the rocker arm with the felt-tip pen and then continue with the next cylinder according to the table.

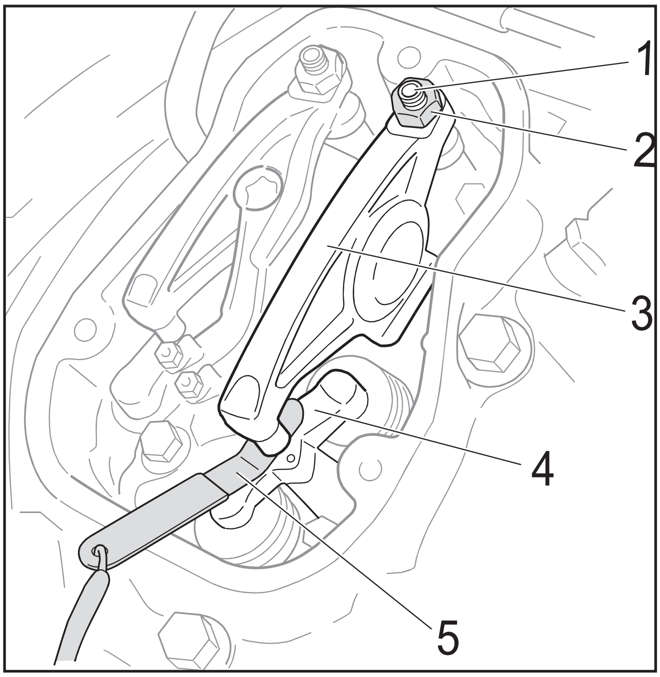


Figure 84

1. Adjusting screw
2. Lock nut
3. Rocker arm
4. Valve bridge
5. Feeler gauge

Turbocharger

The purpose of the turbocharger is to increase the volume of air entering the engine's cylinders. With more air the engine can burn more fuel and so develop more power and achieve cleaner combustion than a corresponding engine without supercharging.

The turbocharger is driven by the engine's exhaust gases and consists of a turbine part and a compressor part. The compressor part compresses the engine's intake air.

The compressor wheel is mounted on the same shaft as the turbine wheel. This shaft runs in a bearing housing between the compressor and turbine.

Higher power output from the engine gives more exhaust fumes and the increased exhaust means that the turbine wheel and therefore the compressor wheel rotate faster. In this way, the quantity of air is adapted to engine requirements without any special control devices.

The turbocharger wheel rotates extremely fast. At full power, speed is about 100,000 rpm. At the same time, the temperature on the exhaust side of the turbine wheel is above 600°C.

This makes big demands on the rotating parts in regard to balance, cooling and lubrication.

The shaft is mounted in two bushings which rotate freely in the bearing housing. The bearing housing seals for the turbine and compressor consist of seals which are similar to piston rings.

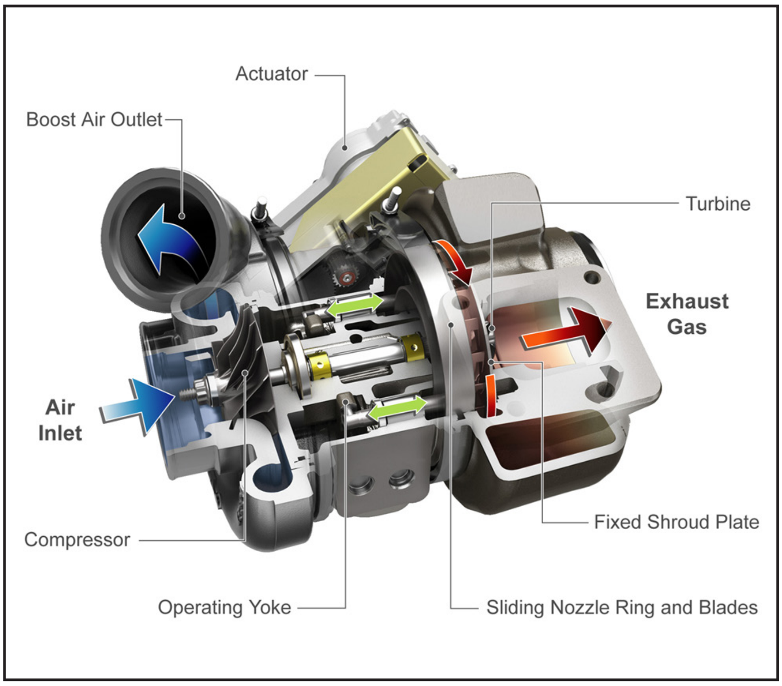


Figure 85

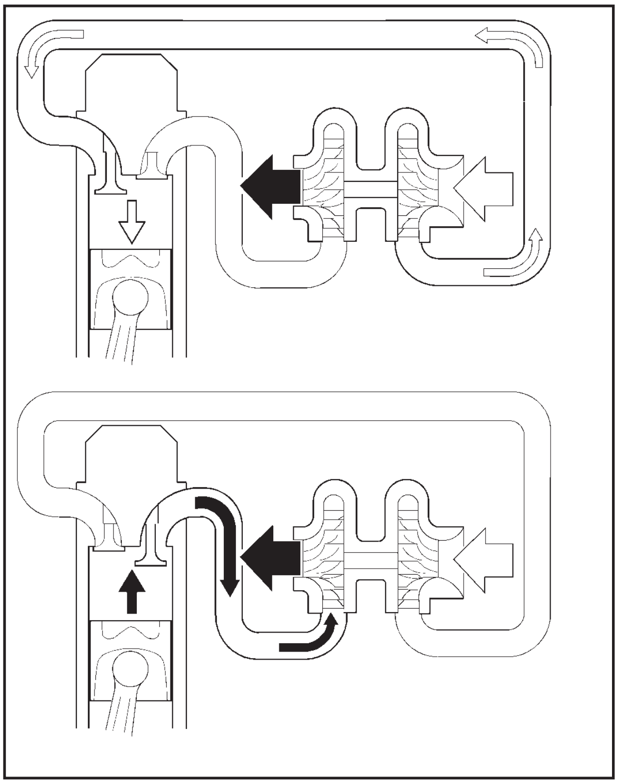


Figure 86

Measuring radial clearance and axial clearance

Measuring radial clearance and axial clearance does no usually give any indication of the remaining service life of the turbocharger.

When the turbocharger is not working correctly or sounds abnormal, measuring charge pressure or measuring radial clearance or axial clearance can show that the turbocharger is defective.

To measure axial and radial clearances it is advisable to remove the turbocharger and bolt it to a steel plate, which will also serve as a base for the magnetic stand holding the dial gauge.

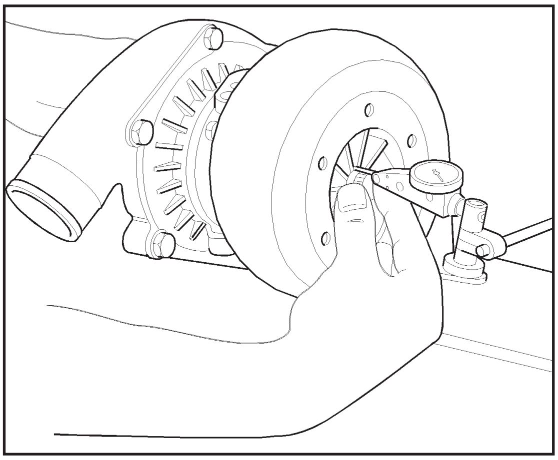


Figure 87

Measuring turbine wheel radial clearance with deflection gauge 8222 and measuring stand 8209

Radial clearance
Take readings on both turbine wheel and compressor wheel.

1. Place the tip of the deflection gauge against the turbine wheel and compressor wheel.
2. Pull both ends of the shaft up. Take a reading.
3. Press both ends of the shaft down. Take a reading. The difference between readings is radial clearance.
4. Repeat measurements three times on each side.
5. If any wheel rubs against the housing, despite radial clearance being within tolerance, the turbocharger should be changed.

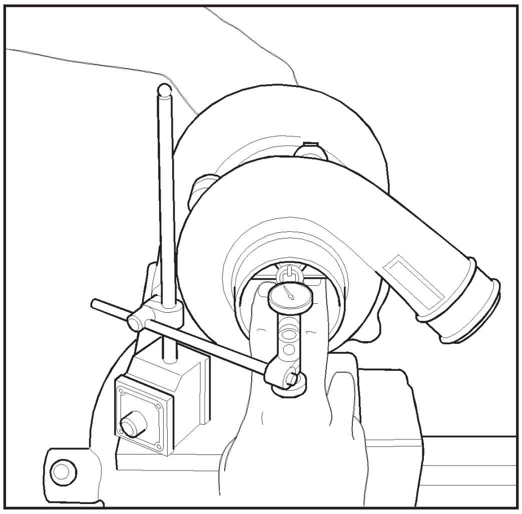


Figure 88

Measuring compressor wheel radial clearance with deflection gauge 8222 and measuring stand 8209

Axial clearance

1. Place the tip of the dial gauge **800109-00288** against the end of the shaft.

2. Press the shaft forwards and backwards and read the dial at the end positions. The difference between readings is axialclearance.

3. Repeat measurements three times.

Wear limits for Holset:

Radial clearance	**0.198-0.564 mm**
Axial clearance (after running in)	**0.025-0.106 mm**

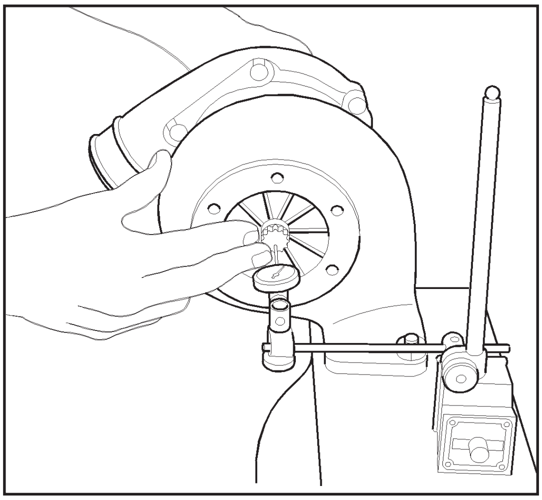


Figure 89

Measuring axial clearance with dial gauge 800109-00288 and measuring stand 850329-00319

If the turbocharger does not work:

1. Check that there is no leakage or loose objects in the line between the air cleaner and turbocharger.

2. Check that there are no loose particles in the exhaust manifold or intake manifold.

3. Check that all valves are intact.

4. Check the lubrication oil return pipe from the turbocharger for blockage or deformation.

5. Check the oil delivery pipe to the turbocharger for any blockage, deformation and leakage under pressure.

6. Check the condition and part number of the oil filter.

7. Check that the air filter is not blocked and that there are no other reasons for the abnormal increase of vacuum in the intake system.

8. Check that engine output is correct. Excessively high output reduces the life of the turbo.

VGT (Variable geometry turbo)

The engine is equipped with VGT (Variable geometry turbo).

Better engine response and improved low-rev torque. The geometry and gas flow in the variable-geometry turbocharger is regulated by an electric actuator.

This allows precise control of both charge-air to the engine, to boost low-speed engine power, and the flow of recirculated exhaust gases on the 9 and 13 liter engines.
The intake airflow can be optimized throughout the rev range.

This means that the VGT helps to improve engine response and low-speed torque by maintaining the turbine speed while the gear shifts are being made.

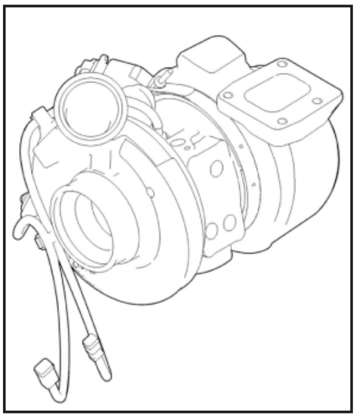


Figure 90

- Produces higher pressure on low engine speed
- Cooled by engine coolant
- Controlled by the S8 (EMS)
- Maximum turbo speed 120,000-130,000 rpm (Monitored by ECU)
- Creates correct pressure ratio between intake and exhaust for proper EGR function

VGT Removal

NOTE

Do not damage the pump housing gasket surface.

1. Drain cooling system.
2. Undo the V-clamp between exhaust pipe and exhaust brake. Move the exhaust pipe (2) out of the way.
3. Detach the exhaust brake and place to one side (3).
4. Remove turbocharger inlet pipe and charge air pipe (4).
5. Remove the coolant pipe on the variable geometry turbocharger.

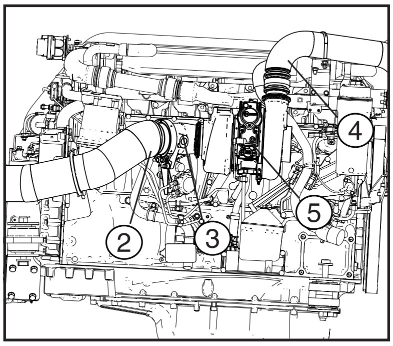


Figure 91

NOTE

Check that the inlet pipe rubber seals comes out with the pipe.

6. Remove coolant pipes to the electric motor if fitted.
7. Detach the coolant pipe from the variable geometry turbocharger (6).
8. Undo the hose clamps for the oil hose (7).
9. Detach the pressure pipe at the variable geometry turbocharger (8).
10. Undo the connectors for the rotational speed sensor electric motor.
11. Remove the variable geometry turbocharger.

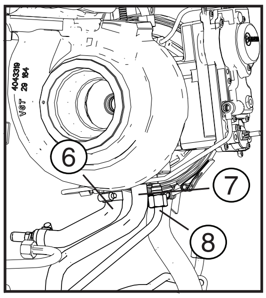


Figure 92

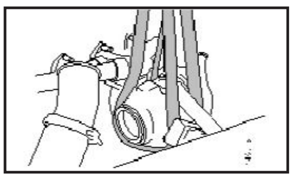


Figure 93

VGT fitting

NOTE

The joint between the turbocharger and turbo manifold should be tightened using new parts: screw, spacer, nut and gasket.

When the electric motor for the variable geometry turbocharger has been removed, basic setting and calibration of the electric motor must always be carried out using SDP3. Also use SDP3 to carry out a condition test on the variable geometry turbocharger after calibration.

NOTE

If the turbocharger caused oil carryover when it broke down, the catalytic converter may have been damaged. If the vehicle is equipped with SCR, run a validation test with SDP3 to check whether the catalytic converter is working.

WARNING

If the turbocharger caused oil carryover, oil may have entered the exhaust system and the catalytic converter may have temporarily been ignited when the engine was under load and a high level of heat was generated. Take care when warming up for the first time after renewing the turbocharger.

1. If studs are used in the joint, lubricate the stud threads with heat resistant lubricant.
2. Clean the turbocharger and exhaust manifold sealing surfaces.
3. Fit the oil hose on the oil pipe and pull it up on the pipe. Fit the turbocharger with a new gasket.
4. Fit the coolant pipes.
5. Fit the oil hose.
6. Fill the turbocharger with engine oil and fit the pressure pipe.
7. Fit the connectors for the rotational speed sensor and electric motor.
8. Fit the charge air cooler pipe and turbocharger inlet pipe.
9. Check that the guide pins are in position in the turbocharger. Fit the exhaust brake and exhaust pipe by the exhaust brake.
10. Tighten the V-clamp.
11. Refill the cooling system.

NOTE

After warming up the engine, tighten the V-clamps: Torque 20Nm.

NOTE

After warming up the engine, tighten the variable geometry turbocharger retaining screws.

General

NOTE

Whenever working on the turbocharger, observe utmost cleanliness. The oil intake and outlet connections must never be left open. A foreign body in the bearing housing can quickly cause total breakdown.

Oil leakage
With a clogged air cleaner, the vacuum in the intake pipe will be excessive. There is then a risk that oil mist will be sucked out of the turbocharger's bearing housing.

If the seal on the turbine side is worn, exhaust gas is blue when idling.

If the oil outlet pipe from the turbocharger is damaged, there is a risk of oil leaking out through the seals due to lubrication oil pressure.

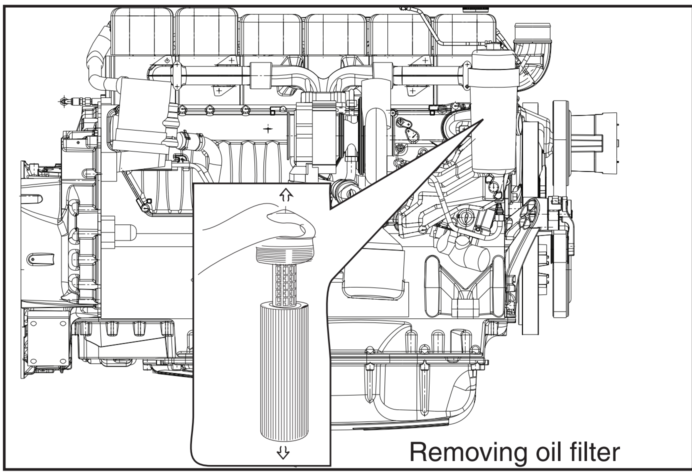
Oil filter
The turbocharger rotates at high speed, sometimes above 100.000 rpm.

The oil lubricates and cools the turbocharger. Efficient lubrication is extremely important. There is no separate turbo filter and the oil passes through the engine oil filter. For this reason, change the oil filter and clean the oil filter assembly in accordance with our instructions.

Use filter wrench **850329-00421** when removing the oil filter.

If the oil filter assembly is not cleaned, the oil filter will soon become clogged and its resistance to the flow of oil will increase.

A valve in the filter holder then opens and allows the oil to pass through the filter without being cleaned (filtered). Unfiltered oil is consequently supplied to the turbocharger with heavy bearing wear as a result.
The valve is designed for genuine filters and only these should be used.



Removing oil filter

Figure 94

Foreign bodies
Foreign bodies, such as grains of sand or metal filings, in the turbine or compressor will damage their blades.

This leads to imbalance and bearing wear. Engine output falls off and continued operation could give rise to overheating damage on account of a decrease in the supply of air.

This type of overheating cannot be observed on the coolant temperature gauge.

NOTE

Never attempt to straighten a damaged impeller. It will usually break in operation causing the turbocharger to break down and may also cause engine damage. Change the entire turbocharger.

Air and exhaust leakage
Even small leaks in the line between the air cleaner and turbocharger cause dirt deposits on the compressor wheel.

Charge pressure decreases with increased exhaust temperature, causing smoke. In addition, the engine is worn unnecessarily.

Exhaust leakage between cylinder head and turbocharger also results in lower charge pressure.

Cleaning the compressor wheel
Low charge pressure can be caused by a dirty compressor wheel, for example.

- Remove the compressor housing.

- Wash the compressor wheel using white spirit and a brush.

- Fit the compressor housing and measure charge pressure again.

NOTE

The compressor wheel must not be removed from the shaft. Imbalance may occur when it is refitted.

Changing oil filter

NOTE

Use only genuine oil filter according to parts catalogue.

NOTE

Clean the centrifugal oil cleaner when renewing the oil filter. Otherwise, the oil filter will be blocked and resistance in the filter will increase. If this happens, an overflow valve in the filter holder opens and lets the oil pass without being filtered.

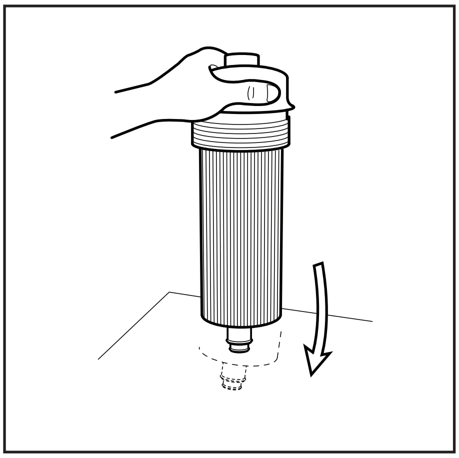


Figure 95

1. Unscrew the filter cover with a closed tool with 36 mm socket.
2. Lift out the filter housing cover with filter. The filter housing will drain automatically once the filter has been removed.
3. Remove old filter from the cover.
4. Assemble new filter and tighten filter cover to 25 Nm.

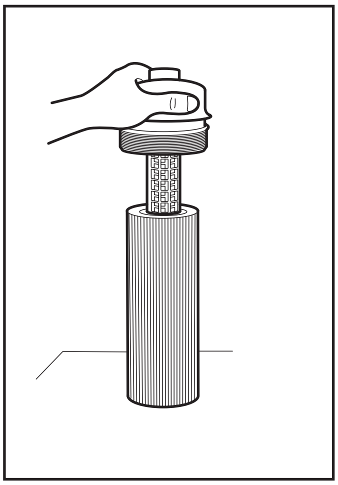


Figure 96

CAUTION

Avoid spillage when handling oil.

NOTE

Do not use an adjustable wrench or other open tool as there is risk of damaging the filter cover.

Oil analysis

Oil analysis may be necessary to determine a different oil change interval from that recommended here.

Oil companies can offer analysis of the engine oil.

Such analysis measures the oil's TBN (Total Base Number), TAN (Total Acid Number), fuel dilution, water content, viscosity and the quantity of particles and soot in the oil.

The result of a series of analyses is used as the basis for establishing a suitable oil change interval.

If the conditions are changed, a new oil analysis programme must be carried out to establish new change intervals.

Checking oil level

Checking the Oil Level with the Engine Switched Off

NOTE

Leave the engine off for at least 1 minute before checking the oil level.

1. Remove oil dipstick (1 LHS of engine) and check the oil level. The correct level is between the minimum and maximum marks on the oil dipstick.

2. Top up with oil when the oil level is at or below the minimum mark.

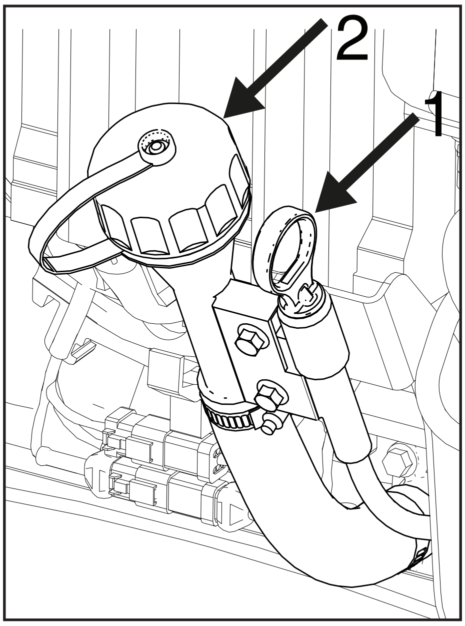


Figure 97

Changing the oil

NOTE

Renew the oil filter and clean the centrifugal oil cleaner when changing oil.

WARNING

AVOID DEATH OR SERIOUS INJURY

• Hot oil can cause burns and skin irritation. Wear protective gloves and goggles when changing hot oil.
• Make sure that there is no pressure in the lubrication system before starting work on it.
• The oil filler cap must always be in place when starting and running the engine to prevent oil being ejected.

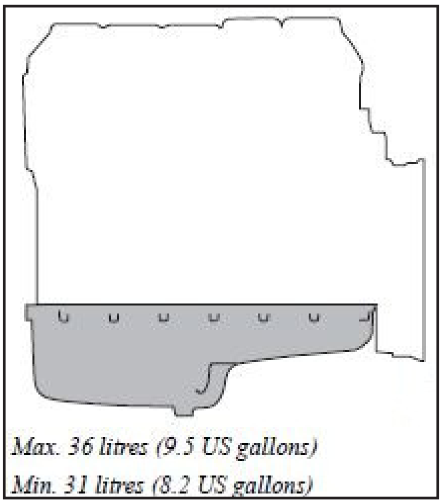


Figure 98

NOTE

Use a container to avoid spillage. Used oil must be disposed of as specified in national and international law.

NOTE

Change oil more often if the engine is subjected to particularly demanding operation, such as a dusty environment, or if deposits in the centrifugal oil cleaner are thicker than 28 mm.

1. Unscrew the oil plug and drain the oil when the engine is hot. In certain engines the oil is pumped out by means of a bilge pump.

2. Clean the magnet on the oil plug.

3. Refit the oil plug.

4. Fill up with oil.

5. Check the level on the dipstick.

Maximum angles of inclination during operation.

Maximum permissible angles during operation vary, depending on the type of oil sump; see Figure 99.

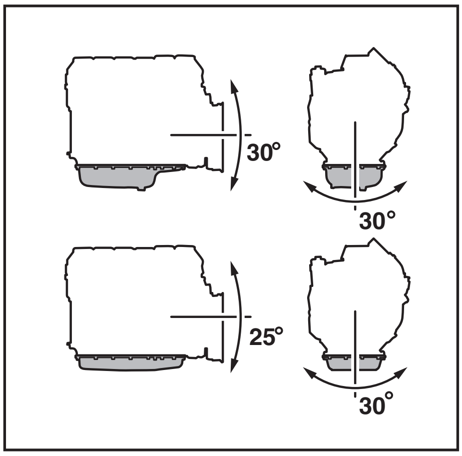
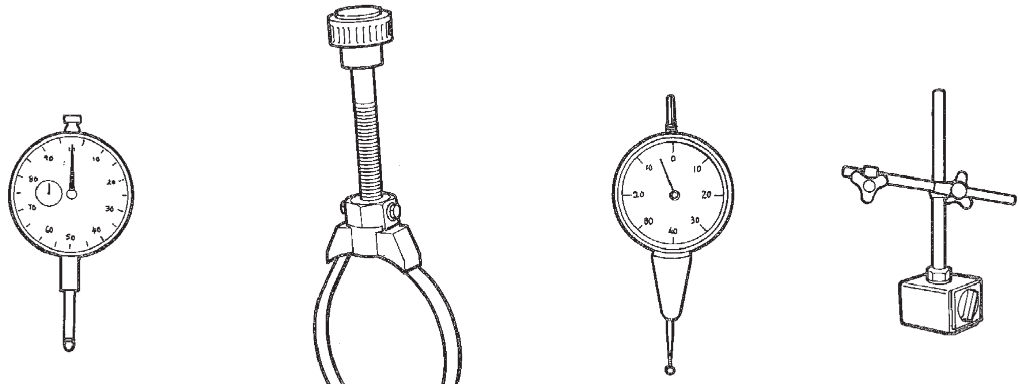


Figure 99

Special tools



800109-00288 850329-00421 (1) Deflection gauge 850329-00319

Figure 100

800109-00288	Dial gauge
850329-00421	Filter wrench
(1)	Deflection gauge
850329-00319	Stand

Pistons and cylinder liners

1. O-ring
3. Cylinder liner for steel piston
5. O-ring
6. Compression ring
7. Compression ring
8. Oil scraper ring
9. Circlip
10. Steel piston
12. Gudgeon pin
13. Circlip
14. Bearing bushing
15. Connecting rod
16. Crankshaft
17. Bearing shell
18. Bearing cap
19. Flange bolt

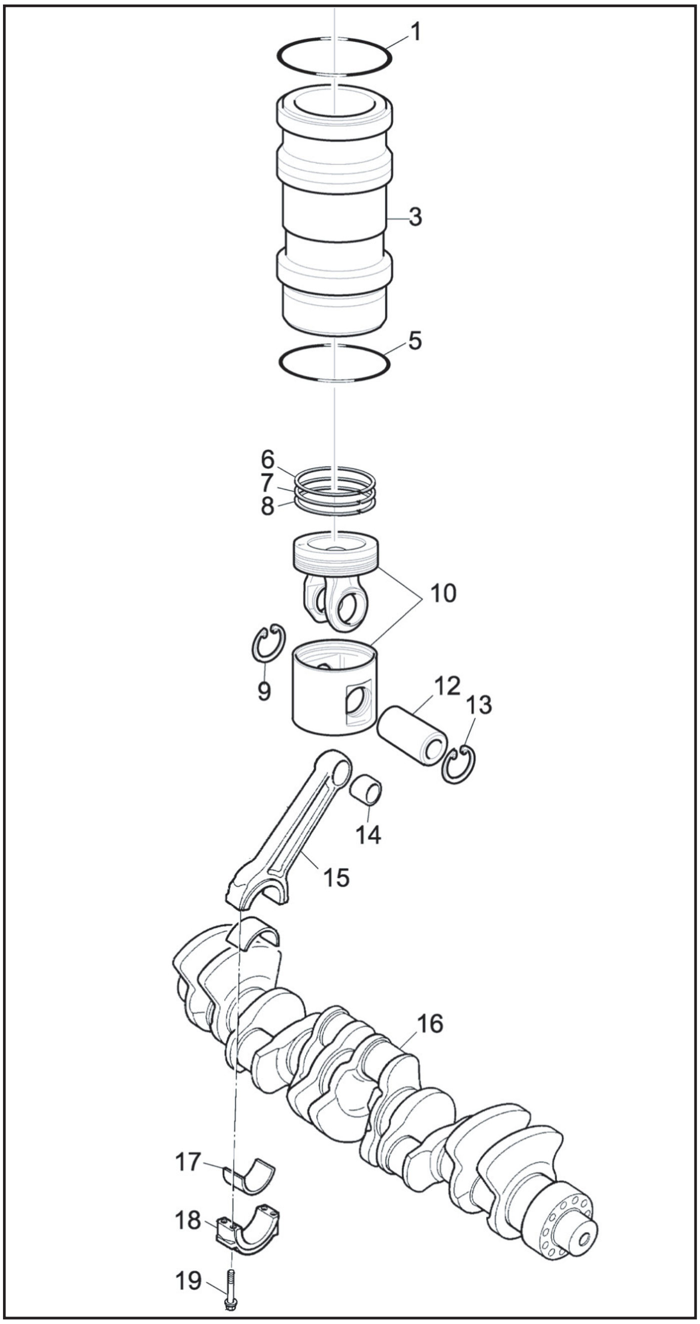


Figure 101

Special tools

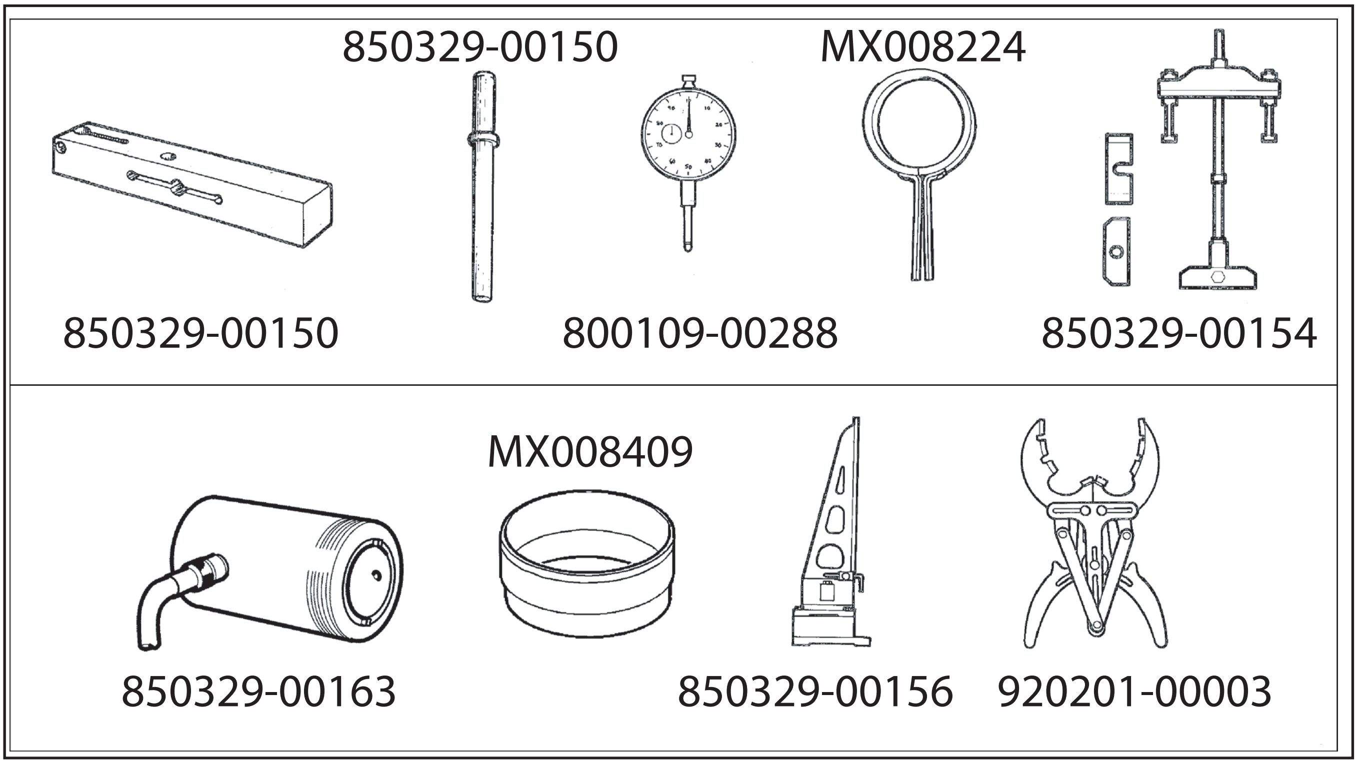


Figure 102

850329-00150	Rule for dial gauge
850329-00151	Drift
800109-00288	Dial gauge
MX008224	Piston ring compressor
850329-00152	Pressing tool
850329-00163	Hydraulic cylinder
850329-00154	Puller for cylinder liner
MX008049	Impact drift
850329-00155	Dismantling tool
MX008409	Assembly tool
850329-00156	Test apparatus for connecting rods
920201-00003	Piston ring expander

Connecting rods

The connecting rod and big-end cap consist of a single casting which is split during the machining operation.

To prevent the big-end cap from being displaced in relation to the connecting rod, the contact surfaces are provided with grooves and guide pins. The surfaces are machined together to ensure a precise and accurate fit. The parts are also marked so that they can always be fitted in the same position.

The connecting rod and big-end cap are split obliquely, partly so that the con rod bolts will not be subjected to excessive loads and partly to enable the piston and con rod to be withdrawn through the cylinder.

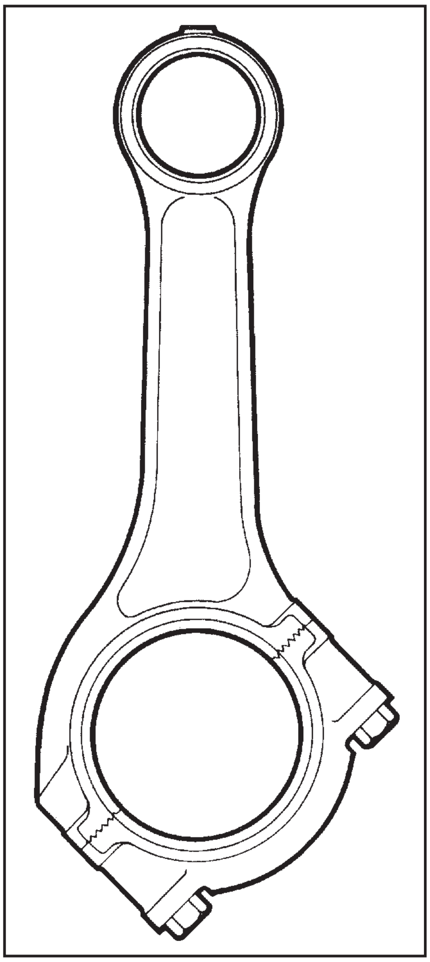


Figure 104

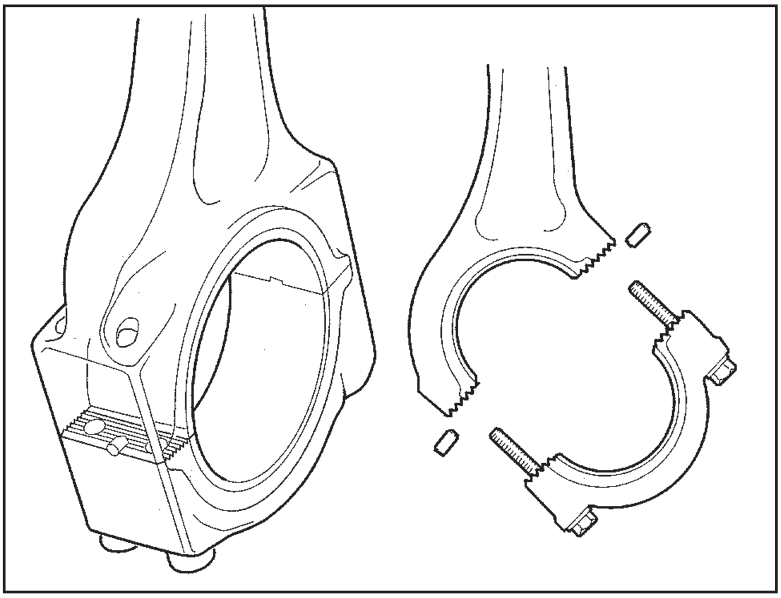


Figure 103

Connecting rod cap: Torx 50Nm + 90°

The upper part of the connecting rod is wedge shaped. This allows a larger journal surface on the underside of the gudgeon pin where load is greatest during combustion.

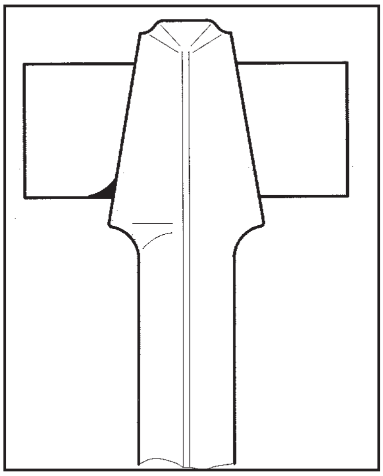


Figure 105

Removing and dismantling connecting rods and pistons

1. Remove the cylinder head and oil sump.

2. Remove the piston cooling nozzle in the cylinder block.

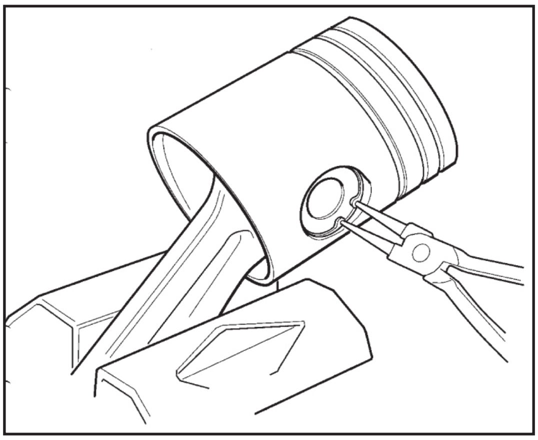


Figure 106

NOTE

The piston cooling nozzle must not be damaged. The oil jet must hit the piston precisely. If it does not, the piston will become too warm resulting in engine breakdown. Damaged nozzles must not be straightened. They must be renewed.

3. Remove the bearing cap and bearing shells. Protect the oil way in the crankcase using, e.g. adhesive tape, applied with the sticky side out.

4. Mark the piston and connecting rod before removing them. They must be refitted in the same place and in the same way.

5. Lift out the piston and connecting rod.

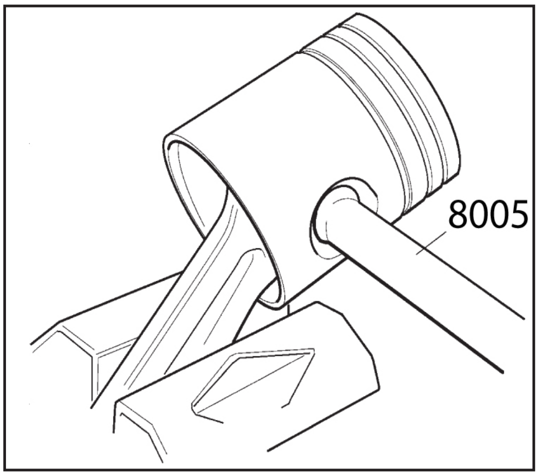


Figure 107

6. Place the connecting rod in a vice with soft jaws. Remove the retaining rings for the gudgeon pin.

7. Push out the gudgeon pin using drift 850329-00151.

8. Remove the piston rings using tool 920201-00003, taking care to avoid scratching the surface of the piston skirt with the piston rings.

9. When cleaning graphited pistons in a machine, the graphiting may disappear. This does not matter after they have been in use for a while. However, new pistons should be washed carefully using white spirit or the like.

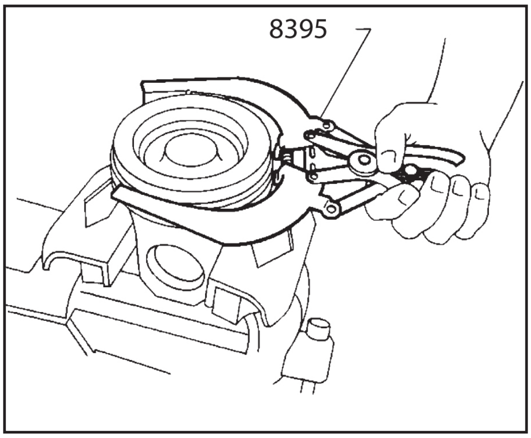


Figure 108

NOTE

Always inspect the connecting rod in cylinders which have seized, been filled with water or where the valve has broken. Bent connecting rods must not be straightened.

Checking connecting rods
Check the connecting rods using tool 587 110.
Proceed as follows:

1. When the gudgeon pin bushing has been checked, insert the bearing cap as marked and tighten the bolts to full torque.

2. Mount the connecting rod in the tool using the expander and place the gudgeon pin in its bushing. Then place indicator studs on the gudgeon pin.

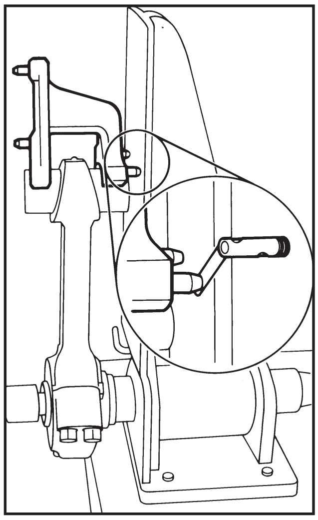


Figure 109
Checking if connecting rod is twisted

- Check whether the connecting rod is twisted with the indicator studs horizontal.

- Check whether the connecting rod is bent with the indicator studs vertical.

- The distance between the indicator studs on the tool illustrated here is 75 mm.

- The distance between one of the indicator studs and the measuring surface must be max. 0.1 mm when measured using this tool.

- Check with a feeler gauge.

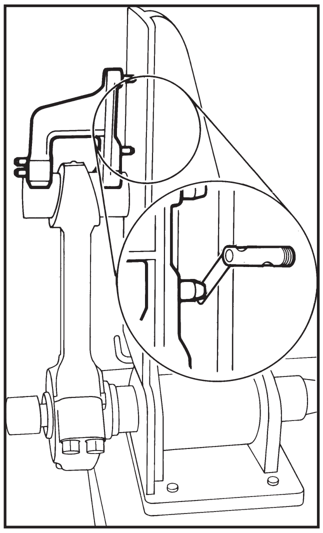


Figure 110

Checking if connecting rod is bent

NOTE

The difference must not exceed 0.6 mm.

- Also check whether the connecting rod is bent into an S - shape. This is done by measuring the distance between the outside of the connecting rod bushing and the level surface of the tool.

- Turn the connecting rod around and measure the corresponding distance.

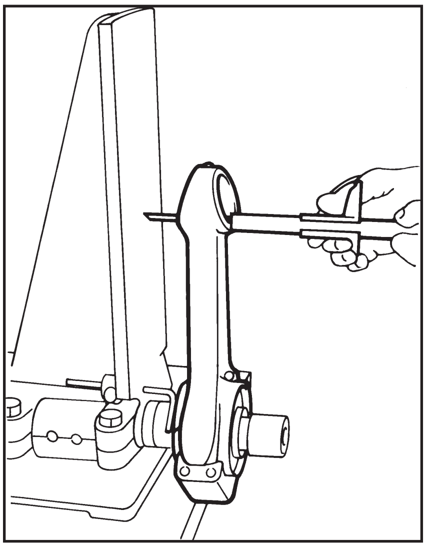


Figure 111

Checking whether the connecting rod is bent into an S shape

Renewal of bearing bushing in connecting rod

Use tool 512564 when renewing the bearing bushing.

The tool comprises three parts:

1. Pressplate with guide pin
2. Press drift
3. Supports

There are different supports, depending on the engine type.

The support marked with a D should be used for the 12 engine.

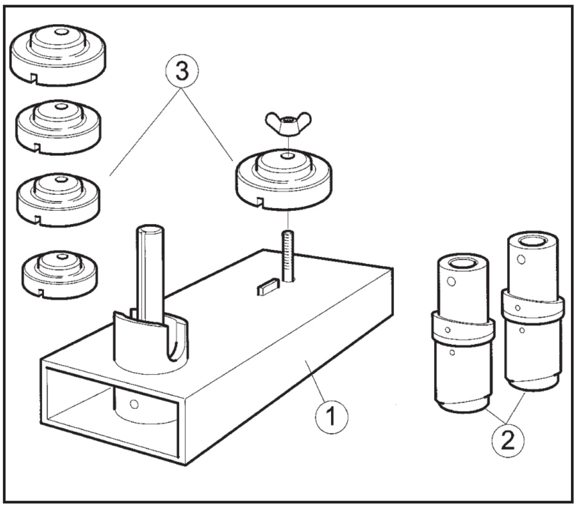


Figure 112

NOTE

Before carrying out this procedure, the connecting rod should be checked for straightness in accordance with Checking connecting rods

Work description

1. Fit the correct support on the pressplate and place the connecting rod so that the wide end of the connecting rod is resting against the support. Turn the press drift with the smaller diameter against the bearing bushing and press it out.

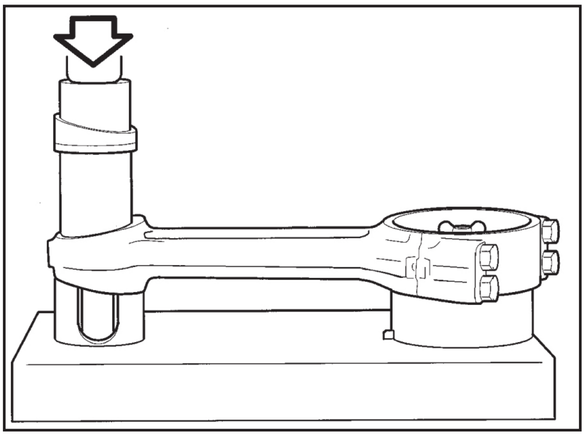


Figure 113

2. Turn over the press drift and mount a new bearing bushing onto it. Press in the bearing bushing.

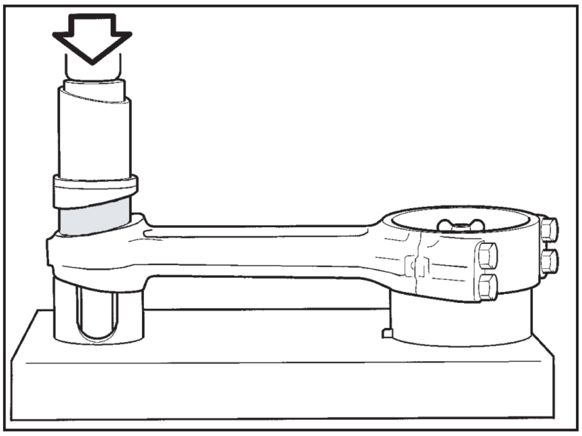


Figure 114

3. After pressing in a new bearing bushing, it must be finish-turned. This requires special equipment.

Diameter, d = 54.030 - 54.043 mm
Surface quality = 0.6 Ra

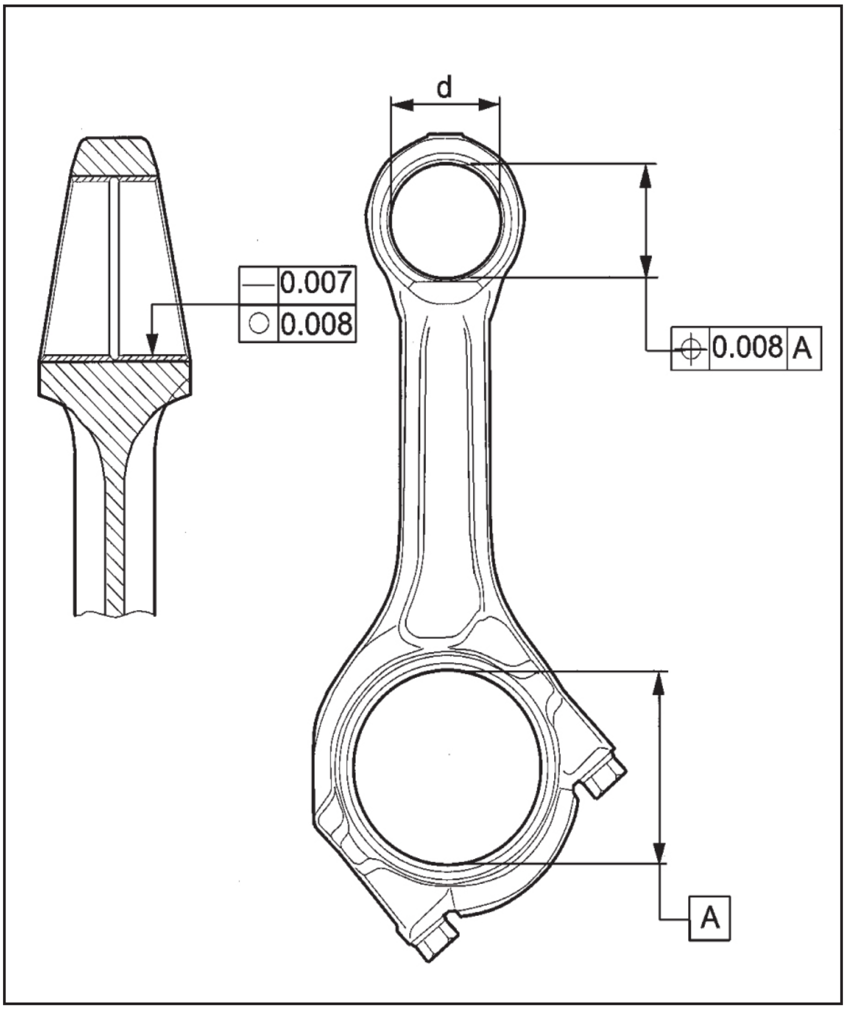


Figure 115

Pistons

The pistons which are used in DA40 engine is of type; articulated pistons.
Articulated pistons are split and have an aluminium skirt and a steel crown.

(For the aluminium piston to resist the high pressure and high temperature prevailing in the combustion chamber, the material is thicker at the piston crown and piston ring grooves than in the remainder of the piston.)

One of the advantages of articulated pistons is that they can tolerate higher loads than conventional pistons completely made of aluminium.

As the piston crown is made of steel it can withstand higher temperatures and pressure in the combustion chamber.

This enables more power to be extracted from engines with articulated pistons.

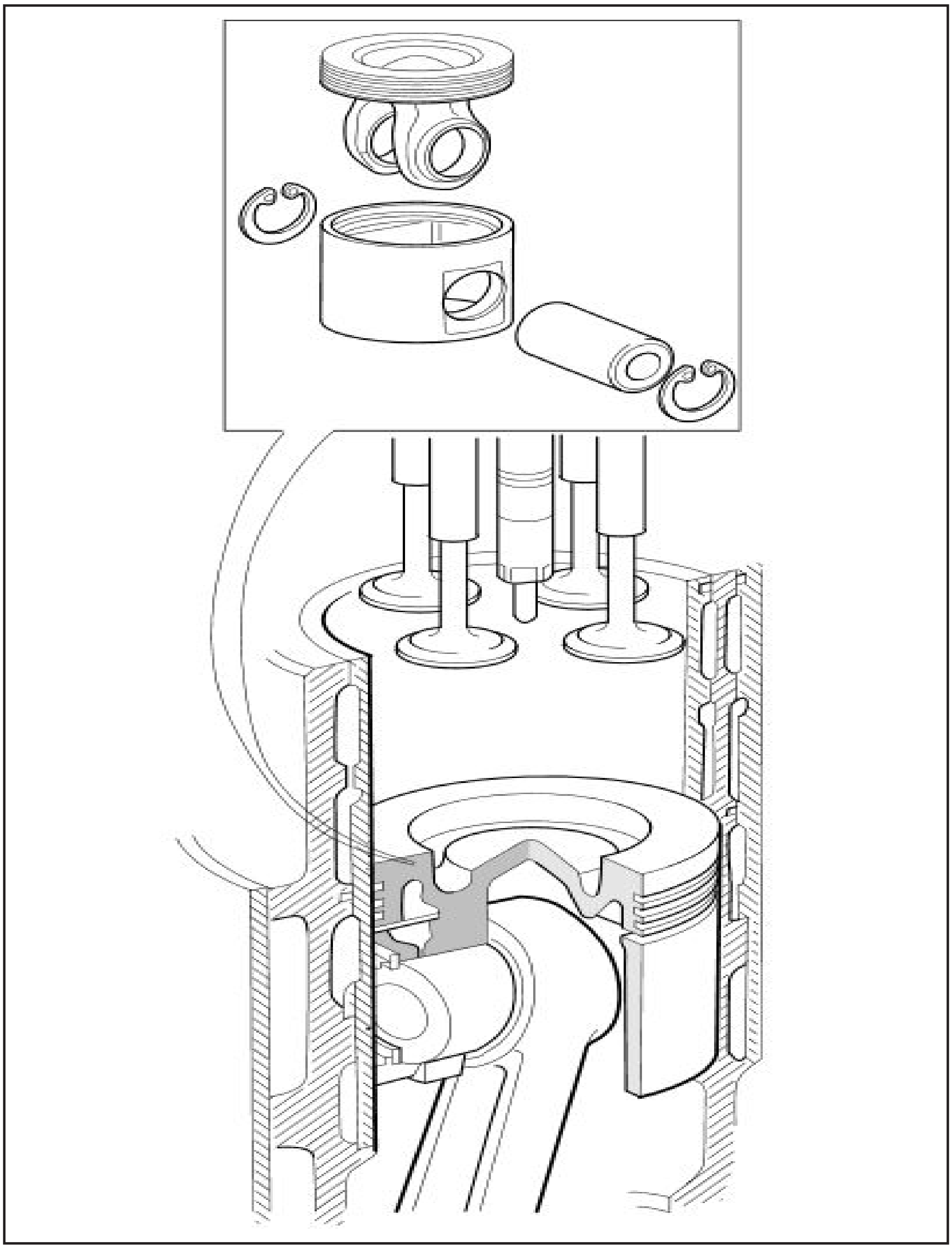


Figure 116

The bowl-shaped combustion chamber in the piston crown has a protuberance in the centre. The design of this protuberance ensures that the fuel injected at the end of the compression stroke is quickly mixed with the air in the combustion chamber.

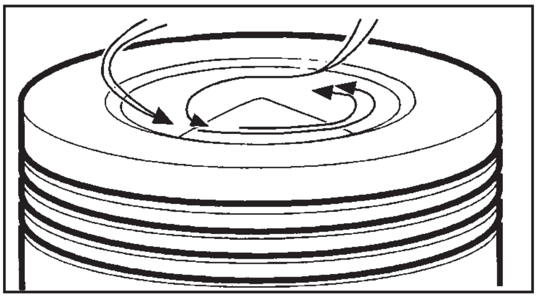


Figure 117

Piston rings

For the piston to travel freely, a gap is required between the piston and cylinder liner.

The piston therefore has two compression rings which seal this gap and conduct the heat from the piston.

The upper of these rings is exposed to higher pressure than the intermediate ring and is therefore wedge-shaped, a “keystone” ring, which increases the force pressing it against the cylinder wall.

Since the greatest stress is on the upper piston ring groove, and also to reduce wear, a reinforcement of cast iron is incorporated in the piston.

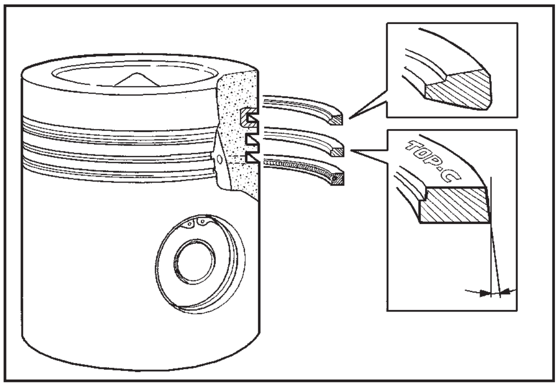


Figure 118

The bottom piston ring, the oil scraper ring, prevents oil from the crankcase from finding its way up to the combustion chamber.

In the oil scraper ring is a coil spring which presses it against the cylinder wall.

The design and quality of the pistons and piston rings are extremely important for the reliability and lubrication of the engine as well as oil and fuel consumption.

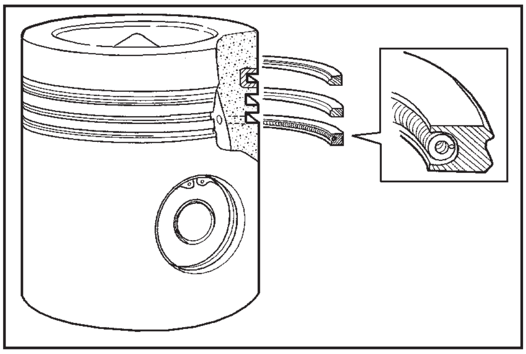


Figure 119

Turn the piston rings so that the gaps are distributed around the piston.

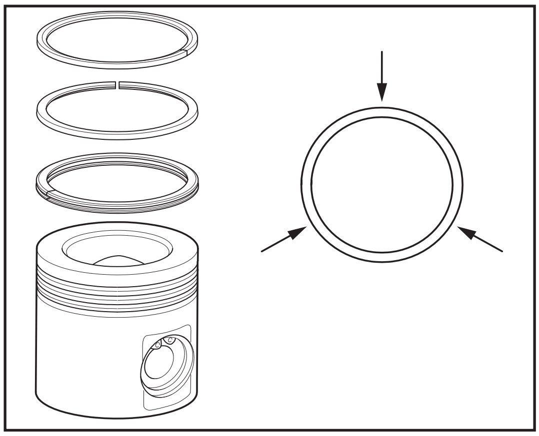


Figure 120

Assembling piston and connecting rod

1. Clean the piston and its rings thoroughly without scratching the sides of the ring grooves. The oil holes in the piston should be cleaned using a suitable drill.

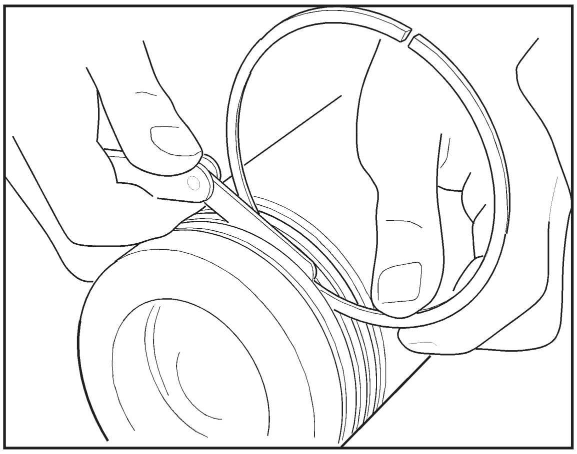


Figure 121

2. Make sure the piston ring gaps do not exceed the permitted limit. Place the piston rings in the cylinder liner and measure the gap using a feeler gauge. For permitted gap, see section entitled Specifications, piston rings.

Make sure the piston ring gaps do not exceed the permitted limit. Place the piston rings inside the cylinder liner and measure the gap with a feeler gauge. Permitted gap according to values listed below.

Maximum piston ring gap for 9 and 13 liter engines with XPI:

Compression ring 1 (upper)	0.9 mm
Compression ring 2 (lower)	1.1 mm
Oil scraper ring	0.8 mm

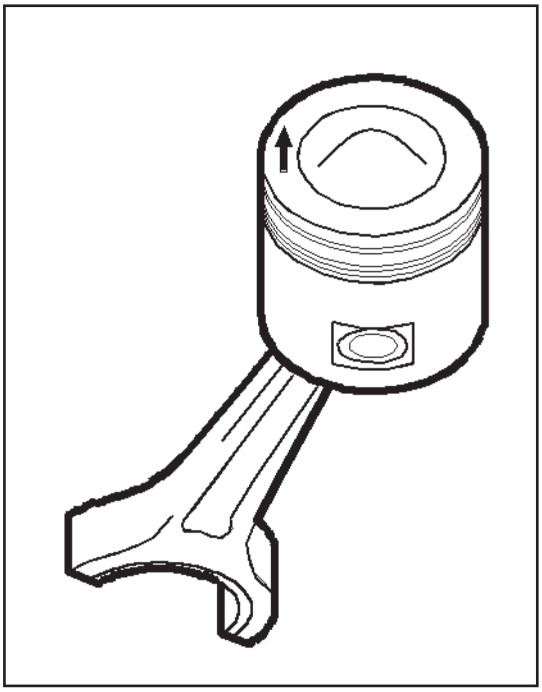


Figure 122

3. Fit the piston rings using tool 920201-00003. The oil scraper ring has an expander. Pistons rings marked with TOP must be turned with TOP face up.

4. Oil all the bushings, the gudgeon pin hole and the gudgeon pin before assembling.

5. Place one of the retaining rings in the piston.

6. Turn the piston and connecting rod as illustrated. The arrow mark should point forward on the engine.

7. Insert the gudgeon pin using tool 850329-00151 and fit the second retaining ring for the gudgeon pin.

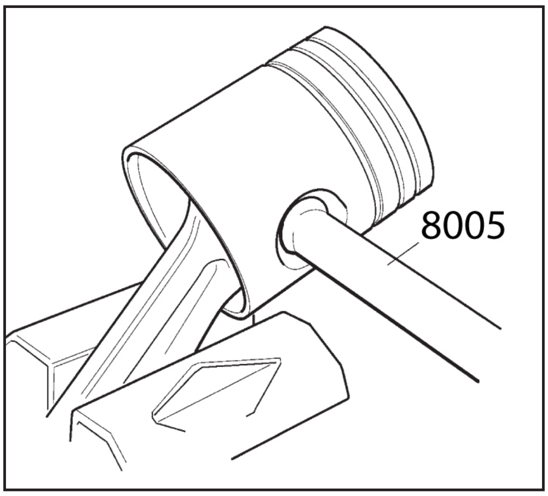


Figure 123

Cylinderblock

The cylinder block is a one-piece casting. It has 6 cylinder bores. There is a separate cylinder head for each cylinder.

The seal between cylinder block and cylinder head consists of a steel/elastomer gasket. Seals are bonded in place at the oil and coolant passages.

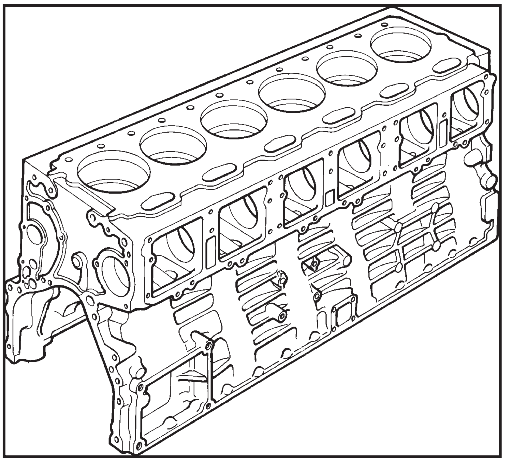


Figure 124

Cylinder liner

The cylinder liners are of the “wet” type, i.e. they are surrounded by coolant.

To ensure a good seal, the edge of the cylinder liner protrudes slightly above the surface of the cylinder block.
This ensures that the cylinder head gasket is pressed against the cylinder head.

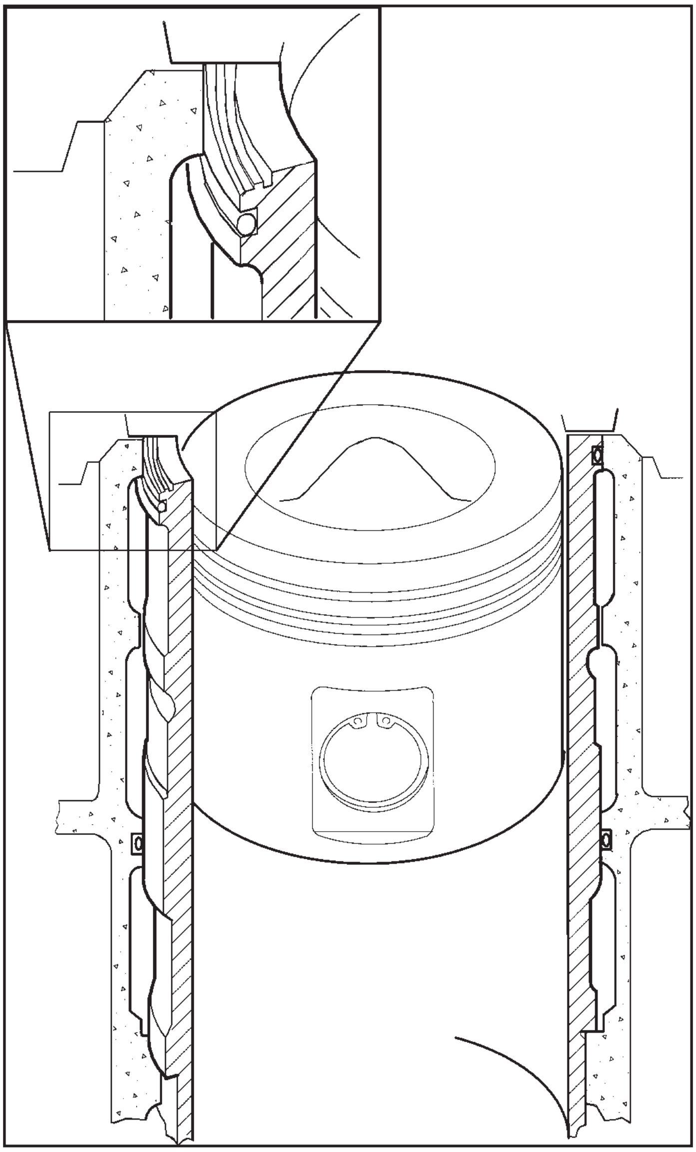


Figure 125

The inside of the cylinder liner is machined by what is known as plateau honing. This type of machining leaves a fine pattern of grooves which ensures that the oil needed for lubrication between piston rings and liner remains on the wall of the liner.

The design of the pattern is of major importance for ensuring low oil consumption in the engine.
Two sealing rings, one in the block and one in the liner, seal off the coolant jacket. The surface of the liner in contact with the liner shelf seals off the lubricating oil.

In the space between liner shelf and sealing ring in the block is an overflow hole which discharges in the side of the cylinder block under the side covers.

Leakage at any of the sealing surfaces will result in oil or coolant coming out of the overflow hole.

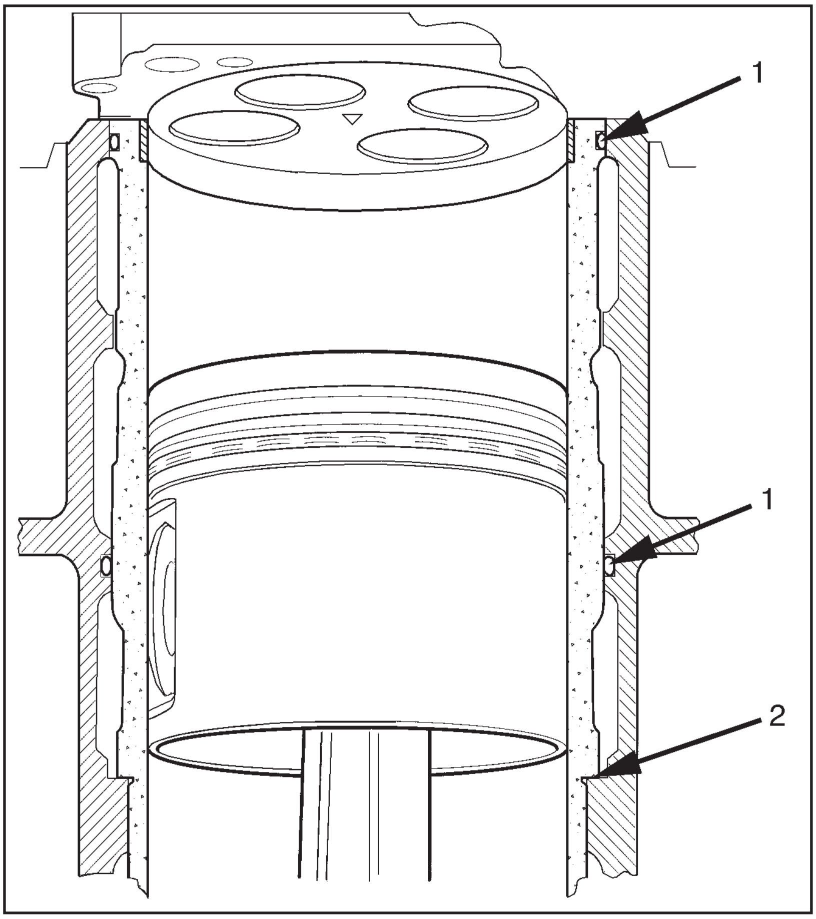


Figure 126

1. Seal for coolant
2. Support point for liner

Removing the cylinder liners

1. Mark the liners with the numbers 1- 6. The mark is necessary so that the liners can be refitted in the same place and position as previously.

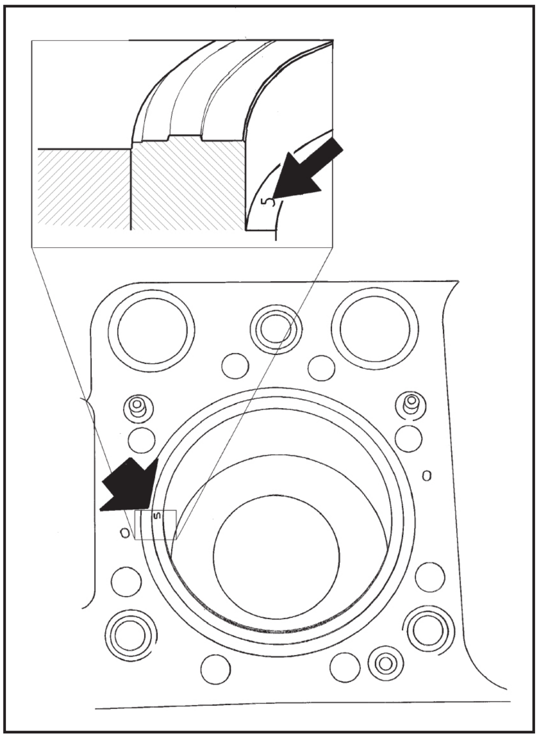


Figure 127

NOTE

The mark must be made only on the surface indicated in "Figure 127". Other surfaces are for sealing, If you use a marker, you can mark anywhere.

2. Withdraw the cylinder liner using puller 850329-00154 and hydraulic cylinder 850329-00163. Fit spacers under the support lugs to avoid damaging the surface of the block.

3. Remove the sealing ring in the cylinder block.

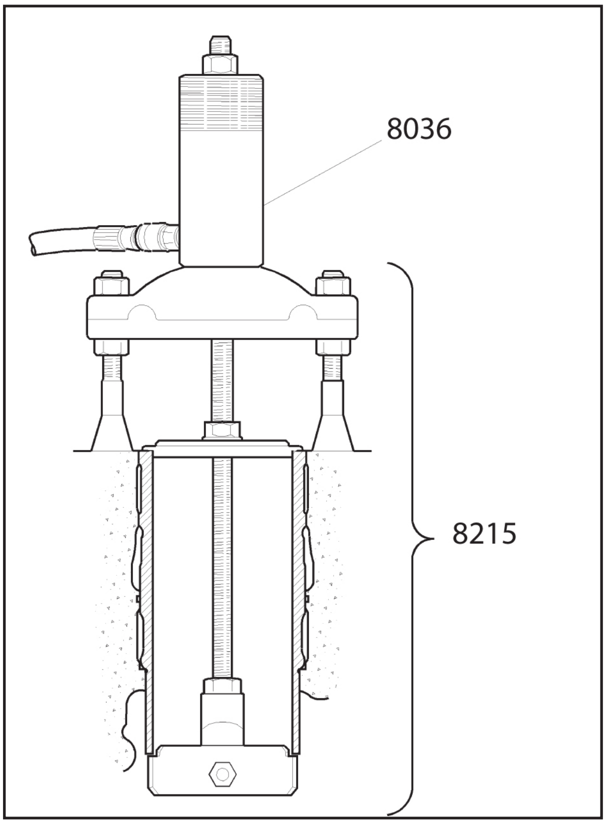


Figure 128
Cylinder liner extractor with hydraulic cylinder

Measuring the cylinder liner height

1. Thoroughly clean the cylinder block liner shelf, the face around the cylinder, the cylinder liner shelf and the upper face of the cylinder liner.
2. Fit the cylinder liner without O-rings and twist down by hand into position.
3. Lift out the liner and wipe the liner shelf in the cylinder block and the cylinder liner shelf.
4. Insert the cylinder liner without O-rings and twist it down into position again by hand.
5. Place straight edge 87 198 with dial gauge 98 075 on the liner and zero the dial gauge to the liner (A). Slide the tip of the dial gauge over to the cylinder block (B) and measure the height of the liner (A-B) as illustrated.
6. Measure each liner at two diametrically opposite points transversely across the engine.

   - The cylinder liner must be slightly above the face of the cylinder block.

   - The difference between the two measurements on the same liner must not exceed 0.02 mm.

   - The height of the cylinder liner D (=A-B) above the block should be 0.20 – 0.30 mm.

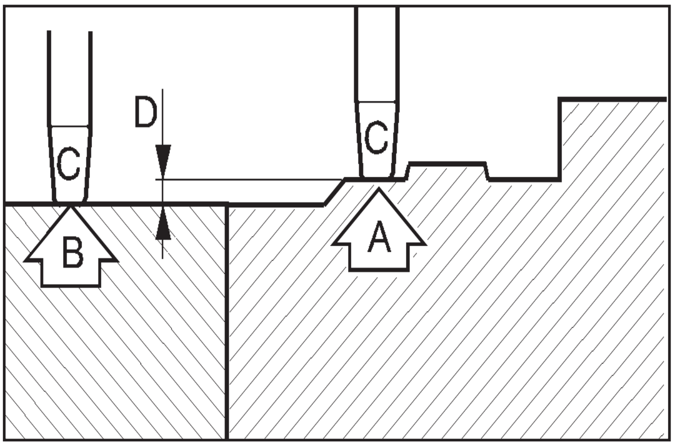


Figure 129

A = Measuring surface on cylinder liner
B = Measuring surface on cylinder block
C = Tip of dial gauge
D = Cylinder liner height D = A-B

Measuring cylinder liner height

Measuring the cylinder wear ridge and cylinder bore

C Measure the diameter of the cylinder wear ridge 2-8 mm down the cylinder bore.

D Measure the diameter of the cylinder bore 10-12 mm down the cylinder bore.

2. Cylinder liner type A

The difference between the diameter of cylinder wear ridge C and the diameter of cylinder bore D must not exceed 0.06 mm

Cylinder liner type B

The difference between the diameter of cylinder wear ridge C and the diameter of cylinder bore D must not exceed 0.06 mm

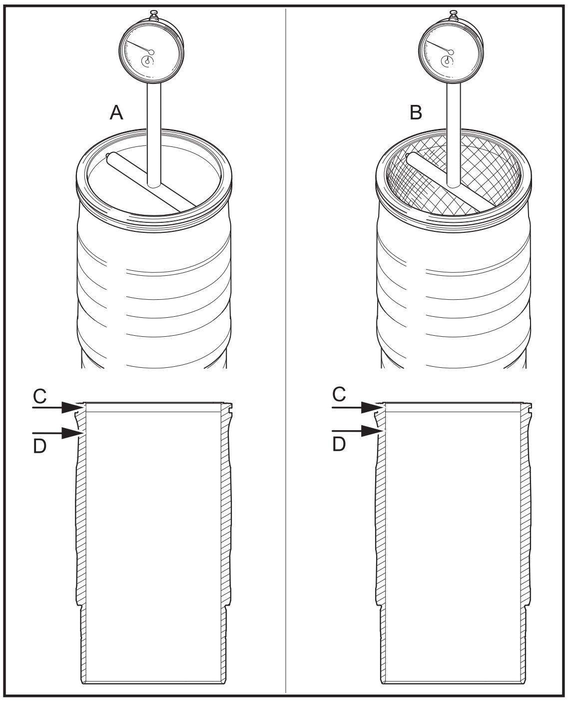


Figure 130

Fitting the cylinder liners

1. Check cylinder liner height as described in the section entitled Measuring the cylinder liner height.

2. Make sure the interior of the cylinder block is clean. Clean the O-ring surfaces.

3. Check that the holes for coolant going to the cylinder head and cylinder liner are not clogged.

4. Carefully check the cylinder liners, both new and old, for cracks which might have arisen during transport or careless handling.

5. Tap the liner carefully with a metal object. It should give a clear metallic ring if it is intact.

6. If it sounds cracked, renew it.

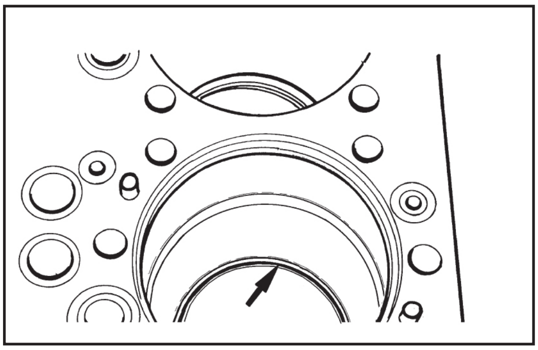


Figure 131

NOTE

Use only glycerol to lubricate the cylinder block, cylinder liner and O-rings. Other lubricants may cause the O-rings to swell.

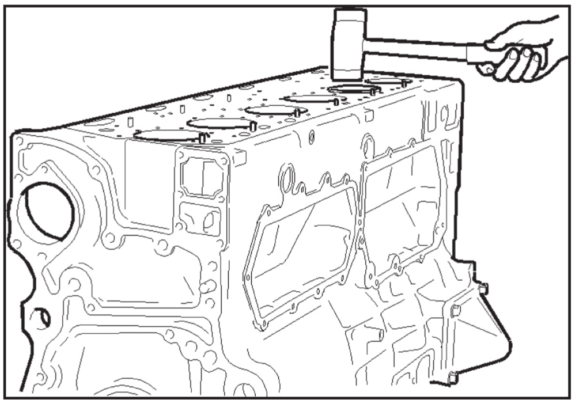


Figure 132

7. Lubricate the sealing ring to be fitted in the cylinder block with engine oil and fit it in place.

8. Lubricate the sealing ring to be fitted in the cylinder liner with engine oil and fit it in place.

9. Turn the liner with the stamped cylinder number facing forward and carefully tap it down with a rubber mallet.

10. Fit the scraper ring in place after the piston has been fitted.

11. Check that the liner goes down completely.

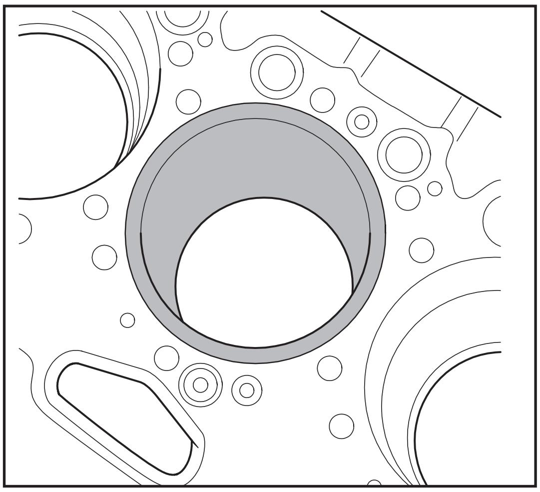


Figure 133

Fitting the piston and connecting rod

1. Lubricate the piston, piston rings, cylinder liner and piston ring compressor with engine oil.

2. Remove the protection on the connecting rod journal and lubricate the journal.

3. Turn the piston rings so that the ring gaps are evenly distributed round the piston.

4. Fit the upper connecting rod bearing shell to the connecting rod and lubricate the bearing surface.

5. For engines with a scraper ring in the liner:
   Fit assembly tool MX008409 instead of the scraper ring in the liner.

6. Carefully insert the connecting rod and piston so that the arrow mark on the piston points forward.

7. Clamp piston ring compressor MX008224 round the piston and push the piston down into the cylinder past the assembly tool.

8. Remove the assembly tool and press in the scraper ring. Be careful to press it in straight so that it does not tilt.

9. For engines without a scraper ring in the liner: Insert the connecting rod and piston. On aluminium pistons the arrow mark on the piston should point forward.

10. Clamp piston ring compressor 98 212 round the piston and push the piston down into the cylinder.

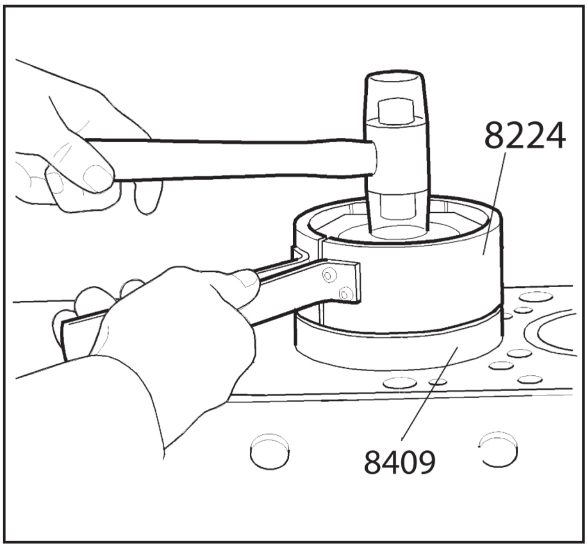


Figure 134

11. Fit the lower connecting rod bearing shell into the cap and lubricate the bearing surface. Fit the cap. Check that the connecting rod and cap have the same marking and that they are opposite each other.

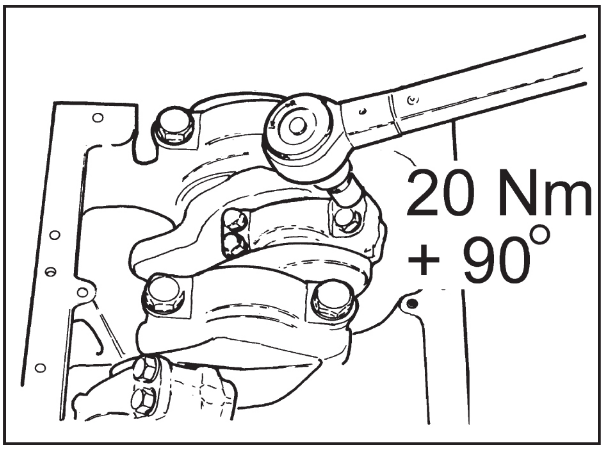


Figure 135

12. Lubricate the bolts, fit them and tighten to 20 Nm + 90°. Check that the pistons nozzles are in perfect condition and fully open. If necessary, blow clean with compressed air.

13. Fit the piston cooling nozzle and tighten the banjo bolts to 23 Nm.

NOTE

The piston cooling nozzle must not be damaged. The oil jet must hit the piston precisely. If it does not, the piston will become too warm resulting in engine breakdown. Damaged nozzles must not be re-aligned, renew them instead.

14. Fit the oil sump and tighten the bolts to 30 Nm.

15. Fit the cylinder head. Tighten the cylinder head bolts as described in the section Cylinder head.

Flywheel and flywheel housing

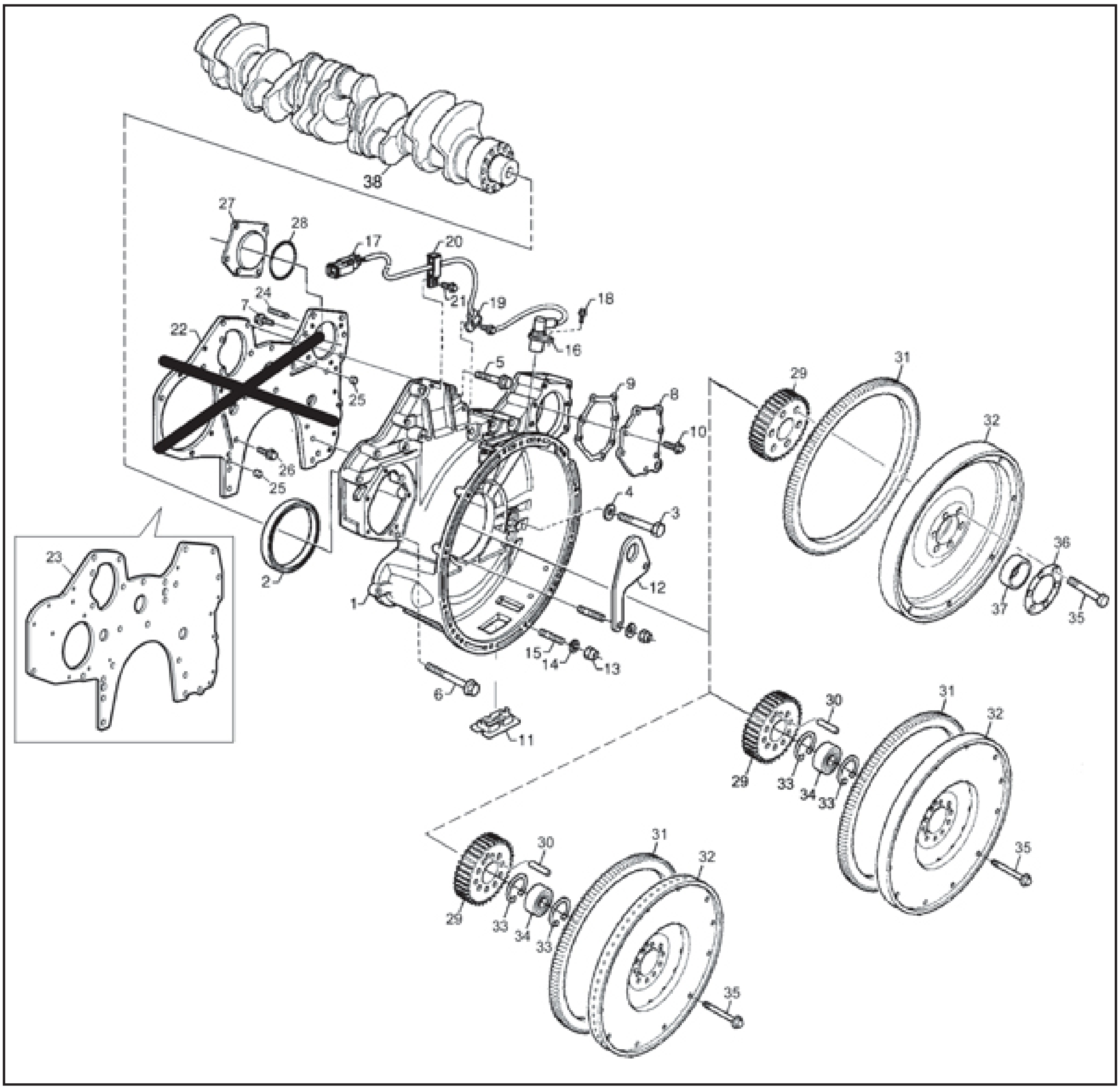


Figure 136

1. Flywheel housing
2. Seal
3. Bolt
4. Washer
5. Flange bolt
6. Flange bolt
7. Flange bolt
8. Cover
9. Gasket
10. Flange bolt
11. Cover
12. Lifting eye
13. Hexagon nut
14. Washer
15. Stud
16. Rotation speed sensor
17. Contact housing
18. Flange bolt
19. Clamp
20. Clamp
21. Bolt
22. Timing gear plate, engines with injection pump
23. N/A
24. Stud
25. Pin
26. Flange bolt
27. Cover
28. O-ring
29. Crankshaft gear PF
30. Pin
31. Ring gear
32. Flywheel
33. Circlip
34. Ball bearing
35. Bolt
36. Washer
37. Guide sleeve
38. Crankshaft

Special tools

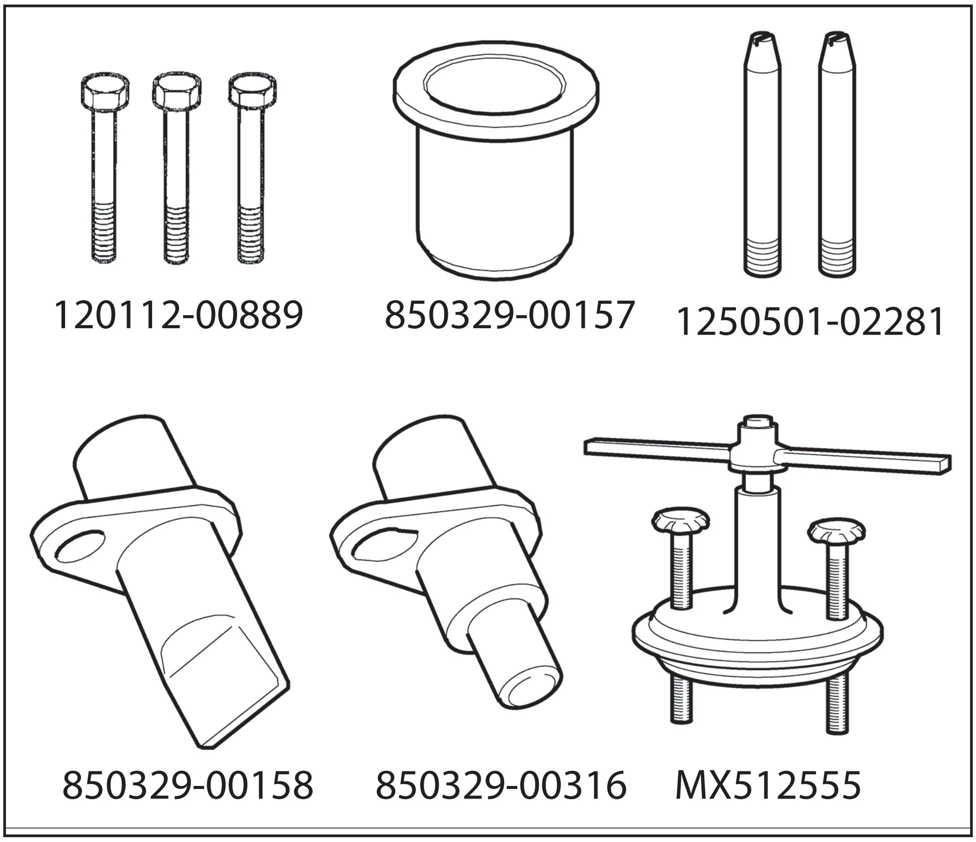


Figure 137

12112-00889	Puller bolts	Not illustrated:	
850329-00157	Drift		
1250501-02281	Guide pins	850329-00446	Air powered sprayer
850329-00158	Assembly tool	MX512557	Cartridge adapter
850329-00316	Assembly tool	MX512558	Nozzle
MX512555	Assembly tool		

Removing the flywheel

1. Remove the engine speed sensor(s) in the flywheel housing.
2. Remove the bolts for the flywheel. 14” flywheel: Also remove the washer.
3. Pull off the flywheel from the crankshaft using puller bolts 12112-00889.

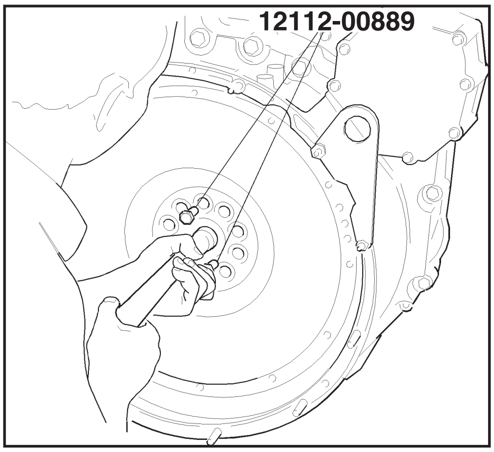


Figure 138

Renewing support bearing

1. Remove the retaining rings on both sides of the support bearing.

2. Knock out the support bearing from the flywheel using drift 850329-00157.

3. Fit the inner retaining ring and fit the new support bearing with drift 850329-00157.

4. Fit the outer retaining ring.

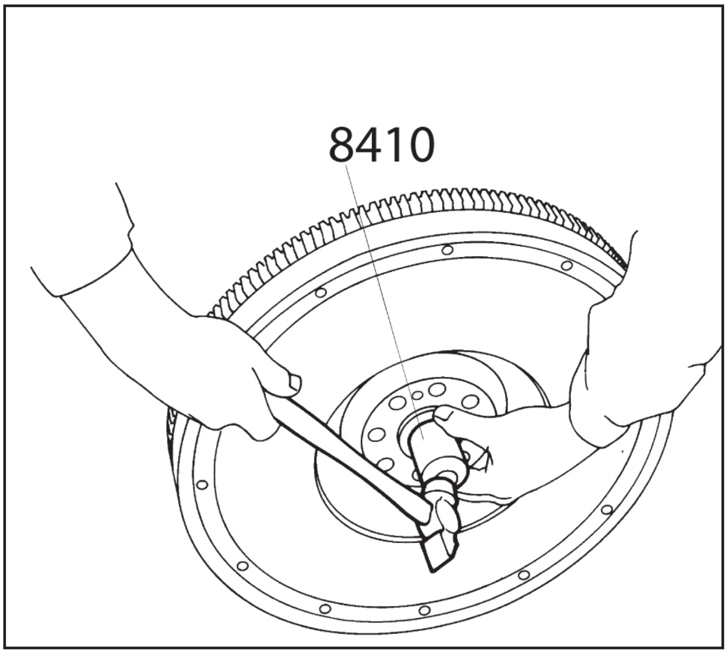


Figure 139

Renewing ring gear

Renew the flywheel ring gear if the gear teeth have become so worn that the starter motor pinion will not engage.

1. Grind a groove as deep as possible in the ring gear and crack it open with a chisel. Remove the ring gear from the flywheel.

WARNING

Use protective goggles due to the risk of metal shivers.

2. Clean the contact surfaces on the flywheel with a wire brush.

3. Heat the new ring gear evenly around its circumference to 100 - 150°C.

4. Place the heated ring gear on the flywheel so that the marking with the part number is facing the engine when fitting the flywheel. Make sure the ring gear is securely against the flywheel. If necessary, knock down the ring gear with a plastic hammer.

5. The ring gear must not be cooled rapidly but be left to cool in the open air.

Renewing the rear crankshaft seal

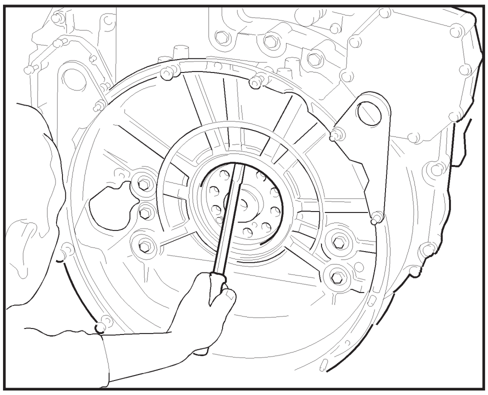


Figure 140

1. Remove the crankshaft seal using a screwdriver. Take care not to scratch the sealing surfaces on the crankshaft and the flywheel housing.

NOTE

The crankshaft seal must be fitted dry and must not be lubricated.
The sleeve in the seal should be left in place until the seal is fitted.
The crankshaft should be degreased before the new seal is fitted.

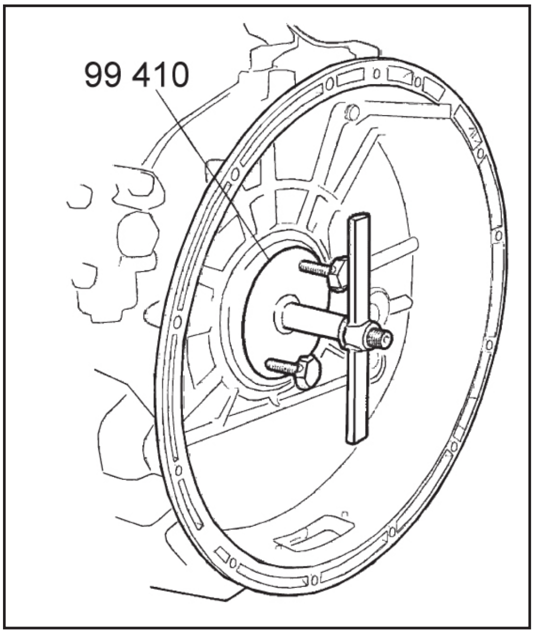


Figure 141

2. Fit the new crankshaft seal using tool MX512555. Place the crankshaft seal on the tool and fasten the tool with the bolts.

3. Turn the tool clockwise until is stops in order to attain the correct crankshaft seal position.

Removing the flywheel housing

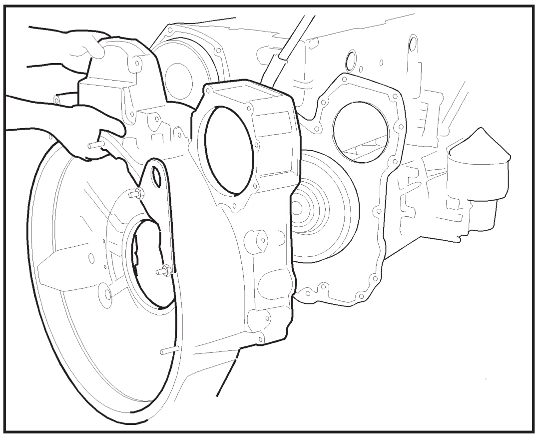


Figure 142

1. Remove the starter motor.

2. Remove flywheel housing.

Fitting flywheel housing

1. Remove all old sealing compound on the sealing surfaces of the timing gear casing and timing gear plate. Clean off any oil and grease using an alcohol based cleaning agent.

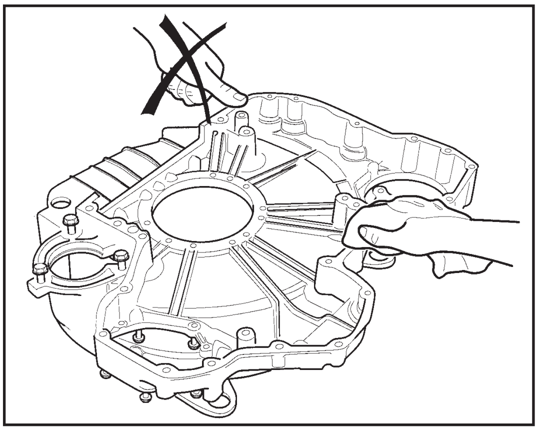


Figure 143

NOTE

The sealing surfaces must be absolutely clean and free from grease. Do not touch the surfaces after degreasing.

2. Apply the sealing agent (512565) on the timing gear housing with the air powered sprayer (850329-00446), cartridge adapter (512565) and nozzle (MX512558). The width of the bead should be between 0.8 and 1.2 mm. Follow the pattern as illustrated.

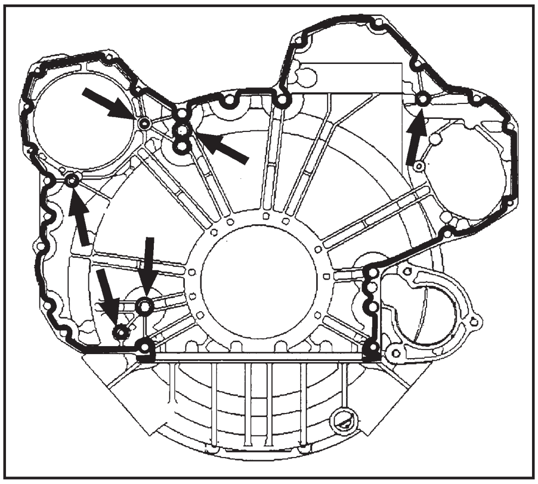


Figure 144

CAUTION

Ensure that you apply sealing agent inside the screw holes, but without allowing sealing agent into the crankcase. The sealing agent may block channels and nozzles. This is particularly important to bear in mind around oil ways, where the flow of oil to the air compressor or injection pump can be blocked.

NOTE

Assembly must be completed within 25 minutes of starting to apply the sealing agent. The bolts are of various sizes and lengths. Ensure that they are fitted in the correct places. See also the illustrations on the next page.

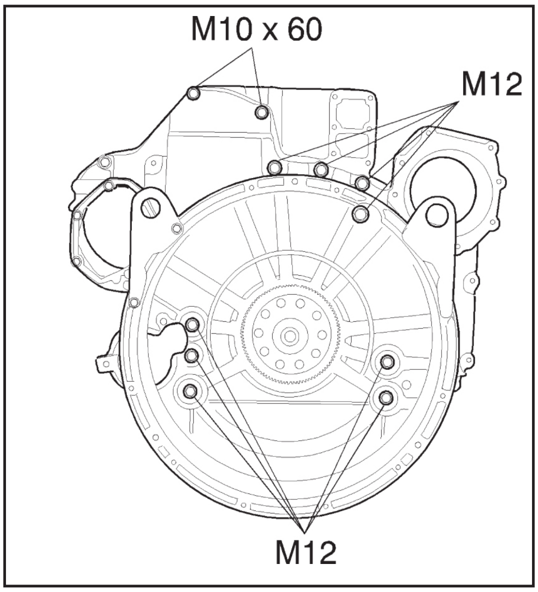


Figure 145

3. Torque tighten the M12 bolts to 90 Nm and the M10 bolts to 50 Nm.

4. Fit the starter motor.

5. Apply the sealing agent on the timing gear housing side against the transmission plate. Apply the sealing agent around the screw holes marked with arrows.

4. Torque tighten the M12 bolts to 90 Nm and the M10 bolts to 50 Nm.

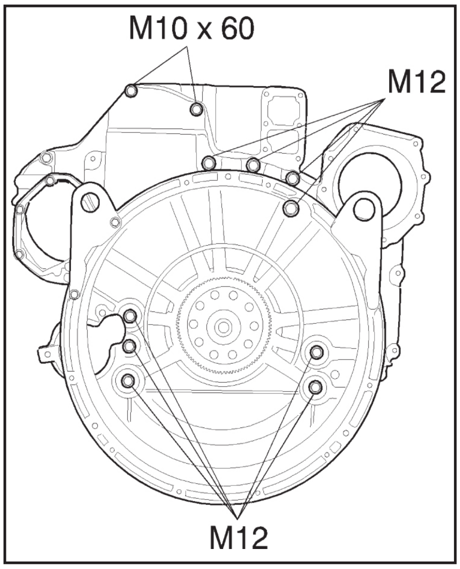


Figure 146

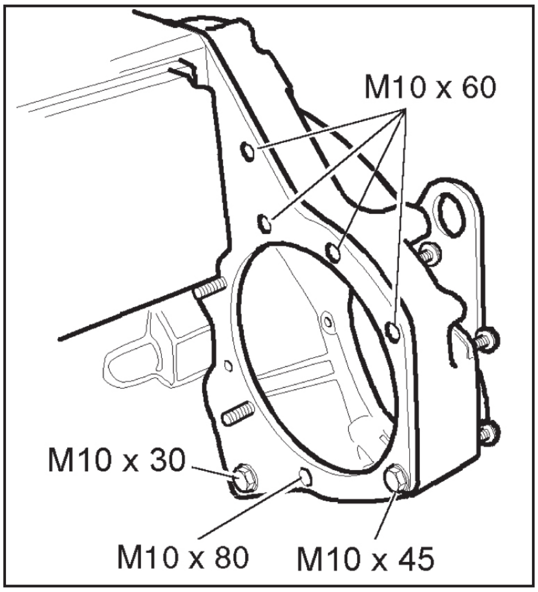


Figure 147

5. Fit the power steering pump.

6. Fit the starter motor.

7. Fit the flywheel, see Fitting of flywheel.

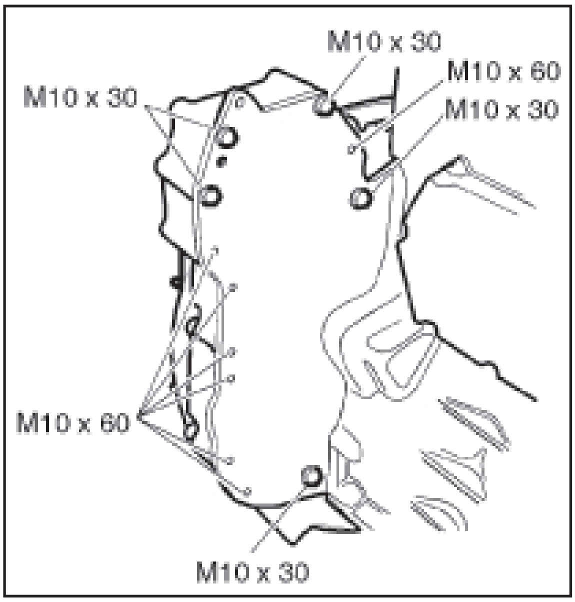


Figure 148

Fitting the flywheel

1. Fit two guide pins **1250501-02281** in the crankshaft flange.
2. Fit the flywheel on the crankshaft.

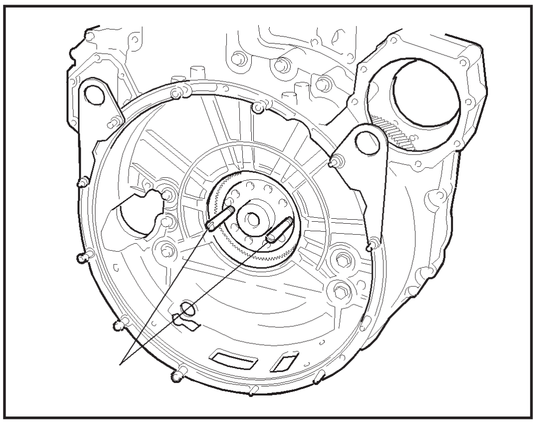


Figure 149

NOTE

Always use new bolts and washers.

3. Lock the flywheel using tool: 512563 for engines with unit injector.
4. Torque tighten the bolts alternately to 130 Nm and then a further 90°.
5. Fit the engine speed sensors.

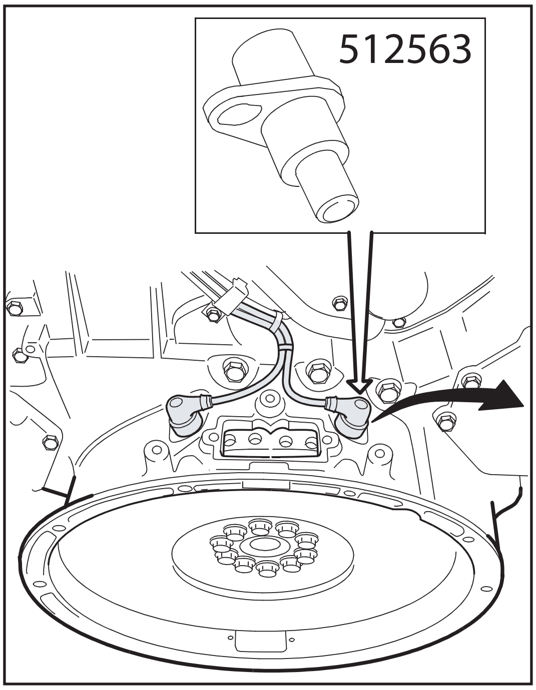


Figure 150

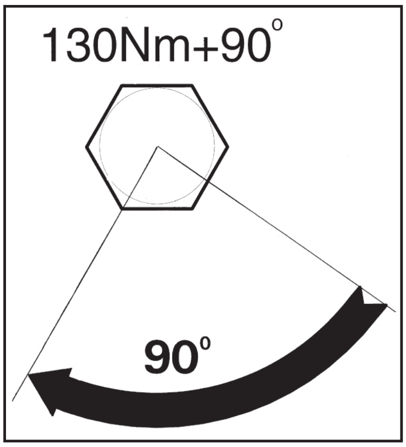


Figure 151

Flexible coupling

Safety instructions

For all work on the coupling it must be ensured that both the drive engine and the driven
machine are at a standstill and cannot be started up under any circumstances.
Work should only be begun when the coupling has cooled down to below 30°C.

Rotating parts such as the coupling itself and exposed shaft components are to be fitted
with a guard to prevent injuries. However, this must not impair ventilation.
The coupling contains flammable materials. This must be taken into account when operating the coupling.

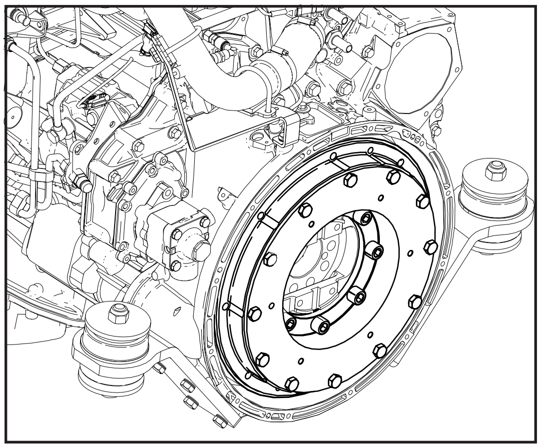


Figure 152

Functional description

The flexible coupling is an industrial torsional vibration damper, which both displaces resonance frequencies and dampens torque peaks.

For this purpose, the drive line is coordinated with the aid of the coupling by arranging mass inertias, torsion spring strengths and dampings in such a way that the permitted torsional vibration or load surge levels are not exceeded.

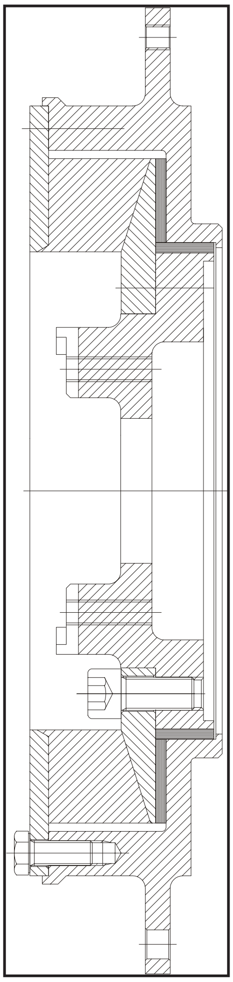


Figure 153

Disassembly and dismantling the coupling

To disassemble the coupling, the cardan shaft bolted onto the universal shaft coupling is unbolted and removed.
Then the flywheel connection bolts are undone so that the coupling can be completely removed.

After undoing the bolts (7) and the inner bolted connection (6), the coupling can be dismantled into its individual components.
This applies only up to →7x1126;→8x1128

NOTE

All parts should be cleaned after dismantling the coupling. After the technical change the new coupling is available only as a complete unit.

NOTE

All bolted connections should generally be replaced

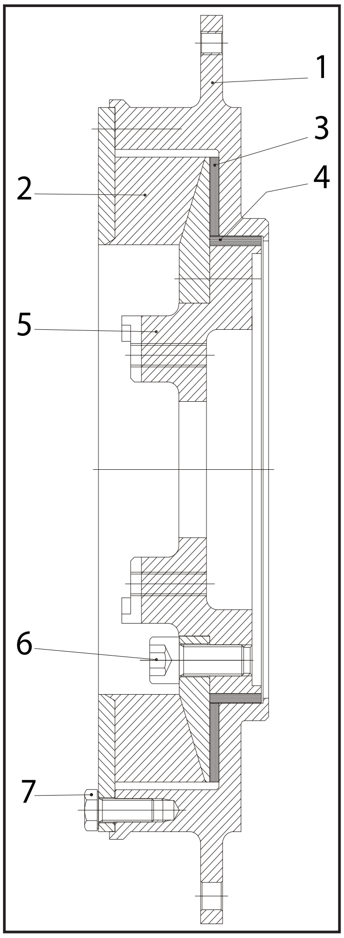


Figure 154

Assembling the coupling →7x1126;→8x1128.

When assembling the coupling, the bolt tightening torques must be observed.

Assembly is begun by inserting the friction ring (4) and the friction disk (4) into the flange casing (1). When reusing the friction disk (3) and the friction ring (4), the surfaces should be brushed lightly with mineral oil.

No other lubricants or auxiliary materials may be used, in particular no greases with metallic soaps or dry-film lubricants.

Then the hub (5) is pushed in and the coupling element (2) inserted. The coupling is bolted tight with the inner (6 [Torque: 390Nm]) and outer fixing bolts (7 [Torque: 125Nm]).

Installation instructions

Before installation, the corrosion protection on the contact surfaces of the coupling must be removed with a conventional solvent. The coupling is attached in assembled state to the engine flywheel with the flywheel bolted connection.

M12x20 8pcs	M12x90 8pcs
Torque: 136Nm.	Torque: 86Nm.
Use Loctite® 245	Use Loctite® 245

No washers are to be used.

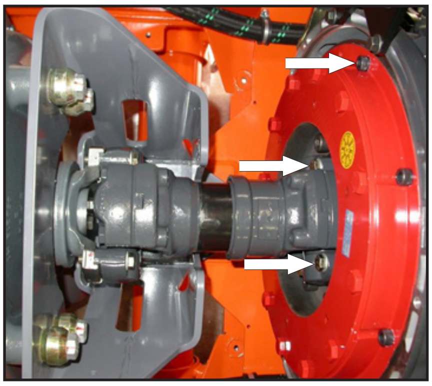


Figure 155

The cardan shaft can now be mounted and assembled.
Mount shaft with dust sealing forward (log on driving side). Enter two screws and tighten until there is a 3mm gap. Then enter the two remaining screws (same side) all the way and then the first ones. Same procedure on both sides.

Torque: 141Nm. Use Threebond® 1374 on screws.

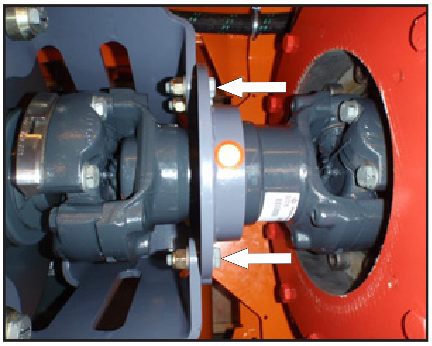


Figure 156

Mount lower flange-half all the way down and equal clearance on both sides of shaft.
Mount upper flange-half all the way up and equal clearance on both sides of shaft.

Torque: 114Nm

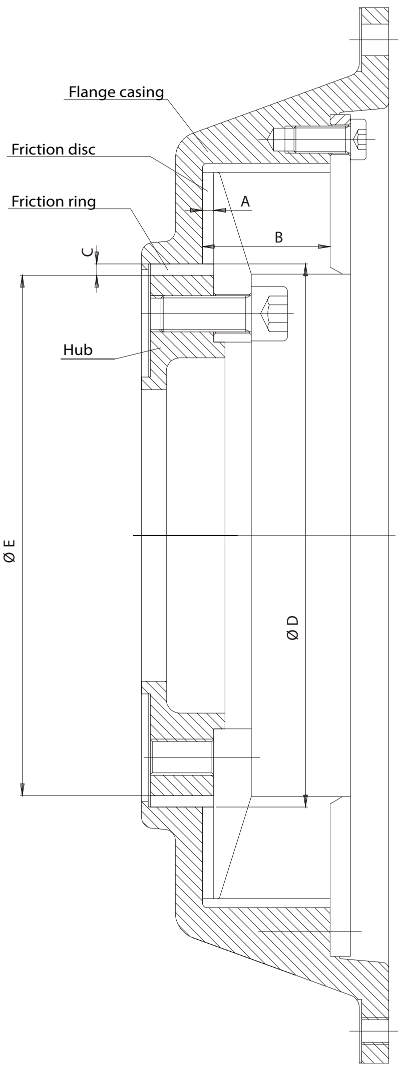
WARNING

If unusual torsional vibrations (high noise level) occur after the engine or drive unit is switched on, the system is to be shut down immediately.

Friction disk, friction ring

The friction disk and friction ring are components which due to their design are subject to a certain degree of wear. The opposite steel surfaces of these components may also be subject to a small degree of wear.

The wear threshold values for the friction disk, the friction ring, the housing bore and the hub diameter are given in the following table.



Manufactured size	055	
Friction disk thickness "A"	5,0	mm
Wear threshold value	4,5	mm
Flange casing depth element seat on outer ring up yo striking surface "B"	63,1	mm
Wear threshold value	63,4	mm
Friction ring thickness "C"	5,0	mm
Wear threshold value	4,5	mm
Flange casing diameter bearing seat "D"	266,0	mm
Wear threshold value	266 ,3	mm
Hub diameter on bearing seat "E"	256,0	mm
Wear threshold value	255,7	mm

Figure 157

If these wear threshold values are exceeded on the housing (dimensions B and D) or values are below these limits for the friction ring, friction disk or hub, the parts must be replaced or reworked. In the event of grooves, ripples and burn marks, the housing must always be replaced. When replacing the coupling element, the friction disk and friction ring should also be replaced.

NOTE

Not applies to the new type of coupling . Refer to Parts Catalogue for parts identification.

Timing gear - 13 and 9 liter with XPI

Gear drive

The crankshaft gear drives two intermediate gears and the oil pump gear. One intermediate gear drives the camshaft, air compressor and hydraulic pump. The other intermediate gear drives the power take-off and on buses it also drives a hydraulic pump which in turn drives the fan motor.

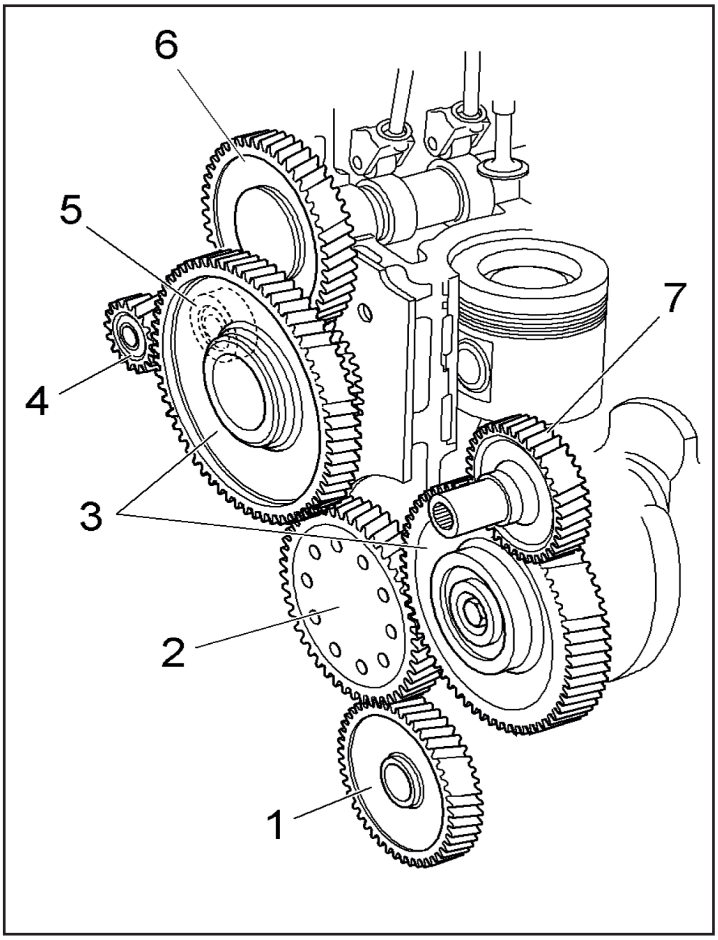


Figure 158

Engine with unit injector

1. Oil pump gear
2. Crankshaft gear
3. Intermediate gear
4. Hydraulic pump gear
5. Compressor gear (compressed air)
6. Camshaft gear
7. Power take-off

To facilitate assembly the gears have markings, either on a tooth or in a tooth gap.

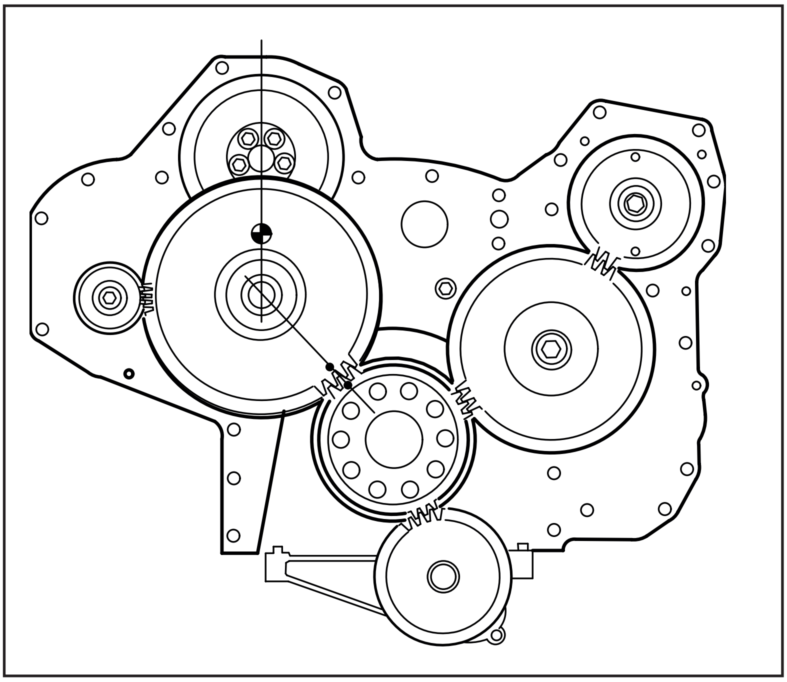


Figure 159

Belt drive collant pump, generator and AC compressor

The coolant pump and alternator are driven by the belt drive, as also is the A/C compressor.

(The fan is mounted on a special bracket and is driven by the hydraulic system. See in chapter 5 Hydraulic system)

The drive belt is a “Multigroove V-belt”, i.e. the belt has numerous V-shaped grooves on the drive side. The pulleys are of corresponding design and the belt therefore has an extremely large contact surface for its width. A large contact surface reduces the risk of belt slippage.

Included in the belt circuit are also jockey pulleys, the purpose of which is to give the belt a good arc of contact round the pulleys.

An automatic belt tensioner is used to obtain the correct belt tension.

1. - Spacing sleeve
2. - Roller
3. - Roller
4. - Roller
5. - Belt tensioner
6. - Poly V belt
7. - Alternator
8. - Coolant pump
9. - A/C compressor
10. - Pulley

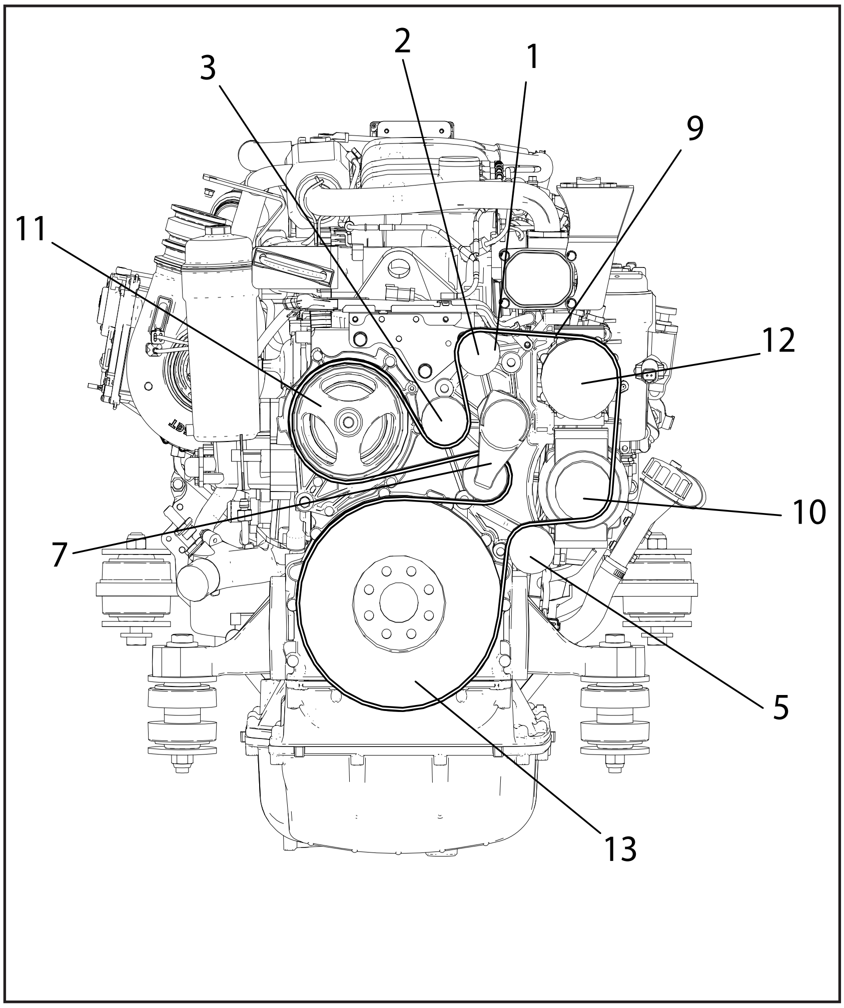


Figure 160

Checking the drive belt

CAUTION

Disconnect the cable terminal prior to charging to prevent control unit damage. Avoid boost charging as this damages the battery over time.

Check the drive belt thoroughly, particularly at the idler rollers.

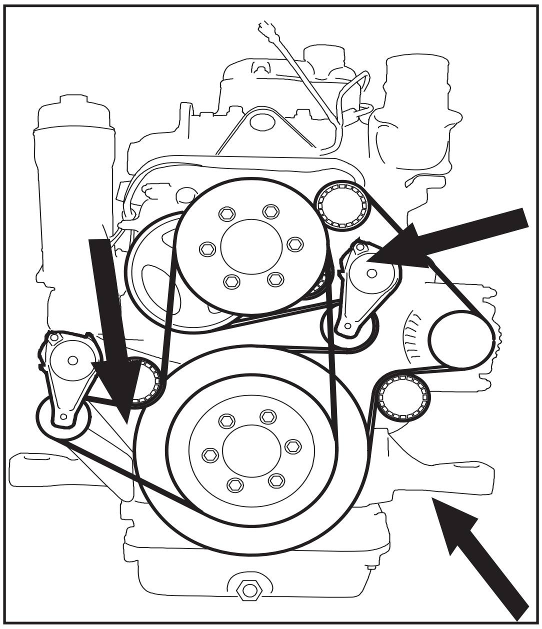


Figure 161

Check the drive belt for cracks.

NOTE

Example of a minor crack in the drive belt. The drive belt can be refitted.

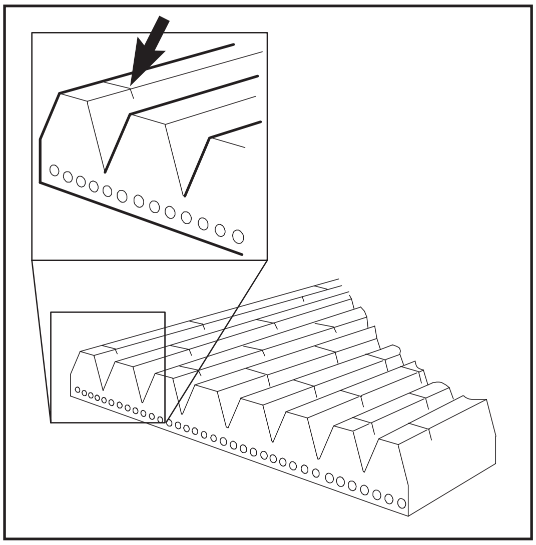


Figure 162

NOTE

The drive belt has deep cracks and must be renewed.

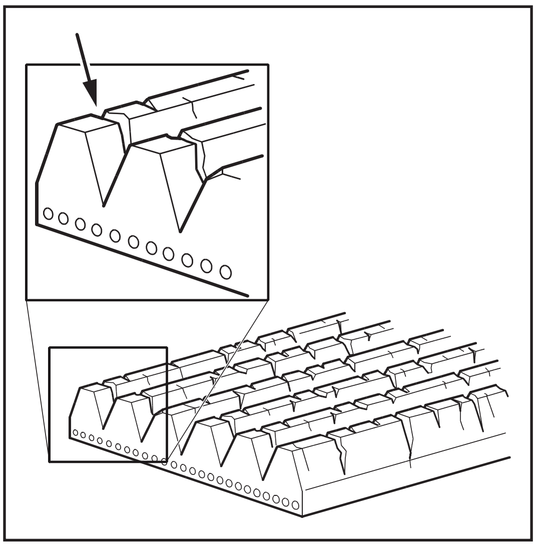


Figure 163

Check drive belt wear.

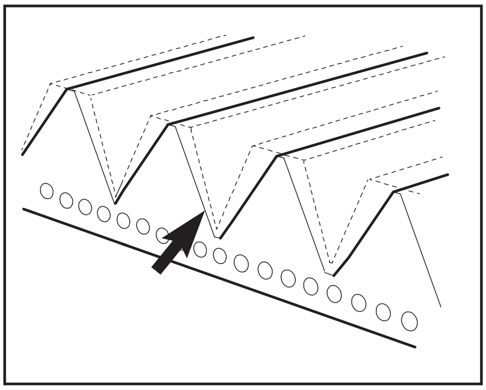


Figure 164

NOTE

The drive belt is starting to become worn, but can be refitted.

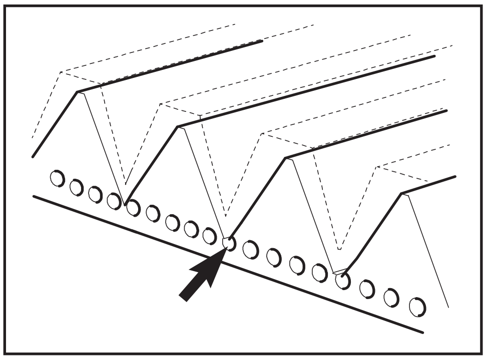


Figure 165

NOTE

The belt is worn down to the cord. The drive belt must be renewed.

Check for leaks

- Start the engine.
- Check for oil, coolant, fuel, air or exhaust leaks.
- Tighten or renew leaking connections. Check the overflow holes which show whether the O-rings between the cylinder liners and crankcase are leaking.
- Check whether the drain hole on the coolant pump is blocked. If there is a leak, renew the seal in the pump or the complete coolant pump.

NOTE

If serious leakage occurs, contact your nearest Hyundai workshop.

Renewing the seal in the front cover

1. Remove the fan ring and the fan. Thermostatic fan: Store it upright (vertical).
2. Remove the belt(s), crankshaft damper and belt pulley.
3. Remove the driver bolts and withdraw the driver. Mind the sealing surface.
4. Pull or prise off the seal in the cover. Take care to avoid damaging the sealing surface in the cover.
5. Wipe the sealing surface in the cover clean.

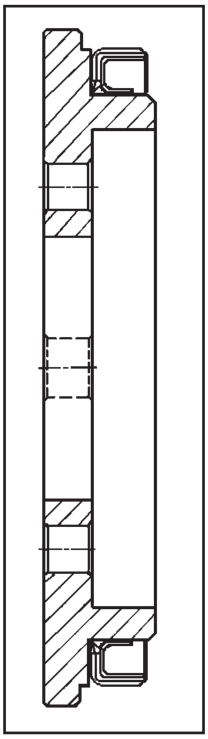


Figure 166

Tool 524615 with crankshaft seal

NOTE

The crankshaft seal must be fitted dry and must not be lubricated. The sleeve in the seal should be left in place until the seal is fitted.

6. Place the new seal on tool 8421 and press it in place by tightening the diametrically opposite bolts alternately. The seal is correctly fitted when the tool comes up against the cover.
7. Remove the tool by screwing the bolts into the threaded holes.
8. Wipe the driver sealing surface clean. Fit a new seal on the end surface of the driver and push the driver onto the spacing sleeve on the end of the crankshaft.
9. Bolt the driver to the crankshaft flange and tighten the flange bolts to 135 Nm.
10. Bolt the crankshaft damper and possibly the belt pulley to the hub and tighten to 110 Nm.
11. Fit the belt(s), fan ring and fan.

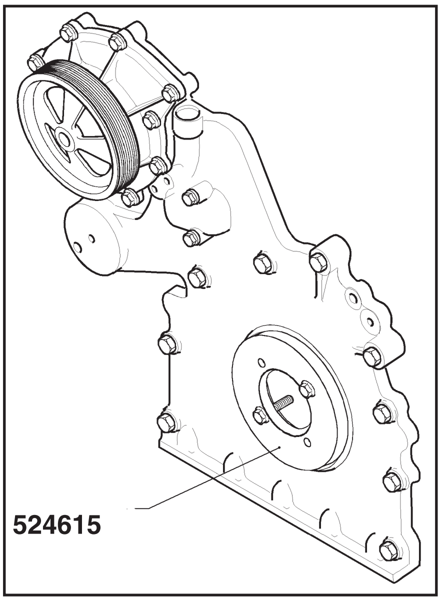


Figure 167

Crankshaft damper

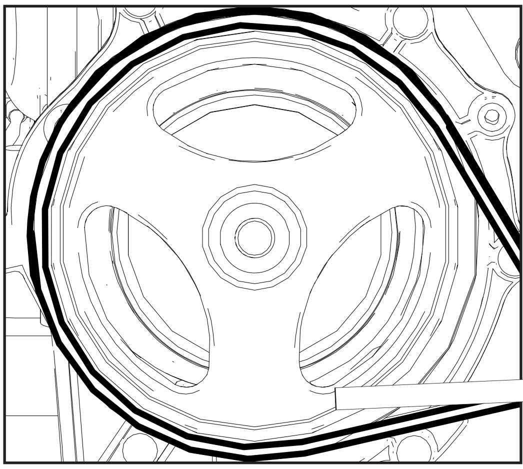


Figure 168

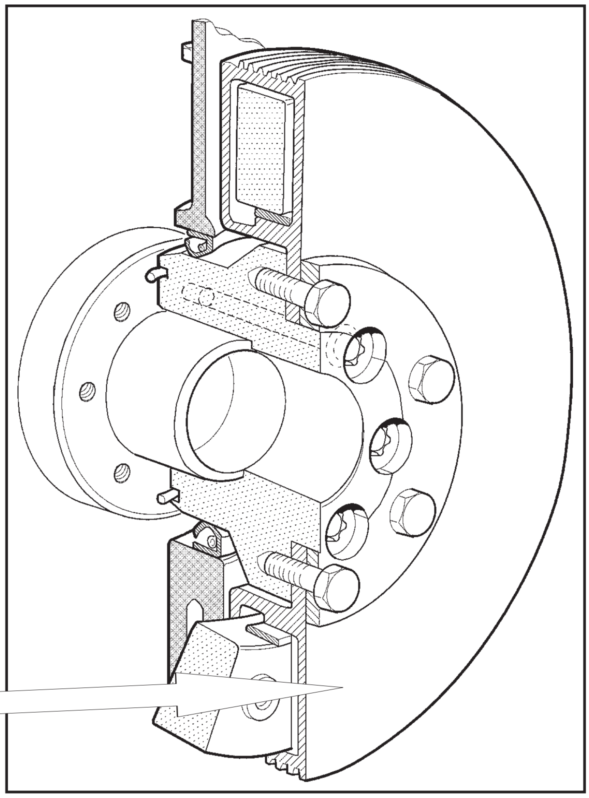


Figure 169

The power impulses from the connecting rods give rise to torsional oscillation in the crankshaft. These oscillations are severest at certain engine speeds which vary with the design of the engine, how it is loaded, etc.

Torsional oscillation is characterised as follows:

The flywheel (at the "rear" end of the crankshaft) rotates at an almost constant speed throughout each revolution of the crankshaft. Relative to the flywheel, the rotational speed of the front end of the crankshaft will increase and decrease several times during each revolution.
To reduce the amplitude of the oscillation, a crankshaft damper is attached to the front end of the crankshaft.

A ring of steel is incorporated in the circular and completely enclosed housing of the crankshaft damper. The housing is bolted onto the crankshaft.

There is a heavy oil between the housing and ring which damps the relative movement between the two. The oscillation at the front of the crankshaft is damped by the ring striving to rotate with even speed.

The crankshaft damper has numerous belt grooves for a "Multigroove V-belt".

Timing gear, exploded view

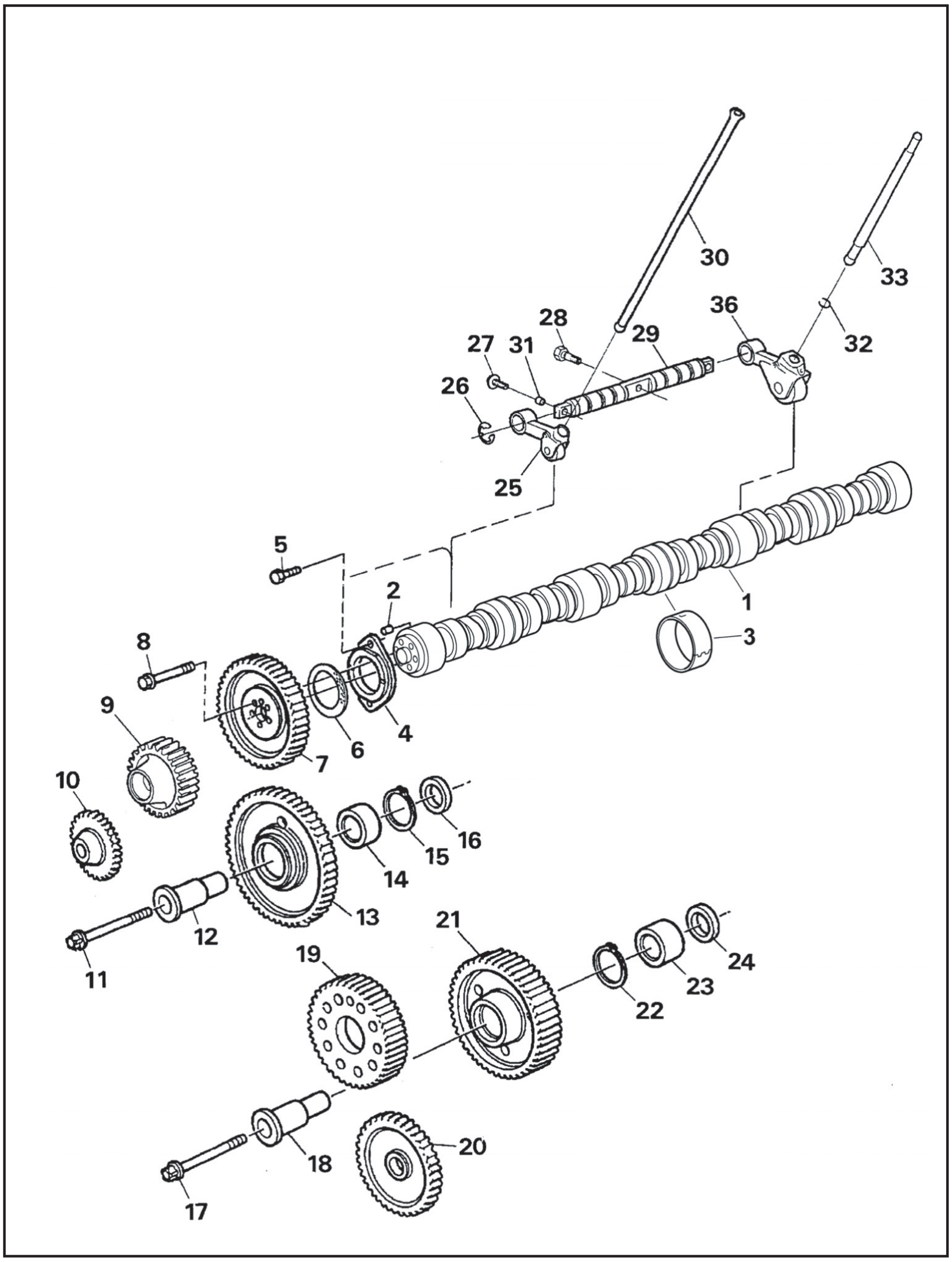


Figure 170

1. Camshaft
2. Pin
3. Camshaft bearing
4. Guide flange
5. Flange bolt
6. Thrust washer
7. Camshaft gear
8. Flange bolt
9. Compressor gear
10. Hydraulic pump wheel
11. Flange bolt
12. Shaft
13. Intermediate gear
14. Ball bearing
15. Snap ring
16. Spacing sleeve
17. Bolt
18. Shaft
19. Crankshaft gear
20. Oil pump gear
21. Intermediate gear
22. Snap ring
23. Shaft
24. Spacing sleeve
25. Roller tappet
26. Circlip
27. Flange bolt
28. Banjo screw
29. Shaft
30. Pushrod
31. Slide ring
32. Snap ring
33. Pushrod
34.
35.
36. Roller tappet

Special tools

Special tools, gear

850329-00159 Drift
850329-00160 Drift
MX008049 Impact drift
850329-00161 Support drift
850329-00174 Flywheel turning tool

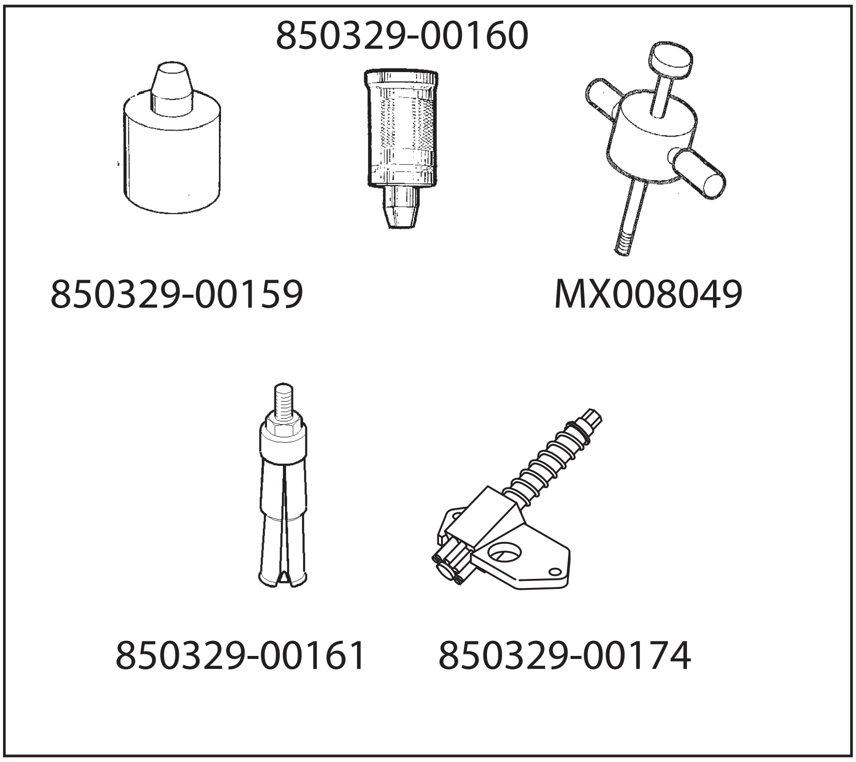


Figure 171

Special tools, replacement of camshaft bearing

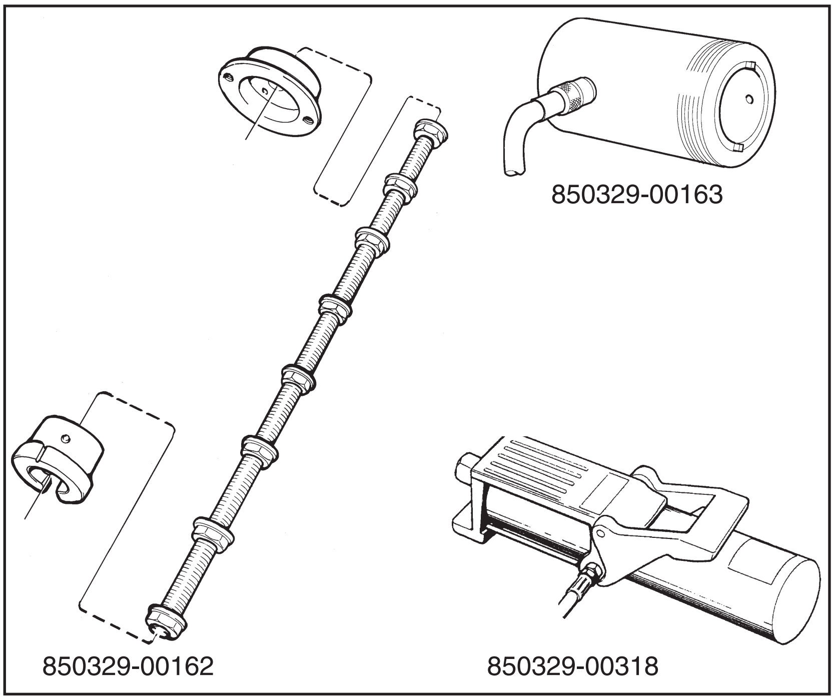


Figure 172

850329-00162	Tool for replacing camshaft bearing
850329-00163	Hydraulic hole cylinder
850329-00318	Compressed air powered hydraulic pump

Intermediate gear

Intermediate gear

Removal

- The timing gear has two intermediate gears.

- One for the camshaft and pump drive and one for driving the compressor.

- Both these gears should be removed in the same manner.

1. Turn the crankshaft so that cylinder number 1 is close to TDC. Use tool 850329-00174 on the flywheel.

2. Remove the flywheel as described in the section Removing the flywheel.

3. Remove the flywheel housing as described in Removing the flywheel housing.

4. Manufacture a thread block according to the sketch.

5. The shaft on which the gear is located has a groove. Fit puller 850329-00161, slide hammer MX008049 and the thread block. Loosen the gear and shaft.

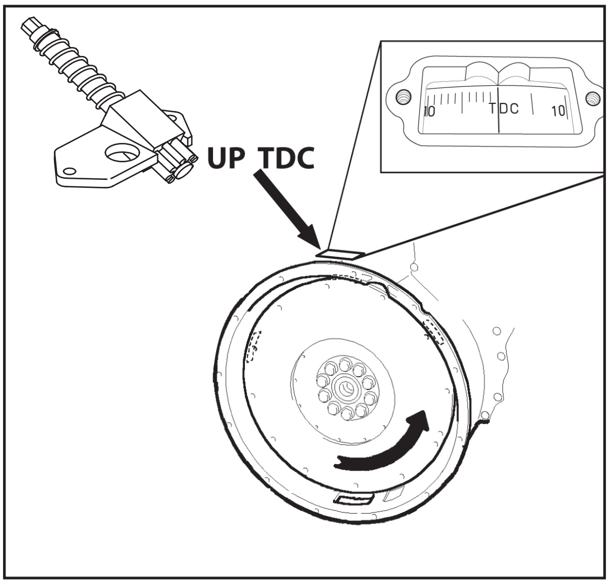


Figure 173

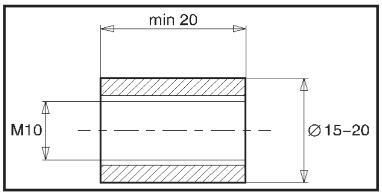


Figure 174

NOTE

After removing the intermediate gear, neither the camshaft or the crankshaft must be rotated. This may cause pistons and valves to collide and be damaged.

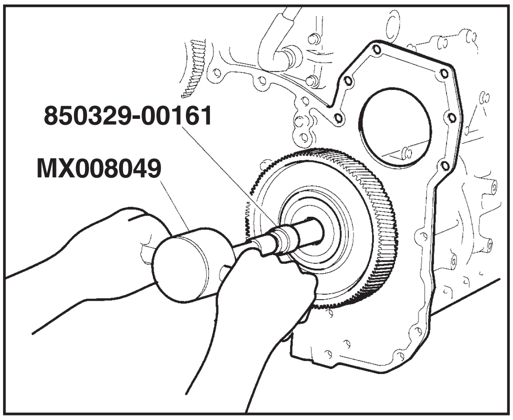


Figure 175

1. Press the shaft out of the bearing.

2. Press the bearing inner race shell from the shaft and remove the retaining ring.

3. Place the removed bearing inner race in the bearing and press out the bearing using drift 850329-00159.

4. Press a new bearing onto the shaft journal using drift 850329-00159.

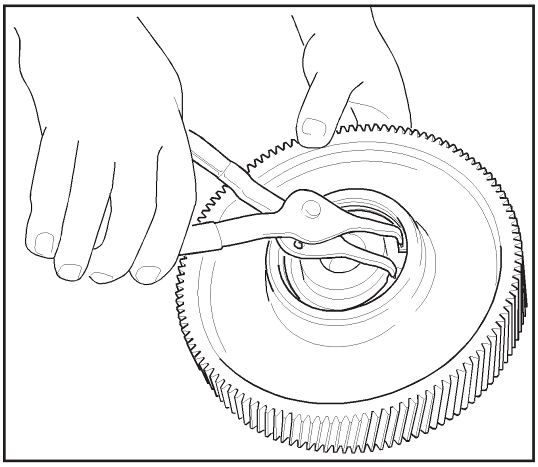


Figure 176

NOTE

Do not press on the outer race.

5. Press the bearing and shaft journal into the intermediate gear using drift 850329-00160

6. Fit the snap ring.

7. Press the spacing ring onto the shaft journal. Ensure that the shaft journal is on the press table.

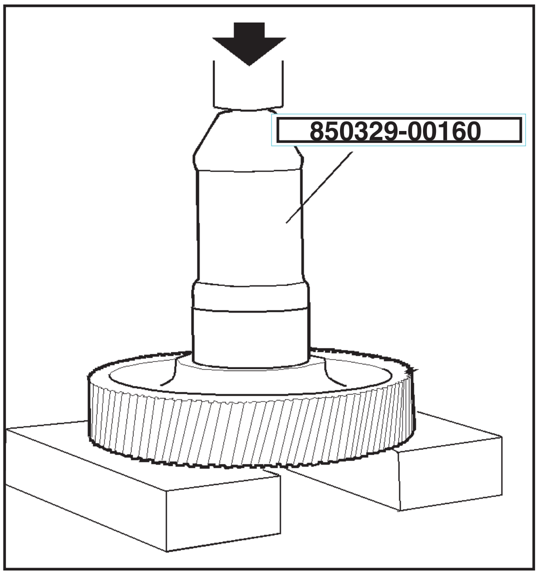


Figure 177

Fitting

1. Check that cylinder number 1 is close to TDC. The markings on the camshaft gear and crankshaft gear must point towards the centre of the intermediate gear.
2. Lubricate the bearing surfaces.
3. Fit the intermediate gear against the camshaft gear and the crankshaft gear so that the markings point towards each other.
4. Fit the second intermediate gear.
5. Tighten the bolts on the intermediate gears to 50 Nm + 60°.
6. Fit the flywheel housing as described in the section Fitting the flywheel housing.
7. Fit the flywheel as described in the section Fitting the flywheel.

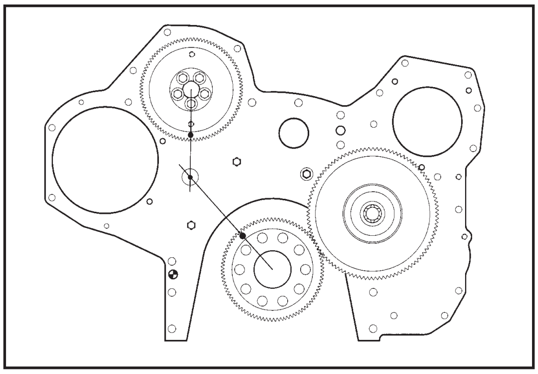


Figure 178

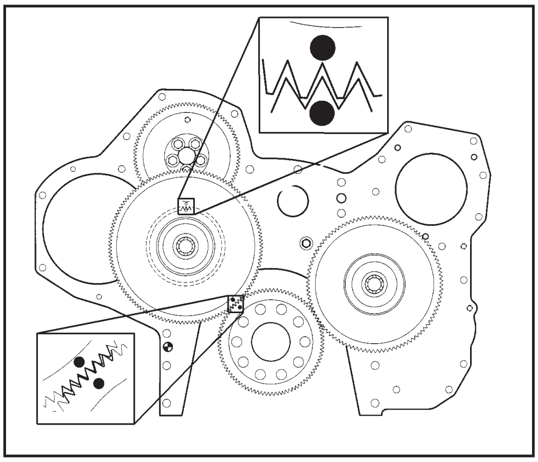


Figure 179

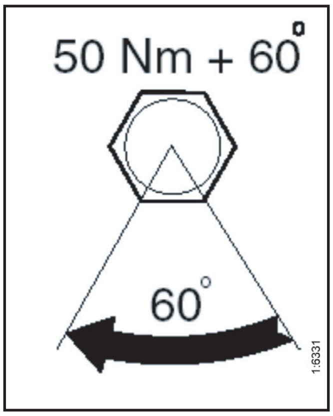


Figure 180

Camshaft gear

Removal

1. Turn the crankshaft so that cylinder number 1 is close to TDC. Use tool 850329-00174 on the flywheel.
2. Remove the flywheel as described in the section Removing the flywheel.
3. Remove the flywheel housing as described in the section Removing the flywheel housing.
4. Remove the intermediate gear.

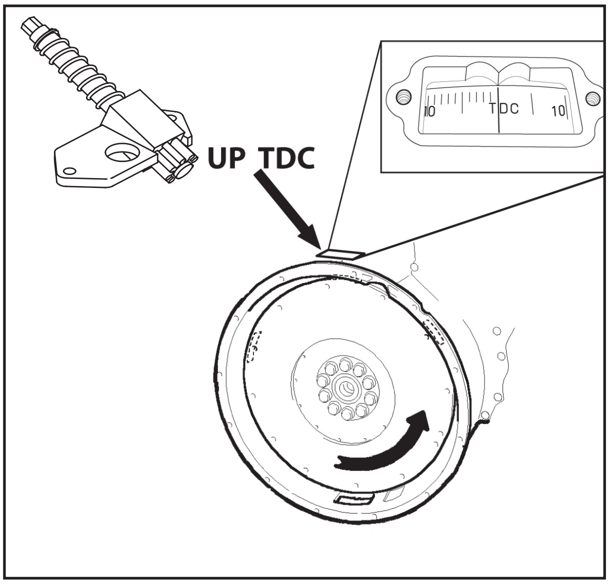


Figure 181

NOTE

After removing the intermediate gear, neither the camshaft nor the crankshaft must be rotated. This may cause pistons and valves to collide and be damaged.

5. Remove the camshaft gear.

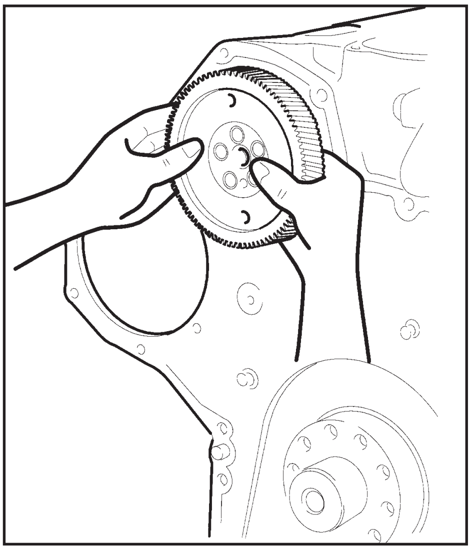
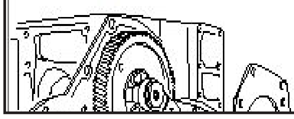


Figure 182

Fitting

1. Fit the camshaft gear and torque tighten the bolts to 63 Nm.
2. Fit the intermediate gear as described in Intermediate gear, fitting.
3. Fit the flywheel housing as described in the section Fitting the flywheel housing.
4. Fit the flywheel as described in the section Fitting the flywheel.

Camshaft gear 	20 Nm + 40°

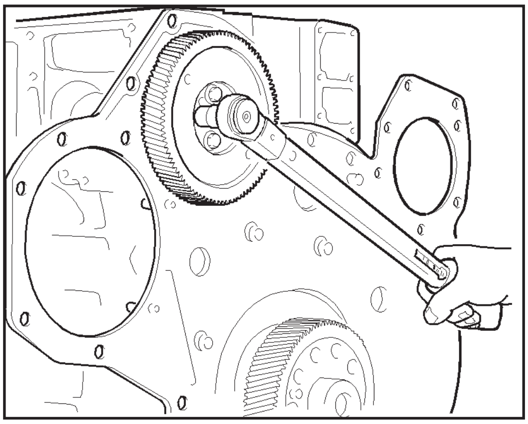


Figure 183

Crankshaft gear

Removal

1. Turn the crankshaft so that cylinder number 1 is close to TDC. Use tool 850329-00174 on flywheel.

2. Remove the flywheel as described in the section Removing the flywheel.

3. Remove the flywheel housing as described in the section Removing the flywheel housing.

4. Remove the intermediate gear.

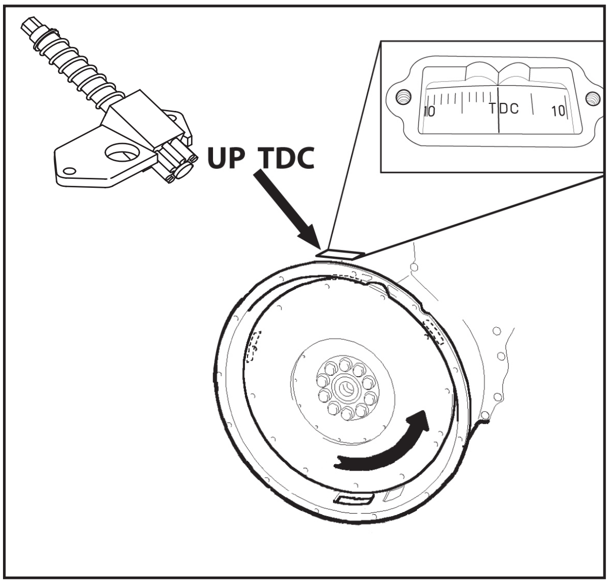


Figure 184

NOTE

After removing the intermediate gear, neither the camshaft nor the crankshaft must be rotated. This may cause pistons and valves to collide and be damaged.

5. Remove the crankshaft gear.

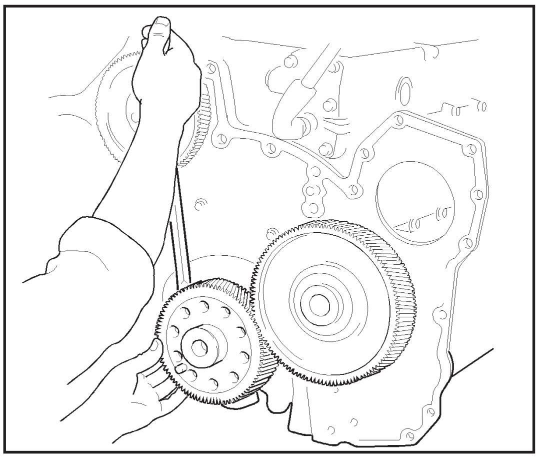


Figure 185

Fitting

1. Fit the crankshaft gear and guide pin.

2. Fit the intermediate gear as described in Intermediate gear, fitting.

3. Fit the flywheel housing as described in the section Fitting the flywheel housing.

4. Fit the flywheel as described in the section Fitting the flywheel.

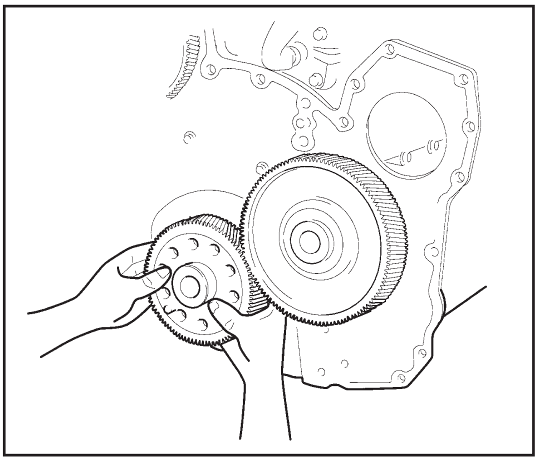


Figure 186

Camshaft

Removal

1. Remove the flywheel as described in Removing the flywheel.
2. Remove the flywheel housing as described in Removing the flywheel housing.
3. Remove rocker arms, pushrods and valve bridges.
4. Remove the camshaft gear.
5. Remove the intermediate gear and the guide flange bolts.
6. Remove the timing gear plate.
7. Remove the camshaft covers.
8. Remove the valve tappets.

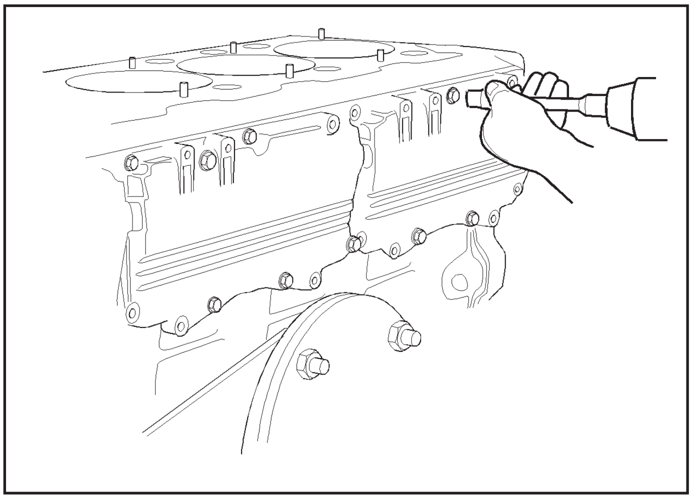


Figure 187

NOTE

Mark the valve tappets because they must be refitted in the same places.

9. Pull the camshaft backwards. Take care not to damage the cams and bearings.

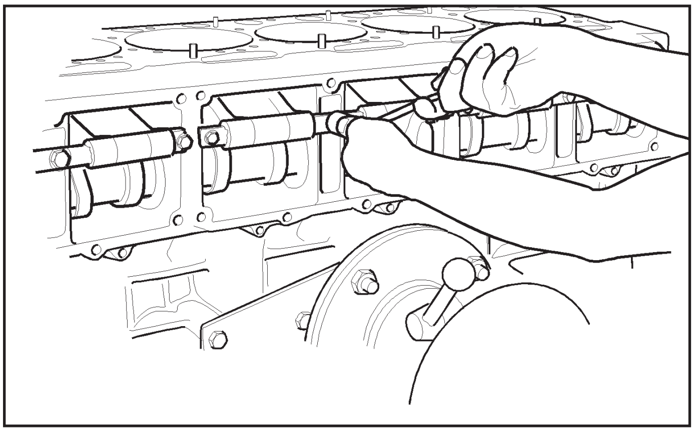


Figure 188

Replacement of camshaft bearing

Work description

1. Remove the camshaft according to the section Camshaft, removal.
2. Remove the camshaft cover at the front end of the engine.

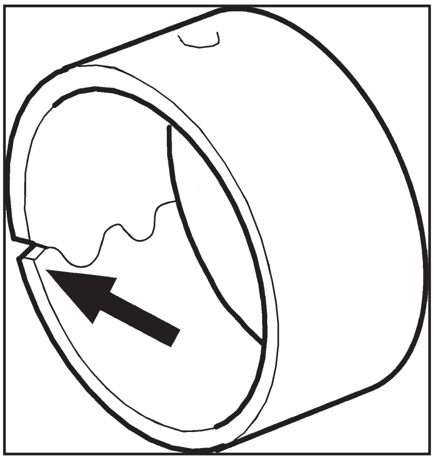


Figure 189

NOTE

Wipe around the edges and the bearing seat surfaces around the old bearings to avoid damaging the contact surfaces when fitting the new bearings.

3. Wipe the bearing seat surfaces clean around the old bearings.

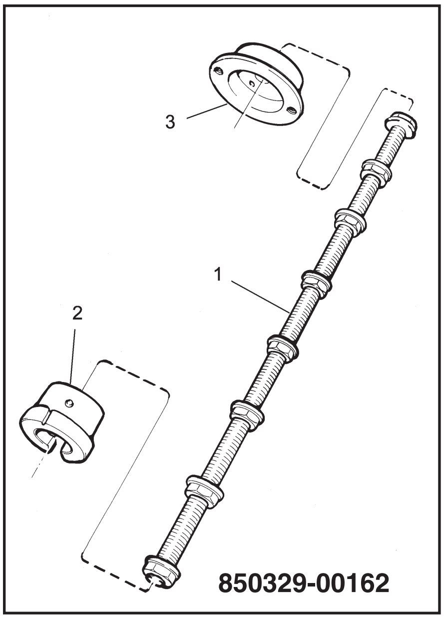


Figure 190

1. Threaded stem with eight flange nuts
2. Press drift
3. Flange

NOTE

The recess in the bearing joint must be turned towards the front of the engine.

4. Place the new bearings in the space between the bearing seats for the camshaft.
5. Place the flange nuts on the threaded stem, included in tool 850329-00162, as illustrated.

850329-00162

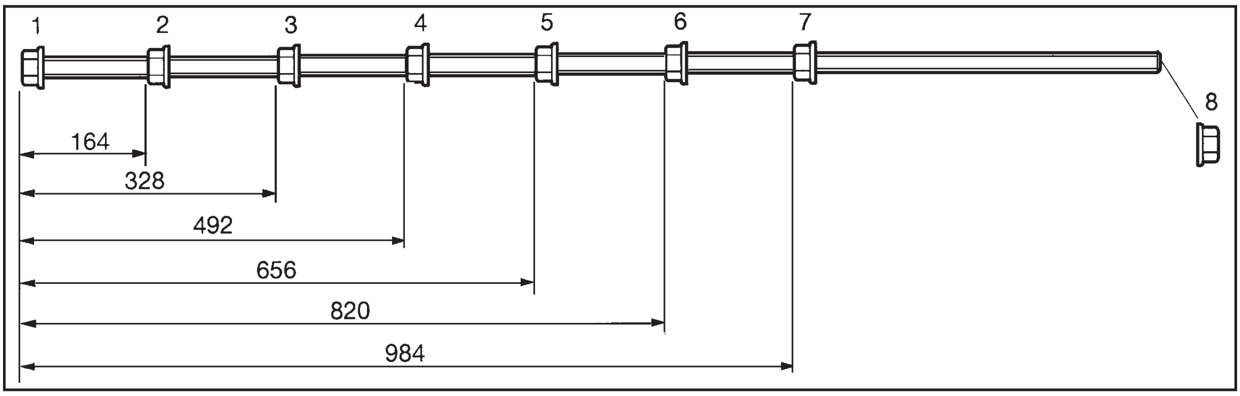


Figure 191

6. Take the threaded stem and insert the end with flange nut number 1 from the rear edge of the engine past the rear most bearing seat. Insert it further through the bearing seats and the new bearings until flange nut 1 protrudes from the front of the engine.

7. Screw the flange part of tool 850329-00162 securely onto hydraulic cylinder 850329-00163 with two M6x12 bolts. Press together cylinder 850329-00163 if not already in neutral position.

8. Screw the flange securely to the hydraulic cylinder at the rear of the engine with two of M10x25.

9. Screw on flange nut 8, from tool 850329-00162, onto the threaded stem.

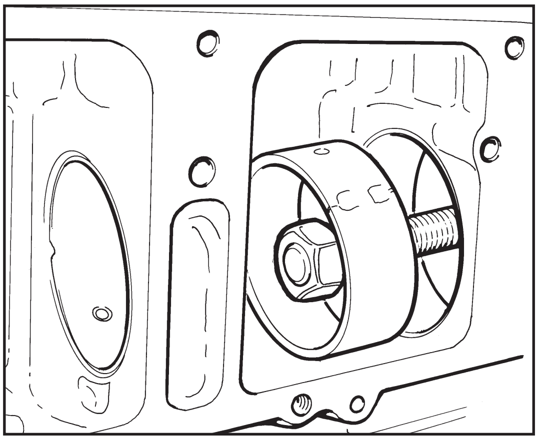


Figure 192

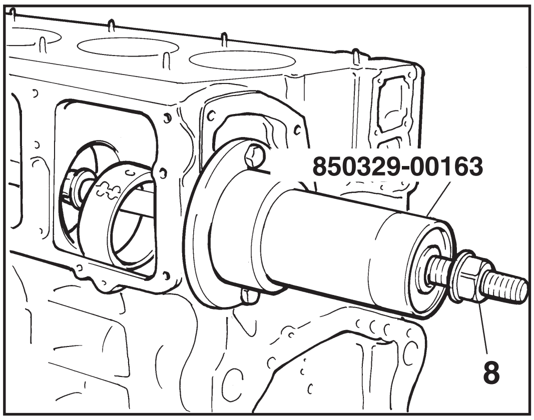


Figure 193

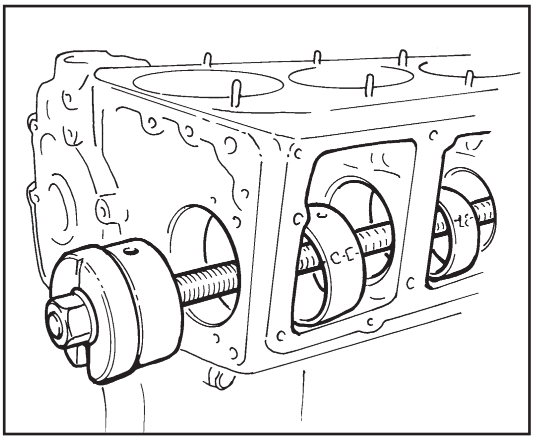


Figure 194

10. Hang a new bearing on the stem at the front of the engine.

11. Place the press drift on the threaded stem and place the bearing on the drift.

NOTE

The recess in the bearing joint must be turned towards the flange on the press drifts. Secure the bearing on the drift by placing the spring-loaded ball in an oil way. The bearing is correctly located on the drift when the ball and a marking hole are centred on the bearing oil hole.

The bearing is correctly located on the drift when the ball and a marking hole are opposite the bearing's oil hole

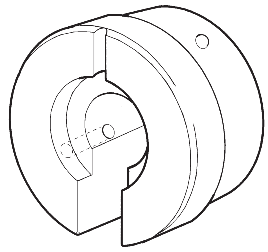


Figure 195

12. Clean around the bearing contact surface.

NOTE

The marking on the drift must be uppermost and vertical so that the oil hole in the bearing will be central to the oil ways.

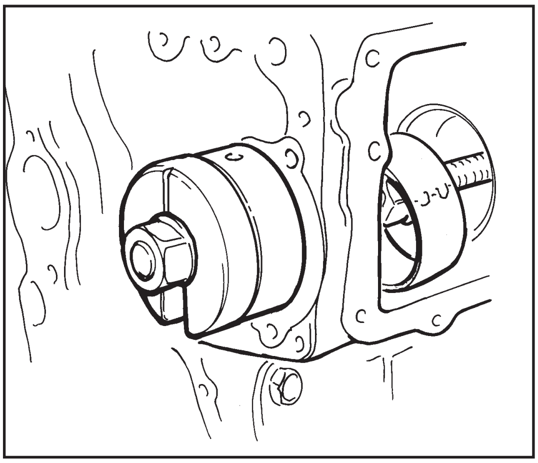


Figure 196

13. Hold the press drift with the new bearing against the old.

Secure the threaded stem between the press drift and hydraulic cylinder 850329-00163 by tightening flange nut 8 on the stem.

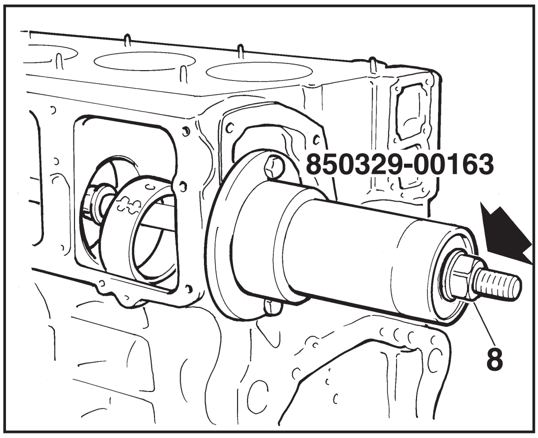


Figure 197

NOTE

The new bearing is in the correct position before the old bearing is completely released. The new bearing has the correct position when the distance from the front edge of the cylinder block to the front edge of the press drift has a permitted value according to the table.

By -12 mm it means that the drift should protrude 12 mm out of the block.

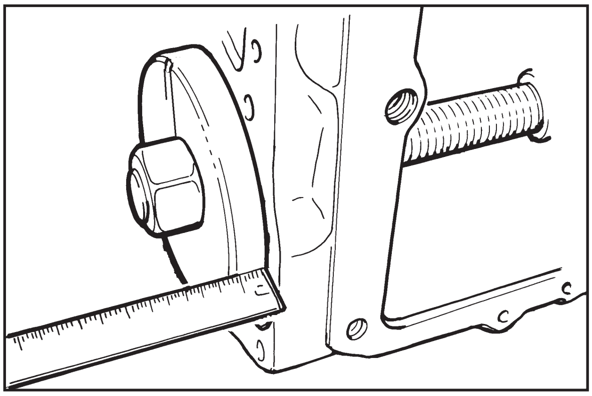


Figure 198
Control measurement of bearing number 1

Table for correctly located camshaft bearing

Camshaft bearing

no.	Distance (mm)
1	-12 to -14
2	150 to 152
3	314 to 316
4	478 to 480
5	642 to 644
6	806 to 808
7	970 to 972

14. Press in the new bearing at the same time as pressing out the old bearing with hydraulic cylinder 850329-00163 and hydraulic pump 850329-00318. Check that the bearing is corectly positioned by measuring.

15. Remove the press drift by detaching flange nut 8 and pushing in the threaded stem.

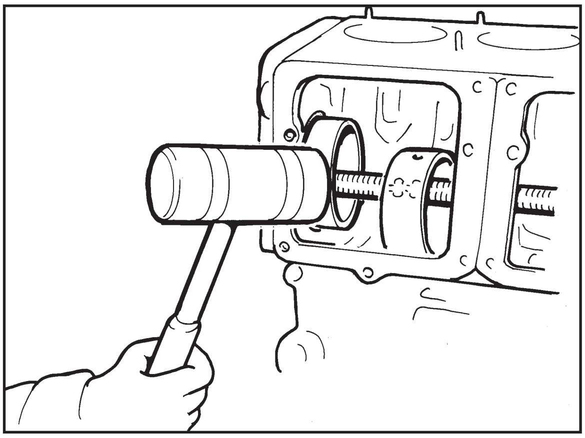


Figure 199

16. Check that the bearing oil hole is opposite the cylinder block oil ducts.

NOTE

The seats for camshaft bearings 2, 4 and 6 have two oil ducts. The others only have the lower one.

17. Repeat the procedure for the remaining bearings.
18. Carefully knock with a plastic hammer to release the old bearings.
19. Clean the sealing surface, take a new gasket and fit the cover for the camshaft at the front of the engine.
20. Refit the camshaft according to the section Fitting the Camshaft. Then perform a check on the camshaft setting.

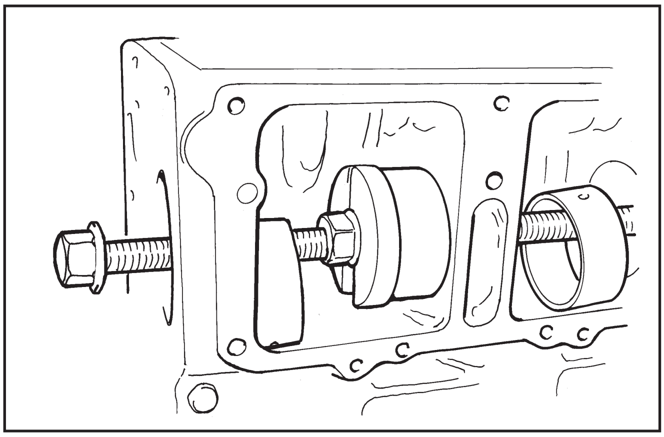


Figure 200
Extraction and pressing of bearing number 2.

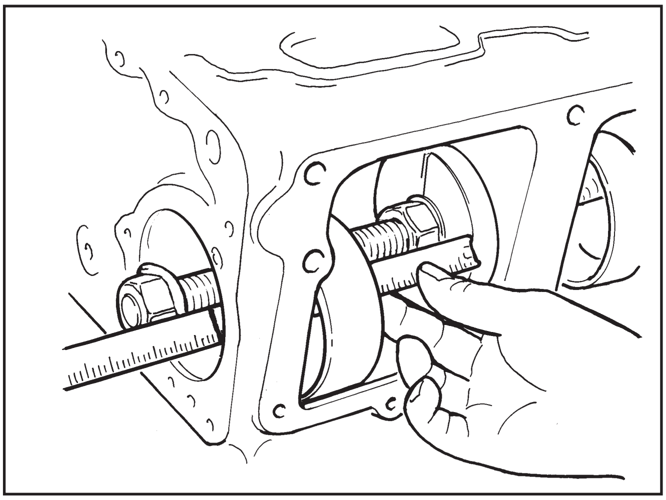


Figure 201
Check measurement of bearing number 2

Fitting

1. Fit the camshaft. Take care not to damage the cams and bearings.

2. Lubricate with engine oil and fit the valve tappets in the same places as they were before removal.

3. Tighten the banjo bolts to 32 Nm.

4. Fit the camshaft covers. Fit the guide flange bolts.

5. Remove all old sealing compound on the sealing surfaces of the timing gear casing and timing gear plate. Clean off any oil and grease using an alcohol based cleaning agent.

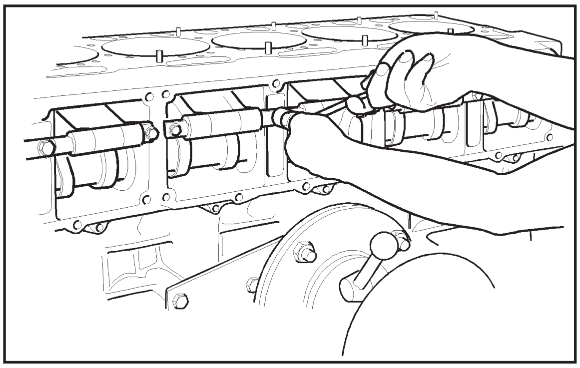


Figure 202

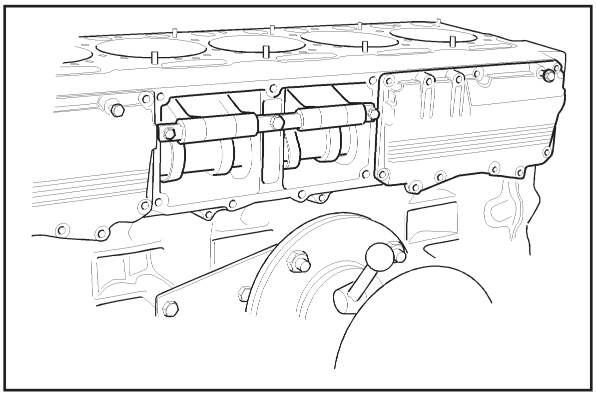


Figure 203

NOTE

The sealing surfaces must be absolutely clean and free from grease. Do not touch the surfaces after degreasing.

6. Apply the sealing agent (512565) to the timing gear casing with the special nozzle. The width of the bead should be between 0.8 and 1.2 mm. Follow the pattern as illustrated.

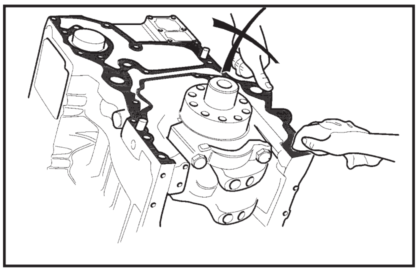


Figure 204

NOTE

Ensure that you apply sealing agent inside the screwholes, but without allowing sealing agent into the crankcase. The sealing agent may block channels and nozzles. This is particularly important to bear in mind around oil ways, where the flow of oil to the air compressor or injection pump can be blocked. Important! Assembly must be completed within 25 minutes of starting to apply the sealing agent.

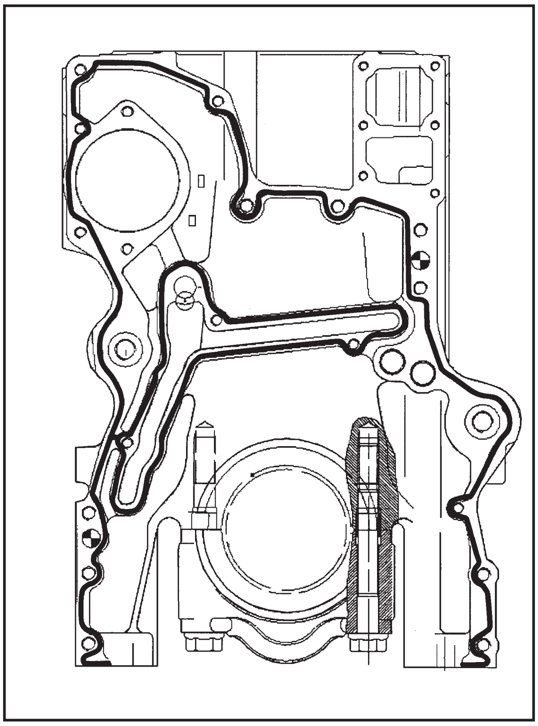


Figure 205

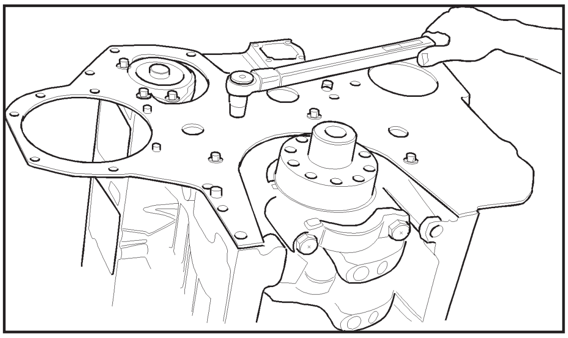


Figure 206

7. Fit the timing gear plate on the engine block. Tighten the bolts to 63 Nm.

8. Fit the intermediate gear as described in Intermediate gear, fitting.

9. Ensure that the markings on the camshaft gear point towards the centre of the intermediate gear.

10. Fit the camshaft gear and torque tighten the bolts to 63 Nm.

11. Fit the flywheel housing as described in Fitting the flywheel housing.

12. Fit the flywheel as described in Fitting the flywheel.

Checking camshaft setting

1. Set the crankshaft to TDC after the compression stroke on cylinder number one.

2. Put two dial gauges against the valve spring thrust washers.

3. Adjust the rocker arms to remove the free play and then adjust them further so that both valves are open 0.1 mm.

4. Zero both the dial gauges.

5. Turn the crankshaft one revolution in its direction of rotation until TDC position is again achieved.

6. Read off both dial gauges and compare with the values given below:

- Intake valve lifting height 0.37-1.47
- Exhaust valve lifting height 0.16-1.16

Crankshaft

Each compression stroke ”brakes” the crankshaft and each combustion stroke attempts to increase the speed of rotation of the crankshaft.

The pistons and connecting rods change their direction of travel twice during each rotation of the crankshaft. This exposes the crankshaft to numerous power pulses during each revolution.

The material is of major importance for the useful life of the crankshaft. Its design and surface treatment also help to extend its life - for instance, the surface quality of the shaft journals is an important factor in providing protection against fatigue failure.

The bearing surfaces on the crankshaft are hardened to a depth which allows them to be ground several times.

Only the bearing surfaces are hardened as it is important to retain the toughness of the material in other parts.

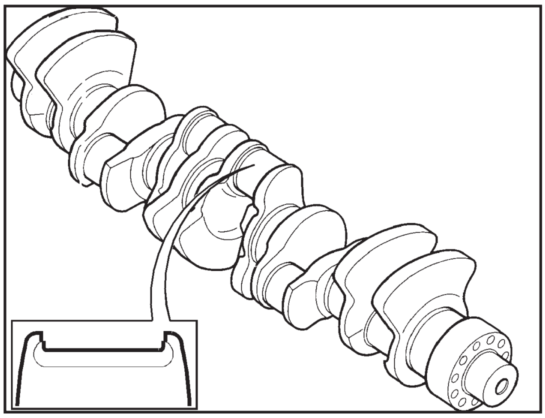


Figure 207

The bearing shells of the main and big-end bearings consist of three layers. An outer layer or backing of steel, an interlayer of lead-bronze and, nearest the crankshaft, an overlay consisting of a mixture of lead and indium or lead, tin and copper. The innermost layer is usually worn away during the course of engine utilization. Thrust washers are used for endways location of the crankshaft at the rear main bearing. These thrust washers are available in different thicknesses so that the crankshaft can be adjusted to the correct clearance. The thrust washers have the same types of layer as the big-end bearing shells.

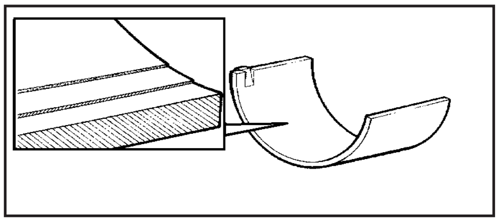


Figure 208

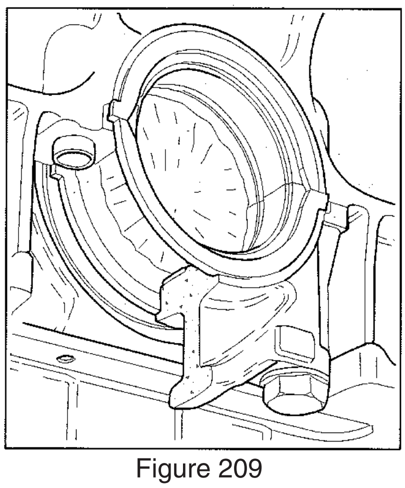


Figure 209

Removal

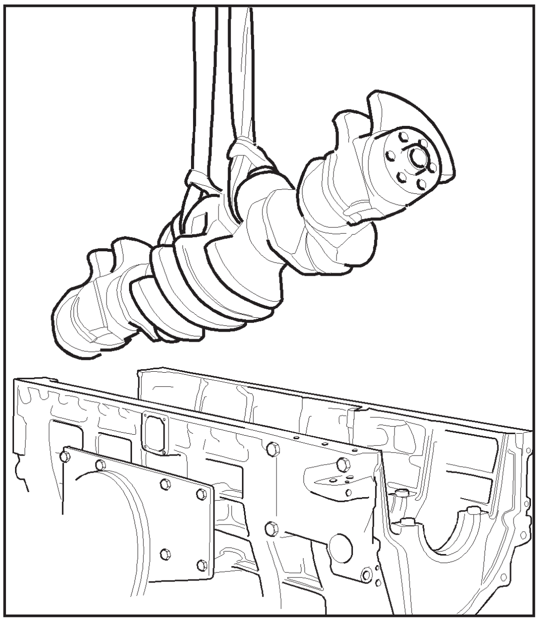


Figure 210

1. Remove the crankshaft gear as described in Removing the crankshaft gear.

2. Remove the crankshaft pulley as described in the work description Removing the pulley.

3. Remove the oil sump, oil suction pipe with strainer and the oil pump.

4. Remove the pistons and connecting rods as described in Removing connecting rods and pistons.

5. Remove the crankshaft bearing caps and main bearings.

NOTE

The main bearings and bearing caps are marked and must be refitted in the same place.

6. Lift out the crankshaft.

Checking and grinding

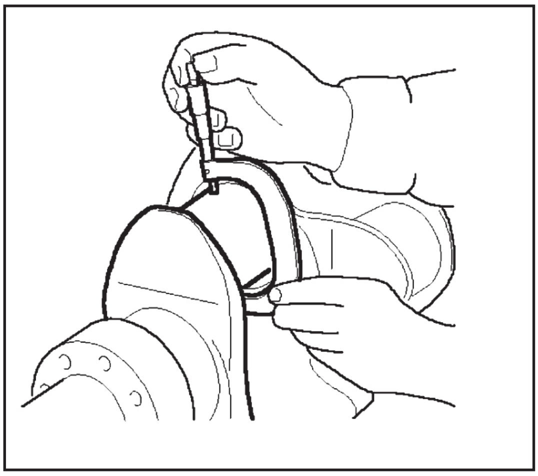


Figure 211

- Measure the crankshaft journals. Use a micrometer to measure two diameters at right angles to each other.

- If either of these diameters is lower than the minimum indicated limit, regrinding of the crankshaft should be considered.

- Consideration must also be given to oil pressure, which is in turn affected by such things as main bearing and crankshaft bearing wear.

- When regrinding, stated undersize must be complied with. Suitable bearings are available for these sizes.

- Refer to the next page for the diameters required for different undersize.

- It is important that the fillet radius of the journals is correct.

- After grinding the journals, the oil hole connections to the bearing surfaces should be rounded off and polished.

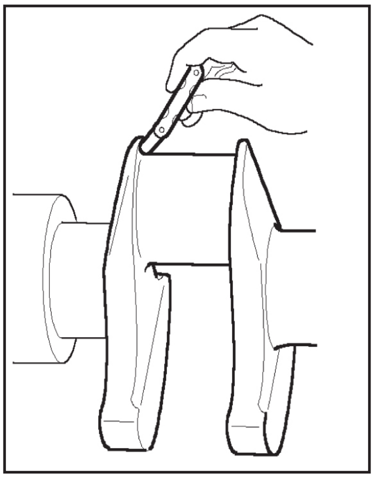


Figure 212

Cylinder block

Reconditioning

Heat arising from the main bearings seizing and rotating in the cylinder block will change the properties of the material in the cylinder block. These cylinder blocks must be discarded.

If the main bearing seizes but does not rotate in the cylinder block, the cylinder block can be overhauled. The main bearing seats must comply with the demands on roundness given in the table. Machining out-of-round main bearing seats is something we do not recommend.

1. Measure the diameter at four different positions as illustrated. The diameter must be measured with the main bearing caps tightened and without main bearings.

2. Check the dimensions with those in the table.

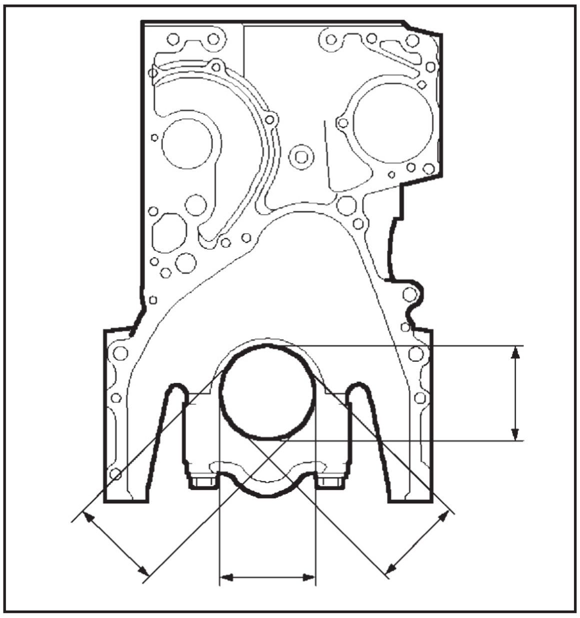


Figure 213

Minimum permitted diameter	Maximum permitted diameter	Maximum permitted difference*
112.200 mm	112.222 mm	0.016 mm

* Maximum permitted difference between the largest and smallest diameter on the same main bearing seat.

Dimensions when regrinding

Main bearing journals

Standard, diameter	107.978-108.000 mm
Undersize 1, diameter	107.728-107.750 mm
Undersize 2, diameter	107.428-108.500 mm
Undersize 3, diameter	107.228-107.250 mm
Undersize 4, diameter	106.978-107.000 mm
Hole recess radius	4.75-4.85 mm
Surface quality	0.25 Ra

Connecting rod journals

Standard, diameter	86.978-87.000 mm
Undersize 1, diameter	86.728-86.750 mm
Undersize 2, diameter	86.478-86.500 mm
Undersize 3, diameter	86.228-86.250 mm
Undersize 4, diameter	85.978-86.000 mm
Hole recess radius	4.8-5.2 mm
Surface quality	0.25 Ra
Width, max.	56.05
Radial clearance	0.20-0.35 mm

Thrust washers

Standard, thickness	46.70-46.78 mm
Oversize 1, thickness	46.86-46.94 mm
Oversize 2, thickness	46.96-47.04 mm
Oversize 3, thickness	47.22-47.30 mm
Oversize 4, thickness	47.72-48.80 mm
Axial clearance	0.18-0.37 mm

Fitting

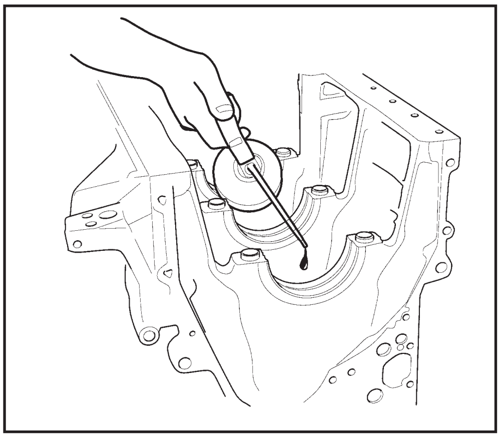


Figure 214

1. Place the bearing shells in the main bearing seats in the cylinder block and in the main bearing caps. Then lubricate the bearing surfaces with engine oil.

2. Lift in the crankshaft.

NOTE

The outside of the bearing shells must not be lubricated.

3. Lubricate the bolt thread and the surface of the main bearing cap where the bolt is tightened, see illustration. Scania engine oil can be used.

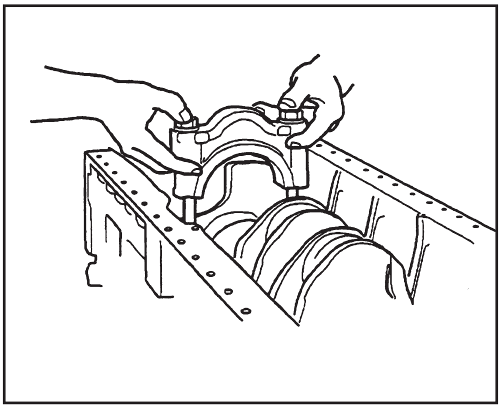


Figure 215

4. Insert the main bearings in the crankshaft bearing caps and fit them.

Main bearing cap: 110Nm + 90°

NOTE

Fit the main bearings and caps in the same place as before removal.

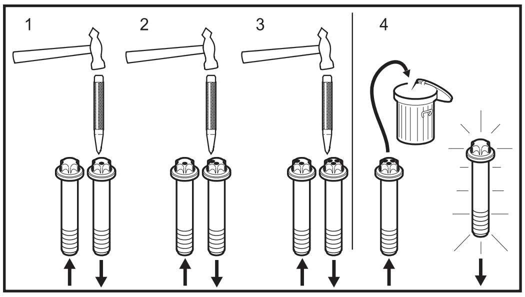


Figure 216

CAUTION

The bolts can only be reused three times. Check the number of punch marks on the head, if a screw has three punch marks it must be replaced.

NOTE the machine serial number!

5.
Machine 810001 - 810108
Tighten the bearing cap bolts to 50 Nm + 90°.

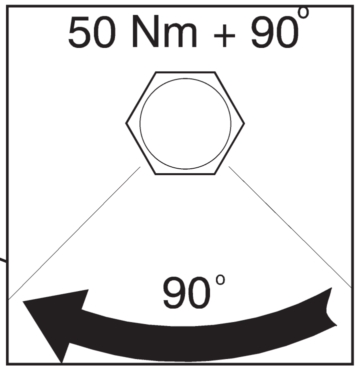


Figure 217

5.
Machine 810109 (Tier3) -
Tighten the bearing cap bolts to 200 Nm + 90°.

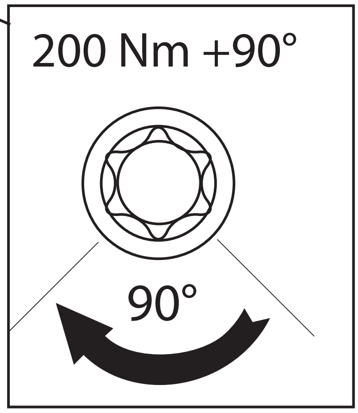


Figure 218

6. Fit the pistons with connecting rods as described in Fitting the connecting rod and piston.

7. Fit the oil pump, oil suction pipe with strainer and the oil sump.

8. Renew the seal in the front cover. Fit the spacing sleeve on the crankshaft journal. Fit the driver and crankshaft damper. See Belt transmission, Renewing the seal in the front cover.

9. Fit the crankshaft gear as described in Crankshaft gear, fitting.

Adjust - Machining the crankshaft

1. Measure the diameter of the crankshaft bearing journal using a micrometer. Measure at several points around the bearing journal.
   If any of these diameters is lower than the minimum indicated limit, regrinding of the crankshaft should be considered. Refer to the dimensions under the tab “Specification”.
   Oil pressure should also be checked, as it is affected by such factors as wear in the main bearings and connecting rod bearings.

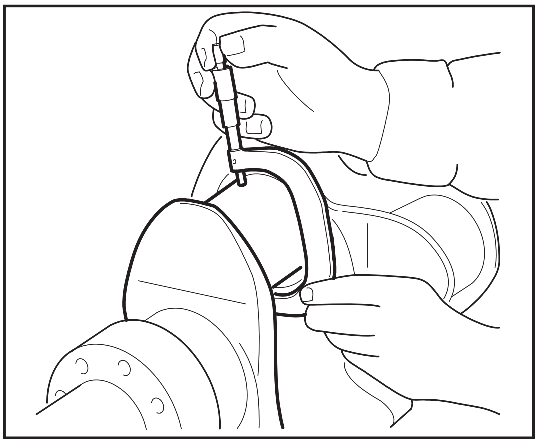


Figure 219

2. When regrinding, keep to the undersizes indicated in the “Specification” tab. Suitable bearings are available for these sizes. It is important that the fillet radius of the bearing journals is correct. Use a template to check fillet radius.

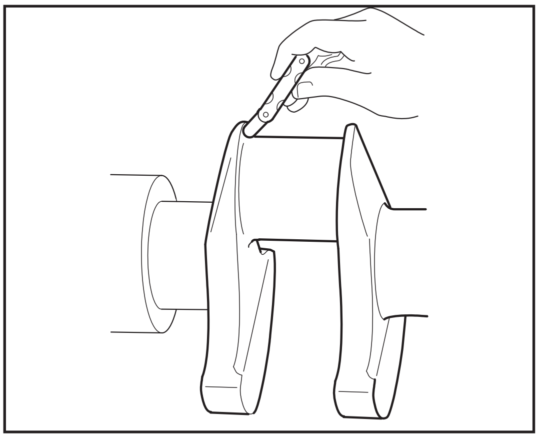


Figure 220

Lubrication system

General

Lubricating oil consumption refers to the lubricating oil that is consumed through combustion in the engine.

Take into account the fuel consumption when assessing the lubricating oil consumption. Both lubricating oil and fuel consumption is affected by driving style and operating conditions.

Lubricating oil consumption is usually higher when the engine is new. Only when the engine has been run in, i.e. after 600 operating hours, can lubricating oil consumption be considered to be constant. Normally, lubricating oil consumption in Scania engines will then fall under 0.3% of fuel consumption.

Prolonged driving at high engine speeds with low power output, however, will increase lubrication oil consumption slightly in relation to fuel consumption.

In such conditions, the lubrication oil consumption can be considered as acceptable even if it exceeds 0,3 % of fuel consumption.

Checking lubricating oil consumption

In order to avoid having to take premature measures, lubricating oil consumption should be carefully monitored for at least 300-500 operating hours after the running-in period mentioned above.

If the follow-up shows that the lubrication oil consumption is really abnormally high, the engine must be inspected and repaired.

Directions and follow-up documentation

Fuel consumption and lubricating oil consumption calculations must be based on information that is as accurate as possible.

Start with the fuel tank full and the lubricating oil topped up to the maximum mark on the dipstick.

Read the oil dipstick when all the lubricating oil in the engine has collected in the oil sump. The vehicle must be level.

With an engine at operating temperature, the oil dipstick can be read 7 minutes after shutdown. Wait for at least 30 minutes between the shutdown and the readout if the engine has been started but not attained operating temperature.

Copy the form Driver's log-book for measuring oil consumption on next page and use it to note when fuel and lubrication oil has been filled, as well as operating hours and type of driving during the follow-up period.

Driver's logbook

Example of driver's log-book

Engine serial number	5 555 555	Make of oil	Shell
Oil change interval	400 h	Designation	Myrina
Responsible	Sven Svensson	Viscosity	15W/40

Date	Odometer reading (h)	Filled fuel (l)	Full tank	Lubrication oil consumption (l)	Main type of driving
01/04/15	600		Yes		
03/04/15	625	1,200		7	Driving on road
...	...	...	...	...	
...	...	...	...	...	
...	...	...	...	...	
...	...	...	...	...	
...	...	...	...	...	
01/06/15	1,100	800	Yes	5	
	Total	20,000		100	

Fuel consumed = 20,000 litres
Oil consumed = 100 litres
Oil consumption as a % of fuel consumption =
100/20,000 x 100 = 0.5%

Driver's log-book for measuring oil consumption

Engine serial number ____________________ Make of oil ____________________

Oil change interval ____________________ Designation ____________________

Responsible ____________________ Viscosity ____________________

Date	Odometer reading (h)	Filled fuel (l)	Full tank	Lubrication oil consumption (l)	Main type of driving

Figure 234

Oil pump

The oil pump is a gear pump driven by the crankshaft gear and generates the pressure necessary for the lubricating oil to reach all lubrication points.

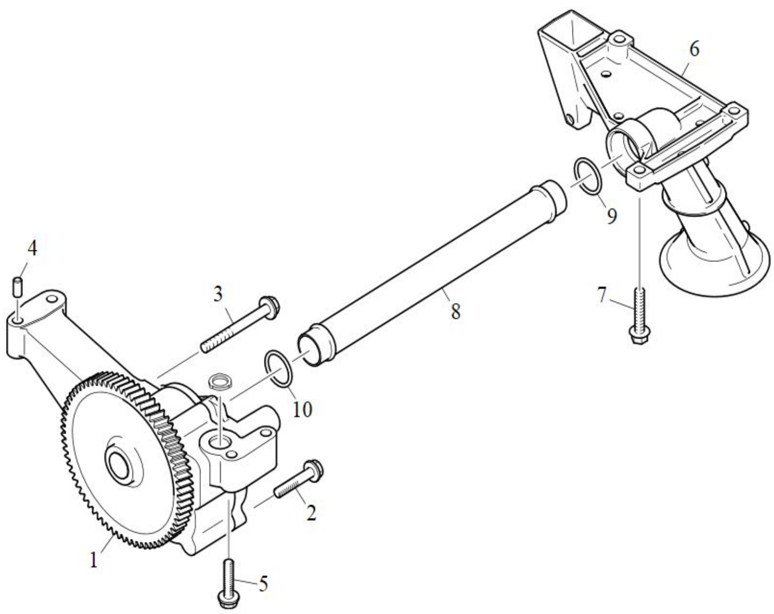
The oil pressure must be high enough to ensure that each lubrication point receives a sufficient amount of oil for lubrication and cooling.

Too high oil pressure could cause excessive stress to components in the lubrication system.

Particularly when the oil is cold there is a risk that the pressure will be high and for this reason a safety valve is incorporated in the oil pump. If the pressure is too high the oil pressure valve will allow oil to escape (and run back to the sump) so that the pressure will not be so high as to cause any damage.

NOTE

In the case of leakage or fault in the oil pump, it should not be reconditioned but renewed as a unit.



1. Oil pump
2. Flange screw
3. Screw
4. Guide sleeve
5. Flange screw
6. Suction pipe
7. Flange screw
8. Pipe
9. O-ring
10. O-ring

Figure 221

Lubrication oil-ways

The oil pump draws lubrication oil from the oil sump via the oil strainer.

After the oil pump, the lubricating oil passes a safety valve. If the oil pressure exceeds 9.5 bar, the safety valve will open and allow the lubricating oil to return to the oil sump. If the oil pressure is to high, the oil pump and other lubrication system components may be exposed to severe stress.

The lubrication oil then passes through the oil cooler. Some of the lubrication oil is passed through the centrifugal oil cleaner. After cleaning, the oil is fed back to the oil sump.

The rest of the lubrication oil passes through a relief valve which regulates the pressure in the oil system. Excess lubricating oil is drained back to the oil sump.

The lubricating oil continues to the oil filter for cleaning and then on to the main oilway.

1. Oil strainer
2. Oil pump
3. Safety valvle (located in the oil pump)
4. Oil cooler
5. Centrifugal oil cleaner
6. Relief valve (located in the oil cleaner housing)
7. Oil filter
8. Piston cooling valve (located in the oil cooler housing)
9. Oil pressure sensor (located in the oil filter housing)

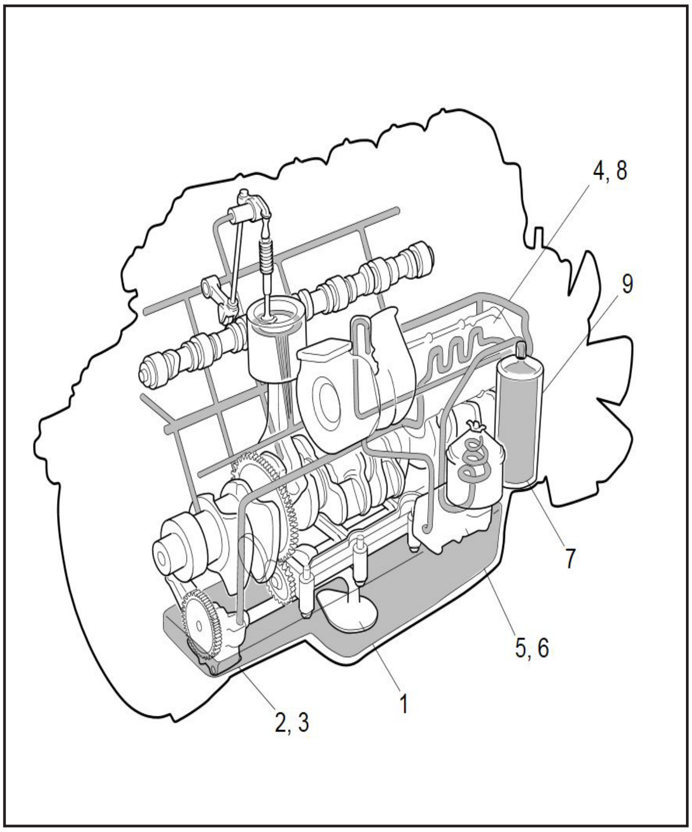


Figure 222

Oil pressure

NOTE

High lubricating oil pressure (above 6 bar) is normal when starting a cold engine.

Max. oil pressure:
Warm engine running at a speed above 800 rpm 6 bar

Normal oil pressure:
Warm engine running at an operating speed of 3 - 6 bar

Min. oil pressure:
warm engine running at a speed of 1000 rpm 1.0 bar

The control system has the following alarm levels:
- at a speed of less than 1000 rpm and an oil pressure of less than 1.0 bar
- at a speed of more than 1000 rpm and an oil pressure of less than 2.3 bar for longer than 5 seconds.

The following functions are available if there is an alarm:
- Alarm which only switches on the warning lamp and diagnostics lamp.

A fault code is generated in the control unit.

After an alarm, approved values should be registered for more than 1 second to reset the alarm.

The pistons are cooled by the lubrication oil.
Oil is sprayed up under the piston crown through special nozzles, one for each cylinder.
Since piston cooling is not needed at low engine rpm, an oil pressure valve in the oil cooler housing opens at 3 bar.

See the next page.

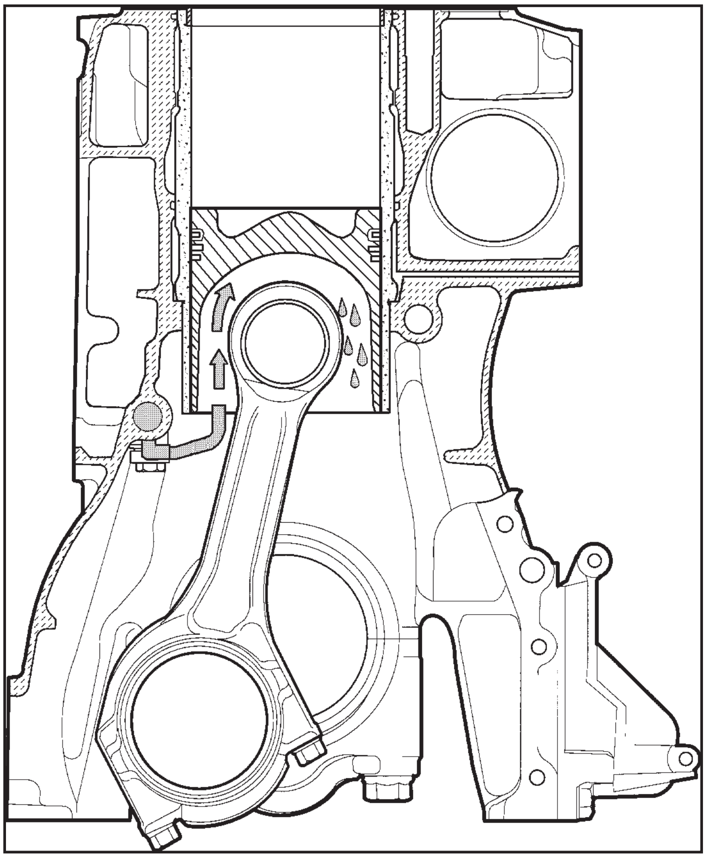


Figure 223

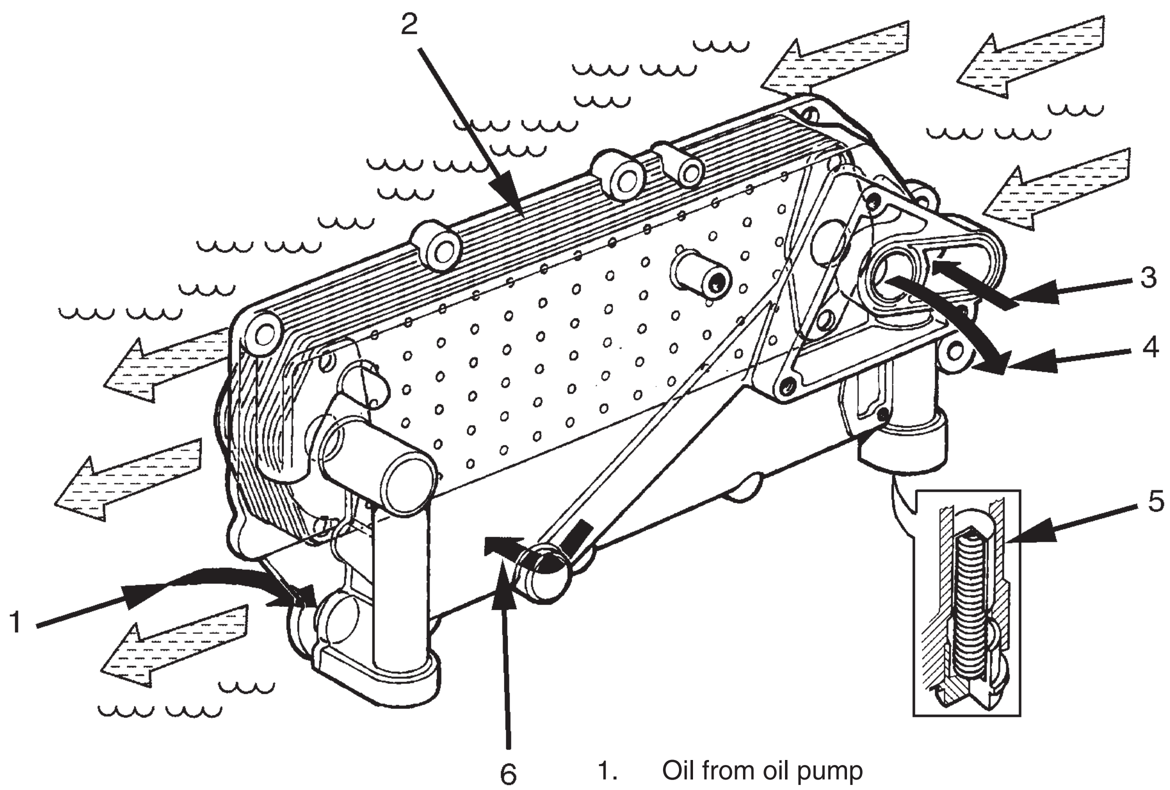
Oil cooler, engine

From the oil pump, the lubricating oil flows via passages in the block to the oil cooler located inside the front side cover on the right-hand side of the block.

The oil cooler is a plate heat exchanger.

All the oil flows through the cooler where it is cooled by the coolant from the cooling system.

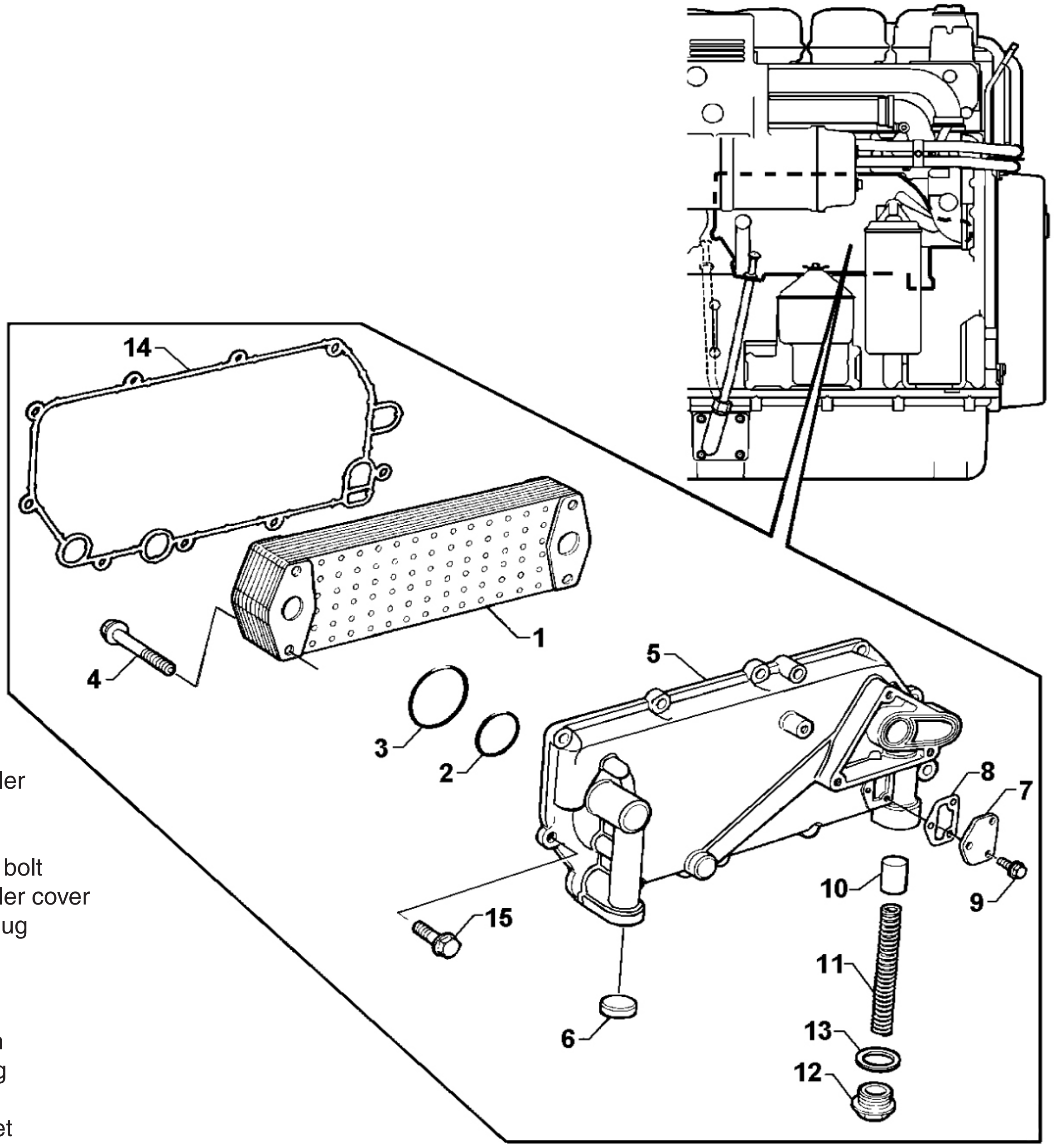
An oil pressure valve (5) is located in the coil cooler housing for cooling the pistons.
It has an opening pressure of 3 bar. No piston cooling therefore takes place at low engine speeds (idling).
See also under **Lubrication oil-ways**.



1. Oil from oil pump
2. Heat exchanger assembly
3. Oil from filter into engine
4. Cooled oil to paper filter
5. Delivery valve for piston cooling
6. Partial flow to centrifugal cleaner

Figure 224

Oil cooler view



1. Oil cooler
2. O-ring
3. O-ring
4. Flange bolt
5. Oil cooler cover
6. Core plug
7. Cover
8. Gasket
9. Bolt
10. Piston
11. Spring
12. Plug
13. Gasket
14. Gasket
15. Flange bolt

Figure 225

Important !
Oil cooler core tightening torques: 26 Nm

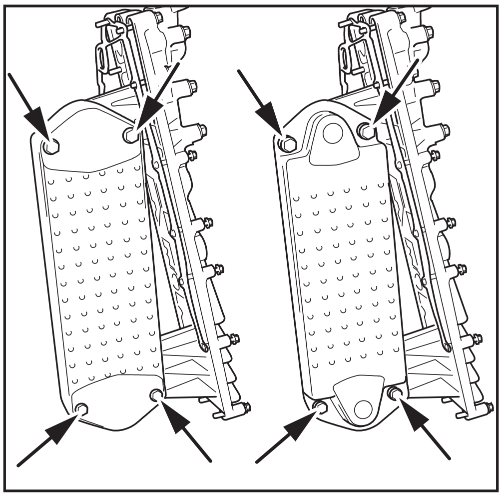


Figure 226

Renewing seals and leakage testing

1. Remove the side cover and oil cooler from the block.

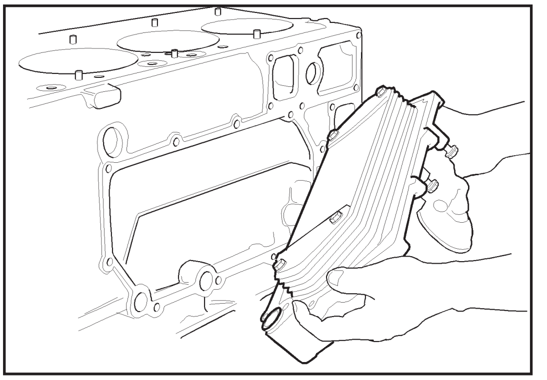


Figure 227

2. Remove the 4 bolts securing the oil cooler to the side cover.

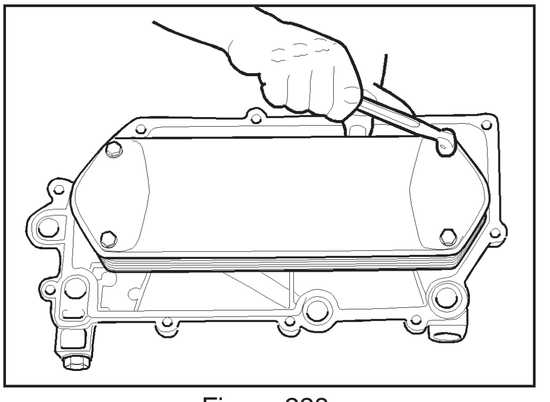


Figure 228

3. Remove the oil cooler.
4. Renew the 4 O-rings.
5. Fit the oil cooler insert and bolt securely to the side cover using 26 Nm torque.
6. Bolt the side cover to the block.

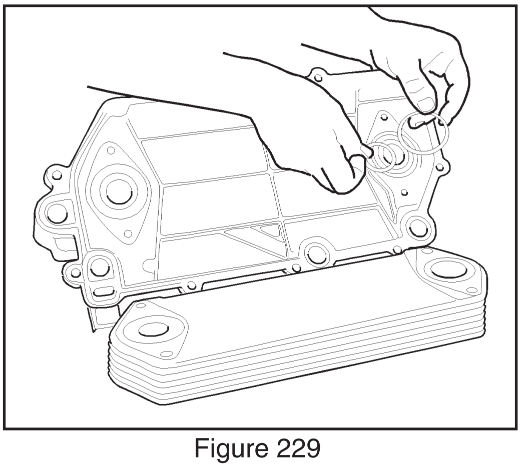


Figure 229

Leakage testing (12 Liter engine)

Connect tool 532335 and 532336
Lower the oil cooler complete with the housing into a water bath.
Raise the pressure to 2 bars using the handle.

Maintain the pressure for at least one minute.

Where there is leakage, renew the parts which leak and carry out the pressure test one more tim

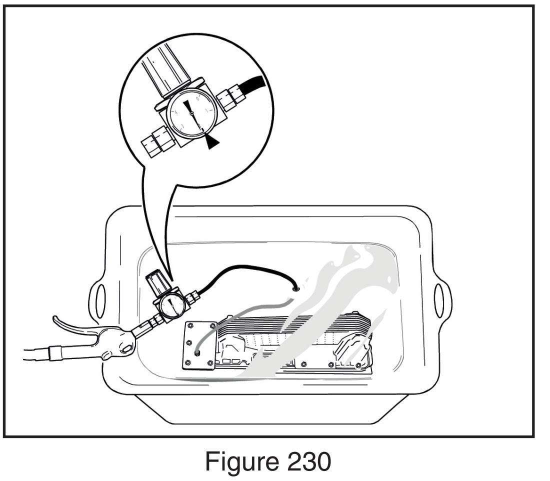


Figure 230

Oil filter

From the oil cooler, the oil passes through a large-capacity full-flow filter of paper.

This filter also cleans the oil to the turbocharger.

The oil filter has an overflow valve which opens if the filter becomes clogged. Unfiltered oil than continues to the engine and only some of the oil is cleaned in the centrifugal cleaner.

It is therefore especially important to change the filter at the intervals recommended in the **Operating & Maintenance Manual**.

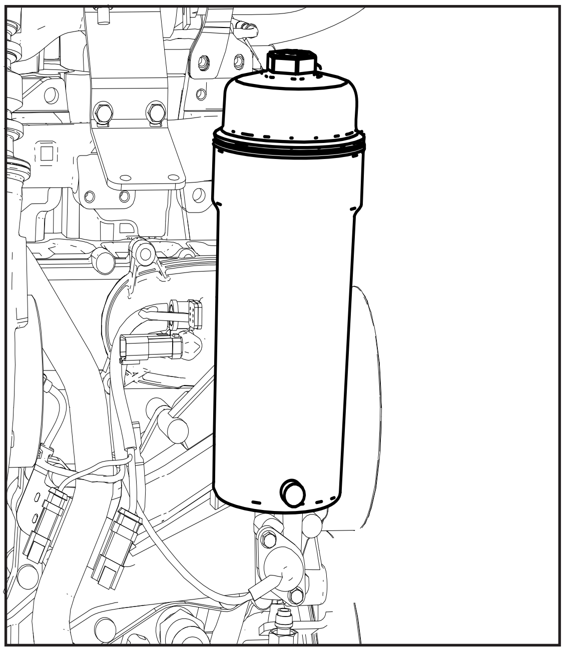


Figure 231

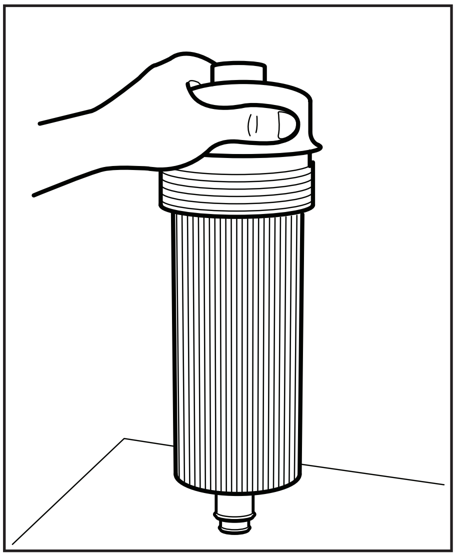


Figure 232

Centrifugal oil cleaner

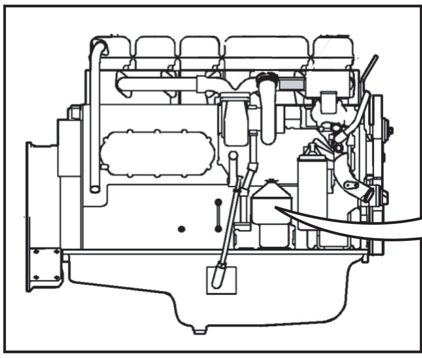
Some of the oil passes from the main passage in the oil cooler cover to the centrifugal cleaner and then, after cleaning, flows back to the sump.

Surplus oil is drained back to the sump via an overflow valve. This ensures that the pressure in the oil system is not too high.

The centrifugal cleaner's rotor is caused to spin by the force of the oil which squirts out through two nozzles at the bottom of the rotor.

Dirt particles are slung against the wall of the rotor by centrifugal force and fasten there as a coating.

The rotor should be dismantled and cleaned at definite intervals according to the inspection programme included in the operator's manual.



1. Housing
2. Plug
3. Gasket
4. Spring
5. Piston
6. Plug
7. Washer
8. Shaft
9. Nozzle
10. Rotor
11. Strainer
12. O-ring (change when cleaning)
13. Rotorbowl
14. Nut
15. Snap ring
16. O-ring (change when cleaning)
17. Cover
18. Lifting eye
19. O-ring
20. Lock nut
21. Nipple
22. Gasket

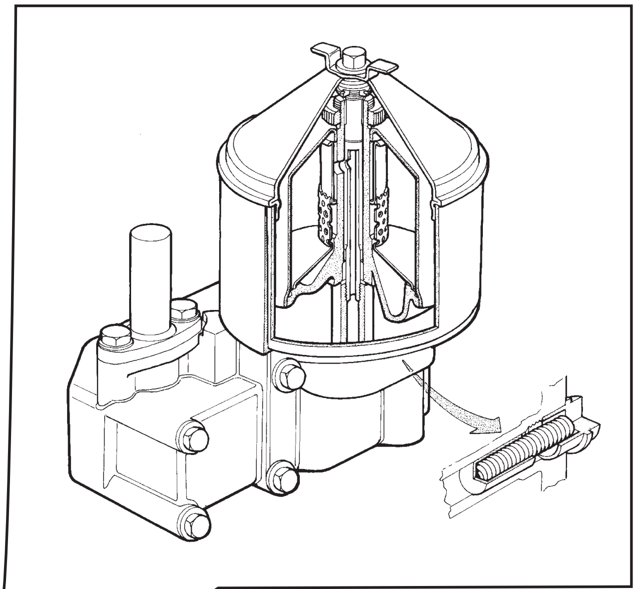


Figure 233

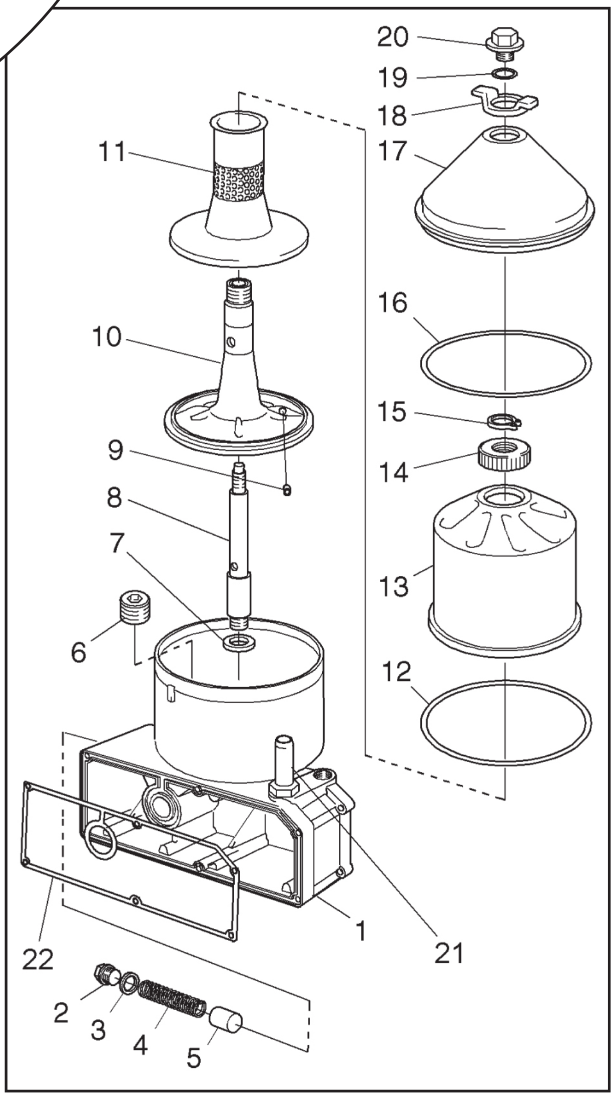


Figure 234

Dismantling and assembly

- During routine cleaning of the oil cleaner, there should be a certain amount of dirt deposits in the rotor bowl.

- If this is not the case, it indicates that the rotor is not spinning. The cause of this must be immediately investigated.

- If the dirt deposit exceeds 28 mm at the recommended intervals, the rotor bowl should be cleaned more often.

1. Clean the cover.
2. Unscrew the nut securing the outer cover.
3. Let the oil run out from the rotor.
4. Lift out the rotor. Wipe off the outside.
5. Loosen the rotor nut and unscrew it about turns.

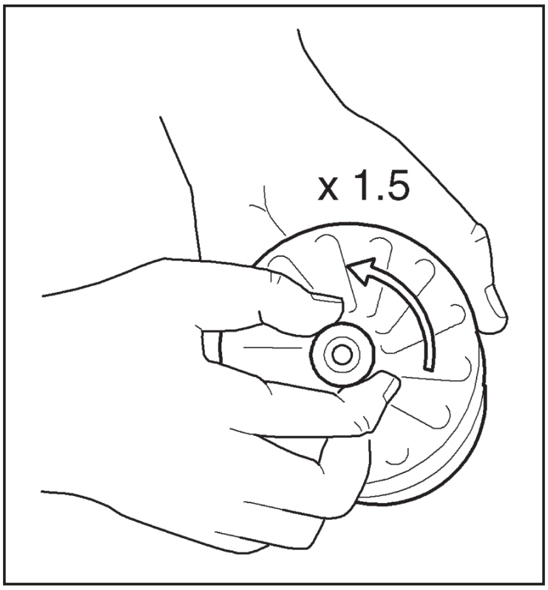


Figure 235

NOTE

The rotor must not be put in a vice. Never strike the rotor bowl. This may cause damage resulting in imbalance.

6. If the rotor nut is jammed: Turn the rotor upside down and fasten the rotor nut in a vice. See illustration.
7. Use protective jaws so as not to damage the grooves of the rotor nut.
8. Turn the rotor 1.5 turns anti-clockwise by hand.
9. If this does not work: Screw two nuts together with an M20 screw.
10. Position the screw head at the bottom of therotor.
11. Position a ring spanner on the lower nut and turn the rotor 1.5 turns anti-clockwise.

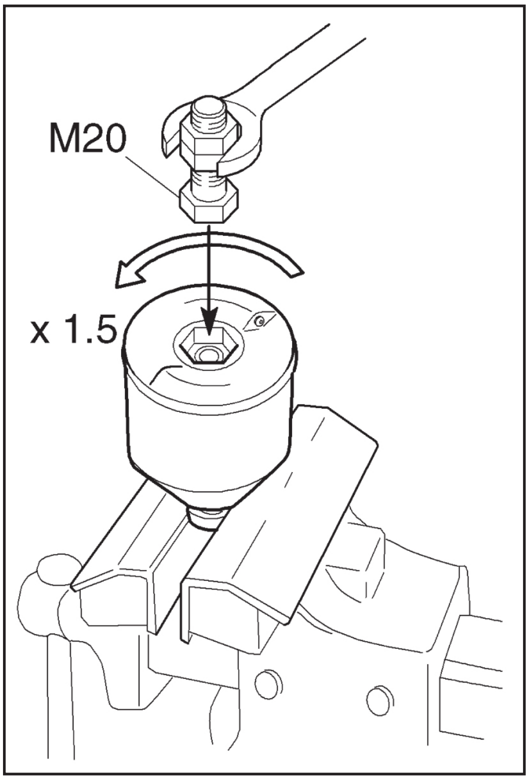


Figure 236

IMPORTANT!

Do not attach the rotor directly to the vice. Never strike the rotor cover.

12. Remove the rotor cover by holding the rotor in both hands and tapping the rotor nut against the table. Never strike the rotor directly as this may damage its bearings.

13. Remove the strainer from the rotor cover. If the strainer is stuck, insert a screwdriver between the rotor cover and strainer and carefully prise them apart.

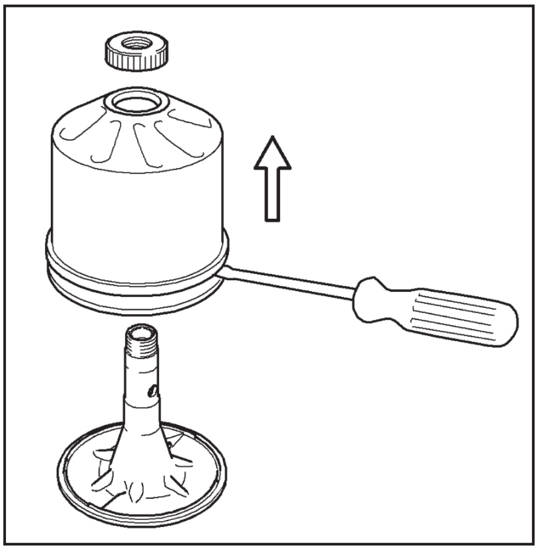


Figure 239

14. Remove the paper insert.

15. Scrape off any remaining dirt deposits from the inside of the rotor cover. If the deposits on the paper are thicker than 28 mm (1.1 in), the centrifugal oil cleaner must be cleaned-more often.

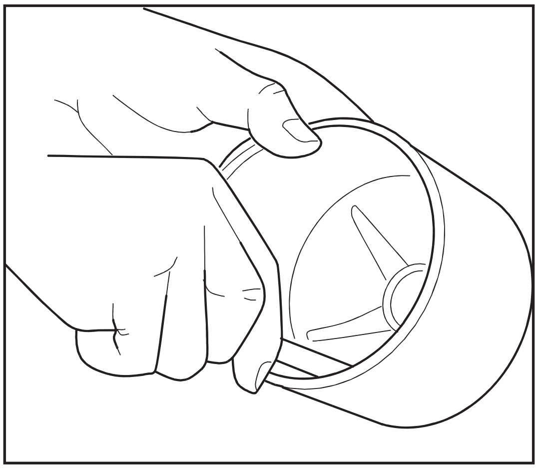


Figure 237

16. Wash the parts according to the applicable industrial method.

17. Check the 2 nozzles on the rotor. Ensure that they are not blocked or damaged. Renew any damaged nozzles.

18. Check that the bearings are undamaged. Renew damaged bearings.

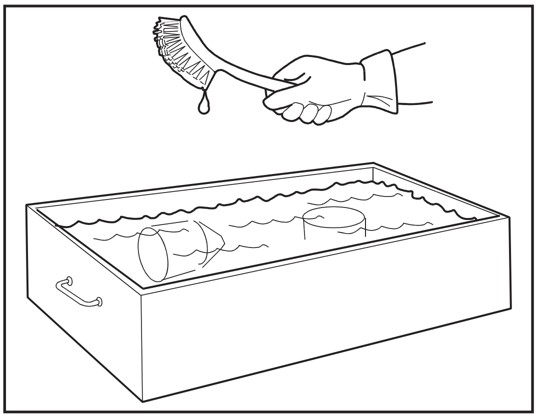


Figure 238

19. Fold and fit a new paper insert on the inside of the rotor cover as illustrated.

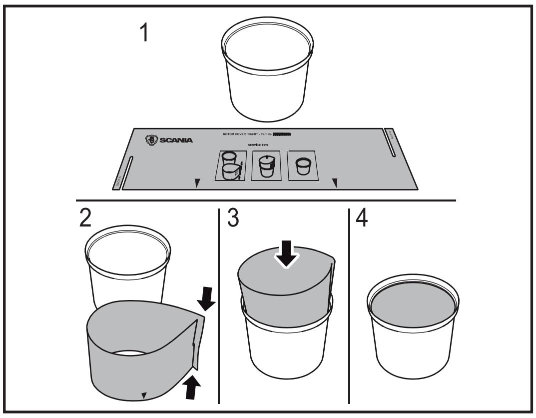


Figure 242

20. Fit the strainer onto the rotor.

21. Fit a new O-ring to the foot of the centrifugal oil cleaner.
22. Refit the rotor cover. Ensure that the O-ring is not outside the edges, but is in the groove.

23. Screw the rotor nut back on by hand.

24. Check that the shaft is not damaged or loose. Contact a Scania workshop if the rotor shaft needs renewing.

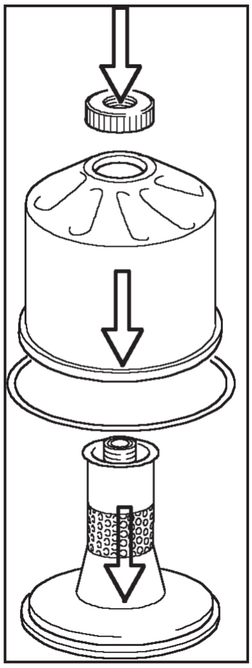


Figure 240

NOTE

Take care not to damage the rotor shaft

25. Refit the rotor and rotate it by hand to makesure it rotates easily.

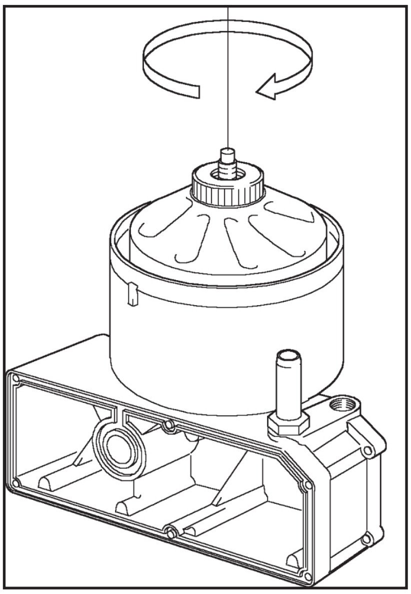


Figure 241

26. Fit a new O-ring in the cover.

27. Refit the cover and tighten the lock nut. Tightening torque 20 Nm (15 lb/ft).

IMPORTANT!

To reduce the risk of oil leakage it is important to tighten the cover to the correct tightening torque.

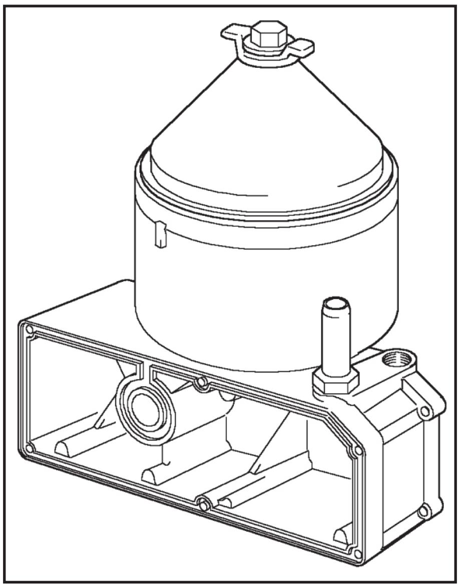


Figure 243

Operational testing of the centrifugal oil cleaner

Operational testing need only be carried out if it is suspected that the centrifugal oil cleaner is malfunctioning. For example, if the dirt deposit is abnormally small given the distance driven.

The rotor rotates very fast and should continue to turn when the engine has stopped.

1. Run the engine until it reaches normal operating temperature.

2. Turn off the engine and listen for the sound from the rotor. Use your hand to feel if the filter housing is vibrating.

3. If the filter housing is not vibrating, dismantle and check the centrifugal oil cleaner.

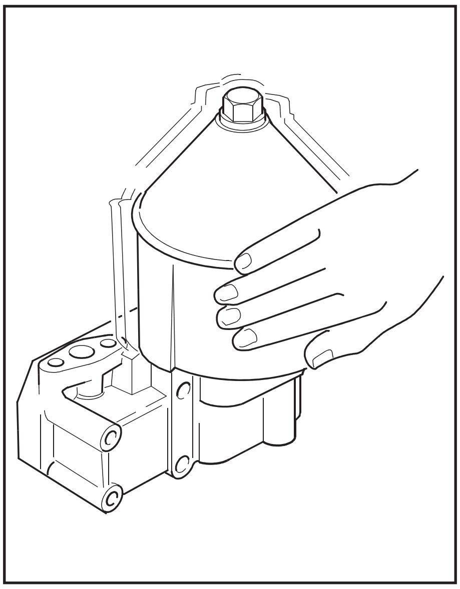


Figure 244

Oil mist separator

General

A certain amount of oil is always found in the crankcase gases, and this is normal. The amount of oil mist increases with the engine's operating time.
The closed crankcase ventilation system is very sensitive to changes in the flow of crankcase gases in the engine.
If the flow of crankcase gases increases, the amount of oil which passes through the crankcase ventilation also increases. The crankcase gases can then take with them small drops of oil from the crankcase.
The causes of too high a flow of crankcase gases can be difficult to determine, and troubleshooting must therefore be carried out methodically.
When the flow of crankcase gases is too high, the primary symptom is an increased amount of oil mist.
If the engine's oil sump is filled with too much oil, or if the oil cannot be separated, oil will be sucked up with the crankcase gases.
Faults which can arise in the engine and which are caused by the oil mist separator fall into 3 different categories:

- Too high a flow of crankcase gases
- Increased crankcase pressure
- Increased amouts of oil carryover

High levels of oil carryover

High levels of oil carryover mean large amounts of oil coming from the crankcase ventilation. High levels of oil carryover are often due to excessive amounts of oil entering the crankcase ventilation, and the oil can therefore not be separated quickly enough in the oil mist separator. There may also be a blockage in the return pipe for the separated oil.

Common causes of levels of oil carryover being too high:

- Worn rocker arm shafts on cylinder 6 (cylinder 5 on five cylinder engines).
- Too much oil in the oil sump.
- Gas leakage at valve guides, particularly during exhaust braking.
- Internal oil leakage.
- Blockage in the return pipe for the separated oil.

Fault causes,
The most common faults when there are problems with crankcase gases. See table next page.

Componenet	Cause	Affects
Air filter	Blocked filter	The vacuum in the engine increases, but this does not result in increased crankcase gases.
Turbocharger, exhaust brake	Internal exhaust leakage in turbocharger.	Increased flow of crankcase gases, which also leads to increased amounts of oil carryover, particularly during exhaust braking.
Charge air cooler	Blocked charge air cooler.	Can be caused by too high a level of oil carryover or a frozen charge air cooler.
Cylinder liners/piston rings	Leakage between liners and pistons.	Increased flow of crankcase gases.
Rocker arm shaft/cylinder head	Worn valve guides, worn rocker arm shafts.	Increased flow of crankcase gases, particularly during exhaust braking.
		Can also result in increased amounts of oil carryover.
Oil sump	Oil level too high.	Increased amounts of oil carryover.
Oil dipstick	Defective oil dipstick	Can result in too high an oil level in the engine.
	Air leakage at oil dipstick/oil filler.	Flow of crankcase gases through the engine is increased if the air filter is blocked.
Oil mist separator	Defective centrifuge	Can result in increased vacuum in the engine if the air filter is blocked.
	Blocked return pipe for oil separated from the crankcase gases.	Increased amounts of oil carryover.
	Broken O-ring.	Increased amounts of oil carryover.
Air compressor	Worn seals	Increased flow of crancase gases through the engine and the oil mist seperator.
	Blocked outlet valves.	Increased flow of crankcase gases.
Cylinder head	Cracks	High crankcase pressure, increased flow of crankcase gases.

NOTE

The vehicle's operating profile and area of usage also affect the crankcase gases and oil mist in the engine.
Operating profiles which affect this include crane operation, exhaust braking, acceleration, and rapid throttle actuation.

Crankcase pressure measurement

The measurement should be carried out with a laden vehicle.

To check the engine crankcase pressure, a manometer shoud be used together with an adater which replaces the oil filler cap.

Measurement:

The measurement should be carried out with a laden vehicle. Note the readings on the form.

1. Connect a hose between the adapter and manometer which is long enough for the manometer to be taken into the cab.
2. Take the manometer into the cab and carry out the test as described below.

   Measuring with throttle

3. Note the crankcase pressure when the vehicle is stationary, no throttle.
4. Drive the vehicle and rev the engine up to 1,900 rpm and note the crankcase pressure.
5. Repeat the procedure 3 times.

   Measuring with exhaust brake (If installed)

6. Activate the exhaust brake on a downhill stretch.
7. Repeat the procedure 3 times.

Oil mist separator exploded view

The oil mist separator is driven by oil from the lubrication system. The oil flows into the oil mist separator and is sprayed onto the turbine located on the rotor shaft. The oil then flows out and back to the oil sump.

The rotor consists of a number of tapered plastic plates which are located on top of one another. There is a space for the crankcase gases and oil particles between each plate.

The crankcase gases and oil particles flow into the oil mist separator through the union in the top of the oil mist separator housing. The oil particles stick to the rotating plates and the centrifugal force causes the oil particles to be thrown against the wall of the oil mist separator housing. The oil which has been separated from the crankcase gases runs down along the walls of the oil mist separator housing and then flows out of the oil mist separator via the centrifugal oil cleaner to the oil sump. The centrifugal oil cleaner contains an oil trap. The oil trap is there so that oil from the oil sump is not drawn in the wrong direction.

The cleaned crankcase gases flow out of the oil mist separator via a diaphragm which acts as a pressure regulator. When the vacuum downstream of the oil mist separator is too great, the diaphragm will close the opening until the pressure has risen again.
The oil mist separator does not normally need to be dismantled for cleaning.

NOTE

Remove the oil mist separator from the engine before it is dismantled.

1 Oil mist separator housing (different version for closed crankcase ventilation)
2 O-ring
3 Nipple
4 Heat shield
5 Screw
6 Diaphragm (not used on oil mist separator for closed crankcase ventilation)
7 Diaphragm spring (not used on oil mist separator for closed crankcase ventilation)
8 Cover (different version for closed crankcase ventilation)
9 O-ring
10 Nipple (not used on oil mist separator for closed crankcase ventilation)
11 Screw
12 Screw (not used on oil mist separator for closed crankcase ventilation)
13 Upper bearing retainer
14 Screw
15 Retaining ring
16 Spring
17 Separator
18 Washer
19 Retaining ring
20 O-ring
21 Insert
22 Lower bearing retainer
23 Turbine
24 Retaining ring
25 O-ring
26 O-ring
27 Turbine housing
28 Washer
29 Straight nipple

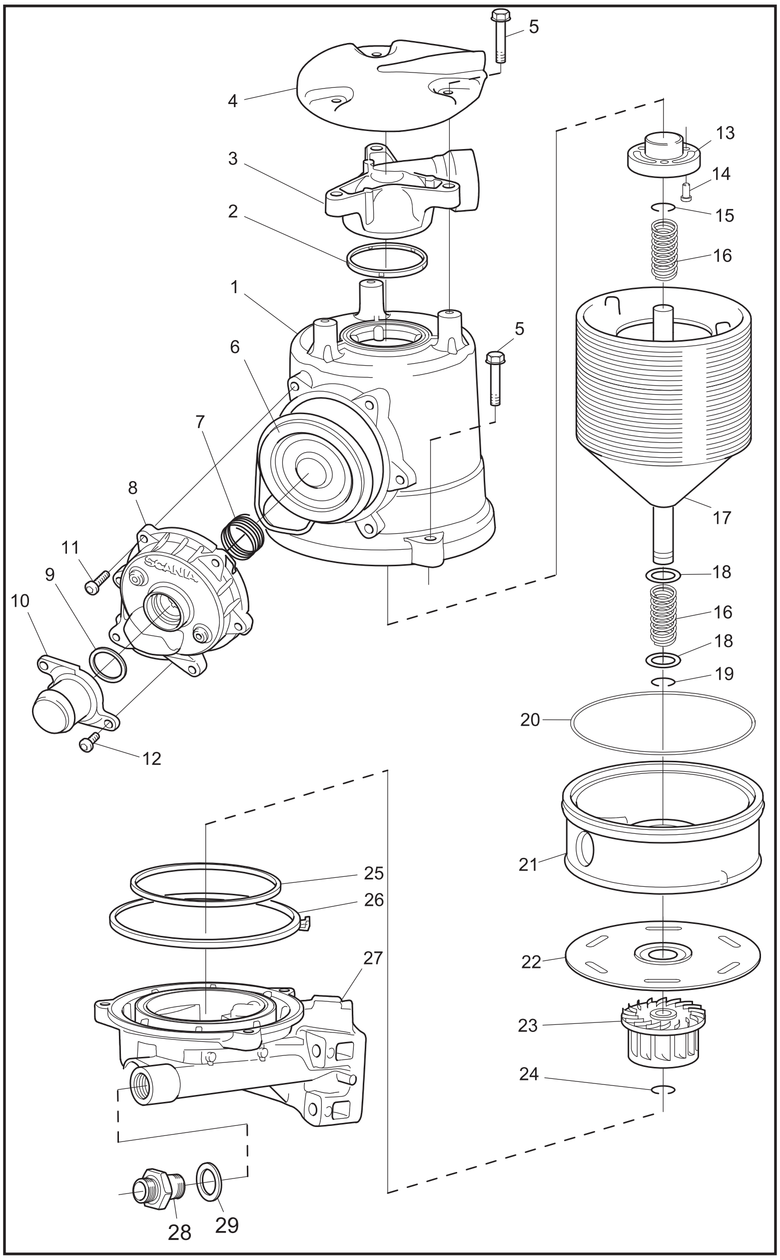


Figure 245

Oil mist separator disassemble

Remove the oil mist separator from the engine before it is dismantled.

1. If the engine has an exhaust brake:
- Remove the exhaust pipe between the exhaust brake and silencer.
- Undo the V-clamp between the turbocharg er and exhaust brake. Lift up the exhaust brake and undo the compressed air hose. Remove the exhaust brake.

2. Remove the outlet pipe and inlet pipe from the compressor.

NOTE

Cover all inlets and outlets.

3. Undo the hose clamps for the lubrication oil return pipe and remove the hose

4. Remove the pressure pipe for the oil mist separator.

5. Undo the inlet pipe for the oil mist separator.

6. Remove the oil mist separator outlet pipe.

7. Remove the oil mist separator.

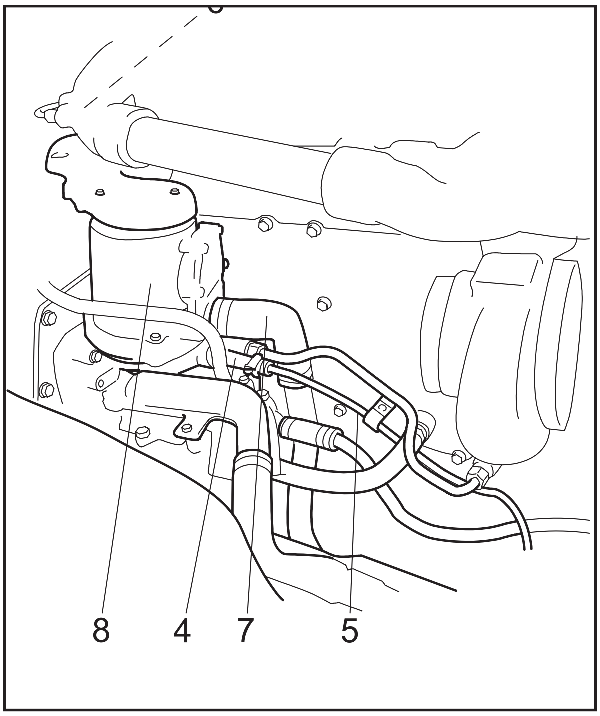


Figure 246

In accordance with the previous page parts view:

1. Remove the gasket (26) between the turbine housing (27) and oil mist separator housing (1).

2. Lift the rotor assembly out of the oil mist separator housing. If the rotor assembly is difficult to remove, use a rubber mallet to carefully tap alternately on the three brackets.

3. Remove the turbine (23) from the rotor unit shaft. Press the turbine downwards and release the retaining ring(24).

4. Detach the rotor discs by removing the retaining ring (19). The magnets fitted in the uppermost rotor disc can easily be detached when the rotor discs are dismantled.

5. Remove the diaphragm cover (8).

6. Remove the diaphragm spring (7) and diaphragm (6).

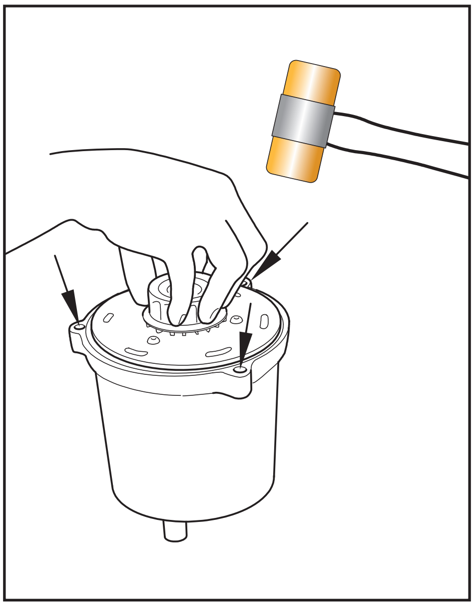


Figure 247

1. Oil mist separator housing (different version for closed crankcase ventilation)
2. O-ring
3. Nipple
4. Heat shield
5. Screw
6. Diaphragm (not used on oil mist separator for closed crankcase ventilation)
7. Diaphragm spring (not used on oil mist separator for closed crankcase ventilation)
8. Cover (different version for closed crankcase ventilation)
9. O-ring
10. Nipple (not used on oil mist separator for closed crankcase ventilation)
11. Screw
12. Screw (not used on oil mist separator for closed crankcase ventilation)
13. Upper bearing retainer
14. Screw
15. Retaining ring
16. Spring
17. Separator
18. Washer
19. Retaining ring
20. O-ring
21. Insert
22. Lower bearing retainer
23. Turbine
24. Retaining ring
25. O-ring
26. O-ring
27. Turbine housing
28. Washer
29. Straight nipple

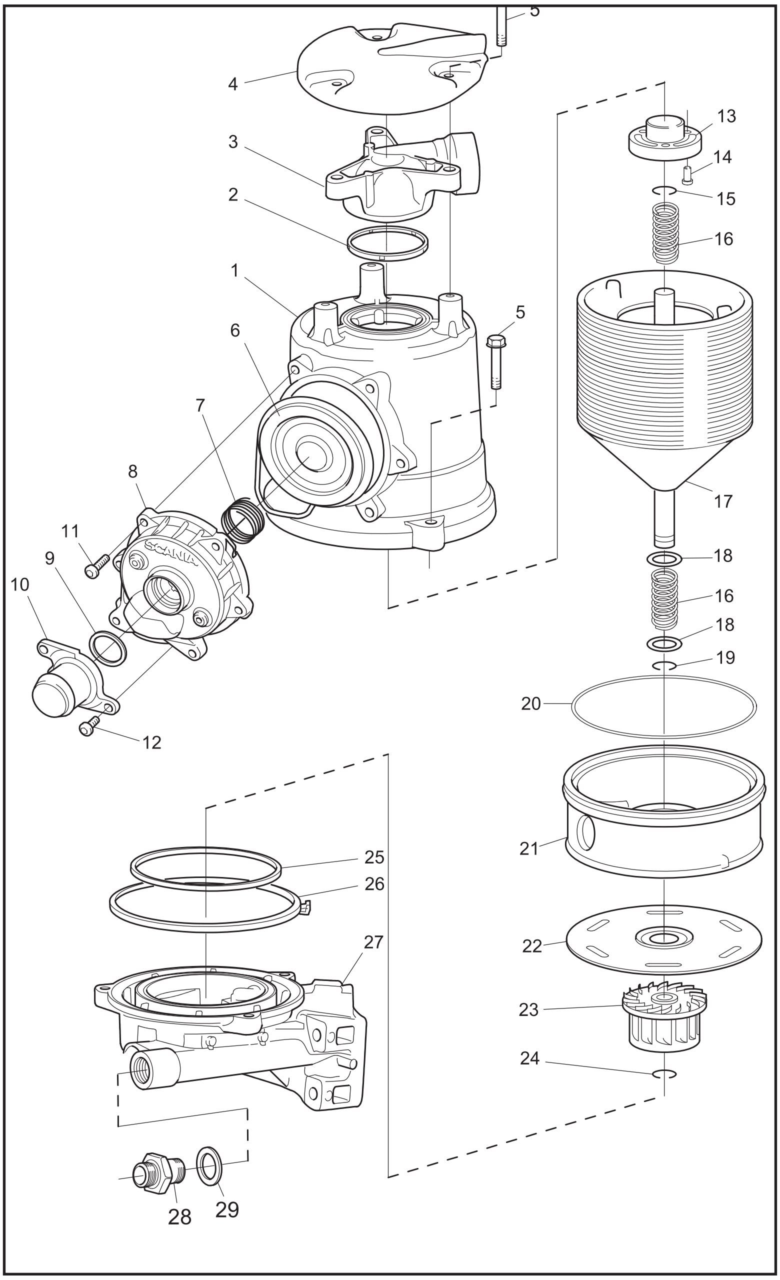


Figure 248

1. Fit the rotor discs (17) on the rotor shaft and fit the retaining ring (19).

2. Fit the rotor in the insert (21).

3. Fit the turbine (23) on the rotor shaft and press on the retaining ring (24).

4. Fit a new O-ring (20).

5. Press the rotor assembly down into the oil mist separator housing (1).

6. Fit the diaphragm (6) and diaphragm spring (7).

7. Fit the diaphragm cover (8).

Check - rotational speed on oil mist separator

An angled ABS sensor should be used to measure the rotational speed on the oil mist separator. Cut the electrical cables and fit 2 switches suitable for a multimeter which can measure Hz.

Cold engine at idling speed, oil temperature of 20–50°C
120 +/-50 Hz

Warm engine at engine speed of 1,000 rpm 150–220 Hz

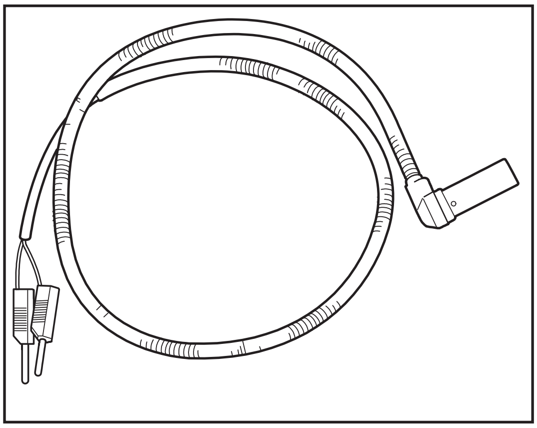


Figure 249

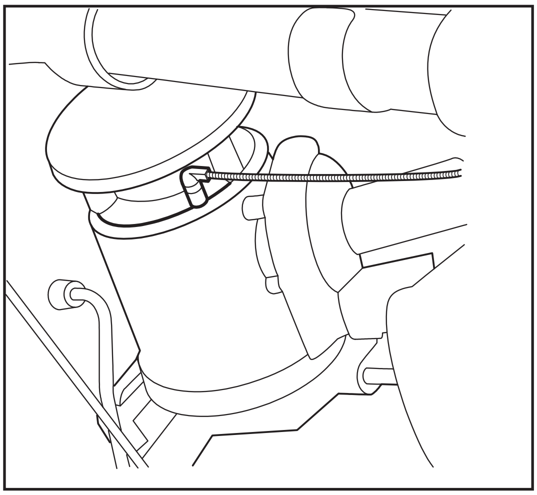


Figure 250

1. Start the engine and rev it up to 1,000 rpm.

2. Hold the sensor against the oil mist separator and read the multimeter. The value should be at least 150 Hz at an engine speed of 1,000 rpm.

Alternator 100 A

Check

CAUTION

Make sure that you never run an alternator without the batteries connected! This may cause the rectifiers and/or charge regulator to be overloaded and damaged.

NOTE

To obtain a correct result, the alternator should be kept at a temperature of 20-25°C. A higher temperature may give a lower current.

When the engine control unit has generated fault codes for the alternator, the following tests can be carried out.

- Output test
- Control voltage test
- Phase measurement
- Length of brushes
- Slip rings, rotor resistance and overcharging

Test	Test values	Measured values	Acceptable value	Incorrect value
1. Output test	Bosch 100A: >40A and 28V		Carry out voltage test	Carry out phase measurement
Control voltage test	28 +/- 1.0V at 20°C		Alternator OK	Check the brush length
Phase measurement	<250 mV		Check the brush length	Renew alternator
Brush length[1]	Bosch 100A: >1.0 mm		Check slip rings	Renew alternator
Slip rings[1]	The surface should be smooth and bright		Check the rotor resistance	Renew alternator
Rotor resistance between the slip rings (at 20°C)[1]	Bosch 100A: 8.5 +/-0.5 ohms		Carry out over-charging test	Renew alternator
Measuring overcharging between slip rings and framework[1]	> 10 MOhm		Renew regulator	Renew alternator

Figure 251

Output test

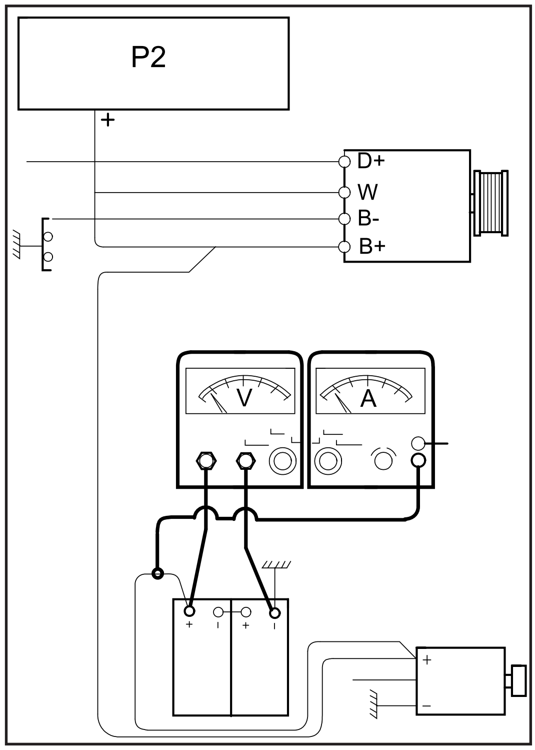


Figure 252

1. Connect an ammeter and a voltmeter to the batteries as illustrated.

Connection to batteries

2. Start the engine and run it at idling speed for a few minutes. Then note how much current is supplied from the alternator to the batteries. Check at the same time that the voltmeter does not fall below 27 V. Run the engine at approximately 500 rpm.

3. Connect the same equipment as before to the central electric unit as illustrated.

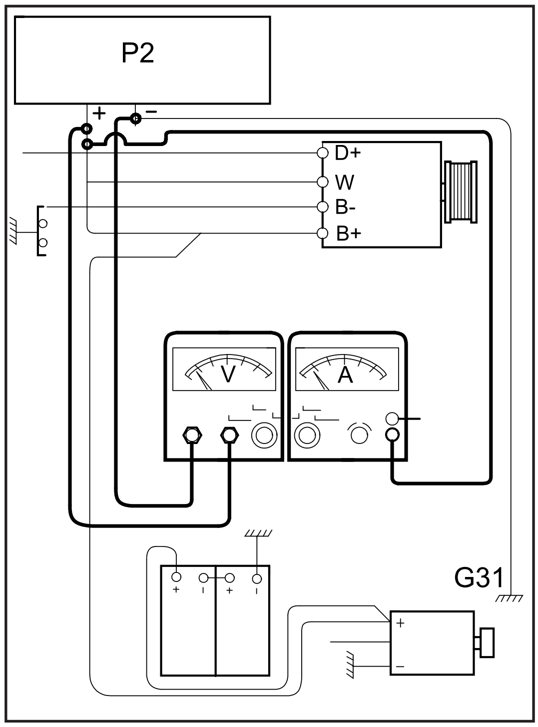


Figure 253

Connection to central electric unit

4. Hold the engine speed at 500 rpm and apply loads to the system by using the vehicle's current consumers in accordance with the test report, column Check value. See below for examples of current consumers.

Add the current you read at the batteries to the sum of the loads you are applying.

Example using 80 A Bosch alternator: If you obtained a value of 10 A at the batteries, you only need to apply a load of 25 A to the alternator instead of 35 A. 10 A+25 A=35 A

5. Run the engine for a time while you are applying the load. Read the voltmeter again. It should still not show less than 27 V.

Examples of current consumers:

Cab fan at maximum	approx. 10 A
Main beam	approx. 6 A
Two auxiliary lamps	approx. 6 A
Seat heater	approx. 2.5 A/seat
Electrically heated mirrors	approx. 2.5 A/mirror
Coolant-operated cab heater	approx. 6 A
Radio	approx. 1.5 A

Voltage test

Carry out this test especially if you suspect there is overcharging.

NOTE

The batteries should be fully charged to give good results, i.e. maximum consumption at 10A.

1. Connect the ammeter and voltmeter to the central electric unit as illustrated. Run the engine at approximately 500 rpm.

Connection to batteries

2. Load the system with approximately 10-20A by using various current consumers.

3. Allow the engine to run for a while. The voltage on the voltmeter should be 28V +/- 0.5V at 20°C.

Phase measurement

Keep the voltmeter connected as it was for the voltage test, but reset it to the AC voltage position.

The voltmeter should be stable around 100 mV and at most 250 mV. If this performance is not achieved, the alternator is defective and must be renewed.

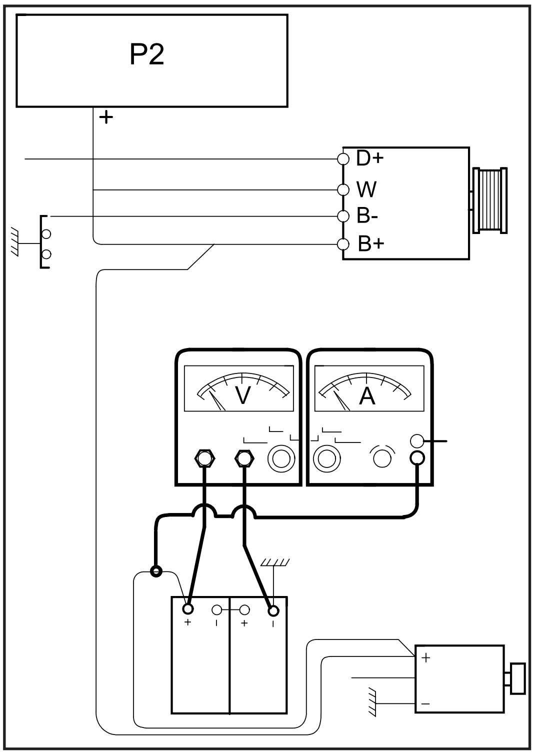


Figure 254

Length of brushes

Check that the length of the carbon brushes does not fall below the permitted length, see specification.

Slip rings/rotor resistance/overcharging

The charge regulator must be removed in order to check the slip rings.

1. Check that the surfaces of the slip rings are smooth and bright. If the surfaces are not bright, this indicates poor contact with the carbon brushes.

2. Measure the rotor resistance, see measurement specification.

3. Measure the insulation resistance between the slip rings and alternator core (chassis earth). The ohmmeter must show infinite resistance (at least 10 MOhm).

If one of the checks is not satisfactory, the alternator must be renewed.

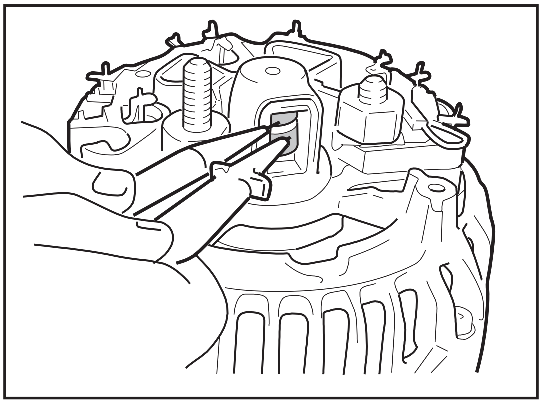


Figure 255

Renewal - bearing and carbon brushes

Specification	Bosch 100 A
Designation	NCB2 28V 40/100A
Output power at 6000 rpm	2800 W
Resistance in rotor	8.5 ohm +/- 5%
Brush length	>1 mm

Engine speed (rpm):	Bosh 100A
500	40
600	60
800	80
1500	100

Max alternator current at an alternator temperature of 20-25 °C

1. Remove the cover washers for the carbon brushes.

Remove the screws holding the carbon brushes.

Important!

Mark the front housing against the rear housing to make it easier when assembly the housings.

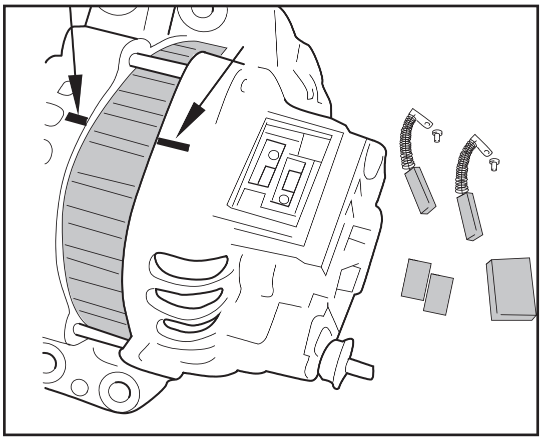


Figure 256

2. Remove the nut and pulley. The Nut should be tightened with a force of 139Nm on assembly.

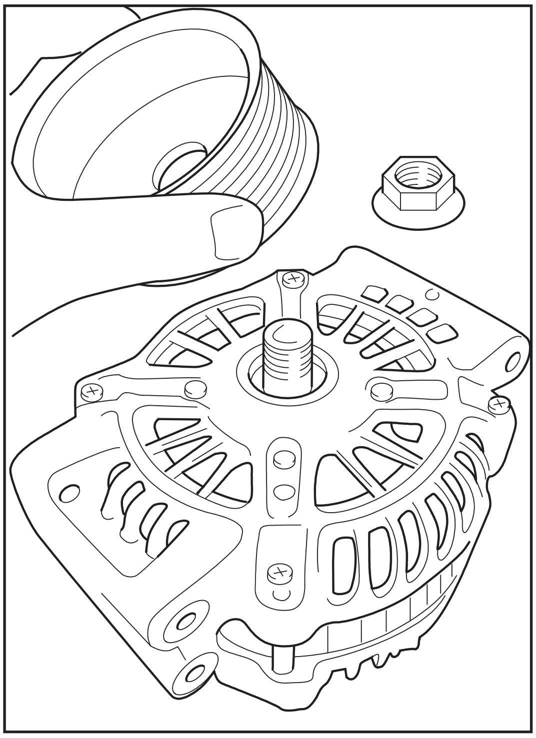


Figure 257

3. Remove the 4 screws which hold the alternator together

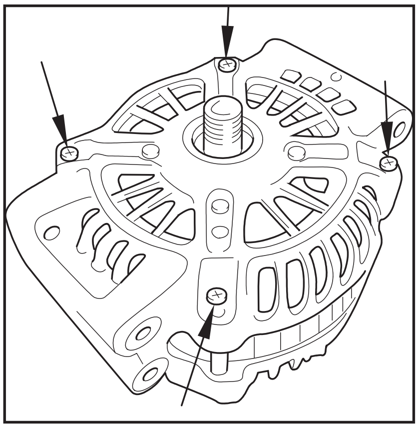


Figure 258

4. Separate the alternator. The stator winding should remain in the rear housing.

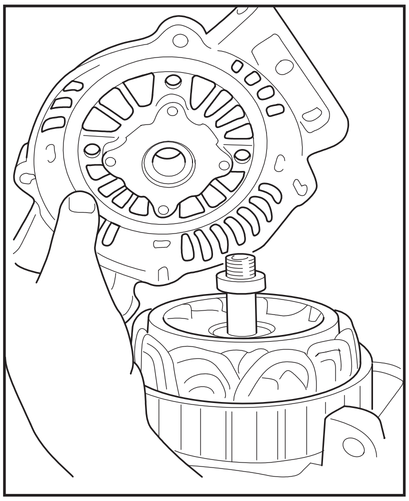


Figure 259

5. Remove the rotor from the rear housing as follows: Refit the nut on the rotor shaft. Hold the rotor in the nut and gently tap all around the housing until the rotor comes loose.

CAUTION

Make sure that you do not damage the stator winding and rotor.

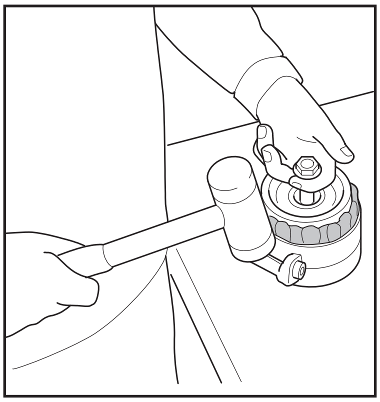


Figure 260

6. Clamp the rotor in the vice.

NOTE

Use soft jaws on the vice so as not to damage the rotor.

Remove the bearing on the rotor using puller plate 587 517 and bearing puller 587 518.

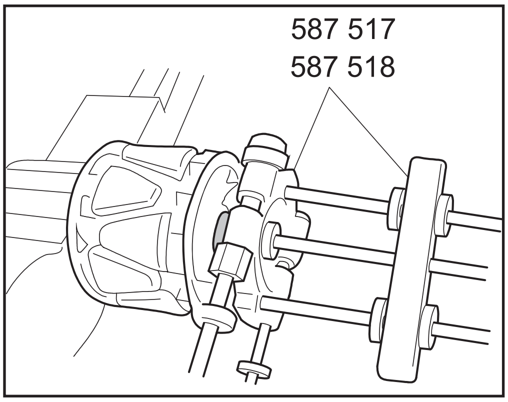


Figure 261

7. Press on the new bearing.

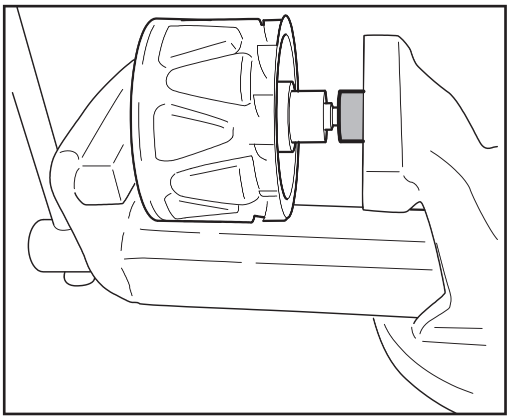


Figure 262

8. Remove the screws and the washer securing the bearing in the front housing.

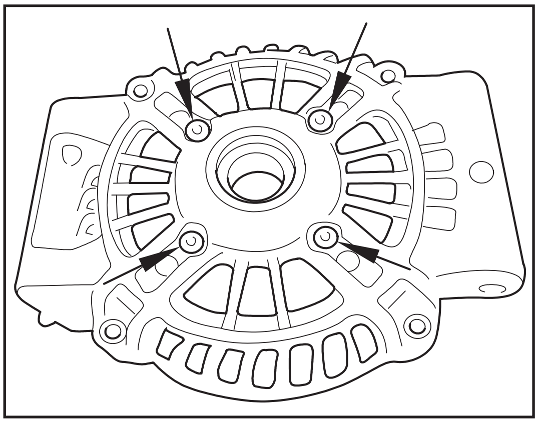


Figure 263

9. Put a sleeve on the bearing and tap out the old bearing from the front housing.

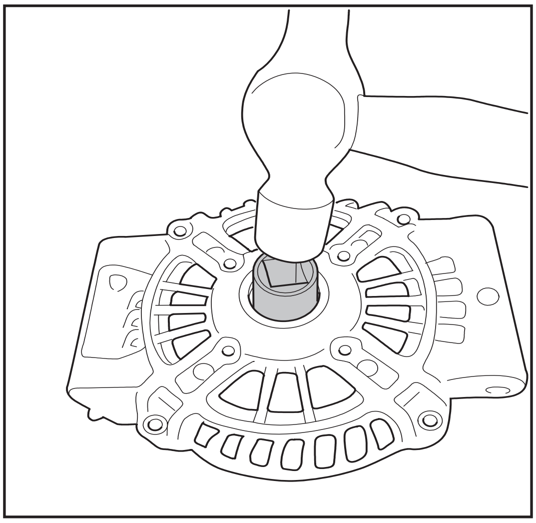


Figure 264

10. Fit a new bearing. Fit the front housing in the vice and press it into position using a sleeve on the outer race.

The refit the washer and tighten the 4 screws.

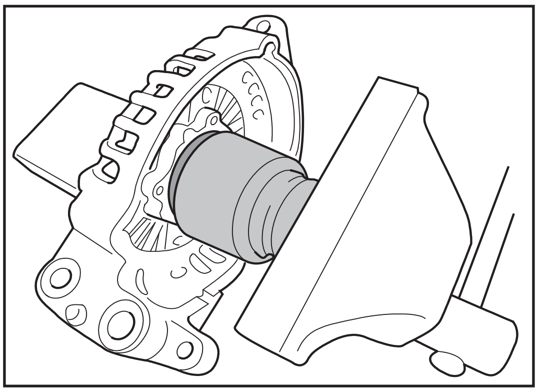


Figure 265

11. Assembly: Fit the rotor in the rear housing.
    Remember to fit the spacing washer between the rotor and bearing in the front housing.

Fit the front housing.

Important!

Check that the marks on the housings are aligned.

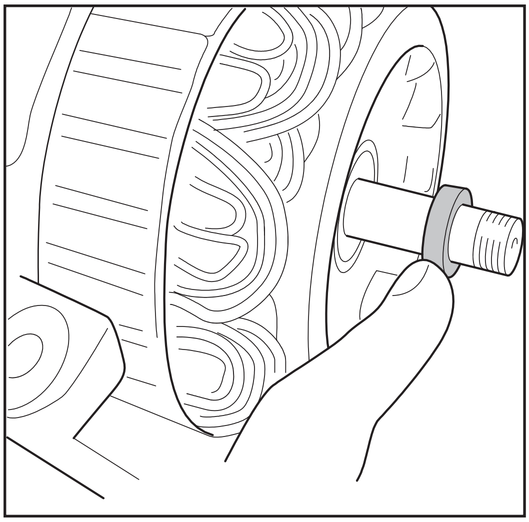


Figure 266

12. Screw on the housing and fit the carbon brushes.

13. Fit the nut and the pulley.

CAUTION

The pulley nut must be tightened to the correct torque, otherwise there is a risk that it will come loose.

Oil pump, brake cooling circulate

Exploded view

1 Pump housing
2 Bolt, 4 off
3 Washer, 4 off
4 O-ring, 2 off
5 Support ring, 2 off
6 Plug
7 O-ring
8 Compression spring
9 Control valve
10 Pressure plate
11 Rotor housing
12 Rotor
13 Vanes
14 Wear plate
15 O-ring
16 Guide pin, 2 off
17 O-ring
18 End plate
19 Spacing ring
20 Sealing ring
21 Washer
22 Axle
23 Retaining ring
24 Bearing
25 Retaining ring
26 Gear
27 Nut
28 Flange
29 Gasket
30 Stud, 2 off
31 Bolt, 5 off

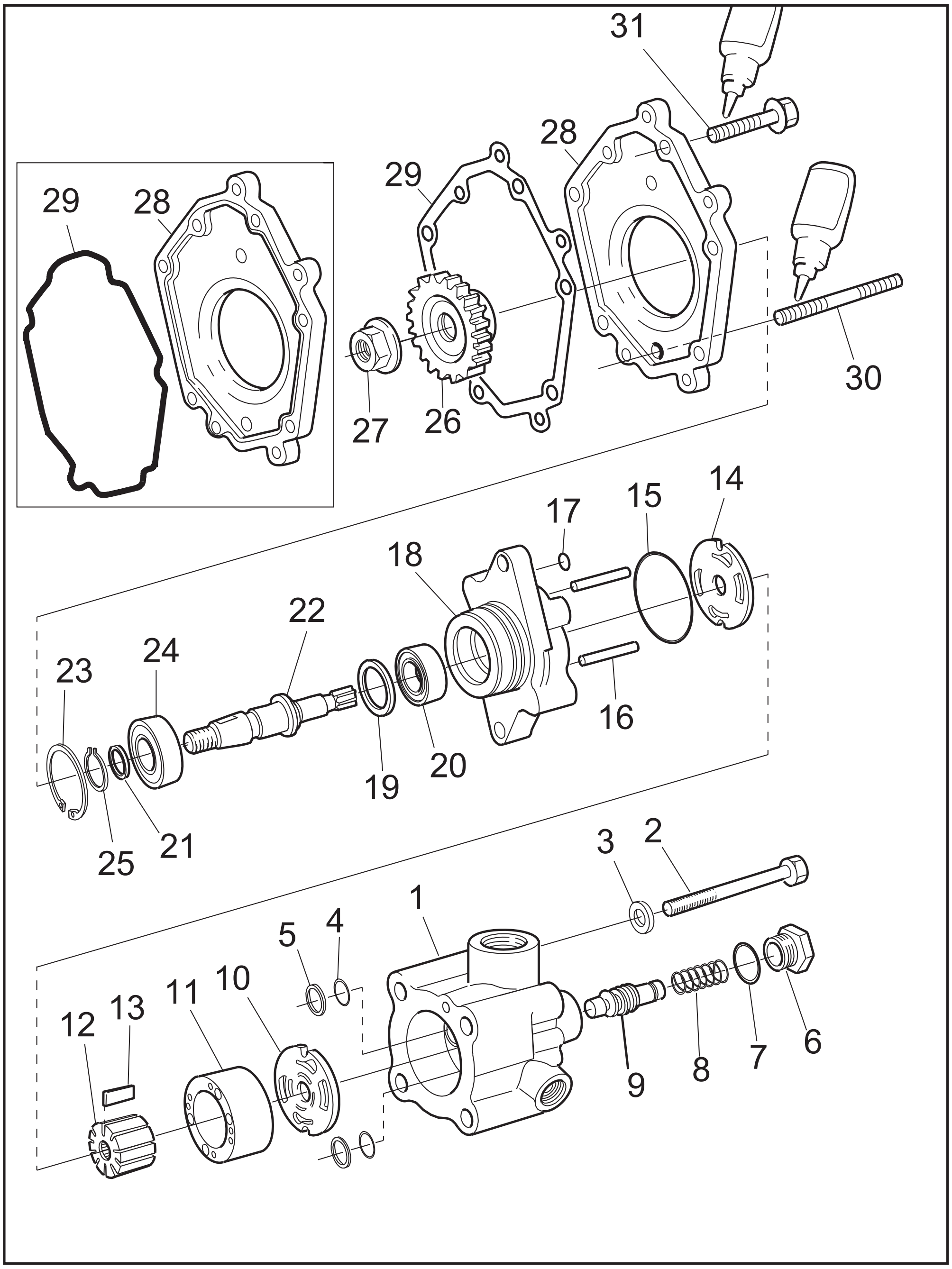


Figure 267

Disassemble and overhaul the oil pump

Brake oil pump is located on the engine's flywheel house on the left.

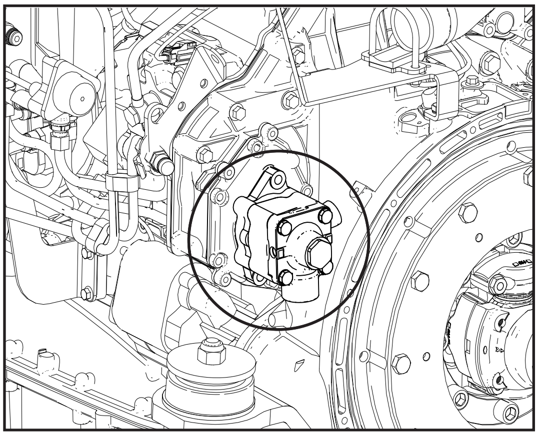


Figure 268

1. Lift the cab and secure with safety device.
2. Drain the oil from the steering system. Place a receptacle under the fluid reservoir. Disconnect the suction pipe first from the fluid reservoir and then from the hydraulic pump.
3. Clean and remove the connections to the hydraulic pump.
4. Detach and remove the hydraulic pump.
5. Screw the new hydraulic pump into place on the engine.
6. Screw the two oil hoses of the hydraulic pump into place.
7. Fill with oil and bleed the steering system as described in Workshop Manual main group 13, Steering, Checking and troubleshooting.
8. Lower the cab into drive position.
9. Check the function.

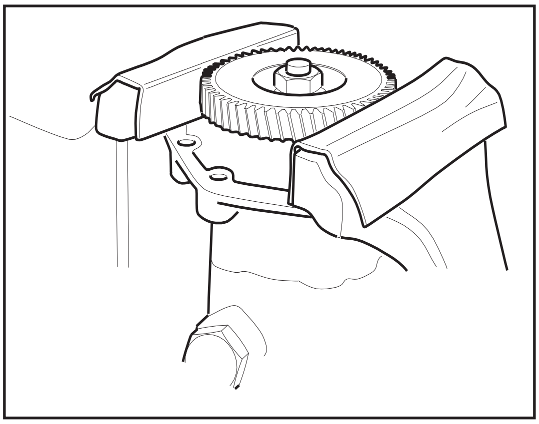


Figure 269

1. Drain all oil from the pump and clean it on the outside.
2. Clamp the gear 26 in a vice with protective jaws. Remove the nut 27.

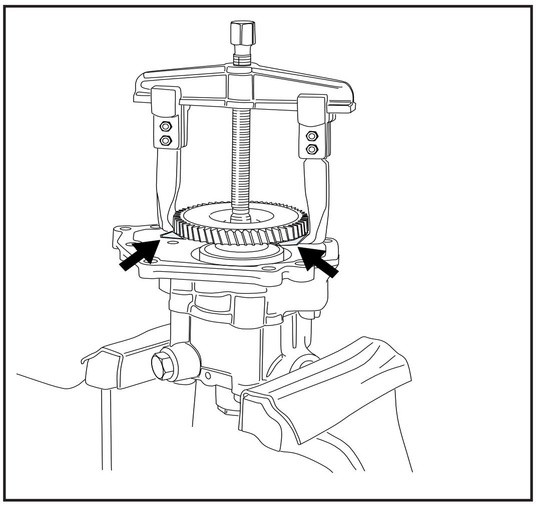


Figure 270

3. Clamp the pump in the vice. Remove the gear 26 using puller 587 315 as illustrated.

NOTE

Use soft jaws on the puller to protect the gear from damage.

4. Remove the plug 6, compression spring 8 and control valve 9.

NOTE

The plug is spring loaded and might fly off.

5. Remove the bolts 2 holding together the pump housing and end plate. Remove the end plate.

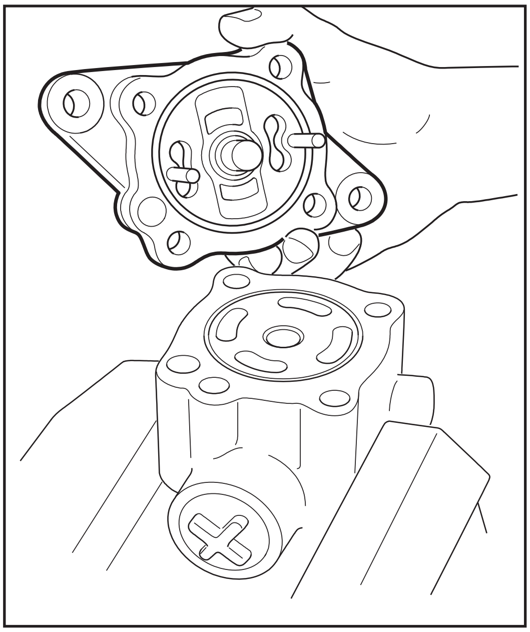


Figure 271

6. Remove the wear plate 14 and the rotor housing 11 with rotor 12 and vanes 13.

7. Remove the pressure plate 10 and guide pins 16.

8. Remove the retaining ring 23 from the end plate 18.

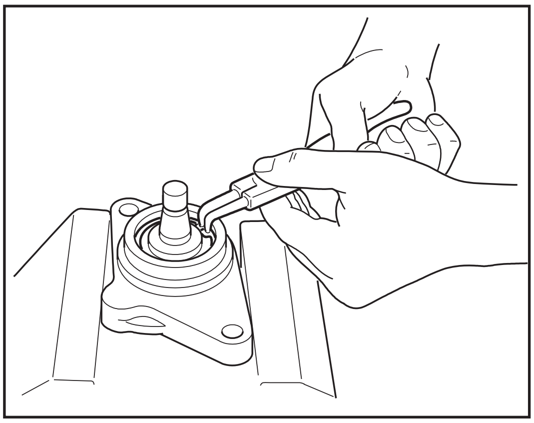


Figure 272

9. Tap out the shaft with a rubber mallet.

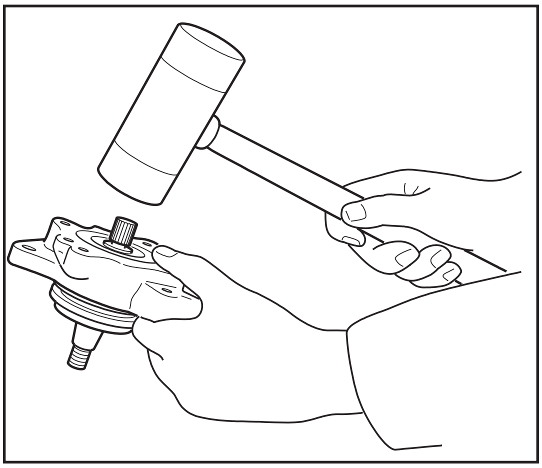


Figure 273

10. Remove the spacing ring 19.

Remove the sealing ring 20 using tool 850329-00335.

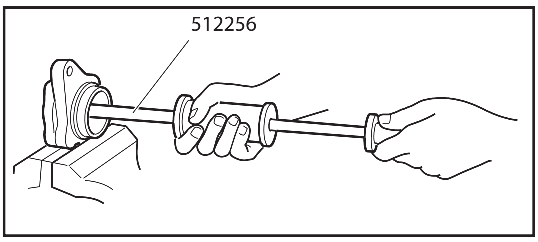


Figure 274

Checking and renewing parts

Clean and check the following parts:
Half shaft 22. Especially check the sealing surface of the sealing ring 20 and the bearing surface of the slide bearing. Slide bearing in end plate.
Plunger 9 in the control valve. The plunger must not jam in the housing.
Blow all channels in the pump housing clean. Ball bearing 24.

NOTE

If any of these parts are damaged or visually worn, the complete pump must be replaced.

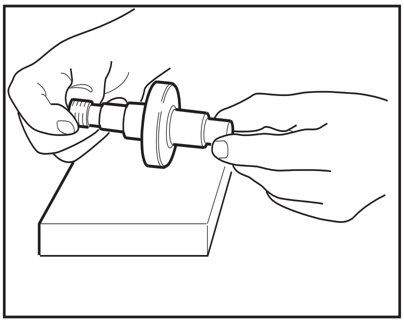


Figure 275

Checking and renewing rotor assembly:
Check the rotor housing 11 with rotor 12 and vanes 13 for wear. The vanes must rotate easily in the rotor. Check the wear plate 14 and pressure plate 10 for discolouring, wear and scratches. Especially check the surfaces contacting the rotor.

NOTE

If any of these parts are damaged or visually worn, the rotor assembly must be renewed. Renew the following parts:
O-rings 4, 7, 15 and 17
Support rings 5
Sealing ring 20
Retaining ring 23

1	Pump housing
2	Bolt, 4 off
3	Washer, 4 off
4	O-ring, 2 off
5	Support ring, 2 off
6	Plug
7	O-ring
8	Compression spring
9	Control valve
10	Pressure plate
11	Rotor housing
12	Rotor
13	Vanes
14	Wear plate
15	O-ring
16	Guide pin, 2 off
17	O-ring
18	End plate
19	Spacing ring
20	Sealing ring
21	Washer
22	Axle
23	Retaining ring
24	Bearing
25	Retaining ring
26	Gear
27	Nut
28	Flange
29	Gasket
30	Stud, 2 off
31	Bolt, 5 off

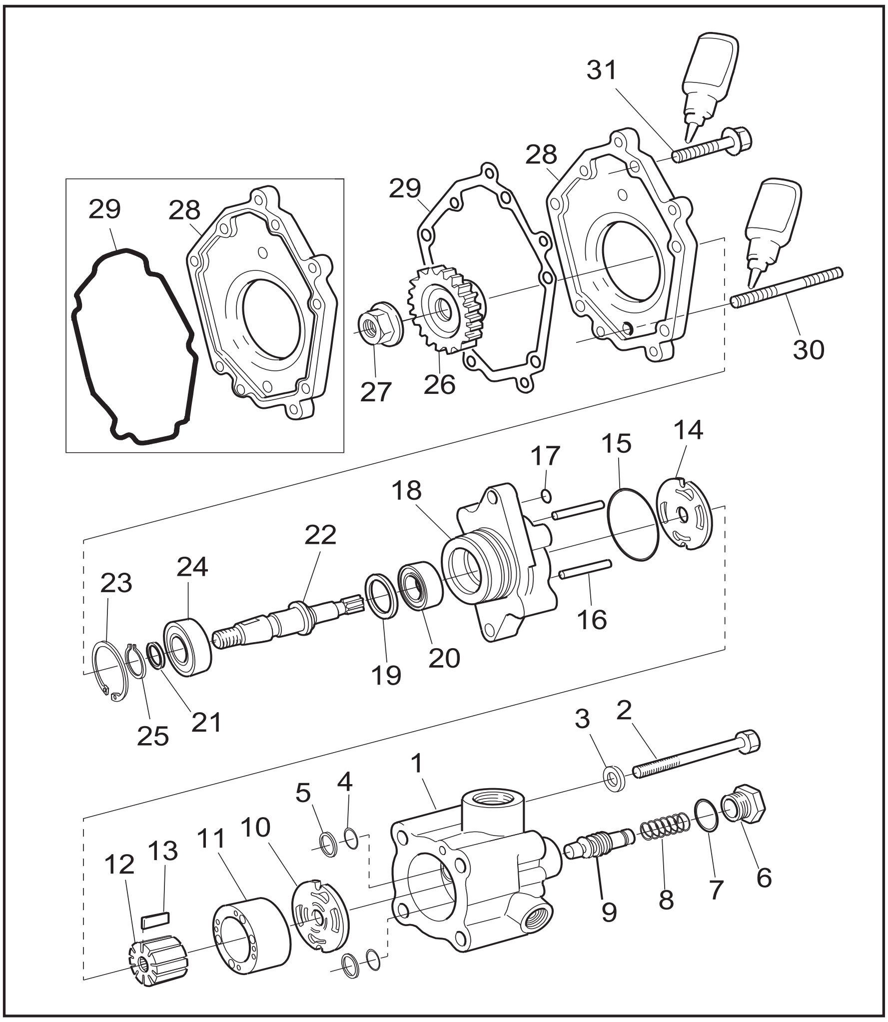


Figure 276

Oil circulate pump assemble.

1. Lubricate the component parts with automatic transmission fluid.

2. Turn the sealing ring as illustrated.

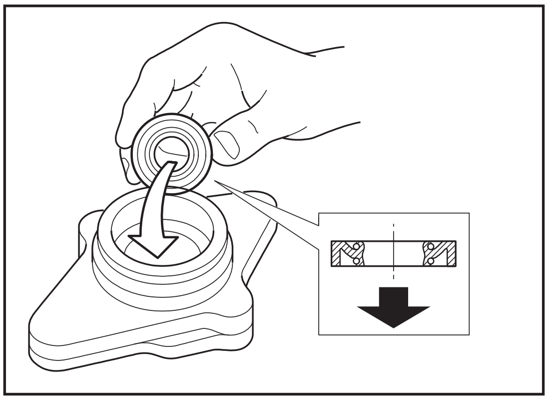


Figure 277

3. Press on the sealing ring using drift 532339 and shank 532340.

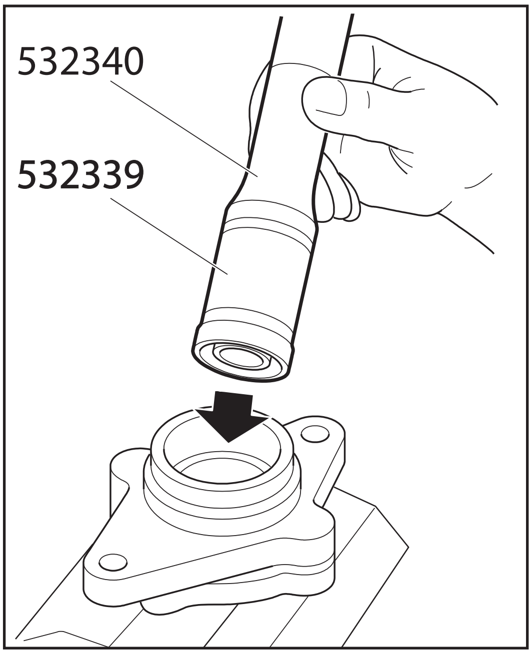


Figure 278

4. Fit the spacing ring 19.

5. Tap the shaft into the end plate with a rubber mallet.

6. Fit retaining ring 23.

7. Fit two new O-rings, 15 and 17, in the mating face. Fit the guide pins 16.

8. Fit the wear plate 14. Turn the wear plate so that the groove faces the rotor housing.

9. Fit the rotor housing 11.

NOTE

Turn the rotor housing so that the oil channels A will not be blocked.

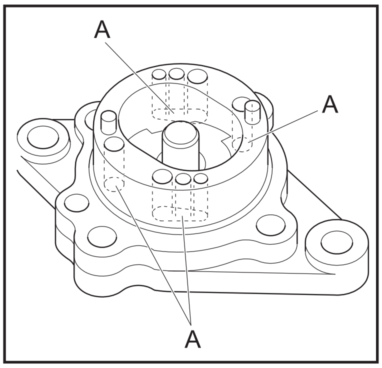


Figure 279

10. Fit the rotor 12 with the chamfered side facing the flange. Make sure that the rounded part of the vanes 13 is facing outwards.

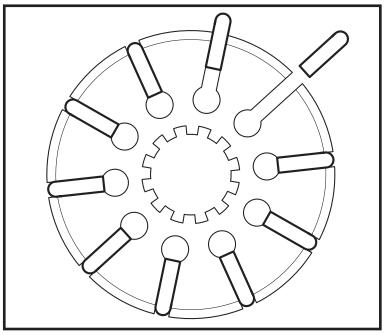


Figure 280

11. Fit the pressure plate 10 with oil channel C facing the rotor housing.

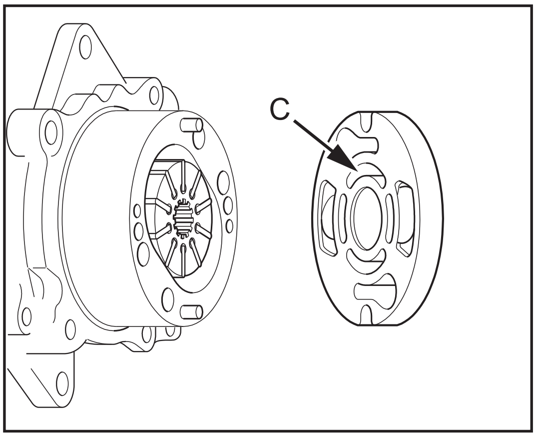


Figure 281

12. Fit new O-rings 4 and oil channel support rings in the pump housing.

13. Assemble the housing and the end plate. Make sure that the oil channels and the O-rings are lined up. Fit the bolts 2.

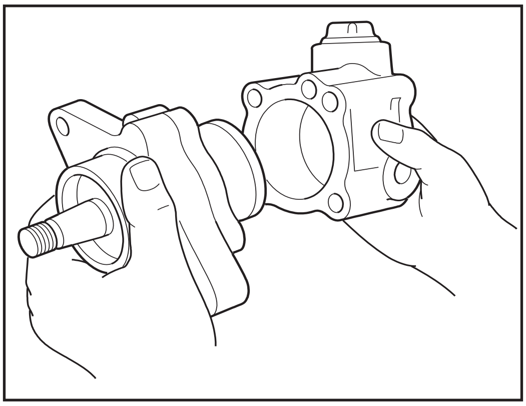


Figure 282

1 Pump housing
2 Bolt, 4 off
3 Washer, 4 off
4 O-ring, 2 off
5 Support ring, 2 off
6 Plug
7 O-ring
8 Compression spring
9 Control valve
10 Pressure plate
11 Rotor housing
12 Rotor
13 Vanes
14 Wear plate
15 O-ring
16 Guide pin, 2 off
17 O-ring
18 End plate
19 Spacing ring
20 Sealing ring
21 Washer
22 Axle
23 Retaining ring
24 Bearing
25 Retaining ring
26 Gear
27 Nut
28 Flange
29 Gasket
30 Stud, 2 off
31 Bolt, 5 off

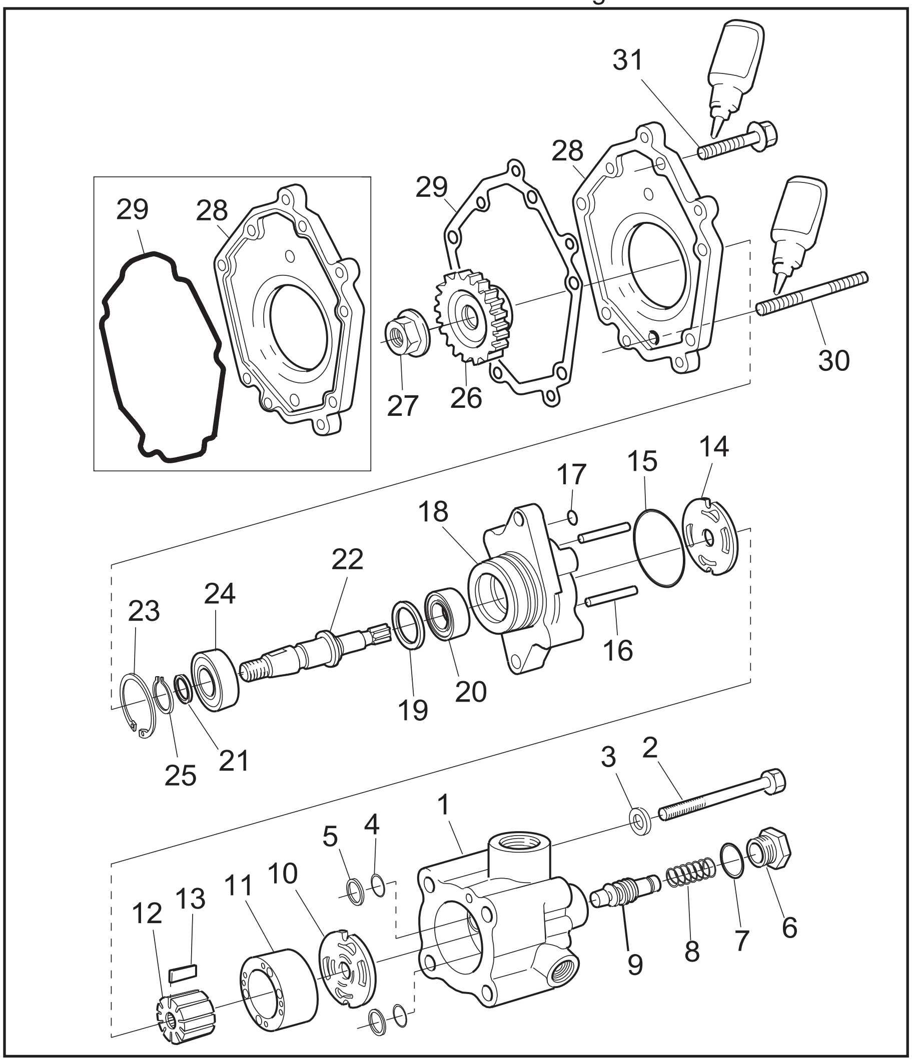


Figure 283

14. Renew the O-ring 7 on the hexagonal plug. Fit the valve insert and spring and screw in the plug.

NOTE

Make sure the control valve is turned as illustrated.

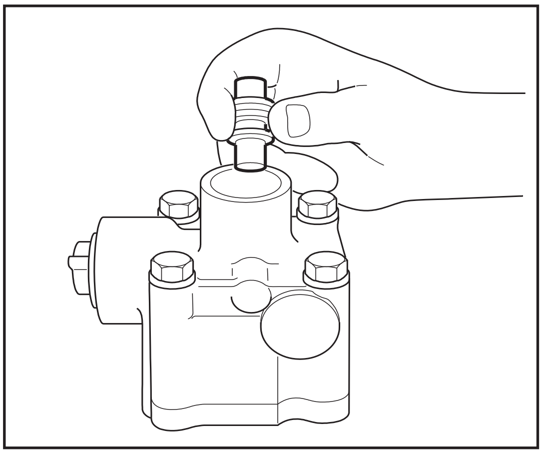


Figure 284

Important!

The shaft end and the gear must be degreased and free of oil and grease before fitting.

15. Fit the gear (26) and the nut (27) as follows:

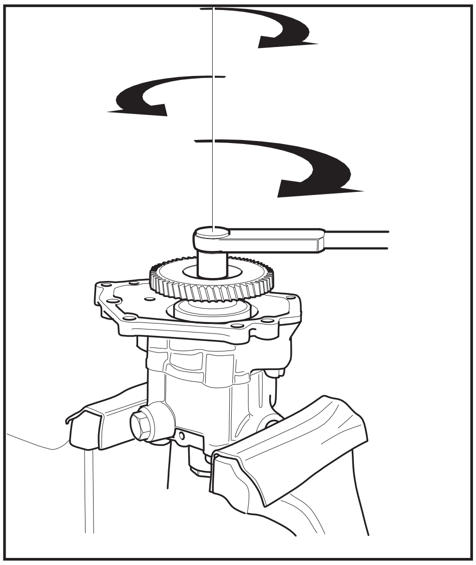


Figure 285

16. Check the pressure and flow after assembly and fitting. See Workshop Manual main group 13, Testing the hydraulic system.

Renewing the gasket

Important !

Use only Loctite® 406 when fitting the gasket. Loctite 406 does not contain any solvents that will damage the gasket

NOTE

Cleanliness when fitting the gasket is essential for the flange to be tight. Keep the surfaces around and on the flange clean and free from dirt.

1 Remove the gasket from the paper.

2 Fit the gasket on the flange.

3 Apply a thin layer (drops) of Loctite 406.

4 Refit the flange. Use existing bolts with sealing agent or new bolts coated with sealing agent.

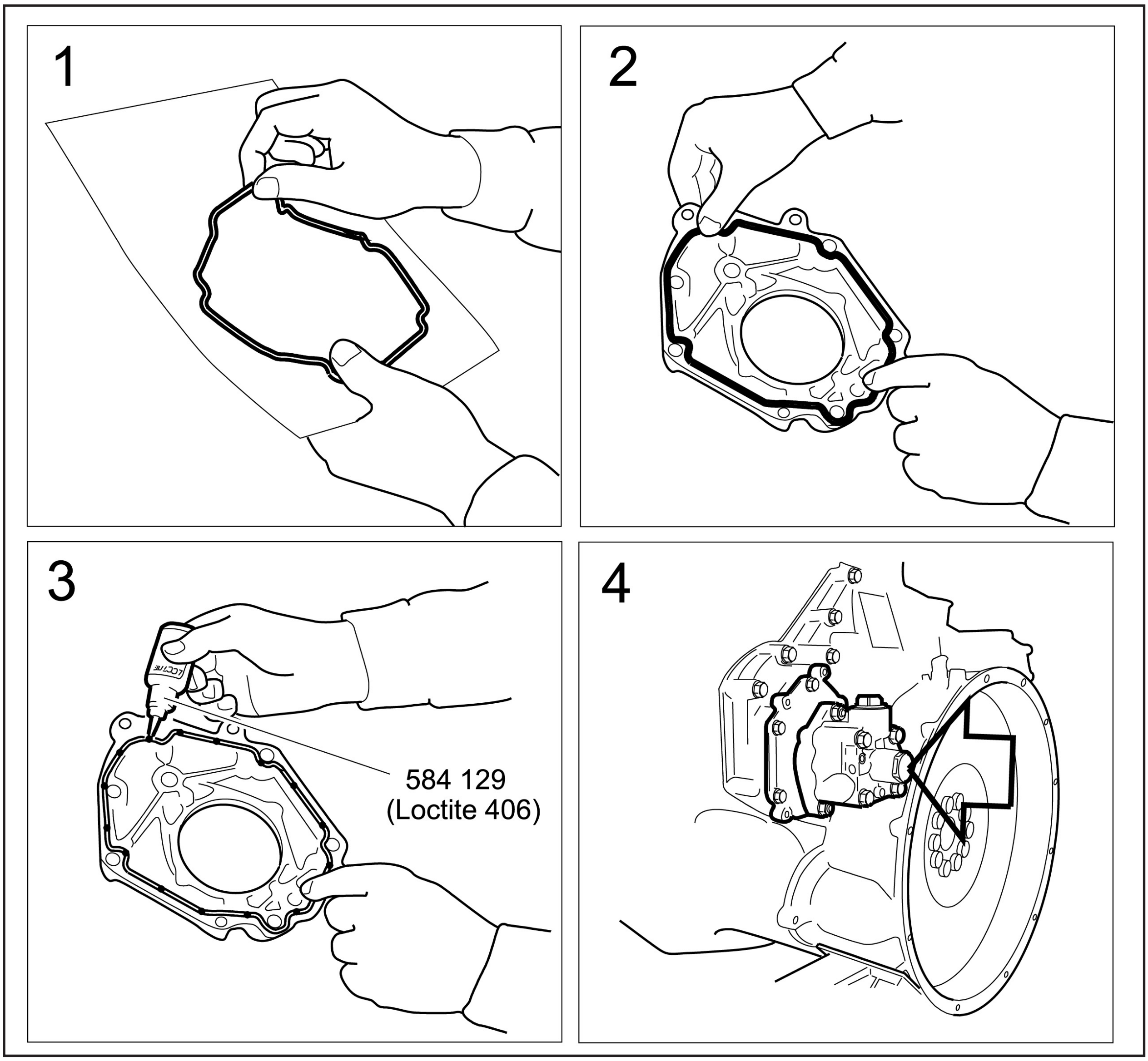


Figure 286

Cooling fan

The fan is driven by the hydraulic system and is moved to the hydraulic chapter.

Look in the Hydraulic chapter 5.

View of the radiator system

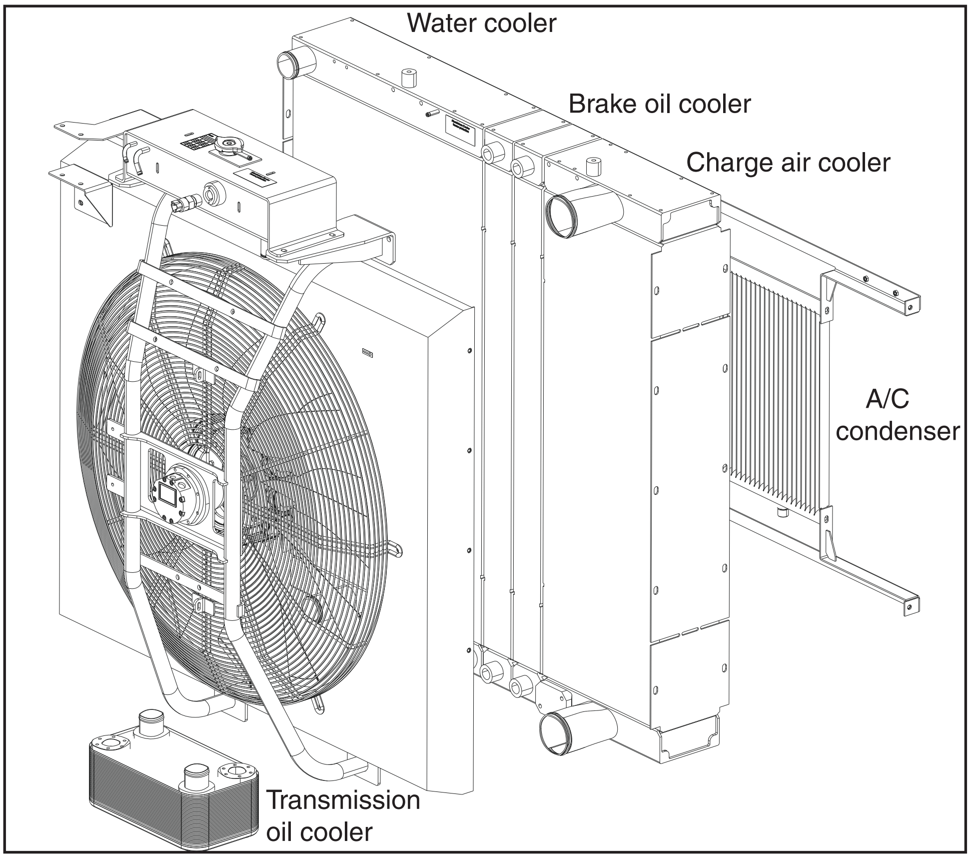


Figure 287

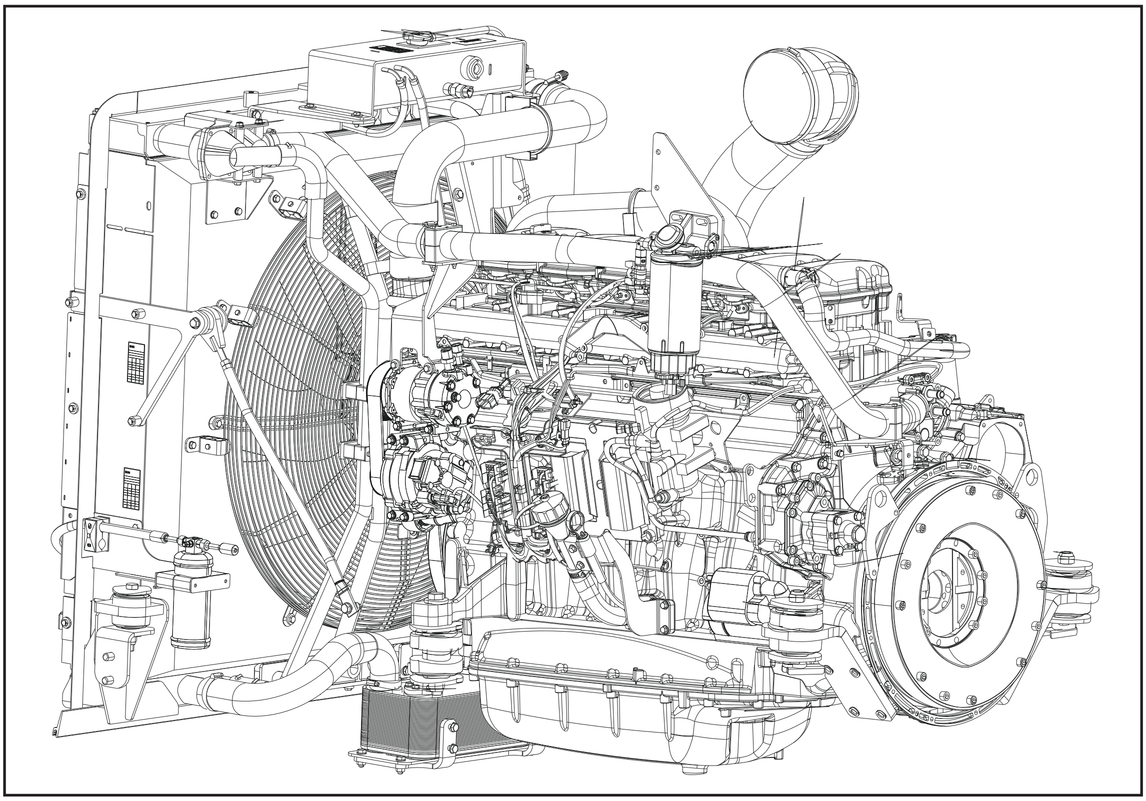


Figure 288

Cooling system

Principal view of the cooling system

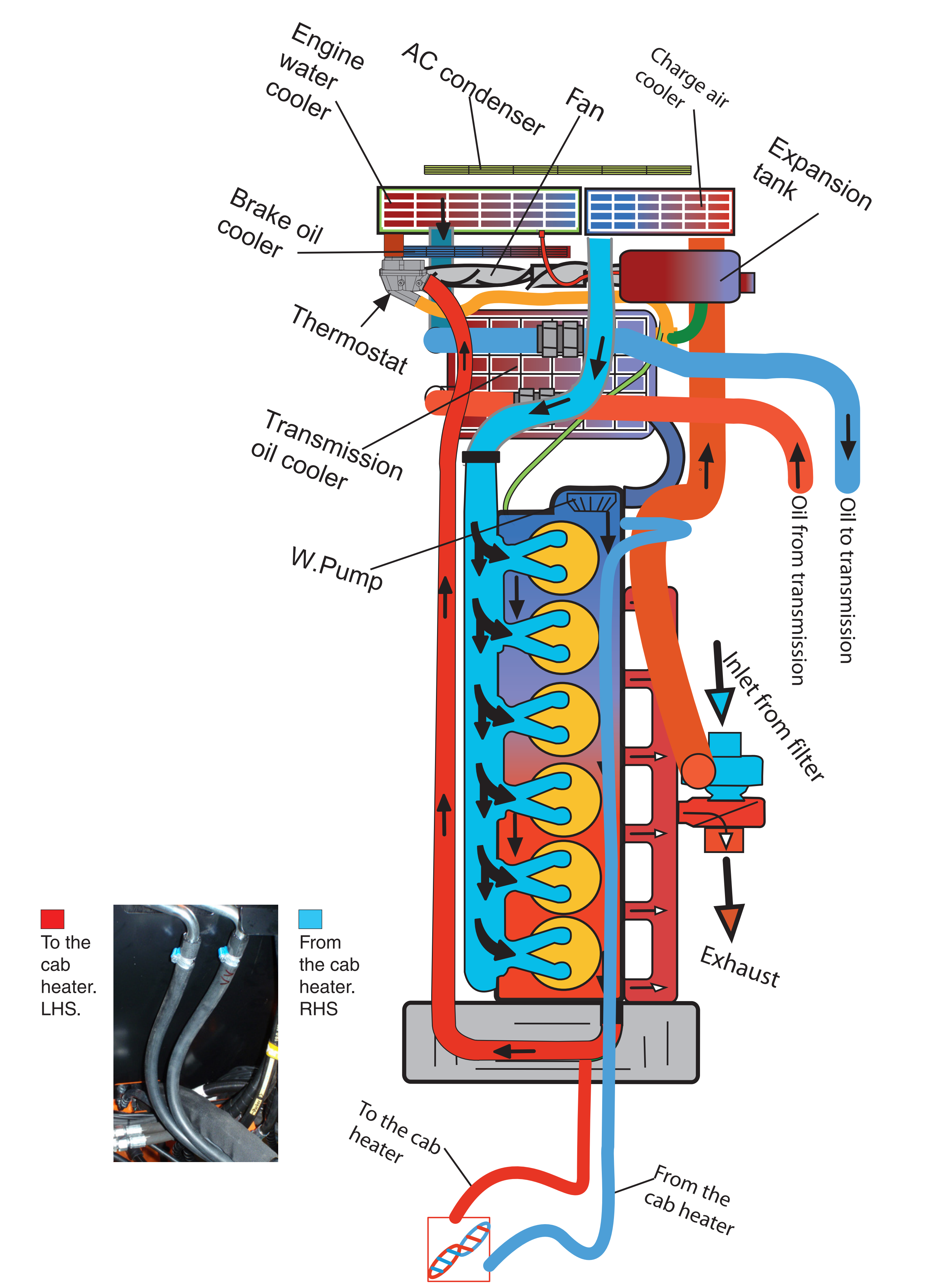


Figure 289

Circulation

From the pump, the coolant is carried into the cyl¬inder block’s longitudinal distribution ducting and then through holes in the cylinder block, washes round the cylinder liners and flows up to the cylinder heads.

The coolant is also forced directly up into the cyl¬inder heads from the distribution ducting via pas-sages which leads to the injectors and exhaust valves.

From the engine’s rear cylinder head the coolant flows forward through the pipe directly into the thermostat housing, which is located on the left-hand side of the radiator shield.
The by pass in the thermostat housing forwards the coolant which is under the temperature limit for the thermostat, back to the engine through the transmission cooler. The coolant which needs to be cooled, are going through the open thermostat and to the radiator cooler system, through the transmission cooler and back to the engine, where the coolant pump is circulating the coolant in the system.

The cab heater takes the heat coolant from the pipe line on the backside of the engine, and after heating the cab, the returned coolant is going to the right-hand side of the engine where the coolant pump is located.

The turbo sucks air through a filter and then pushes the charge air through the charge air cooler. The hot charge air, on the inside of the CAC, is cooled by the cooling air - going through the CAC on the outside. The cooling air on the outside is sucked through all the coolers (in the cooling package) by a hydraulic fan. The pressure of the air, in the air charge system, to the cylinders is approx 1 - 2 bar (gauge), depend on the engine’s rpm.

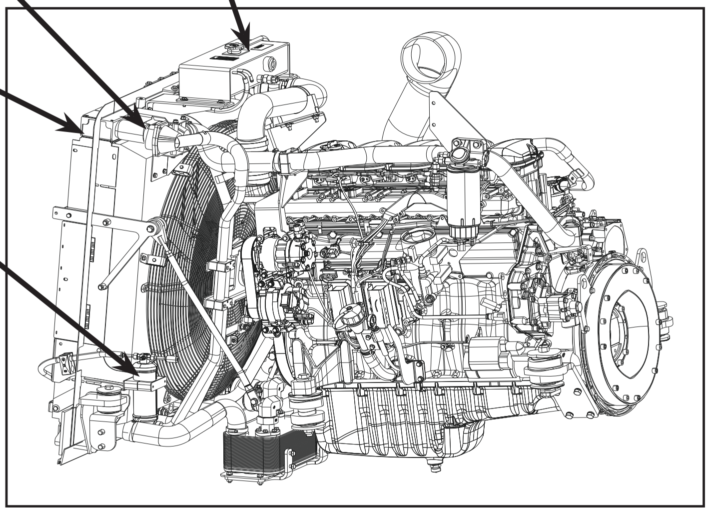


Figure 290

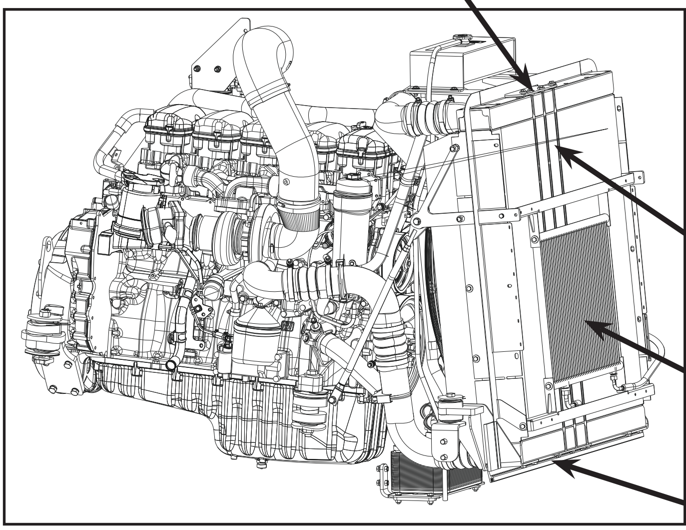


Figure 291

Coolant

NOTE

Coolant additives must be as follows:

• An antifreeze content of minimum 35 and maximum 60 percent by volume when there is a risk of freezing

NOTE

The coolant should be changed when the cooling system is cleaned: every 6,000 hours or at least every 5 years.

Coolant, Resistance to Cold

The following example shows coolant properties with 30 percent by volume of antifreeze:

• Ice slush starts to form at -16°C (3°F).

• At -30°C (-22°F), there is a risk of cooling system malfunction.

• There is no risk of damage by freezing with a minimum antifreeze content of 35 percent by volume.

The diagram depicts coolant properties at different percentages of antifreeze concentration by volume.

A	Ice formation starts (ice slush)
B	Damage by freezing occurs
1	Safe area
2	Malfunctions may occur (ice slush)
3	Risk of damage by freezing

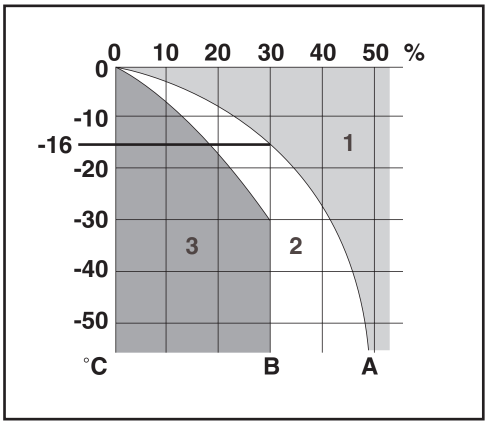


Figure 292

NOTE

Only pour pre-mixed coolant into the cooling system.

Checking coolant Level

WARNING

Never open the coolant filler cap when the engine is hot. Hot coolant and steam may spray out and cause burns. If the cap has to be opened do it slowly and carefully to release the pressure before removing the cap. Wear gloves as the coolant is still very hot.

1. Check coolant level in level glass on the expansion tank. (See the black arrow on figure 292 and 293).

2. Top up with coolant as necessary.

Up to 7X1761 / 8X1730

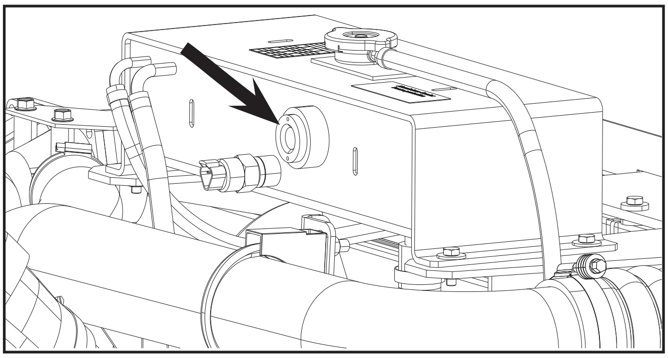


Figure 293

From 7X1762 / 8X1731

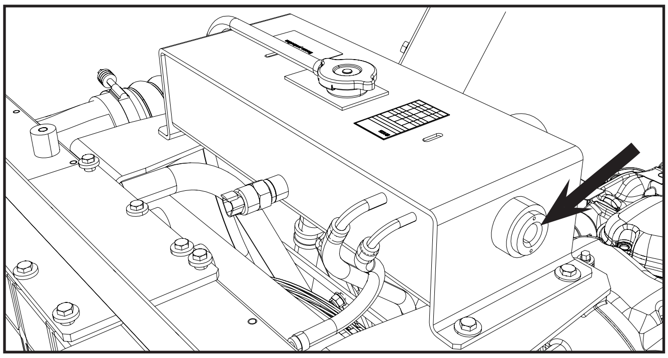


Figure 294

NOTE

It is not advisable to fill large amounts of coolant through the expansion tank. Fill according to the instructions in the section on changing the coolant.

NOTE

Never fill a large amount of cold coolant in a hot engineThere is great risk of cracks forming in the cylinder block and cylinder heads.

External leakage

External leakage is indicated by coolant leaking out onto the ground. First check all hose and pipe connections, including those for the bus heating system.

Internal leakage

Internal leakage in the engine can produce white exhaust gases and coolant in the engine oil. Then engine conditioning is the only solution.
Internal leakage in one of the bus oil coolers can lead to oil in the cooling system or coolant in the oil. Renew the defective oil cooler and clean the cooling system.

Checking the antifreeze level

NOTE

Use only pure fresh water that is free from particles, sludge and other impurities

1. Pour a small amount of coolant into a container and check that the coolant is pure and clear.
2. Change the coolant if it is contaminated or cloudy.
3. Measure the antifreeze content with a refractometer

The following rules apply to ethylene glycol-based coolant:

- The antifreeze content must be minimum 35 percent by volume for corrosion protection to be sufficient.
- Fill with antifreeze if the antifreeze content is below 35 percent by volume.
- Antifreeze content greater than 60 percent by volume impairs the ability to protect against frost.
- If ice forms in the coolant, there are disruptions initially, but there is no immediate risk of damage. The engine should not be subjected to heavy loads when ice starts to form.

Changing coolant

NOTE

Avoid spillage and use a suitable container. Used coolant must be disposed of as specified in national and international law.

1. Pour a small amount of coolant into a container and check that the coolant is pure and clear.
2. Change the coolant if it is contaminated or cloudy.
3. Measure the antifreeze content with one of the following instruments: Refractometer.
   The following rules apply to ethylene glycol-based coolant:

- The antifreeze content must be minimum 35 percent by volume for corrosion protection to be sufficient.
- Fill with antifreeze if the antifreeze content is below 35 percent by volume.
- Antifreeze content greater than 60 percent by volume impairs the ability to protect against frost.

- If ice forms in the coolant, there are disruptions initially, but there is no immediate risk of damage. The engine should not be subjected to heavy loads when ice starts to form.

NOTE

Mix the coolant as specified under the section Coolant.

1. Remove the expansion tank cap.
2. Drain the coolant at the following two locations:

- Lowest point of the cylinder block.
- The lowest point of the cooling system.

3. Close the taps.

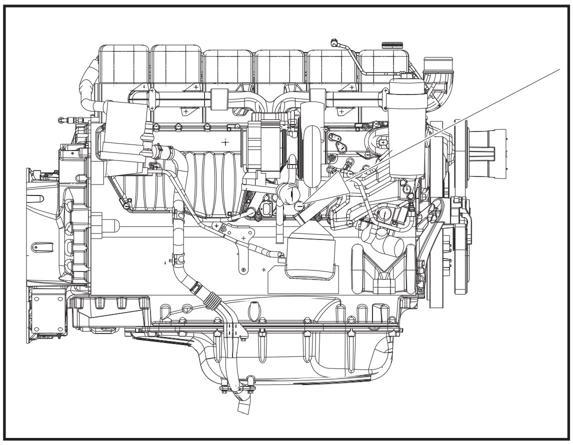


Figure 295

Filling coolant

1. Remove the filler cap from the expansion tank.
2. Close the cocks.
3. Fill with correct mixture, pre-mixed coolant through the expansion tank filler hole.
4. Set the heating control to maximum heating and start the engine. Idling speed must not exceed the normal rpm. Leave the engine idling for 15 minutes.
5. Stop the engine and top up with coolant to the maximum level through the expansion tank.
6. A small amount of air may still be left in pockets of the cooling system which will disappear when the vehicle is back on the road. This means that it will need some topping up to start with.

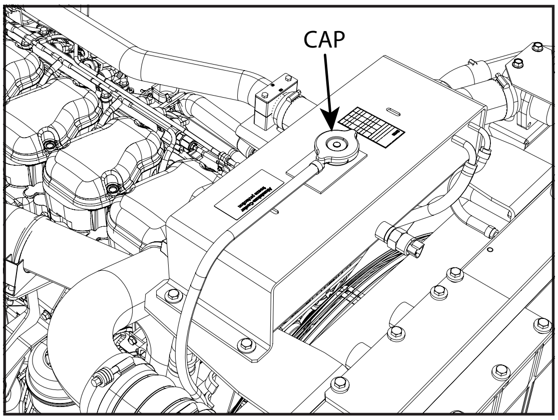


Figure 296

Cleaning the cooling system

NOTE

Clean the cooling system more often if necessary.

NOTE

Do not use caustic soda or other alkaline cleaning agent as this could damage the aluminium.

Cleaning the Radiator and Charge Air cooler (Outer)

1. Check that the radiator and the charge air cooler are not clogged on the air side and that the cooling fins are not damaged.
2. Carefully scrape away any deposits from the radiator cooling fins. Use a paraffin-based engine cleaner if necessary.
3. Carefully straighten bent cooling fins using a steel brush or similar.

WARNING

To ensure proper handling of cooling system detergent, study the warning text on the package

Removing Oil and Grease (Inner)

1. Run the engine until it has reached operating temperature and then drain the cooling system.

2. Remove the thermostats.

3. Fill the system with clean, hot water mixed with liquid dishwasher detergent intended for household appliances. Concentration 1%.

4. Run the engine until it has reached operating temperature for approximately 20-30 minutes. Remember to switch on the cab heating system, if one is installed.

5. Drain the cooling system.

6. Refill the system with clean hot water and run the engine for about 20-30 minutes.

7. Drain the water from the system.

8. Refit the thermostats.

9. Fill the system with new coolant following the specification under Coolants earlier in the document.

NOTE

Avoid spillage and use a suitable container. Used coolant must be disposed of as specified in national and international law.

Disassemble the cooling unit

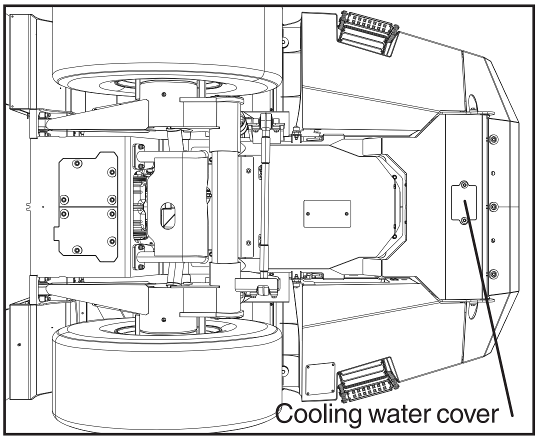


Figure 297

1. Drain the coolant. First, remove the cover on the front left underside.

Connect drain hose with Rölex connection to radiator and drain the coolant

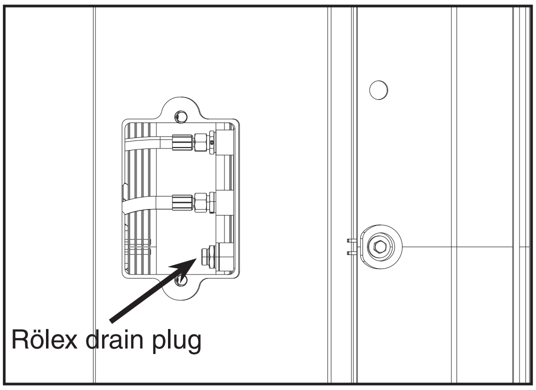


Figure 298

NOTE

Use a clean drum or similar if the cooling water should be reused. It is recommended to supply with new oil when refilling oil to the transmission.

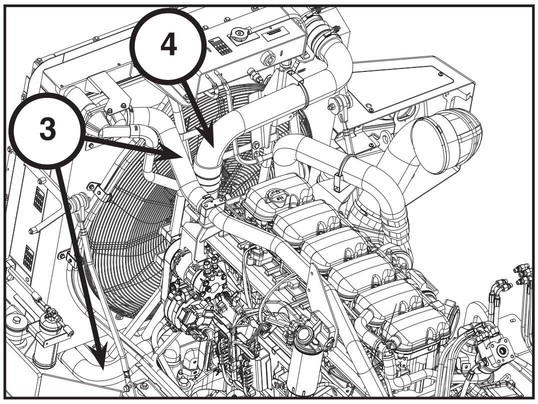


Figure 299

2. Disassemble the wiring and hoses, remove the wiring strips and clamps from the brackets.
3. Disconnect the cooling hoses from the thermostat housing and transmission oil cooler.
4. Disassemble the charge air hose.
5. Disconnect hoses between the expansion tank and the engine. Remove clamps.
6. Disassemble oil hoses from fan motor, hydraulic oil cooler and brake oil cooler. Remove clamps, there are two clamps on HA30, while on HA45 there is three clamps.

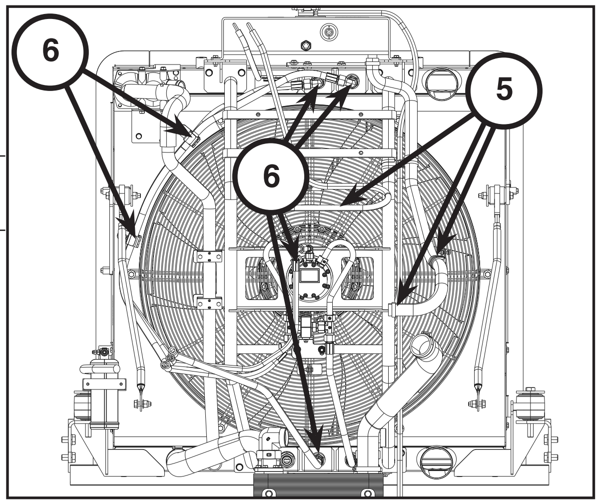


Figure 300

NOTE

Oil under hydraulic pressure !

The oil system for the fan motor is in the same oil system as the brake, therefore it is recommended when disassembling hoses or units from this system, always to eliminate pressure in the accumulator, located on the right side, under the cab. This can be done by operating the brake pedal several times. (Approx 15-20 times)

7A. Disassemble the sealing plate on the left side.

7B. Disassemble the drying filter, incl bracket.

7C. Disassemble the condenser, leaving the top frame.

Place the condenser and the dryer filter on the left side of the engine.

NOTE

Do not disassemble the air condition hoses from the condenser filter or the compressor.

Up to 7X1761 / 8X1730

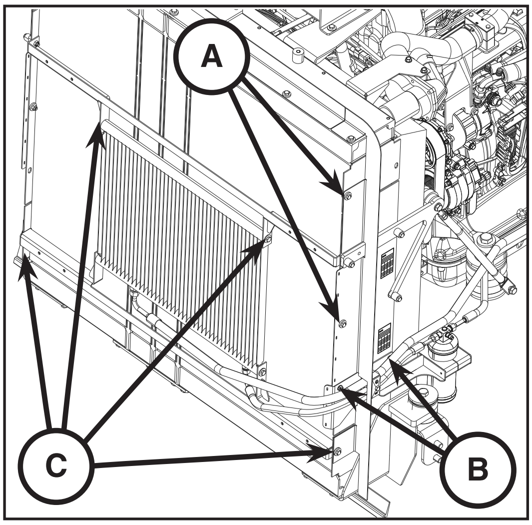


Figure 301

From 7X1762 / 8X1731

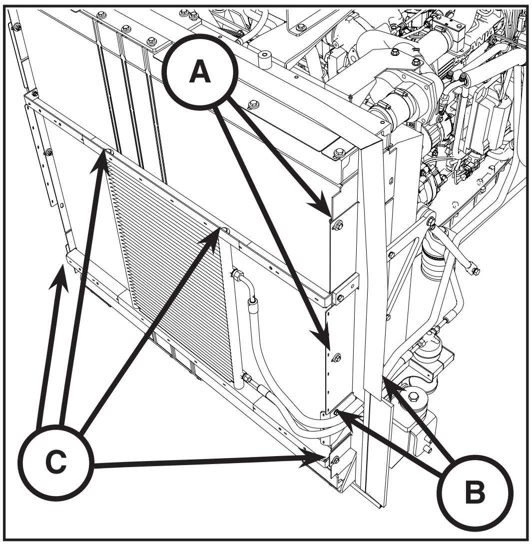


Figure 302

8. Fasten 2 pcs M10 lifting eyes on top of the cooling unit, and attach the lifting device to these.

Check that all cooling pipes and hoses are disassembled

9. Disassemble the stay bars from the frame (both sides).

10. Disassemble lower fastening 2 screws (left and right hand side).

11. Check again that all wiring and hoses are disassembled.

Carefully lift the cooler unit out from the frame.

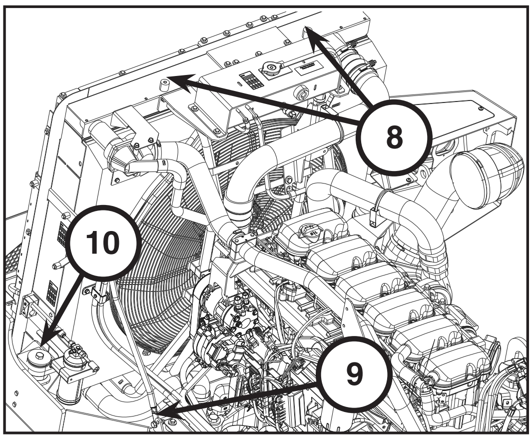


Figure 303

Disassemble the cooling unit

1. Drain the coolant from the cooling system (See chapter on disassembly of cooling pack)
2. Drain the transmission oil.

   Removeright side cover under transmission.

   Connect drain hose with Rölex connection and drain oil.

   Beware that some amount of oil may be left in hoses and cooler.

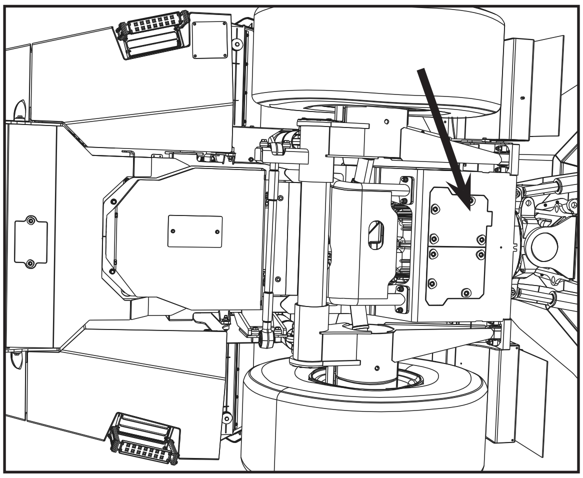


Figure 304

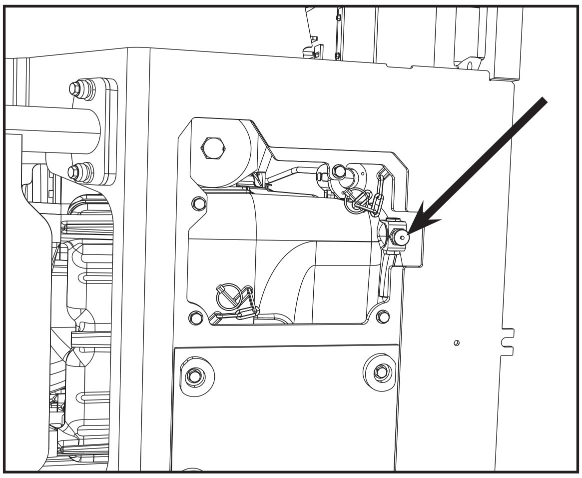


Figure 305

3. Disconnect water hoses.
4. Disconnect oil hoses.
5. Disconnect oil cooler.

   Carefully lift the oil cooler out from the frame.

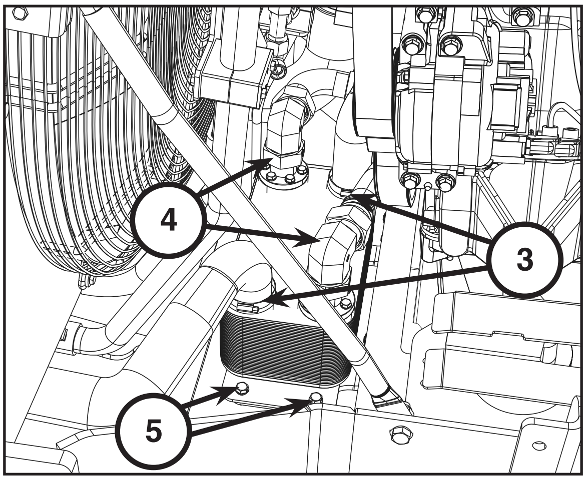


Figure 306

Thermostat and thermostat housing

The engine have a double thermostat.

When a double thermostat are used they have the same opening temperature as standard.

The thermostats use wax as the temperature-sensitive medium.

At coolant temperatures below the opening temperature of the thermostats, nearly all the coolant circulates between the engine's coolant passages and the coolant pump without passing through the radiator.

When the coolant temperature in the engine is higher than the temperature for fully open thermostat, the by-pass channel is closed and all coolant flows through the thermostats and on to the radiator.

If temperature equilibrium occurs within the operating range of the thermostats, i.e. between the temperature limits for fully closed and fully open thermostat, the thermostat valves will assume a corresponding intermediate position.
Some of the coolant will then be directed to the coolant pump without being cooled and the remainder directed to the radiator.

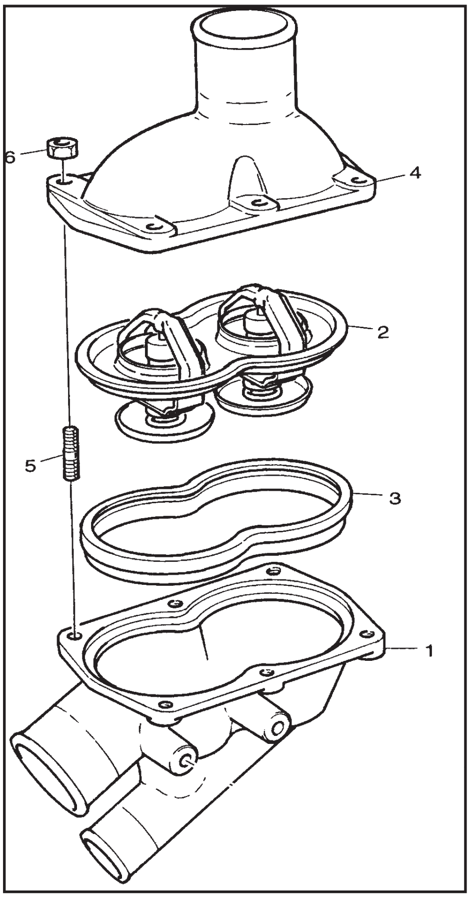


Figure 307

1. Termostat housing
2. Thermostat
3. Gasket
4. Cover
5. Stud
6. Flange nut

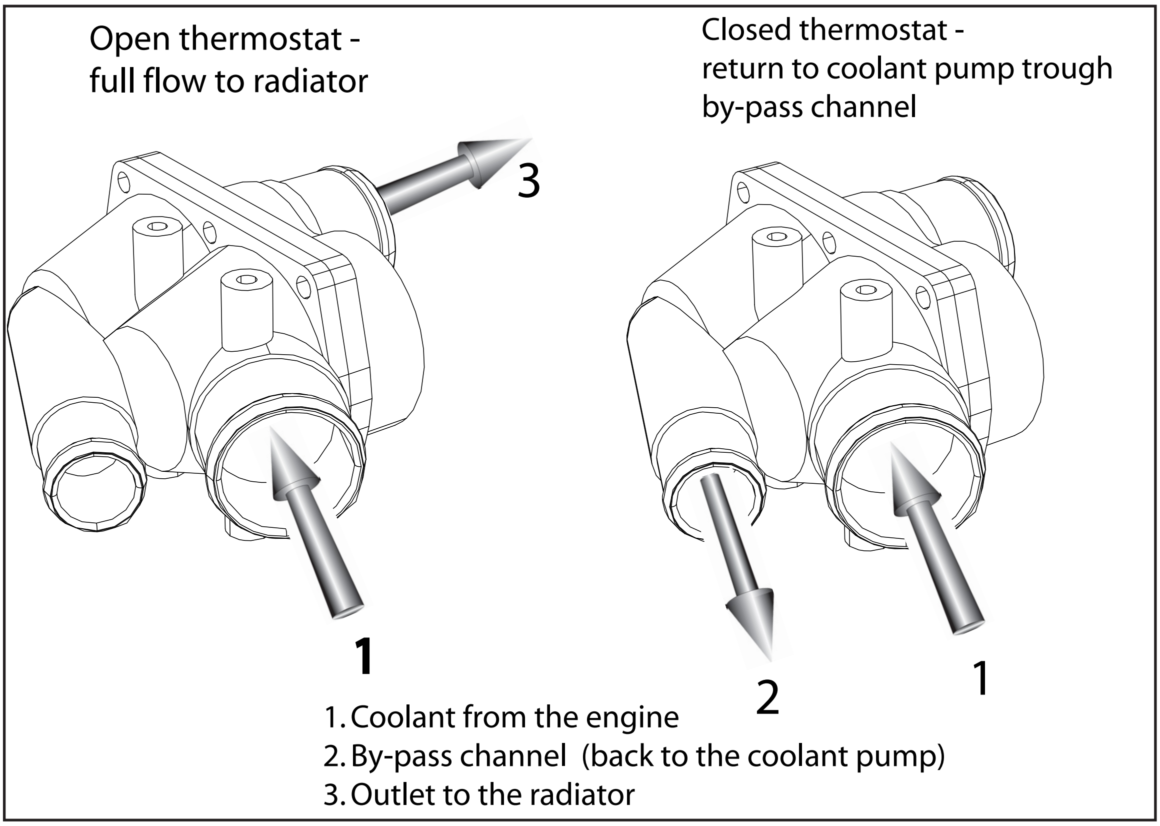


Figure 308

Removing and fitting thermostat

Removing

1. Remove the expansion tank filler cap.

Drain a sufficient amount of coolant from the system.

2. Remove the hose from the thermostat housing cover.

Detach the thermostat housing cover and remove the thermostat (double thermostat).

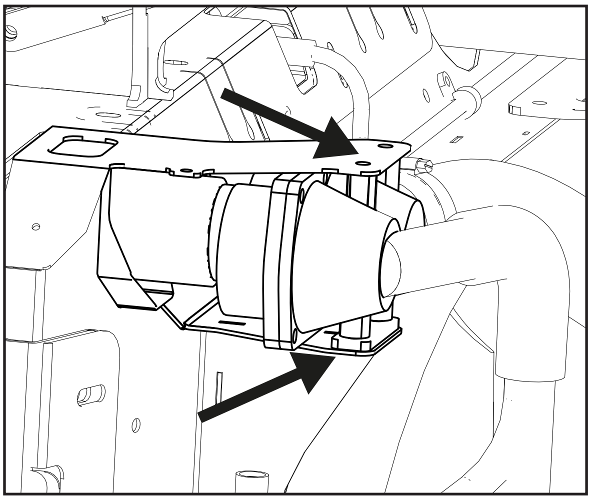


Figure 309

Fitting

1. Clean the thermostat housing and check that nothing obstructs the function of the thermostat.

2. Insert the thermostat in the housing. Fit new gaskets and screw the thermostat housing together.

3. Fill the system with coolant. See **OPERATING & MAINTENANCE MANUAL** chapter 7 for the composition of the coolant.

4. Start the engine and check that there are no leaks. Check the coolant level and top up as necessary.

Apply Loctite No. 510
Part No. 516204

Assemble cover;
Screw No. 051735 M8 x 38 - 8.8
Nut No. 502975 M8

Torque with 24 Nm

Figure 310

Coolant pump

The coolant pump is located at the front side of the front cover on the right-hand side of the engine.

The coolant pump is driven by a multigroove belt directly from the crankshaft damper.

The pump is of centrifugal type and consists of a spiral shaped pump housing with an impeller directly mounted on the driveshaft. The shaft is mounted in the housing and by means of two permanently lubricated ball bearings.

The pump shaft bearing is sealed against the ingress of coolant by an elastic axial seal.

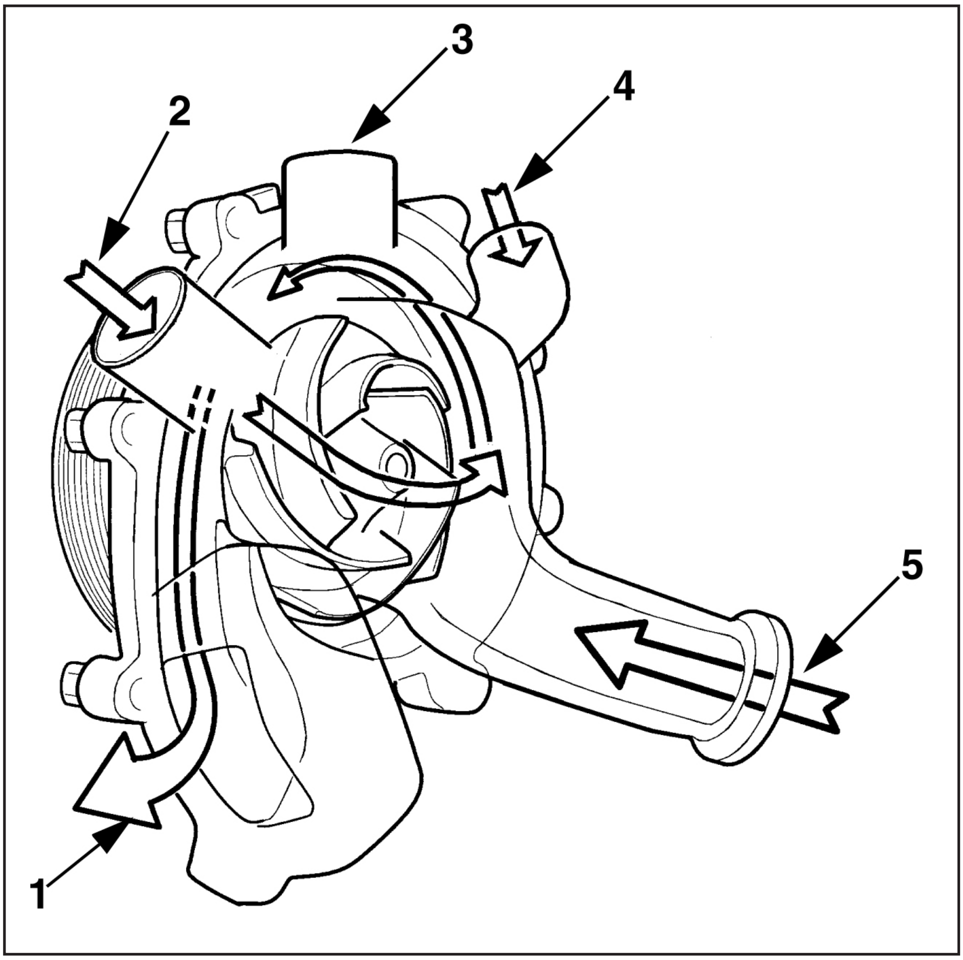


Figure 311
Circulation through coolant pump

1. Outlet to engine
2. By-pass channel
3. Static line
4. Return from charge air cooler
5. Coolant from radiator

Removing

1. Drain the cooling system through the drain taps in the block and in the pipe from the outlet on the radiator.

2. Remove any protection meshes and fan ring with sealing ring to gain access to the fan.

3. Remove the fan.

4. Turn the automatic belt tensioner and prise the poly-V-belt off the coolant pump pulley.

5. Remove the coolant pump assembly. Fitting the pump

6. Clean old gasket debris from the sealing surfaces.

7. Fit the pump without damaging the seal(s).

8. Fit the automatic belt tensioner.

9. Fit the (poly-V) drive belt and any protection mesh and fan ring with sealing ring.

10. Fit the fan.

11. Fill the cooling system. See booklet 00:03-01 for the composition of the coolant.

12. Start the engine and check that no leakage occurs. Check the level of the coolant and top up as necessary.

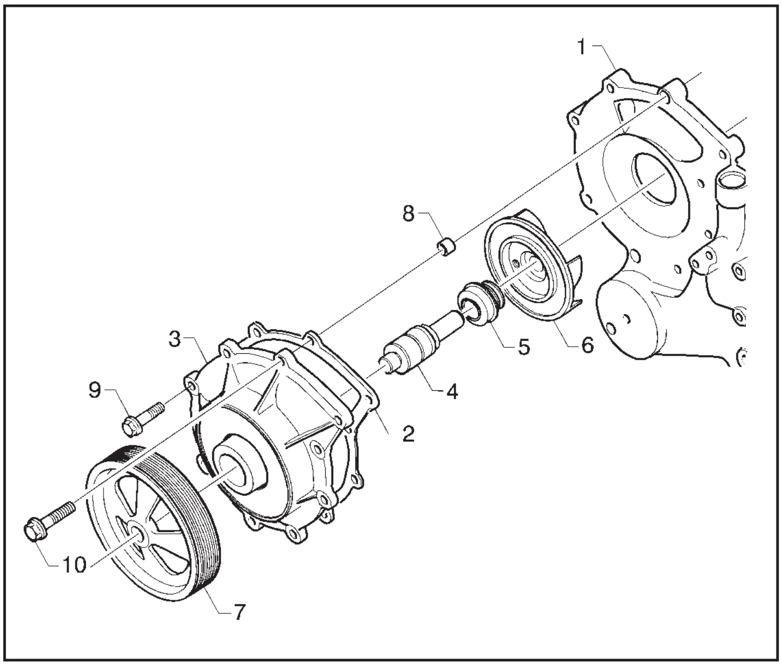


Figure 312

1. Front cover
2. Gasket
3. Pump cover
4. Shaft with bearing
5. Sealing ring
6. Impeller
7. Pulley
8. Guide sleeve
9. Flange screw
10. Flange screw

Changing the pulley

1. Remove the pulley using puller 501348 and drift 501349.
2. Press the pulley on until it is flush with the shaft end face.

The pulley is removed

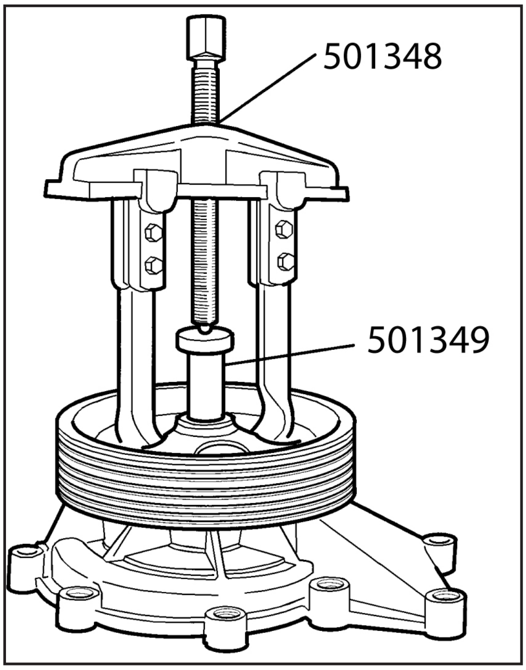


Figure 313

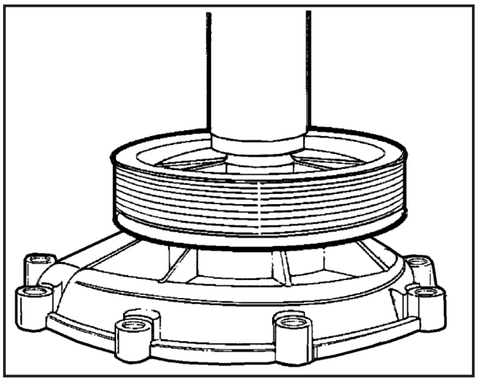


Figure 314

The pulley is pressed on

Changing the sealing ring

If coolant has leaked out inside the housing behind the pulley, the sealing ring can be changed.

1. Place the pump with pulley on a flat and level surface.
2. Fit puller 501354 using two M 8 x 65 mm bolts and drift 501349. Pull off the impeller.
3. Split the carbon ring on the seal and remove the debris.

The impeller is removed

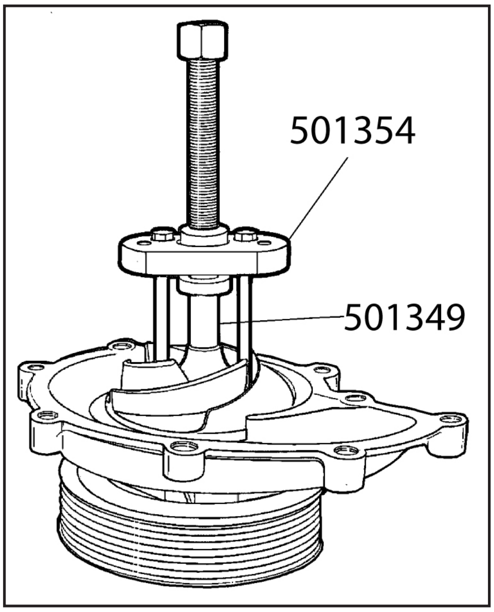


Figure 315

4. Prise off the seal using two screwdrivers and separator plates.

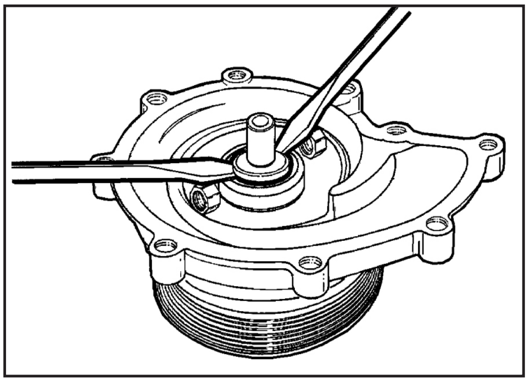


Figure 316
The seal ring is removed

NOTE

Do not damage the pump housing gasket surface.

5. Apply sealing agent (501350) to the inside and outside (brass sleeve) of the sealing ring. Make sure that no sealing agent gets onto other sealing surfaces.

Important!

Sealing agent (501350) should be used sparingly. There is a risk of the sliding surfaces being glued together.

6. Press in the new sealing ring with drift 501351 until the edge of the brass sleeve abuts against the pump housing. Keep it under pressure for about 10 seconds.

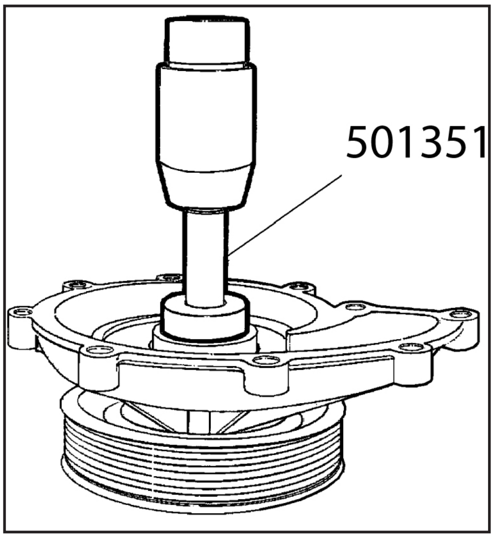


Figure 317
The new seal ring is pressed in

NOTE

It is very important that tool 501351 is used. It is designed to correctly preload the spring which holds the seal.

7. Press on the impeller using drift 501351 until the clearance between the gasket surface of the pump housing and the end of the impeller shaft is 13.3 - 13.7 mm.

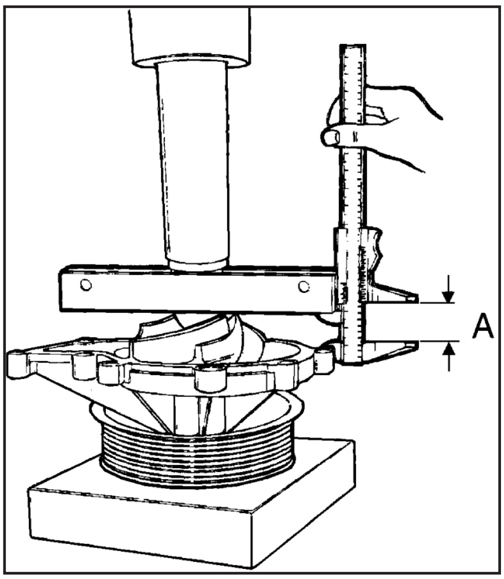


Figure 318

A = 13,3 - 13,7 mm
The clearance is measured

Important!

The shaft must not change position in the pump housing as there is a danger that the sealing ring would then also change its position.

Puller for pulley	501348
Drift for pulley	501349
Puller for impeller	501354
Drift for pressing in sealing ring and for impeller	501351

External cleaning

Radiator

- Check that the radiator is not clogged on the air side and that the cooling fins are not damaged.
- Carefully scrape the deposit off the radiator's cooling fins. If necessary, a paraffin-based engine cleaner can be used.
- Bent fins can be straightened using a wire brush, for example, and exercising care.

Internal cleaning

Removing oil and grease

- If possible, run the engine until it has reached the operating temperature and then drain the cooling system.
- Remove the thermostat.
- Fill the system with clean, hot water mixed with liquid dishwasher detergent intended for household use. Concentration 1% (0.1/10 l).
- Run the engine until warm for about 20-30 minutes. Do not forget the cab heating system (if fitted).
- Drain the cooling system.
- Fill the system again using clean, hot water and run the engine for approximately 20-30 minutes.
- Drain the water from the system.
- Refit the thermostat.
- Fill up with new coolant.

WARNING

Handling cleaning agents for the cooling system: Read the warning label on the container.

Removing deposits

- If possible, run the engine until it has reached operating temperature and then drain the cooling system.
- Remove the thermostat.
- Fill the system with clean, hot water mixed with a commercially available radiator cleaner based on sulphamic acid and containing dispersing agents. Follow the manufacturer's instructions for mixing proportions and cleaning times.
- Run the engine for the specified time and then drain the cooling system.
- Refill the system with hot water and run the engine for approximately 20-30 minutes.
- Drain the water from the system.
- Refit the thermostat.
- Fill up with new coolant according to the specification on page 179.

Mind the environment!

Always collect fluid in a suitable container to avoid spillage when draining coolant.
Dispose of used coolant through an authorized waste disposal contractor.

Technical data DC13 with XPI

General data

Number of cylinders and configuration	6, straight
Working principle	4 stroke engine
Cylinder diameter (mm/in)	130/5.12
Piston stroke (mm/in)	140/5.51
Displacement (dm^3/in^3)	12.7/775.0
Firing sequence	1-5-3-6-2-4
Compression ratio	17.3:1
Engine direction of rotation, viewed from rear	Anticlockwise
Fan direction of rotation, viewed from front	Clockwise
Cooling	Coolant
Valve clearances, cold engine intake valve (mm/in) outlet valve (mm/in)	 0.45/0.018 0.70/0.028
Number of teeth on the flywheel	158
Low idling speed (rpm)	600–750
Maximum full-load speed (rpm)	2,100
Fuel	Diesel
Weight, without coolant and oil (kg/lb)	1,050/2,315

Lubrication system

Oil volume	See Inspection
Oil cleaning	Centrifugal oil cleaning
Oil cooler	Coolant cooling, full flow
Oil filter	Paper filter from Scania
Interval between oil changes (h)	500
Oil pressure (kp/cm^2 (bar)/psi) With the engine at operating temperature, operating speed minimum permitted at idling speed	 3–6/43.5–87 0.7/10.2
Crankcase pressure with closed crankcase ventilation mmH_2O/inH_2O	-55–+20/-2.2–+0.8

Injection system

Type	XPI (Extra High Pressure Injection)
Control system	EMS
Fuel filter	Paper filter from Scania
Fuel filter with water separator	Paper filter from Scania

Cooling system

Volume, excluding radiator (dm^3/US gallons)	16/4.2
Coolant temperature (°C/°F)	80–90/176–194
Number of thermostats	1
Thermostat, opening temperature (°C/°F)	80/176

Intake system

Permissible pressure drop in system with cleaned or new filter (mmH_2O/inH_2O)	400/16
Permissible pressure drop in system with blocked (dirty) filter (mmH_2O/inH_2O)	650/26

Electrical system

Type	1-pin, 24 V, DC
Starter motor (standard equipment)	1-pin, 24 V, 5.5 kW
Alternator (standard equipment)	1-pin, 28 V, 100 A

Technical data DC9 with XPI

General data

Number of cylinders and configuration	5, straight
Working principle	4 stroke engine
Cylinder diameter (mm/in)	130/5.12
Piston stroke (mm/in)	140/5.51
Displacement (dm^3/in^3)	9.3/567.5
Firing sequence	1-2-4-5-3
Compression ratio	16:1 [a]
Engine direction of rotation, viewed from rear	Anticlockwise
Fan direction of rotation, viewed from front	Clockwise
Cooling	Coolant
Valve clearances, cold engine intake valve (mm/in) outlet valve (mm/in)	 0.45/0.018 0.70/0.028
Number of teeth on the fly wheel	158
Low idling speed (rpm)	720
Maximum full-load speed (rpm)	2,100
Fuel	Diesel
Weight, without coolant and oil (kg/lb)	950/2,094

a. For engines with performance and certification code 078 and 080, the compression ratio is 18:1.

Lubrication system

Oil volume	See Inspection
Oil cleaning	Centrifugal oil cleaning
Oil cooler	Coolant cooling, full flow
Oil filter	Paper filter from Scania
Interval between oil changes (h)	500
Oil pressure (kp/cm^2(bar)/psi) normal with the engine at operating temperature, operating speed minimum permitted at idling speed	 3–6/43.5–87 0.7/10.2
Crankcase pressure with closed crankcase ventilation mmH_2O/inH_2O	-55–+20/-2.2–+0.8

Injection system

Type	XPI (Extra High Pressure Injection)
Control system	EMS
Fuel filter	Paper filter from Scania
Fuel filter with water separator	Paper filter from Scania

Cooling system

Volume, excluding radiator (dm^3/US gallons)	15/4.0
Coolant temperature (°C/°F)	80–90/176–194
Number of thermostats	1
Thermostat, opening temperature (°C/°F)	80/176

Intake system

Permissible pressure drop in the system with cleaned or new filter (mmH_2O/inH_2O)	400/16
Permissible pressure drop in the system with blocked (dirty) filter (mmH_2O/inH_2O)	650/26

Electrical system

Type	1-pin, 24 V, DC
Starter motor (standard equipment)	1-pin, 24 V, 6 kW
Alternator (standard equipment)	1-pin, 28 V, 100 A

Troubleshooting SDP3 / Canbus

To do:

The troubleshooting manual is included in the machinery computer system.
Please connect Scania software system.

Troubleshooting - basic info.

Troubleshooting in electronic control systems requires access to a multimeter and/or PC and SDP3.

Our electronic control systems store fault codes in their control units. The fault code can be read off using a PC and SDP3. It is generally possible to locate faults and test various components relatively easily using a PC and SDP3.

Control Area Network, CAN

Our electronic control systems operate in networks with other control units and components, CAN communication.
It is not possible to carry out troubleshooting with a test lamp in electronic control systems which use CAN communication. Troubleshooting is carried out on these control systems with a PC and SDP3. Cables which form part of CAN communication controlled circuits are marked with the letters CAN on their connections.

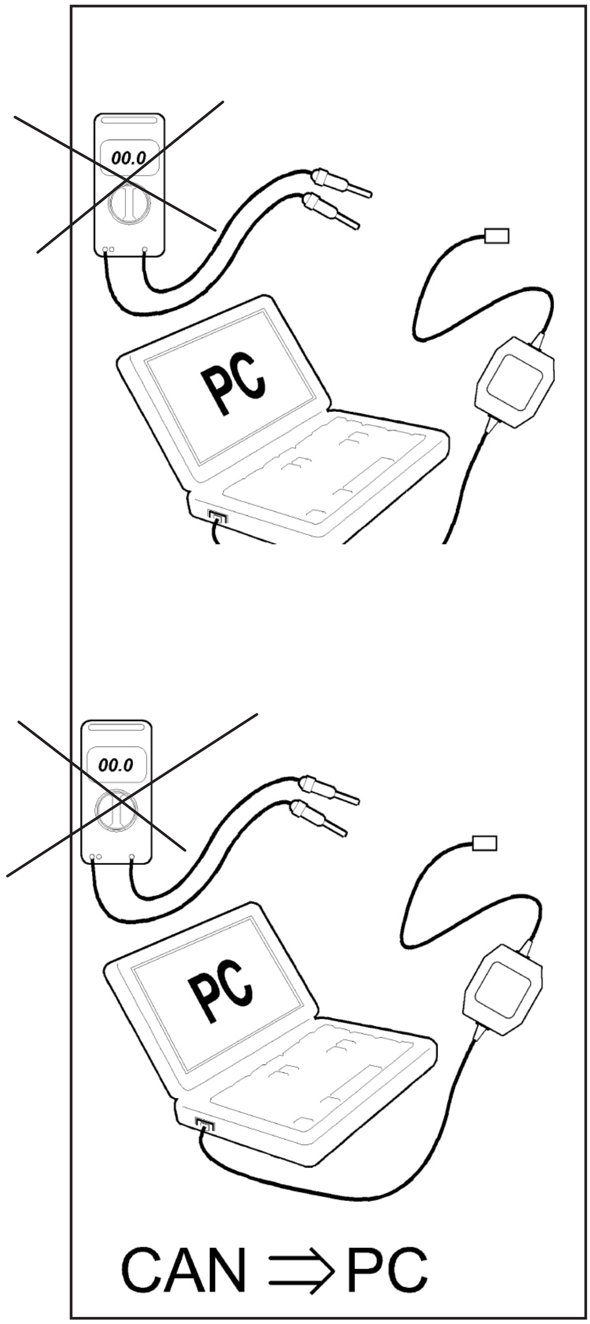


Figure 319

Troubleshooting fuel system

Troubleshooting guide

The fuel system is very sensitive to dirt. It is therefore very important that everything is as clean as possible when work is carried out on the fuel system.

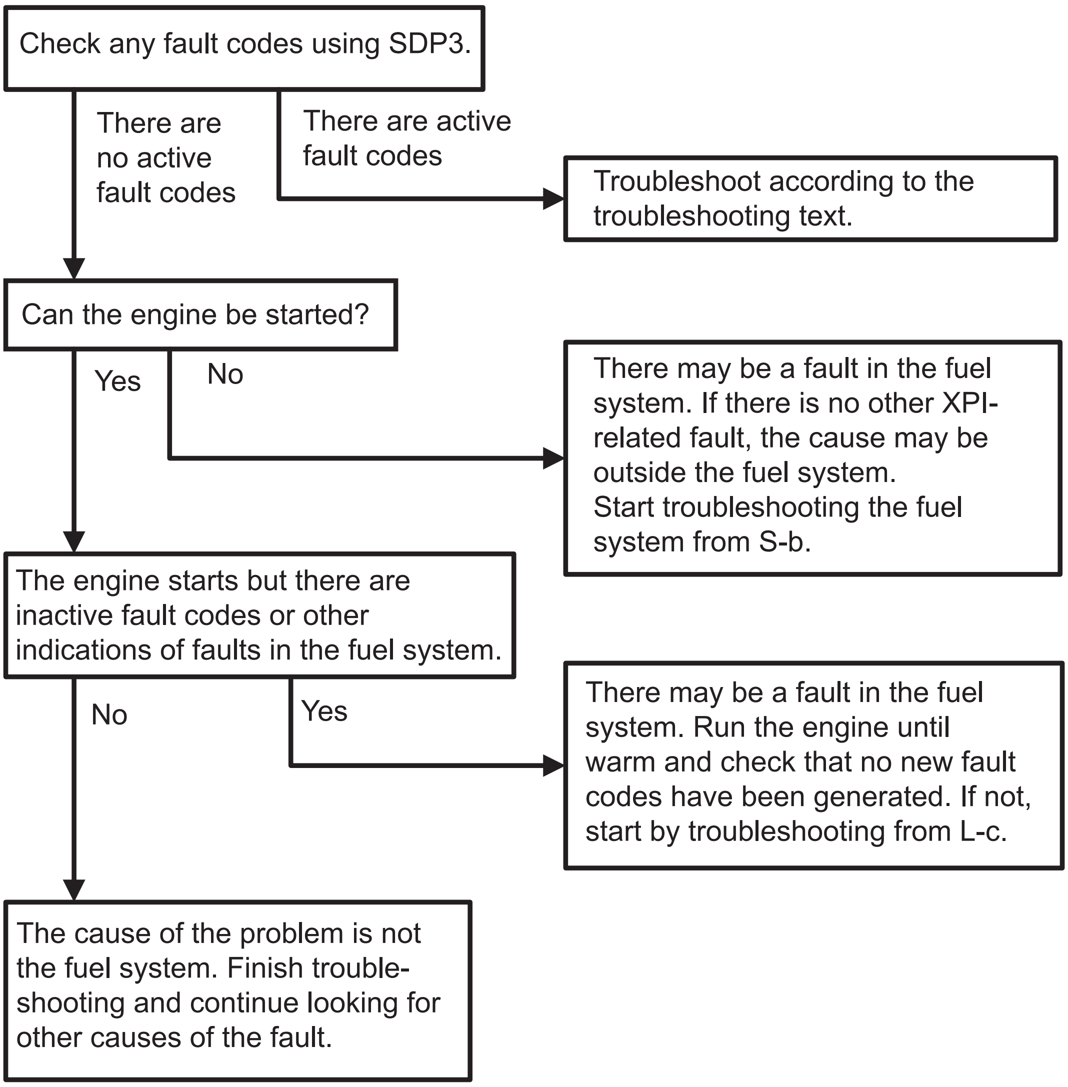
Using the troubleshooting guide

Start troubleshooting by looking at troubleshooting tree S-a. This troubleshooting tree helps you to choose where to start troubleshooting.

The troubleshooting trees are read from the top down. The boxes contain instructions you can follow. These instructions sometimes refer to other more detailed instructions further on in the document. After having carried out the instructions, you should continue to the next set of instructions indicated by the arrows.

S-a basic check

Before and after troubleshooting the XPI fuel system, check the following:



S-b Start up check

S-b Check that there is fuel in the tank and that it does not contain water.

There is fuel and no water in the tank

There is no fuel or there is water in the tank

The cause may be no fuel or water in the tank. Rectify the problem and continue from S-a.

Pump with the hand pump until resistance builds up. Check for external fuel leaks at the feed pump, filter housing and fuel pipes. Open the ventilating valve to release the pressure

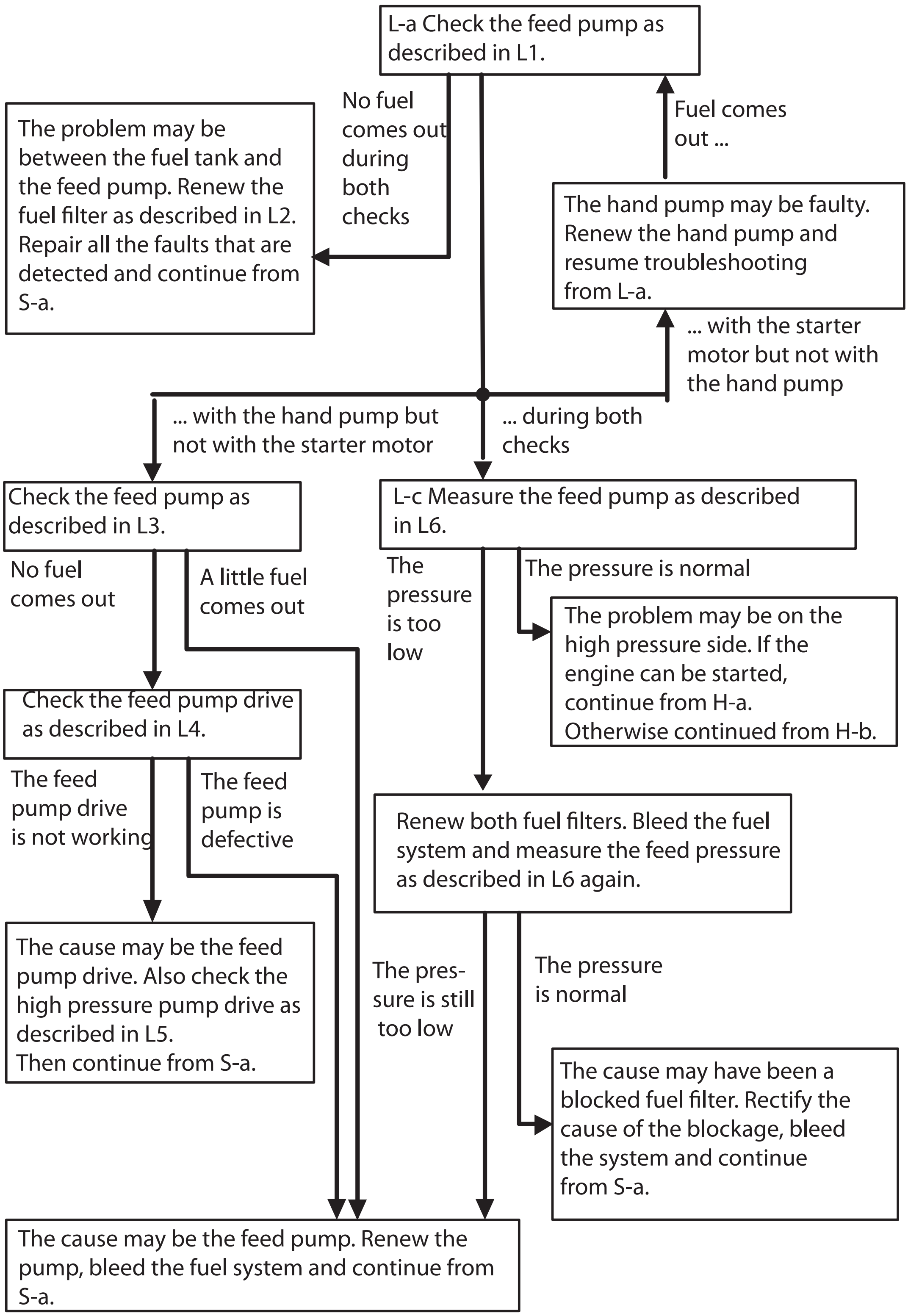
There is no external leakage or it is not possible to build up the pressure

There is external leakage

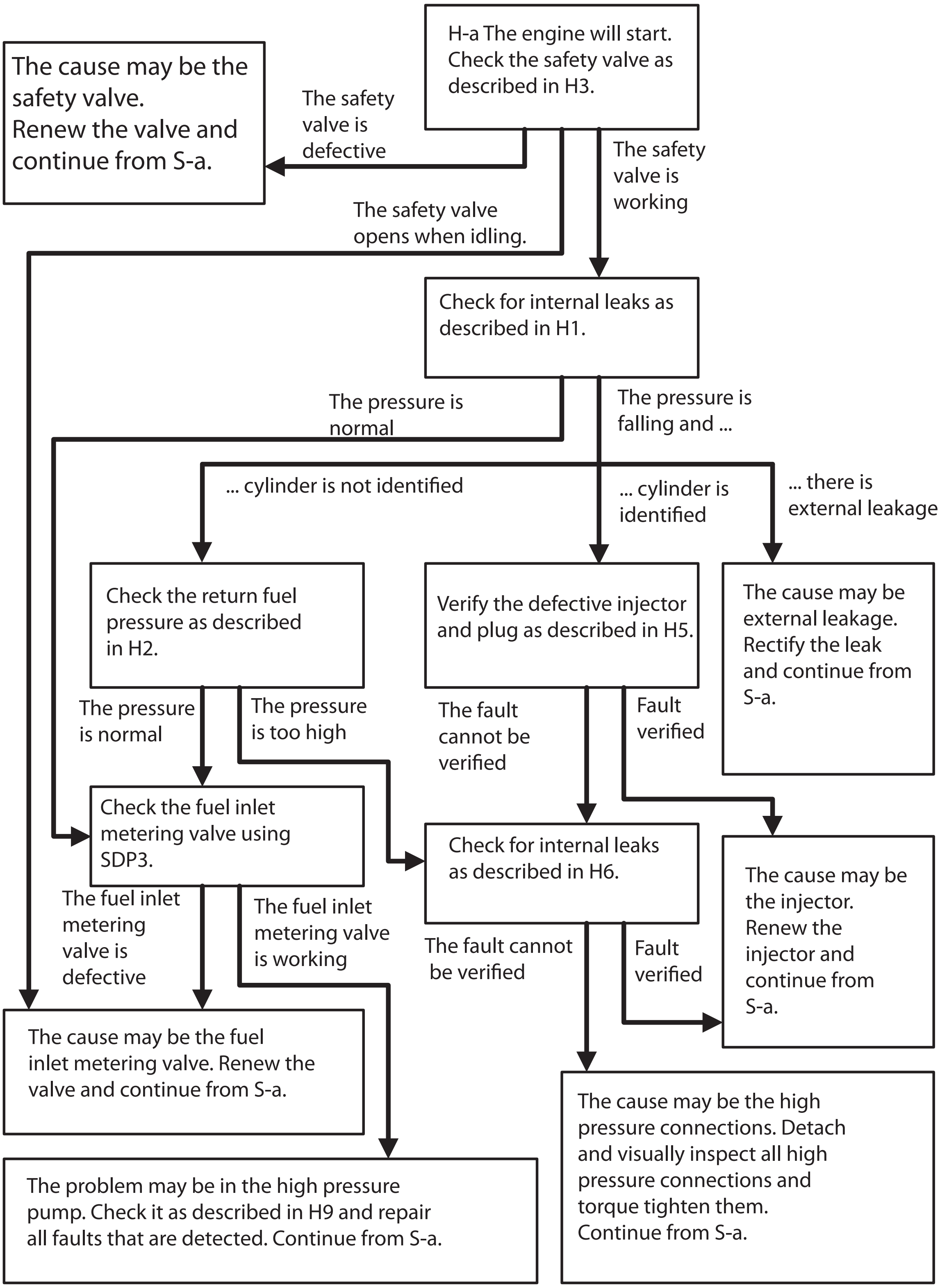
The cause may be external leakage. Rectify the leakage and continue from S-a.

The problem may be present in the low pressure section or in the high pressure section. Start by troubleshooting the low pressure section from L-a.

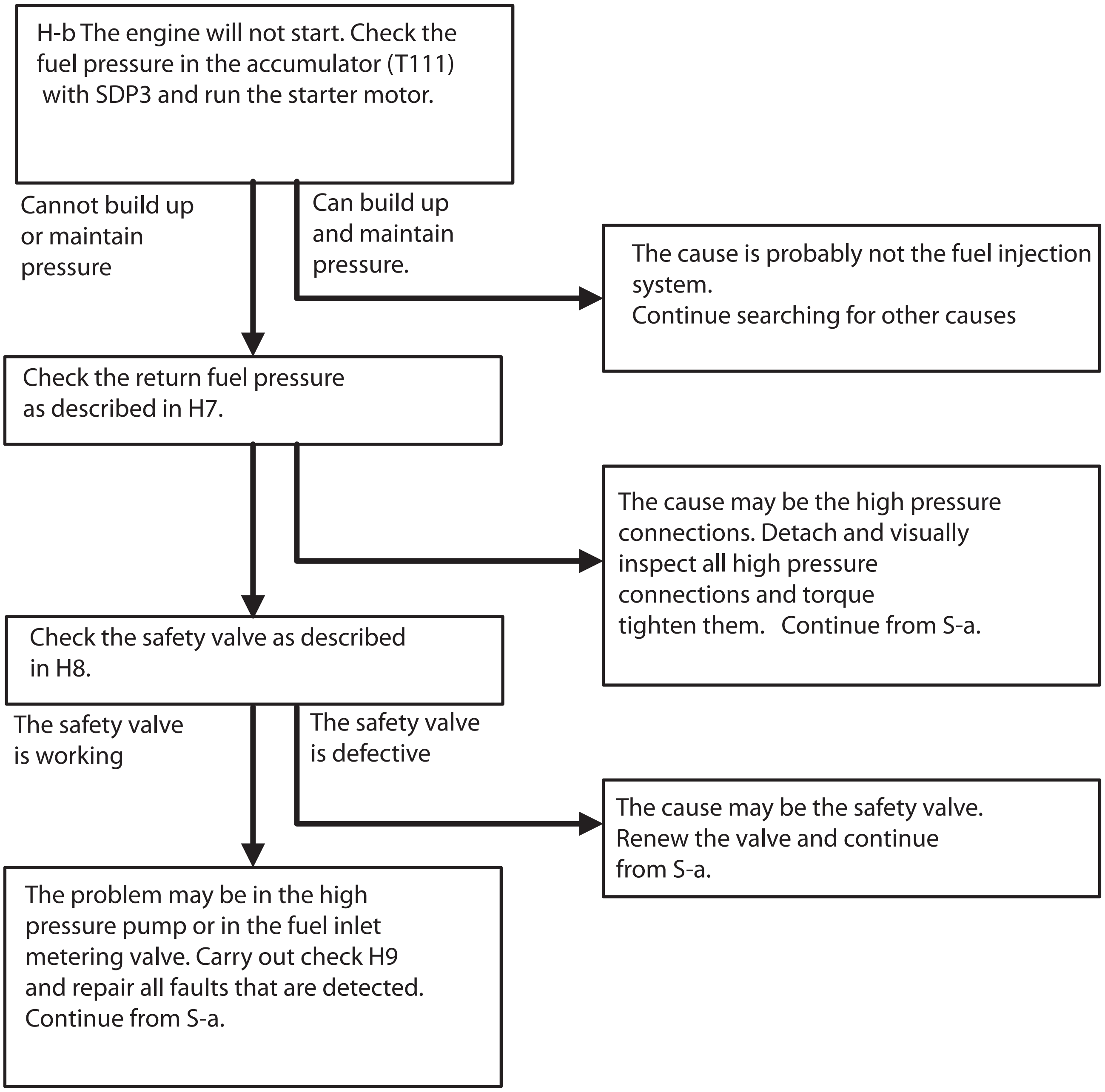
L-a Low pressure check



H-a High pressure check when the engine will start



H-a High pressure check when the engine will not start.



Descriptions, Low pressure check

L1 – Low pressure check

1. Open the test connection on the high pressure pump.
2. Pump using the hand pump. Check that fuel comes out of the test connection.
3. Turn the engine over using the starter motor. Check that fuel comes out of the test connection.
4. Close the test connection.

L2 – Checking the suction filter

Note: When renewing the suction filter, check the following with the suction filter removed.

1. Pump with the hand pump and check that fuel free from air flows out of the hole on the inside of the filter housing.
2. If no fuel comes out, check the suction strainer and all joints on the suction pipe up to the fuel tank armature. Renew the seals and check-tighten the connections.
3. If fuel comes out, fit a new filter and bleed the fuel system.

L3 – Checking the feed pump

1. Detach the pipe for outlet fuel from the feed pump. Place a container under the free end of the pipe.
2. Turn the engine over using the starter motor for about 20 seconds. The feed pump provides about 1.2 l/min. The correct quantity for 20 seconds is 0.3-0.4 liters.

L4 – Checking the feed pump drive

1. Remove the feed pump from the high pressure pump bracket.
2. Turn the feed pump by hand. The pump should rotate freely and the drive shaft in the pump should be intact.
3. Check that the drive pins in the high pressure pump are intact.
4. Turn the engine over using the starter motor. Check that the feed pump drive in the high pressure pump rotates.

L5 – Checking the high pressure pump drive

1. Remove the high pressure pump.
2. Turn the engine over using the starter motor. Check that the high pressure pump drive rotates in the timing gear.
3. Renew the pump drive gear if it does not rotate or is damaged. Check for resulting damage to the high pressure pump gear. Damaged gears should be renewed.
4. If the pump drive gear in the timing gear rotates and is not damaged:
   Check that the high pressure pump gear is properly seated on the shaft. If the gear is loose, the shaft may be damaged. Do not tighten the gear. Renew the high pressure pump. If the gear is jammed, the high pressure pump is defective. Renew the high pressure pump.

L6 – Checking the supply pressure at the test connection on the high pressure pump

1. Connect pressure gauge 99 362 to the test connection on the high pressure pump and open the test connection.

2. Turn the engine over using the starter motor. Read the pressure after approximately 20 seconds.
   The pressure should be more than 2 bar.

NOTE

Low feed pump pressure may be caused by a defective feed pump, or may be a symptom of a high pressure pump with a defective cylinder head. Note: Make sure that the battery level is high enough to run the engine at 90 rpm with the starter motor.

3. If the engine will start. Increase the engine speed to 1,500 rpm. Read the pressure. The pressure should be between 9 and 14 bar.

NOTE

Bear in mind when doing this that there is no method of confirming whether a fuel filter is blocked. If the complaint is that fault code 135 is activated when under heavy load, this is a probable cause. The high pressure pump can still create a pressure of between 9 and 14 bar even with a blocked filter.

4. Close the test connection and remove the pressure gauge.

Descriptions, high pressure check

H1 – Checking for internal leak

NOTE

Always use the latest version of SDP3 if possible.

For SDP3 version 2.8 onwards:

Follow the instructions for “Fuel leak test” in SDP3. For SDP3 version 2.7:

1. Start the engine

2. Start the test “Checking for internal leaks” in SDP3.

3. Switch off the engine. Read the pressure remaining in the accumulator using SDP3. There should be some pressure remaining. If the pressure falls more than 300 bar within one (1) minute, there are internal leaks.

4. Check cylinder balancing at idling speed using SDP3. Note if any cylinder deviates.

5. Perform a cylinder output test using SDP3. Note which cylinder deviates from the others by having a higher output.

6. By comparing the two results with each other, a cylinder with deviations in both tests can be identified.

NOTE

Remember that several injectors can sometimes be faulty at the same time.

H2 – Checking the return fuel pressure

1. Connect pressure gauge 99 362 to the test connection on the return fuel manifold and open the test connection.

2. Start the engine. Read the pressure with the engine idling. The pressure should be below 0.8 bar. If the pressure exceeds 0.8 bar the overflow valve on the return fuel manifold should be cleaned and visually inspected. Start again from step 1.

NOTE

When the overflow valve is removed air will be introduced, against the direction of flow. It will take some time for the system to bleed itself. During this time the measurement is not reliable. Leave the engine idling for a while before repeating the test. If the pressure still exceeds 0.8 bar, there is internal leakage in an injector.

3. Switch off the engine, remove the pressure gauge and close the test connection.

H3 – Checking the safety valve

1. Start and run the engine at idling speed for 15 seconds and then switch off with the key. Check whether the return line from the safety valve to the return fuel manifold is hot.

2. If it is hot this is because the safety valve was open when the engine was last run. The most probable cause of this is that the fuel inlet metering valve is stuck in the open position. Continue troubleshooting by renewing the fuel inlet metering valve.

3. If the return line is not hot, start the engine and run the check “Leak testing the safety valve” with SDP3 without removing the return line.

WARNING

For safety reasons it is important that the return line is not removed during step 3. If the safety valve were to open during the check with the line removed, hot fuel would spray out with great force.

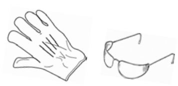
4. If the return line becomes hot during the check “Leak testing the safety valve” the safety valve is faulty. Continue troubleshooting by renewing it.

5. If the return line does not become hot but the accumulator pressure does not reach 2,400 bar, the safety valve is probably working. Cancel the check and continue troubleshooting the fuel system.

WARNING

The accumulator may be under high pressure. Reduce the pressure using SDP3 before starting work. Wear protective goggles

There is a risk of burn injuries when the safety valve is open.



6. If the return line does not become hot and the accumulator pressure reaches 2,400 bar, remove the return line and run the check “Leak testing the safety valve” again. If the safety valve leaks more than 3 drops a minute it is faulty and needs to be renewed.

7. Refit the engine pipes. Torque tighten.

H5 – Verification of a faulty injector

1. Remove the high pressure pipe to the injector which has been identified in H1.

2. Plug the outlet of the identified injector at the outlet port on the fuel accumulator using tool 99 019. If the outlet port of cylinder 1 has to be plugged, see the instructions in TI 03-08 01 28.

3. Start the engine and repeat H1. This system should be able to maintain pressure.

NOTE

Remember that several injectors can sometimes be faulty at the same time. Therefore if a faulty injector cannot be verified, plug it and repeat step H1. If no other faulty injector can be verified, continue troubleshooting as described in H6.

H6 – Checking for internal leaks

Wear protective goggles.There is a risk of fuel spraying from the high pressure connections when pressurised.

The accumulator may be under high pressure.
Reduce the pressure using SDP3 before starting work.

A tool must be made to determine whether the fuel system is leaking. A pressure regulator, a shut-off valve, two hose couplings, hose clamps, hose and Tema quick release coupling 1100N for connection to the test connection are required. Assemble the parts as illustrated on the next page. It is vital that all couplings and connections are tight.

1. Detach and remove all high pressure pipes between the accumulator and the high pressure connections.

2. Connect the tool to the test connection on the return fuel manifold and open the test connection.

Important !

Open the fuel filler cap so that the pressure does not deform the tank.

3. Pressurise the return fuel manifold. Slowly increase the pressure. Listen for a bubbling noise in the tank. The bubbling noise indicates at what pressure the overflow valve opens. The pressure should be higher than 0.5 bar. Then pressurise the manifold to max. 3 bar.

4. Listen for return leakage in the injectors by blocking one high pressure connection at a time and quickly removing the obstacle. If there is internal leakage in the injector, a hissing sound will be heard.

5. Renew the injector or injectors with internal leakage as described above. When renewing an injector, the tuning code of the new injector must be programmed to the correct cylinder using SDP3 and basic setting of injector adaptation must be performed.

Important !

After renewing an injector with internal leakage, the engine oil must be changed and the oil filter renewed. If there is internal leakage, soot quickly builds up in the engine oil. (For fluid type and specifications, refer to the Hyundai Operating & Maintenance Manual Chapter 6)

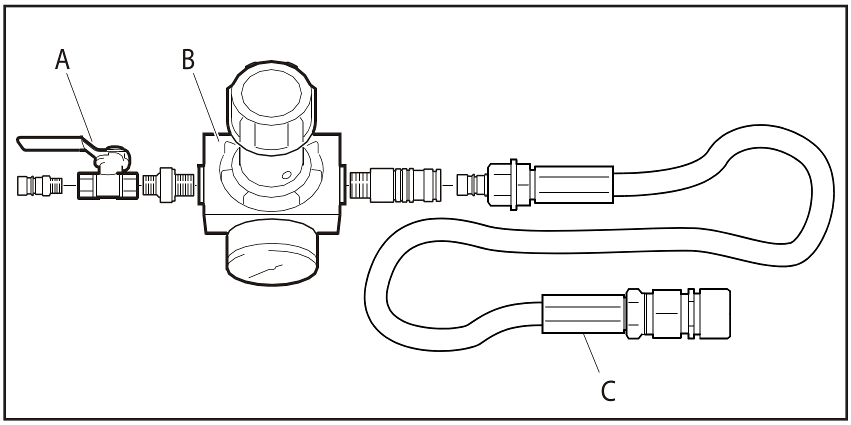


Figure 320

Tools for test pressurising the fuel system
A - Shut-off valve
B - Pressure regulator
C - Hose for connection to the fuel system

H7 – Checking the return fuel pressure

1. Connect pressure gauge 99 362 to the test connection on the return fuel manifold and open the test connection.

2. Crank the engine using the starter motor. Read the pressure after approximately 20 seconds. The pressure should be below 0.8 bar.

3. If there is no detectable value after 20 seconds, let the starter motor cool and repeat step 2.

NOTE

If there is air in the filter housing, pressure cannot build up. Vent the filter housing and try again.

4. Remove the pressure gauge and close the test connection.

H8 – Checking the safety valve

1. Remove the return line from the safety valve to the return fuel manifold so that it vents straight out into the atmosphere.

2. Crank the engine using the starter motor. If fuel leaks out of the safety valve, it is faulty and must be renewed.

3. Refit the engine pipes. Torque tighten.

H9 – Checking the high pressure pump

1. Check the cylinder head on the high pressure pump as described in the workshop manual, see section 03-00 Fuel system Scania XPI. If a fault is detected, then renew the cylinder head.

2. If the cylinder head is OK or if there are still problems, it may be due to a defective fuel inlet metering valve. Try fitting a new fuel inlet metering valve.

3. If the problem still persists, the problem may be in the high pressure pump. Renew the high pressure pump and continue to S-a to confirm.

Descriptions, High pressure check

Checking for internal leaks

1. Start the engine.
2. Start the test "Checking for internal leaks " in SDP3.
3. Switch off the engine. Read the pressure remaining in the accumulator using SDP3. There should be some pressure remaining. There are internal leaks if the pressure approaches 0 bar within 1 min.

H2 - Checking the return fuel pressure

1. Connect pressure gauge 99 362 to the test connection on the return fuel manifold and open the test connection.

2. Start the engine. Read the pressure with the engine idling. The value should be below 0.8 bar. If the pres sure exceeds 0.8 bar the overflow valve on the return fuel manifold should be cleaned and visually inspected.

Start again from step 1.

NOTE

When the overflow valve is removed air will be introduced, opposite the flow direction. It will take some time for the system to bleed itself. During this time the measurement is not reliable. Leave the engine idling for a while before repeating the test. If the pressure still exceeds 0.8 bar, there is internal leakage in an injector.

3. Switch off the engine, remove the pressure gauge and close the test connection.

H3 - Checking the safety valve for leaks

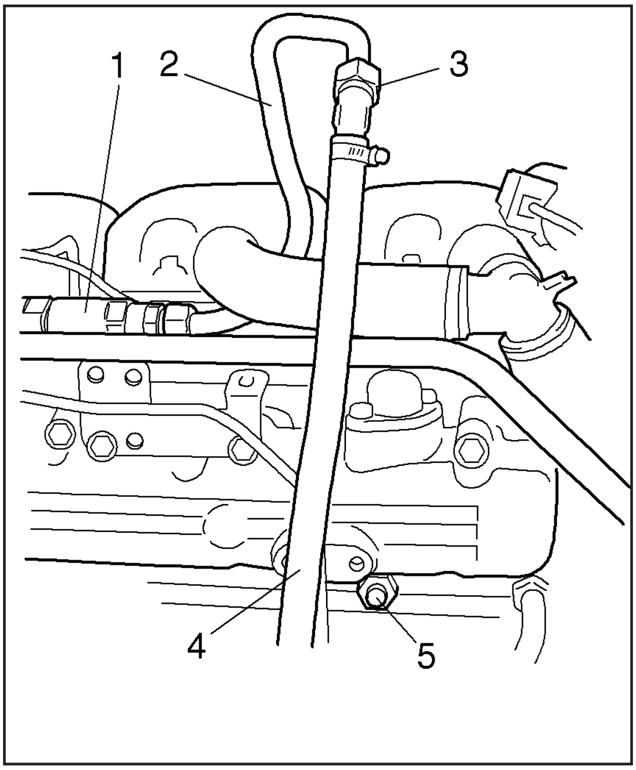


Figure 321

WARNING

The accumulator may be under high pressure. Reduce the pressure using SDP3 before starting work.

Wear protective goggles.

There is a risk of burn injuries when the safety valve is open.

1. Remove the return pipe 2 from the safety valve 1 to the return fuel manifold 5.
2. Plug the connection in the return fuel manifold with cap nut 812 890 or 814 555 and sealing plug 813 878.
3. Refit the return pipe at a slight angle to the engine. Connect a transparent hose 4 to a union 3 - 366 082 on the pipe. Pull the hose down into a can or similar.
4. Start the engine.
5. Start “Checking the safety valve for leaks” in SDP3. Follow the instructions in the check.
6. Refit the engine pipes. Torque tighten.

If the check failed:

Check that the following starting conditions have been met and try again.

- The engine must be running.
- Parking brake activated.
- Gearbox in neutral.
- Clutch pedal released.

H4 - Checking injectors using SDP3

1. Check cylinder balancing at idling speed using SDP3. Note if any cylinder deviates.
2. Perform a cylinder output test using SDP3. Note which cylinder deviates from the others by having a higher output.
3. By comparing the two results with each other, a cylinder with deviations in both tests can be identified. Continue troubleshooting on the injector for that cylinder.

H5 - Verification of a faulty injector

1. Remove the high pressure pipe to the injector which has been identified in H4.
2. Plug the outlet of the identified injector at the outlet port on the fuel accumulator using tool 99 019. If the outlet port of cylinder 1 has to be plugged, see the instructions in TI 03-08 01 28.
3. Start the engine and run it at idling speed for at least 15 seconds.
4. Switch off the engine. Read the pressure remaining in the accumulator using SDP3. If the pressure is more than 0 bar after 1 minute, the faulty injector has been found and must be renewed. If the faulty injector cannot be verified, continue troubleshooting in accordance with H6.

H6 - Checking for internal leak

WARNING

Wear protective goggles.

There is a risk of fuel splashing from the high pressure connections when pressurised.
The accumulator may be under high pressure. Reduce the pressure using SDP3 before starting work.
A tool must be made to determine whether the fuel system is leaking. A pressure regulator, a shut-off valve, two hose couplings, hose clamps, hose and Tema quick release coupling 1100N for connection to the test connection are needed. Assemble the parts as illustrated on the next page. It is vital that all couplings and connections are tight.

1. Detach and remove all high pressure pipes between the accumulator and the high pressure connections.
2. Connect the tool to the test connection on the return fuel manifold and open the test connection.

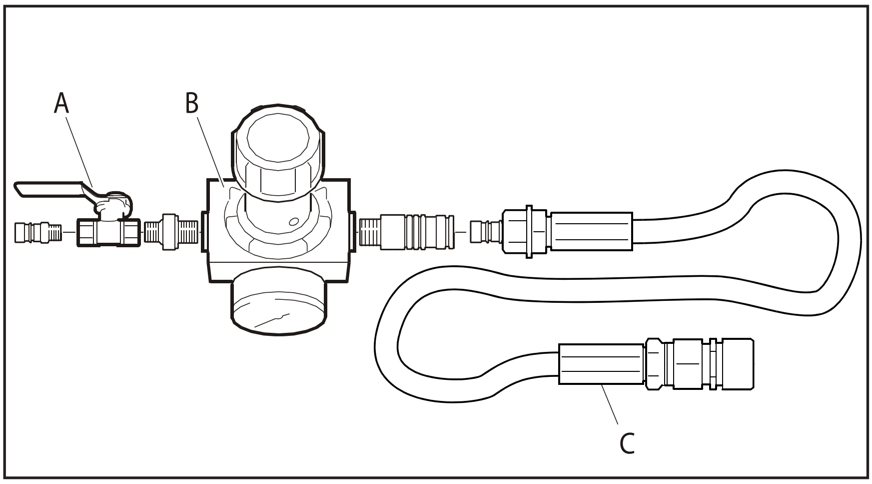
CAUTION

Open the fuel filler cap so that the pressure does not deform the tank.

3. Pressurise the return fuel manifold. Slowly increase the pressure. Listen for a bubbling noise in the tank. The bubbling noise indicates at what pressure the overflow valve opens. The pressure should be higher than 0.5 bar. Then pressurise the manifold to max. 3 bar.
4. Listen for return leakage in the injectors by blocking one high pressure connection at a time and quickly removing the obstacle. If there is internal leakage in the injector, a hissing sound will be heard.
5. Renew the injector or injectors with internal leakage as described above.
6. When renewing an injector, the tuning code of the new injector must be programmed to the correct cylinder using SDP3 and basic setting of injector adaptation must be performed.

IMPORTANT!

After renewing an injector with internal leakage, the engine oil must be changed and the oil filter renewed.
If there is internal leakage, soot quickly builds up in the engine oil. (For fluid type and specifications, refer to the Hyundai Operating & Maintenance Manual Chapter 6)



Tools for test pressurising the fuel system
A - Shut-off valve
B - Pressure regulator
C - Hose for connection to the fuel system

Figure 322

H7 - Checking the return fuel pressure

1. Connect pressure gauge 99 362 to the test connection on the return fuel manifold and open the test connection.
2. Turn the engine over using the starter motor. Read the pressure after approximately 20 seconds. The value should be below 0.8 bar.
3. if there is no detectable value after 20 seconds, let the starter motor cool and repeat step 2.

NOTE

If there is air in the filter housing, pressure cannot build up. Vent the filter housing and try again.

4. Remove the pressure gauge and close the test connection. H7 - Checking the return fuel pressure

H8 - Checking the safety valve

WARNING

The accumulator may be under high pressure. Reduce the pressure using SDP3 before starting work. Wear protective goggles.

1. Remove the return pipe 2 from the safety valve 1 to the return fuel manifold 5.
2. Plug the connection in the return fuel manifold with cap nut 812 890 or 814 555 and sealing plug 813 878.
3. Refit the return pipe at a slight angle to the engine. Connect a transparent hose 4 to a union 3 - 366 082 on the pipe. Pull the hose down into a can or similar.
4. Turn the engine over using the starter motor. If fuel leaks out of the safety valve, it is faulty and must be replaced.
5. Refit the engine pipes. Torque tighten.

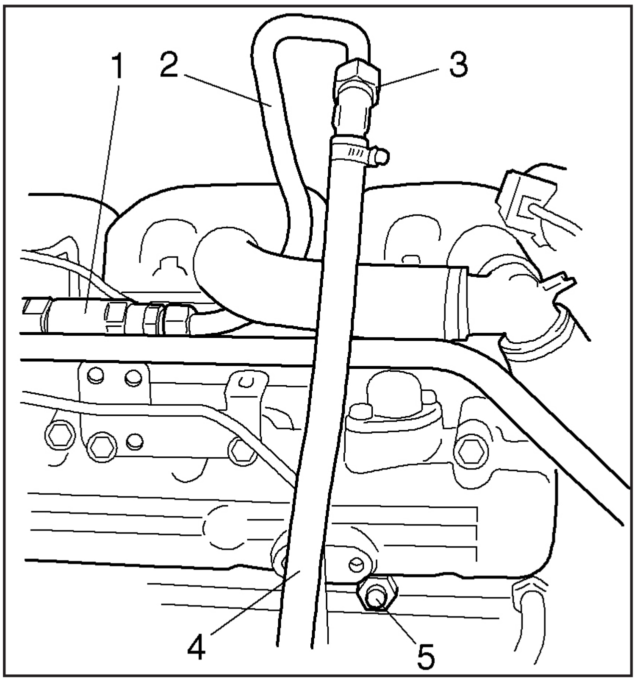


Figure 323

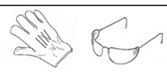
H9 - Renewing the cylinder head on the high pressure pump

WARNING

The fuel system has a very high fuel pressure of up to 3,000 bar. The fuel system must be depressurised before any work is started. Use SDP3 to minimise the high pressure in the fuel system. A jet of fuel at high pressure can cut through the skin. The system should always be treated as pressurised, even when the engine is switched off.

NOTE

Wear protective gloves and goggles.



WARNING

The fuel system is very sensitive to dirt. It is therefore very important that everything is as clean as possible when work is carried out on the fuel system.

Do not use compressed air to blow components in the fuel system clean.

When cleaning, cloths or paper which shed fibres must not be used. Use lint-free cloths.

Clean tools before use.

Do not use worn chrome-plated tools as flakes of chrome may come off.

Plug or tape connections on components which are removed.

CAUTION

A high pressure pipe that has been detached or removed must never be refitted but must be replaced with a new one.

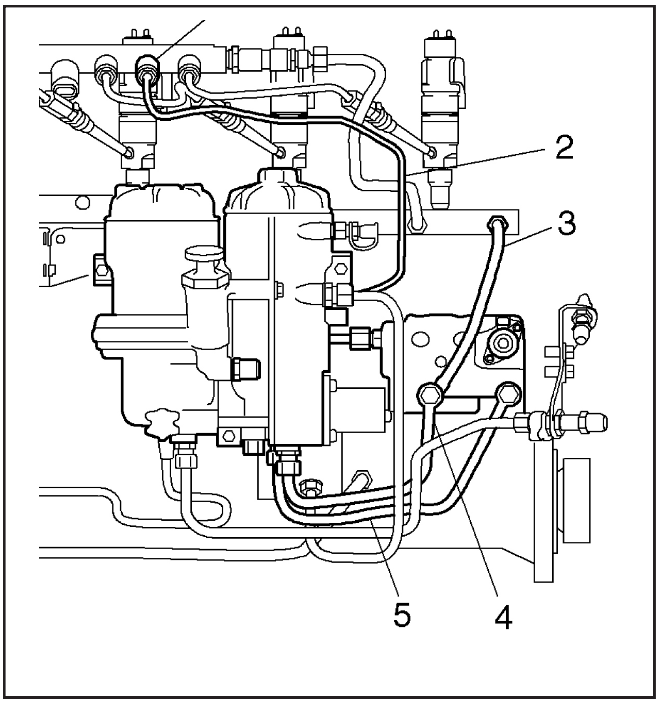


Figure 324

NOTE

The high pressure pipe must not be reused.

9. Clean the pump surface that faces against the cylinder head. Check that the guide pins under the roller tappets are straight and that the roller tappets are correctly positioned so that they go down completely in their seats. Screw the cylinder head bolts in alternately.
Tightening torque 68 Nm.

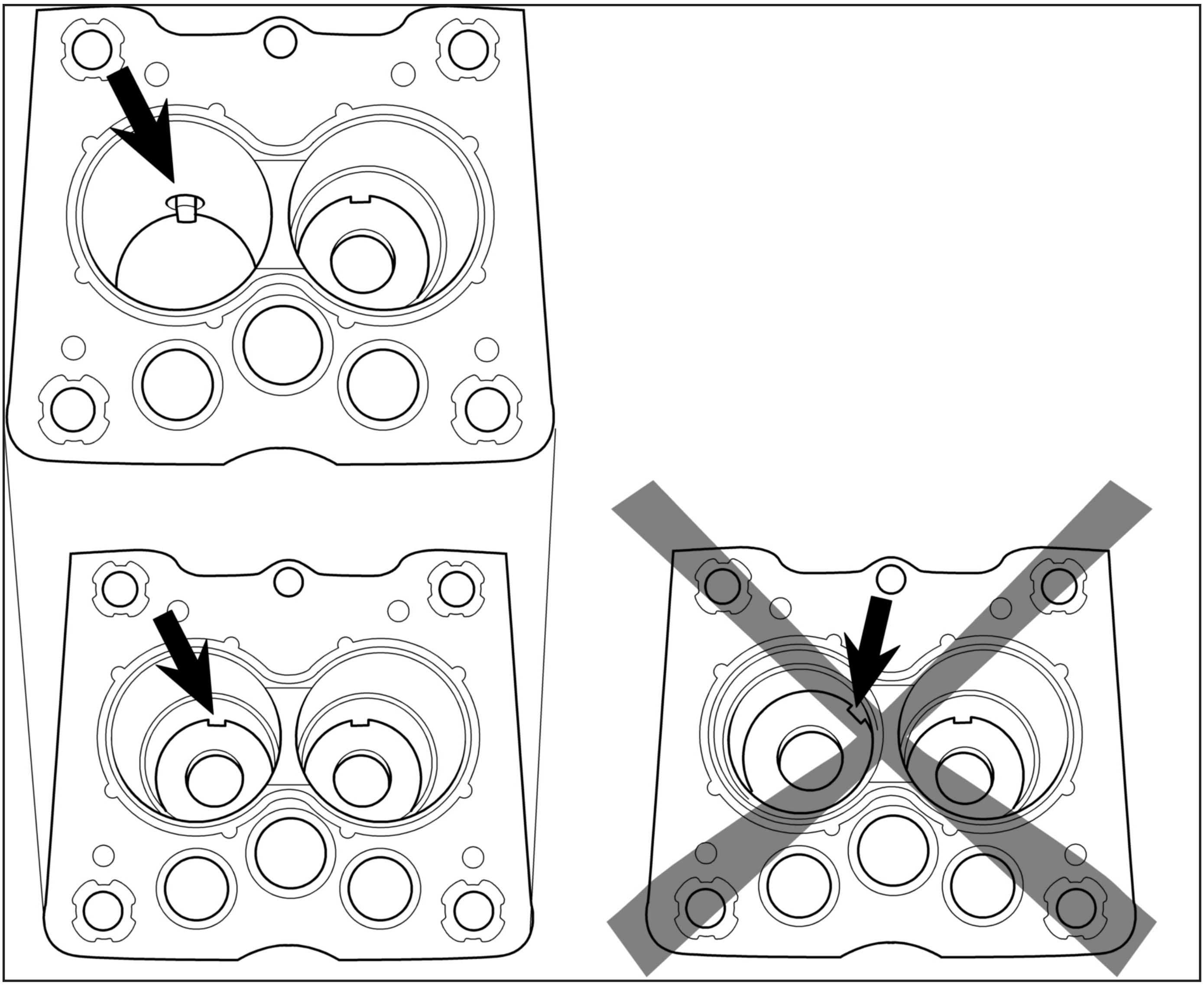


Figure 325

10. Fit the pipes (3, 4 and 5). Use new washers. Tightening torque for the banjo unions - 55 Nm.

11. Fit a new high pressure pipe (2). Tightening torque - 38 Nm.

12. Fit the high pressure pipe brackets. Tightening torque 22 Nm.

13. Fit the cable connection.

14. Test start and delete the fault codes.

Diagnostic procedure

Use of diagnostic kit

1. Disassemble cover inside cab right side rear for connection point.

Figure 326

Connection point Canpc + Testman

Connect diagnostic cable to laptop.

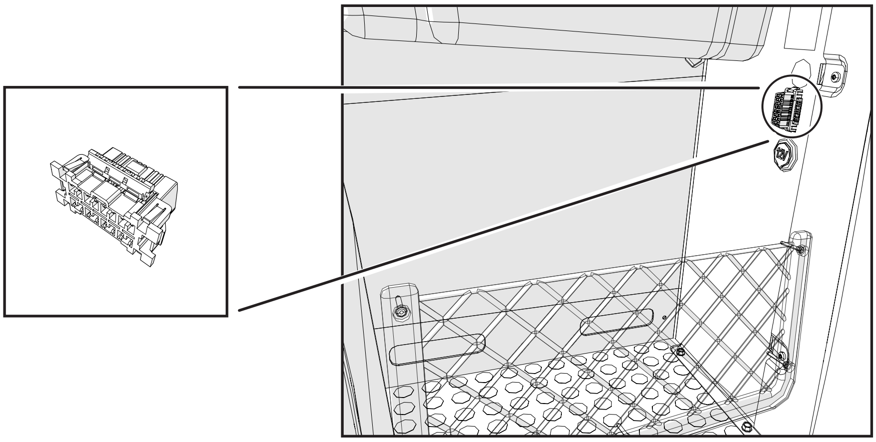


Figure 327

Can bus overview

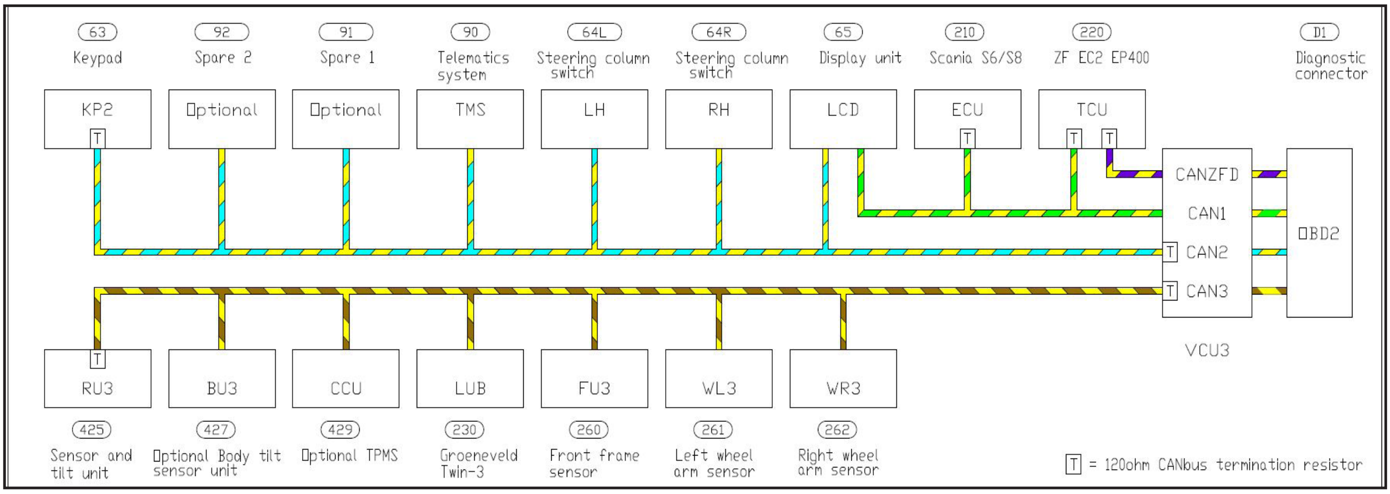


Figure 328

SDP3 Scania diagnostic

On left side of the engine there is the connection point for VCI (Scania Diagnostic tool).

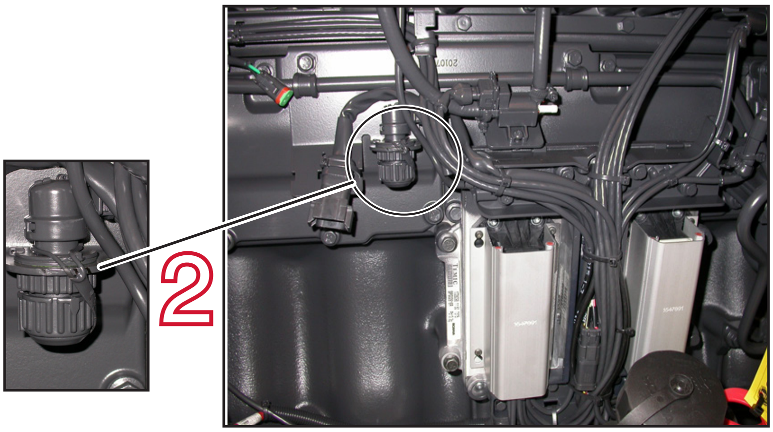


Figure 329

Connect the VCI:

1. Switch on the laptop.
2. Connect the cabelend (2) to the engine testport.
3. Connect the USB plug (3) to the Laptop.
4. Put in the USB-licence key.
5. Switch on the ignition key (If read the setting parameters).
6. Start on laptop the engine SDP3.
7. Start the engine. (If controlling of the parameters).

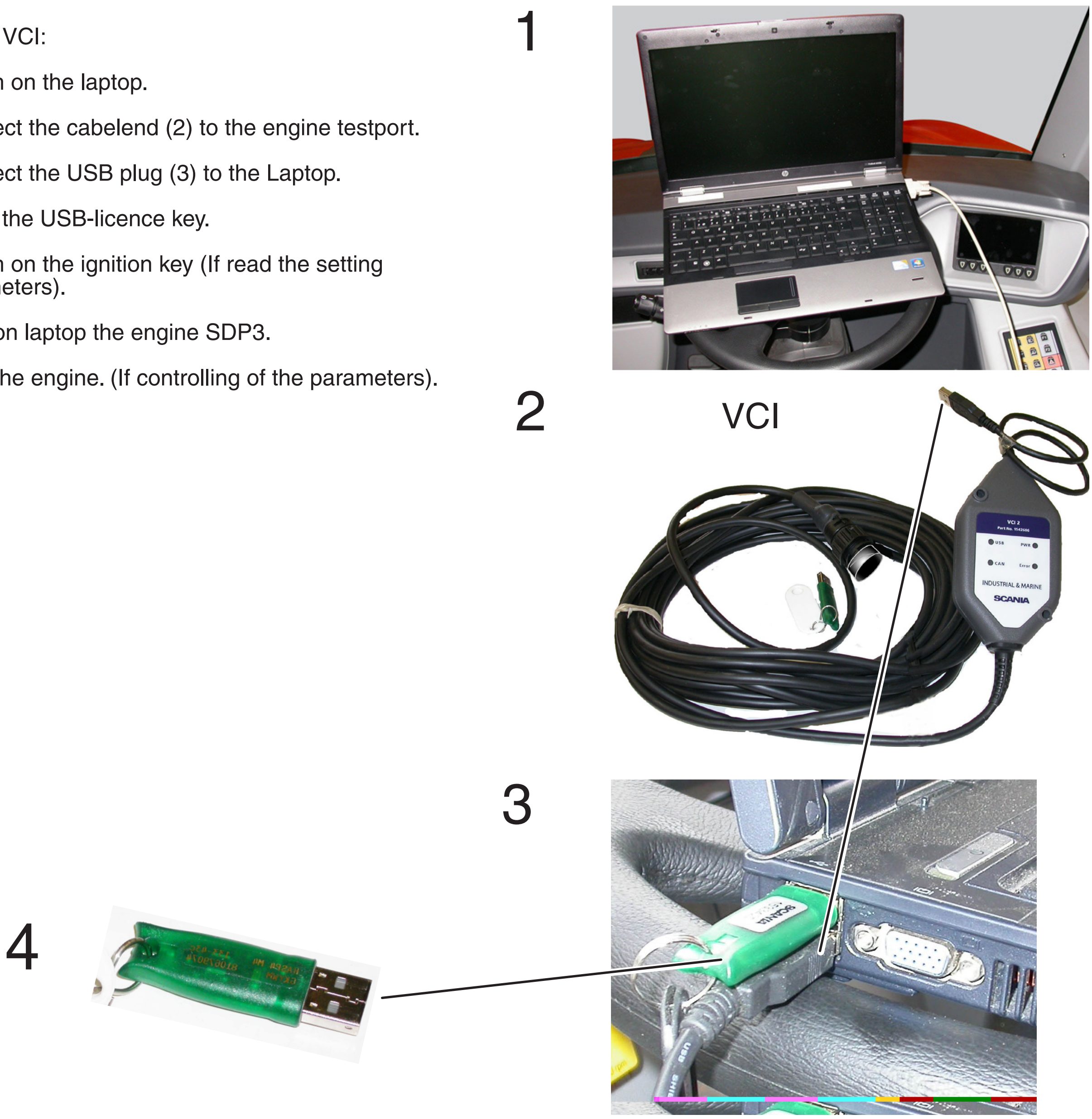


Figure 330

Troubleshooting Manual

The trouble shooting schedule is intended as a guide and source of ideas for practical trouble shooting carried out on the spot by experienced mechanics. The schedule contains the causes of faults which they the Scania have encountered over the years and it will be expanded with new causes of faults as they occur and as we gather knowledge about them.
If you like, use the form on the last page to report anything you think is missing from the trouble shooting schedule. That is the best way of keeping it up-to-date. The columns in the trouble shooting schedule headed “Trouble shooting” and “Action” describes such matters th at are not covered in other parts of the workshop manual. If these columns are empty, instructions can be found in other sections.

White smoke

Effect	Cause	Trouble shooting	Action
Incompletely burnt fuel	Cold engine	The white smoke starts to turn blue and disappears when the engine is warmed up	- If possible: reduce engine speed or put the engine under load - Install a white smoke limiting device (exhaust brake) - Install flame heater - Install an engine heater
Too much fuel in relation to air at low combustion temperatures	Injection timing too late		
	Inlet valve does not open properly. Valve adjustment disturbed		
	Broken delivery valve spring, uncontrolled injection	Disconnect one delivery pipe at a time and listen for changes in the engine sound. WARNING! Be careful when disconnecting the delivery pipes as the pressure is extremely high and could cause injury	
	Leaky injector, dripping?		

White smoke, water vapour

Effect	Cause	Trouble shooting	Action
Water in the combustion chamber	Leaky charge air cooler	Test pressure (air 0.5 bar, liquid 4 bar)	
	Leaky cylinder head gasket	The fault is also present when the engine is hot	
	Cracked water-cooled exhaust manifold		
	Cracked cylinder head (not cracks between valve seats).	If the fault is hard to trace: Change all cylinder heads for exchange cylinder heads. (Or test pressurize all cylinder heads. Heat the cylinder heads before pressurizing them.)	
	Crack in cylinder liner		

Effect	Cause	Trouble shooting	Action
Too much fuel in relation to air at high combustion temper atures	"Adjusted" injection pump, attempt to boost	Check the lead seal	- Test in test bench
	Injection timing too late		
	Inlet valve does not open properly. Valve adjust-ment disturbed		
	Broken delivery valve spring, uncontrolled injection	Disconnect one delivery pipe at a time and listen for changes in the engine sound. WARNING! Be careful when disconnecting the delivery pipes as the pressure is extremely high and could cause injury	
	Leaky injector, drip-ping?		
	Nozzle tip jams		
	Incorrect spray pattern from nozzle		
	More than 1 washer under injector		
	Fault in turbo	Check charge air pres-sure	
	Clogged air filter		
	High exhaust counter-pressure	See trouble shooting for High exhaust temperature	
	Worn intake valves		
	Clogged intake port		

Black smoke on starting

Effect	Cause	Trouble shooting	Action
Engine difficult to start	Binding control rack	Open the cover (RQ/ RQV) or hexagon (RSV) on the governor and check with a finger on the control rod that it goes to the maximum stop bracket. (This applies to engines without a smoke limiter on the governor hous-ing.)	- Take the pump to a Bosch workshop for repair

Blue smoke

Effect	Cause	Trouble shooting	Action
	Oil coating past piston rings		
	Oil leakage in turbo-charger	Check for oil in the intake manifold after the turbocharger	
	Damaged piston cooling nozzles		- Change damaged nozzles
	Petrol in diesel oil		

Fuel in the oil

Effect	Cause	Trouble shooting	Action
Dilution of oil in sump	Unburnt fuel passes the piston		- Normally about 1% of fuel in the lubricating oil per 200 h
	Defective injector		
	Internal leakage in injection pump (worn pump element or crack in pump housing)		
	Worn/broken O-ring at feed pump pushrod		
	Frequent cold starts		
Dilution of oil in sump	Worn engine	Check "blow-by" in crankcase Correct value for new engine: 0 - +10 mm wc (flow rate 60 - 100 l/min.) Closed crankcase ventilation: -50 - +20 mm wc	
	Intake valve not opening		

Oil in coolant

Effect	Cause	Trouble shooting	Action
	Oil cooler leaks when engine is running	Test pressurize the oil cooler Note: classed oil cooler, test pressurized: 10 bar oil on the oil side, 0.5 bar air on the water side, immersed in water 25 - 27° C	
	Defective cylinder head gasket		
	Crack in cylinder head (not cracks between valve seats). (On 11-series engines: look for cracks between the water jacket and oil duct.)	If the fault is hard to trace: Change all cylinder heads for exchange cylinder heads. (Or test pressurize all cylinder heads. Heat the cylinder heads before pressurizing them.)	

Coolant/water in oil

Effect	Cause	Trouble shooting	Action
Dilution of oil in sump	Oil cooler leaks when engine is not running	Test pressurize the oil cooler, see above	
	Leaky O-rings at cylinder liner	Leakage in telltale hole?	- Change liner seals
	water is condensed in crankcase ventilation and runs down into the sump		
	14-series engine: Clogged drain hole in coolant pump in combination with leaking pump seal		
Dilution of oil in sump	Crack in cylinder head	Run the engine until warm. Remove the oil sump and all side covers. Test pressurize the cooling system. If coolant seeps out behind side covers or at the camshaft bearing there is probably a crack in one of the cylinder heads. As a rule it is possible to see which cylinder head or heads are leaking.	- Change the cylinder head for a exchange cylinder head - If no leakage can be found, change <u>all</u> cylinder heads for exchange cylinder heads
	Crack in water jacket on cylinder block/cylinder head. (Coolant runs down through the push rod hole.)		
	Crack in water jacket on cylinder head. (Coolant runs down via the oil duct for rocker arm lubrication.)		
	Cracked water-cooled exhaust manifold		
	Leakage in charge air cooler core	Test pressure (air 0.5 bar, liquid 4 bar)	
	Water enters via the exhaust/intake system		- Install a self-closing cover on the exhaust pipe - Position the air cleaner so that water cannot run into it

Low oil pressure

Effect	Cause	Trouble shooting	Action
Gauge shows low pressure	Defective sensor/instrument	Take a reading of the oil pressure on warmed-up engine using a mechanical pressure gauge directly on the engine: Minimum 1 bar at 800 r/min. Maximum 6 bar > 800 r/min. Obs! Single-speed engines must not be tested at 800 r/min. Risk of damage to the flexible coupling	
	Incorrectly adjusted oil relief valve		- 1 shim = 0.2 bar (screw adjustment on 14-series engines)
	Broken spring in oil relief valve (14-series engines, earlier version)	Max. oil pressure 2 bar at 2000 r/min	- Check/remedy relief valve
	The piston in the oil relief valve has jammed in open position		
Gauge shows low pressure	Loosened guide plates in the oil cooler prevent passage of the oil		
	Worn/damaged oil pump		
	Plug in cylinder block under the relief valve has come loose (11-series engine)		
	Clogged oil cooler		
	Seized/worn bearings in compressed air compressor, see Compressed air sys.	Pressure varies when compressor charges/ relieves	
	Loose screws in timing gear's intermediate gear		
	Crankshaft bearing/main bearing of wrong size has been fitted on reground crankshaft	Max. oil pressure 2 bar also when engine cold	- Change to bearings of the correct size. Check the bearing seats before assembly
	Excessive play in big-end and main bearings		
	Seizing in camshaft bearings	If the bushing slides all the way out of the bearing seat, the oil pressure warning lamp will come on. The engine throws out oil through the crank case ventilation	

Continuation next page

	Piston cooling nozzle has come loose		
	Seizing in the bearing on engine power take-off ED140 (14-series engine)	Oil pressure can be increased ~ 1 bar when the power take-off is under load	
	Loosened oil duct plugs at camshaft bearing seats, under the protection plate in the V (14-series engine)	Pressure drops to 0 bar	
	Suction pipe to oil pump has come loose, the pump sucks air		
	Engine too hot		
	Extremely low lubricating oil viscosity		- Choose a viscosity that is suitable for the ambient temperature
	Worn bushings or loose shaft in oil cleaner		- Change rotor if bushing is worn oval - Change worn/damaged shaft
	Broken O-ring on cyclone part of oil cleaner		
	Defective oil pump drive		
	Internal leakage in oil cleaner Loosened guide plates in the oil cooler prevent passage of the oil	Check that the oil cleaner is correctly assembled	
	Worn/damaged oil pump Plug in cylinder block under the relief valve has come loose (11-series engine)		
	Clogged oil cooler		
	Seized/worn bearings in compressed air compressor, see also page	Pressure varies when compressor charges/relieves	
	Loose screws in timing gear's intermediate gear		
Gauge indicates low pressure at maximum speed but not at idling speed	The main oil duct (to piston cooling nozzles) plug in the rear of the engine has come loose (also at front of engine, 9-series engine)	Oil pressure at idling/low engine speed is not affected since the delivery valve closes at 3 bar	
No oil pressure at idling speed (14-series engine)	Oil valve sleeve screwed out of oil pump housing (gives "by-pass" and disables the overflow valve)	Check that the oil valve sleeve is correctly fitted	- Tighten the oil valve sleeve - If damaged, change the sleeve

High oil pressure (engine warmed up)

Effect	Cause	Trouble shooting	Action
Gauge indicates high pressure	Defective sensor/instrument	Take a reading of the oil pressure on the warmed-up engine using a mechanical pressure gauge directly on the engine: Minimum 1 bar at 800 r/min. Maximum 6 bar > 800 r/min. Note! Single-speed engines must not be tested at 800 r/min. Risk of damage to the flexible coupling	
	Oil viscosity too high		- Choose a viscosity that is suitable for the ambient temperature
Gauge indicates high pressure	Incorrectly adjusted oil relief valve		- 1 shim = 0.2 bar (screw adjustment on 14-series engines)
	Piston in oil relief valve jammed in closed position		
	Valve in oil duct to piston cooling nozzles is binding		

Abnormal wear (liner, piston rings, etc.)

Effect	Cause	Trouble shooting	Action
Short service life	Unclean induction air due to inadequate filtering (wrongly dimensioned air filter)	Wear ridge (ring travel shoulder) at piston top dead centre	- Fit a more efficient air filter
	Unclean intake air due to leakage in intake piping		
	Wrong grade of oil, polishing damage		
	Changing of filters and oil has been neglected		
	Low coolant temperature (cold engine)		
	Excessive sulphur content in fuel		- Change the fuel - Change to oil with a higher base number - Shorter oil change intervals
	Defective injector (causes oil film to be washed off)		

Vibration, no driven components engaged

<table>
<tr><th>Effect</th><th>Cause</th><th>Trouble shooting</th><th>Action</th></tr>
<tr><td rowspan="7"></td><td>Wrong injection timing</td><td></td><td></td></tr>
<tr><td>Broken delivery valve spring</td><td colspan="2" rowspan="2">Disconnect one delivery pipe at a time and listen for changes in the engine sound.
WARNING!
Be careful when disconnecting the delivery pipes as the pressure is extremely high and could cause injury</td></tr>
<tr><td>Individual injectors not operating</td></tr>
<tr><td>Fan imbalance</td><td rowspan="7"></td><td rowspan="7"></td></tr>
<tr><td>Flywheel has come loose</td></tr>
<tr><td>Crankshaft hub loosened</td></tr>
<tr><td>Abnormally worn main bearings</td></tr>
<tr><td>Vibration or unusual noise at
1500 - 1700 r/min</td><td rowspan="2">Defective vibration damper</td></tr>
<tr><td>Drive belts run off pulleys</td></tr>
<tr><td>Only when compressed air compressor is charging, worst at about 1000 r/min, see Compressed air sys.</td><td>Compressor operates with excessive counter-pressure (e.g. clogged piping/air dryer) or excessively high safety valve opening pressure</td></tr>
<tr><td rowspan="3"></td><td>Alignment fault</td><td>Check engine alignment</td><td></td></tr>
<tr><td>Unsuitable rubber suspension and location of same</td><td></td><td>- Change to rubber elements of different hardness</td></tr>
<tr><td>Weak engine bed</td><td>Movement at engine attachment points</td><td>- Reinforce the engine bed</td></tr>
</table>

Vibration when the clutch or reverse gear is engaged

Effect	Cause	Trouble shooting	Action
	Imbalance in driven unit		- Balance the unit
	Imbalance in clutch		
	Inadequate alignment between engine and driven unit	Check alignment	- Carry out alignment more accurately
	Unsuitable suspension of engine or driven unit		
	Weak engine bed	Movement at attachment points	- Reinforce the engine bed
	Defective flexible coupling between clutch/reverse gear and driven unit		- Change rubber element in flexible coupling (consumption item)
	Unsuitably mounted propeller shaft, e.g. excessive deflection angle or excessive deviation in parallelism between flanges		- Reposition the engine or driven unit so that the propeller shaft's working range is in accordance with recommendations
	Propeller shaft too long and weak		

Vibration when alternator is in operation

Effect	Cause	Trouble shooting	Action
	Imbalance in generator		
	Imbalance in coupling	Dismantle the coupling. Assemble the coupling halves rotated half a turn relative to each other	
	Bearing damage in alternator		
	Defective flexible coupling between engine and alternator		- Change the rubber element or type of coupling
	Fault in reduction gear		

Engine speed hunting - single-speed engines with RQ governor

Effect	Cause	Trouble shooting	Action
Hunting when engine is running under light load (15 - 20 kW) or no-load conditions	Play in flexible coupling between engine and alternator (worn coupling)	Apply a light load, at a load of about 20 kW the hunting disappears	- Change the rubber element/check the coupling hub and flange
	Play in new coupling		- Choose a coupling without play, e.g. Scania standard coupling
	Not enough flywheel mass in the driven unit, e.g. alternator		- Mount extra flywheel mass
	Skew engine brackets (engine suspension) could under unfavourable circumstances worsen engine speed hunting		- Change to harder rubber elements for the engine/alternator suspension
	Incorrect injection timing		
	Individual injectors not operating	Disconnect one delivery pipe at a time and listen for changes in the engine sound. WARNING! Be careful when disconnecting the delivery pipes as the pressure is extremely high and could cause injury	

Engine speed hunting - single-speed engines with RSV governor

Effect	Cause	Trouble shooting	Action
Engine speed hunting at 4-5% speed droop	The RSV governor should not nowadays be used for single-speed operation (except on 9-series engines)		- Change the injection pump delivery valves (1-hole or 2-hole) for 0-hole valves
Engine speed hunting at idling	Governor incorrectly adjusted		- Tighten the idling spring and adjust engine speed
	Below 700 r/min the standard starter spring, 282 544 (Bosch 1 424 650 006) is too strong		- Fit a weaker starter spring, part number 268 866 (Bosch 1 424 650 056)

Delivery pipe fractures

Effect	Cause	Trouble shooting	Action
	No clamping		
	Carelessly handled delivery pipe		
	Internal cavitation in delivery pipe Note: Single-pipe sys - tem is not permitted		Fit 0-hole delivery valves for single-speed operation

External corrosion on cylinder liner

Effect	Cause	Trouble shooting	Action
	Unsuitable corrosion protection agent, glycol or water in coolant		- Clean the cooling sys- tem and fill up with coolant as described in the maintenance instructions

Engine difficult to start

Effect	Cause	Trouble shooting	Action
Air in fuel system	Leakage in suction pipe		
	The highest fuel level in the tank is lower than the feed pump. A longer standstill (days) the fuel in the suction pipe may run back to the tank because of a leaky overflow valve		- Install a ”daily supply tank” at a higher location than the feed pump
	Leaky overflow valve		
	Low battery voltage		
	Ambient temperature too low		- Starting aids are not normally needed at temperatures above -15 ° C
	Oil viscosity too high		
	Paraffin precipitation in the fuel		
	Blocked intake or exhaust system		
	No fuel		
	Stop lever in stop position		- Check the stop solenoid and links
	Wrong injection timing		
	Faulty injector		
	Control rack/pump element will not go into the cold start position. Binding control rack/ pump element	Open the cover (RQ/ RQV) or hexagon (RSV) on the governor and check with a finger on the control rod that it goes to the maximum stop bracket. (This applies to engines without smoke limiter on the governor housing.)	- Take the pump to a Bosch workshop for repair
			- Preheat the engine combustion chambers by running the starter motor with the stop control in stop position for about 15 seconds. Then start in the usual way.

Fluid stroke

Effect	Cause	Trouble shooting	Action
Starter motor not powerful enough to pull the piston over the compression stroke (if the engine fires a connecting rod could be bent)	Leaky charge air cooler	Test pressure (air 0.5 bar, liquid 4 bar)	
	Leaky cylinder head gasket		
	Crack in cylinder head	If the fault is hard to trace: Change all cylinder heads for exchange cylinder heads. (Or test pressurize all cylinder heads. Heat the cyl-inder heads before pressurizing them.)	
	Crack in cylinder liner		
Starter motor not powerful enough to pull the piston over the compression stroke (if the engine fires a connecting rod could be bent)	Water has entered the engine via the exhaust/ intake system		- Install a self-closing cover on the exhaust pipe - Position the air cleaner so that water cannot run into it
	Crack in water-cooled exhaust manifold		
	Injector open		

Knocking/noise

<table>
<tr><th>Effect</th><th>Cause</th><th>Trouble shooting</th><th>Action</th></tr>
<tr><td rowspan="3">Exhaust valves close too late and strike the piston crowns</td><td>Timing gears incorrectly meshed</td><td rowspan="3">Check the valve timing, see “Service data, engines”</td><td rowspan="4"></td></tr>
<tr><td>The crankshaft gear has come loose</td></tr>
<tr><td>Valve mechanism not operating</td></tr>
<tr><td>Rapidly increasing valve clearances</td><td>Disturbances in the supply of lubricant for the rocker arms</td><td></td></tr>
<tr><td>The piston strikes the cylinder head</td><td>Loosened big end cap (wrong tightening torque after repair)</td><td></td><td>- Tighten to the torque specified in the Workshop manual</td></tr>
<tr><td></td><td>Foreign objects in the piston crown</td><td></td><td></td></tr>
<tr><td rowspan="3"></td><td>Piston seizure (may be caused by clogged piston cooling nozzles)</td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>Wrong injection timing</td></tr>
<tr><td>Worn collets on exhaust valves</td></tr>
<tr><td rowspan="2">Broken upper piston rings</td><td>Incorrectly adjusted injection pump</td><td colspan="2" rowspan="2">Disconnect one delivery pipe at a time and listen for changes in the engine sound.
WARNING!
Be careful when disconnecting the delivery pipes as the pressure is extremely high and could cause injury</td></tr>
<tr><td>Broken delivery valve spring (after-injection)</td></tr>
<tr><td rowspan="6"></td><td>Connecting rod bearing seizure</td><td rowspan="4"></td><td rowspan="4"></td></tr>
<tr><td>Faulty injector (seized, worn, incorrect or cracked tip, fatigued spring)</td></tr>
<tr><td>Incorrectly adjusted injector</td></tr>
<tr><td>More than 1 washer under injector</td></tr>
<tr><td>Fuel leakage in flame start</td><td colspan="2">Check whether it leaks. (Take out the flame start and run the engine with fuel pipe connected)</td></tr>
<tr><td>Loosened big end cap</td><td></td><td rowspan="3"></td></tr>
<tr><td rowspan="2">Melting damage on piston crown</td><td>Injection timing extremely advanced, 30 ° BTDC or more</td><td>Check the injection timing</td></tr>
<tr><td>Incorrectly adjusted injector</td><td></td></tr>
</table>

High oil consumption

Effect	Cause	Trouble shooting	Action
Blue smoke under load	Piston ring seizure		
	Piston seizure	Combustion temperature too high?	
	Cylinder seizure		
	Liner wear	Unclean intake air?	
	Carbon polishing (in patches)	Poor grade of oil?	
	Piston ring wear		
	Piston rings stuck		
	Tapered piston rings fitted wrong way		
	Broken piston rings	Individual piston rings broken = incorrectly fitted Several upper rings broken = start spray used wrongly, wrong injection timing (too early) Several intermediate rings broken = worn rings or grooves	
	Worn valve guides	Check the clearance between valve and guide. High exhaust temperature? Poor grade of oil?	
	Oil level too high?		
	Defective shaft seals in turbocharger	Check whether oil is present in the compressor or intake manifold	
	Clogged air filter		
	Excessive vacuum in the air intake before the turbocharger	Measure the vacuum (max. 500 mm wc) Check the air filter	
	Oil viscosity too low		
	Deformed/incorrectly directed piston cooling nozzles		
	External leakage		
	Leakage in seawater-cooled oil cooler (11-series marine engines)		

High fuel consumption

Effect	Cause	Trouble shooting	Action
	Faulty injector		
	Low charge air pressure		
	Adjusted injection pump	Check in a pump test bench that the amount (Q-mm^3/stroke) corresponds to specification	
	Manner of driving, operating/load conditions		

Low compression

Effect	Cause	Trouble shooting	Action
	Worn engine	Check the compression	
	Broken piston rings		
	Incorrectly adjusted/ defective valves		
	Hydrostatic lock/bent connecting rod		
	Readings not taken correctly	Take compression readings on a hot engine, with all injectors removed, at starter motor speed Check cylinders 1 - 6, then cylinder 1 again Check that starter motor speed does not drop Correct reading: 20 - 30 bar Max. 3 bar difference between cylinders	

Low engine output

Effect	Cause	Trouble shooting	Action
	Low fuel supply pressure (below 0.3 bar)	Check the feed pump and overflow valve for leakage as described in the workshop manual Look for leakage in the suction pipe between tank and feed pump Clogged fuel filter/Paraffin precipitation in fuel	
	Faulty injector		
	Fuel too hot		
	Incorrect fuel specification	Check density and viscosity	
	Low charge air pressure	Check charge air pressure	
	Abnormal pressure drop in intake piping	Check the vacuum before the turbocharger, max. 500 mm wc Check the air filter	
	Worn engine	Check “blow-by” in crankcase Correct value for new engine: 0 - +10 mm wc (flow rate 60 - 100 l/min.) Worn crankcase ventilation: -50 - +20 mm wc	
	Leaky valves	Take compression readings and compare those of the different cylinders	
	Wrong injection timing		
	Incorrectly adjusted governor/throttle control	Check that the governor starts deregulating at the intended speed Check that the throttle control goes to the maximum stop bracket	
	Intake air temperature too high	Check the temperature of the air before the engine. Above +25 ° C reduces engine power	
	Exhaust counterpressure too high	Take a reading, recommended counterpressure: 500 mm wc, max. 1000 mm wc	
	Intake counterpressure too high	See “Low charge air pressure”, page“Low charge air pressure”	
	Incorrectly adjusted injection pump	Check in a pump test bench	
	Blocked fuel consumption gauge		
	Binding injector	Injector’s nozzle nut tightened too hard	
	Exhaust brake/white smoke limiter throttle in closed position		

Hot engine

Effect	Cause	Trouble shooting	Action
Instrument shows high temperature	Defective sensor/instrument	Check that sensor and instrument suit each other (120 and 150 ° C) Check with a separate instrument	
	Low coolant level		
	Clogged seawater filter		
	Clogged freshwater/seawater cooling system		- Clean the cooling system internally and externally
	Pressure cap not operating	Test pressurize	
	Impeller on freshwater/seawater pump worn or damaged		
	Incorrect cam/worn cover on seawater pump		
	Restriction in coolant flow, e.g. pieces of rubber from seawater impeller		
	Cooling capacity too low	Take a reading of the cooling capacity	
	Gas leakage (causes loss of coolant)		
	Defective thermostats	Check opening temperature of thermostats	
Reduced coolant flow	Drive belts slip or pump wheel loose on pump shaft		
	Air pockets in engine's outer cooling circuit		- Vent at the cooling system's highest point - Check that the ventilation piping to the expansion tank is not clogged
	Excessive pressure drop in the external cooling system	Check with forcibly opened thermostats	
	Clogged radiator		
	Circulation of cooling air	Check by taking temperature readings	
	Cavitation damaged impeller in coolant pump		
	Leakage in charge air cooler		

Cold engine

Effect	Cause	Trouble shooting	Action
Instrument indicates low temperature	Defective sensor/instrument	Check that sensor and instrument match each other (120 and 150 ° C) Check with a separate instrument	
	Thermostat jammed in open position	Check operation of thermostat	
	Low power output at low ambient temperature (large external cooling surface)	- Fit a thermostat fan - Fit a smaller fan - Install a KLAFFO radiator shutter NOTE: NOT A RADIATOR BLIND Risk of fan blade breakage - Reduce the air flow - Reduce fan/coolant pump gear ratio	
	Large leakage flow in thermostat housing (9- and 11-series marine engines)		

Coolant loss

Effect	Cause	Trouble shooting	Action
	Defective cylinder head gasket (external leakage)		
	External leakage		
Coolant pressed out of radiator on DSI engines	Turbocharging pressure enters cooling system via leaking charge air element	Test pressure (air 0.5 bar, liquid 4 bar)	
White smoke when engine hot indicates water vapour	Crack in cylinder head (not cracks between valve seats)	If the fault is hard to trace: Change all cylinder heads for exchange cylinder heads. (Or test pressurize all cylinder heads. Heat the cylinder heads before pressurizing them.)	
	Cracked cylinder liner	Grey oil = Coolant in oil Locate the leak by removing the oil sump and pressurizing the cooling system while turning the engine over by hand	

Effect	Cause	Trouble shooting	Action
	Faulty inhibitor		- Clean the cooling system and fill it with coolant as described in the maintenance instructions
	Overdosed corrosion inhibitor		

Polluted coolant

Effect	Cause	Trouble shooting	Action
Boiler scale on engine heater	Incorrect mixture or type of glycol and/or corrosion inhibitor Anti-freeze with phosphate-based inhibitor must not be used		- Clean the cooling system and fill it with coolant as described in the maintenance instructions
Short service life	The heater is not designed for continuous engagement. Suitable temperature for thermostat control = 40 - 60° C		

High oil temperature

Effect	Cause	Trouble shooting	Action
- Instrument indicates too high temperature	- Defective sensor/ instrument	Check with separate instrument	
	- Poor water flow in oil cooler		

High exhaust temperature

Effect	Cause	Trouble shooting	Action
	Adjusted injection pump	Check the lead seal, check CRO if necessary	- Test in test bench
	Wrong injection timing	Check the injection timing	
	Nozzle drips	Check type, opening pressure and general condition	
	High exhaust counter pressure	Take a reading, recommended counterpressure: 500 mm wc, max. 1000 mm wc Check silencer, spark arrester, length and inside diameter of exhaust pipe	
	High inlet air temperature		
	Low charge air pressure		
	Clogged air filter		

Low charge air pressure

Effect	Cause	Trouble shooting	Action
	Dirty/damaged turbine/ compressor wheel in turbocharger		- Check/clean
	Leakage between turbocharger and cylinder head		- Check/change gaskets
	Bearing seizure in turbocharger	Check bearing play	- Recondition/change turbocharger
	Clogged air filter	Check the vacuum before the turbocharger, max. 500 mm wc	
	High exhaust counterpressure	Take a reading, recommended counterpressure: 500 mm wc, max. 1000 mm wc Check silencer, spark arrester, length and inside diameter of exhaust pipe	
	High fuel temperature		

Low fuel pressure

Effect	Cause	Trouble shooting	Action
	Clogged fuel filter		
	Defective overflow valve		
	Defective feed pump		
	Air leakage in suction pipe		
	High pressure drop in suction pipe		

Low system voltage

Effect	Cause	Trouble shooting	Action
(Normal charging voltage: 27 - 28 V)	Broken alternator drive belt		
	Slipping alternator drive belt		
	Batteries in poor condition		
	Alternator fault		
	Voltage regulator fault		
	Battery charger fault		

High system voltage

Effect	Cause	Trouble shooting	Action
(Normal charging voltage: 27 - 28 V)	Voltage regulator fault		
	Battery charger fault		

External oil leakage

Effect	Cause	Trouble shooting	Action
	Crankcase pressure too high	Check "blow-by" in crankcase Correct value for new engine: 0 - +10 mm wc (flow rate 60 - 100 l/min.) Closed crankcase ventilation: -50 - +20 mm wc	
	Leaky crankshaft seal		
	Leakage at liner seal via overflow hole in cylinder block		
	Defective cylinder head gasket		
Leakage in manifold joint	Low load		

External fuel leakage

Effect	Cause	Trouble shooting	Action
	Damaged injector and injection pump connections/gaskets		
	Defective pulsation damper		
	Blocked overflow valve	Leakage at high engine speed and low power output	- Change to Bosch overflow valve (with ball)

External coolant leakage

Effect	Cause	Trouble shooting	Action
	Leakage in cylinder liner seal		
	Cold leakage		- Change to hoses of better quality (preferably silicone hoses)
	Defective cylinder head gasket		
	Water pump leakage	Check at the water pump housing's telltale hole	
	Leakage at charge air cooler connection		
Loss of coolant in stationary installations with self-venting valves	Coolant pressed out of expansion tank	Check that the self-venting valve is not situated higher than the highest coolant level and that air is not drawn in through the valve	- Change the valve or fit a manual air screw

Oil pressed out via crankcase ventilation

Effect	Cause	Trouble shooting	Action
	Hole in piston crown	Increases when white smoke limiting device is engaged or exhaust brake applied	
	Bearing seizure in turbocharger		
	Oil seepage via pistons - liner		
	Oil seepage in air compressor		

Turbocharger breakdown

Effect	Cause	Trouble shooting	Action
Loss of power	Excessive bearing play in turbocharger		
	Lubrication piping between turbocharger and filter incorrectly connected		- Check the connections

Compressed air system

Effect	Cause	Trouble shooting	Action
Compressor does not maintain sufficient pressure in the system	Too much carbon in compressor cylinder head or discharge piping	Empty the compressed air tank, retain the air in connected compressed air components. Run the engine at 1200 r/min and note the time it takes for the compressor to discharge: 3 - 3.5 min. for 9/11-series engines with 90-110 dm^3 tank capacity 2.5 - 3 min. for 14-series engine with 90-110 dm^3 tank capacity	- If charging time exceeds specified values: - Rectify leakage, if any - Check/rectify pressure regulator - Check/rectify compressor
	Exhaust valves leak		
	Worn pistons and cylinders		
	Leaking/jammed intake valves		
	Defective pressure regulator		
	Leakage in compressed air piping		
Noise	Too much carbon in compressor cylinder head or discharge piping	Check/rectify compressor as described in the Workshop Manual	
	Worn big end/main bearings		
	Worn pistons and cylinders		
	Compressor gear loose on shaft, see also “Knocking/noise”, page“Knocking/noise”		
Compressor allows passage of oil, see also “High oil consumption”, page “High oil consumption”	Worn pistons and cylinders		
	Piston rings fitted wrongly		
	Overpressure in engine crankcase.		
Compressor does not discharge	Defective seals on discharge pistons		
	Discharge mechanism binding		
	Defective pressure regulator		
Moisture/oil in compressed air system	Air dryer not working properly	Check operation of air dryer, change desiccant. If desiccant is oily, see “Compressor allows passage of oil” above	

Note