Workshop Manual

Groups 21–26

E
2(0)

D16C-A/B/C/D MH, D16C-A MG

The following RTV preparations are used on the engine:
Volvo Penta sealant (silicone, cartridge 0.31 l, part No. 1161231, or tube 20 g., part No.1161277) and part No. 840879 (tube 25 g).

Remove old sealant with denatured alcohol.

Anaerobic agents. These agents cure in the absence of air. These preparations are used when two solid components, such as two cast components, are fitted together without a gasket. Common uses are also to lock and seal plugs, stud threads, taps, oil pressure monitors etc.

Hardened anaerobic preparations are glassy and for this reason, the preparations are colored to make them visible.
Hardened anaerobic preparations are highly resistant to solvents, and the old compound cannot be removed. On re-assembly, it is important to degrease components carefully first, wipe off and apply new sealant in accordance with the instructions.

The following anaerobic preparations are used on the engines:
Volvo Penta locking fluid (part No. 1161053).

Safety Precautions for Fluorocarbon Rubber

Fluorocarbon rubber is a common material in sealing rings for shafts, and in O-rings, for example.

When fluorocarbon rubber is subjected to high temperatures (above 300°C), **hydrofluoric acid** can be formed, which is highly corrosive. Contact with the skin can result in severe chemical burns. Splashes in your eyes can result in severe chemical burns. If you breathe in the fumes, your lungs can be permanently damaged.

⚠ **WARNING!** Be very careful when working on engines which have been exposed to high temperatures, e.g. overheating during a seizure or fire. Seals must never be cut with a flame torch during disassembly, or burned in uncontrolled circumstances afterwards.

- Always use gloves made of chloroprene rubber (gloves for handling chemicals) and protective goggles.
- Handle the removed seal in the same way as corrosive acid. All residue, including ash, can be highly corrosive. Never use compressed air to blow anything clean.
- Put the remains in a plastic jar which is sealed and provided with a warning label. Wash the gloves under running water before removing them.

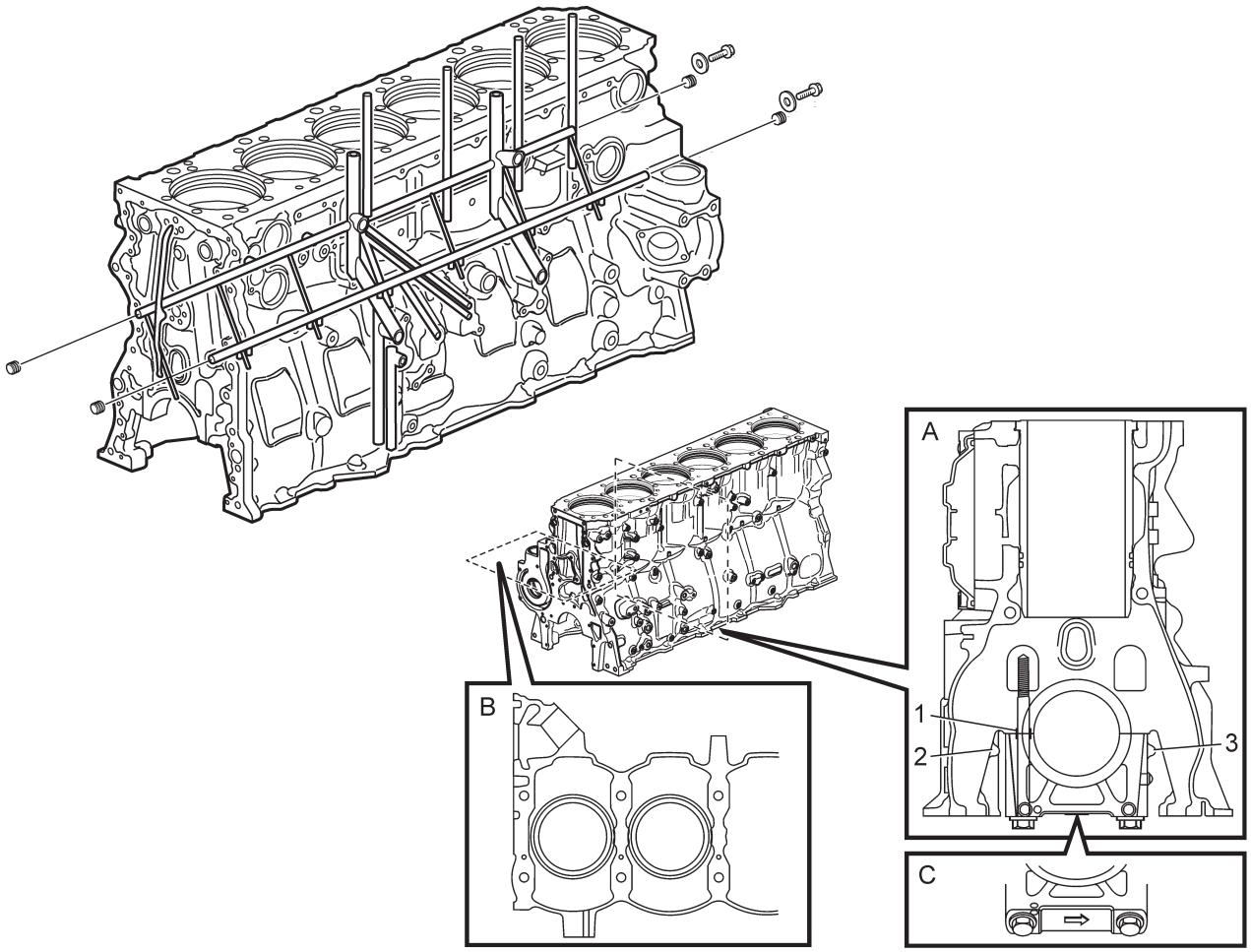
The following seals are most probably made from fluorocarbon rubber:

Seal rings for the crankshaft, camshaft, idler shafts.

O-rings, regardless of where they are installed.
O-rings for cylinder liner sealing are almost always made of fluorocarbon rubber.

Note that seals which have not been subjected to high temperature can be handled normally.

NOTE: As the illustrations in the service literature refer to several engine variants, certain details may differ from any particular engine. The essential information in the illustrations is always correct, however.



Cylinder Block

The cylinder block is made of cast iron and cast in one piece. The sides of the cylinder block are arched around each cylinder, for high stiffness and good sound damping.

All lubricating oil channels have been machined directly in the block. There are two longitudinal oil channels. The piston cooling channel on the right side and the main lube oil channel on the left side. The channels are plugged front and back. The rear face also has a channel for oil supply to the timing gear.

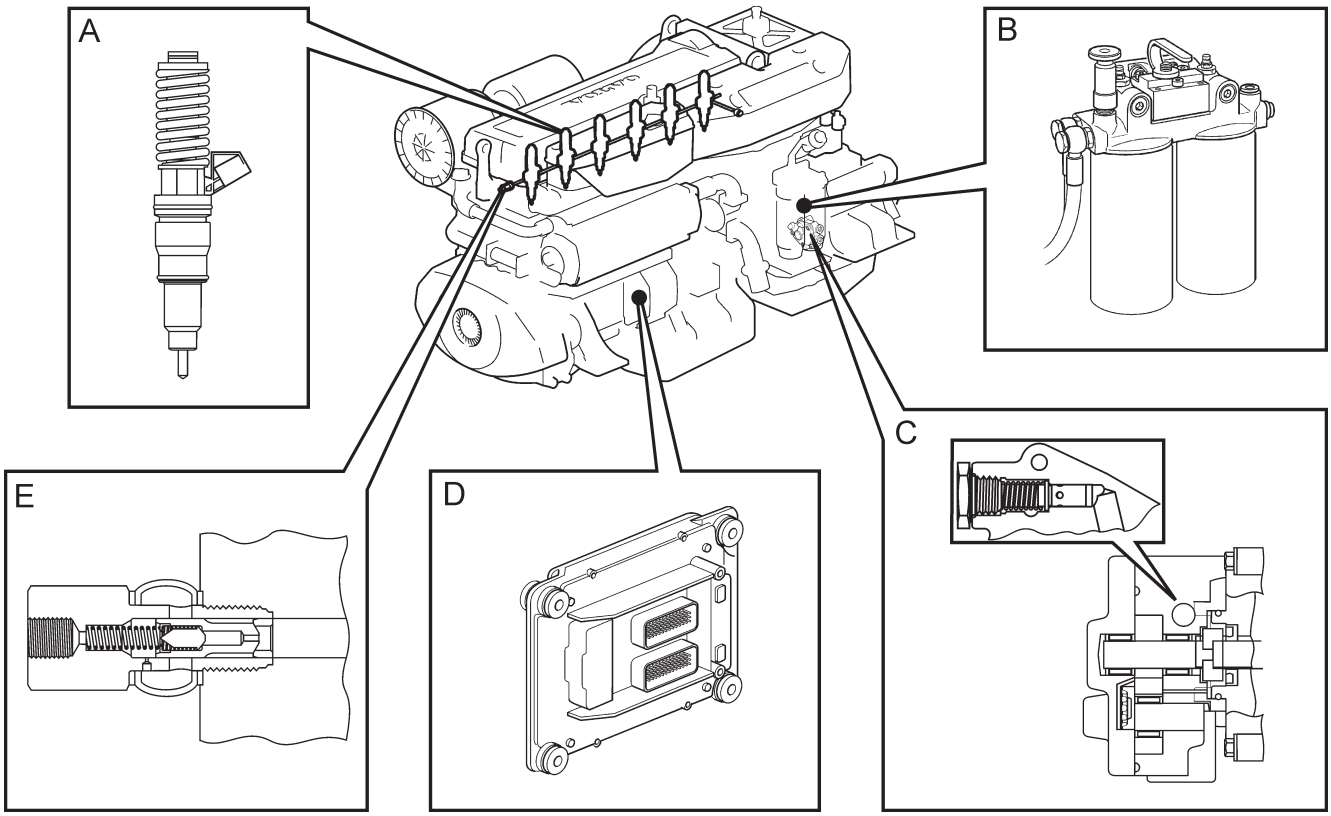
A bracing frame is fitted to the underside of the block to reduce vibration and thereby also engine noise.

The oil pan is made from plastic and is attached with spring loaded bolts. The seal between block and oil pan consists of a rubber strip, in one piece, placed in a groove in the sump.

The main bearing caps are aligned by pressed-in sleeves in the cylinder block (1). To prevent incorrect mounting, the caps are numbered 1–7 and have cast bosses on both block (2) and caps (3). The underside of the bearing caps are also marked with arrows, which should be turned towards the engine's inlet side.

The cylinder head gasket is made from steel. The gasket incorporates vulcanized rubber seals for oil and coolant channels. The gasket has also a number of convex embossings* to allow the cylinder head to slide on the gasket during installation, and to prevent damaging the rubber rings in the gasket.

* **Note.** During installation, the cylinder head is lowered onto the guide pins in the cylinder block at a small distance from the timing gear plate. After this, the cylinder head is pulled horizontally towards the timing gear plate. When the cylinder head is in place, it is tightened against the cylinder block and the embossings in the gasket are flattened.



A. The unit injector is a combination of an injection pump and an injector that works at a much higher pressure than an ordinary injector. The opening pressure is approx. 320 bar (4641 psi) and the working pressure can be up to 2000 bar (29007 psi).

The injection timing and the volume of fuel to be injected is determined by the engine control unit, which sends signals to solenoid fuel valves built into the unit injectors. The pressure force in the unit injector is taken from a lobe on the camshaft via a rocker arm.

B. The fuel filter housing has a hand pump for purging the fuel system. Draining water takes place by hand at the water trap on the fuel pre-filter. A built-in check valve in the pump prevents the fuel from flowing back when the engine is shut-down.

C. The gear-type feed pump is driven from the crankshaft by an idler gear. High feed pressure is needed to ensure complete filling of the unit injectors. The flow must be sufficient to even out any temperature differences in the cylinder head fuel channel.

D. The engine control unit is attached to the engine via four vibration absorbing rubber mounts. The control unit receives continuous information from a number of sensors on the engine, to allow it to calculate the fuel volume and timing for injection. Control signals to the unit injector fuel valves are sent via electric cables. The control unit stores any faults and divergences which occur in the system. Intermittent faults are also stored so that they can be traced at a later date.

E. Excess fuel form the overflow valve is mixed with fuel from the suction side of the filter housing and is fed back to the feed pump.

The feed pressure to the fuel system is controlled by a bypass valve that is integrated in a hollow screw, located in the return line from the cylinder head. Opening pressure is 400–550 kPa (58–79.8 psi). The high feed pressure is required to ensure complete filling of the unit injectors. The bypass valve also has an integrated purging valve that automatically purges the system, allowing a small volume of fuel back to the tank.

Actions with low charge air pressure

1. Air inlet

Check that the ventilation inlet to the engine room is large enough. Please refer to the installation instructions.

2. Air filter

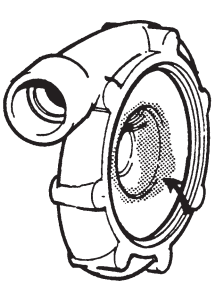
Check that the air filter is not blocked (pressure drop indicator shows red) and that the correct filter is in use. Change filter as necessary.

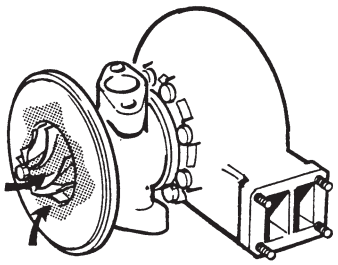
3. Sealing

The inlet and exhaust manifolds and other unions must not have any leaks. Also check that the joints between the compressor bearing housing and turbine and the compressor housing itself seal correctly.

4. Turbocharger

Check that the rotor shaft does not bind and that the exhaust turbine or compressor turbine do not rub against this housings. Turn the wheel, firstly with light pressure, then after displacing the shaft axially. If the turbine is stiff to turn, the turbocharger must be changed or overhauled as soon as possible. Check the turbines for damage.





If the engine is operated in dusty or oily air every day, regular cleaning of the compressor housing and compressor turbine is recommended. A fouled compressor section can cause low charge air pressure.

The compressor section can be cleaned with the unit installed, as follows:

Remove the compressor housing. Clean the compressor housing, compressor turbine and end wall in white spirit or equivalent substance. Install the compressor housing and tighten the V-clamp to **12.2 ±0.7 Nm** (9 ±0.5 lbf.ft).

Measure the charge air pressure again.

5. Charge air cooler

Check that the charge air cooler is not blocked. Clean as necessary, according to the instruction on page 202.

General advice

When working with chemicals, fuel and lubricating oil

⚠ **IMPORTANT!** Lubricate hands with a barrier cream and always use protective gloves during work where you risk contact with oil, fuel, etc.

Continuous skin contact with engine oil dries your skin and can be hazardous.

Before working in a boat

1
Disconnect power at the main switch and check that the engine is without power.

2
Clean the outside of the engine.

NOTE: Make sure that wash residue is collected for destruction and does not inadvertently end up in the water.

3
Work involving the cooling system:

Close the sea cocks and drain the coolant from the seawater- and freshwater systems.

⚠ **WARNING!** Make sure that all seawater inlets are securely closed, so that water cannot find its way in during removal of cooling system components.

Before lifting the engine

1
Remove battery power. Undo the connections from the starter motor.

2
Disconnect the engine and instrument wiring connector block(s).

3
Remove the seawater or hull cooling connections.

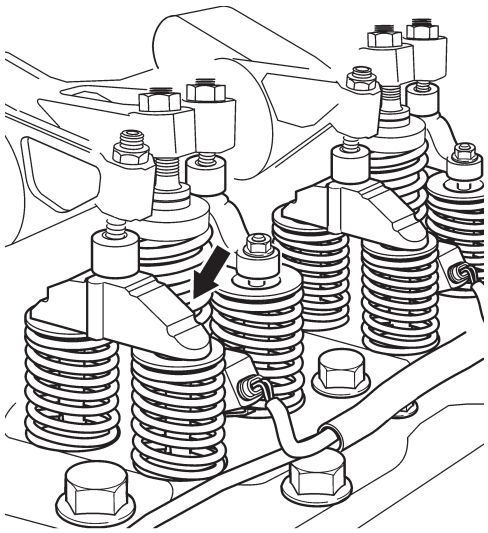
4
Remove the exhaust system.

5
Close the fuel stopcocks.

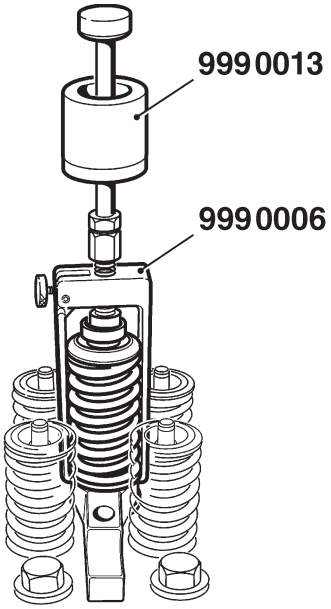
Remove the fuel connections.

6
Undo the two cable connections from the connection box and the wiring to the reverse gear.

7
Disconnect the propshaft from the reverse gear. Undo the engine mounting pads from the bed and lift the engine out.



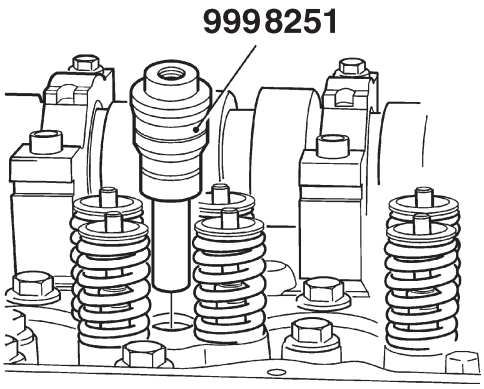
24
Mark the valve yokes and remove them.



25
Clean around the unit injectors and unscrew the bolts for the injector yokes.

Remove the unit injectors, one at a time.

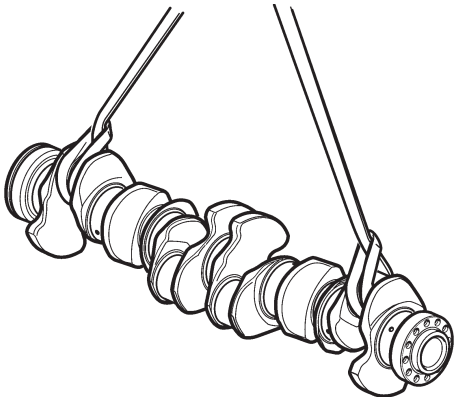
26
Extract the injectors using tool 9990006 and slide hammer 9990013.



27
Fit sealing plug 9998251 in the cylinder head immediately after removal.

Mark the injectors and fit protective sleeves 9998249 to the injectors.

NOTE: Check that the tools are clean.



68
Carefully lift out the crankshaft.

NOTE: The crankshaft weighs about 80 kg (176 lbs).

69
Before washing the cylinder block, all plugs, bolts and remaining brackets must be removed.

70
Clean the contact surfaces of parts that are to be reused.

Crankshaft, assembly

71
Inspect the crankshaft, refer to “Crankshaft, inspection” on page 114.

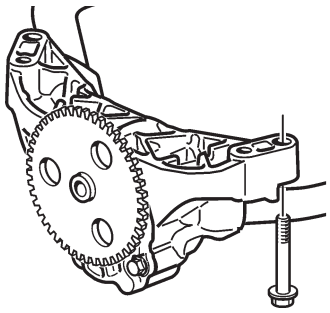
72
Check the crankshaft oil ways and contact surfaces for the bearing shells as well as the cylinder block and bearing caps.

73
Install new main bearing shells.

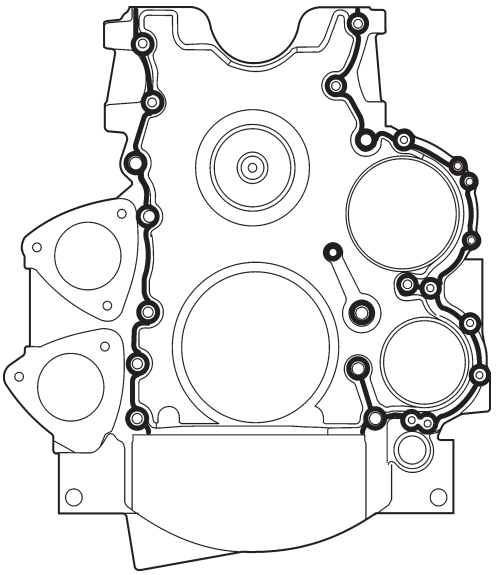
74
Position the bearing shells in the correct places in the cylinder block and bearing caps. Make sure that bearing shells or caps are not damaged.

NOTE: Make sure that the upper bearing shells to be fitted into the cylinder block have oil holes.

75
Lubricate the bearing journals and shells with engine oil and carefully lift the crankshaft into place.

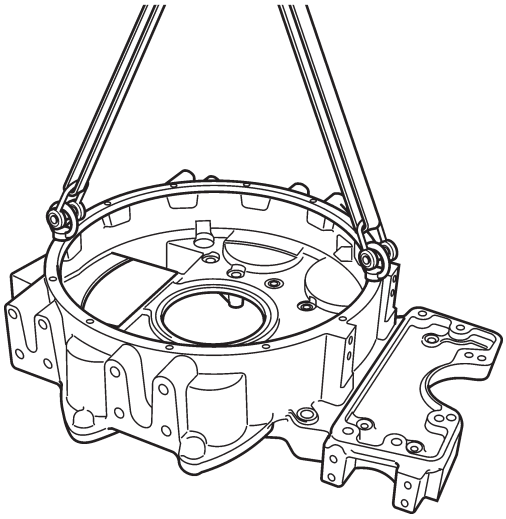


109
Install the lube oil pump.



110
Remove the old crankshaft seal from the flywheel cover.

Apply sealant (part No. 1161231) to the flywheel cover contact surface on the cylinder block.



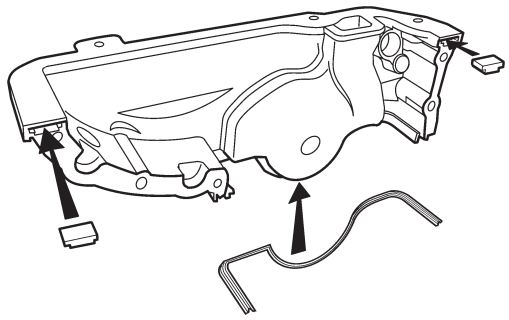
111
Install the flywheel cover and tighten the bolts in three stages. Check that the cover aligns with the under edge of the cylinder block.

Stage 1: Tighten all M14 bolts to **160 ±20 Nm** (118 ±15 lbf.ft).
Stage 2: Tighten all M10 bolts to **48 ±8 Nm** (35.4 ±6 lbf.ft).
Stage 3: Tighten all M8 bolts to **24 ±4 Nm** (17.7 ±3 lbf.ft).

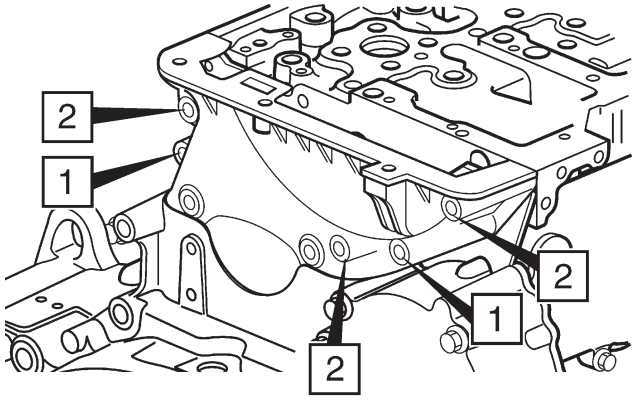
Refer to the torque schedule in “Technical Data”.

112
Install a new crankshaft seal. Refer to “Crankshaft seal rear, replace” on page 127.

NOTE: No lubrication. This should be installed completely dry.

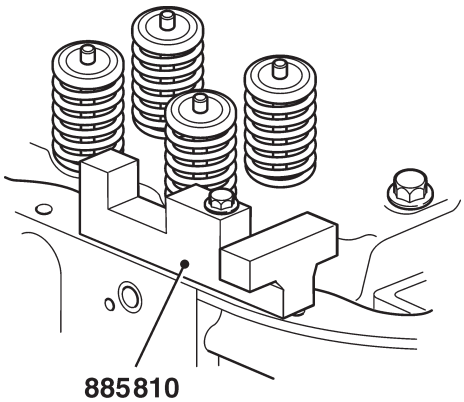


162
Install the rubber seal and mount the timing gear cover.



163
Only fit bolt (1) and tighten by hand.

Note. The hole is elongated so that the cover can be pressed down onto the rubber seal.

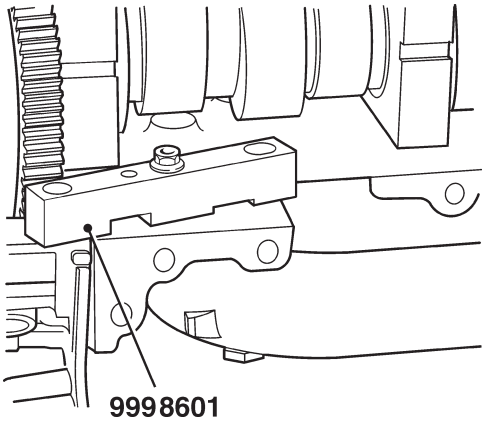


164
Press the cover down with tools 885810 and 999 8601 so that the cylinder head and the upper timing gear cover sealing surfaces are aligned.

Install the remaining bolts (2), upper figure. Torque the screws to **27 ±4 Nm** (20 ±3 lbf.ft).

Refer to the torque schedule in “Technical Data”.

NOTE: The timing gear cover must be installed and torqued within 20 minutes after sealant application.



165
Install the camshaft sensor. Refer to “Camshaft sensor distance, check” on page 151.

Cylinder liners and pistons, replace
(all)

Special tools:

Cranking tool	999 3590
Puller	9996645
Spacer	9996394
Spacer	9996395
Puller plate	9996963
Press tools (7pcs)	9990157
Mandrel	9996599
Prying tool	9998511
Piston ring compressor	999 0158
Piston ring pliers	88800083

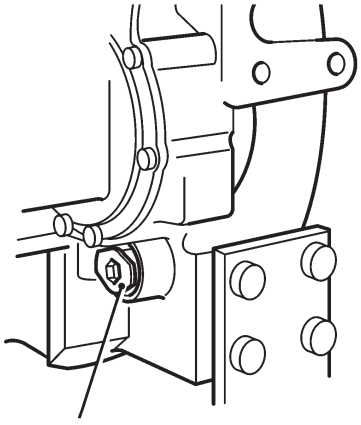
Other special equipment:

Torque wrench (10–100 Nm)	1159794
Torque wrench (40–340 Nm)	1159795
Dial gauge	9999876
Holder	9992479

Removal

Cylinder head, oil pan, bracing frame and piston cooling nozzles removed

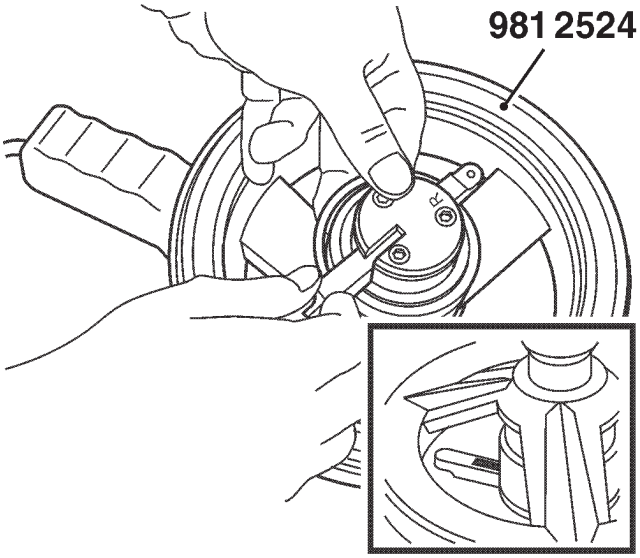
> ⚠ **WARNING!** It is important to remove the piston cooling nozzles before the pistons are removed. Damaged nozzles can cause extensive engine damage.



999 3590

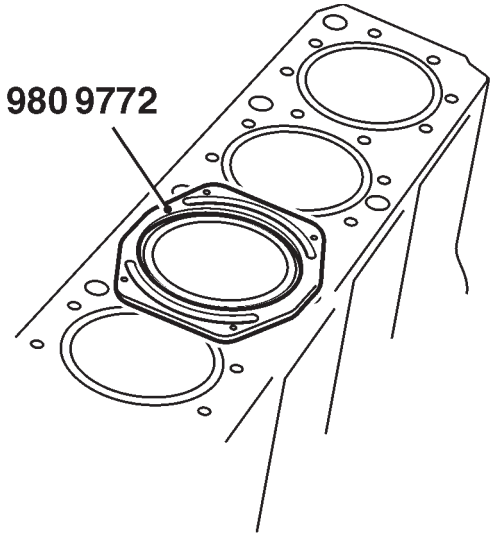
1
Remove the protective cover from the flywheel casing and fit cranking tool 999 3590.

Turn the crankshaft so you can access the bolts on the connecting rod that is to be removed.



8
Use a suitable size of cutter and check that it is undamaged.

Hold up the locking brace and install the cutter. The toothed surface must face the electromagnet and the centering roller on the side of the spindle marked “R”.

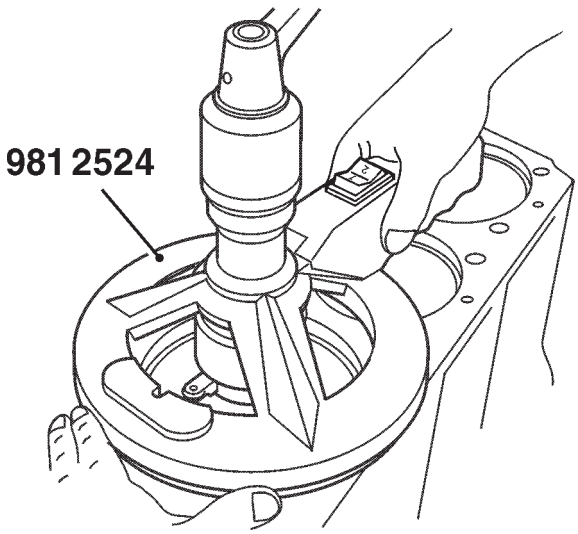


9
If the adjacent cylinders have the liners fitted, spacer 980 9772 must be used.

Spacer height is 4 mm (0.16”). If the liner height is higher, the adjacent liners must be removed.

NOTE: Check that the spacer and the cylinder head plane are carefully cleaned.

NOTE: When the cylinder liner beside the timing gear plate is milled, the milling tool must be extended. Refer to “Cylinder liner, milling” on pages 107/113.

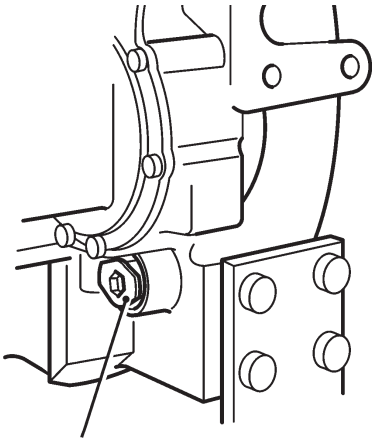


10
Place the milling cutter 981 2524 so that it is somewhat displaced with respect to the cylinder center.

Big end bearings, replace (all)

Oil pan, oil suction pipe and bracing frame removed

Special tools:
Cranking tool 999 3590



999 3590

Removal

1
Fit cranking tool 999 3590 in the flywheel cover and turn the flywheel until the bearing caps on connecting rod 1 and 6 are in a position where you can remove the bolts.

2
Mark and remove bearing caps on connecting rods 1 and 6.

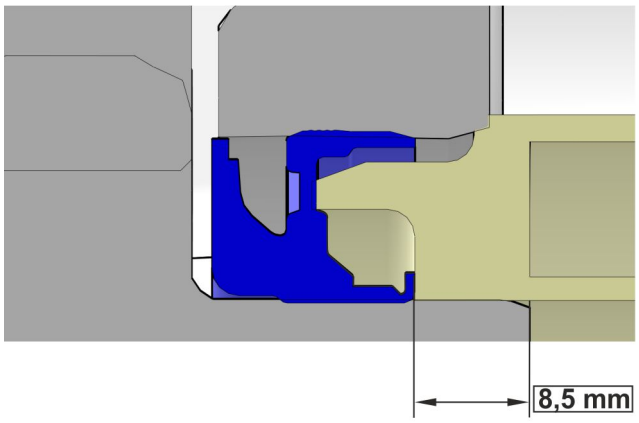
NOTE: Be careful not to damage the surfaces.

3
Remove the bearing shells and clean the bearing seat and bearing cap.

NOTE: Make sure the bearing caps are installed on the same connecting rod.

4
Check the bearing journals and bearing shells.

5
Check the measurements of the bearing journals. If any of the values exceed the maximum permissible values, the crankshaft must be removed and rectified.



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3 Reference dimension for a correctly installed seal.

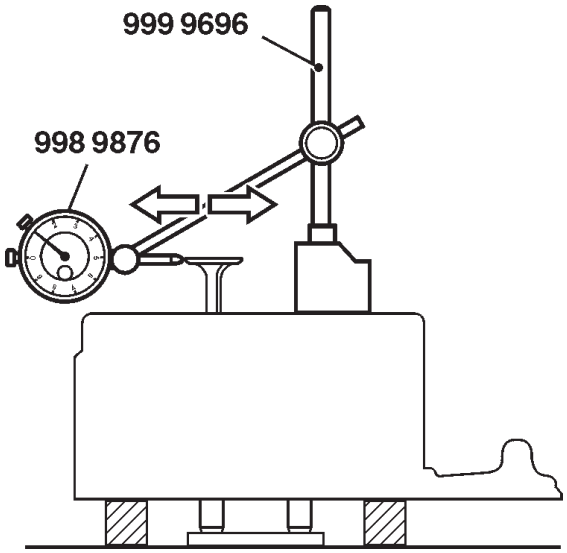
21410

Valve guides, inspection

Cylinder head removed

Special tools:

Dial indicator 998 9876
Magnetic stand 9999696



1
Remove the valve stem seals from the valve guides.

2
Place the cylinder head on the workbench with the valve heads facing up.

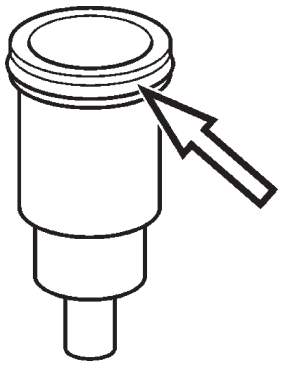
⚠ **IMPORTANT!** The cylinder head must not be put down so its entire weight rests on the valve guides (see figure).

3
Place a **new** valve in the valve guide with the valve stem end in the same plane as the edge of the guide. Use a suitable counterhold under the valve stem.

4
Place dial gauge 998 9876 with magnetic stand 9999696 so that the probe presses against the edge of the valve head.

Move the valve sideways in the direction of the outlet- and intake ducts. Read off the value on the dial gauge.

5
Check all valve guides. If the measurement values exceed the values noted in the specifications, the valve guide must be changed. Refer to “Technical Data”.

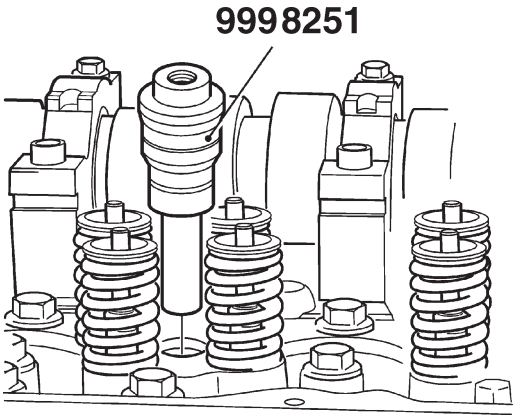


Copper sleeve for unit injector, replace

Unit injector removed

Special tools:

Thread cutting tool	9809667
Cranking tool	9993590
Seal ring	9998250
Sealing plug	9998251
Thread cutter	9998252
Puller	9998253
Cleaning kit	9998599
Expander	88800102

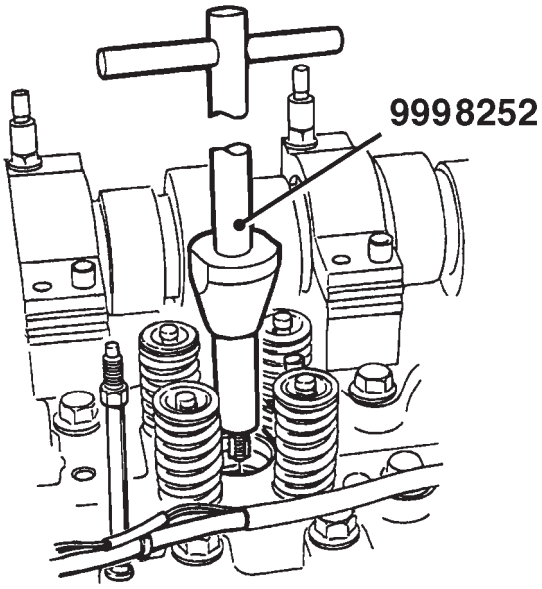


1
Drain the coolant. Refer to “Cooling system, draining” on page 187.

2
Remove the sealing plug 9998251.

3
Install 2 sealing rings, 9998250 in order to prevent dirt from entering the fuel channels when the copper sleeve is removed.

NOTE: Ensure that the piston is in its lower position.

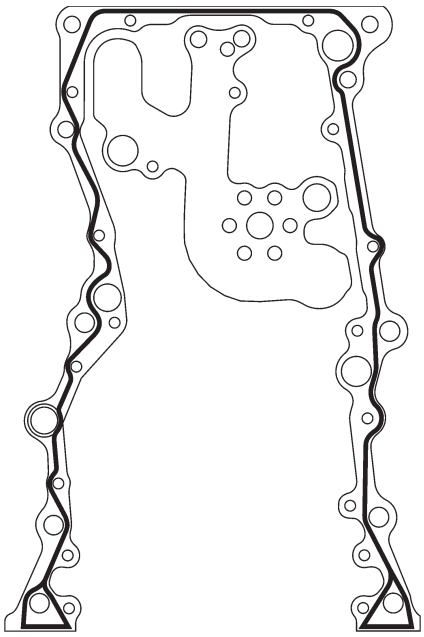


4
Grease the thread cutter 9809667 in order to prevent swarf from falling into the cylinder.

Screw the tap at least 20 mm (0.8”) into the copper sleeve with tool 9998252.

NOTE: Use thread cutter 9809667.

5
Remove the tool 9998252 and thread cutter.



Installation

NOTE: Lubricate the bearing surfaces of the gears before assembly.

1
Apply an approx. 2 mm (0.079”) wide bead of sealant (part No. 1161231) to the cylinder block as illustrated.

Note. Use a marker pen to mark up where the sealant should be applied.

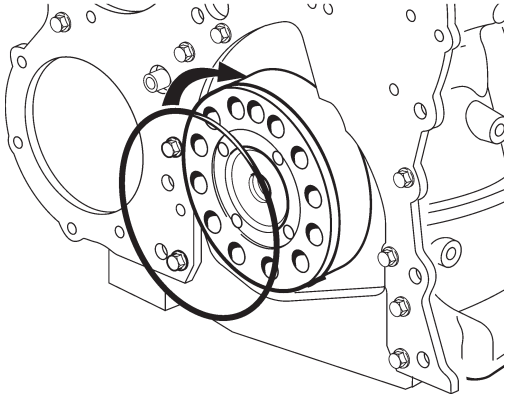
2
Install the timing gear plate if it has been removed.

⚠ **IMPORTANT!** Use **new** bolts that are treated with locking fluid.

Tighten the bolts to **28 ±4 Nm** (20.7 ±3 lbf.ft) (M8), and **60 ±8 Nm** (44.3 ±6 lbf.ft) (other bolts). Refer to the torque schedule in “Technical Data”.

NOTE: Torque within 20 minutes after sealant has been applied.

3
Oil the spacer plate and place it together with the upper (adjustable) idler gear (2). Tighten to a low torque (max. 10 Nm / 7.4 lbf.ft).

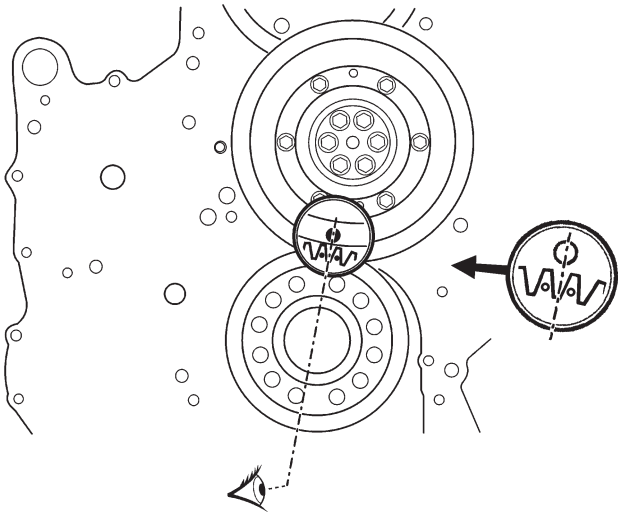


4
Fit a new O-ring to the crankshaft.

5
Install the crankshaft gear (4) and tighten the Allen bolts in two stages.

Stage 1: **60 ±5 Nm** (44.3 ±3 lbf.ft).
Stage 2: **Angle tighten 120° ±10°**.

NOTE: Make sure that the mating surfaces on crankshaft and gear are clean and flawless.



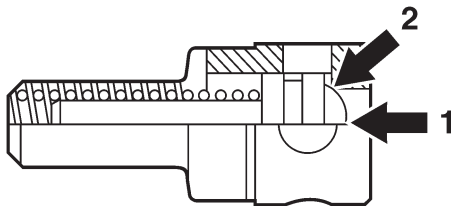
6
Install the bull-gear (3) with the mark in between the two marks on the crankshaft gear.

NOTE: The inner and outer gears have different pitches. For the camshaft to be set correctly, the markings must be correct.

Tighten the bolts in two stages.

Stage 1: **45 ±5 Nm** (33.2 ±3 lbf.ft).
Stage 2: **Angle tighten 90° ±5°**.

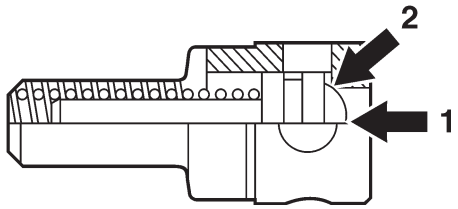
Refer to the torque schedule in “Technical Data”.



Pressure reduction valve, checking

1
Check that the reduction valve is **blue** in color.

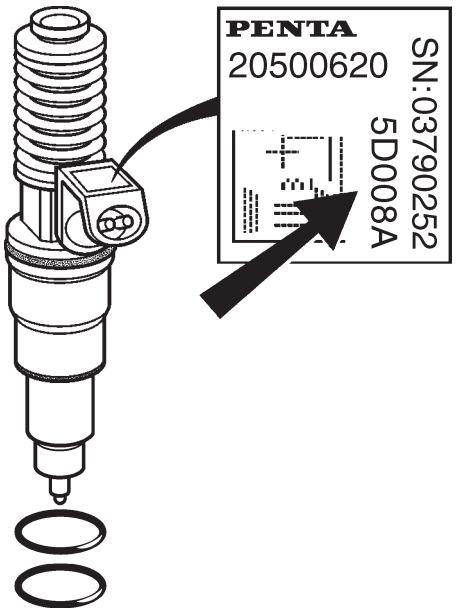
2
Check that the valve is not damaged, which would impair its function.
Press in the valve poppet (1) with a blunt object and check that it does not seize and that it seals against the seat (2).



Safety valve, check

1
Check that the safety valve features a **purple** color marking.

2
Check that the valve is not damaged, which would impair its function.
Press in the valve poppet (1) with a blunt object and check that it does not seize and that it seals against the seat (2).



Installation

NOTE: Note the trim code of the new unit injector and the cylinder involved, before installation.

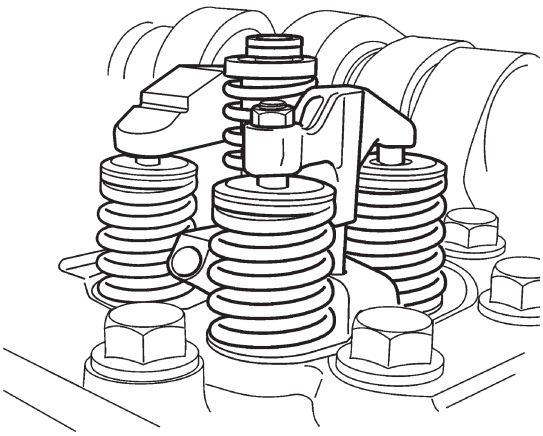
The code consists of six characters and is noted on the unit injector (the trim code is “5D008A” in the figure above).

Note. Once a unit injector has been changed, the new trim code for the relevant cylinder must be programmed into the engine control module. Refer to “Unitinjector, programming of trim code” on page 178.

13
Install **new** seal rings on the unit injectors and check that they are correctly located.

Lubricate the rings with diesel oil.

Upper O-ring – large diameter
Lower O-ring – small diameter



14
Install the unit injector and **yoke**. Center the unit injector between the valve springs.
Tighten the unit injector as follows.

NOTE: Different tightening torques are used, depending on whether the unit injector copper sleeve has been replaced or not.

New copper sleeve:

First tightening

Stage 1: **20 ±5 Nm** (14.8 ±4 lbf.ft).
Stage 2: **Angle tighten 180° ±5°**.

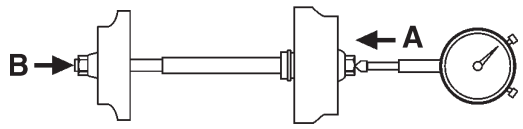
Note. Undo the bolt for the unit injector fixing yoke before the second tightening.

Second tightening

Stage 1: **20 ±5 Nm** (14.8 ±4 lbf.ft).
Stage 2: **Angle tighten 60° ±5°**.

Old copper sleeve:

Stage 1: **20 ±5 Nm** (14.8 ±4 lbf.ft).
Stage 2: **Angle tighten 60° ±5°**.



2
Press in the exhaust turbine (**A**) by hand. Zero the dial gauge.

3
Press in the compressor turbine (**B**) by hand. Read the end float on the dial gauge.

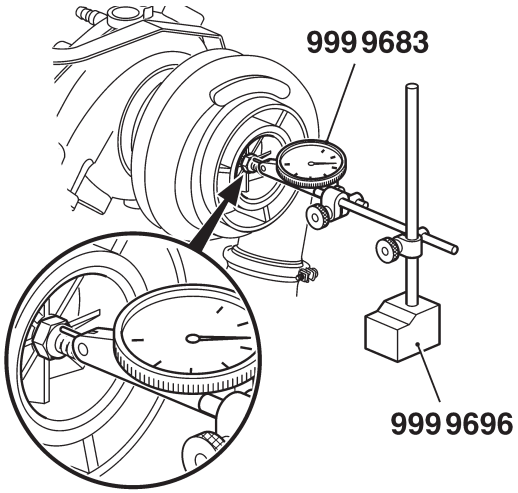
Permissible end float: **Max. 0.12 mm** (0.0047”).

Replace/overhaul the turbocharger if the wear tolerances are exceeded.

Checking the radial clearance

Special tools:

Dial gauge 999 9683
Magnetic stand 9999696



1
Mount the dial indicator 999 9683 on the magnetic stand. Put the measurement tip on the round surface on the compressor turbine’s locknut.

2
Press the compressor turbine down at the same time as the other end of the shaft (the exhaust turbine end) is moved upwards. Zero the dial gauge.

3
Move the compressor turbine upwards, at the same time as the other end of the shaft is pressed down. Read off the radial clearance on the dial gauge. Then rotate the shaft 90° and repeat the measurement.

NOTE: Be careful to ensure that the shaft is not rotated during measurement.

Permissible radial clearance (compressor side):
Max. 0.74 mm (0.0291”).

Permissible radial clearance (exhaust turbine side):
Max. 0.56 mm (0.0220”).

Replace/overhaul the turbocharger if the wear tolerances are exceeded.

5
The pressure must not drop during **two minutes** for the cooling system to be considered free from leaks.

NOTE: Repeat the pressure testing if you are uncertain whether the cooling system leaks or not.

6
Release the excess pressure and remove the pressure testing unit.

7
Check the coolant level in the expansion tank. Install the ordinary filler cap.

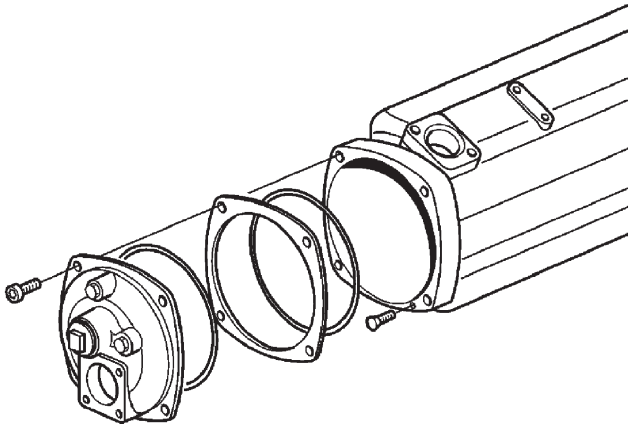
8
Start the engine and check that no leakage occurs.

Coolant filler cap, replace

NOTE: Always change the coolant filler cap on an engine that has been overheated. The pressure relief valve in the cap (plastic cap) might have been damaged by the heat.

Heat exchanger, cleaning

The water side is cleaned when the engine cooling system is cleaned. Refer to “Cooling system, cleaning” on page 189.

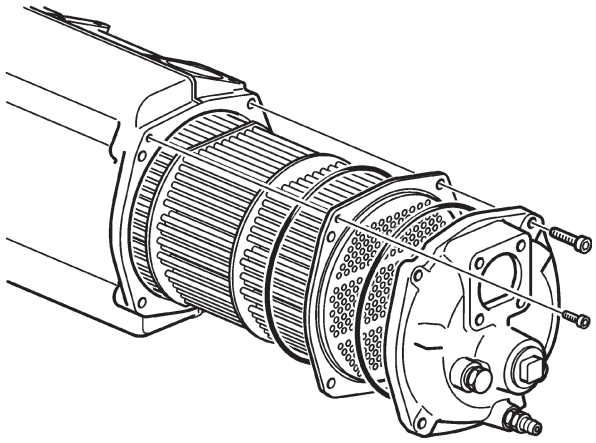


1
Close the sea cock(s) and drain the cooling system. Refer to “Cooling system, draining”, page 187.

2
Remove the heat exchanger. Refer to “Heat exchanger, removal and installation” on the previous page.

NOTE: The heat exchanger insert (seawater side) can also be cleaned with the heat exchanger still on the engine, once the two end pieces have been removed.

3
Remove the end pieces from the heat exchanger. (First remove the bolts on the end pieces, then the two screws for the insert).



4
Remove the O-rings (2 pcs at the front, one at the rear) and press the insert out.

NOTE: The insert can only be pressed out backwards since it has a flange at the rear edge.

The insert can also be pressed out of the housing by screwing two M10 bolts into the threaded holes in the flange.

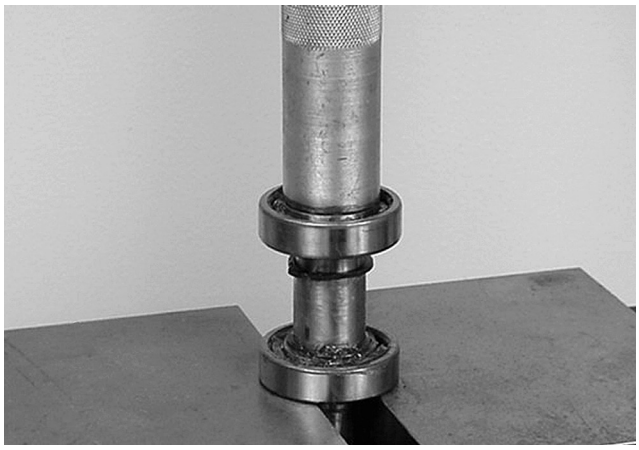
5
Clean the entire length of the heat exchanger piping. Use fresh water and suitable brushes. Flush the pipes and keep brushing until no more loose particles come away with the water. Also flush and clean the outside of the insert. Also clean the housing and the end caps.

Assembly

1

Grease the sealing ring (16) with water-resistant grease (Volvo Penta part No. 828250) and tap it into the bearing housing.

Note. Put the old support washer (8) over the ring to protect it. The side of the seal with the spring should face inwards towards the bearing housing.

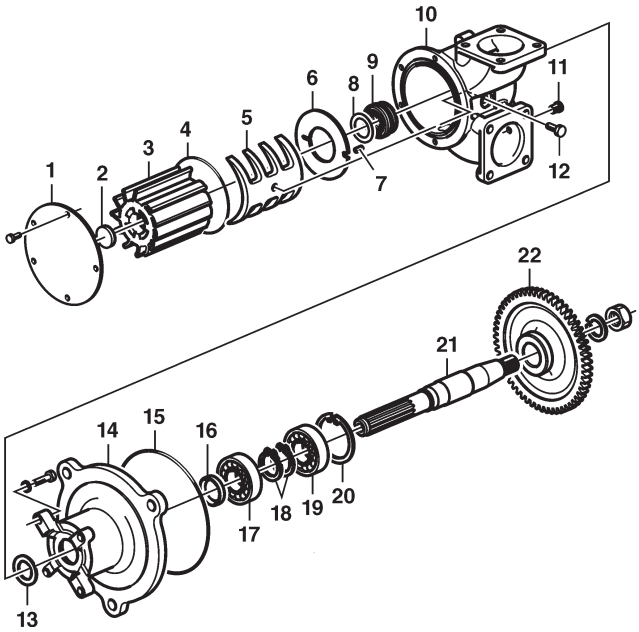


2

Install the inner circlips on the pump shaft and press the bearings on. **Note.** Drift 884167 can be used.

Or the bearing can be heated to approx. 100°C (212°F) and then be tapped into place.

Fill the bearings with grease (after they have cooled).



1. Cover
2. Rubber washer
3. Impeller
4. O-ring
5. Cam disc
6. Wear ring
7. Pin
8. Support washer
9. Shaft seal, compl.
10. Pump housing
11. Plug
12. Screw
13. Deflector ring
14. Bearing housing
15. O-ring
16. Seal ring
17. Ball bearing
18. Circlips
19. Ball bearing
20. Circlip
21. Pump shaft
22. Gear wheel