

# Workshop and repair manual

**VOLVO**

**Engine**

**TAD1343GE**

**TAD1344GE**

**TAD1345GE**





# Workshop Manual

Group 00-08, 20-26, 32

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TAD1340VE, TAD1341VE, TAD1342VE, TAD1343VE, TAD1344VE,  
TAD1345VE, TAD1350GE, TAD1351GE, TAD1352GE, TAD1353GE,  
TAD1354GE, TAD1355GE



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# 00-0 General

## General information

This Service Manual contains technical data, descriptions and maintenance and repair instructions for standard model Volvo Penta products. A list of these products may be found in the section **Specifications**.

The product designation and the serial number and specification is indicated on the engine decal or type plate. This information must be included in all correspondence regarding the product.

The service manual is produced primarily for the use of Volvo Penta workshops and their qualified personnel. It is assumed that any person using the Service Manual has a fundamental knowledge of the product and is able to carry out mechanical and electrical work to trade standard.

Volvo Penta continually develops its products; we therefore reserve the right to make changes. All information in this manual is based on product data which was available up to the date on which the manual was printed. New working methods and significant changes introduced to the product after this date are communicated in the form of **Service bulletins**.

## Spare Parts

Spare parts for the electrical and fuel systems are subject to various national safety standards. Volvo Penta Original Spare Parts meet these standards. No damage of any kind caused by the use of spare parts not approved by Volvo Penta will be compensated by any warranty undertaking.

## About this Workshop manual

### Certified engines

**When carrying out service and repair on emission-certified engines, it is important to be aware of the following:**

Certification means that an engine type has been inspected and approved by the relevant authority. The engine manufacturer guarantees that all engines of the same type are manufactured to correspond to the certified engine.

This places special demands on service and repair work, namely:

- Maintenance and service intervals recommended by Volvo Penta must be complied with.
- Only spare parts approved by Volvo Penta may be used.
- Service on injection pumps, pump settings and injectors must always be carried out by an authorized Volvo Penta workshop.
- The engine must not be converted or modified, except with accessories and service kits which Volvo Penta has approved for the engine.
- No changes to the exhaust pipe and engine air inlet duct installations may be made.
- No warranty seals (where present on the product) may be broken by unauthorized persons.

The general instructions in the Operator's Manual concerning operation, service and maintenance apply.

### IMPORTANT!

Neglected or poorly-performed care/service and the use of spare parts not approved by Volvo Penta, will mean that AB Volvo Penta no longer guarantees that the engine conforms to the certified model.

Volvo Penta accepts no responsibility for damage or costs arising as a result of failure to follow the above mentioned standards.

## Introduction

The working methods described in this manual are based on a workshop scenario where the product is mounted in a holding fixture. Maintenance work is often carried out in situ, in which case – if nothing else is indicated – using the same working methods as the workshop.

Warning symbols that occur in the service manual. For significance, refer to **Safety Information**.



**DANGER!**



**WARNING!**



**CAUTION!**

### **IMPORTANT!, NOTICE!**

are by no means comprehensive since not everything can be foreseen as service work is carried out in the most varied of circumstances. We call attention to risks that may occur due to incorrect handling during work in a well-equipped workshop using working methods and tools tried and tested by us.

The service manual describes work operations carried out with the aid of Volvo Penta Special Tools, where such have been developed. Volvo Penta Special Tools are designed to ensure the safest and most rational working methods possible. It is therefore the responsibility of anyone using tools or working methods other than those we recommend to ensure that no risk of personal injury or mechanical damage is present, or that malfunction can result.

In some cases, special safety regulations and user instructions may be in force for the tools and chemicals mentioned in the Service Manual. These regulations must always be followed, and no special instructions regarding this are to be found in the Service Manual.

By taking these basic precautions and using common sense it will be possible to guard against most elements of risk. A clean workplace and a clean product will eliminate many risks of personal injury and malfunction.

Above all, when working on fuel systems, hydraulic systems, lubrication systems, turbochargers, inlet systems, bearings and seals, it is of the utmost importance that dirt and foreign objects are kept away, as malfunctions or shortened service intervals may otherwise result.

## Repair instructions

### Our mutual responsibility

Each product comprises a large number of interacting systems and components. A deviation from the technical specification may dramatically increase the environmental impact of an otherwise reliable system. It is therefore critical that the stated wear tolerances be adhered to, that systems which can be adjusted be correctly set up and that only Volvo Penta Original Parts are used. The intervals in the care and maintenance schedule must be followed.

Some systems, e.g. fuel systems, often require special expertise and test equipment. A number of components are factory-sealed, for among other things environmental reasons. Warranty-sealed components may not be worked on without authorization to perform such work.

Remember that most chemical products, incorrectly used, are harmful to the environment. Volvo Penta recommends the use of biodegradable degreasers whenever components are cleaned, unless otherwise specified in the Service Manual. When working outdoors, take especial care to ensure that oils and wash residues etc. are correctly properly for destruction.

### Tightening torques

Tightening torques for vital fasteners that must be applied using a torque wrench are indicated in the Service Manual, chapter **Tightening torques** and in the Manual's work descriptions. All torque indications apply to clean threads, bolt heads and mating faces. Indicated torque data apply to lightly-oiled or dry threads. If lubricants, locking fluids or sealants are required for fasteners, the correct type will be noted in the job description.

## Torque, angle tightening

When torque/angle tightening, the fastener is tightened to a specified torque, and tightening then continues through a pre-determined angle.

Example: For 90° angle tightening, the fastener is turned a further 1/4 turn in one sequence, after the specified tightening torque has been achieved.

## Lock nuts

Removed locknuts may not be re-used; they must be replaced by new ones, as locking properties are impaired or lost with re-use.

In the case of lock nuts with plastic inserts the tightening torque indicated must be reduced if the nut has the same nut height as a standard, all-metal hexagonal nut.

Reduce the torque by 25% for bolt sizes of 8 mm or larger.

In the case of lock nuts with plastic inserts with a high nut-height (where the all-metal thread is as high as a standard hexagonal nut), the indicated torque applies.

## Strength classes

Nuts and bolts are subdivided into different strength classes. The classification is shown by a marking on the bolt head. Markings of a higher number indicate stronger material. For example, a bolt marked 10-9 is stronger than one marked 8-8.

For this reason, it is important that when bolts are removed they are returned to their original locations on re-assembly. When replacing bolts check the applicable **Spare parts catalogue** to ensure the correct bolt is used.

## Sealing compounds etc.

To ensure service work is correctly carried out it is important that the correct type of sealants and locking fluids are used on joints where such are required.

In each service manual section concerned, the sealants used in product manufacture are indicated. The same sealants, or sealants with equivalent properties, must be used for maintenance work.

Make sure that mating surfaces are dry and free from oil, grease, paint and anti-corrosion agent before applying sealant or locking fluid. Always follow the manufacturer's instructions regarding applicable temperatures, hardening times and such.

Two basic types of compound are used:

### RTV preparations (Room Temperature Vulcanizing).

Used most often together with gaskets, e.g. sealing gasket joints, or are brushed on gaskets. RTV sealants are completely visible when the part has been removed. Old RTV sealant must be removed before the component is sealed again. Use denatured alcohol.

### Anaerobic agents.

These agents cure (harden) in the absence of air. These preparations are used when two solid components, e.g. 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 old compound cannot be removed. On re-assembly, it is important to carefully degrease and wipe dry components first, before applying new sealant in accordance with the instructions.

## Safety regulations for fluorocarbon rubber

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

When fluorocarbon rubber is exposed to high temperatures (above 300°C/572°F), hydrofluoric acid can form. This is highly corrosive. Contact with the skin can result in severe chemical burns. Splashes in your eyes can result in chemical wounds. If you breathe in the fumes, your lungs can be permanently damaged.



### **WARNING!**

Seals must never be cut with a torch, or be burnt afterwards in an uncontrolled manner. Risk for poisonous gases.



### **WARNING!**

Always use chloroprene rubber gloves (gloves for chemicals handling) and 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 clean.

Put the remains in a plastic container, seal it and apply 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.

**Please note that seals which have not been exposed to high temperature can be handled normally.**

## 00-9 Miscellaneous

### Fan

#### **IMPORTANT!**

The engine is equipped with a so-called visco-fan. When the fan is removed the viscous coupling must **always stand upright**.

The coupling contains oil that will run out if it is laid on its side, and because the oil cannot run back in the fan will seize.



## 03-2 Specifications, Engine

### General Tightening Torques

#### General Tightening Torques

M6 standard bolt 8.8	$10 \pm 1.5 \text{ Nm}$ ( $7.4 \pm 1.1 \text{ lbf ft}$ )
M8 standard bolt 8.8	$24 \pm 4 \text{ Nm}$ ( $17.7 \pm 2.95 \text{ lbf ft}$ )
M10 standard bolt 8.8	$48 \pm 8 \text{ Nm}$ ( $35.4 \pm 5.9 \text{ lbf ft}$ )
M12 standard bolt 8.8	$85 \pm 15 \text{ Nm}$ ( $62.7 \pm 11.1 \text{ lbf ft}$ )
M14 standard bolt 8.8	$140 \pm 25 \text{ Nm}$ ( $103.3 \pm 18.4 \text{ lbf ft}$ )
M16 standard bolt 8.8	$220 \pm 35 \text{ Nm}$ ( $162.3 \pm 25.8 \text{ lbf ft}$ )

**NOTICE!** Only torqued bolts may be re-installed.

#### Angle-tightened / stretch-limit bolts:

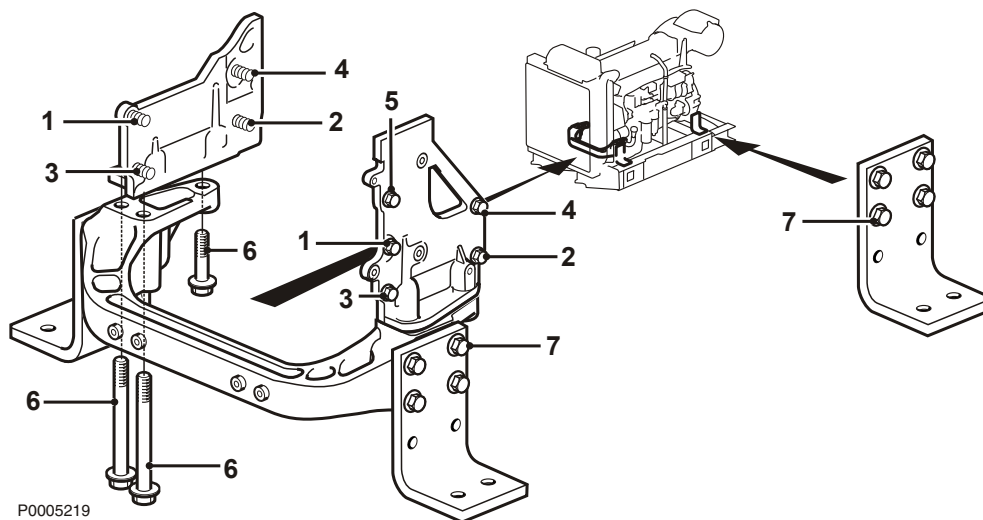
8.8	Must not be re-installed
10.9	May be re-installed
12.9	May be re-installed

#### **IMPORTANT!**

Check bolts which are to be re-installed. Damaged bolts, e.g. with shear marks under heads must be scrapped.

## Special Tightening Torques

### Group 21: Engine



#### Front engine mountings, engine block

Stage 1: Tighten bolt (1)	$85 \pm 5 \text{ Nm}$ ( $62.69 \pm 3.69 \text{ lbf ft}$ )
Step 2: Tighten the bolts 2–4	$105 \pm 15 \text{ Nm}$ ( $77.44 \pm 11.06 \text{ lbf ft}$ )
Stage 3: Angle tighten the bolts 2–4 in sequence	$60^\circ \pm 5^\circ$
Stage 4: Tighten bolt (1)	$105 \pm 15 \text{ Nm}$ ( $77.44 \pm 11.06 \text{ lbf ft}$ )
Stage 5: Angle tighten bolt 1	$60^\circ \pm 5^\circ$
Stage 6: Tighten bolt 5	standard bolt torque
Tighten the upward-facing engine bolts 6	$275 \pm 10 \text{ Nm}$ ( $202.83 \pm 7.376 \text{ lbf ft}$ )

#### Front and rear L brackets

Tighten the bolts 7	$220 \pm 35 \text{ Nm}$ ( $162.3 \pm 25.8 \text{ lbf ft}$ )
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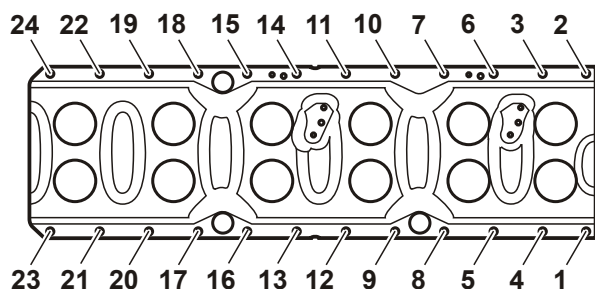
#### Main bearing caps

Stage 1	$150 \pm 20 \text{ Nm}$ ( $110.6 \pm 14.75 \text{ lbf ft}$ )
Stage 2 (angle tightening)	$120^\circ \pm 5^\circ$

#### Big end bearing cap

Stage 1	$20 \pm 3 \text{ Nm}$ ( $14.75 \pm 2.21 \text{ lbf ft}$ )
Stage 2	$60 \pm 3 \text{ Nm}$ ( $44.25 \pm 2.21 \text{ lbf ft}$ )
Stage 3 (angle tightening)	$90^\circ \pm 5^\circ$

## Frame reinforcement



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**NOTICE!** Tighten the bolts in sequence, as illustrated.  
The screws may **not** be reused.

### Frame reinforcement

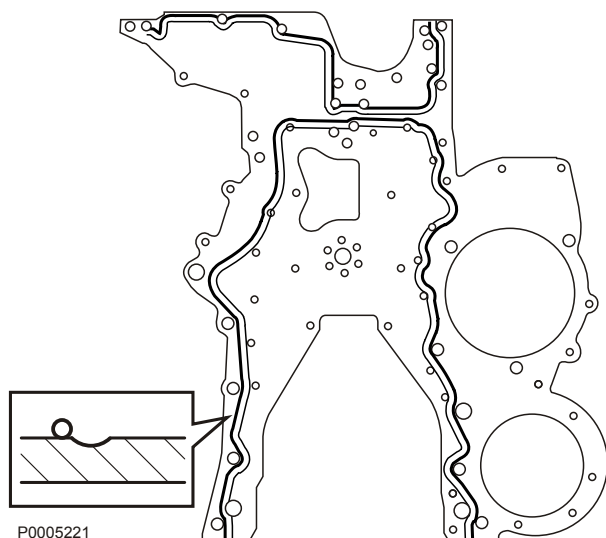
stage 1: Tighten the bolts **1–24** in sequence

$45 \pm 5 \text{ Nm}$  ( $33.2 \pm 3.69 \text{ lbf ft}$ )

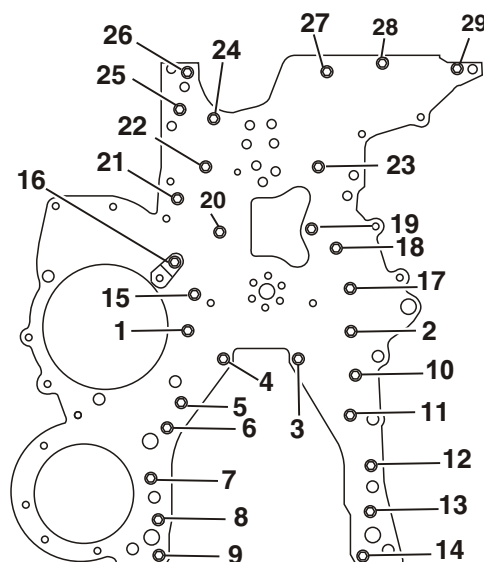
stage 2: Tighten the bolts **1–24** in sequence (angle tightening)

$60^\circ \pm 5^\circ$

## Timing gear plate



P0005221



P0005222

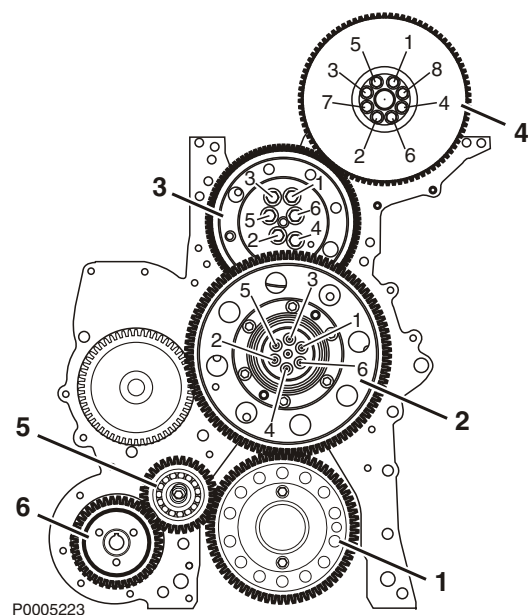
**NOTICE!** Run an approx. 2 mm (0.0787 in) silicone bead outside the groove as illustrated above, max 20 min before installation.

### Timing gear plate

Tighten all bolts in sequence to the following torque:

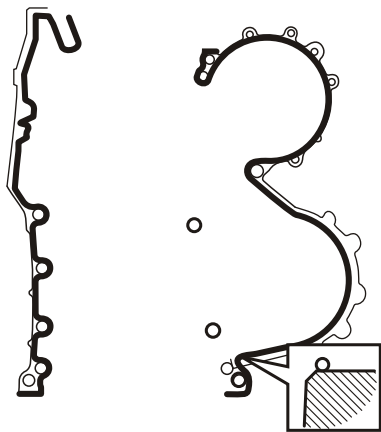
$28 \pm 4 \text{ Nm}$  ( $20.65 \pm 2.95 \text{ lbf ft}$ )

Timing gear wheels

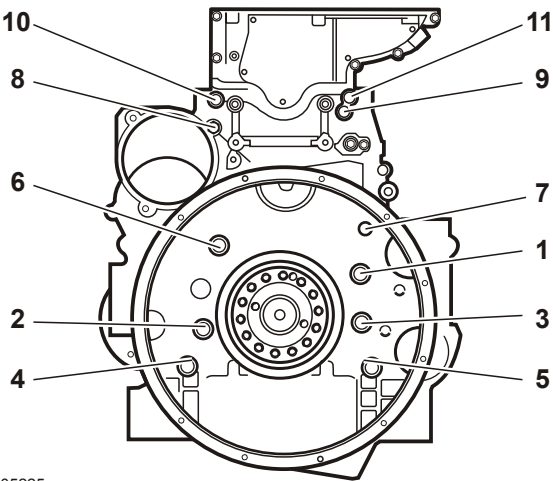


1 Drive gear, crankshaft	24 ± 4 Nm (17.7 ± 2.95 lbf ft)
2 Idler wheel, double gear outer:	
Stage 1	25 ± 3 Nm (18.44 ± 2.21 lbf ft)
Stage 2 (angle tightening)	110° ± 5°
<b>NOTICE!</b> Tighten in the order illustrated.	
3 Intermediate gear, adjustable:	
Stage 1	35 ± 4 Nm (25.81 ± 2.95 lbf ft)
Stage 2 (angle tightening)	120° ± 5°
<b>NOTICE!</b> Tighten in the order illustrated.	
4 Drive gear, camshaft (incl. vibration damper):	
Stage 1	45 ± 5 Nm (33.19 ± 3.69 lbf ft)
Stage 2 (angle tightening)	90° ± 5°
<b>NOTICE!</b> Tighten in the order illustrated.	
5 Intermediate gear	140 ± 10 Nm (103.3 ± 7.38 lbf ft)
6 Drive gear, power steering and fuel feed pump	100 ± 10 Nm (73.76 ± 7.38 lbf ft)

Flywheel and timing cover



P0005224



P0005225

**NOTICE!** Run an approx. 2 mm (0.0787 in) silicone bead as illustrated above, max 20 min before installation.

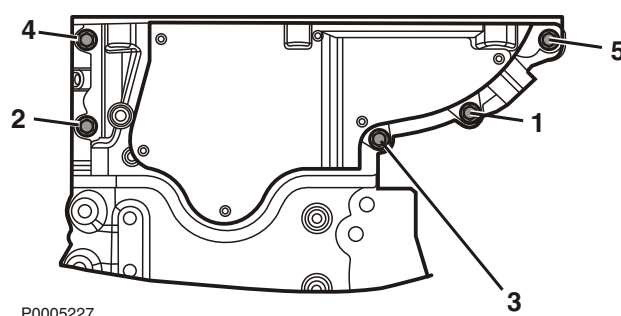
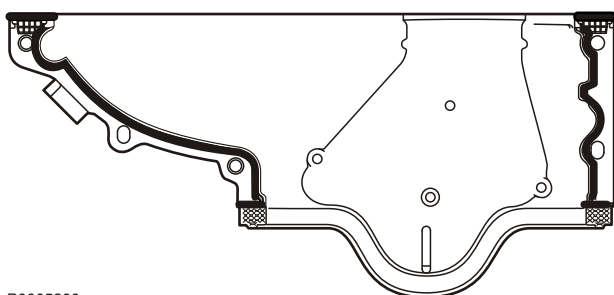
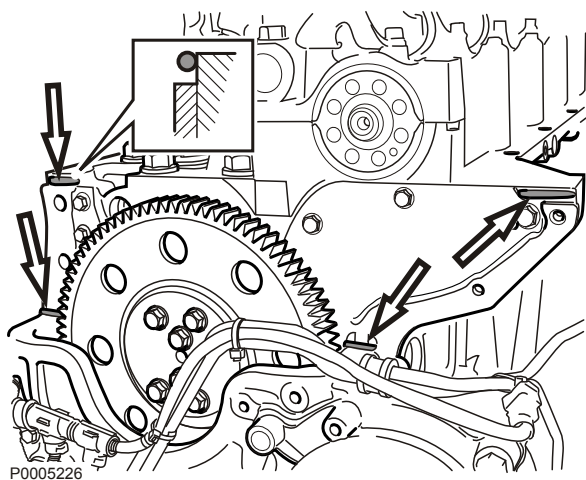
Flywheel housing

Tighten all bolts in sequence to the following torque:

M14 bolts	
M10 bolts	
M8 bolts	

140 ± 20 Nm (103.3 ± 14.75lbf ft)
48 ± 8 Nm (35.4 ± 5.9 lbf ft)
24 ± 4 Nm (17.7 ± 2.95 lbf ft)

## Timing Gear Cover, Upper



**NOTICE!** Run an approx. 2 mm (0.0787 in) silicone bead as in the illustrations, max 20 min before installation. Tighten the contact surfaces carefully.

Install the cover in two stages:

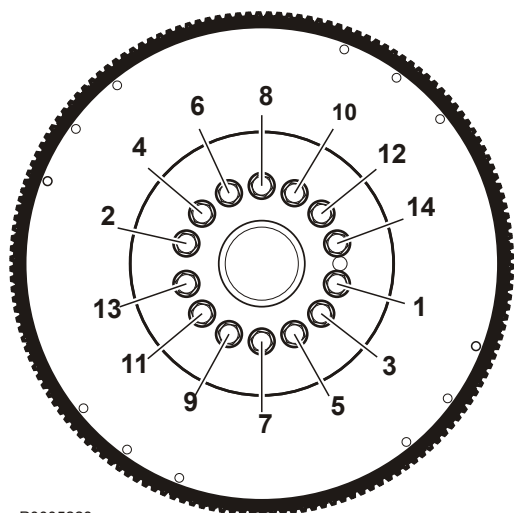
stage 1: Fasten the cover with bolts **1** and **2**. Use the special tool to press the cover into position

stage 2: Tighten the bolts in sequence, as illustrated

$4 \pm 1 \text{ Nm}$  ( $2.95 \pm 0.738 \text{ lbf ft}$ )

$24 \pm 4 \text{ Nm}$  ( $17.7 \pm 2.95 \text{ lbf ft}$ )

## Flywheel



P0005228

### Flywheel

stage 1: Tighten the bolts in sequence, as illustrated

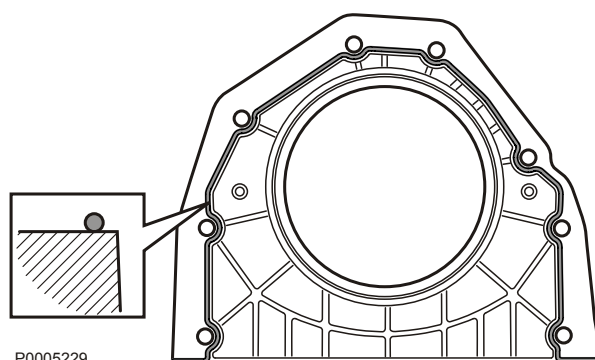
stage 2: (angle tightening)

$60 \pm 5 \text{ Nm}$  ( $44.25 \pm 3.69 \text{ lbf ft}$ )

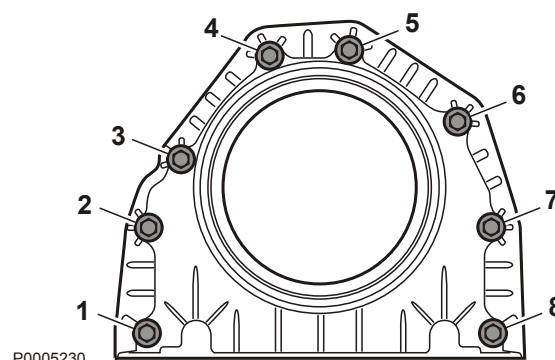
$120^\circ \pm 10^\circ$

**NOTICE!** Carefully check that the flange is clean and dry.  
Tighten the bolts in sequence, as illustrated.

## Cover, crankshaft seal



P0005229



P0005230

**NOTICE!** Run an approx. 2 mm (0.0787 in) silicone bead as illustrated above, max 20 min before installation.

### Cover, crankshaft seal:

stage 1: Fasten the cover with bolts **2** and **7** and tighten until it makes contact

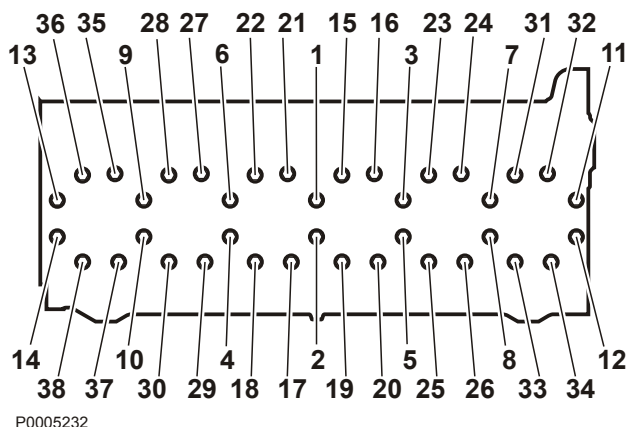
stage 2: Torque bolts **2** and **7**

stage 3: Tighten the bolts in the sequence **1, 3–6, 8** as illustrated.

$24 \pm 4 \text{ Nm}$  ( $17.7 \pm 2.95 \text{ lbf ft}$ )

$24 \pm 4 \text{ Nm}$  ( $17.7 \pm 2.95 \text{ lbf ft}$ )

## Cylinder Head



<u>stage 1: Tighten the bolts in sequence, as illustrated</u>	35 ± 5 Nm (25.81 ± 3.69 lbf ft)
<u>stage 2: Tighten the bolts in sequence, as illustrated</u>	90 ± 10 Nm (66.38 ± 7.38 lbf ft)

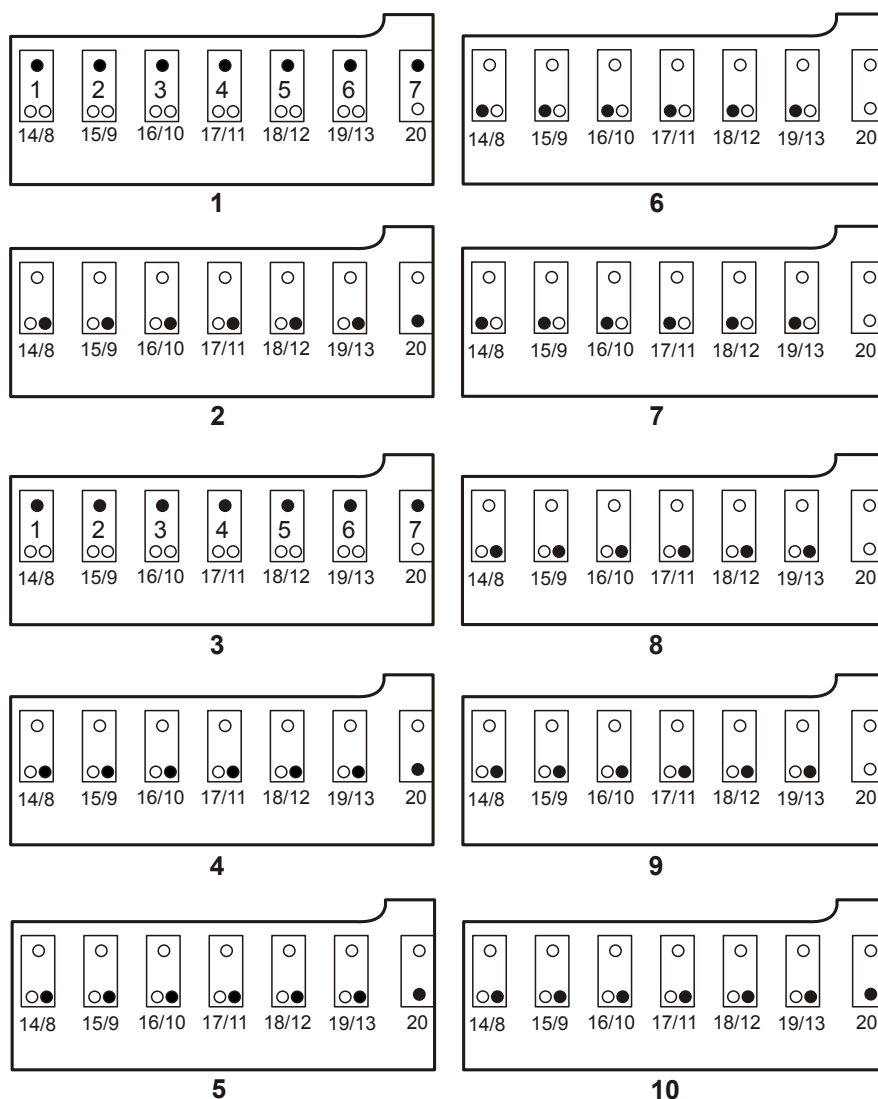
**NOTICE!** The vibration damper 8.8 bolts may not be re-used.

**NOTICE!** The cylinder head must be installed according to the “Installation” section in 21-1, *Cylinder Head, Change*.

stage 1: Tighten the bolts in sequence, as illustrated	100 ± 5 Nm (73.76 ± 3.69 lbf ft)
stage 2 (angle tightening)	120° ± 5°
stage 3 (angle tightening)	90° ± 5°



## Bearing caps, camshaft/rocker arm shaft



P0005233

### Camshaft: (camshaft and bearing caps in place)

stage 1: Tighten bolts 1–7

$25 \pm 3 \text{ Nm}$  ( $18.44 \pm 2.21 \text{ lbf ft}$ )

stage 2: (with shorter extra bolts) Tighten bolts 8–13 and 20

$60 \pm 5 \text{ Nm}$  ( $44.25 \pm 3.69 \text{ lbf ft}$ )

stage 3: Angle tighten bolts 1–7

$90^\circ \pm 5^\circ$

stage 4: Remove the extra bolts 8–13 and 20

### Rocker arm shaft: (rocker arm shaft in place)

stage 5: Tighten bolts 8–13 and 20 in stages in the sequence 11, 10, 12, 9, 13, 8, 20

$60 \pm 5 \text{ Nm}$  ( $44.25 \pm 3.69 \text{ lbf ft}$ )

stage 6: Tighten bolts 14–19

$25 \pm 3 \text{ Nm}$  ( $18.44 \pm 2.21 \text{ lbf ft}$ )

stage 7: Angle tighten bolts 14–19

$120^\circ \pm 5^\circ$

stage 8: Undo bolts 8–13

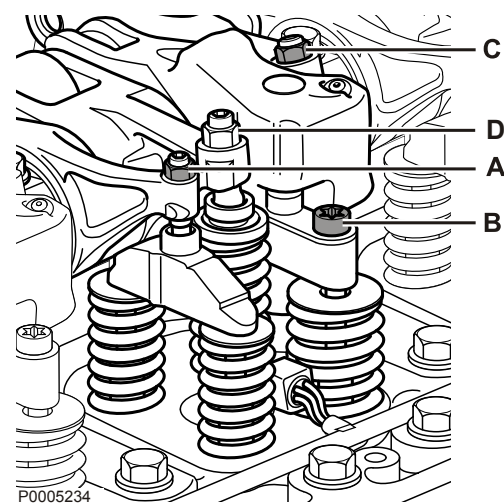
stage 9: Tighten bolts 8–13

$25 \pm 3 \text{ Nm}$  ( $18.44 \pm 2.21 \text{ lbf ft}$ )

stage 10: Angle tighten bolts 8–13 and 20

$120^\circ \pm 5^\circ$

Valves / floating rocker arm / EGR



Locking nut (A), valve adjuster screw:  
(angle tightening)

$60^{\circ} \pm 5^{\circ(1)}$

Bolt (B), floating rocker arm:  
(angle tightening)

$30^{\circ} + 15^{\circ} / - 0^{\circ(1)}$

Locking nut (C), EGR rocker arm:  
(angle tightening)

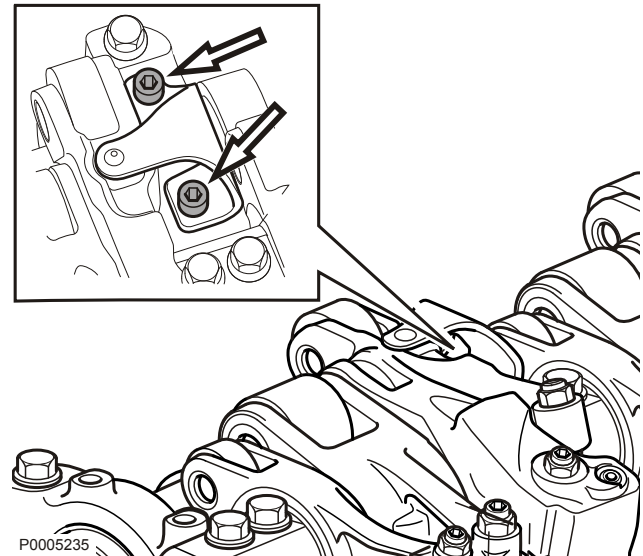
$45^{\circ} \pm 5^{\circ(1)}$

Locking nut, unit injector (D), valve adjuster screw

$52 \pm 4 \text{ Nm } (38.35 \pm 2.95 \text{ lbf ft})$

1) after contact

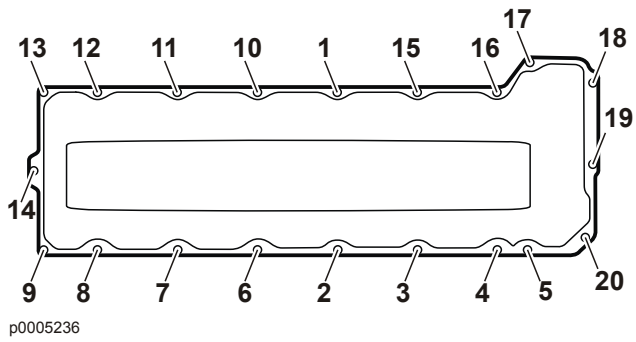
Spring plate



Spring plate

$25 \pm 3 \text{ Nm } (18.44 \pm 2.21 \text{ lbf ft})$

## Valve Cover



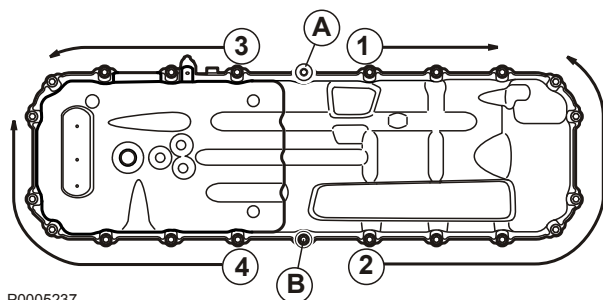
### Valve Cover

Tighten the bolts in sequence, as illustrated

$24 \pm 4$  Nm ( $17.7 \pm 2.95$  lbf ft)

## Group 22: Lubrication System

### Sump



P0005237

#### Oil sump (material: plastic)

Fasten the oil sump with bolts **A** and **B** and torque them

$24 \pm 4 \text{ Nm}$  ( $17.7 \pm 2.95 \text{ lbf ft}$ )

Tighten the bolts outwards from the center in the sequence **1–4** as illustrated above

$24 \pm 4 \text{ Nm}$  ( $17.7 \pm 2.95 \text{ lbf ft}$ )

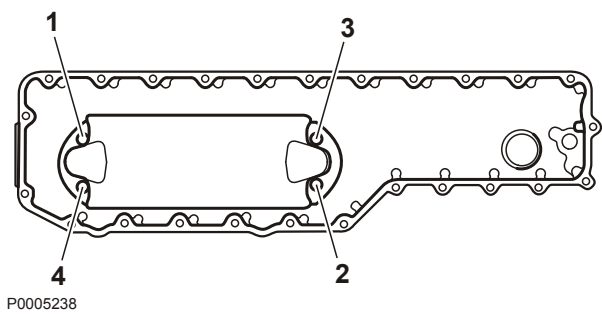
Finish off by checking the torque of bolts **A** and **B**

$24 \pm 4 \text{ Nm}$  ( $17.7 \pm 2.95 \text{ lbf ft}$ )

#### Drain plug, oil sump

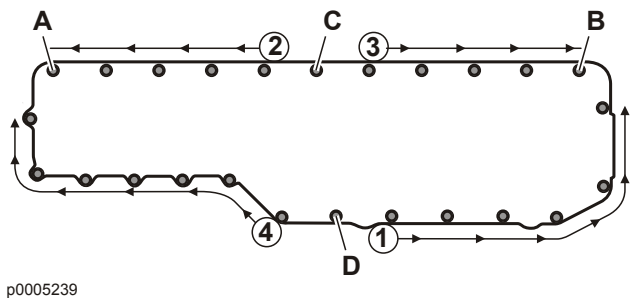
$60 \pm 10 \text{ Nm}$  ( $44.25 \pm 7.38 \text{ lbf ft}$ )

Oil Cooler



**NOTICE!** Tighten the bolts diagonally and finish off by tightening the first bolts again.  
**Oil Cooler, attachment bolts**

27 ± 4 Nm (19.91 ± 2.95 lbf ft)



**Oil cooler cover**

Install the cover on the engine block and fasten bolt **A** in the oval hole.  
Press the cover toward the water pump housing with an installation tool and install bolt **B**.  
Check that the cover is in position; refer to the service instruction.

Install bolts **C** and **D** and torque them

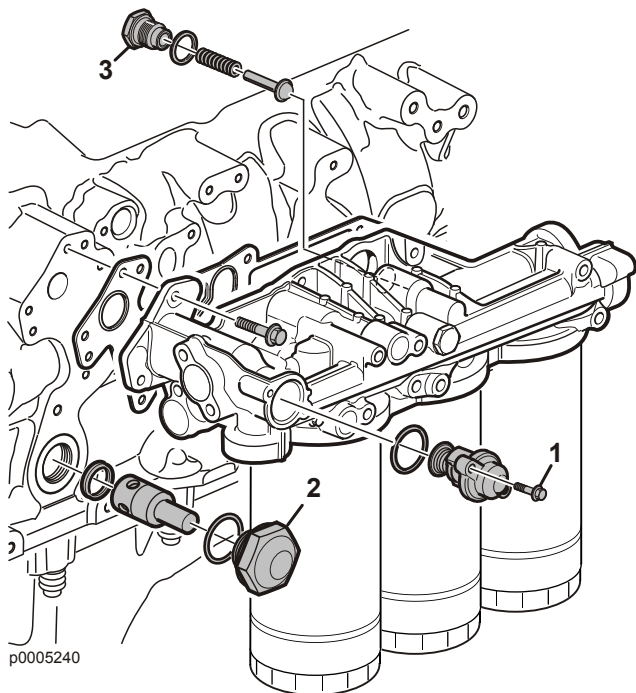
24 ± 4 Nm (17.7 ± 2.95 lbf ft)

Tighten the cover bolts outwards from the center in the sequence **1–4** as illustrated above

24 ± 4 Nm (17.7 ± 2.95 lbf ft)

Finish off by checking the torque of bolts **C** and **D**

24 ± 4 Nm (17.7 ± 2.95 lbf ft)



### Oil filter housing

Thermostat valve or pressure valve, oil cooler, bolt (1)

Safety valve, oil pressure, plug (2)

Overflow valve, oil filter, plug (3)

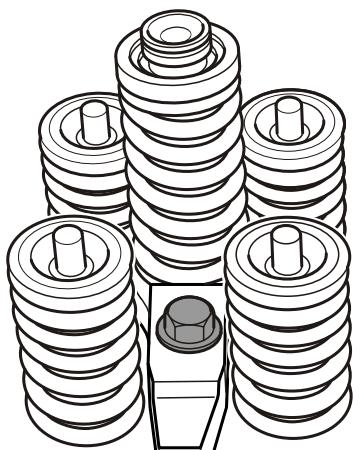
M6 standard bolt torque

$50 \pm 5$  Nm ( $36.88 \pm 3.69$  lbf ft)

$55 \pm 5$  Nm ( $40.57 \pm 3.69$  lbf ft)

## Group 23: Fuel System

### Unit injector



p0005241

#### Yoke, unit injector (when replacing copper sleeve)

First tightening:

stage 1

$20 + 5 / - 0$  Nm ( $14.75 + 3.69 / - 0$  lbf ft)

stage 2 (angle tightening)

$180^\circ \pm 5^\circ$

**NOTICE!** Loosen the yoke bolt before the second tightening.

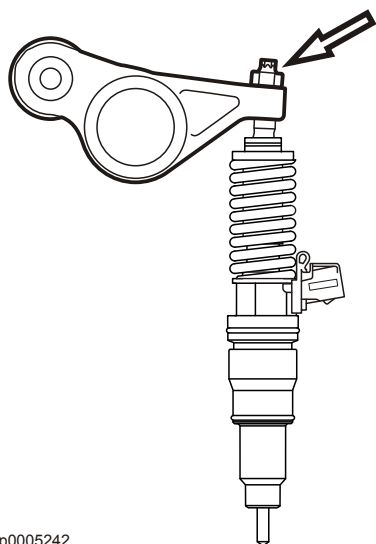
Second tightening:

stage 1

$20 + 5 / - 0$  Nm ( $14.75 + 3.69 / - 0$  lbf ft)

stage 2 (angle tightening)

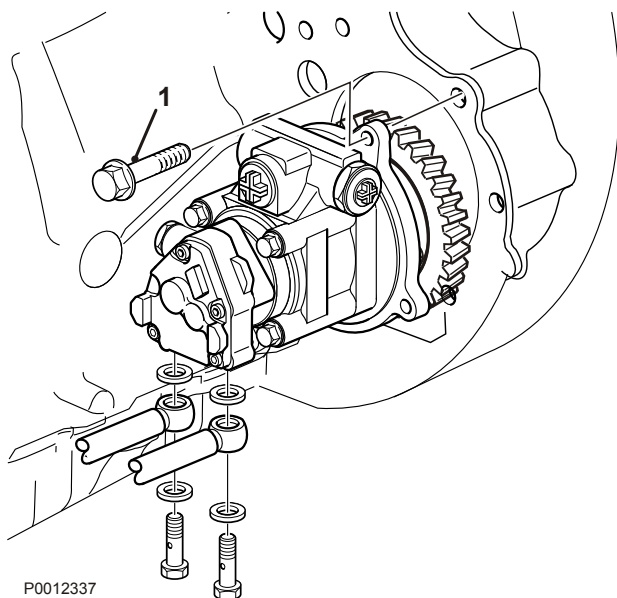
$90^\circ \pm 5^\circ$



p0005242

Locknut for adjuster screw, unit injector

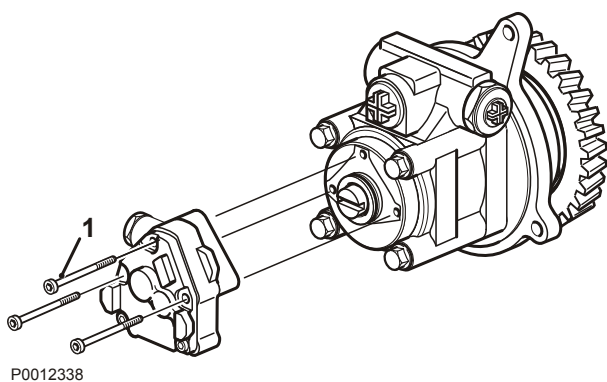
$52 \pm 4$  Nm ( $38.35 \pm 2.95$  lbf ft)



---

Bolts (1) for adapter incl. fuel pump

$24 \pm 2 \text{ Nm}$  ( $17.7 \pm 1.48 \text{ lbf ft}$ )



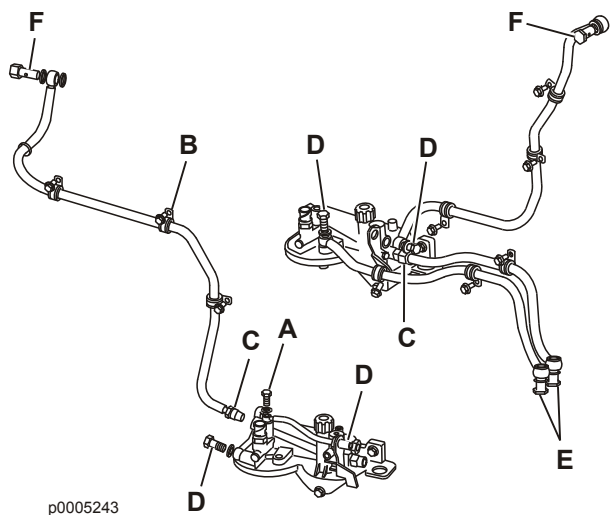
---

Bolts (1) for fuel pump (installed on adapter)

$8 + 2 / - 0 \text{ Nm}$  ( $5.90 + 1.48 / - 0 \text{ lbf ft}$ )



Bypass valve / fuel line brackets



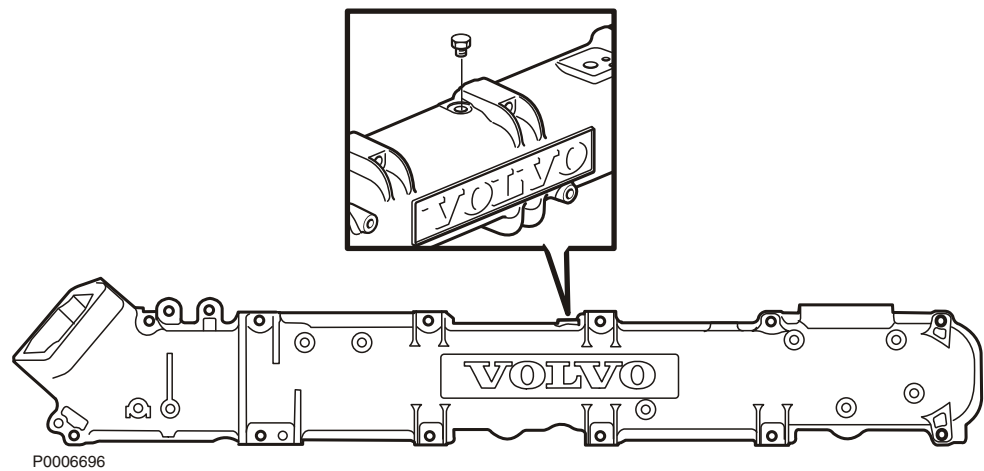
p0005243

Fuel line brackets, tightening torques:

A	18 ± 3 Nm (13.28 ± 2.21 lbf ft)
(B) Brackets	24 ± 4 Nm (17.7 ± 2.95 lbf ft) [standard tightening torque]
C	30 ± 4 Nm (22.13 ± 2.95 lbf ft)
D	35 ± 5 Nm (25.81 ± 3.69 lbf ft)
E	40 ± 5 Nm (29.50 ± 3.69 lbf ft)
F	48 ± 5 Nm (35.40 ± 3.69 lbf ft)

Group 25: Inlet and Exhaust System

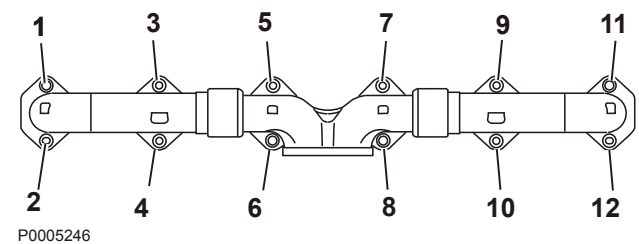
Inlet Manifold



Inlet Manifold

Torque the bolts	$24 \pm 4 \text{ Nm}$ ( $17.7 \pm 2.95 \text{ lbf ft}$ )
M10 plug, inlet manifold	$20 \pm 3 \text{ Nm}$ ( $14.75 \pm 2.21 \text{ lbf ft}$ )

Exhaust Manifold



Exhaust Manifold

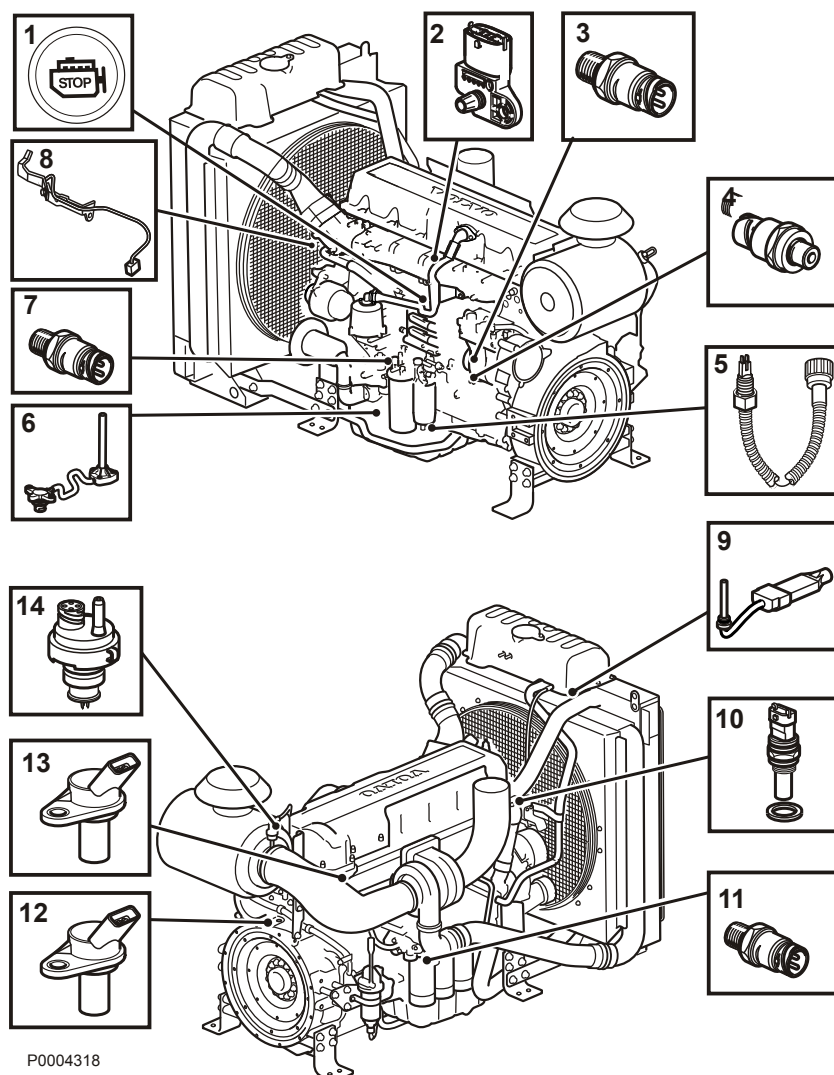
Stage 1:

Tighten the bolts <b>1, 4</b> and <b>5, 8</b> and <b>9, 12</b> until they make contact	$(10 \pm 1.5 \text{ Nm})$ [ $7.38 \pm 1.11 \text{ lbf ft}$ ]
--	--

Step 2:

Torque bolts <b>3</b> and <b>2</b>	$48 \pm 8 \text{ Nm}$ ( $35.4 \pm 5.9 \text{ lbf ft}$ )
Torque bolts <b>7</b> and <b>6</b>	$48 \pm 8 \text{ Nm}$ ( $35.4 \pm 5.9 \text{ lbf ft}$ )
Torque bolts <b>11</b> and <b>10</b>	$48 \pm 8 \text{ Nm}$ ( $35.4 \pm 5.9 \text{ lbf ft}$ )
Torque bolts <b>1</b> and <b>4</b>	$48 \pm 8 \text{ Nm}$ ( $35.4 \pm 5.9 \text{ lbf ft}$ )
Torque bolts <b>5</b> and <b>8</b>	$48 \pm 8 \text{ Nm}$ ( $35.4 \pm 5.9 \text{ lbf ft}$ )
Torque bolts <b>9</b> and <b>12</b>	$48 \pm 8 \text{ Nm}$ ( $35.4 \pm 5.9 \text{ lbf ft}$ )

## Location of Sensors



P0004318

1	Auxiliary stop	
2	Charge pressure sensor / Charge air temperature sensor	M6 standard bolt torque
3	Oil pressure sensor	$30 \pm 5$ Nm
4	Crankcase sensor	$30 \pm 5$ Nm
5	Water separator level sensor	not replaceable, integrated in lines
6	Oil level and oil temperature sensor	standard bolt torque
7	Fuel pressure sensor	$30 \pm 5$ Nm
8	Pressure drop indicator / Air temperature	clamp
9	Coolant level sensor	insertable type
10	Coolant temperature sensor	$22 \pm 3$ Nm
11	Piston cooling oil pressure	$30 \pm 5$ Nm
12	Flywheel position and rotation speed	M6 standard bolt torque
13	Camshaft position sensor	M6 standard bolt torque

## Group 26: Cooling System

Refer to *General Tightening Torques* page 7.

## Engine, General

**NOTICE!** Because the illustrations in the maintenance literature are used for different engine variants, certain details may vary compared to the actual model concerned. The essential information is always correct, however.

TAD1341GE, TAD1343GE, TAD1343GE,  
TAD1344GE, TAD1345GE, TAD1340VE,  
TAD1341VE, TAD1342VE, TAD1343VE,  
TAD1344VE, TAD1345VE, TAD1350GE,  
TAD1351GE, TAD1352GE, TAD1353GE,  
TAD1354GE, TAD1355GE

Type designation	
No. of cylinders	6
Cylinder diameter, std	131 mm (5.16 in)
Stroke	158 mm (6.22 in)
Cylinder volume	12.78 liter (779.9 in <sup>3</sup> )
Injection sequence	1–5–3–6–2–4
Compression ratio	18,1:1
Compression	3,7 MPa (537 psi)
Low idle	900 rpm
High idle	1800 rpm
Dry weight, engine	1295 kg (2855 lb)
Dry weight, engine with generator set	1715 kg (3781 lb)
Wet weight, engine	1325 kg (2921 lb)
Wet weight, engine with generator set	1790 kg (3946 lb)
Total length	2204 mm (86.77 in)
Total width	1106 mm (43.54 in)
Total height	1391 mm (54.76 in)

# Engine

## Technical Data

### Engine body

#### Cylinder Head

Max unevenness (bottom surface)	0.1 mm (0.00394 in)
---------------------------------	---------------------

#### Cylinder Head Bolts

No./cylinder head	38
Thread dimension	M16
Length	200 mm (7.87 in)

#### Cylinder block

Length	1052 mm (41.41 in)
Height, upper block plane-crankshaft center	422 mm (16.61 in)
Height, lower block plane-crankshaft center	120 mm (4.72 in)

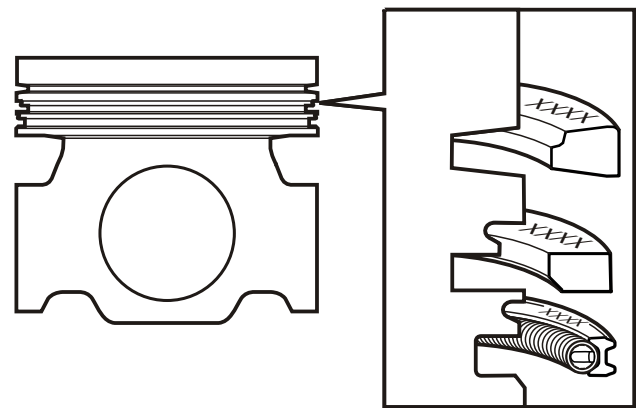
#### Cylinder Liner

Type	Wet, replaceable
Sealing surface height above block plane	0.15–0.21 mm (0.00591–0.00827 in)
No. of seal rings per cylinder liner	1 + 3

#### Piston

Height above cylinder block plane, steel pistons	0.1 (min)–0.7 (max) mm [0.00394–0.0276 in]
No. of ring grooves	3
Front marking	Forward pointing arrow

Piston rings



p0005201

Compression Rings

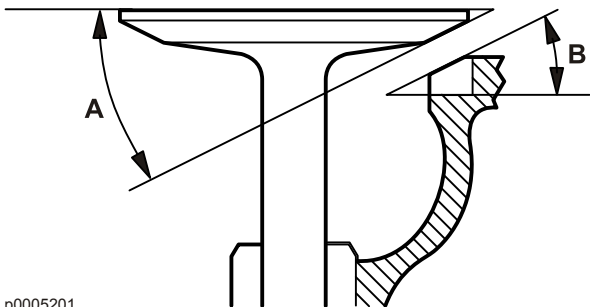
Quantity	2
Marking	Up (color marking to left of gap)
Piston ring clearance in groove:	
upper compression ring	(trapezoid profile)
lower compression ring	0.09–0.14 mm (0.00354–0.00551 in)
Piston ring gap, measured at ring opening:	
upper compression ring	0.40–0.55 mm (0.0157–0.0217 in)
	Wear tolerance < 0.65 mm (0.0256 in)
lower compression ring	1.30–1.50 mm (0.0512–0.0591 in)
	Wear tolerance < 1.65 mm (0.065 in)

Oil Scraper Ring

Quantity	1
Marking	Up (color marking to left of gap)
Piston ring clearance in groove	0.05–0.10 mm (0.00197–0.00394 in)
Piston ring gap, measured at ring opening	0.30–0.55 mm (0.0118–0.0217 in)
	Wear tolerance < 0.70 mm (0.0276 in)

Valve mechanism

Valves



Valve head, diameter:

Inlet	42 mm (1.654 in)
Exhaust	40 mm (1.575 in)

Valve stem, diameter:

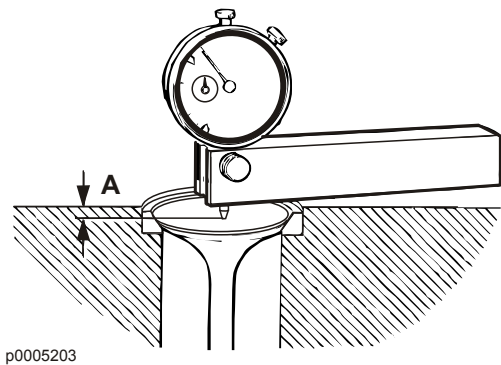
Inlet / exhaust	8 mm (0.315 in)
-----------------	-----------------

Valve seat angle (A):

Inlet	24,5° ± 0,2°
Exhaust	39,5°

Seat angle in cylinder head (B):

Inlet	25°
Exhaust	40°



Specifications

Dimension (A) between valve head and cylinder head plane:

	Min. (A)	Wear value
Inlet	1.0 mm (0.0394 in)	Max 1.7 mm (0.0669 in)
Exhaust	1.35 mm (0.0531 in)	Max 2.1 mm (0.0827 in)

Valve clearance, cold engine, setting value:

Inlet	0.2 mm (0.00787 in)
Exhaust	0.8 mm (0.0315 in)
Exhaust, EGR	Counter clockwise adjustment, 1 ¾ turns, (630°)

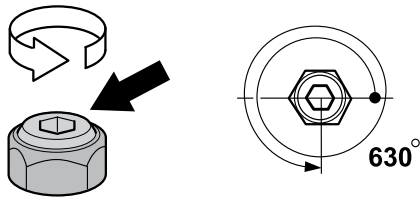
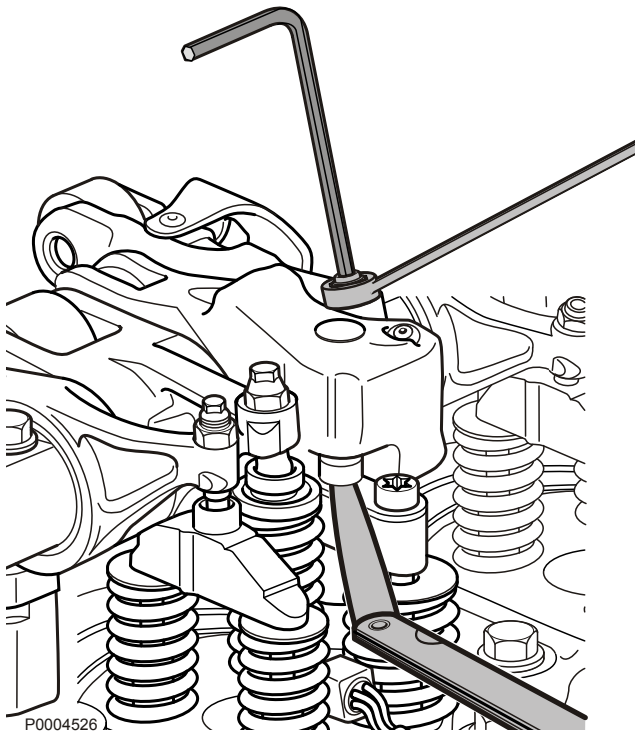
**Rocker arm, EGR**

TAD1350GE, TAD1351GE, TAD1352GE,  
TAD1353GE, TAD1354GE, TAD1355GE

**Rocker arm, EGR, adjustment:**

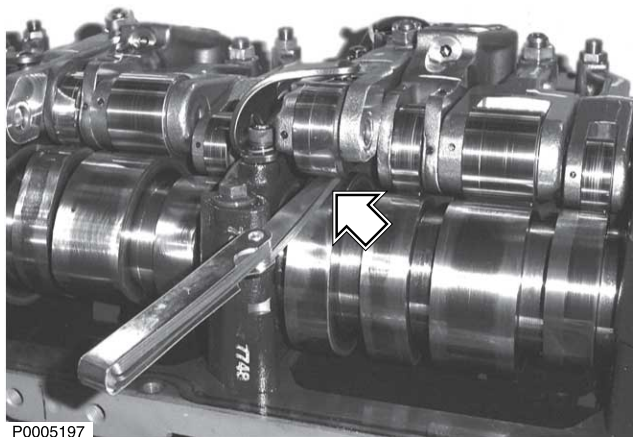
Allow the feeler gauge to remain in place after adjusting the valve clearance and adjust the EGR rocker arm by loosening the locking nut and adjusting the screw until no clearance is attained.

Check by rotating the rocker arm roller at the camshaft.



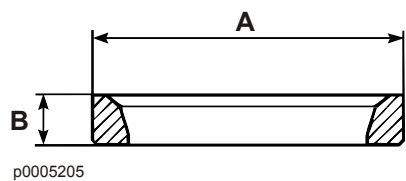
Undo the adjuster screw 1 ¾ turns, (630°). Tighten the lock nut. Remove the feeler gauge from the exhaust valve.





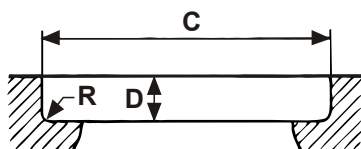
Rocker arm, EGR, check value	3.8 ± 0.1 mm (0.15 ± 0.00394 in)
------------------------------	----------------------------------

**Valve seats**



Outer diameter (A):	Standard	Oversize dimension
Inlet	45.1 mm (1.7756 in)	45.3 mm (1.7835 in)
Exhaust	43.1 mm (1.6968 in)	43.3 mm (1.7047 in)
Height (B):		
Inlet	7.55 mm (0.2972 in)	
Exhaust	7.5 mm (0.2952 in)	

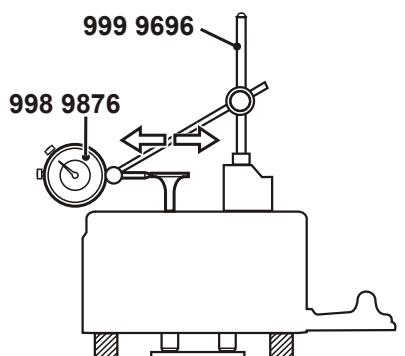
## Valve seat position



p0005206

Diameter (C):	Standard	Oversize dimension
Inlet	45.0 mm (1.772 in)	45.2 (1.7795 in) [0/+0.025 mm] (0/+0.000984 in)
Exhaust	43.0 mm (1.693 in)	43.2 (1.7008 in) [0/+0.025 mm] (0/+0.000984 in)
Depth (D):		
Inlet	11.8 ± 0.13 mm (0.4645 ± 0.005118 in)	
Exhaust	11.2 ± 0.13 mm (0.4409 ± 0.005118 in)	
Seat bottom radius (R):		
Inlet / exhaust	max 0.8 mm (0.0315 in)	

## Valve guides



p0005207

Length:	
Inlet / exhaust	83.5 mm (3.287 in)
Inner diameter:	
Inlet / exhaust	8 mm (0.315 in)
Height above cylinder head spring plane:	
Inlet / exhaust	24.5 ± 0.2 mm (0.9645 ± 0.00787 in)

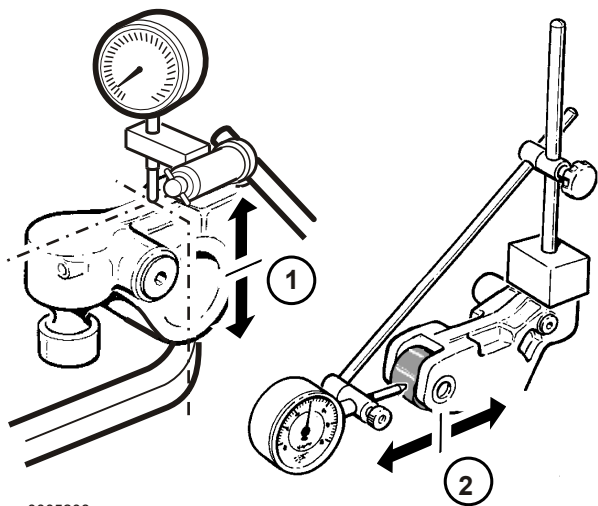
### Wear value (See figure)

Clearance, valve stem guide:<sup>(1)</sup>

Inlet	max 0.7 mm (0.0276 in)
Exhaust	max 0.7 mm (0.0276 in)

1) The dimension is calculated for the measurement method in the service literature; Refer to *Valve Guides, Inspection* page 188.

Rocker Arm



p0005208

Wear values

Bearing play (1)	max 0.1 mm (0.00394 in)
Roller cam follower, clearance (2)	max 0.1 mm (0.00394 in)

Valve springs

Inlet

Length uncompressed	73.8 mm (2.9055 in)
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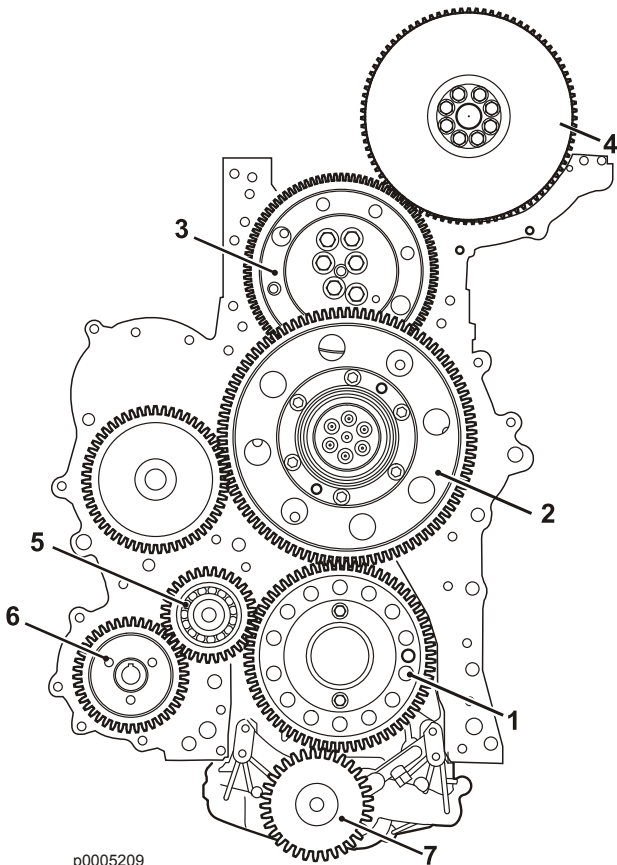
Exhaust

Length uncompressed	73.8 mm (2.9055 in)
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## Engine Transmission

### Timing gear wheels

- 1 Drive gear, crankshaft
- 2 Intermediate gear: outer gearwheel, inner gear-wheel
- 3 Intermediate gear (adjustable)
- 4 Drive gear, camshaft
- 5 Intermediate gear
- 6 Drive gear, power steering pump and fuel feed pump
- 7 Drive gear, lubrication oil pump



p0005209

Gear lash, adjustable intermediate gear to camshaft drive gear

0.05–0.15 mm (0.00197–0.00591 in)

Gear lash, oil pump

0.05–0.40 mm (0.00197–0.0157 in)

Gear lash, other

0.05–0.17 mm (0.00197–0.00669 in)

Radial clearance for intermediate gear

max 0.05 mm (0.00197 in)

### Camshaft

Camshaft drive	gearwheel
No. of bearings	7
Diameter, bearing journals, standard	69.97–70.00 mm (2.755–2.756 in)
Diameter, bearing journals, undersize:	
0.25 mm (0.00984 in)	69.72–69.78 mm (2.745–2.747 in)
0.50 mm (0.0197 in)	69.47–69.53 mm (2.735–2.737")
0.75 mm (0.0295 in)	69.22–69.28 mm (2.725–2.728 in)
Permissible wear, entire camshaft profile	max 0.1 mm (0.00394 in)
Unit injector, stroke	18 mm (0.709 in)
<b>Wear value</b>	
Max end float	0.24 mm (0.00945 in)
Bearing, max permissible radial wear	0.1 mm (0.00394 in)

### Camshaft Bearings

Camshaft bearing thickness, standard	1.92 mm (0.0756 in)
Oversize dimension:	
0.25 mm (0.00984 in)	2.04 mm (0.0803 in)
0.50 mm (0.0197 in)	2.17 mm (0.0854 in)
0.75 mm (0.0295 in)	2.29 mm (0.0902 in)

Crank Mechanism

Crankshaft

Wear value

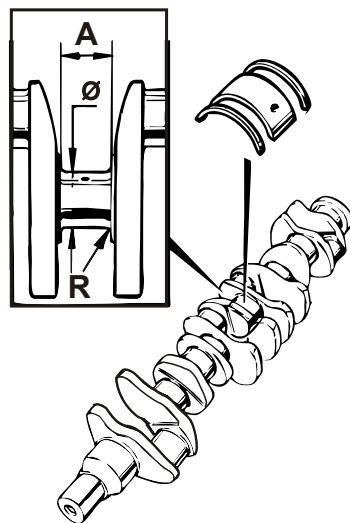
Crankshaft end float <sup>(1)</sup>	max 0.4 mm (0.01575 in)
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Machining value

Ovality of main bearing journals and connecting rod journal	max 0.006 mm (0.0002362 in)
Center main bearing runout	max 0.15 mm (0.00591 in)

1) Dimensions refer to greased components.

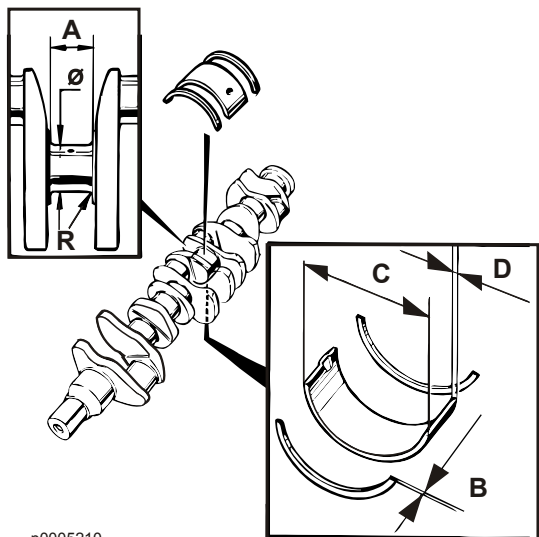
Main bearing journals



P0005849

Diameter (Ø) standard	108.0 mm (4.252 in)
Undersize dimension:	
0.25 mm (0.00984 in)	107.75 mm (4.242 in)
0.50 mm (0.0197 in)	107.50 mm (4.232 in)
1.00 mm (0.0394 in)	107.00 mm (4.213 in)
Surface fineness, main bearing journals	Ra 0.25 (9.84·10 <sup>-6</sup> in)
Surface fineness, radius	Ra 0.4 (1.575·10 <sup>-5</sup> in)
Width, thrust bearing journal (A) standard	47.0 mm (1.850 in)
Oversize dimension:	
0.2 mm (0.00787 in), thrust bearing 0.1 mm (0.00394 in)	47.2 mm (1.858 in)
0.4 mm (0.01575 in), thrust bearing 0.2 mm (0.00787 in)	47.4 mm (1.866 in)
0.6 mm (0.02362 in), thrust bearing 0.3 mm (0.0118 in)	47.6 mm (1.874 in)
Fillet radius (R)	4.0 mm (0.1575 in)

Thrust washers (thrust bearing)



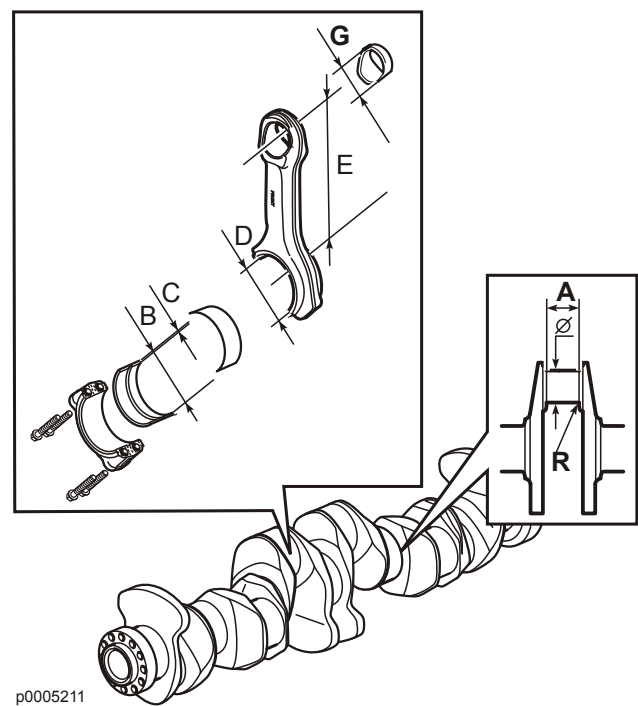
p0005210

Width <b>(B)</b> standard	3.18 mm (0.1252 in)
Oversize dimension:	
0.1 mm (0.00394 in)	3.28 mm (0.1291 in)
0.2 mm (0.00787 in)	3.38 mm (0.1331 in)
0.3 mm (0.0118 in)	3.48 mm (0.1370 in)

Main bearing cup

Thickness <b>(D)</b> standard	2.48 mm (0.0976 in)
Oversize dimension:	
0.25 mm (0.00984 in)	2.61 mm (0.1028 in)
0.50 mm (0.0197 in)	2.74 mm (0.1079 in)
1.00 mm (0.0394 in)	2.98 mm (0.1173 in)

Big-end journals



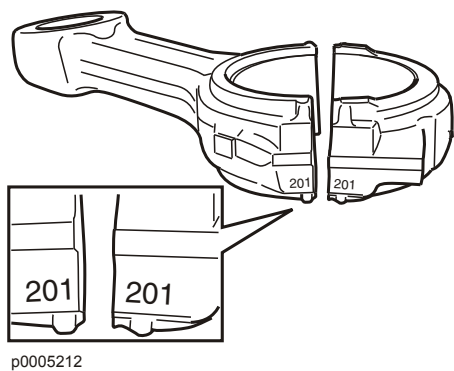
Diameter ( <b>Ø</b> )	99.0 mm (3.898 in)
Undersize dimension:	
0.25 mm (0.00984 in)	98.75 mm (3.8878 in)
0.50 mm (0.0197 in)	98.50 mm (3.8779 in)
0.75 mm (0.0295 in)	98.25 mm (3.8681 in)
1.00 mm (0.0394 in)	98.00 mm (3.8583 in)
1.25 mm (0.0492 in)	97.75 mm (3.8484 in)
Surface fineness, big-end journals	Ra 0.25 (9.84·10 <sup>-6</sup> in)
Surface fineness, radius	Ra 0.4 (1.575·10 <sup>-5</sup> in)
Width ( <b>A</b> )	57.0 mm (2.244 in)
Fillet radius ( <b>R</b> )	4.0 mm (0.1575 in)
Connecting rod big end, diameter ( <b>D</b> )	103.84 mm (4.0882 in)
Connecting rod, length ( <b>E</b> )	267.5 mm (10.5315 in)
Connecting rod small end, diameter ( <b>G</b> )	58.0 mm (2.2835 in)

Connecting rod bearing cup

Thickness ( <b>C</b> ) standard	2.39 mm (0.0941 in)
Oversize dimension:	
0.25 mm (0.00984 in)	2.51 mm (0.09882 in)
0.50 mm (0.0197 in)	2.64 mm (0.10394 in)
1.00 mm (0.0394 in)	2.89 mm (0.1138 in)



Connecting rod



**Marking:**  
"FRONT" on the connecting rod faces forward.  
The connecting rod and bearing caps are marked in pairs with a three-digit serial number (see illustration).

**Wear value <sup>(1)</sup>**

End float, connecting rod–crankshaft	max 0.35 mm (0.01378 in)
Connecting rod bearing, radial clearance	max 0.1 mm (0.00394 in)

1) Dimensions refer to greased components.

**Flywheel, installed**

Runout, measured radius 150 mm (5.905 in)	< 0.20 mm (0.0787 in)
---	-----------------------

**Flywheel housing, installed**

Runout for contact surface	max 0.2 mm (0.0787 in)
Radial play for steering	max 0.26 mm (0.01024 in)

## Lubrication System

### Technical Data

#### Oil

Oil change volume	36 liter	_____	9.51 US gals
Oil volume between min and max markings	11 liter	_____	2.91 US gals

#### Oil Pressure

Operating speed (above 1100 rpm)	300–550 kPa	_____	43.5–79.8 psi
Cold engine (above 1100 rpm)	–650 kPa	_____	–94.3 psi
Low idle (min)	min 250 kPa	_____	min 36.3 psi
Piston cooling pressure, hot engine (above 1100 rpm)	200–300 kPa	_____	29–43.5 psi

#### Oil pressure, rocker arm shaft

Non-activated EGR	80–120 kPa	_____	11.6–17.4 psi
Activated EGR (900–2300 rpm)	min 220 kPa	_____	min 31.9 psi

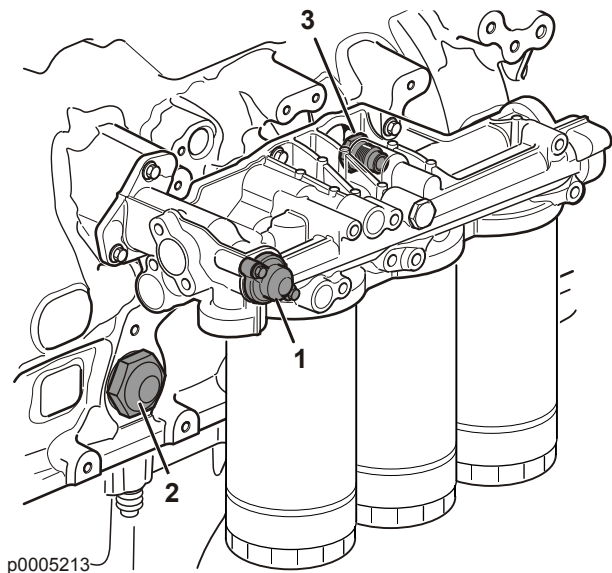
#### Oil temperature

Max oil temperature in oil sump	130 °C	_____	266 °F
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Oil Filter

<b>Number</b>	
Full flow filter	2
Bypass filter	1

Oil valves



<b>1 Thermostat valve, oil cooler</b>	
Opening temperature	105–107 °C (221–224.6 °F)
<b>2 Safety valve, block</b>	
Marking	Yellow
<b>3 Bypass valve, full flow filter</b>	
Spring, free length	69 mm (2.717 in)
Compressed 13–15 N (2.9–3.4 lbf)	40 mm (1.575 in)

# Fuel System

## Technical Data

**NOTICE!** For the below-mentioned values, fuel is required to fulfill the requirements specified in *03-0, Fuel and Oils*.

### Feed pump

Feed pressure at:			
600 rpm	100 kPa		14.5 PSI
1200 rpm	300 kPa		43.5 PSI
full load	300 kPa		43.5 PSI

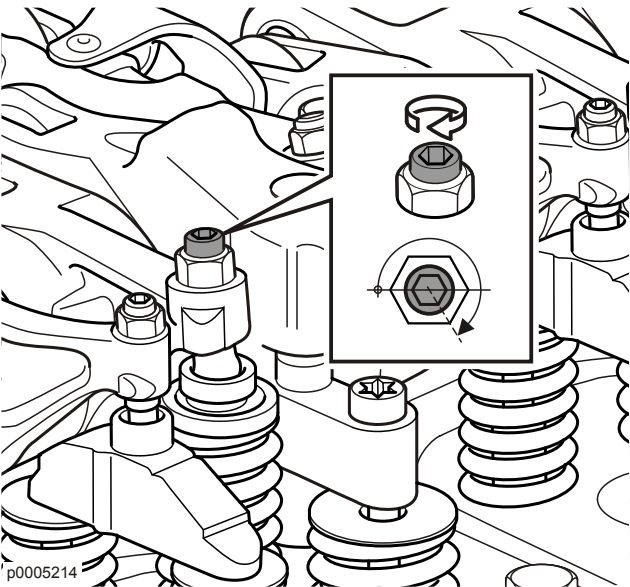
### Bypass valve

Opening pressure	300–550 kPa		43.5–79.8 PSI
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### Unit injector

#### Pre-load

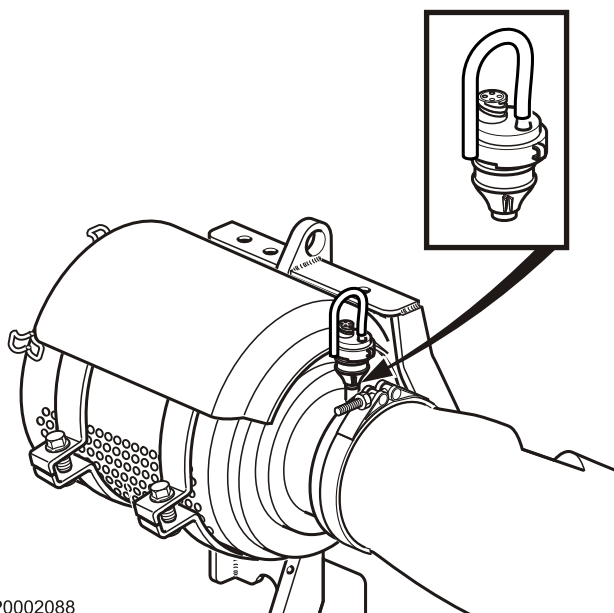
Tighten the adjuster screw to zero-clearance against the camshaft. Then turn 4 flats; see illustration.



## Inlet and Exhaust System

### Technical Data

#### Pressure drop indicator



P0002088

The pressure drop indicator control lamp lights up at a pressure drop relative to ambient air pressure of:

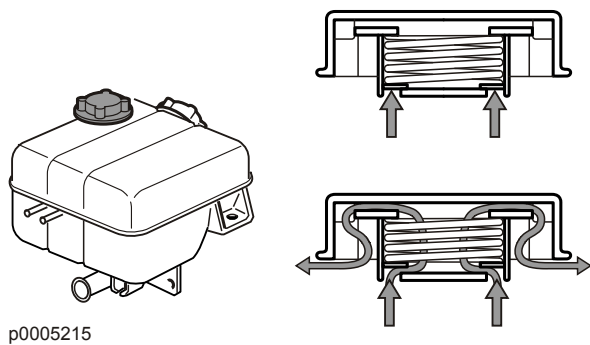
$50 \pm 5$  kPa

$7.25 \pm 0.7$  PSI

# Cooling System

## Technical Data

### Pressure cap



p0005215

Pressure cap opens at	75 kPa (10.88 PSI)
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### Thermostat

Quantity	1
Opening temperature:	< 82 °C (179.6 °F)

### Coolant

Type	Volvo Penta Coolant
Color	Green
Contains	Ethylene glycol and anti-corrosion additives
Mix with	Water (According to ASTM D4985)
Mixing proportions (conc. coolant/water)	40/60

**NOTICE!** Do not use Volvo Coolant VCS (yellow in color) in Volvo Penta engines.

**NOTICE!** Do not mix different kinds of coolant.

### Refill quantity

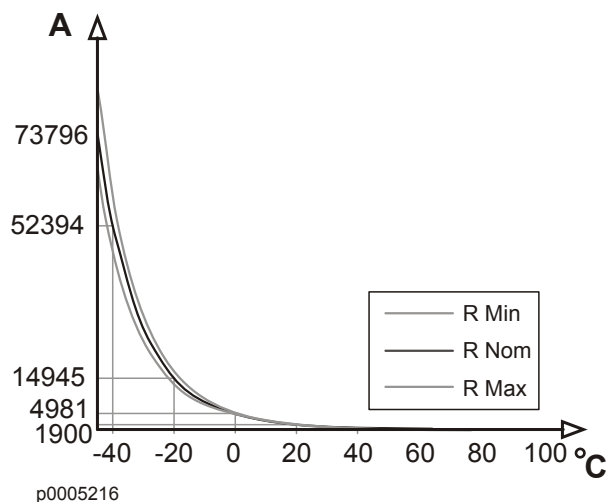
Coolant quantity (engine, radiator and hoses):	
TAD1340–53 GE/VE	44 liter (46.49 quart)

## 03-3 Specifications, Electrical

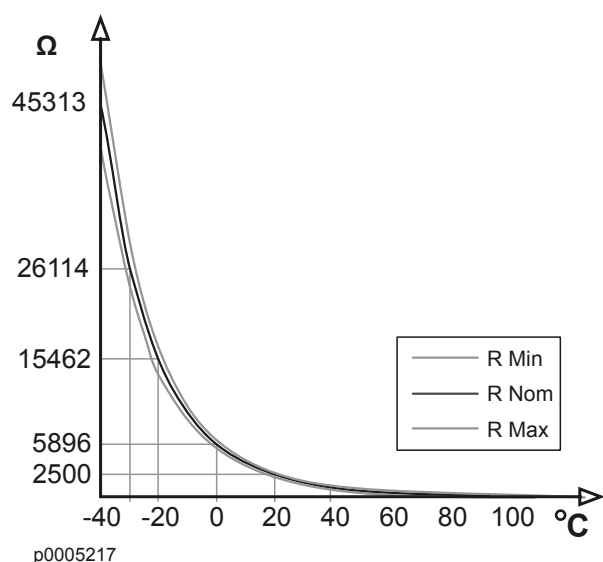
### Steering System

#### Sensor

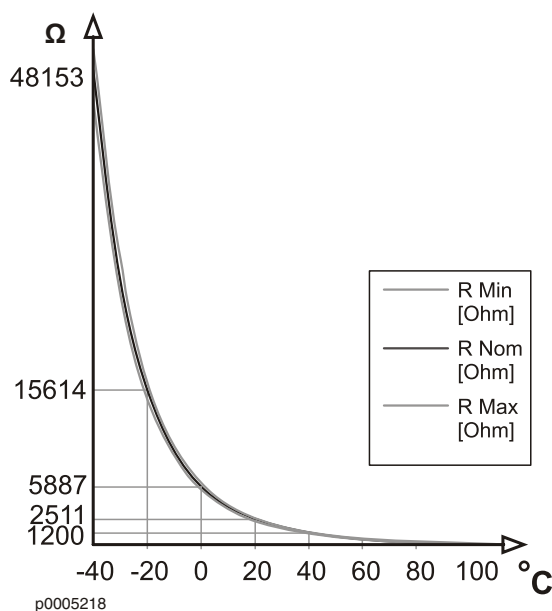
#### Engine oil temperature sensor



Temperature		Impe- dance R <sub>min</sub>	Impedance R <sub>nom</sub>	Impe- dance R <sub>max</sub>
(°C)	(°F)	(Ω)	(Ω)	(Ω)
-50	-58	89496,5	105290,0	121083,5
-40	-40	45163,6	52394,0	59624,4
-30	-22	23871,0	27375,0	30879,0
-20	-4	13181,5	14945,0	16708,5
-10	14	7555,7	8480,0	9404,3
0	32	4477,9	4981,0	5484,1
10	50	2747,3	3029,0	3310,7
20	68	1736,6	1900,0	2063,4
30	86	1127,3	1224,0	1320,7
40	104	750,0	809,1	868,2
50	122	510,4	547,0	583,6
60	140	354,5	377,9	401,3
70	158	251,6	266,5	281,4
80	176	181,4	191,2	201,0
90	194	133,1	139,7	146,3
100	212	99,2	103,6	108,0
110	230	75,0	78,0	81,0
120	248	57,6	59,6	61,6
130	266	44,7	46,1	47,5
140	284	34,8	36,0	37,2
150	302	27,4	28,5	29,6

**Coolant temperature sensor**

Temperature		Impedance $R_{min}$	Impedance $R_{nom}$	Impedance $R_{max}$
(°C)	(°F)	(Ω)	(Ω)	(Ω)
-40	-40	40490	45313	50136
-30	-22	23580	26114	28647
-20	-4	14096	15462	16827
-10	14	8642	9377	10152
0	32	5466	5896	6326
10	50	3542	3792	4043
20	68	2351	2500	2649
25	77	1941	2057	2173
30	86	1615	1707	1798
40	104	1118	1175	1231
50	122	798	834	870
60	140	573	596	618
70	158	421	435	451
80	176	313	323	332
90	194	237	243	250
100	212	182	186	191
110	230	140	144	148
120	248	109	113	116
130	266	86	89	93
140	284	68	71	74

**Charge air temperature sensor**

Temperature		Impedance $R_{min}$	Impedance $R_{nom}$	Impedance $R_{max}$
(°C)	(°F)	(Ω)	(Ω)	(Ω)
-40	-40	45301,0	48153,0	51006,0
-30	-22	25350,0	26854,0	28359,0
-20	-4	14785,0	15614,0	16443,0
-10	14	8951,0	9426,0	9901,0
0	32	5605,0	5887,0	6168,0
10	50	3618,7	3791,1	3963,5
20	68	2401,9	2510,6	2619,3
30	86	1644,7	1715,4	1786,2
40	104	1152,4	1199,6	1246,7
50	122	819,1	851,1	883,0
60	140	590,3	612,3	634,2
70	158	431,0	446,3	461,6
80	176	318,68	329,48	340,27
90	194	238,43	246,15	253,86
100	212	180,42	186,0	191,58
110	230	137,63	142,08	146,52
120	248	106,09	109,65	113,21
130	266	82,58	85,45	88,32



**Pressure drop indicator**

Active	$V = 0.48 \times U_{\text{bat}} \pm 10 \%$
Inactive	$V = 0.12 \times U_{\text{bat}} \pm 10 \%$

**Camshaft sensor**

Distance to gearwheel	$1.1 \pm 0.4 \text{ mm } (0.0433 \pm 0.01575 \text{ in})$
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**Crankcase sensor**

Sensor alarm limit	5 kPa (0.725 PSI)
Crankcase pressure, normal value	< 1.0 kPa (0.145 PSI)

# 05-1 Safety Instructions



P0003451

## Safety Information

This Service Manual contains repair instructions, descriptions and technical data for products or product designs from Volvo Penta. Ensure that you are using the correct service manual.

Read the safety information below and the service manual section **About this Workshop manual** and **Repair instructions** carefully before repair and service work is begun.



This symbol is used in the service manual and on the product, to call attention to the fact that this is safety information. Always read such information very carefully.

**Safety texts in the manual have the following order of priority:**



### **DANGER!**

Indicates a hazardous situation which, if not avoided, will result in death or serious injury.



### **WARNING!**

Indicates a hazardous situation which, if not avoided, could result in death or serious personal injury.



### **CAUTION!**

Indicates a hazardous situation which, if not avoided, could result in minor or moderate personal injury.

### **IMPORTANT!**

Is used to draw your attention to something that may cause minor damage or a minor malfunction to the product or property.

**NOTICE!** Is used to draw your attention to important information that will facilitate the work or operation in progress.



This symbol is used on our products in certain cases and refers to important information in the instruction book. Make sure that warning and information symbols on the engine are clearly visible and legible. Replace symbols which have been damaged or painted over.

A compilation of safety precautions that must be taken and risks which must be paid attention to is presented in the following pages.



Immobilize the engine by turning off the power supply to the engine at the main switch (switches) and lock it (them) in the off position before starting work. Post a warning notice at the main circuit breaker.



Avoid opening the coolant filling cap when the engine is hot. Steam or hot coolant can spray out and system pressure will be lost. Open the filler cap slowly, and release the pressure in the cooling system if the filler cap or valve has to be opened, or if a plug or coolant hose has to be removed when the engine is hot.



As a rule, all service operations must be carried out with the engine stopped. However, some work, such as adjustments, will require the engine to be running. Approaching an engine which is running is a safety risk. Bear in mind that loose clothing or long hair can fasten in rotating parts and cause serious personal injury.



Hot oil can cause burns. Avoid skin contact with hot oil. Ensure that the lubrication system is not under pressure before any work is begun. Never start or operate the engine with the oil filler cap removed, because of the risk of oil ejection.



Be aware of hot surfaces (exhaust pipes, turbos, charge air pipes, starting heaters etc.) and hot fluids in pipes and hoses on an engine that is running or has just stopped. If work is done adjacent to a running engine, a careless movement or a dropped tool may in the worst case lead to personal injury.



Never start the engine without installing the air filter. The rotating compressor turbine in the turbocharger can cause severe injury. Foreign objects entering the intake ducts can also cause mechanical damage. Install all protective covers before the engine is started.



Ensure that the warning symbols or information decals on the product are always clearly visible. Replace decals which have been damaged or painted over.



Only start the engine in a well-ventilated space. When running in a confined space, exhaust fumes and crankcase gases must be led away from the engine bay or workshop area.



Avoid getting oil on your skin! Protracted or repeated exposure to oil can cause skin to become dry. Irritation, dryness, eczema and other skin problems may then result. From a health standpoint, used oil is more dangerous than new. Use protective gloves and avoid oil-soaked clothes and rags. Wash regularly, especially before eating. Use suitable barrier creams to counteract drying out of the skin and to aid dirt removal.



The majority of chemicals e.g. engine and transmission oils, glycol, gasoline, and diesel oil, together with chemicals for workshop use such as degreasing agents, paints and solvents, are injurious to health. Carefully read the instructions on the product packaging! Always follow a product's safety directions, e.g. use of protective mask, glasses, gloves etc. Ensure that other personnel are not exposed to substances that are injurious to health. Ensure good ventilation. Handle used and leftover chemicals in the prescribed manner.



Stop the engine and turn off the electrical supply at the main switch(es) before carrying out work on the electrical system.



Clutch adjustments must be carried out with the engine stopped.



Always use protective glasses or goggles when carrying out work where a risk of splinters, grinding sparks, splashes from acid or other chemicals is present. Your eyes are extremely sensitive; injury may cause blindness!



Never use start gas or similar products as a starting aid. They may cause an explosion in the inlet manifold. Danger of personal injury.



All fuels, as well as many chemicals, are flammable. Do not allow open flames or sparks in their vicinity. Gasoline, some thinners, and hydrogen gas from batteries are extremely flammable and explosive when mixed with air in the correct proportions. **No Smoking!** Ensure that the work area is well ventilated and take the necessary safety precautions before welding or grinding work is begun. Always ensure that there are fire extinguishers close at hand in the work area.



Batteries must never be exposed to open flames or electric sparks. Never smoke in the vicinity of the batteries; they generate hydrogen gas when charged, which is explosive when mixed with air. This gas is easily ignited and highly explosive. A spark, which can be caused by incorrect battery connection, is sufficient to cause a battery to explode and cause damage.

Do not touch the connections during start attempts. Sparking hazard! Do not lean over batteries.



Never transpose the positive (+) and negative (-) battery posts when installing batteries. Such a transposition can result in serious damage to electrical equipment. Refer to the wiring diagram.

Always use protective goggles when charging and handling the batteries. Battery electrolyte contains sulfuric acid which is highly corrosive. Should the battery electrolyte come into contact with unprotected skin, wash it off immediately using soap and copious amounts of water. If you get battery acid in your eyes, flush at once with copious amounts of water and seek medical assistance immediately.



Never start the engine with the valve cover removed. There is a risk of personal injury.



Stop the engine before working on the cooling system.

Marine engines: Close the sea cock / cooling water inlet valve before work on the cooling system is begun.



Make sure that oil, fuel-soaked rags, and used fuel and oil filters are stored in a safe manner. Rags soaked in oil can spontaneously ignite under certain circumstances. Used fuel and oil filters are environmentally hazardous waste and must be handed to an approved waste management facility for destruction, as must any used lubrication oil, contaminated fuel, paint residue, solvents, degreasers and wash residue.



Never work alone when removing heavy components, even when using lifting devices such as locking tackle lifts. When using a lifting device, two people are usually required to do the work - one to take care of the lifting device and the other to ensure that components are lifted clear and not damaged during the lifting operations.



The existing lugs on the engine should be used for lifting. Always check that the lifting equipment used is in good condition and has the load capacity to lift the engine (engine weight including gearbox or extra equipment). For safe handling and to avoid damaging components fitted to the top of the engine, the engine must be lifted with a correctly adjusted lifting boom. All chains or wires must run parallel to each other and as perpendicular to the engine as possible. If other equipment attached to the engine has altered its center of gravity, special lifting devices may be needed to obtain the correct balance for safe handling. Never perform any work on an engine that is only suspended from the lifting equipment.



The components in the electrical and fuel systems on Volvo Penta products are designed and manufactured to minimize the risk of fire and explosion. The engine must not be run in areas where there are explosive materials.



Exercise extreme caution when leak-detecting on the fuel system and testing the fuel injector nozzles. Use eye protection. The jet from a fuel nozzle has very high pressure and great penetration power. Fuel can force its way deep into body tissue and cause severe injury. There is a risk of blood poisoning (septicemia).



Only use fuels and lubricating oils recommended by Volvo Penta. Refer to the Operator's Manual for the product in question. Use of fuels that are of a lower grade may damage the engine, the injection pump and the injectors. On a diesel engine, low grade fuel can cause the control rod to bind and the engine to over-rev, with the risk of engine damage and personal injury as a result. Low fuel and oil grades may result in high service, maintenance and repair costs.



Never use a high-pressure washer for cleaning the engine.  
Pay attention to the following when using a high-pressure washer on components other than the actual engine: Never direct the water jet at seals, rubber hoses or electrical components.

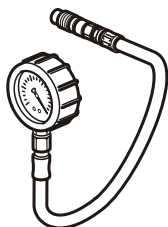


Fuel delivery pipes must not be bent or straightened under any circumstances. Cracks may occur. Damaged pipes must be replaced.

## 08-2 Special Service Tools

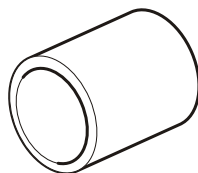


The following special tools are used when working on the engine. The tools can be ordered from AB Volvo Penta by specifying the number indicated.



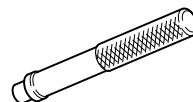
### 9996398 Manometer

Adjusting e.g. lubricating oil pressure.



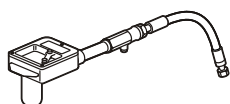
### 1678297 Spacer

For use with 9996398 Manometer.

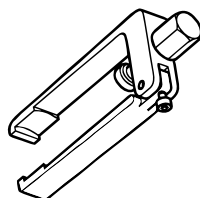


### 9991801 Standard handle

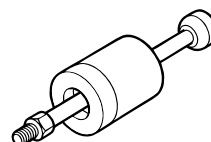
Flywheel bearing



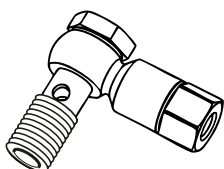
### 9988539 Compression meter



### 9990006 Puller

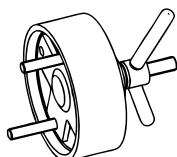


### 9990013 Slide hammer



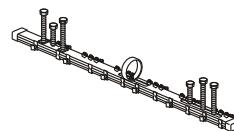
### 9990124 Nipple

Banjo fitting, for use with 9996398 Manometer.



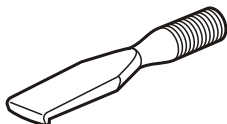
### 9990166 Mounting tool

Crankshaft seal.



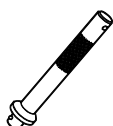
### 9990185 Lifting tool

Lifting rocker arm bridge.



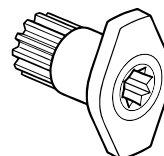
### 9990192 Puller

Crankshaft seal.



### 9992000 Handle

Replacement of e.g. crankshaft seal.

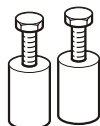


### 9993590 Rotation tool

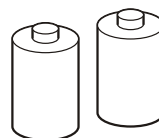
As a counterhold, or for rotating, gearwheels.



**9996049 Draining hose**  
Cooling system, draining.



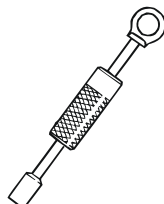
**9996394 Support**  
Support leg for 9996645 Puller.



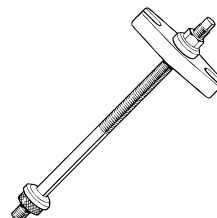
**9996395 Support**  
Support leg for 9996645 Puller.



**9986179 Puller**  
Flywheel bearing



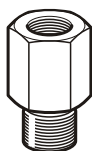
**9996400 Slide hammer**



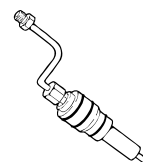
**9996645 Puller**  
For use with cylinder liners.



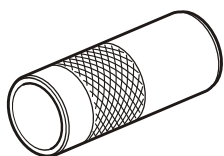
**9996666 Nipple**  
For use with, among other things, 9996398 Manometer.



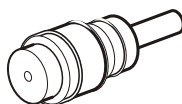
**9998007 Adapter**  
For use with 9996400 Slide hammer.



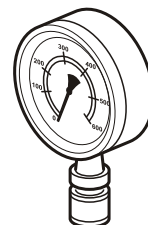
**9998248 Adapter**  
Compression test (6 pcs. required).



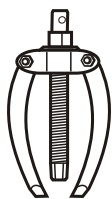
**9998249 Protective sleeve**  
Protects removed injectors.



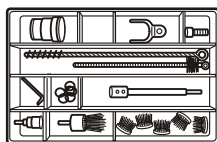
**9998251 Protection plug**  
Replacement for removed injectors.



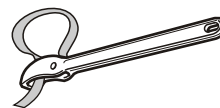
**9998339 Manometer**  
Checking charge air pressure.



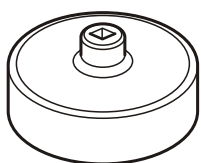
**9986173 Puller**  
Flywheel bearing



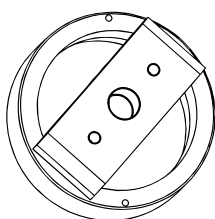
**9998599 Cleaning kit**  
**The tool kit includes:**  
- 9808570 Brush  
- 9808616 Extender  
- 9998580 Protective sleeve.



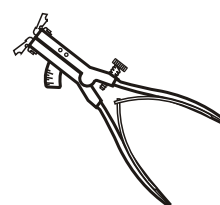
**9999179 Extractor oil filter**  
Removal of filters.



**9998487 Sleeve**  
Removal of filters.



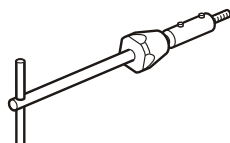
**88800021 Drift**  
Removal of crankshaft seal.



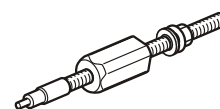
**88800083 Piston ring pliers**  
Installation of piston rings.



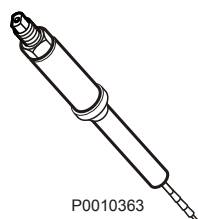
**9998250 Sealing ring**  
Cylinder head fuel ducts (the kit contains 12 pcs.).



**9998252 Thread cutting tool**  
Removal of copper sleeve.

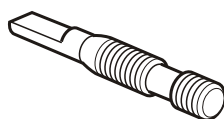


**88800191 Extractor**  
Removal of copper sleeve.

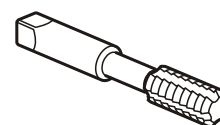


P0010363

**88800196 Drift**  
Installation of copper sleeve.

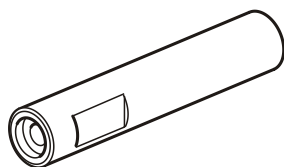


**9809668 Extractor**  
Removal of copper sleeve.

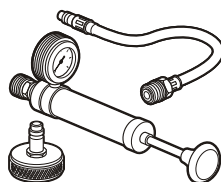


**9809667 Thread tap**  
Removal of copper sleeve.

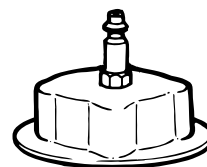


**88800151 Drift**

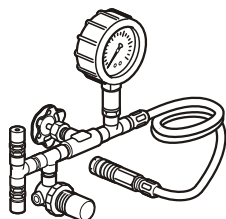
Valve stem seals.

**3849613 Pressure testing kit**

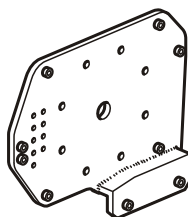
Pressure testing cooling system.

**9996441 Cover, with connecting nipple**

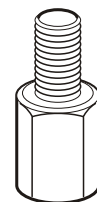
Pressure testing cooling system.

**9996662 Pressure testing kit**

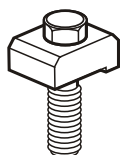
Pressure testing cooling system.

**88800117 Plate**

For use with 88800003 Fixture.

**9998674 Adapter**

Removal of camshaft cap.

**9996966 Press tool**

Holds cylinder liner in place.



P0010361

**3883671 Protective sleeve**

O-ring for injector.



P0010360

**3883672 Protective sleeve**

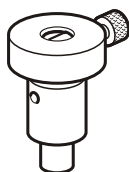
O-ring for injector.



P0010362

**9992955 Plate**

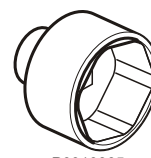
Removal of cylinder liner.



P0010364

**88800031 Measuring tool**

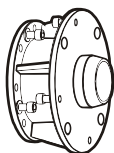
Shimming sensors.



P0010365

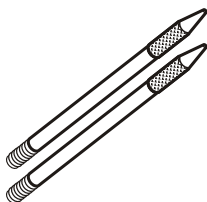
**9998598 Sleeve**

Removal of safety valve cover.



**88800003 Fixture**

For use with 88800117 Plate.



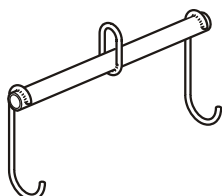
**885519 Guide pin**

Aligning inlet manifold.



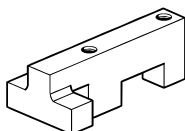
**9996239 Lifting tool**

2 pcs. required.



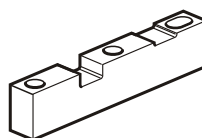
**9998264 Lifting tool**

Lifting the camshaft.



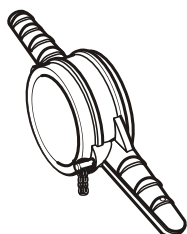
**885810 Fixture**

Installation of upper timing cover.



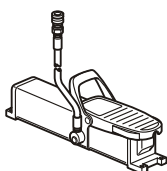
**9998601 Fixture**

Installation of upper timing cover.



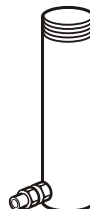
**9998531 Piston ring compressor**

Fitting rings to pistons.



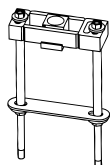
**9809726 Pneumatic hydraulic pump**

Valves and valve guides.



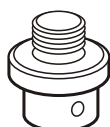
**9809729 Hydraulic cylinder**

Valves and valve guides.



**9990176 Press tool**

Valves and valve guides.



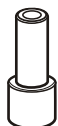
**9996159 Adapter**

For 9809729 Hydraulic cylinder.



**88800064 Drift**

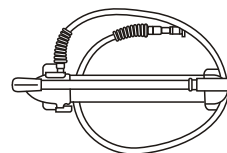
Valve guides.



**88800127 Drift**  
Valve guides.



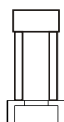
**88800147 Drift**  
Valve guides.



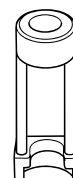
**9992670 Hand pump**  
Alternative to 9809726 Pneumatic hydraulic pump .



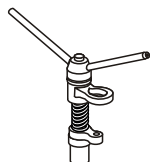
**9990160 Fixture**  
Cylinder head.



**9990174 Drift**  
Valve springs.



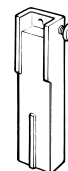
**9998246 Drift**  
Valve springs.



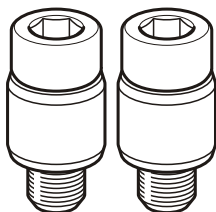
**9990210 Valve spring compressor**



**9990165 Guide sleeve**  
Valve stem seals.



**9992479 Holder for dial indicator**  
For use with 9989876 Dial indicator.



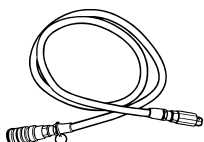
**9998267 Guide sleeve**  
Timing gear plate.



**9992269 Drift**  
Replacement of flywheel bearings.



**9990263 Nipple**  
Measuring oil pressure.



**9998493 Hose**



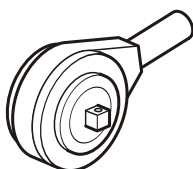
## Other Equipment

The following miscellaneous equipment is used when working on the engine. The equipment can be ordered from AB Volvo Penta by specifying the number indicated.



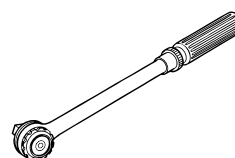
### 885510 Plugs

For use with e.g. fuel pressure lines.

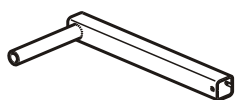


### 885633 Torque multiplier

For use with e.g. the crankshaft.



### 1159794 Torque wrench



### 885648 Counterhold

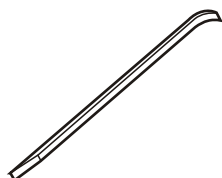
For use with 885633 Torque multiplier.



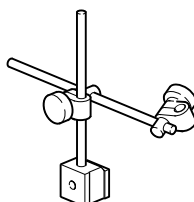
### 885812 Timing tool



### 885822 Magnetic pen



### 9998511 Lever

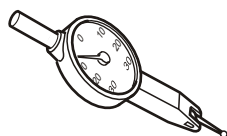


### 9999696 Magnetic stand

For use with 9989876 Dial indicator.

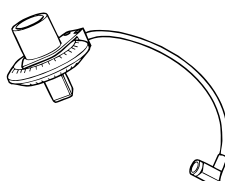


### 9989876 Dial indicator



### 9999683 Dial indicator (short probe)

Checking gear lash.

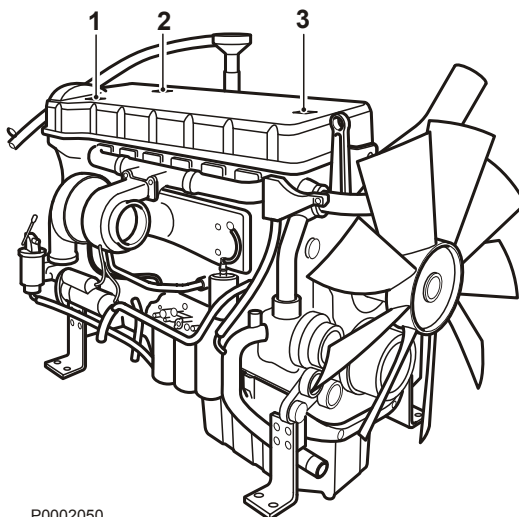


### 885811 Timing tool

# 20-0 Engine Information, General

## Design and Function

### Identification Numbers



P0002050

CHASSIS ID:	<b>A</b>
SERIAL NO:	<b>B</b>

P0002051

1

A Chassis number

B Serial number

<b>VOLVO PENTA</b>	
	<b>A</b>
RATED POWER.	<b>B</b>
RATED SPEED.	<b>C</b>
MSW:	<b>D</b>
DST:1	<b>E</b>
DST:2	<b>F</b>
SPEC. NO.	<b>G</b>

P0002052

2

A Engine designation

B Engine power, net, (without fan)

C Max. engine speed

D Main software

E Dataset 1

F Data set 2

G Product number

<b>VOLVO PENTA</b>	
ENGINE	<b>A</b> <b>B</b> <b>C</b>
<b>CE</b>	

P0002053

3

A Engine designation

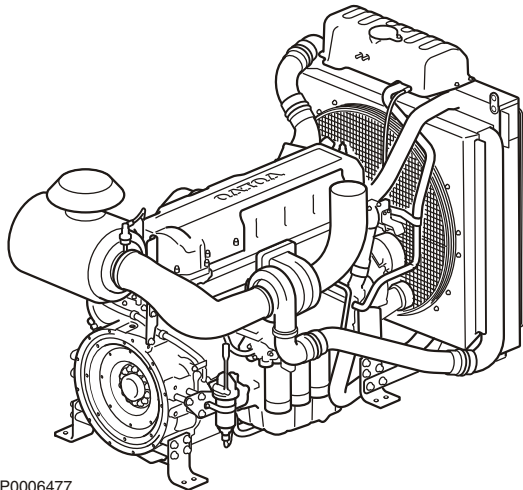
B Specification number

C Serial number

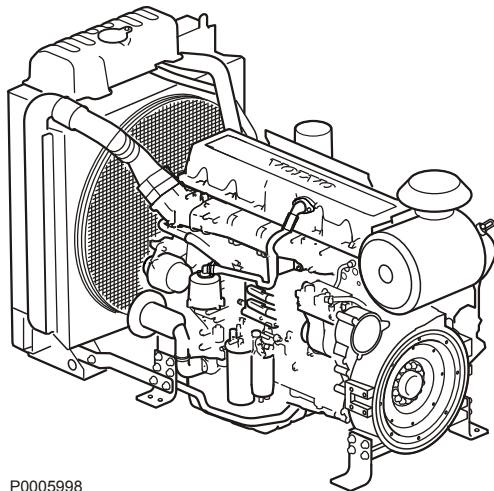
## Group 21: Engine

### General

The engine is an inline six cylinder direct injection turbocharged diesel with charge air cooling and EMS (Engine Management System). The timing is at the rear. The engine is equipped with a one-piece cylinder head, overhead camshaft and unit injectors. In order to fulfill Euro 4 emission standards the engine is equipped with an EGR (Exhaust Gas Recirculation) system (TAD1350–55GE). The turbocharger has waste gate control for engine charge pressure.



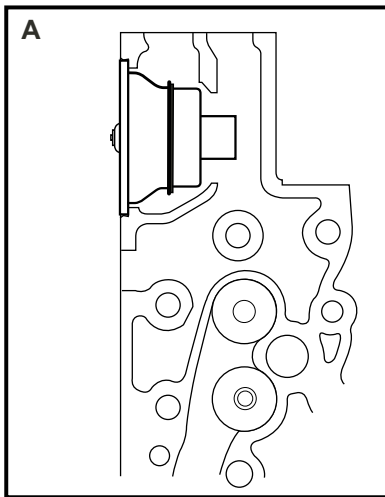
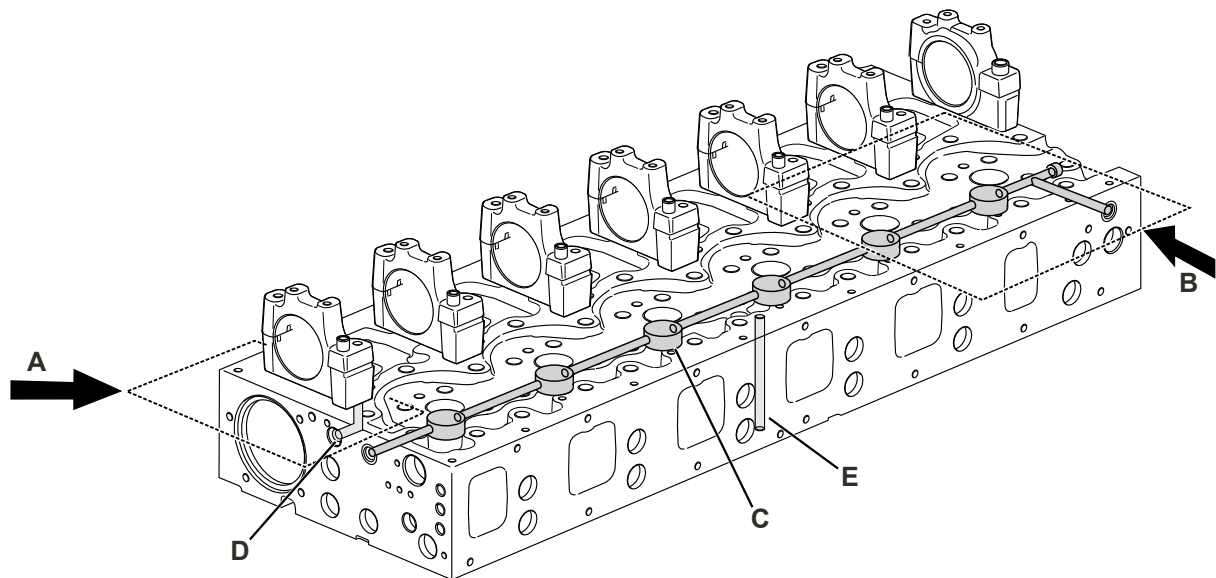
P0006477



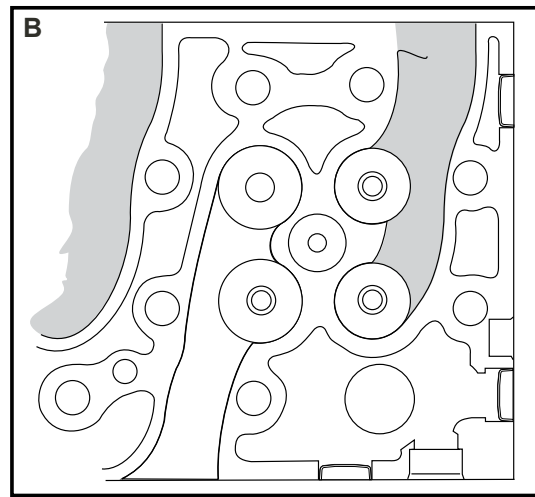
P0005998

The engine has optional open or closed crankcase ventilation. The risk of oil droplets is eliminated with closed crankcase ventilation, which is a legal requirement in most markets.

## Cylinder Head



P0006000



The cylinder head is made from a single piece of cast iron, which provides for stable overhead camshaft bearings.

The camshaft is supported by seven horizontally-split bearing brackets equipped with replaceable bearing cups. In the rear bearing bracket, the bearing cup is also designed as a thrust bearing.

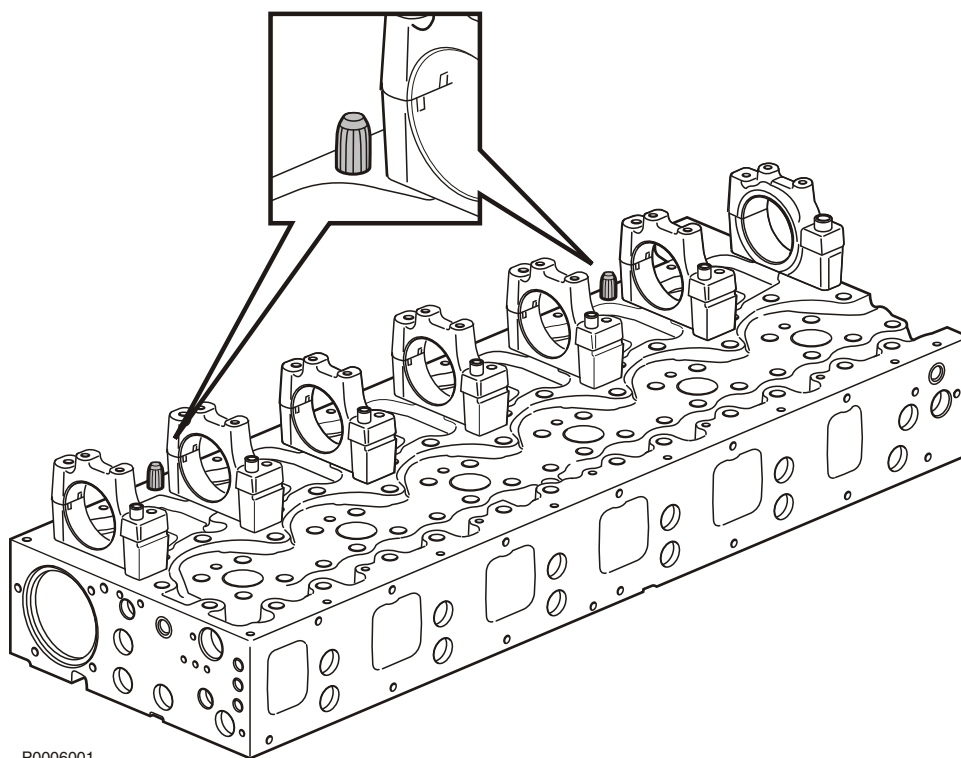
The coolant thermostat housing is machined directly in the cylinder head and located at the front right side (A).

Each cylinder has separate inlet ducts to one side of the cylinder and separate exhaust ducts on the other side, so-called crossflow (B).

The fuel channel to the unit injectors is drilled lengthwise through the cylinder head and has a machined, ring-shaped space around each unit injector (C).

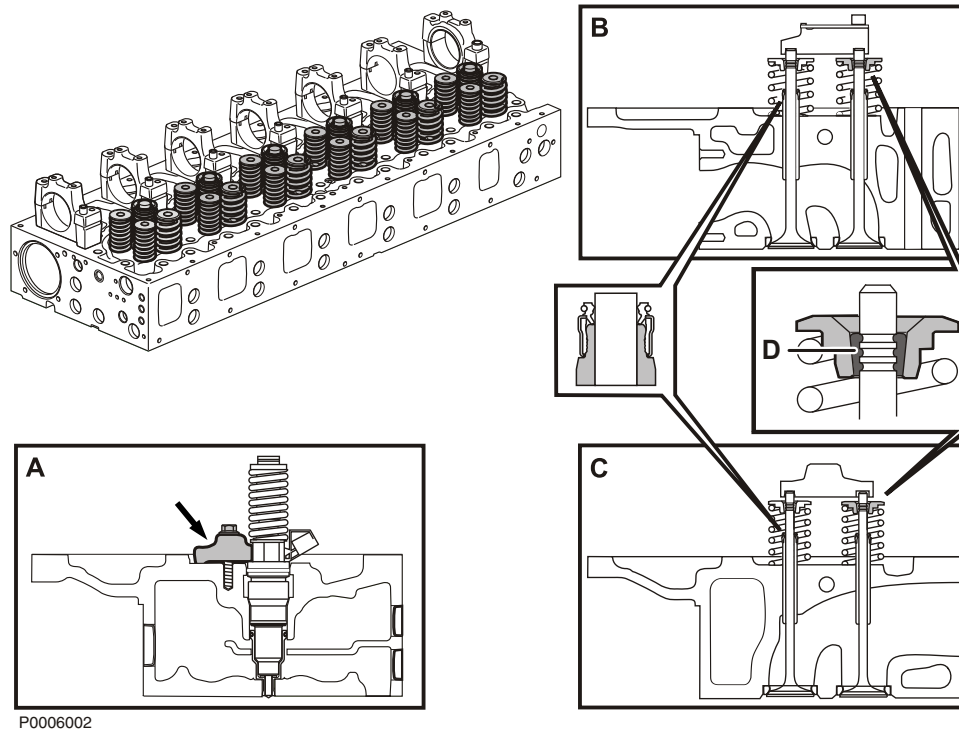
There is a plug at the front (D) that leads to a channel for measuring rocker arm mechanism oil pressure.

The duct (E) leads lubricating oil to the camshaft and rocker arms. It is drilled centrally through the left side of the cylinder head.



There are two guide pins on the right side of the cylinder head that ensure the valve cover is fitted in the correct position.



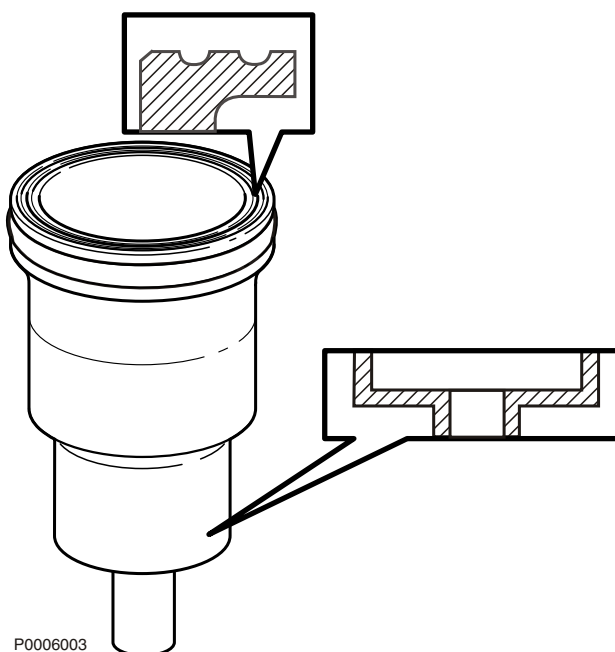


The injectors are centrally located between the four valves and are held in place by yokes (**A**). For maximum cooling the coolant chamber in the cylinder head is equipped with a horizontal baffle that forces coolant past the lower, hottest parts of the cylinder head.

The valve mechanism is equipped with twin inlet and exhaust valves. The exhaust valves have single valve springs (**B**), as do the inlet valves (**C**). The valves are linked in pairs by so-called floating valve yokes that transfer rocker arm movement from

the camshaft to the valve pair. The valves have three grooves and matching collets (**D**). The design of the collets allows the valves to rotate on their seats. For improved heat resistance and heat conduction, more material is used in the exhaust valve discs and the diameter is somewhat smaller than that of the inlet valves.

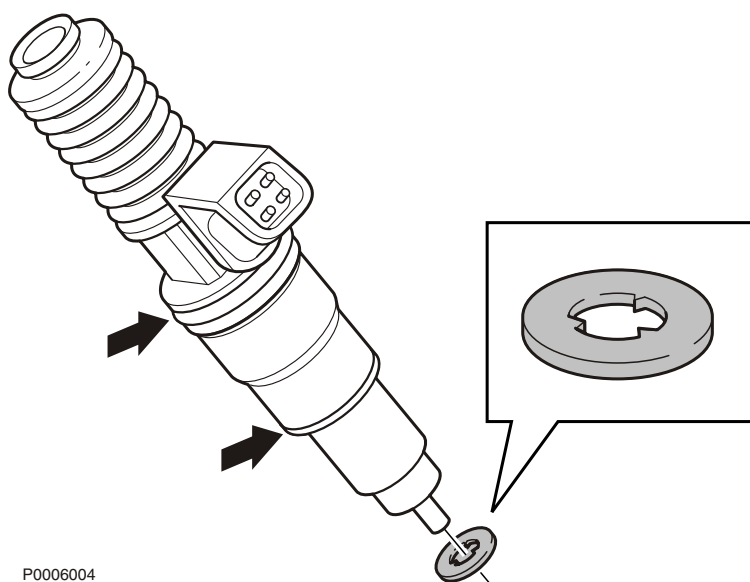
The valve guides are made of alloyed cast iron and all valve guides have double-lipped oil seals. The valve seats are made from hardened special steel; they are replaceable but cannot be machined.



There is a copper sleeve between the lower injector section and the cylinder head. The copper sleeve is of a new, harder type; it has a flat bottom toward the unit injector and is marked with two grooves on its upper side.

The copper sleeve is enlarged in the lower section and sealed with a O-ring at the upper section.

**NOTICE!** The copper sleeve must absolutely not be mistaken for copper sleeves for other variants.

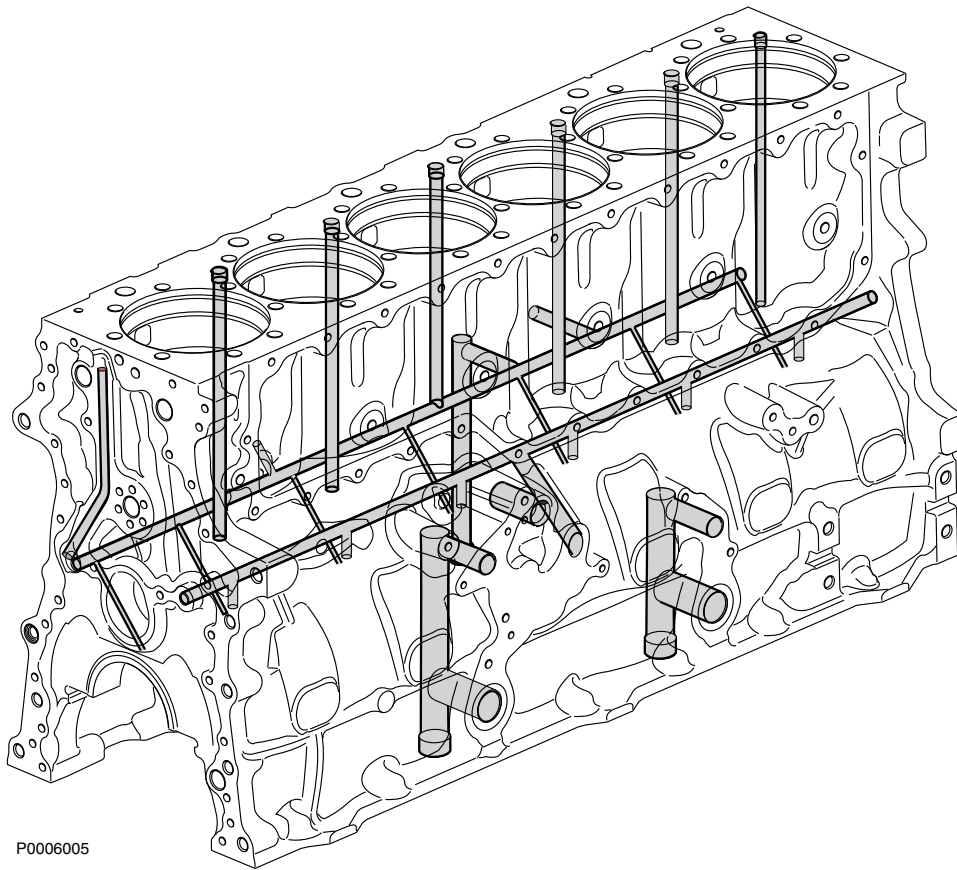


The unit injectors are sealed against the cylinder head with two O-rings located in the injector's ring-shaped notch. The injector's lower part is sealed against the copper sleeve by a steel gasket.

The steel gasket has three projections that keep it in place on the injector. The steel gasket has a sealant coating that requires the gasket to be replaced each time a unit injector has been removed.

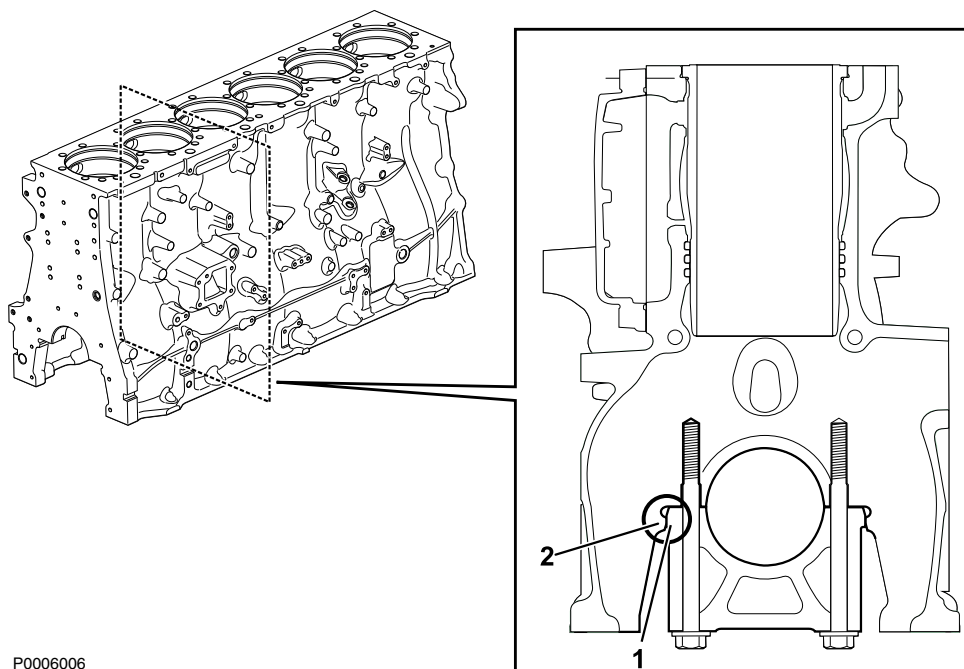
**NOTICE!** Take extreme care with cleanliness when working with unit injectors.

## Cylinder block



The cylinder block is made of cast iron and is cast in one piece.

There are two, drilled, longitudinal ducts for the lubrication system. On the left side of the block there is the main lubrication duct (gallery), and on the right side there is a piston cooling duct. Both ducts are plugged at the front of the engine with plugs equipped with O-rings. At the rear of the engine, the ducts are covered by the timing plate, and the main lubrication gallery discharges into the cast duct that supplies the engine timing with oil.

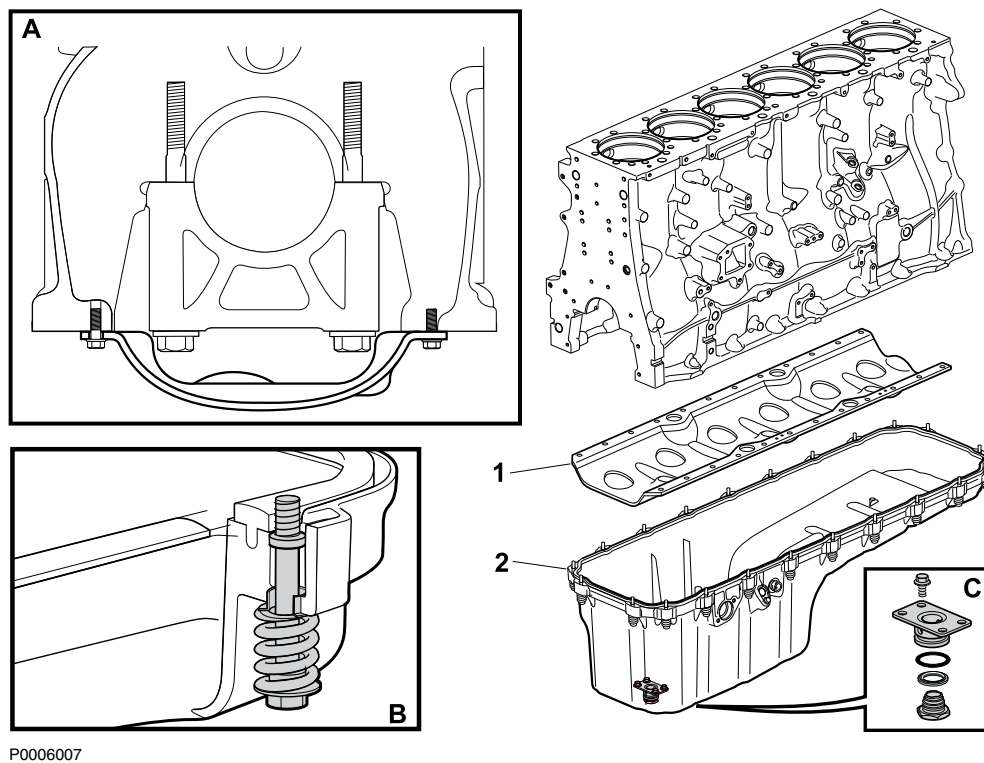


The bowed shape of the block sides at each cylinder provides the cylinder block with high torsional stiffness and sound dampening.

The vertical cross section shows the position of the cylinder liner and cooling jacket in the block.

In order to render impossible the faulty positioning of main bearing caps, they are guided into position by cast, asymmetrically-located tabs (1) into corresponding chamfers (2) in the cylinder block. The main bearing caps are made from nodular iron and are individually adapted. In order for them not to be confused at installation, they are marked 1, 2, 3, 5 and 6 respectively, counting from the front of the engine. The center and rear main bearing caps are uniquely shaped and do not require marking.

## Engine stiffening frame and oil sump

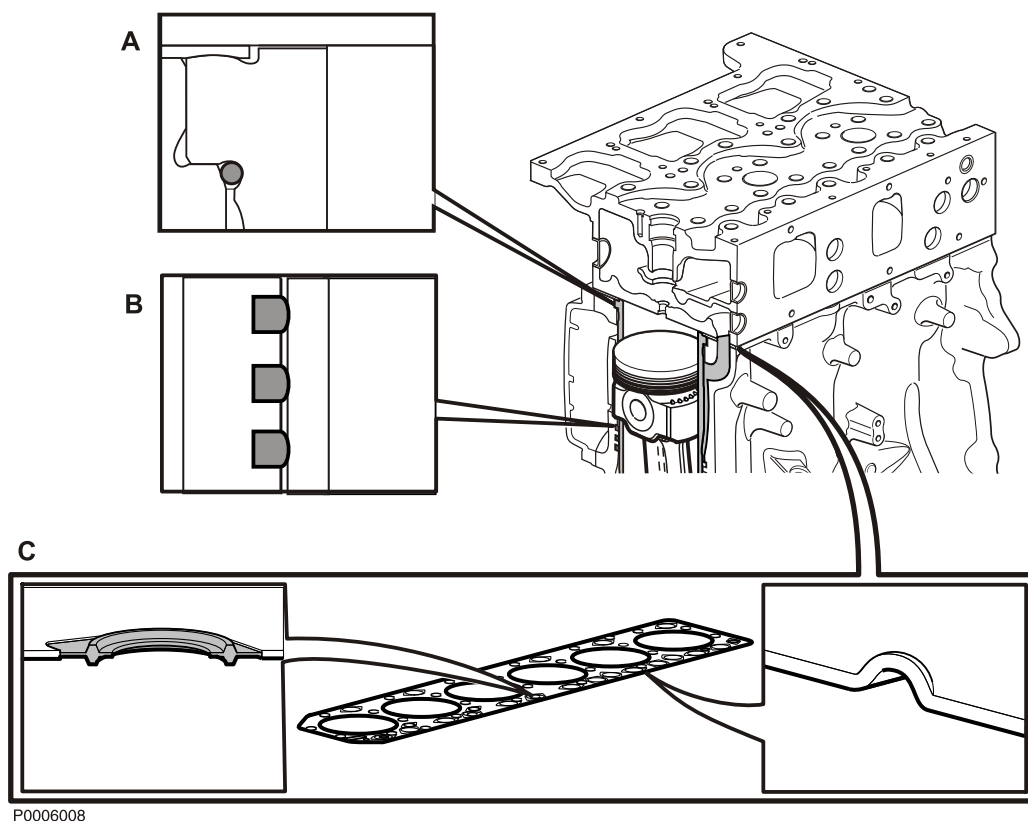


In order to reduce vibrations in the cylinder block, and thus reduce engine noise, there is a stiffening frame (1) installed on the underside of the block. The stiffening frame is made from 6 mm sheet steel and is bolted in place to the lower block plane (A).

The oil sump (2) is made from injection-molded plastic (composite).

The plastic sump seal is made of a rubber strip, manufactured in one piece and located in a groove around the rim. The oil sump is bolted in place with 22 pcs. spring-loaded steel bolts (B). The plastic sump drain plug (C) is threaded into a replaceable, steel reinforcement.

## Sealing joints



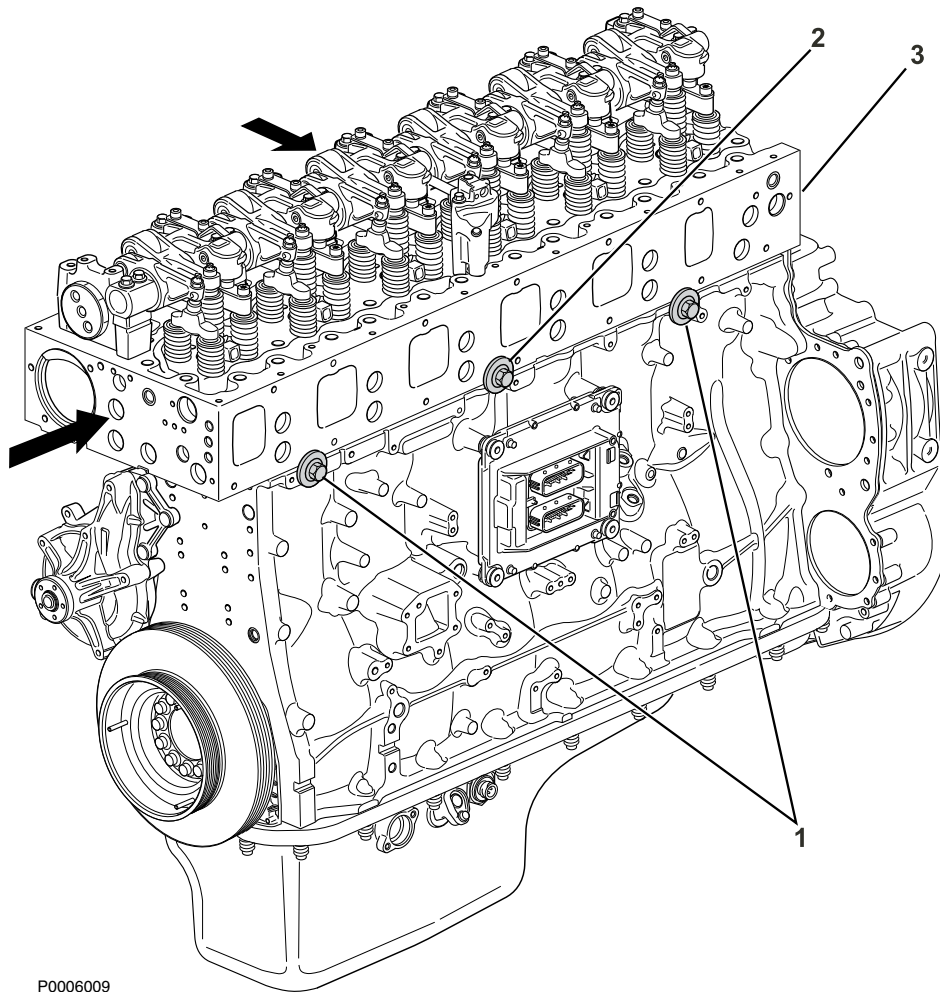
P0006008

The engine has wet cylinder liners for effective heat removal. They are sealed against the cylinder block by rubber rings. The uppermost ring is located immediately below the liner collar (**A**). The liner sealing surface against the cylinder head gasket is convex.

The lower seal comprises three O-rings located in grooves in the cylinder block (**B**). These rings are made from different rubber materials and have different colors to prevent confusion. The two upper (black) rings are made from EPDM rubber and are therefore resistant to coolant, while the lower (purple) is fluoro-rubber and resistant to oil.

The gasket (**C**) between the cylinder head, block and liner is made from steel and has integral vulcanized rubber seals for the coolant and oil channels. In order to protect the rubber seals during cylinder head installation, the gasket has a number of convex indentations for the cylinder head to glide on. These indentations are flattened when the cylinder head is bolted in place.

## Cylinder head, guides to cylinder block

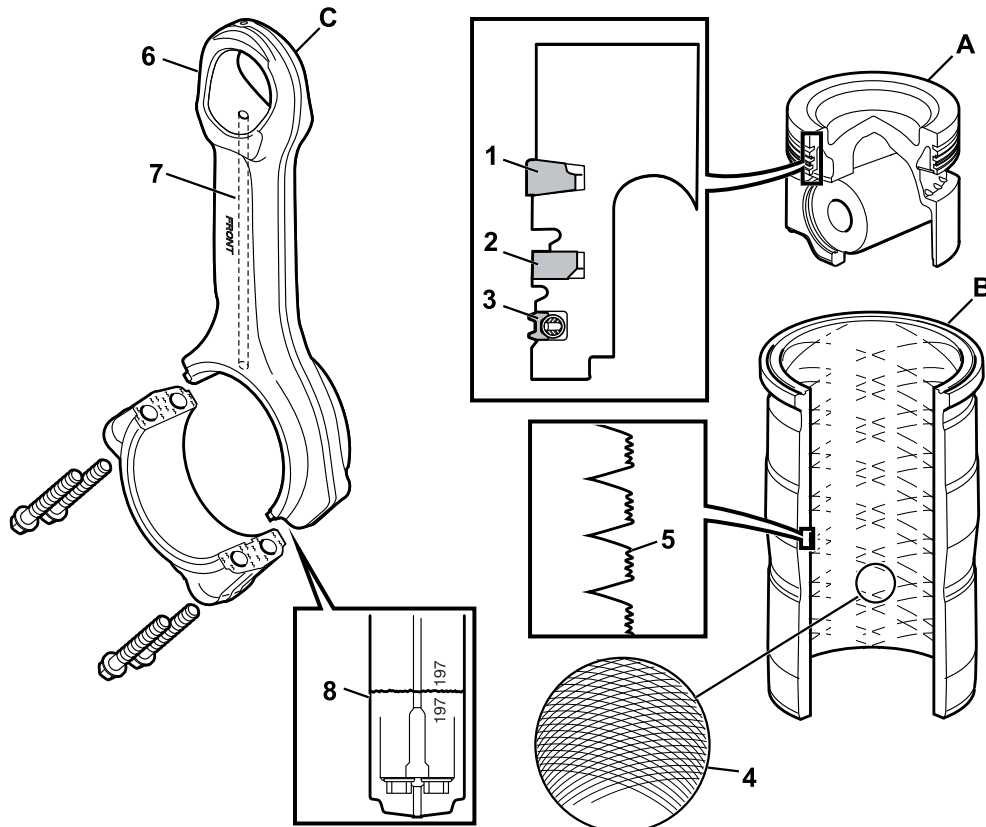


P0006009

In order to facilitate installation and exact positioning of the cylinder head on the cylinder block, there are three guide washers on the left side of the engine – two on the cylinder block (1) and one on the cylinder head (2). These washers determine the transverse position of the cylinder head, while the timing plate (3) determines the longitudinal position. In this way it is possible to precisely fit the cylinder head transversely and longitudinally.

The convex indentations in the cylinder head gasket allow the cylinder head to be slid on the gasket without damaging the rubber seals.

## Piston, cylinder lining, connecting rod



P0006010

The engine has solid, forged steel, oil-cooled pistons. Each piston (A) has two compression rings and one oil scraper ring. The upper compression ring (1) has a trapezoid "Keystone" section. The lower compression ring (2) has a rectangular section. The oil scraper ring (3) at the bottom is spring loaded.

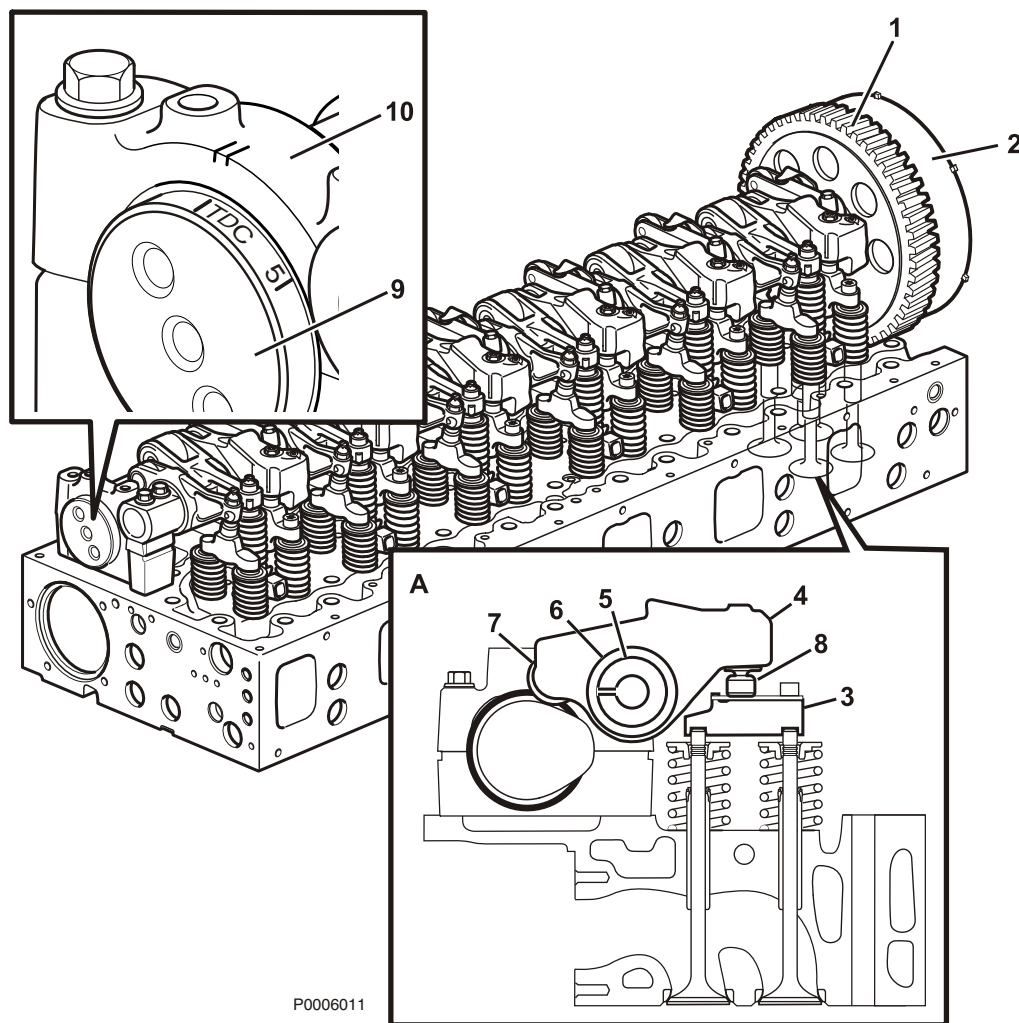
All piston rings are installed with the marking facing up; thus **marking up** also applies when installing the oil scraper ring.

The cylinder liner (B) is replaceable. They are cast centrifugally in iron alloy. The inside of the liner has a crosshatch machining pattern, honing (4). The final cylinder liner fine surface machining is performed using a method called plateau honing (5), where the sharpest apexes from the basic machining are ground away.

The connecting rod is (C) forged and split at the lower end (big end) using a method known as fracture splitting. The upper end (small end) has a pressed-in bush (6) for the piston pin lubricated via a drilled channel (7). The two parts of the big end are fastened together by four bolts, and each connecting rod has a marking from 007 to 999 on the two parts (8). The connecting rod is marked "FRONT" in order for it to be installed correctly.



## Camshaft and valve mechanism



P0006011

The engine has an overhead camshaft and a four-valve system. The camshaft is induction hardened and supported by seven bearing brackets, where the rear bearing also acts as a thrust bearing. Both the bearing cups and bearing brackets are replaceable.

There are cams between each shaft journal: an inlet cam, injection cam, exhaust cam and EGR (TAD1350–53GE). The camshaft is driven by a gear-wheel (1) from the engine timing. A hydraulic vibration damper (2) is installed on the outside of the gear-wheel.

There are also teeth on the vibration damper for the camshaft sensor.

**NOTICE!** The vibration damper must absolutely not be confused with vibration dampers for other variants.

Figure (A) shows a section through the valve mechanism for one pair of exhaust valves.

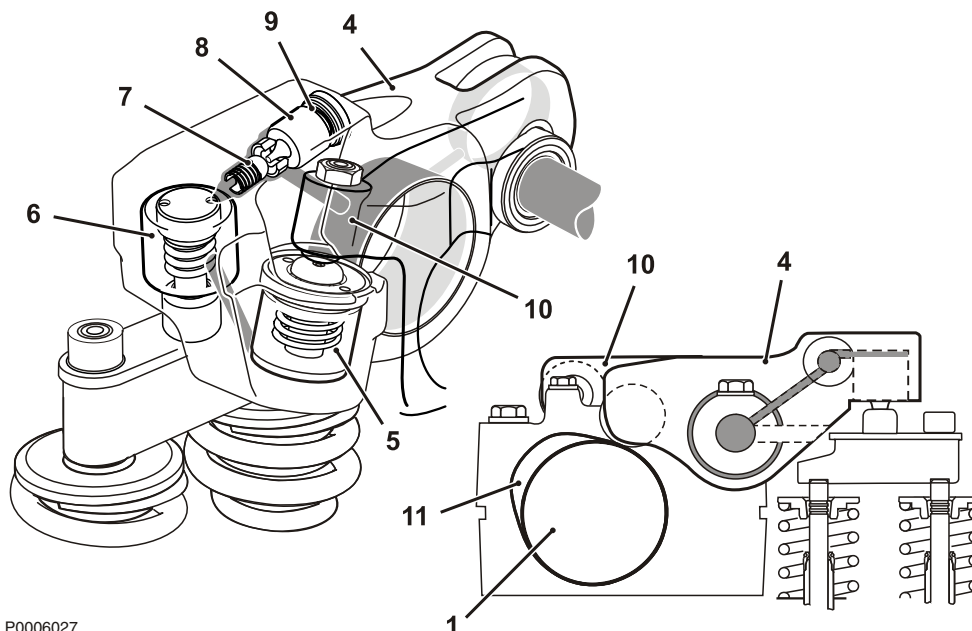
Each rocker arm acts on a so-called floating valve yoke (3) that opens the valves. The rocker arm (4) is supported by a bushing (6) on the rocker shaft (5). Contact with the camshaft takes place via a roller (7) and against the valve yoke by a ball seat (8).

The camshaft marking for static timing (TDC – Top Dead Center) and for valve and injector adjustments is located on the camshaft front end (9) in front of the front bearing bracket (10).

## Internal EGR

TAD1350GE, TAD1351GE, TAD1352GE,  
TAD1353GE, TAD1354GE, TAD1355GE

### General



P0006027

- 1 Camshaft
- 4 Exhaust rocker arm
- 5 Pump piston
- 6 Power piston
- 7 Check valve
- 8 Piston
- 9 Spring
- 10 Rocker arm, EGR
- 11 Exhaust lobe

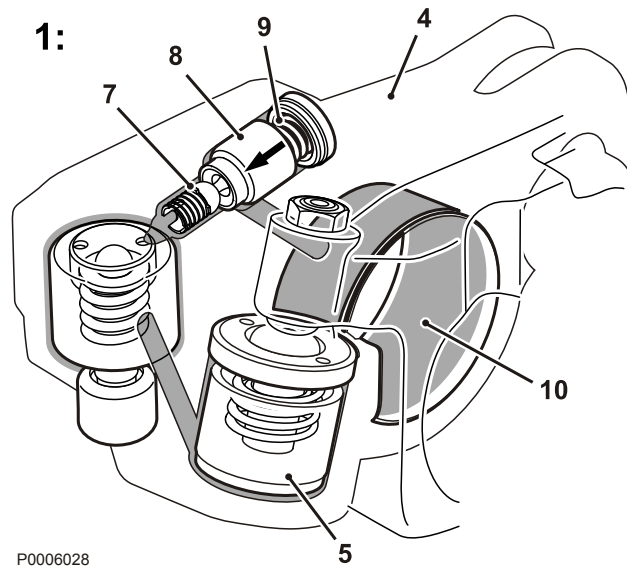
The camshaft (1) on EGR engines has four cams per cylinder; an inlet cam, injector cam, exhaust cam and EGR cam.

Inside the exhaust cam (4) there are two pistons, a pump piston (5) and a power piston (6), a check valve (7), a piston (8) and a spring (9).

The power piston is located immediately above the exhaust valve yoke and it is this piston that presses the yoke down and opens the exhaust valve. The pump piston is located immediately under the EGR rocker arm (10) and it is the pump piston the EGR rocker arm is able to press down.

The exhaust rocker arm (4) is designed so that the EGR rocker arm (10) lies above the exhaust rocker arm and when lubrication oil pressure is sufficiently high the clearance between the two rocker arms is reduced and the brake rocker arm is able to press the pump piston down. The two pistons are connected via an oil channel and when the pump piston is depressed the oil under the piston is forced along to the power piston. At the same time, the check valve closes and the high pressure causes the power piston to press down and open the exhaust valves.

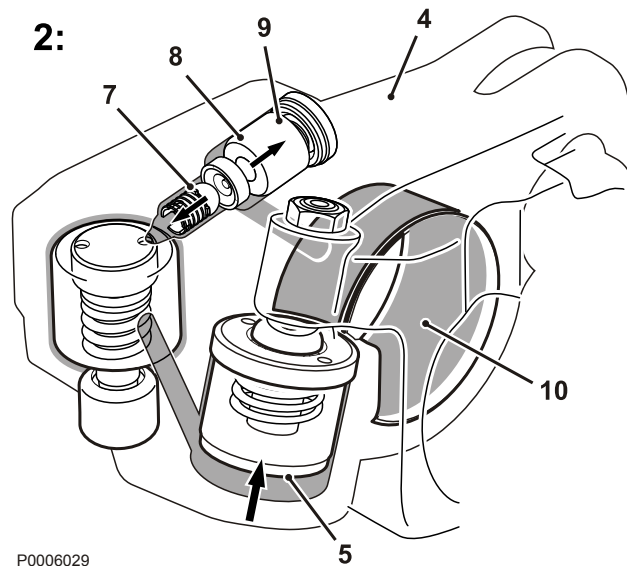
### Normal engine operation



**1/:** The control valve reduces oil pressure; the pressure is around 1 bar in the rocker arm shaft. The check valve (7) is held open by the piston (8) being moved forward by the spring (9). The oil channels are filled with oil but the low pressure is not sufficient to raise the pump piston (5) to its upper position.

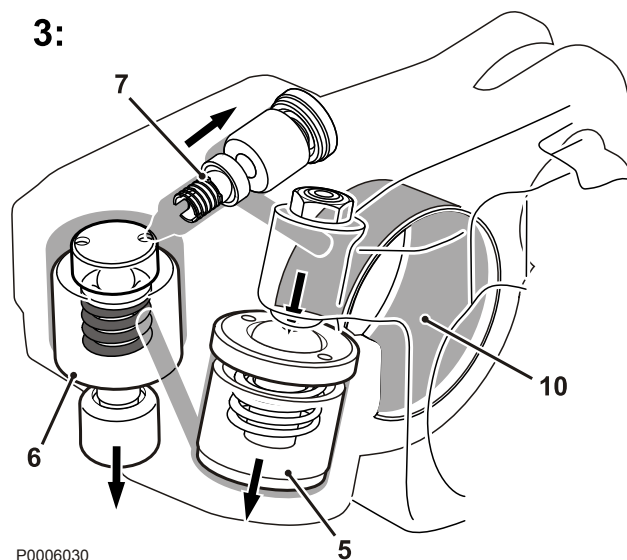
The EGR rocker arm (10) has no contact with the exhaust rocker arm (4). In this situation the exhaust valves are not affected by the EGR cam lobe.

### EGR activation



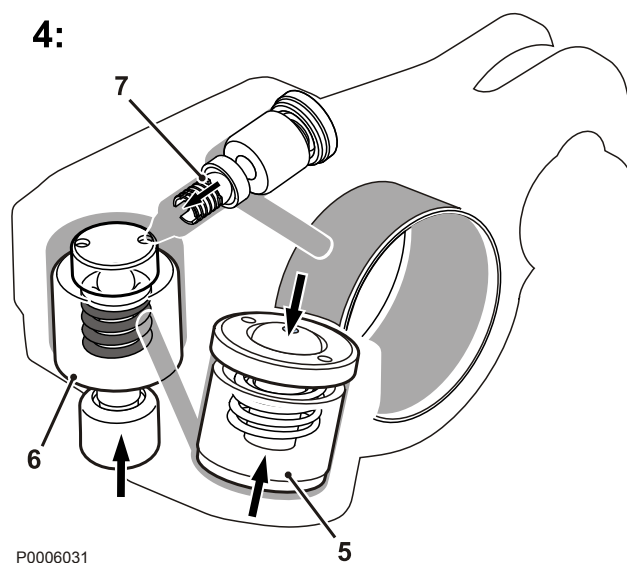
**2/:** The control valve raises the oil pressure to system pressure; the pressure is above 2 bars in the rocker arm shaft. The piston (8) is moved backwards but the check valve (7) is held open by the oil flow. The high pressure is sufficient to lift the pump piston to its upper position.

When the pump piston (5) is forced to the upper position, the clearance between the EGR rocker arm (10) and the exhaust rocker arm (4) is reduced.



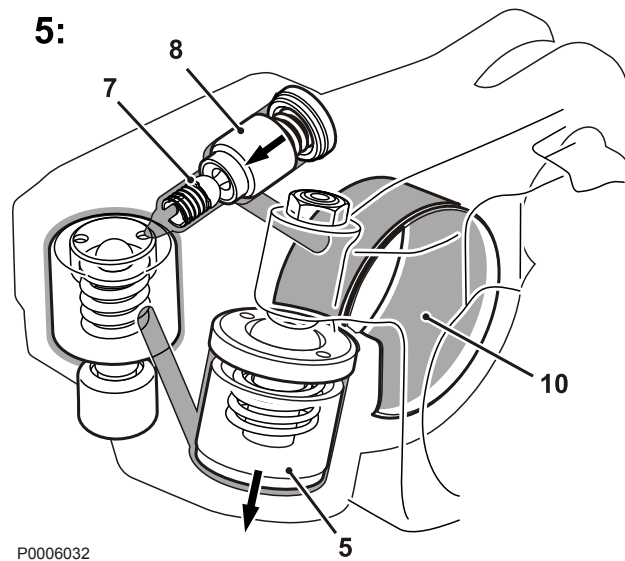
**3/:** The oil pressure lifts the pump piston (5) to the upper position and occupies the space beneath the piston. When oil has completely filled the system and oil flow ceases, the check valve (7) closes. When the EGR rocker arm (10) then rolls over the lobe,

the pump piston is forced down and the oil beneath the piston is forced on to the power piston (6). The piston is pushed down and the exhaust valves open. The check valve (7) is held closed by the high oil pressure during the time the exhaust valves are open.



**4/:** After the exhaust valves have closed and the EGR rocker arm no longer depresses the pump piston, the oil that forced the power piston (6) down flows back to the pump piston (5).

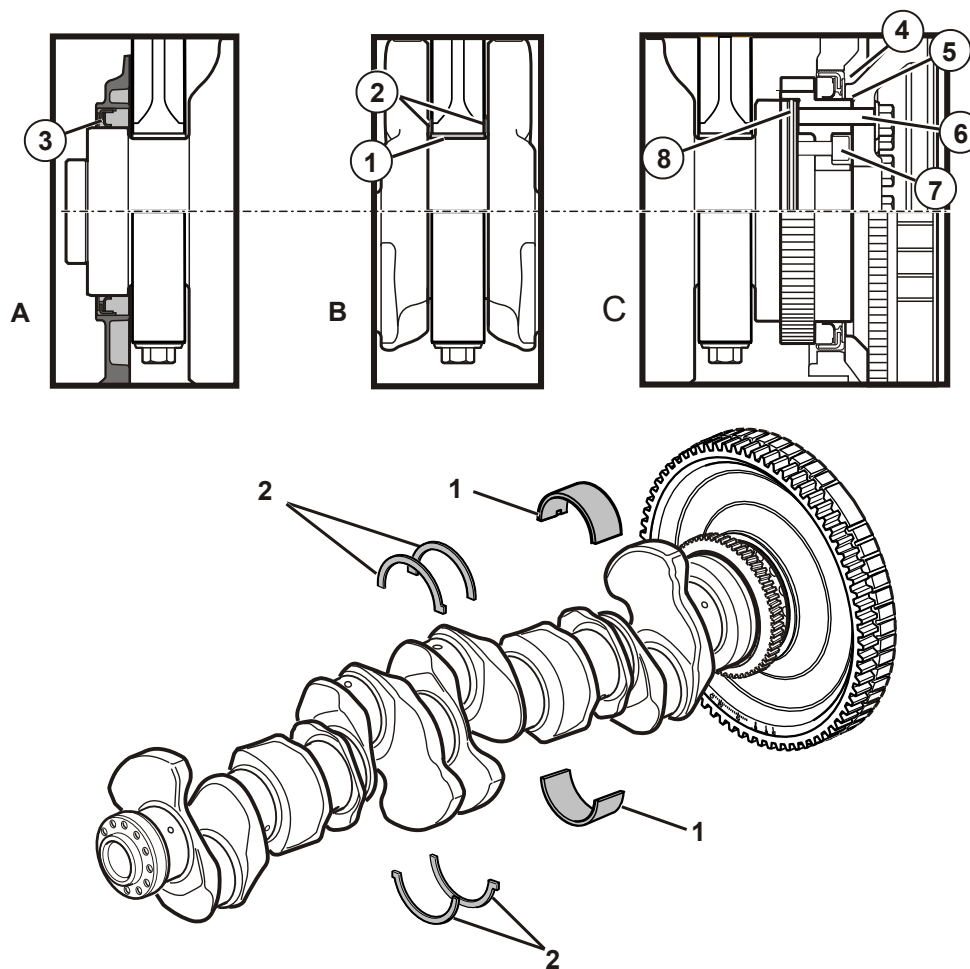
The system is replenished by the check valve (7) opening and allowing a quantity of oil to pass corresponding to the quantity leaked off during the previous cycle.

**Deactivation (return to normal engine operation)**

**5/:** Deactivation takes place when the oil pressure in the rocker arm shaft drops to around 1 bar. The piston (8) opens the check valve (7) so that oil can flow back to the rocker arm shaft.

The pump piston spring then forces the pump piston (5) back to its lower position and the EGR rocker arm (10) can no longer contact the pump piston.

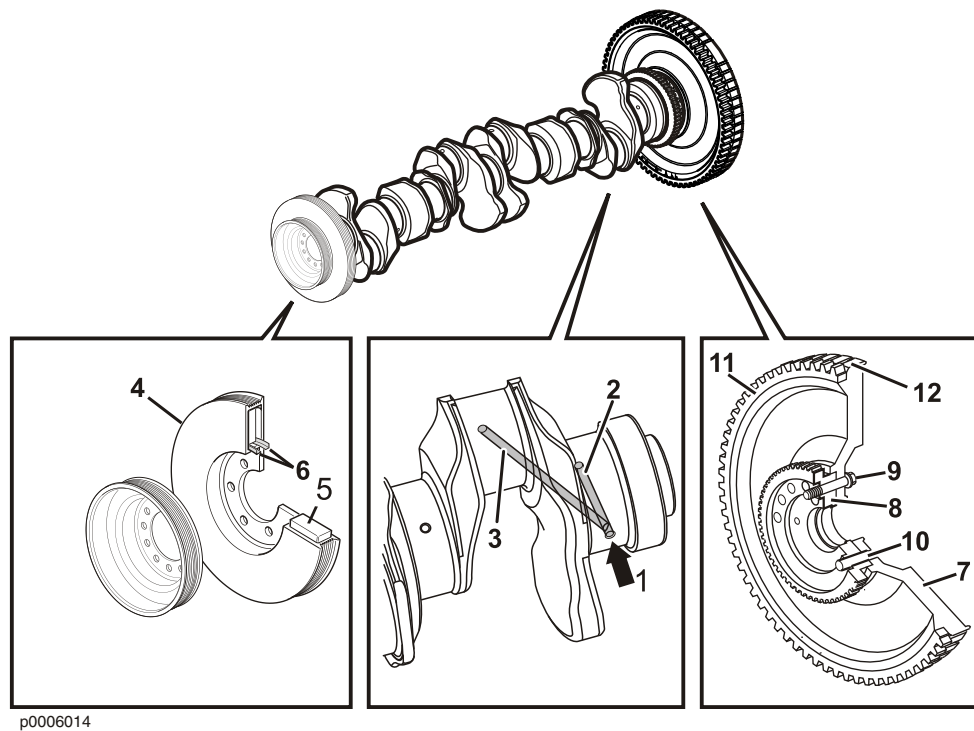
## Crankshaft, vibration damper, flywheel



P0006013

The crankshaft is drop forged and has induction hardened bearing journals and inserts. The crankshaft is supported by seven main bearings with replaceable bearing shells (1). There is also a thrust bearing in the intermediate main bearing (B) comprising four half-moon-shaped washers (2).

Front end (A) sealing is by means of a Teflon seal (3) against the front crankshaft flange. There is also a Teflon seal (4) at the rear (C) that seals against a machined surface on the crankshaft gearwheel (5). The gearwheel is fastened to the crankshaft with a locating pin (6) and two bolts (7). There is a groove in the rear crankshaft flange for an O-ring (8) that seals between the flange and the flywheel.



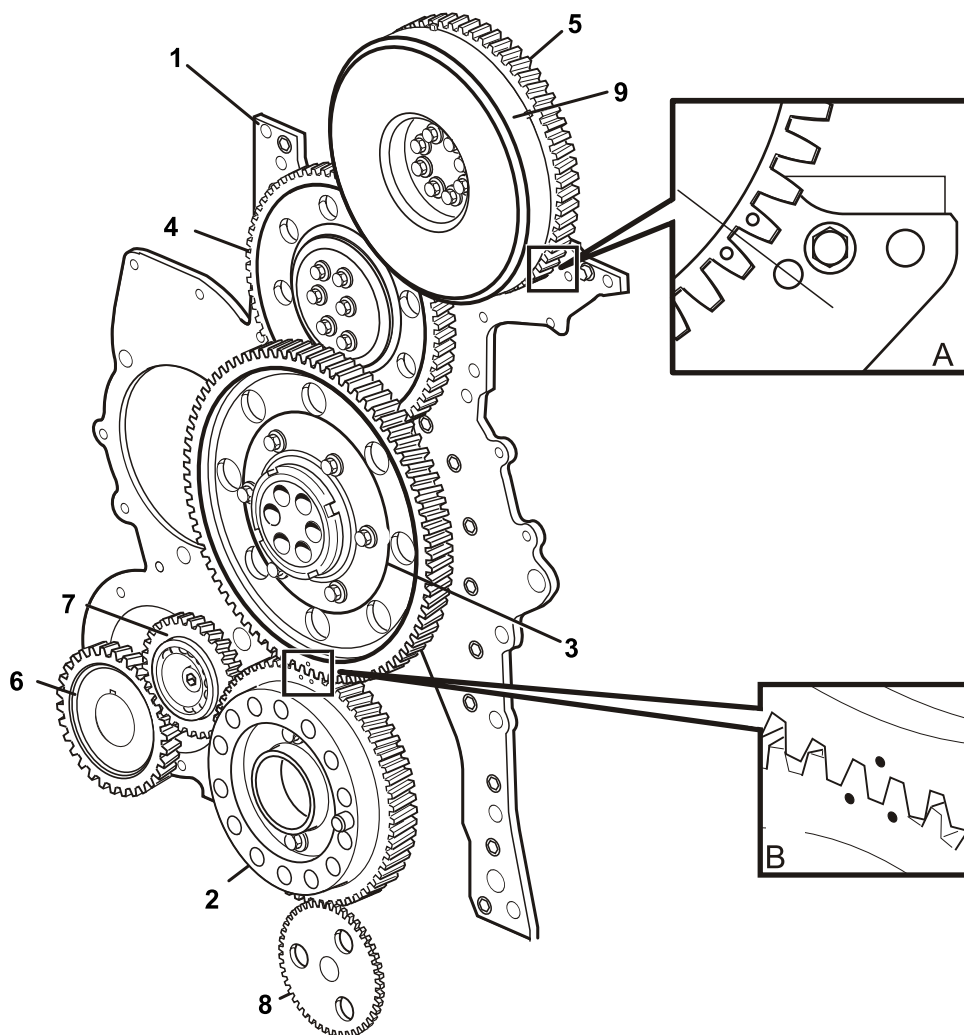
The crankshaft is lubricated via separate channels in the cylinder block feeding each main bearing (1). The main shaft journals have drilled lubrication channels (2), and a drilled channel (3) leads to the nearest crankshaft journal from each main bearing journal except the center one.

The vibration damper is of hydraulic type and bolted directly onto the front crankshaft flange. The damper is also used as a multi-grooved belt pulley to drive the alternator. In the damper housing (4) there is an oscillating mass in the form of a cast iron ring (5) that is able to rotate freely on the bushings (6). The space between the damper housing and the oscillating mass is filled with silicone oil of high viscosity.

When the crankshaft rotates, torsional stresses arise in the crankshaft from piston impulses. The viscous silicone oil evens out the movement between the pulsating crankshaft rotation and the smooth rotation of the oscillating mass, thus reducing the stresses.

The flywheel (7) and the intermediately located gearwheel (8) are fastened to the rear crankshaft flange with 14 M16 bolts (9). The flywheel is positioned on the crankshaft with the same locating pin (10) as the gearwheel. There are grooves milled into the circumference (12) for the engine control system inductive sensor. The starter ring (11) is sweated onto the flywheel and is replaceable.

## Engine Transmission



P0006015

Engine timing is located at the rear of the engine on a 6 mm sheet steel plate (1) according to the same principal for the D9A and D16C engines.

The timing plate is held in place by a number of bolts and is sealed against the cylinder block and cylinder head with silicone. The timing plate has a machined groove toward the block, and a silicone bead is laid around the plate **outside** the groove.

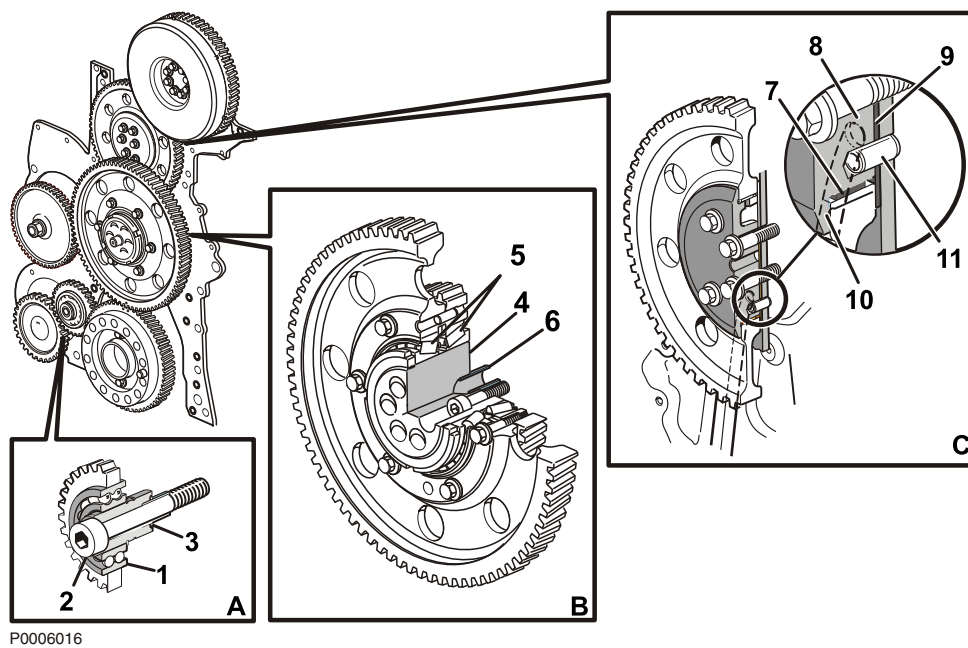
There is a drilled hole in the timing plate which, together with the marking on the camshaft gear (A), is used for installing the camshaft correctly.

The crankshaft gear and the double intermediate gear are marked (B) for correct installation.

- 1 Timing gear plate
- 2 Crankshaft gear
- 3 Intermediate gear, bull gear
- 4 Intermediate gear, adjustable
- 5 Camshaft gear
- 6 Drive gear, power steering and fuel feed pump
- 7 Intermediate gear, power steering and fuel feed pump
- 8 Drive gear, lubrication oil pump
- 9 Vibration damper with "teeth" for camshaft inductive sensor



## Engine timing intermediate gear



P0006016

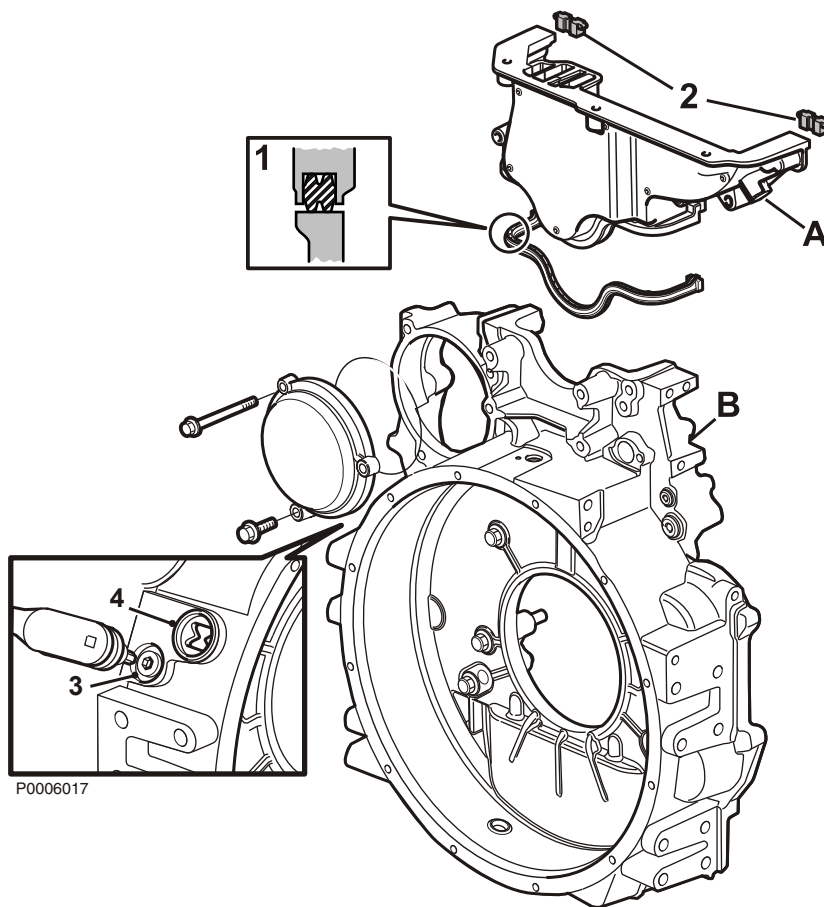
**A:** The small intermediate gear that drives the power steering and the fuel feed pump is supported by a twin-race ball bearing (1) and is held in place by a bolt (2). The bolt passes through the bearing and holds it against the timing plate and is fastened in the cylinder block.

**B:** The lower intermediate gear comprises two gearwheels assembled together. The gearwheels are pre-installed on a hub (4) and supported by two conical roller bearings (5). The locating sleeve (6) guides the intermediate gear in the timing plate.

This intermediate gear with two gear wheels, bearing and hub is a complete unit that cannot be disassembled but must be **replaced as a complete assembly**.

**C:** The adjustable intermediate gear is supported by a bushing (7) on the hub (8). The bushing and the thrust washer (9) are pressure lubricated via a duct (10) that runs between the cylinder block and the timing plate. A locating pin (11) in the lower part of the hub keeps gear lash constant between the two gear lash measurement. Therefore only the gear lash against the camshaft gear need be set when adjusting.

## Covers



There are two engine timing gear covers. The upper timing gear cover (**A**) has an integral oil trap for crankcase ventilation. The lower (**B**) is a combined timing and flywheel housing and has attachment points for the rear engine suspension. The flywheel housing has two locating sleeves that position it against the timing plate.

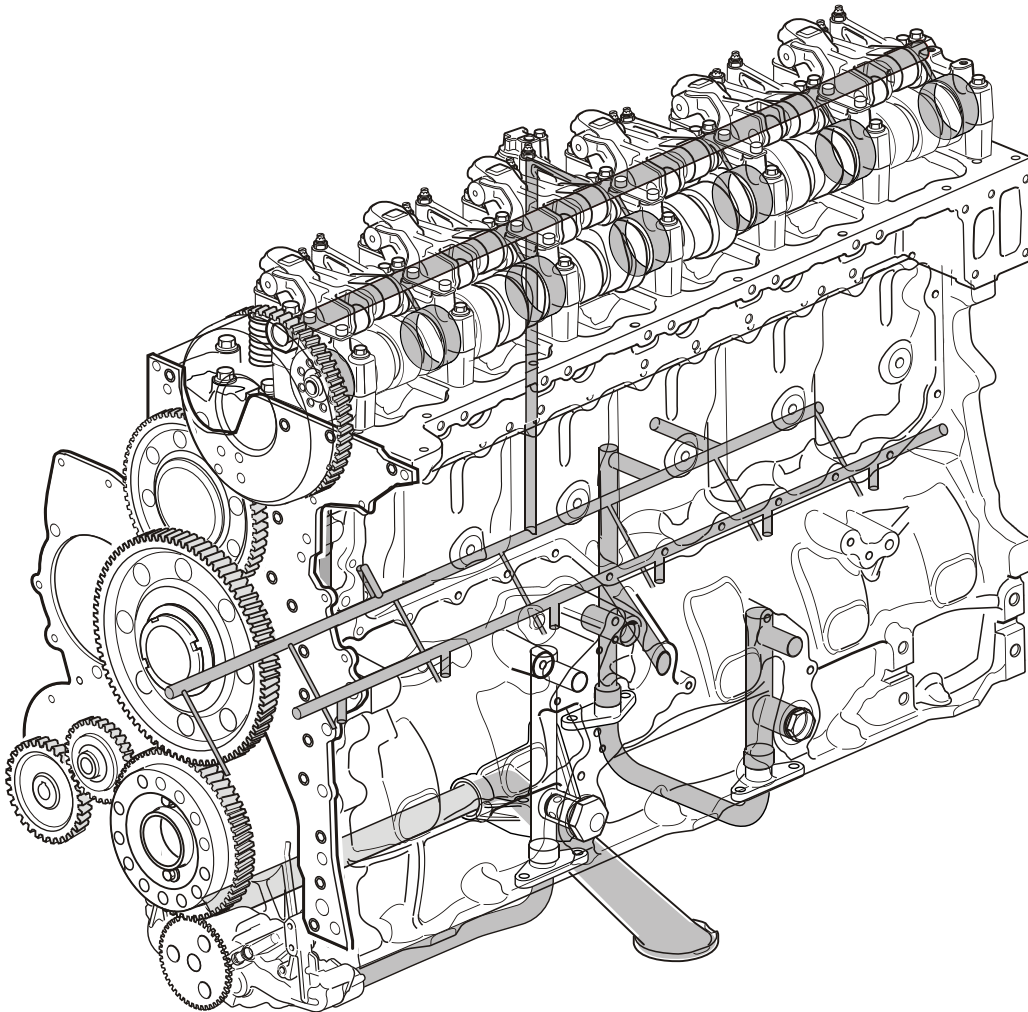
Both covers are sealed against the timing plate with sealant. The seal between the two covers is by a rubber strip (**1**) placed in a groove in the upper cover.

The upper timing gear cover seals against the timing plate with two rubber sealings (**2**). The upper timing gear cover is also sealed with sealant in the join between the rubber strip and the timing plate.

There are two holes in the flywheel housing. One hole is intended for a cranking tool (**3**) for cranking the engine, and the flywheel position marking can be read through the other hole (**4**).

## Group 22: Lubrication System

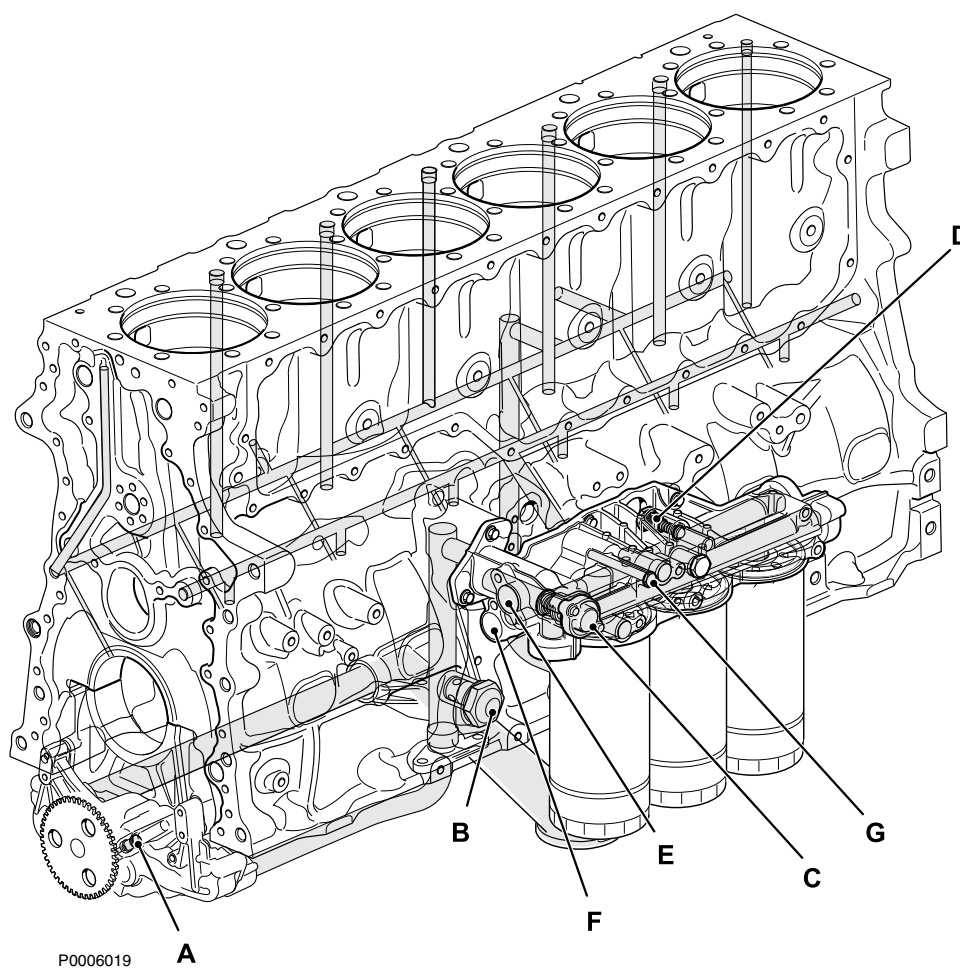
### General



P0006018

The engine is pressure lubricated by a gearwheel pump located at the rear and driven by the engine crankshaft. Two longitudinal ducts for oil are drilled through the cylinder block – the main lubrication duct (gallery) and the piston cooling duct. The main lubrication duct discharges into a cast channel for timing gear lubrication. A centrally-located drilled channel through the cylinder block and cylinder head lead lubrication oil to the control valve and the drilled rocker arm shaft, which lubricates the camshaft and rocker arm bearings through oil channels.

The oil filter housing is bolted to the right side of the engine and has two full-flow filters and one bypass filter. The oil cooler is located in the cylinder head cooling jacket on the same side.

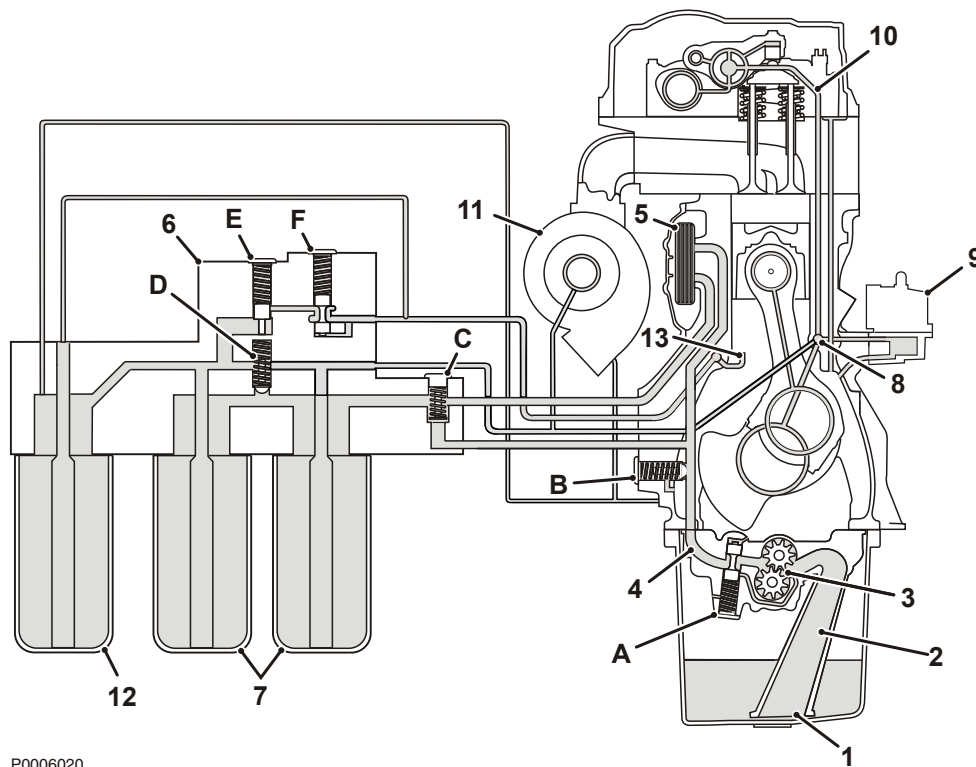


Oil flow in the engine is controlled by six valves located in the cylinder block, the pump and the filter housing.

- A Reduction valve
- B Safety valve
- C Oil cooler thermostat valve
- D Bypass valve for full-flow filter
- E Opening valve for piston cooling
- F Control valve for piston cooling
- G Pressure take-off for piston cooling pressure measurement

The piston cooling valves (**E**) and (**F**) are integrated in the filter housing and are not replaceable. The reduction valve (**A**) is integrated in the oil pump and cannot be replaced separately.

## Lubrication system, principle



P0006020

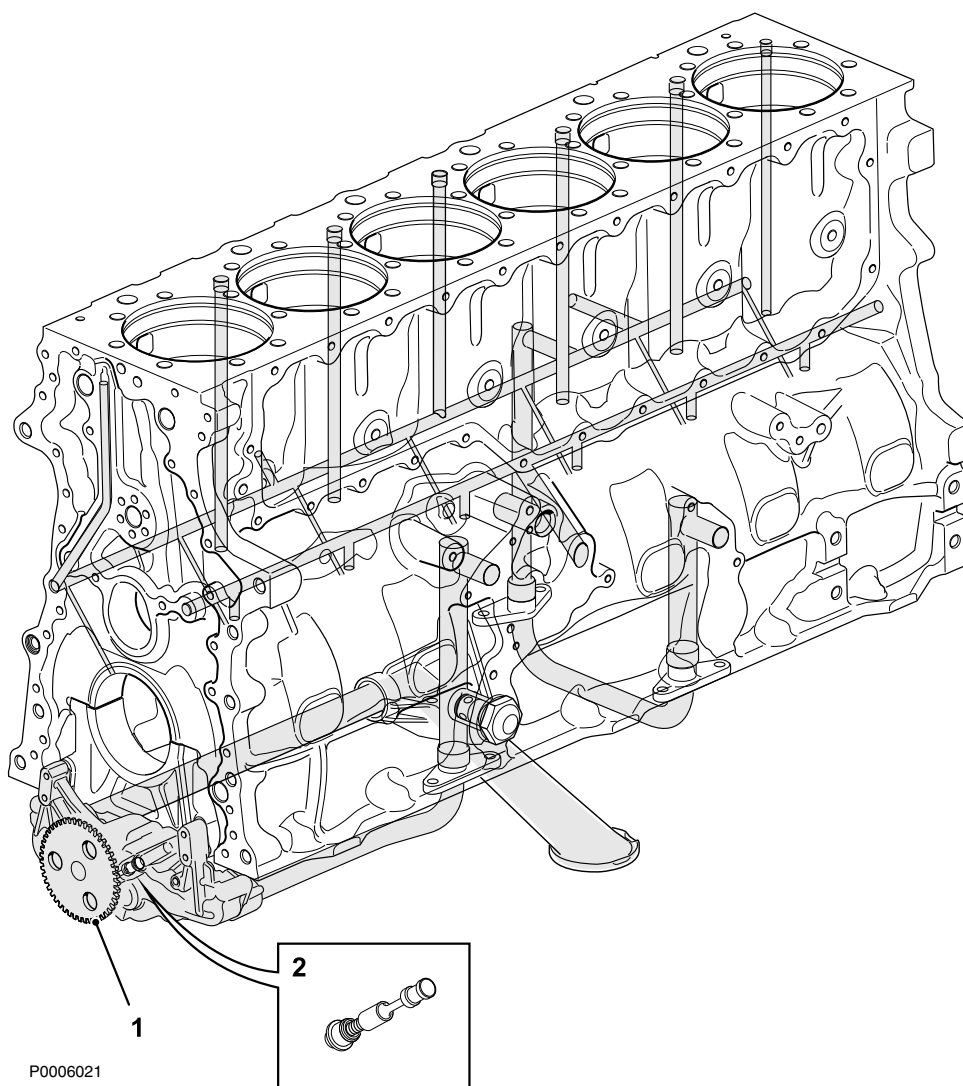
Oil is drawn up through the strainer (1) in the plastic pipe (2) from the oil sump to the lubrication oil pump (3) which forces oil via the delivery pipe (4) to channels in the cylinder block. The oil is led via the oil cooler (5) to the filter housing (6). After the oil is filtered in the two full-flow filters (7) it is led via a connection pipe to the main cylinder block lubrication channel (8) for distribution to all of the engine's lubrication points and to the separator turbine (9) in those cases where CCV, Closed Crankcase Ventilation, has been selected. Lubrication of the valve mechanism takes place via a channel drilled up to the control valve (10).

Two external hoses supply the turbocharger (11) with oil filtered in the full-flow filters (7).

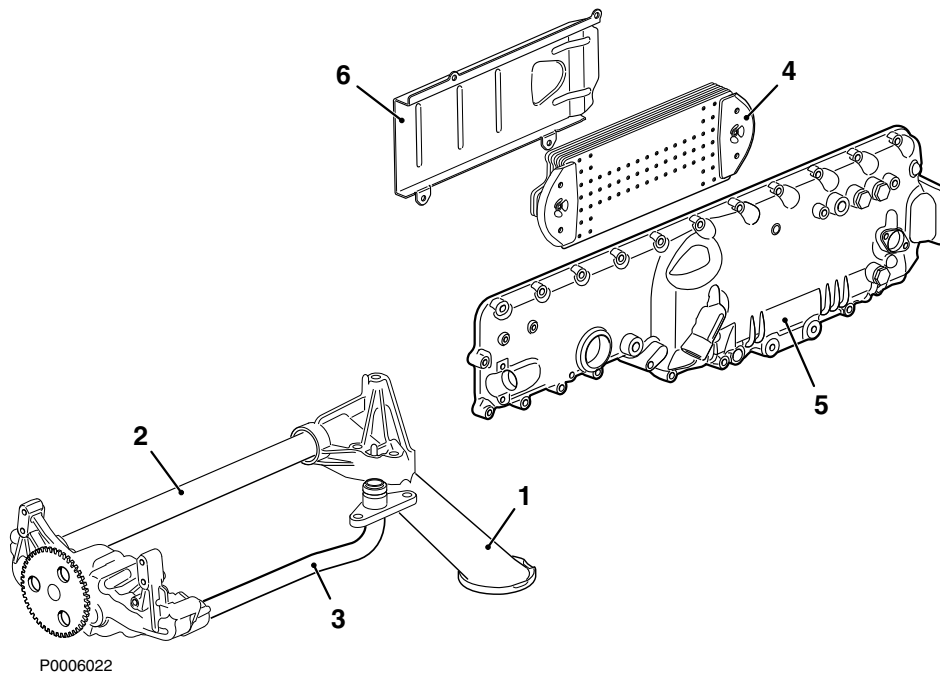
The fine filtered oil from the bypass filter (12) is mixed in with piston cooling oil which is led to the cylinder block piston cooling channel. From here, oil is sprayed against the underside of the pistons through nozzles (13).

- A Reduction valve – maintains oil pressure within the correct values
- B Safety valve – protects the oil pump, filter and cooler against excessive pressure when the oil has high viscosity
- C Oil cooler thermostat valve – regulates oil temperature to the optimum value
- D Overflow valve for full-flow filter – opens and allows oil to pass if the filters are clogged
- E Opening valve, piston cooling – connects piston cooling when the oil pressure reaches a set opening value
- F Control valve, piston cooling – controls the flow of oil to the piston cooling oil channel

## Oil pump and oil cooler



The lubrication oil pump is a gearwheel pump located at the rear of the engine and fastened with four bolts to the rear main bearing cap. It is driven by a gearwheel (1) directly from the engine timing. The pump gearwheel teeth are cut at an angle for lower noise levels, and its shafts are supported via bearings directly in the pump housing, which is of aluminum. The pressure reduction valve (2) is installed in the oil pump and regulates pressure in the lubrication system.



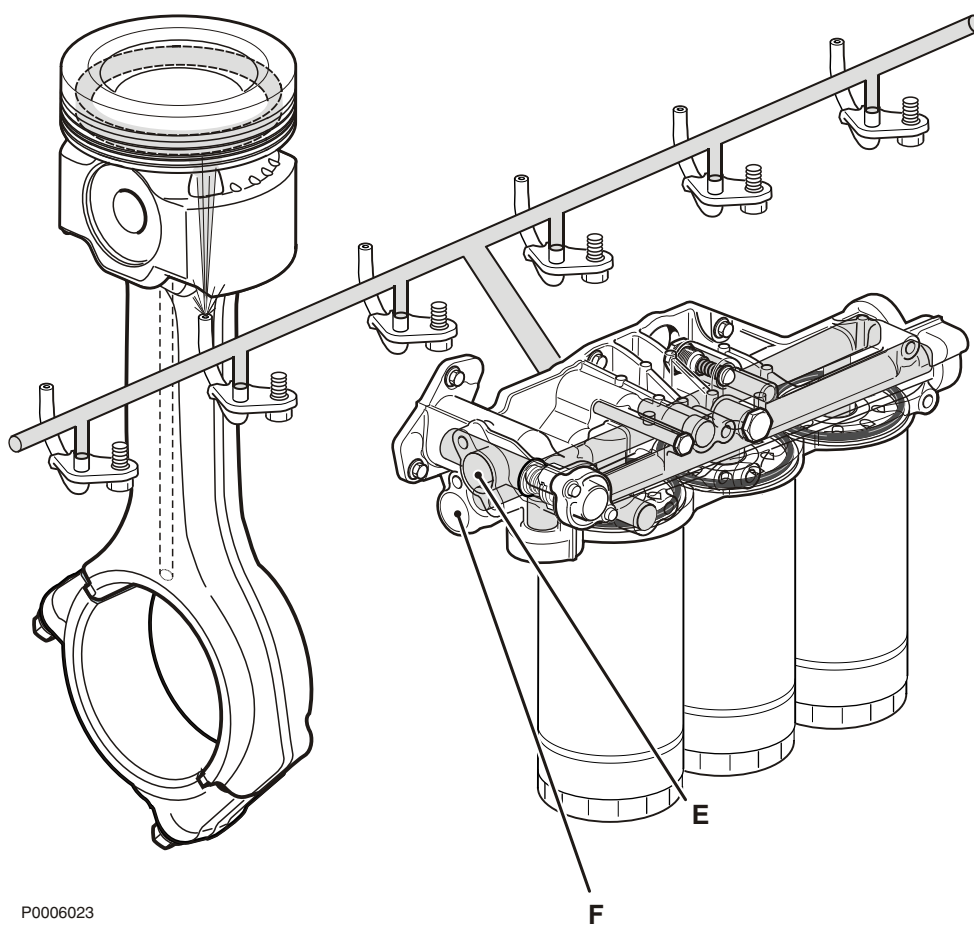
The suction system is in two parts and comprises a plastic pipe (1) with strainer from the oil sump, and a steel or aluminum pipe (2). The plastic pipe is bolted to the stiffening frame. The metal pipe is sealed at the ends with rubber seals, and is in one of two lengths depending on installation. The delivery pipe (3) is made of steel and is fastened to the cylinder block bearing caps and sealed with rubber seals.

A connection pipe from the oil filter housing leads oil to the main lubrication channel.

The oil cooler (4) is bolted directly to the oil cooler housing (5) and is entirely surrounded by coolant thanks to the flow plate (6).



## Piston cooling system



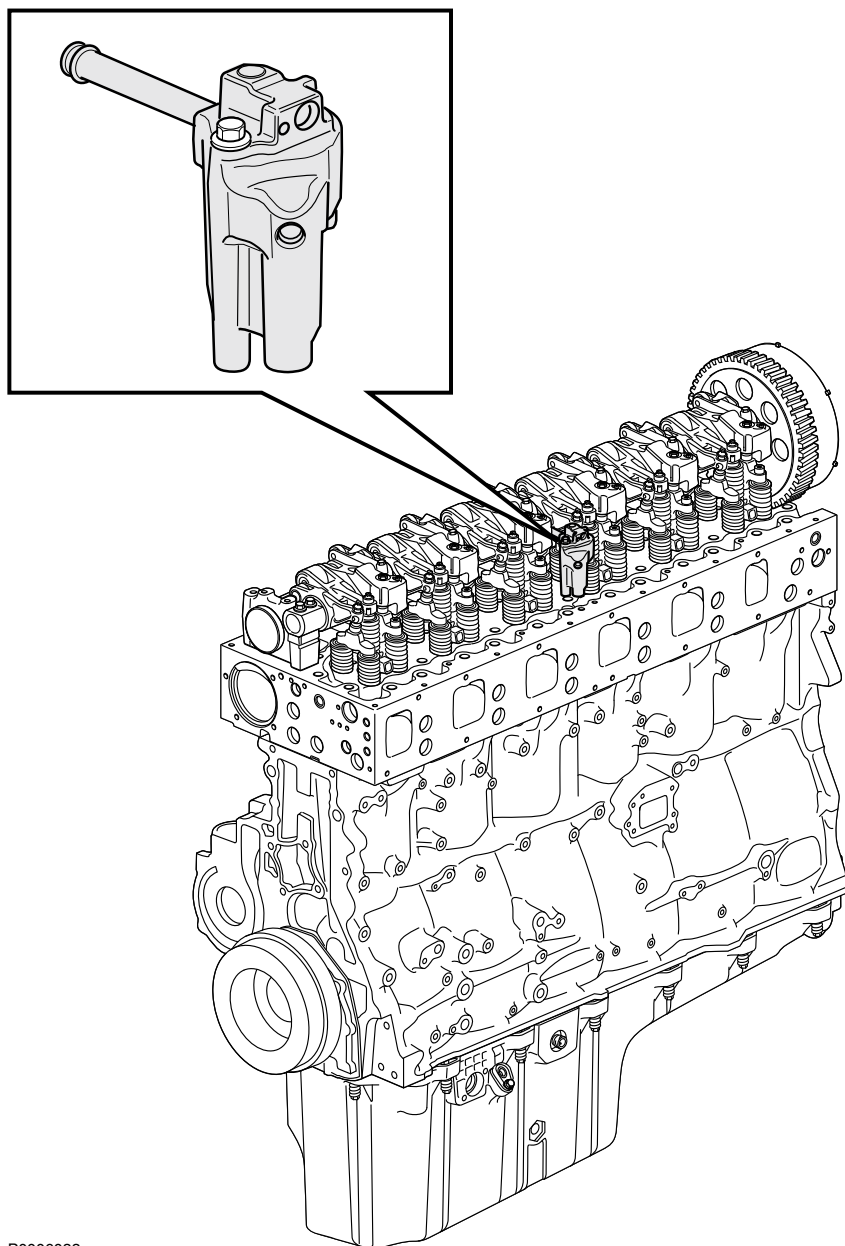
Here piston cooling oil flow is illustrated when the valve (**E**) is open and the valve (**F**) balances oil flow to the piston cooling channels. The piston cooling nozzle is directed such that the oil jet hits the inlet hole to the piston cooling chamber.

By regulating the piston cooling flow via a control valve, a so-called optimized piston cooling system is arrived at with a constant flow regardless of engine rpm.



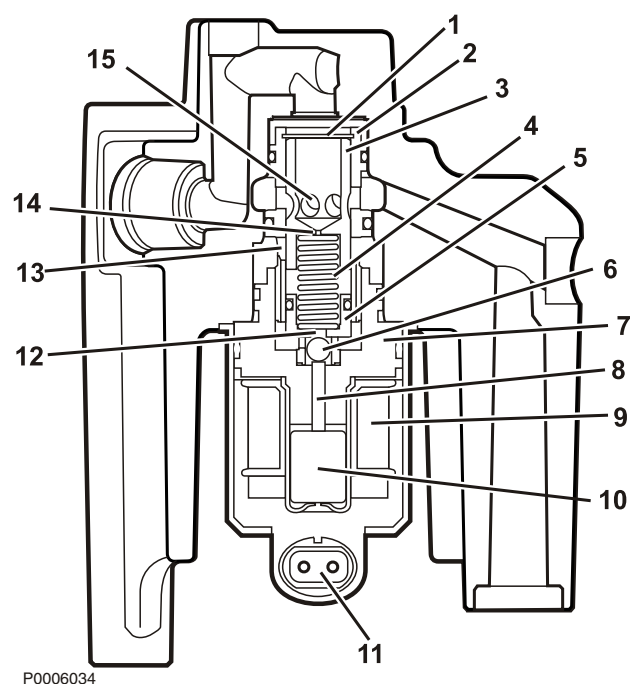
## Control valve

### General



P0006033

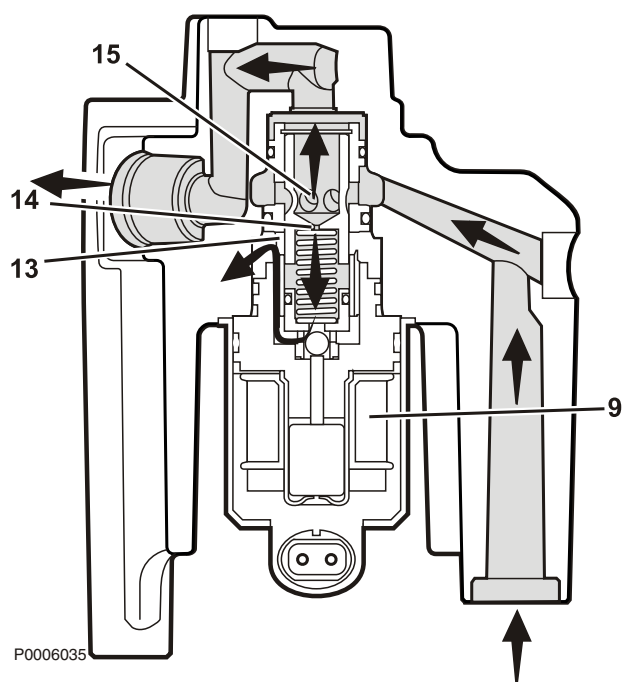
The control valve regulates oil pressure to the rocker arm mechanism and is controlled by the engine control unit (ECU) via the solenoid valve.



## Neutral

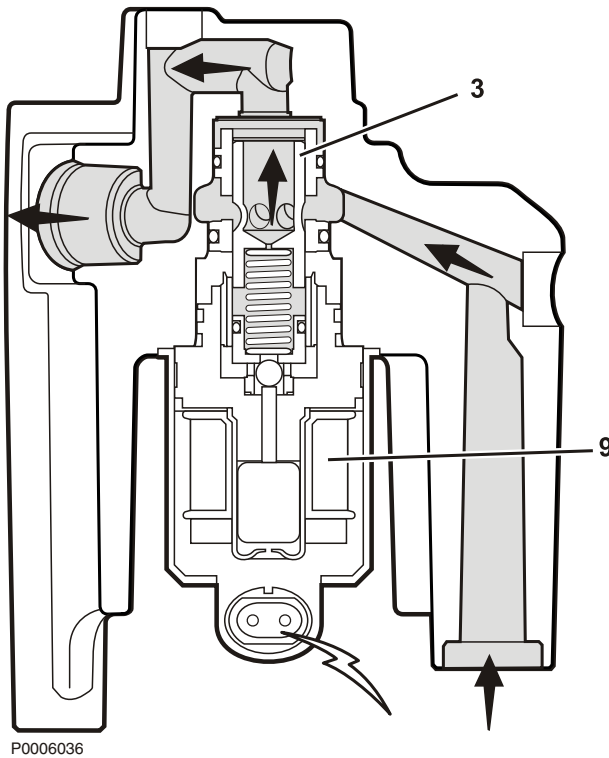
The illustration below shows the control valve in the neutral position, which means the engine is at rest. The solenoid (9) is not activated and the valve slide (3) rests against the retainer ring (1).

- 1 Retainer ring
- 2 Sleeve
- 3 Valve slide
- 4 Balance spring
- 5 Spring seat with ball holder
- 6 Valve ball
- 7 Cylinder
- 8 Bar
- 9 Solenoid
- 10 Piston
- 11 Electrical connection
- 12 Pressure regulation orifice for control flow
- 13 Return orifice
- 14 Calibration orifice
- 15 Hole for oil flow to rocker arm



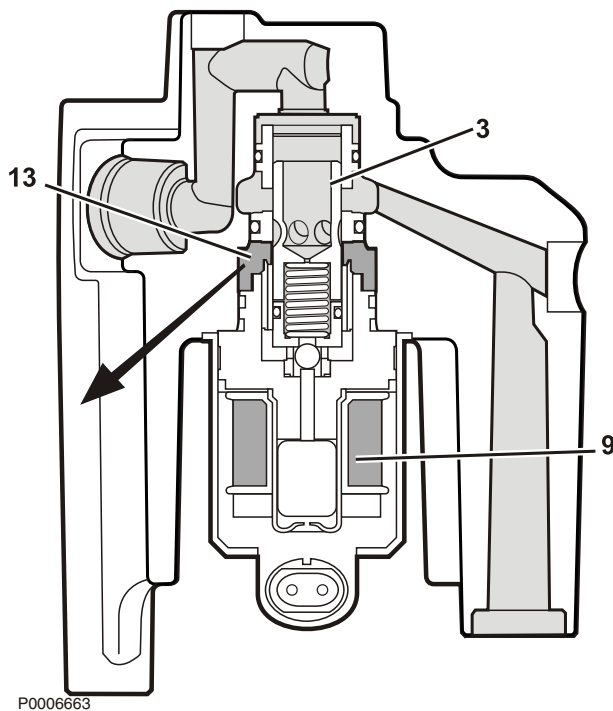
## Normal operations

During normal engine operation the solenoid (9) is not activated. The solenoid is in the control position and forces oil through the orifice (15) to the rocker arm at the same time as oil is able to flow through the calibration orifice (14) and on to the return orifice (13). This reduces oil pressure to 1 bar (100 kPa) [14.5 PSI] which is sufficient for lubricating the camshaft bearings and valve mechanism.



### Activation of EGR

When the engine is running and the EGR is activated, the solenoid (9) is energized and the valve slide (3) is forced to its end position – fully open – in that the enclosed oil acts as a hydraulic lock. Full oil pressure is now delivered to the rocker arm shaft and the EGR function takes over.

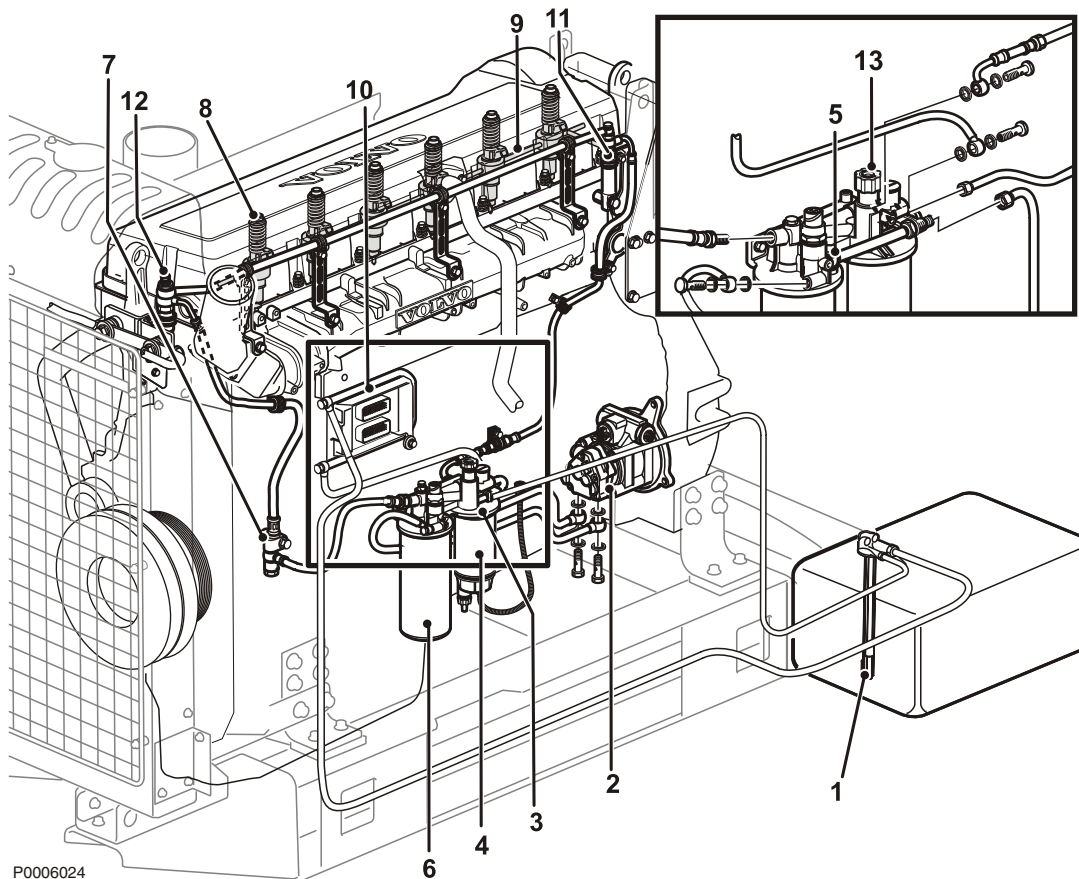


### Deactivation of EGR

When the engine is running and the EGR function released, the solenoid (9) is de-energized. The high pressure that is present in the rocker arm shaft causes the valve slide (3) to rapidly shut so that the oil return connection (13) opens and oil drains out. When the oil pressure falls to 1 bar (100 kPa) [14.5 PSI] the valve slide is returned to the control position.

## Group 23: Fuel System

### General



P0006024

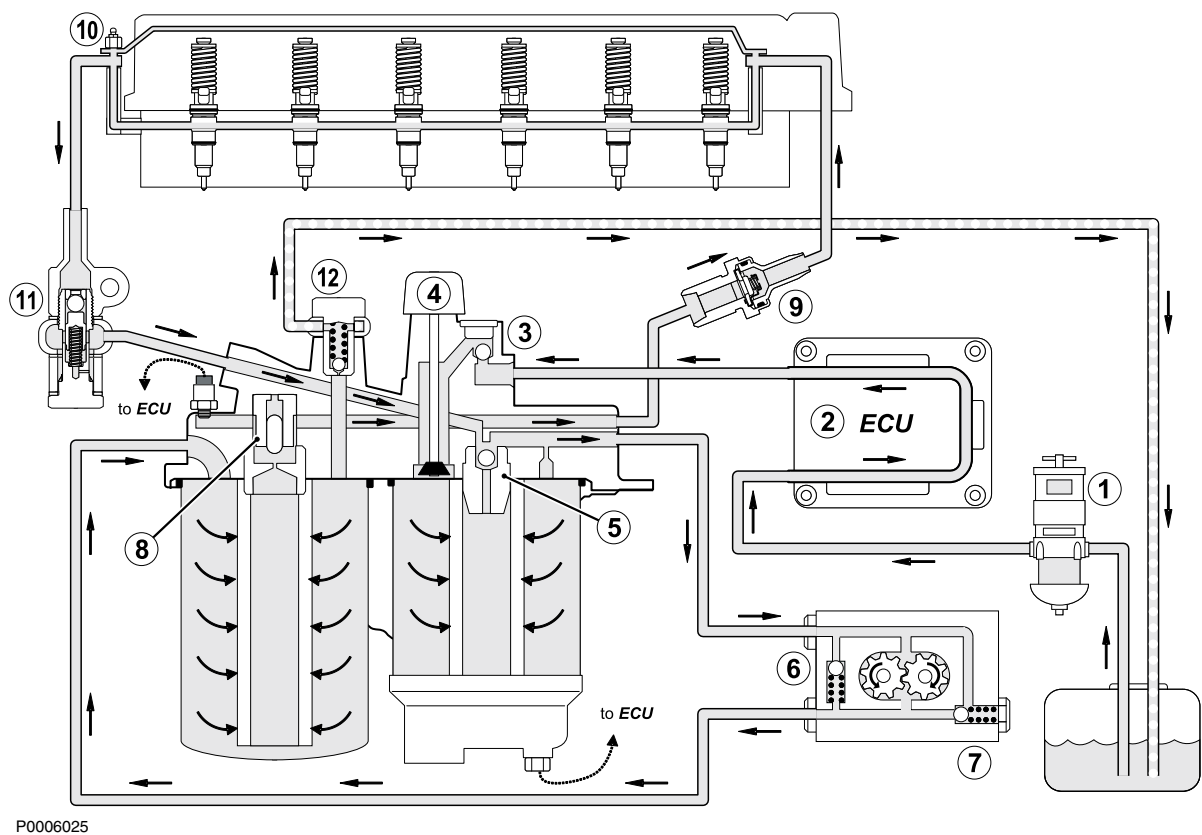
The fuel system is electronically controlled (EMS). Fuel injection takes place via unit injectors, one per cylinder, under high pressure. The high pressure is achieved mechanically via overhead camshafts and rocker arms. Control of fuel amounts and injection timing takes place electronically via the engine control unit (ECU), which receives signals from a number of sensors.

The illustration shows the main components included in the fuel system.

The engine is also equipped with a hand pump, located on the fuel filter housing

- 1 Strainer, fuel gauge sensor
- 2 Feed pump
- 3 Fuel filter housing
- 4 Pre-filter with water separator
- 5 Venting valve
- 6 Fuel filter
- 7 Overflow valve
- 8 Unit injector
- 9 Fuel channel in cylinder head
- 10 Cooling loop for engine control unit
- 11 Level pipe
- 12 Venting nipple
- 13 Hand pump

## Fuel feed system, principle



Fuel is drawn up with the aid of a feed pump, via a check valve, first through the strainer in the fuel gauge sensor, then through the auxiliary <sup>1)</sup> pre-filter (1), then up through the ECU cooling loop (2) and then down to the fuel filter housing. Here the fuel passes a check valve (3) and the pre-filter with water separator. The check valve function is to prevent fuel from flowing back to the tank when the engine is shut down, and during hand pumping.

The feed pump forces fuel to the fuel filter housing through the main filter and up to the cylinder head longitudinal fuel channel via a check valve (9). This channel supplies each unit injector with fuel via a ring-shaped channel in the cylinder head around each injector. The overflow valve (11) regulates fuel feed pressure to the injectors.

Return fuel from the cylinder head fuel channel passes through the overflow valve (11) back to the fuel filter housing.

1) Option.

Return fuel is mixed in the fuel filter housing through channel with fuel from the tank and is drawn on to the feed pump inlet (suction side).

There are two valves in the feed pump. The safety valve (7) allows the fuel to flow back to the suction side when pressure becomes too high, e.g. if the fuel filter is clogged. The check valve (6) opens when the manual fuel pump (4) is used, to make it easier to pump up fuel by hand.

There is also a venting valve (12) located in the fuel filter housing. The fuel system is vented automatically when the engine is started. Any air in the system flows together with a small amount of fuel back to the tank via a line.

There is a venting nipple (10) on the front level pipe for venting a completely empty system.

At filter changes, the valve balls **(5)** and **(8)** close so that no fuel leaks out when the fuel filters are screwed out. Filter venting after each filter change is controlled by the filter housing valves **(5)** and **(8)** and the venting valve **(12)**.

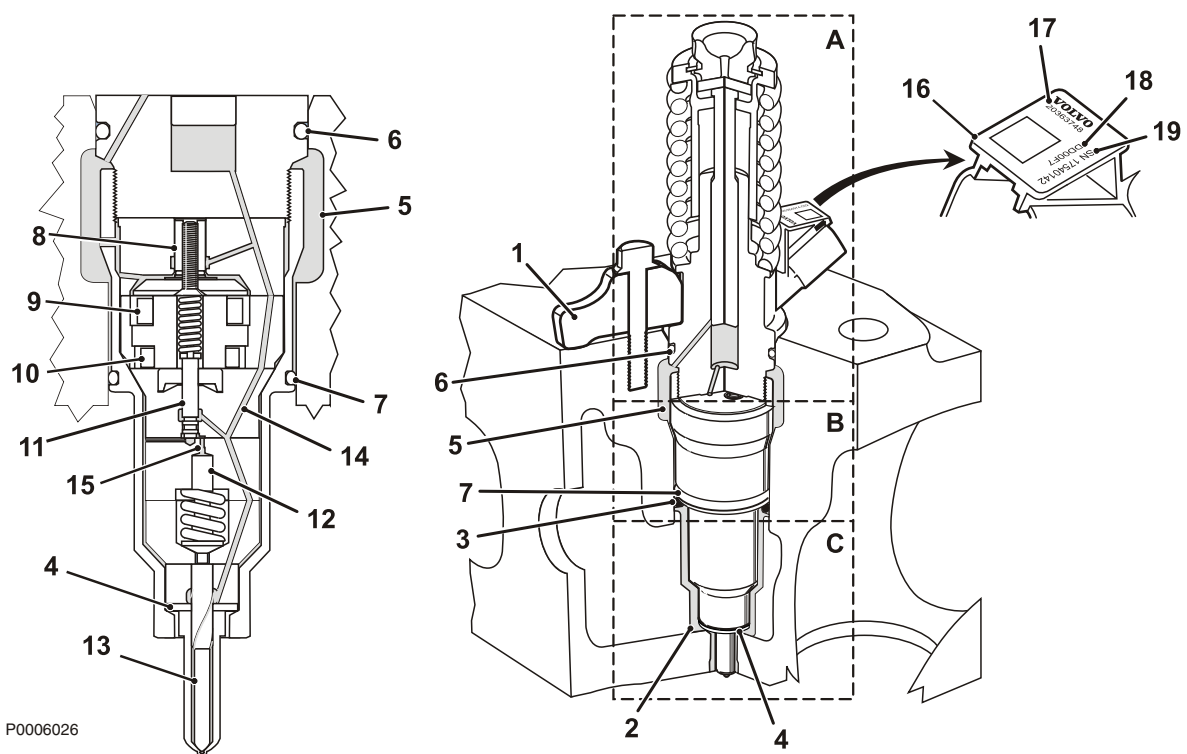
There is a fuel pressure sensor on the fuel filter housing that measures feed pressure after the fuel filter. A fault code is shown on the instrument panel if feed pressure falls below the value according to the fault code book.

There is a level sensor in the water separator that provides a signal to the operator if there is water in the system.

The hand pump **(4)** is located on the fuel filter housing and is used for pumping up fuel (engine stopped) when the fuel system has been emptied.

**NOTICE!** The hand pump may not be used when the engine is running.

## Unit injectors



P0006026

The engine has unit injectors with two solenoids for more precise injection. This provides better combustion and minimizes particle emissions, which provides for cleaner exhaust.

The injectors are centrally located between the four valves and are held in place in the cylinder head by yokes (1). The lower injector section is separated from the cooling jacket by the copper sleeve (2) and the O-ring (3). The unit injector's lower part is sealed against the copper sleeve by a steel gasket (4). The ring-shaped space for fuel metering (5) around each injector is sealed with two O-rings (6 and 7).

A unit injector can in principle be divided into three main parts:

- A Pump section
- B Valve section (actuator)
- C Nozzle section

The valve section contains two solenoid valves – the spill valve (8) and the needle valve (11) with solenoids (9 and 10) and return springs.

During the **filling phase** the pump piston moves up and fuel from the cylinder head fuel channels is forced into the unit injector.

During the **spill phase** the pump piston moves down and fuel is forced back out into the cylinder head fuel channels. During the period when the solenoids are unenergized and the spill valve is open no pressure is able to be built up in the fuel channel to the injector.

In the **pressure building phase** the spill valve solenoid is energized and the spill valve closes. A high pressure then builds up in the fuel channel (14). The pressure also builds up in the chamber (15) behind the needle valve, which acts on the needle valve piston (12) and prevents the needle valve (11) from opening the nozzle valve (13).

When the required fuel pressure is reached, **the injection phase** occurs. The needle valve solenoid is energized and opens the needle valve **(11)**. The high pressure on the needle valve piston is released and the nozzle needle **(13)** opens. Atomized fuel is sprayed at high pressure into the engine combustion chamber.

Fuel injection is stopped by the spill valve opening once again, at which point the pressure on the piston **(12)** drops and the nozzle needle **(13)** closes.

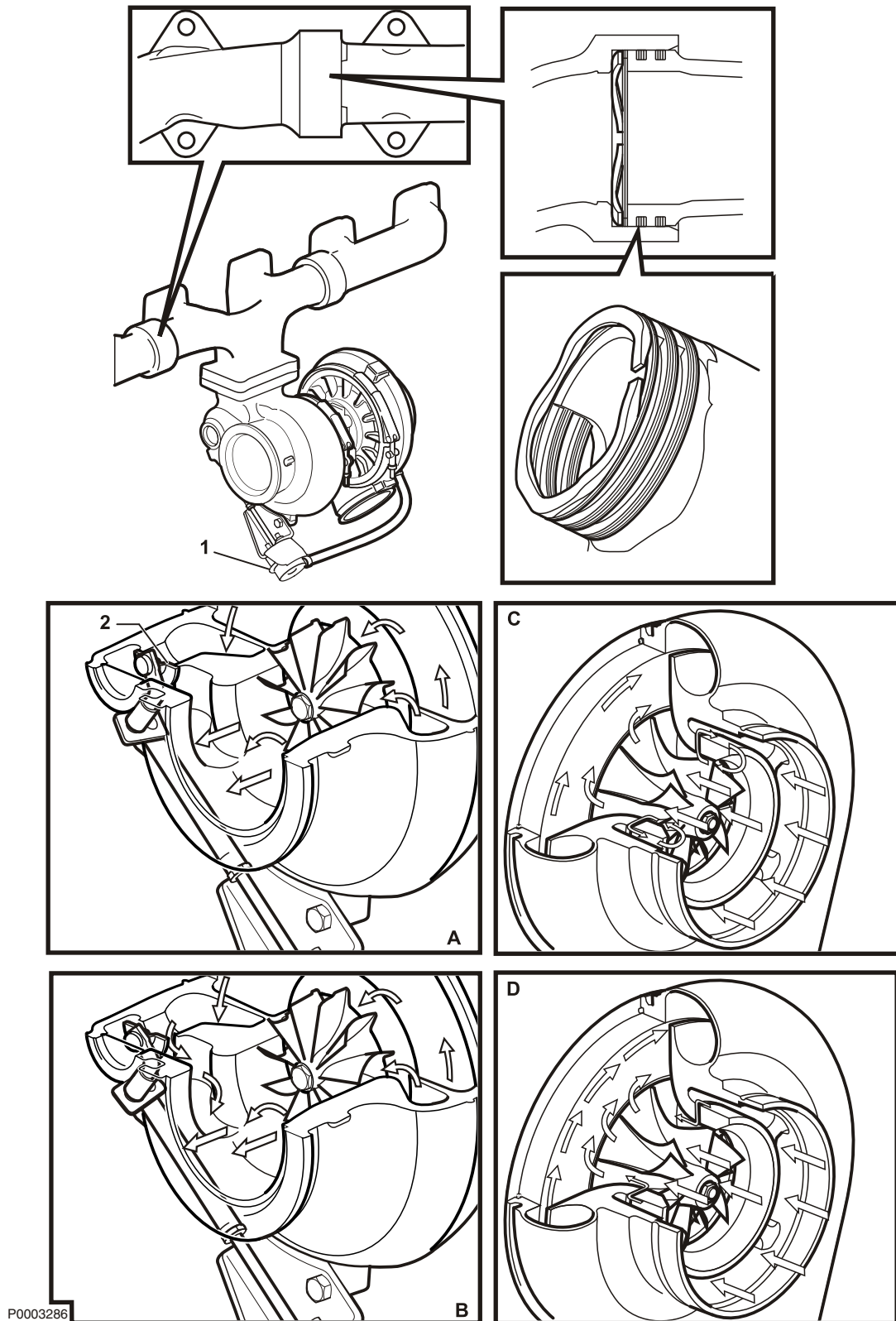
The entire injection process is controlled by the engine management system (EMS).

There are three markings on the injector electrical connection **(16)** – part number **(17)**, trim code **(18)** and production number **(19)**. When changing one or more injectors the engine control unit (ECU) must be programmed with new injector trim codes because each unit injector is unique and the engine is tuned for optimal fuel injection and emissions as low as possible. The trim code is programmed with the aid of parameter programming in VODIA. The programming need only be carried out for the unit injector(s) replaced.



## Group 25: Inlet and Exhaust System

### Exhaust Manifold and Turbo



The exhaust manifold is made in three parts in heat-resistant cast steel. The joints are sealed with seal rings. Between the cylinder head and the manifold flanges, there are gaskets made from graphite coated sheet steel.

The turbocharger has a turbine with a by-pass and is of MWE type (Map Width Enhancement). The compressor's air inlet is divided into an inner and outer area, connected via a ring-shaped chamber.

The by-pass valve on the exhaust side is designed to protect the turbo by reducing its speed at high power levels. The valve is influenced by turbo pressure via an actuator and a lever.

- A Exhaust flow at low turbo pressure is shown here. The valve is closed and the entire exhaust flow is through the turbine rotor.
- B When the turbo pressure reaches a certain level, the valve starts to open. Some of the exhaust gases flow via the valve and by-pass the turbine thus reducing turbine revolutions.
- C When the engine is working hard at low speed, the air that the engine cannot use is recirculated via the ring-shaped chamber.
- D At high engine speed and high turbo pressure, the entire inlet area is used, which provides more air to the engine. The turbo has thus a broader working range and engine torque is improved.

## Crankcase venting

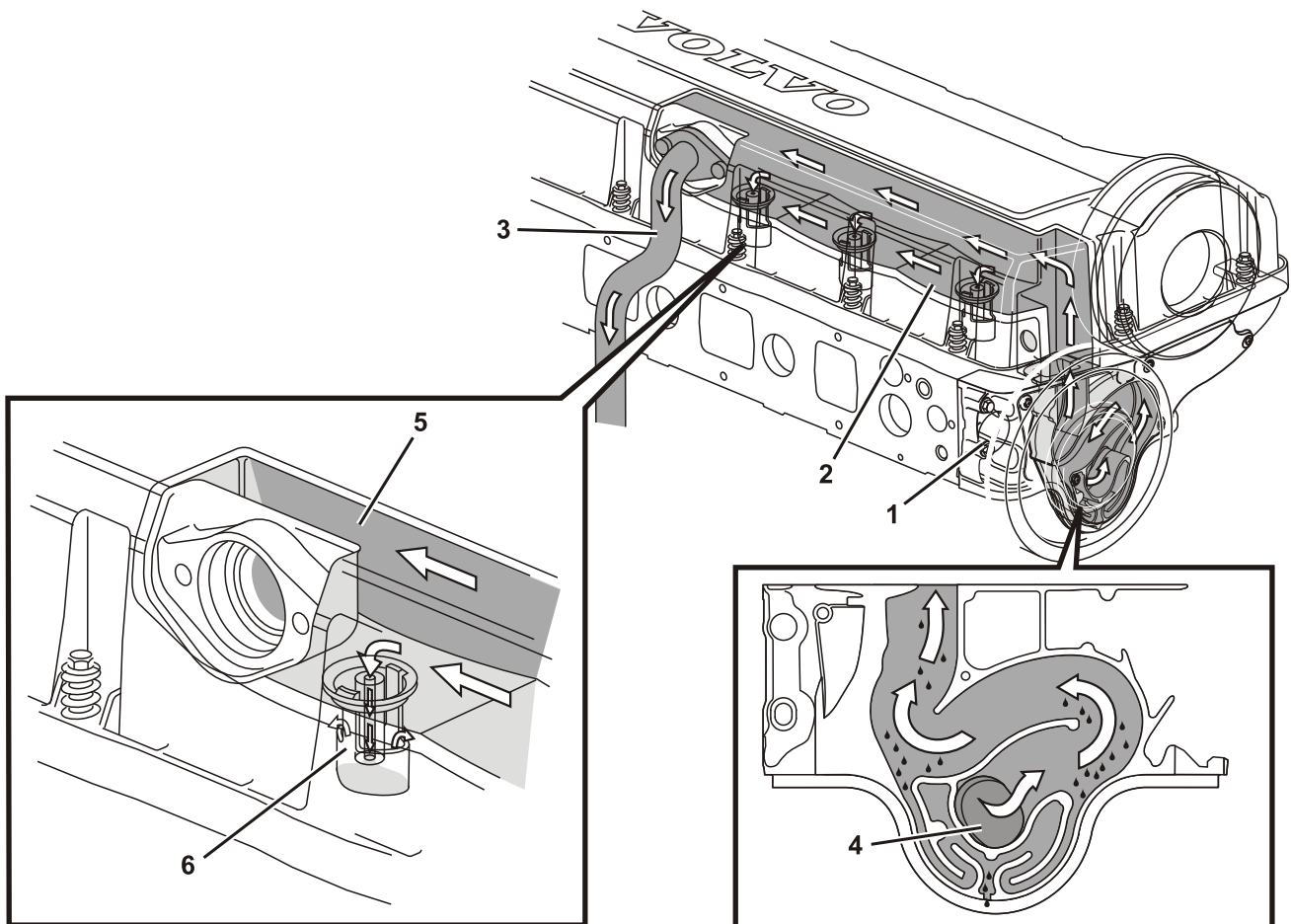
### General

Because some of the products of combustion find their way past pistons and piston rings ("blow by") down to the crankcase, the latter must be ventilated.

The engine can be delivered with one of two types of crank case ventilation:

- Open crankcase ventilation
- Closed crankcase ventilation

### Open crankcase ventilation



P0006037

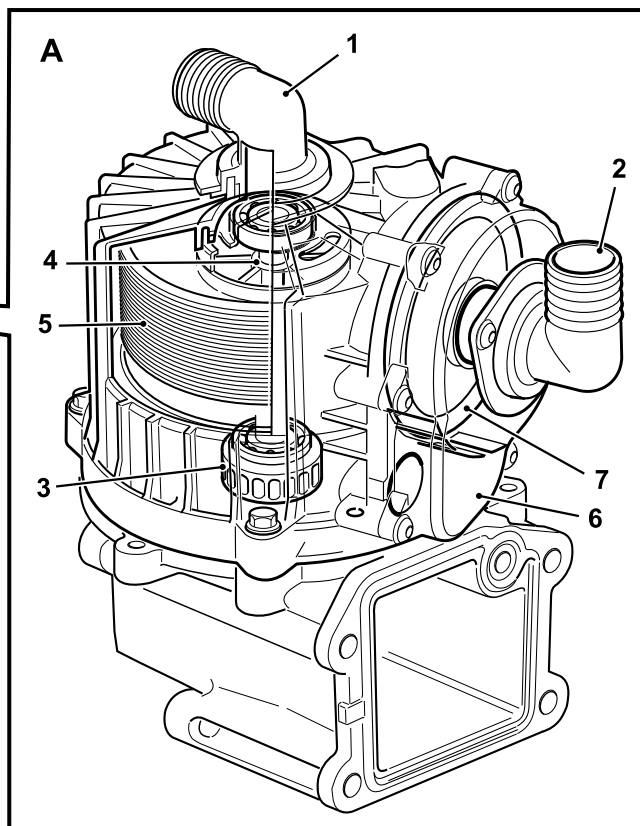
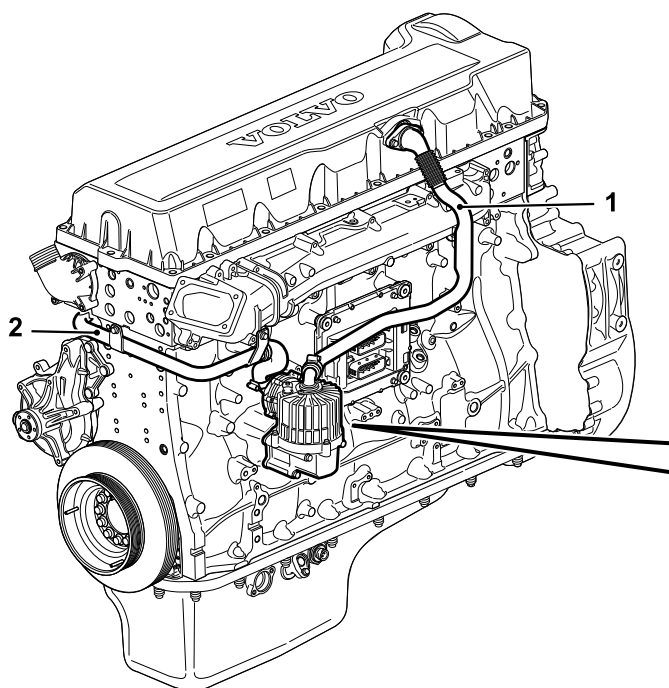
The engine is equipped with two oil traps, one located in the upper timing gear cover (1), and the other in the valve cover (2) and an external pipe (3) to lead away crankcase gasses.

There is an oil trap in the timing gear cover designed as a labyrinth with a connection (4) to the crankcase in front of the center of the intermediate gear.

Intermediate gear rotation creates a relatively oil-free area.

There is an oil trap on the inside of the valve cover – a cast channel (5) with three drains (6) for the separated oil.

## Closed crankcase ventilation



P0006038

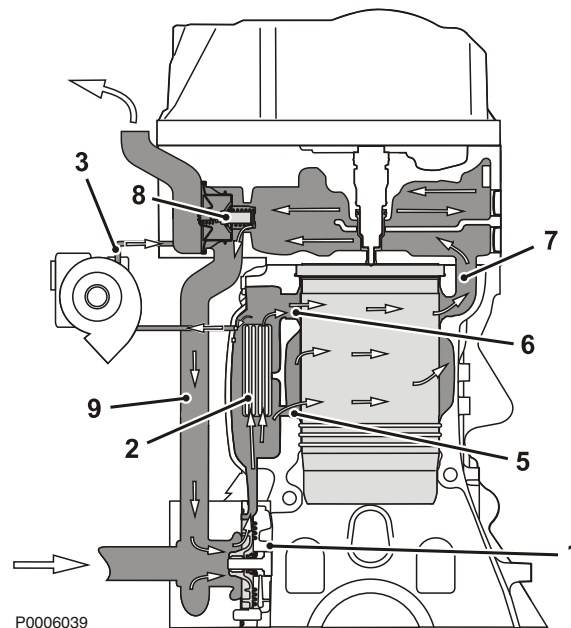
The main component in the new closed crankcase ventilation comprises a separator (**A**) directly attached to the engine block left side. The separator is driven by a turbine(**3**), which is in turn driven by oil from the engine lubrication system via a channel. The turbine is connected to a drive shaft (**4**) with a number of discs (**5**) rotating at approximately 8,000 rpm when the engine is running normally. There is a pressure regulator (**6**) and membrane (**7**) on the side of the separator that shuts off the flow to the separator if too great a pressure drop occurs.

After having passed the oil traps in the upper timing gear cover and valve cover (refer to Open crankcase ventilation), the crankcase gasses are led to the inlet in the top of the separator via a hose connection (**1**) and enter the separator from above directly over the center of the rotating discs. The oil and heavier particles are thrown out to the periphery by centrifugal force and can be led back to the oil sump together with the oil driving the turbine.

The cleaned gases are led to the turbocharger inlet side via a connection (**2**).

## Group 26: Cooling System

### General



Coolant is pumped from the coolant pump (1) up through the oil cooler (2), which is bolted to the coolant cover (oil cooler cover).

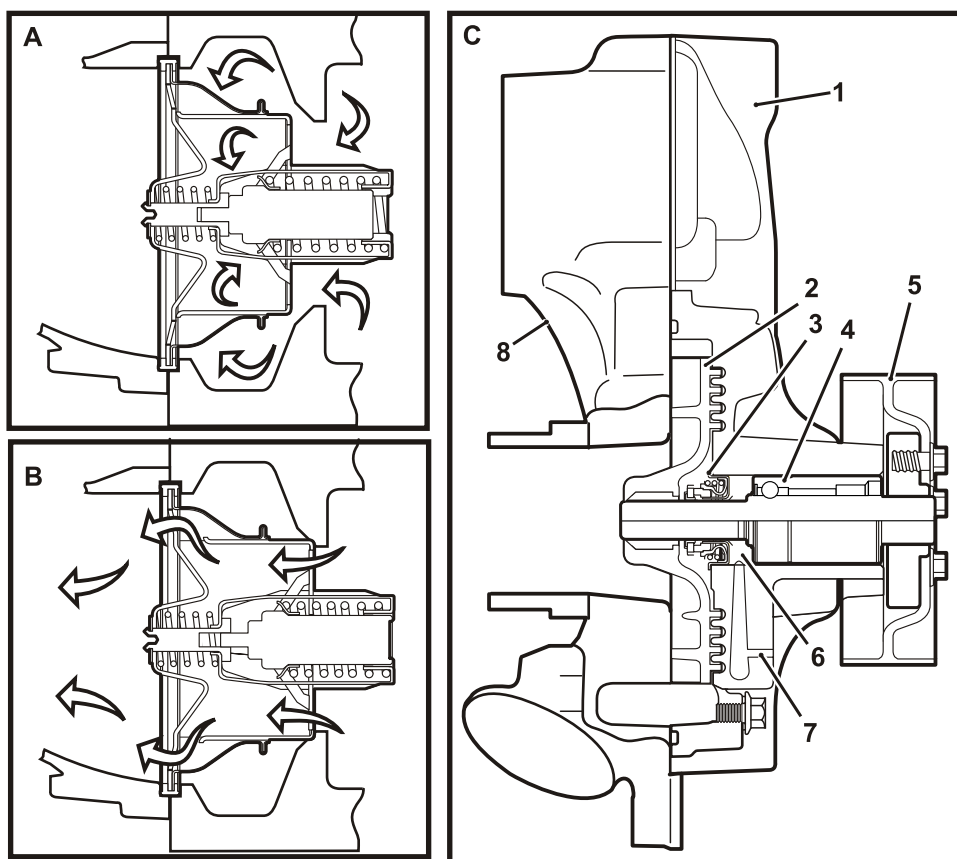
Some of the coolant is then forced to the turbocharger (3).

Another quantity of coolant is forced to the cylinder liner lower cooling jackets via the holes (5), while the largest part of the coolant is forced through the holes (6) to the upper liner cooling jackets. From there the coolant flows to the cylinder head via the channels (7).

The cylinder head has a horizontal intermediate baffle that forces coolant past the hottest parts for effective heat removal.

The coolant then passes through the thermostat (8) which sends coolant via the cooler or via the pipe (9) back to the coolant pump. The route the coolant takes depends on coolant temperature.

## Coolant pump and thermostat

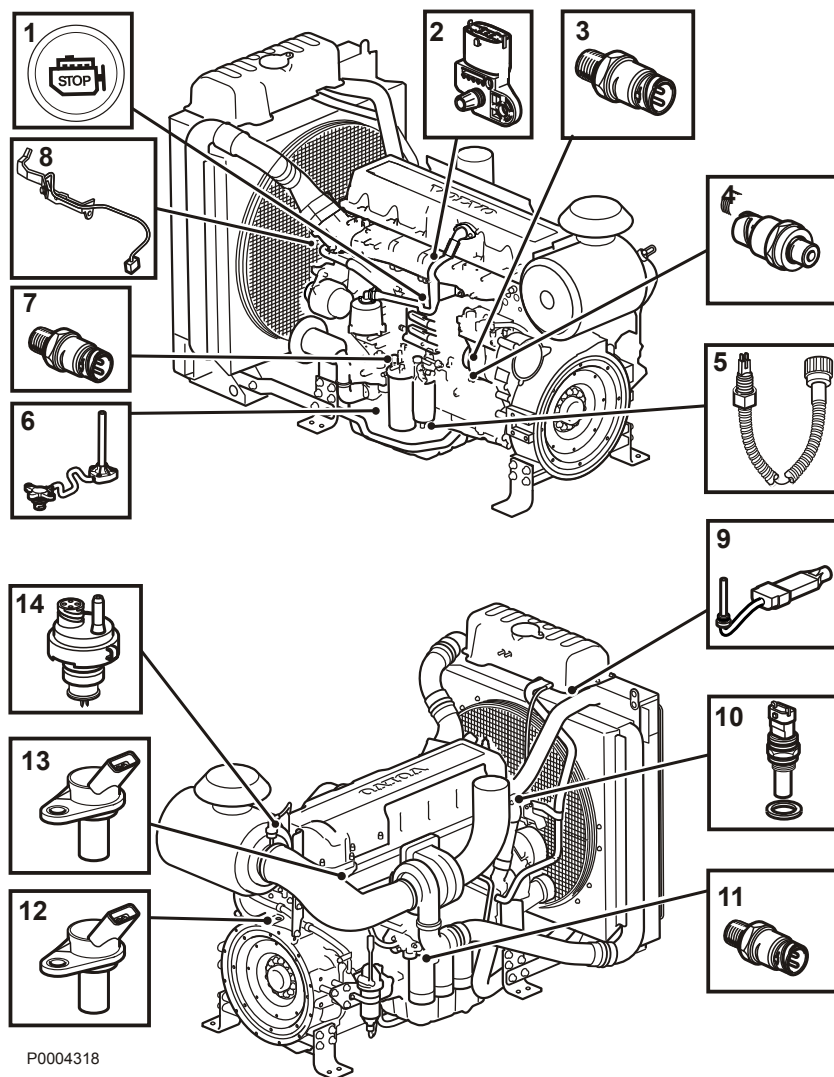


P0006040

The coolant circulation thermostat is of piston type and has a temperature sensitive wax body that controls opening and closing. The thermostat begins to open when coolant reaches 82 °C (179.6 °F).

- A Thermostat in closed position (cold engine).
- B Thermostat in open position (hot engine).
- C the coolant pump cover (1) is made of aluminum. There are channels in the rear section (8) of the pump for coolant distribution, and the cover contains a plastic impeller (2), shaft seal (3), bearing (4) and belt pulley (5). The shaft bearing is a permanently lubricated combined roller bearing. Between the shaft seal and the bearing there is a ventilated space (6) that discharges behind the belt pulley (7). The pump rear section (8) is bolted to the cylinder block.

## Engine control system



The engine fuel system is electronically controlled as regards injected amounts and injection timing. The system is called EMS (Engine Management System). Here follows a short description of the parts of the system included in the engine.

The central part of the system is the engine control unit (ECU) located on the left side of the engine and installed with vibration dampening rubber elements. The control unit requires continuous information from the throttle and a number of sensors on the engine in order to control the amount of fuel and injection timing. Harness connectors for engine sensors have DIN standard connectors.

In the control unit there are sensors for atmospheric pressure and temperature; the other sensors are:

- 1 Auxiliary stop
- 2 Charge air pressure and temperature sensor
- 3 Oil pressure sensor
- 4 Crankcase pressure sensor
- 5 Water separator level sensor
- 6 Oil level and oil temperature sensor
- 7 Fuel pressure sensor
- 8 Air pressure drop and air temperature
- 9 Coolant level sensor
- 10 Coolant temperature sensor
- 11 Piston cooling oil pressure
- 12 Flywheel position and speed
- 13 Camshaft position sensor

## Troubleshooting

A number of symptoms and possible causes of engine malfunctions are described in the table below. Always contact your Volvo Penta dealer if any problems occur which you can not solve by yourself.

### IMPORTANT!

Read through the safety advice for care and maintenance work in the chapter *Safety precautions for boat operation* before you start work.

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### Symptoms and possible causes

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✱ The diagnosis button lamp flashes  
Please refer to *Diagnostic Function*

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Engine can not be stopped  
2, 5

---

Starter motor does not rotate  
1, 2, 3, 4, 5, 6, 7, 24

---

Starter motor rotates slowly  
1, 2

---

Starter motor rotates normally but engine does not start  
8, 9, 10, 11,

---

Engine starts but stops again  
8, 9, 10, 11, 13

---

Engine does not reach correct operating speed at full throttle  
9, 10, 11, 12, 13, 21, 25, 26

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Engine runs roughly  
10, 11

---

High fuel consumption  
12, 13, 15, 25

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Black exhaust smoke  
12, 13

---

Blue or white exhaust smoke  
15, 22

---

Too low lubrication oil pressure  
16

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Excessive coolant temperature  
17, 18, 19, 20, 28

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Too low coolant temperature  
20

---

No, or poor charge  
2, 23

---

Too high exhaust temperature (only TWD1643GE)  
13, 17, 18, 19, 21, 25, 27, 28, 29, 30

---



**Reason code**

- 1 Discharged batteries
- 2 Poor contact/open circuit in electrical wiring
- 3 Main switch turned off
- 4 Main fuse faulty
- 5 Faulty ignition lock
- 6 Faulty main relay
- 7 Faulty starter motor/-solenoid
- 8 No fuel:
  - fuel cocks closed
  - fuel tank empty/wrong tank connected
- 9 Blocked fuel fine-filter/pre-filter (due to contaminations, or stratification in the fuel at low temperature)
- 10 Air in the fuel system
- 11 Water/contamination in fuel
- 12 Faulty unit injectors
- 13 In sufficient air supply to the engine:
  - blocked air filter
  - air leakage between the turbo and the engine's intake manifold
  - dirty compressor part in the turbocharger
  - faulty turbo compressor
  - poor engine room ventilation
- 14 Coolant temperature too high
- 15 Coolant temperature too low
- 16 Oil level too low
- 17 Coolant level too low
- 18 Air in the coolant system
- 19 Faulty circulation pump
- 20 Defective thermostat
- 21 Blocked charge air cooler
- 22 Oil level too high
- 23 Alternator drive belt slips
- 24 Water entry into engine
- 25 High back pressure in the exhaust system
- 26 Break in "Pot+" cable to throttle
- 27 High temperature, charge air cooler
- 28 Blocked radiator
- 29 No pressure in cooling system
- 30 Check wastegate function

## Functional Disturbances

For more detailed information and further fault tracing help, See Operator's Manual, group 30, "MID 128, PID 110, Engine coolant temperature". If there is a malfunction, first check the following items:

- Check that the coolant level is between the markings on the expansion tank (at approx. 20°C) [68 °F]. If the level in the expansion tank is too low, top up and start the engine. If the coolant disappears, there is internal or external leakage.
- Check that the coolant is not contaminated. If the coolant is contaminated, this signifies internal leakage (oil) or that the cooling system has a blockage (deposits). Blockage in the cooling system is caused by one or more of the following factors:
  - 1 The coolant has not been changed at the specified intervals.
  - 2 Incorrect mixture of coolant and water.
  - 3 Contaminated water has been used.

## Clogging

Is often caused by high coolant temperature, internal or external blockage of the cooling system, or a combination of both. If the cooling system is blocked, it must be cleaned.

- **External dirt:** Check that the cooler and/or the charge air cooler are not clogged. If you cannot see light through at least one third, the cooler should be removed and cleaned.  
Check if there is any internal or external leakage in the cooling system.
- **Internal contamination:** Check that the cooler and/or the charge air cooler are not clogged.

## Common Interference Causes

### Suitable actions

---

#### External cleaning:

- 1 Remove guards as necessary, to access the radiator.  
**IMPORTANT!**  
Take care that the radiator lamella are not damaged.  
A high pressure washer may under **no circumstances** be used!
- 2 Clean with water and a mild detergent.  
Use a soft brush.
- 3 Re-install removed parts.

#### Internal cleaning:

- Refer to *Cooling System, Cleaning*.

#### Further checks

- **External and internal leakage in the cooling system:** Check if there is leakage in the system.
- **Coolant circulation:** Check that coolant circulates by letting the engine run at high speed. Also check the expansion tank to see that coolant circulates. This can be an indication of a fault in the cooling system.
- **Thermostat:** Check thermostat function. Drain enough coolant to allow the thermostat to be removed. Check the thermostat; refer to *Thermostat, Function Check* page 293.

## Test and Adjustments

### Compression Test

The fuel system shall be emptied and the rocker bridge removed, see *Draining, Fuel Duct in Cylinder Head* page 246.

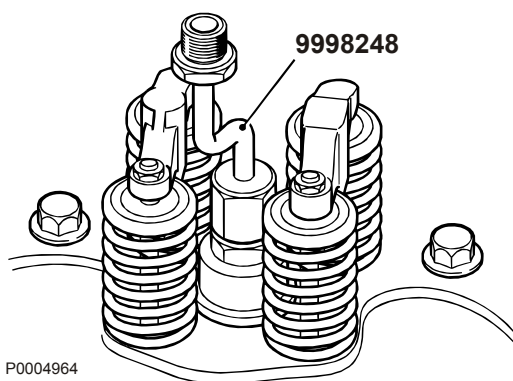
Tools:

9988539 Compression meter

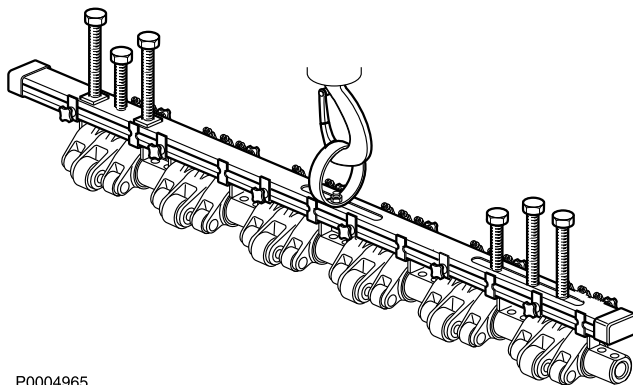
9990185 Lifting tool

9998248 Adapter

### Removal



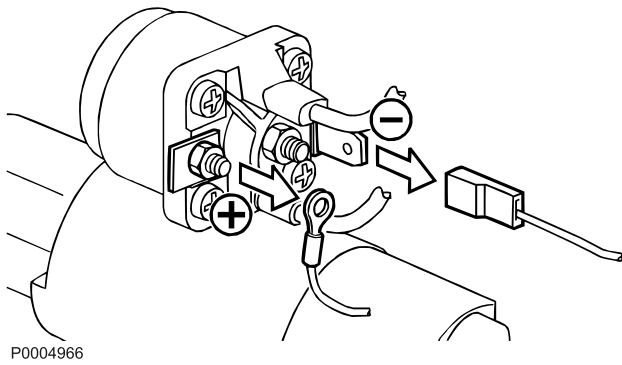
P0004964



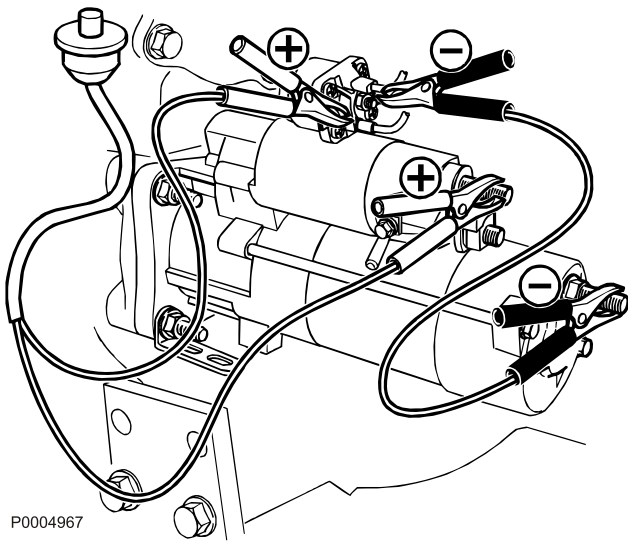
P0004965

- 1 **IMPORTANT!**  
Make sure that the area around the unit injectors is clean before they are removed.  
Remove the unit injectors, see *Unit Injector, Replace* page 255 and mount the unit injector protection (9998249). Clean the copper sleeves as needed with cleaning kit 9998599.
- 2 Fit all<sup>(1)</sup> adapters (6 pcs), tool 9998248 Adapter, to the cylinder head and pull them on with the injector retainers.
- 3 Oil valve caliper, cam shaft ridges and the rocker bridge.
- 4 Fit the rocker bridge with 9990185 Lifting tool.  
Torque the screws evenly along the rocker arm to avoid that the rocker arm bends or warps.  
Make sure that guide pins fit in the camshaft support bearing. Torque the rocker bridge as specified in *Engine, General* page 26. Use torque wrench.
- 5 Install the middle piece and the oil pipe to the rocker bridge.
- 6 Check the valve clearance, see *Valves and Unit Injectors, Adjustment* page 177, for all valves as specified in *Engine, General* page 26.

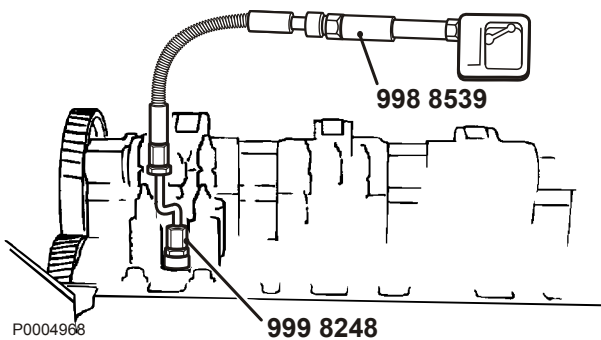
1. This in order to avoid repeating removal/refitting of rocker bridge and unit injector and performing valve adjustment six times.



- 7 Remove both control wires from the starter motor control connector (the two thin cables). Connect one of the two free connectors on the control connector to ground.



- 8 Connect the other connector to a switch, which in turn is connected to the positive (plus) connection on the starter motor.

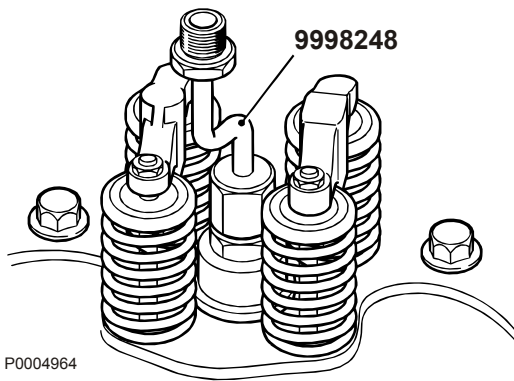


- 9 Connect tool 9988539 Compression meter to 998248 Adapter on the first cylinder.
- 10 **NOTICE!** Do not run the engine for more than 15 seconds at a time with intervals of 60 seconds.

Run the engine with the starter motor until the compression meter needle has stopped (max compression reading).  
Read the value.

Move the compression meter to the next cylinder.  
Repeat the test on all cylinders.

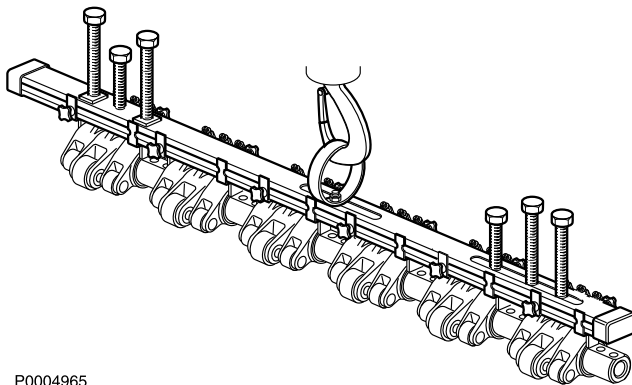
- 11 Remove the middle piece and the oil pipe for the rocker bridge.
- 12 Remove the rocker bridge screws equally in stages so that it is not bent.  
Remove the bolts and carefully lift off the rocker bridge using 9990185 Lifting tool.



P0004964

- 13 Remove all adapters, tool 9998248 Adapter from all cylinders.

## Installation



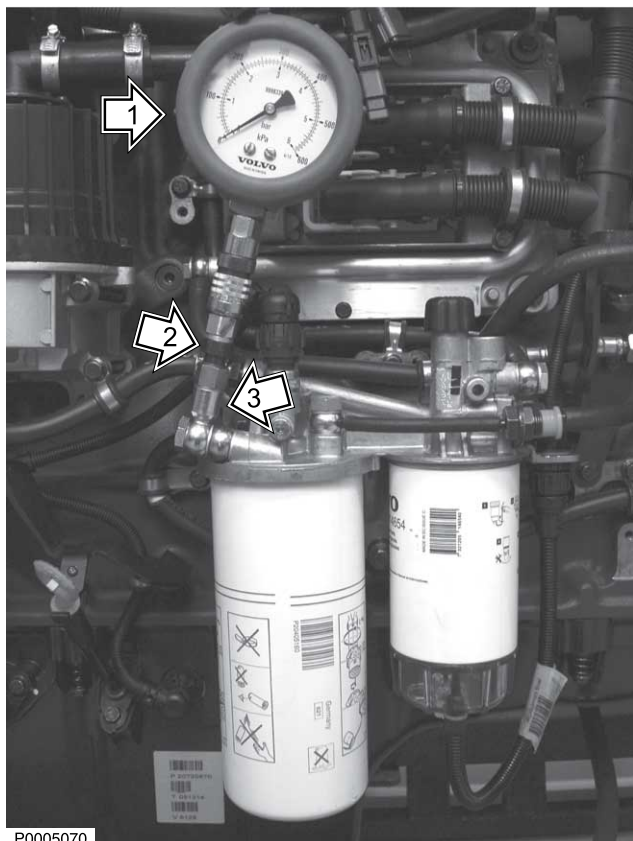
P0004965

- 14 Mount the unit injectors and new o-rings, see the **Installation** section in chapter *Unit Injector, Replace page 255*.
- 15 Fit the rocker bridge with 9990185 Lifting tool. Torque the screws evenly along the rocker arm to avoid that the rocker arm bends or warps. Make sure that guide pins fit in the camshaft support bearing. Torque the rocker bridge as specified in *Engine, General page 26*. Use torque wrench.
- 16 Install the middle piece and the oil pipe to the rocker bridge.
- 17 Adjust valves and unit injectors, see *Valves and Unit Injectors, Adjustment page 177*.
- 18 Check and if needed change the valve cover bearing. Install the valve cover.
- 19 Re-install the fuel lines. Use new sealings.
- 20 Vent the fuel system, see *Fuel system, bleeding page 245*.

## Fuel Feed Pressure, Check

Tools:

9990124 Nipple  
9996666 Nipple  
9998339 Manometer



P0005070

- 1 Install tool:
  - 1 9998339 Manometer
  - 2 9996666 Nipple
  - 3 9990124 Nipple
- 2 Check that the fuel feed pressure is according to specifications: Refer to *Engine, General* page 26.
- 3 Remove the tool.  
Install new fuel line seals.

## Cooling System, Pressure Testing

### Alternative 1

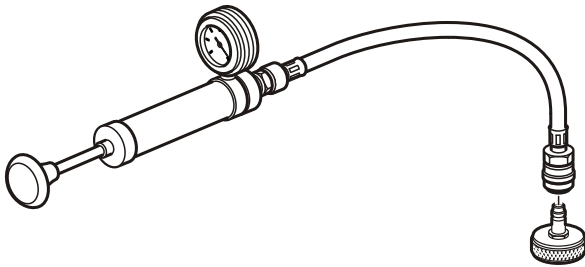
#### **WARNING!**

Do not open the coolant filler cap when the engine is warm. Steam or hot fluid could spray out, causing severe burns.

Tools:

3849613 Pressure testing kit

- 1 Check that all hoses and clamps are undamaged and intact.
- 2 Check the coolant level in the expansion tank.
- 3 Replace the filler cap on the expansion tank with a suitable cover from 3849613 Pressure testing kit.



P0010195

- 4 Connect the pump and pump up a pressure of 70 kPa (0.7 bar).
- 5 Pressure must not drop for a **two minute** test period, for the cooling system to be regarded as being free from leakage.
- 6 Release the excess pressure and remove the pressure testing unit.
- 7 Check the coolant level in the expansion tank. Install the regular filler cap.
- 8 Start the engine and check that no leakage occurs.

### Alternative 2

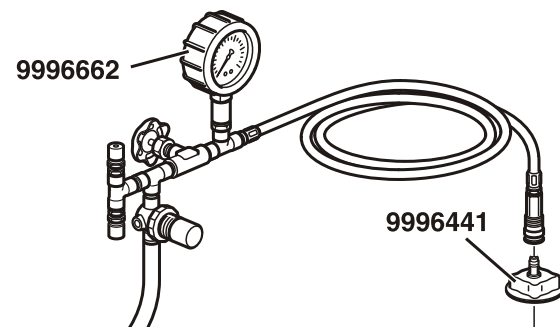
#### **WARNING!**

Do not open the coolant filler cap when the engine is warm. Steam or hot fluid could spray out, causing severe burns.

#### Tools:

9996441 Cover, with connecting nipple

9996662 Pressure testing kit



P0010196

- 1 Check that all hoses and clamps are undamaged and intact.
- 2 Check the coolant level in the expansion tank.
- 3 Replace the filler cap with 9996441 Cover, with connecting nipple. Connect 9996662 Pressure testing kit to the cap. Connect compressed air to the equipment and open the cock. Adjust the pressure to 70 kPa (0.7 bar) with the adjuster knob. Then close the tap.
- 4 Pressure must not drop for a **two minute** test period, for the cooling system to be regarded as being free from leakage.
- 5 Release the excess pressure and remove the pressure testing unit.
- 6 Check the coolant level in the expansion tank. Install the regular filler cap.
- 7 Start the engine and check that no leakage occurs.

### Alternative 3

#### **WARNING!**

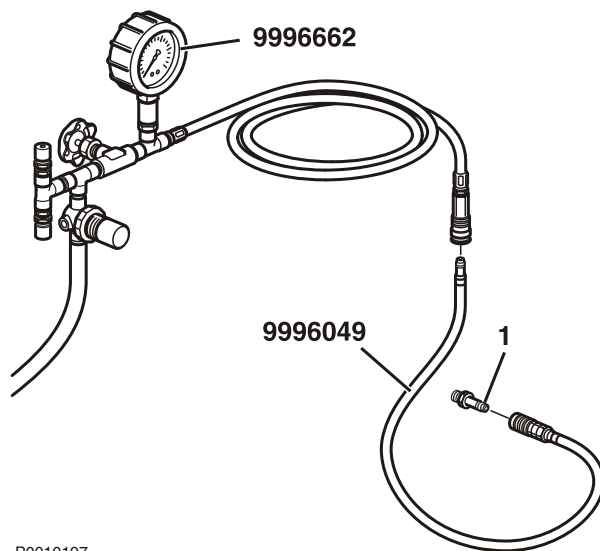
Do not open the coolant filler cap when the engine is warm. Steam or hot fluid could spray out, causing severe burns.

#### Tools:

9996662 Pressure testing kit

9996049 Draining hose

- 1 Check that all hoses and clamps are undamaged and intact.



P0010197

- 2 Check the coolant level in the expansion tank.
- 3 Connect 9996662 Pressure testing kit to 9996049 Draining hose and close the cock. Connect the hose to the engine drain valve (1). Open the cock and adjust the pressure to 70 kPa (0.7 bar) with the adjuster knob. Then close the tap.
- 4 Pressure must not drop for a **two minute** test period, for the cooling system to be regarded as being free from leakage.
- 5 Open the cock and increase the pressure until the filler cap opens (must correspond to opening pressure according to *Technical Data page 44*). Reduce the pressure to 50 kPa (0.5 bar) and then increase to 70 kPa (0.7 bar) and check that pressure is maintained.
- 6 Remove the compressed air connection. Open the control valve so that the pressure drops and shut the cock when coolant runs into the drain hose.  
Remove the drain hose from the engine. Then remove the drain hose from the test equipment and empty the coolant from the hose.  
Re-install the rubber plug in the engine drain valve.
- 7 Check the coolant level in the expansion tank.
- 8 Start the engine and check that no leakage occurs.

## Charge Pressure, Troubleshooting

### Charge Air Pressure, Check

Tools:

9998339 Manometer

9998493 Hose

9996666 Nipple

- 1 Connect the nipple with hose and pressure gauge to the measuring point on the inlet manifold; refer to *Engine Placement*.
- 2 Compare this pressure with the pressure that can be read with the VODIA tool; refer to "Workshop manual, EMS 2".  
If the two measurements show different values, the pressure sensor is faulty and must be changed.

### Exhaust system, inspection

- 1 Check that the exhaust system is a Volvo Penta original part.
- 2 Check whether the exhaust system has been modified, or has bends or damage that prevent exhaust gas from flowing out.  
If the exhaust system is not a Volvo Penta original part, or has been modified, has bends or damage,



the exhaust back pressure may be too high, which will reduce engine power.

### Charge air cooler, checking

- 1 Check the charge air cooler for damage to the cells and connections.  
If there is any damage, change the charge air cooler.
- 2 Check the charge air cooler and radiator for inner clogging.  
If there is any clogging, clean in accordance with *Charge Air Cooler, External Cleaning*.

### Inlet manifold, inspection

- 1 Check that the inlet pipes are clean inside, and undamaged. Crushed, damaged or dirty inlet pipes can reduce the charge pressure.

### Charge air pipes, checking

- 1 Inspect the charge air pipes for visible cracks and external damage.
- 2 Check that there is no oil in the charge air pipes. If the pipes are damaged or the union seal rings leak, the charge pressure will be too low and engine performance will be affected.  
If the pipes are contaminated with oil on the inside, this indicates oil leakage in the turbo-charger turbine shaft seal. In this case, the turbocharger should be changed as a unit.

#### **IMPORTANT!**

If there is oil in charge air pipes and charge air hoses, the charge air cooler and all pipes and hoses in the charge air system must be very thoroughly cleaned inside, before the engine is started.

### Charge Air Cooler, External Cleaning

Remove guards as necessary, to access the cooler. Clean with water and a mild detergent. Use a soft brush. Be careful not to damage the radiator matrix. Re-install the components.

#### **IMPORTANT!**

Do not use a high pressure power washer.

### Charge Air Pipe, Leakage Check

- 1 Inspect the charge air pipes for visible cracks and external damage.
- 2 Check that there is no oil in the charge air pipes. If the pipes are damaged or the union seal rings leak, the charge pressure will be too low and engine performance will be affected. If the pipes are contaminated with oil on the inside, this indi-

cates oil leakage in the turbocharger turbine shaft seal. In this case, the turbocharger should be changed as a unit.

**NOTICE!** If there is any oil in the charge air pipes and charge air hoses, the charge air cooler and all pipes and hoses in the charge air system must be cleaned very carefully before the engine is started.

## **Turbocharger, Inspection**

- 1 Check that the turbocharger part number is correct for the engine variant. The wrong turbocharger for the engine variant might not provide enough charge pressure, which would reduce engine power.
- 2 Check that the turbocharger has the correct compressor housing. If the wrong compressor housing is installed on the turbocharger, the compressor wheel might have been damaged or have too much clearance between wheel and housing. In both cases, charge air pressure will be too low.
- 3 Remove the inlet manifold from the turbocharger.
- 4 Check the turbocharger for damage to the compressor wheel and excessive end float on the turbine shaft.
- 5 If there is any damage on the compressor wheel or excessive end float on the turbine shaft, the turbocharger must be changed as a unit.
- 6 Remove the exhaust pipe (muffler) from the turbocharger and check the turbine disc.
- 7 Check the turbine wheel for damage. If the turbine wheel is damaged, the turbocharger must be changed as a unit.

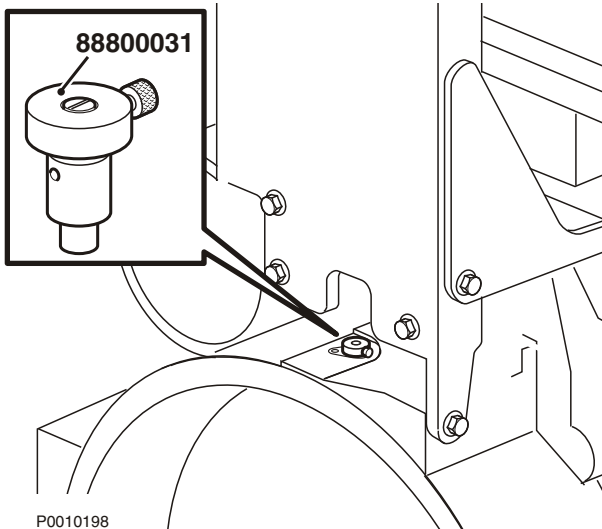
## Sensors, Adjustment

### Sensor removed.

#### Tools:

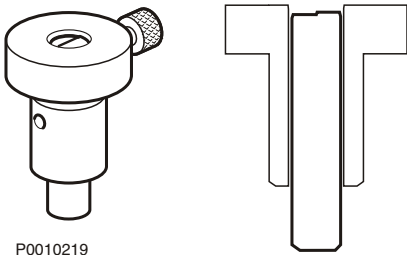
88800031 Measuring tool

- 1 If the camshaft sensor needs to be adjusted, rotate the crankshaft so that one tooth on the camshaft vibration damper is centered in front of the sensor hole.
- 2 Remove any shims beneath the sensor. Clean the tool's contact surface on the engine.
- 3 Insert 88800031 Measuring tool without tightening the lock screw. Press in the tool firmly so that it is in contact with the cover. Press in the center part of the tool until it contacts the gearwheel and tighten the lock screw. Rove the tool and inspect the center section position in its sleeve.

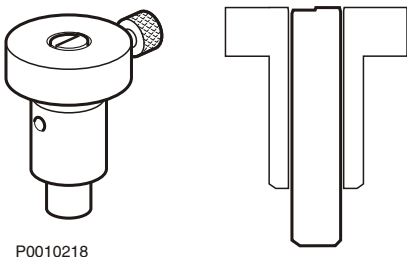


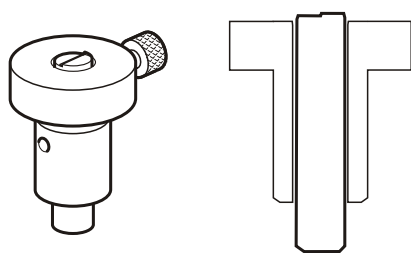
- 4 **Determine further actions according to the following:**

If the center section of the tool is entirely below the sleeve's upper edge, no shims are required.



If only the center section upper surface is above the sleeve's top edge, one shim is required.





P0010220

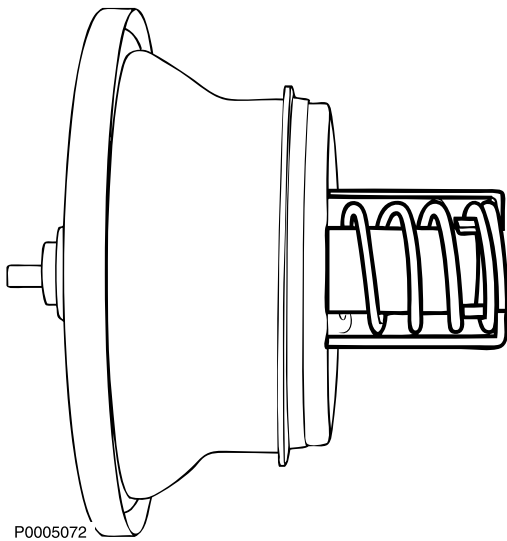
If the two center section surfaces are above the sleeve's top edge, two shims are required.

- 5 Install the sensor with a new seal and any shims.

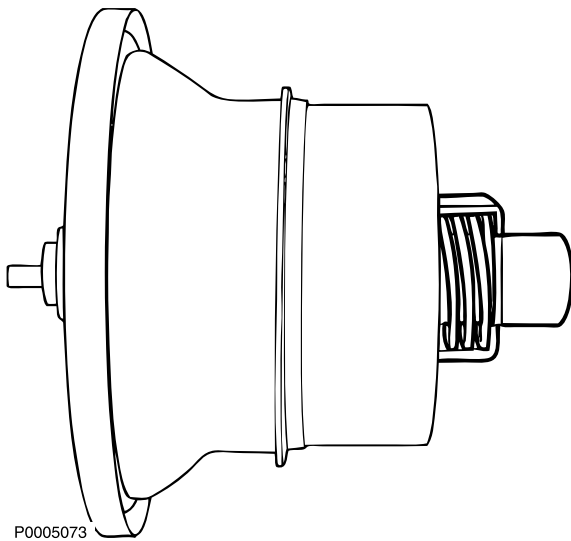
## Thermostat, Function Check

Remove the thermostat, see *Thermostat, Change page 288*.

- 1 Place the thermostat in a big pot with water and heat it to the opening temperature as specified in *Engine, General page 26*.



Closed thermostat.



Open thermostat.

- 2 If the thermostat does not open at specified temperature, it should be replaced.
- 3 Install the thermostat, see *Thermostat, Change page 288*.

**NOTICE!** Always use a new seal, even if the thermostat is not replaced.

## 21-0 Engine Complete, General

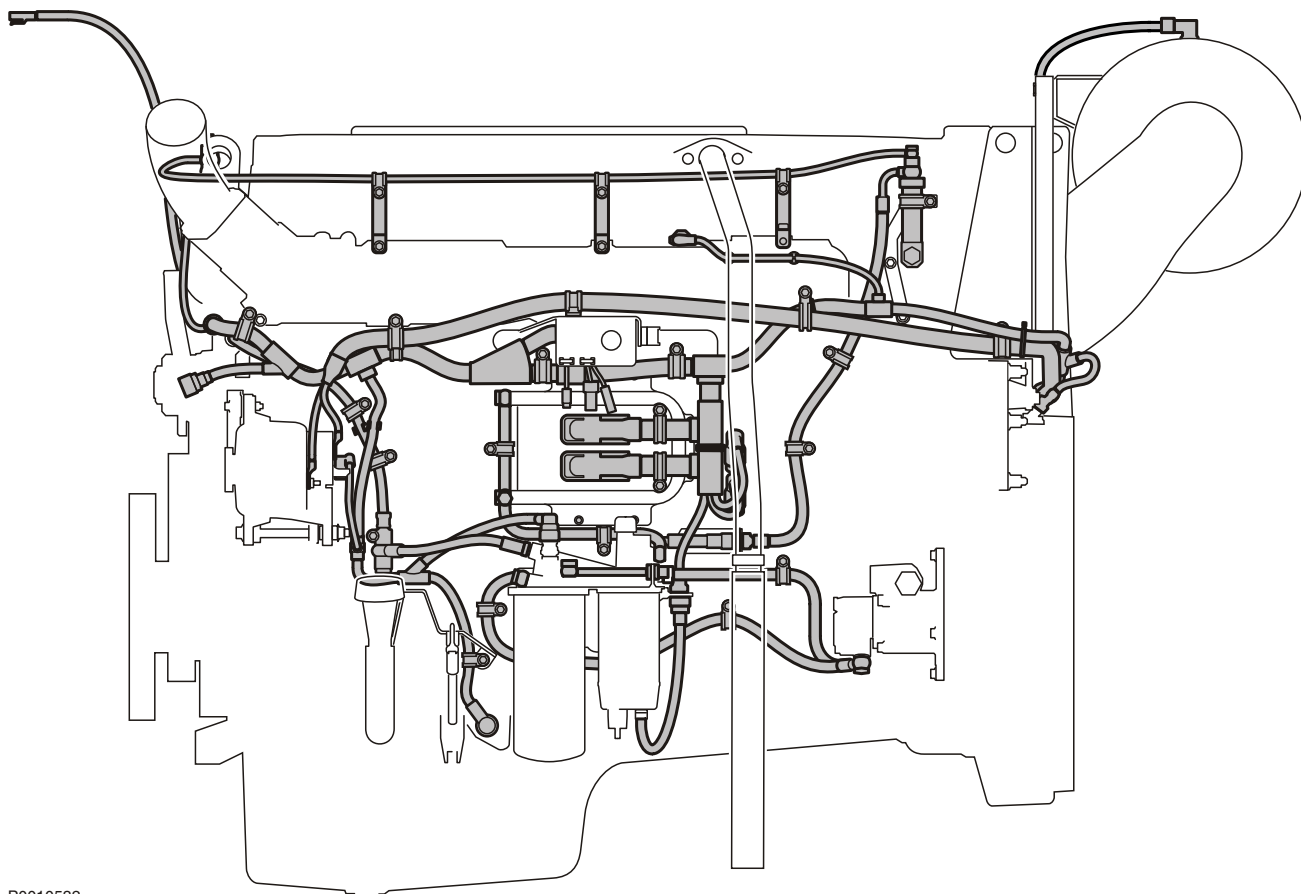
### Exposing the Engine

#### Cable description

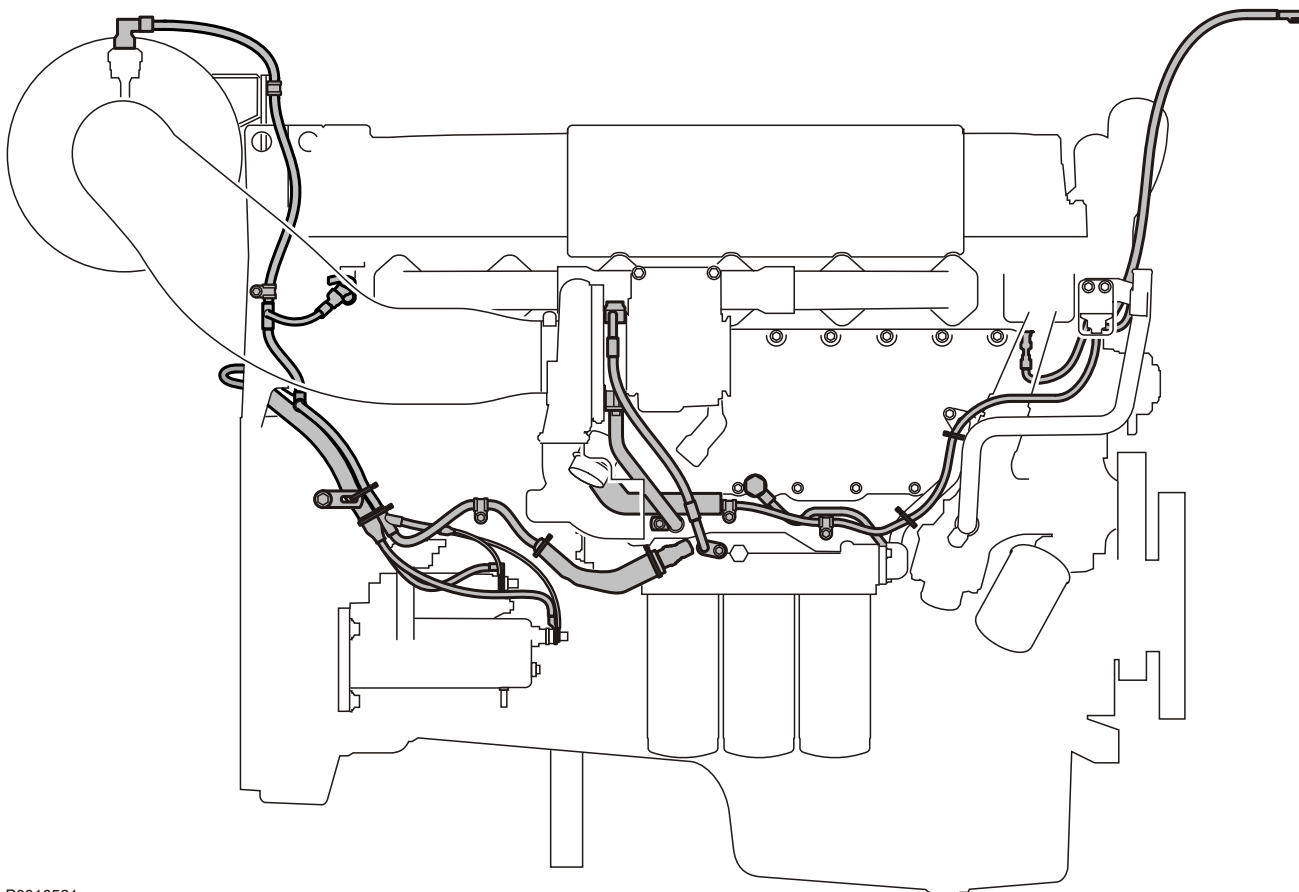
The illustrations show how wire harnesses and hoses are positioned on the engine.

#### **IMPORTANT!**

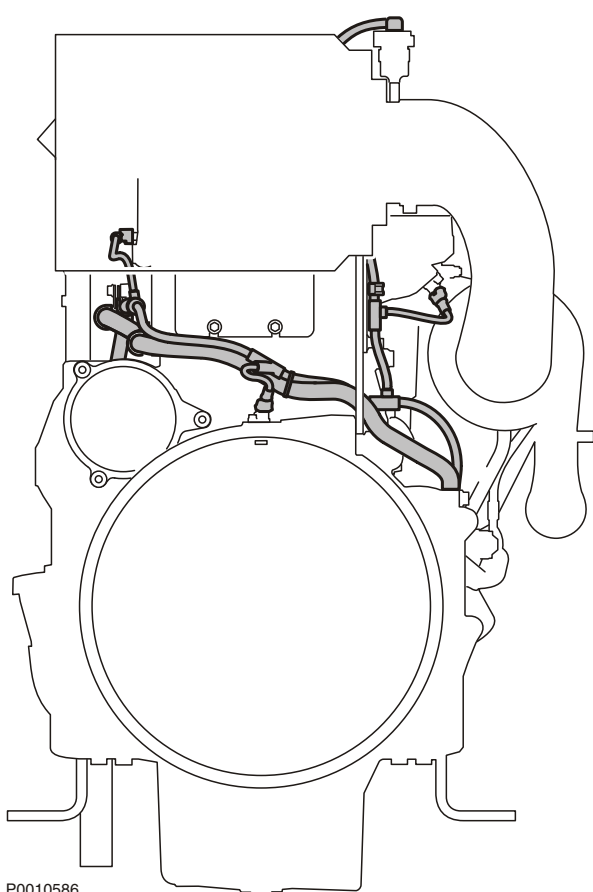
When work on the engine is finished, wire harnesses and hoses that were removed must be reinstalled exactly as illustrated. Incorrect installation will result in vibration damage.



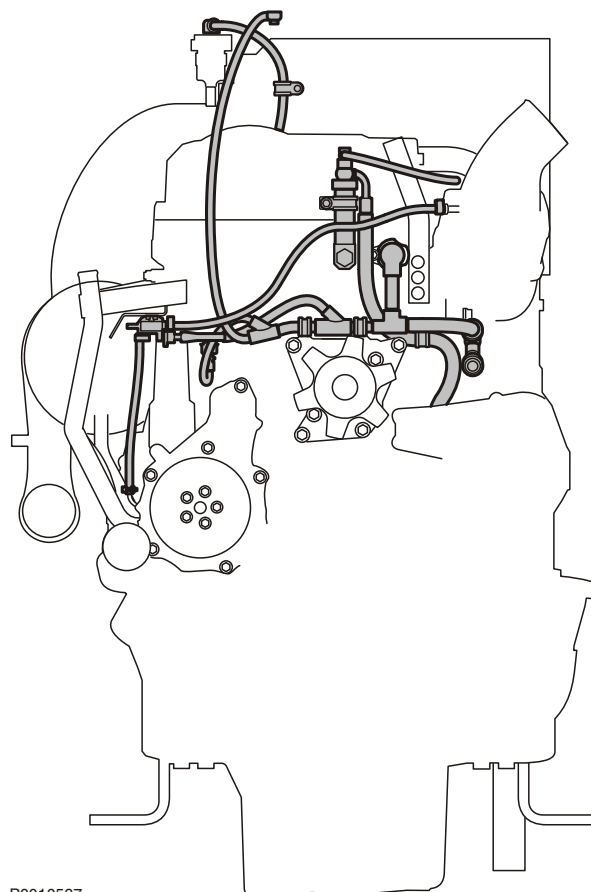
P0010532



P0010531



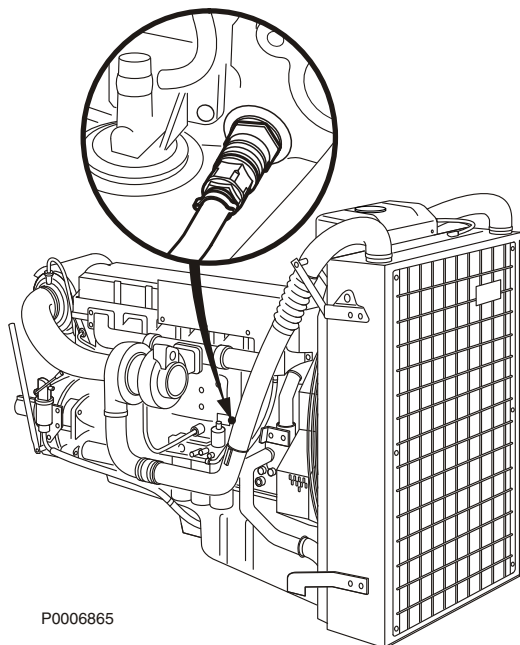
P0010586



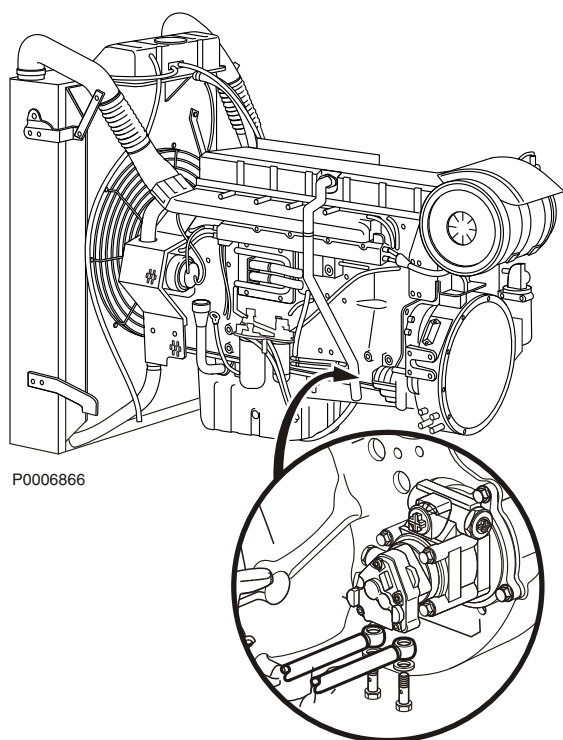
P0010587

## Exposing

- 1 Drain the coolant; refer to *Draining the Cooling System* page 278.  
Drain the engine oil.



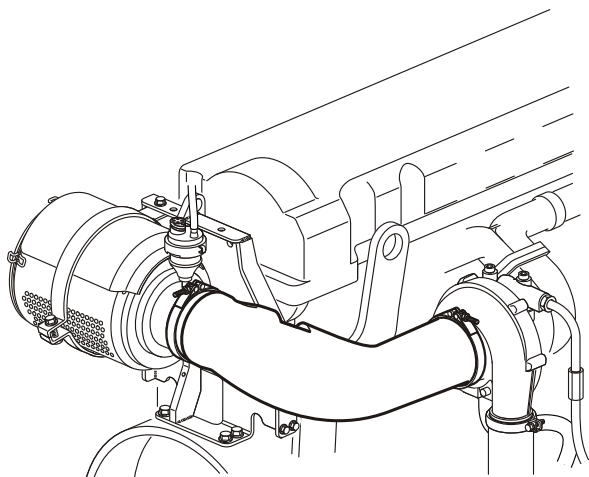
P0006865



P0006866

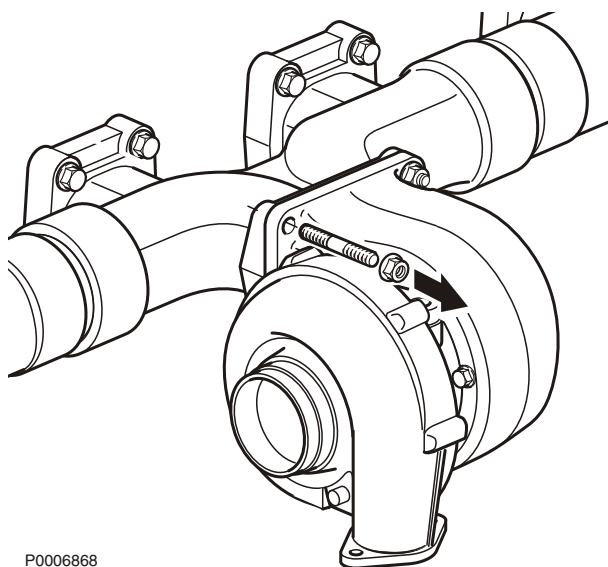
- 2 Remove fuel connections to the fuel pump and allow the fuel to run out into a suitable container. Also loosen the upper connection on the cooling coil and water drain.
- 3 Remove the hoses from the radiator and the expansion tank.
- 4 Remove the heat shield above the turbo, if fitted.





P0006867

- 5 Remove the air filter sensor.
- 6 Remove the pipe between the air filter and turbo-charger. Cover all openings.  
Remove the air filter housing and mounting bracket.



P0006868

- 7 Remove muffler and attachments, if fitted.  
Remove the turbo from the exhaust pipe, plus the two the oil pipes.  
Cover the turbo opening.
- 8 Remove the crankcase breather with its bracket and oil separator.
- 9 Remove the pipe between the inlet manifold and the charge air cooler. Cover all openings.
- 10 Remove the safety cover above the alternator, if fitted.
- 11 Remove the radiator fan safety cover/grille and remove the fan, the hub and its brackets to the cylinder head.
- 12 Remove the coolant pipe from the thermostat.
- 13 Remove the belt guard and drive belts.

## Fitting the Fixture

### IMPORTANT!

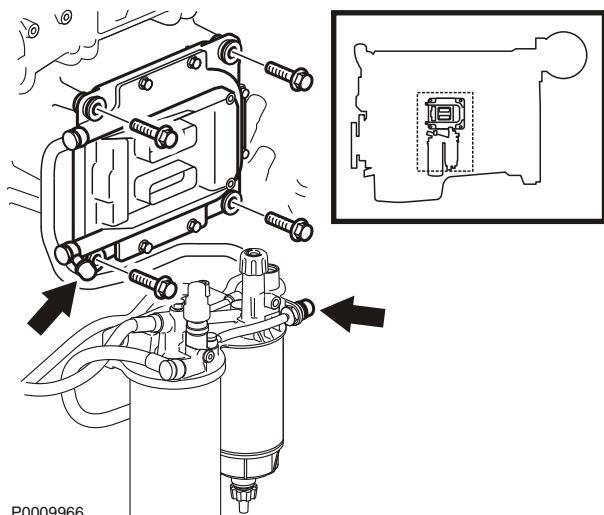
Take great care to keep fuel unions clean. Waste material in the fuel system may cause engine break-down.

#### Tools:

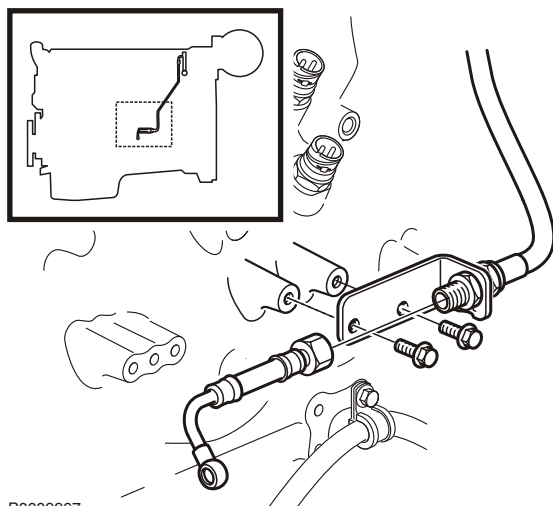
88800117 Plate

88800003 Fixture

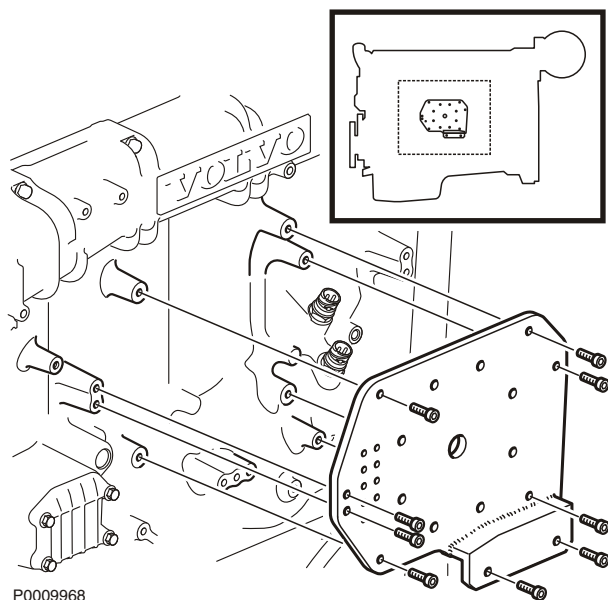
- 1 Remove the engine control unit. Plug all fuel unions.
- 2 Remove the wire harness from the starter motor and sensor (the rear wire harness). Remove the relay and stop button holder. Hang the wire harness in front of the fuel filter bracket.
- 3 Remove the fuel filter bracket; refer to *Fuel Filter Bracket, Change page 248*.
- 4 First remove the fuel hose, and then the engine block attachment.



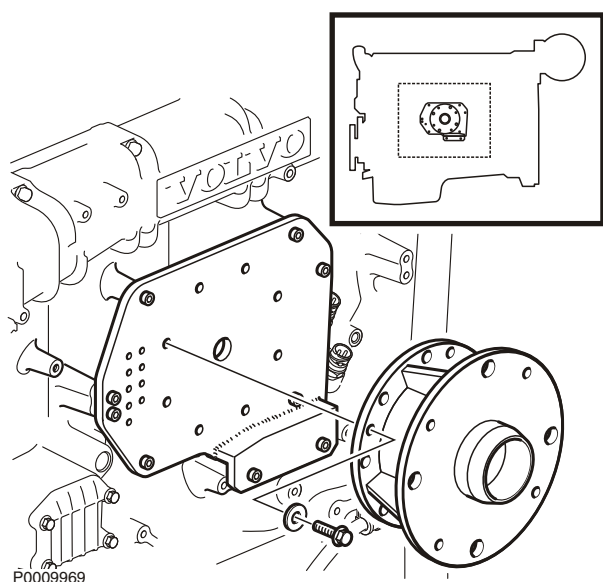
P0009966



P0009967



- 5 Install 88800117 Plate and fasten it with the bolts supplied.



- 6 Fix 88800003 Fixture to the plate and tighten it. Hoist the engine and attach it to the engine stand.

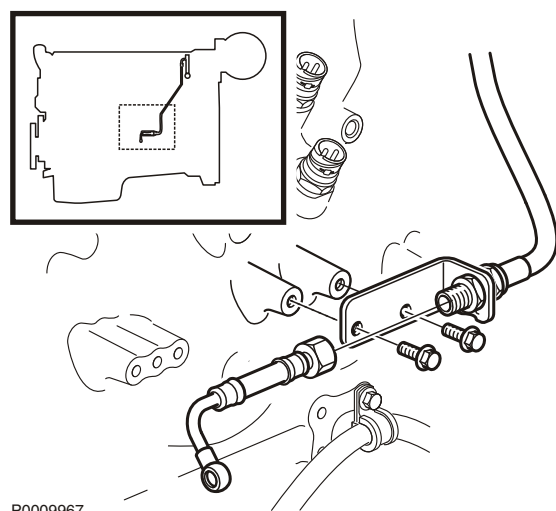
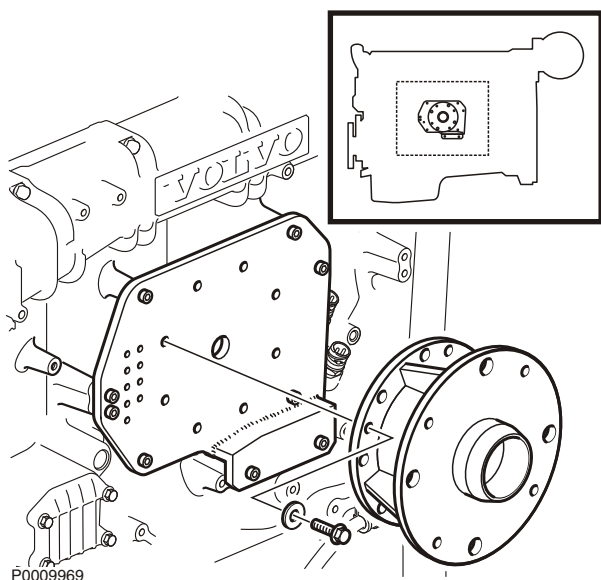
## Engine Fixture, Removal

Tools:

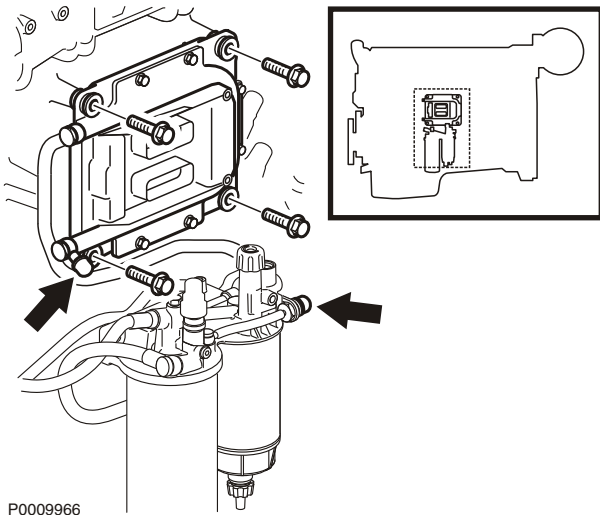
88800117 Plate

88800003 Fixture

- 1 Lower the engine from the engine stand. Remove the fixture and plate from the engine. Install the bolts in their intended locations on the plate.



- 2 Install and fasten the fuel hose attachment to the engine. Install the fuel hose.
- 3 Install the fuel filter bracket: Refer to *Fuel Filter Bracket, Change page 248*.
- 4 Install the engine control unit and connect the fuel lines with new seals.



- 5 Install the relay and stop button holder. Retrieve the wire harness and connect it to the sensor and starter motor. Secure the wire harness with clamps.
- 6 Vent the fuel system; refer to *Fuel system, bleeding* page 245.

## Engine Disassembly

### Timing Gear, Removal

Cylinder head removed; refer to *Cylinder Head, Removal* page 153.

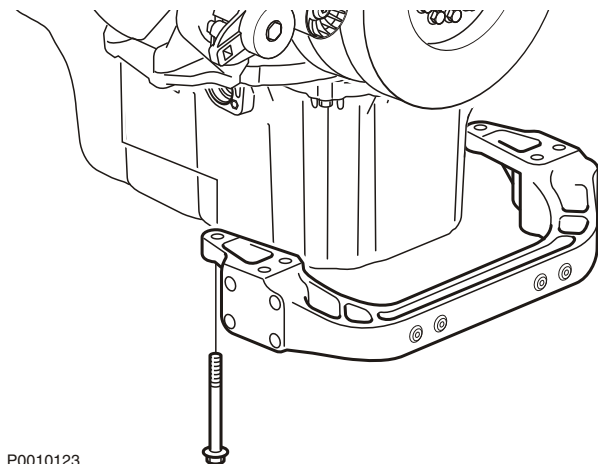
Tools:

9993590 Rotation tool

9998511 Lever

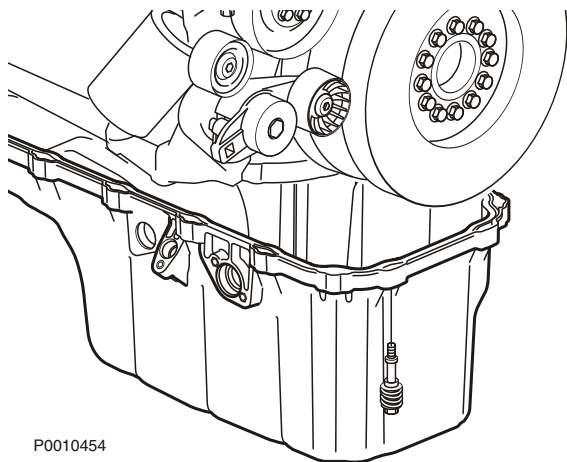
9998267 Guide sleeve

- 1 Remove the front engine mount.



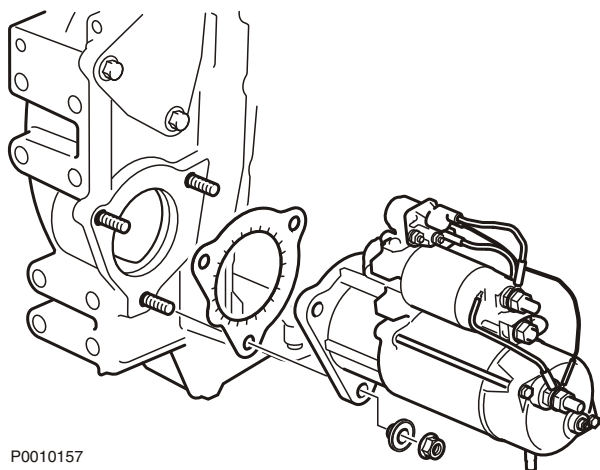
P0010123

- 2 Remove the oil sump bolts and remove the sump.



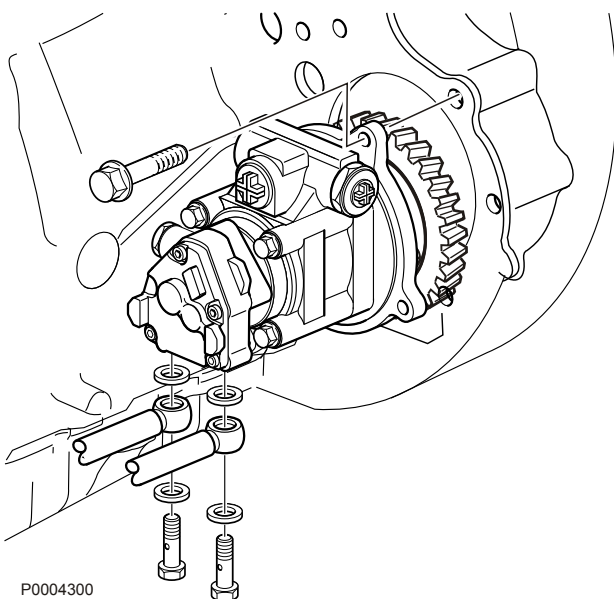
P0010454

- 3 Remove the starter motor.



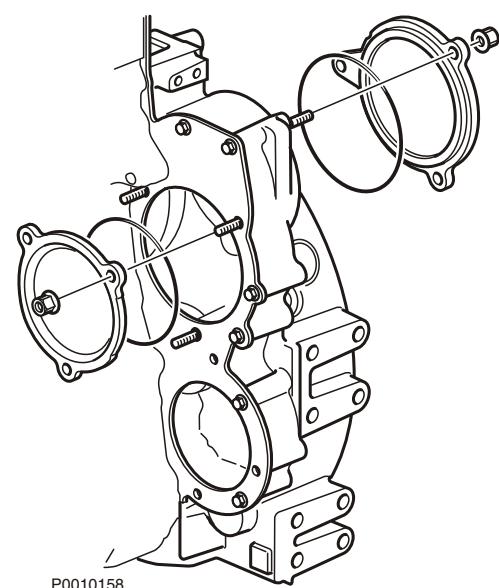
P0010157

- 4 Remove the fuel pump with drive unit; refer to *Fuel Feed Pump, Change page 252*.

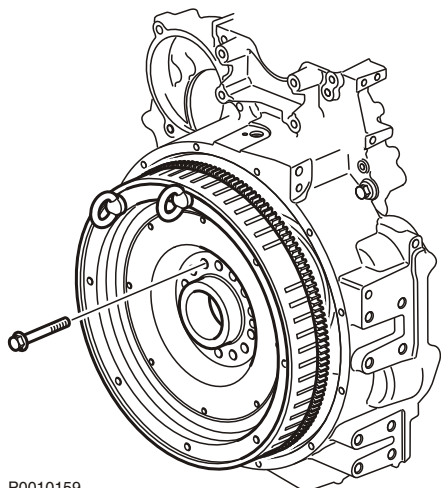


P0004300

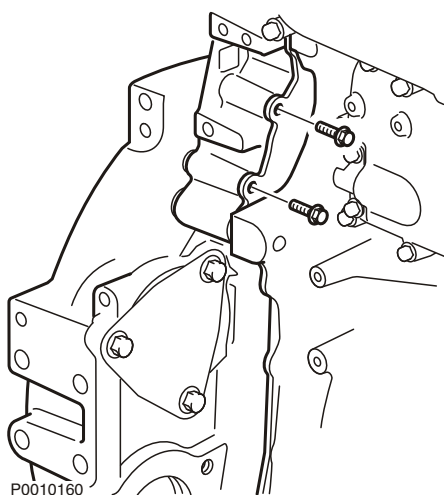
- 5 Remove the two timing gear cover caps. Remove the flywheel sensor.



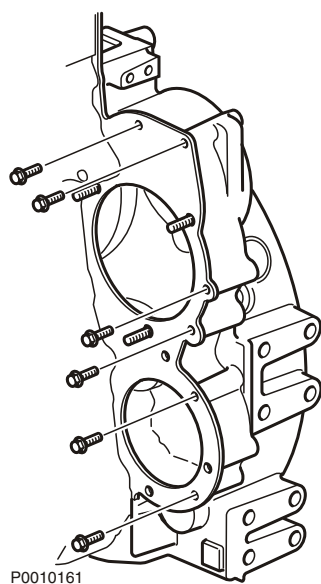
P0010158



- 6 Rotate the flywheel to the zero mark. Check that the crankshaft marking is at TDC. Remove the flywheel bolts. Use 9993590 Rotation tool as a counterhold while undoing the bolts. Hoist the flywheel using suitable lifting eyes.

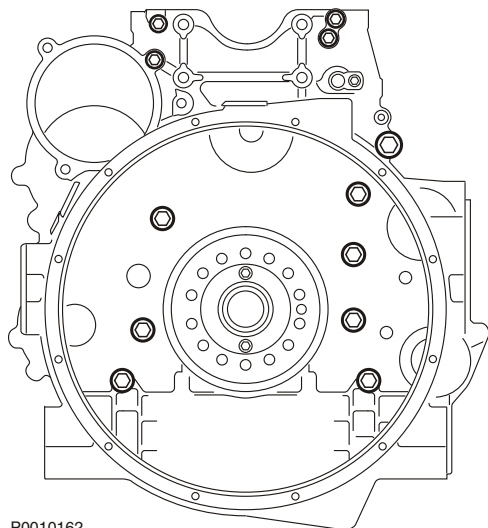


- 7 Remove the lower timing gear cover bolts on the starter motor side (2 pcs.).



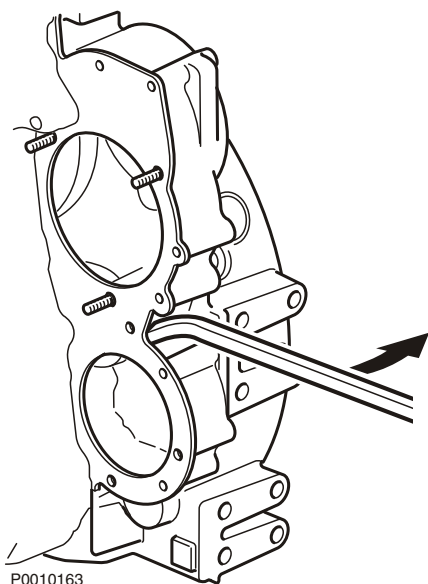
- 8 Remove the bolts on the fuel pump side (6 pcs.).





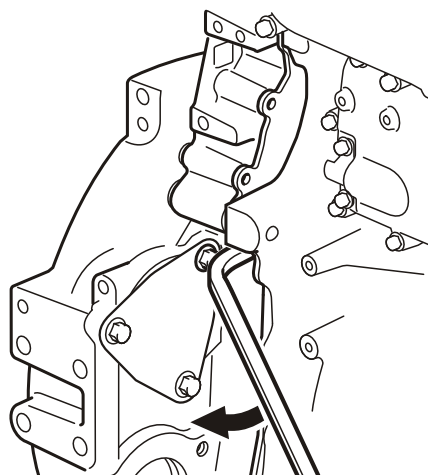
P0010162

- 9 Remove the remaining timing gear cover bolts. Install lifting eyes and connect the lifting tool.



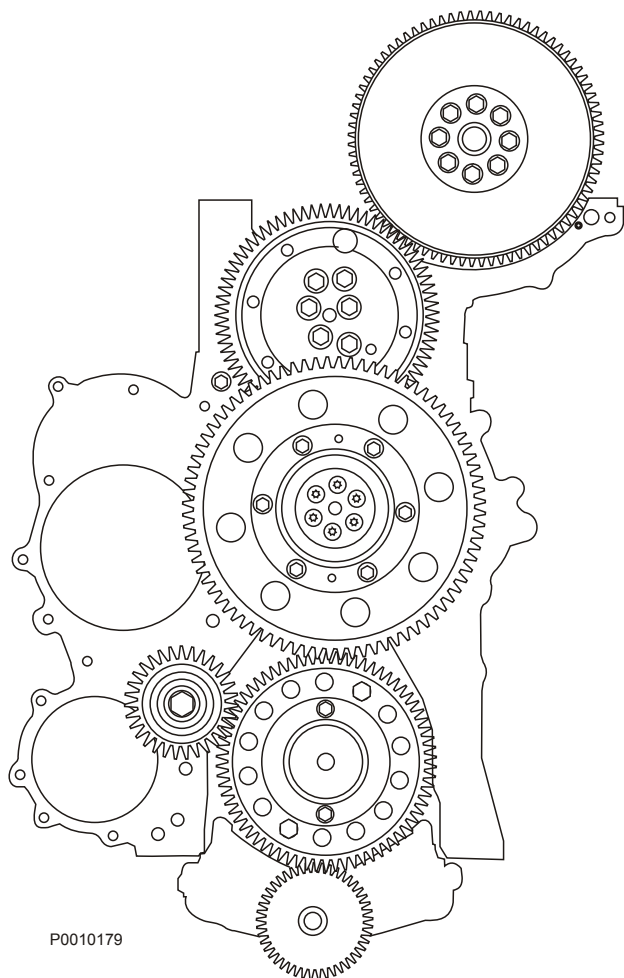
P0010163

- 10 Use 9998511 Lever to loosen the cover from the intermediate plate on the fuel pump side.

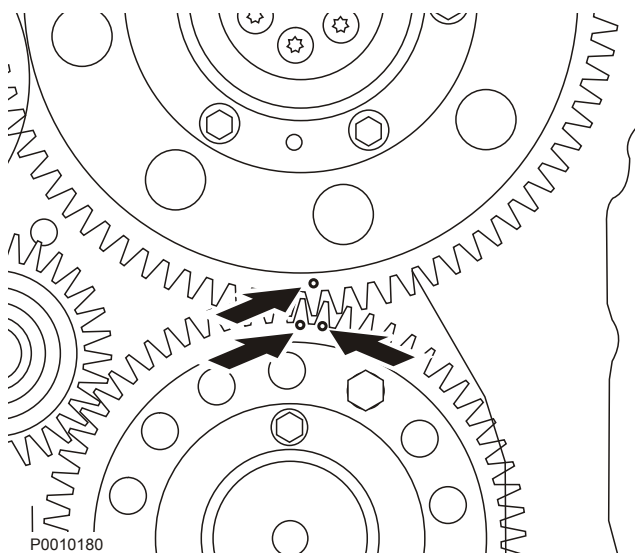


P0010164

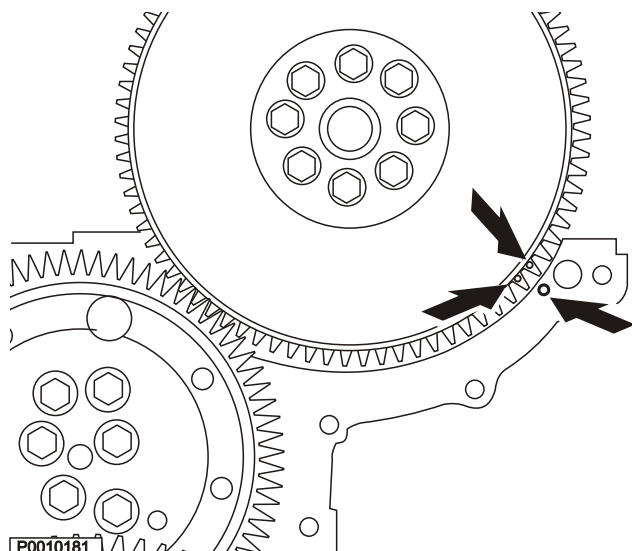
- 11 Use the pry bar in the same way on the starter motor side.



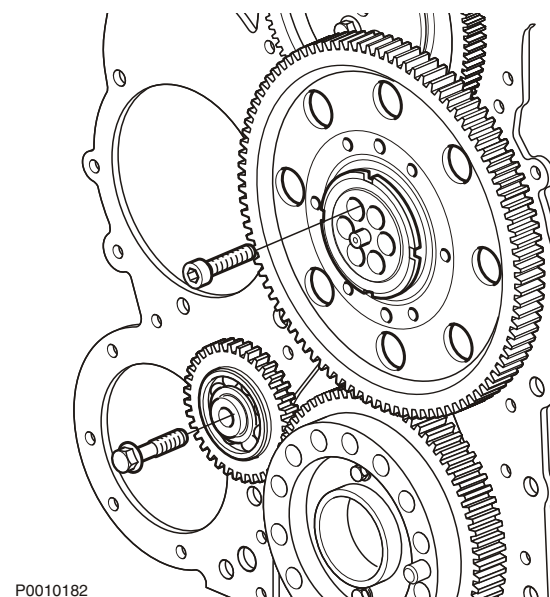
- 12 Lift away the cover. Check which gear requires replacing. The large gear (double gear) must not be separated; it is always replaced complete. If the oil pump gear requires replacing, remove the fuel pump; refer to *Lubrication Oil Pump, Change page 229*.



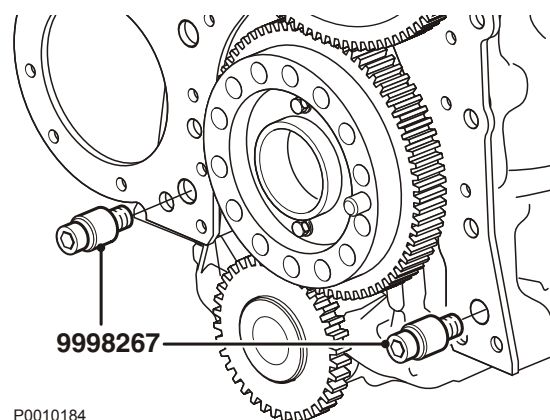
- 13 Check that the crankshaft gear marking corresponds to the double gear.



- 14 Check that the camshaft gear marking corresponds to the timing gear plate hole.

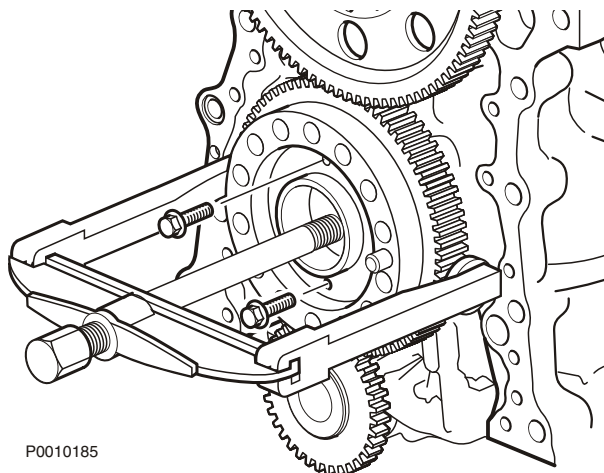


- 15 Remove the lower intermediate gear.  
Remove the double gear (Allen bolts at center).
- 16 Remove the intermediate gear.



- 17 **NOTICE!** Before the timing gear plate is removed, two pcs. 9998267 Guide sleeve must be installed on the engine block (tighten to 60 Nm (44 lbf.ft)). This is to ensure that the plate is replaced in exactly the same position.

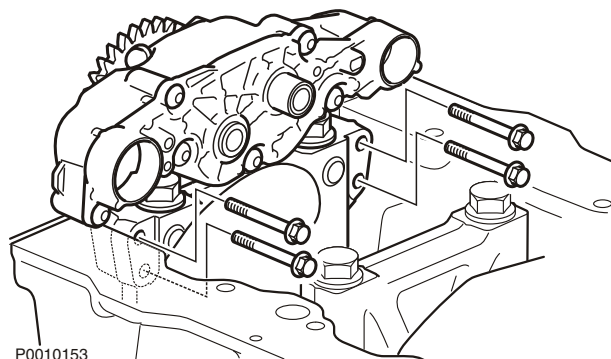
It is now possible to remove the timing gear plate. Remove all bolts. Using a pry bar, carefully prise the plate free (held in place by sealant), but do not prise such that the guide sleeves are budged or damaged



- 18 Remove the two bolts retaining the crankshaft gear.  
Remove the crankshaft gear using a suitable puller. Place a larger washer beneath the puller bolt to protect its thread from damage.
- 19 Clean the plate thoroughly on both sides. Clean the engine block and cylinder head sealing surfaces, but do **not** remove the plate guide sleeves.

## Lube Oil Pump, Removal

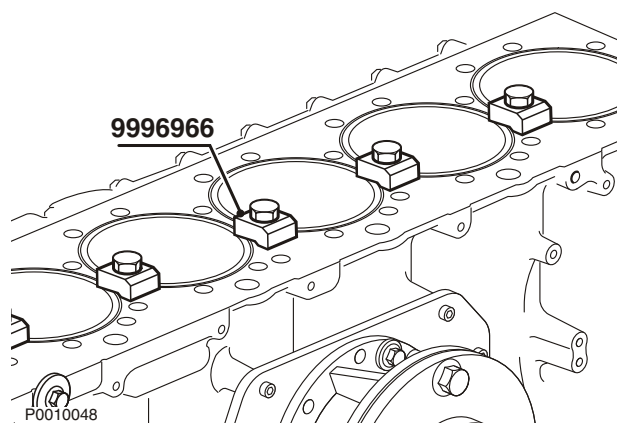
- 1 Remove the oil pump; refer to *Lubrication Oil Pump, Change* page 229.

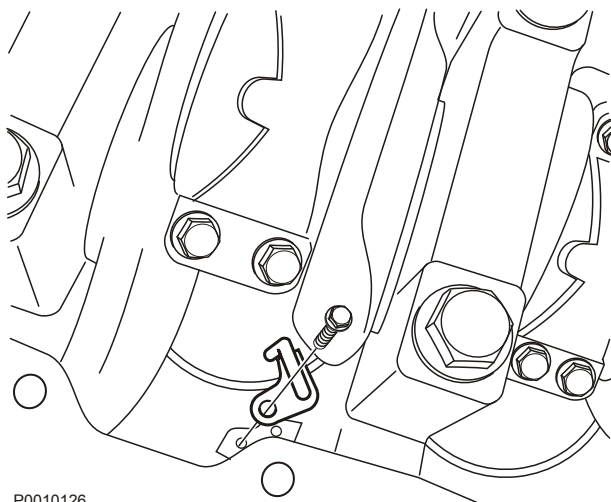


## Pistons, Removal

Tools:  
885822 Magnetic pen

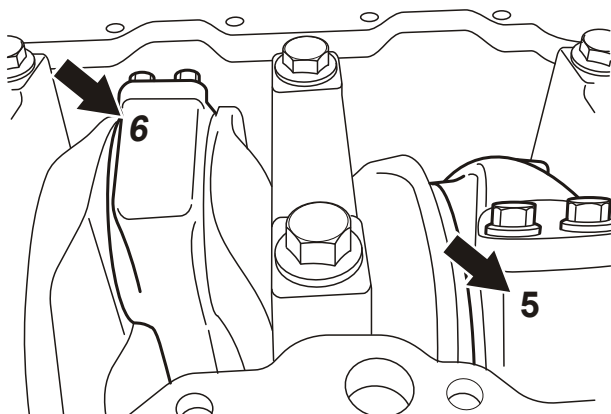
- 1 Remove the carbon uppermost in the cylinder bore.  
Make sure the press tool cannot touch the pistons when the pistons are removed.





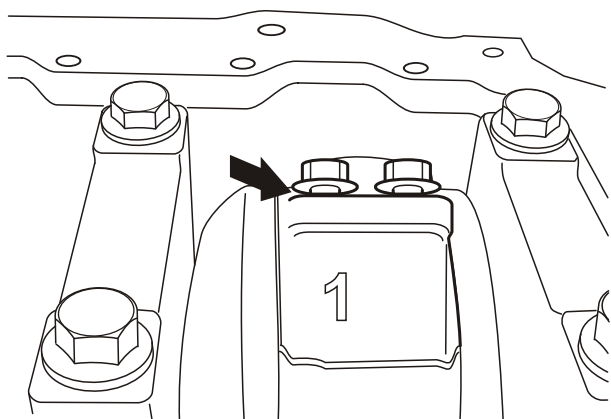
P0010126

- 2 Remove the piston cooling nozzles with the aid of 885822 Magnetic pen.



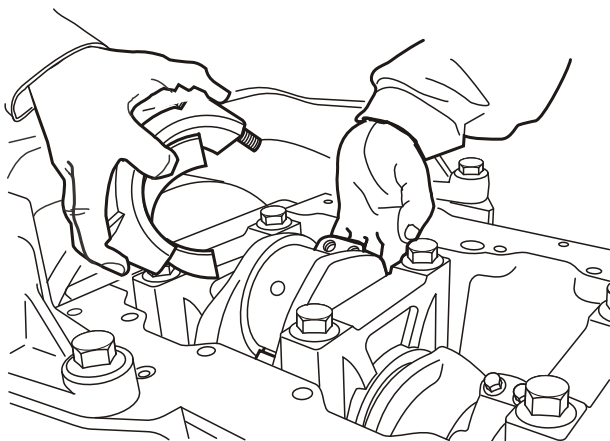
P0010127

- 3 Check that the connecting rods are marked; mark the position if more than one is removed from the engine.



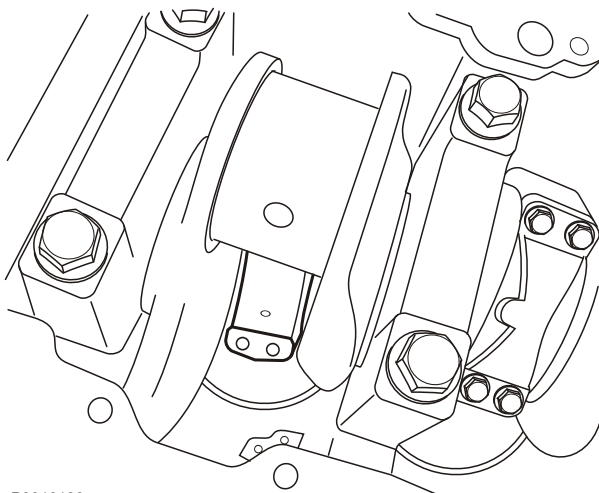
P0010128

- 4 Undo the connecting rod bolts a couple of turns. Tap the bolt heads so that the bearing cap is freed from the connecting rod.



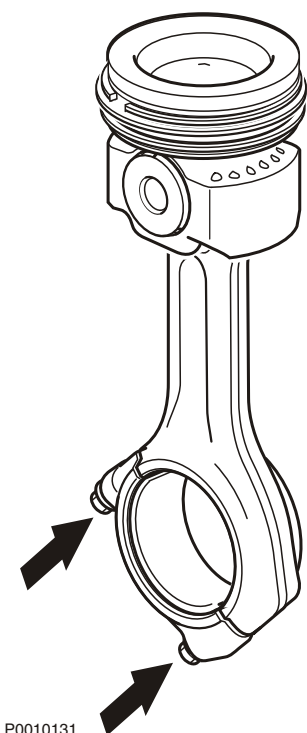
P0010129

- 5 Remove the bolts entirely. Hold the connecting rod in place and lift the bearing cap away at the same time. Take care of the bearing cup if it does not stay in place in the cap.



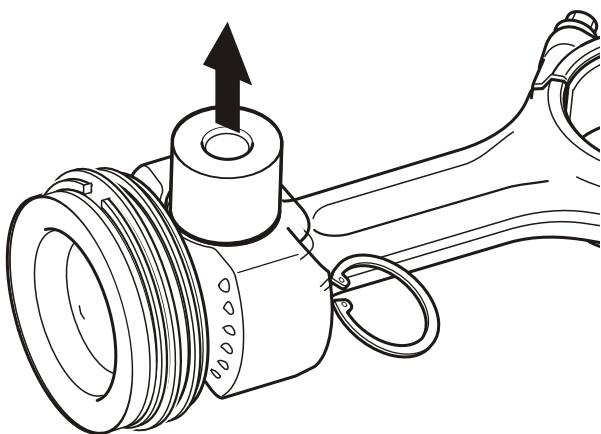
P0010130

- 6 Press out the piston with the connecting rod and catch it under the engine. Make sure it does not fall out and become damaged. The connecting rod separation plane surface is very sensitive and must not be exposed to impact or knocks.



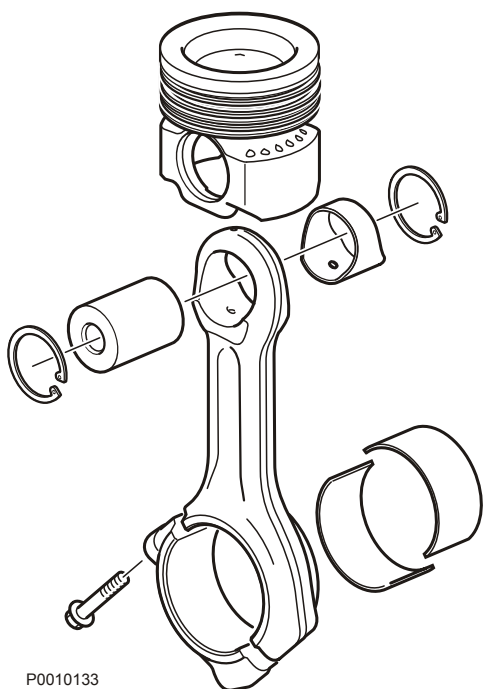
P0010131

- 7 Replace the bearing cap on the connecting rod immediately to protect the separation plane surfaces.
- 8 Remove the remaining pistons the same way.



P0010132

- 9 Remove one retainer ring for the piston pin and press the pin out.



P0010133

- 10 Inspect the connecting rod; refer to *Connecting Rod*, Check page 176.

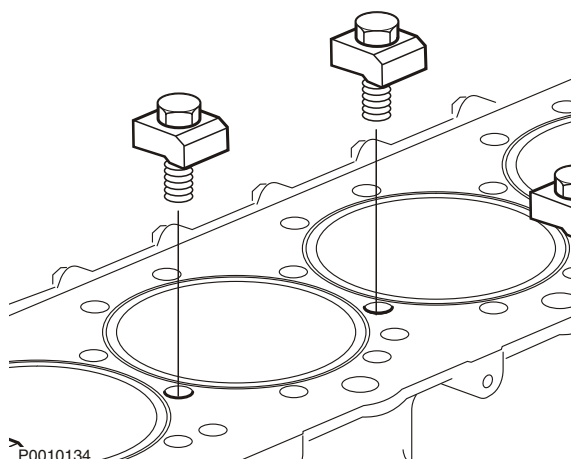
## Cylinder Liners, Removal

### Tools:

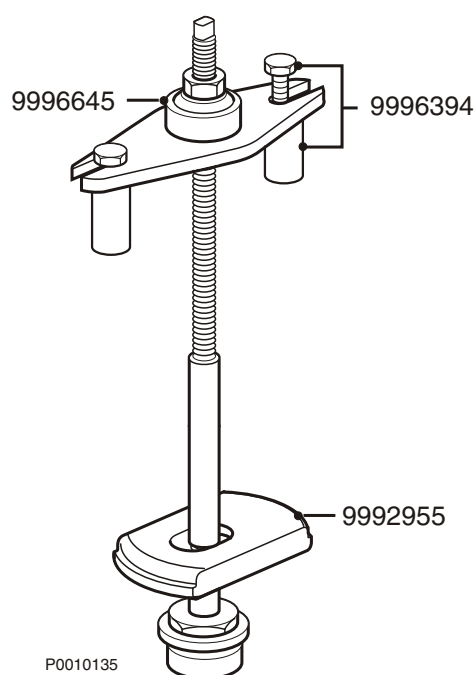
9992955 Plate  
 9996645 Puller  
 9996394 Support  
 9996395 Support

- 1 Turn the engine so that the crankshaft is at the bottom.

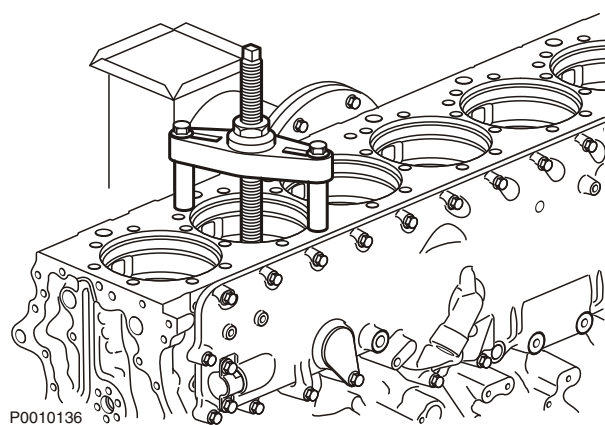
- 2 Remove the press tool holding the liner to be removed.



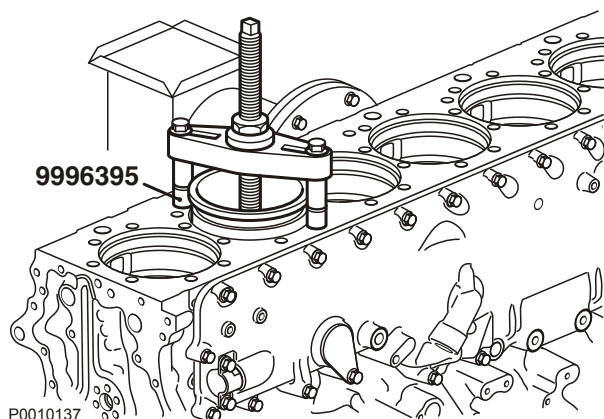
- 3 Assemble the tools 9992955 Plate, 9996645 Puller and 9996394 Support.



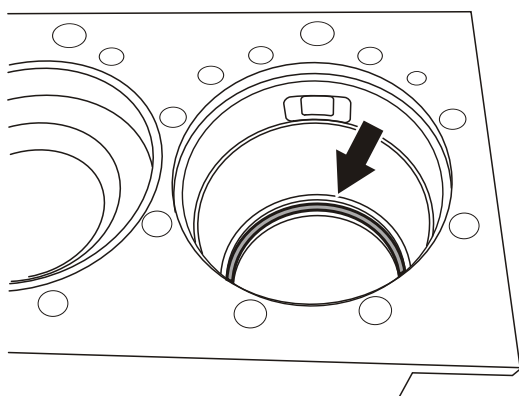
- 4 Insert the tools in the liner to be removed. Make sure the plate ends up directly under the liner. Screw down on the nut so that the liner is drawn up.







- 5 If the liner does not come free when it has reached the puller, release the nut sufficiently for spacer 9996395 to be installed. Continue to pull the liner up until it is free.
- 6 Lift out the liner with the tool and then remove the tool from the liner.
- 7 Remove the remaining liners the same way.
- 8 Inspect the liners; refer to *Cylinder Liner and Pistons, Inspection* page 175.



- 9 Remove the liner O-rings from the engine block. Check the O-ring grooves for corrosion or any other damage.

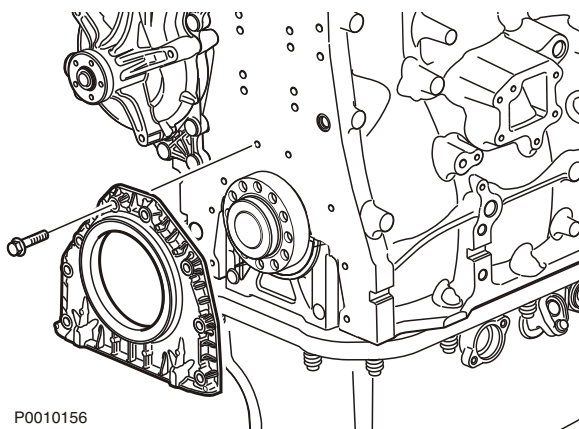
## Crankshaft, Removal

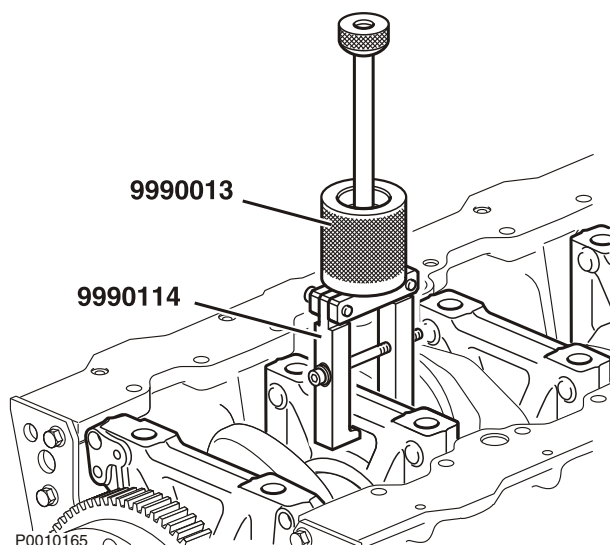
Tools:

9990114 Puller

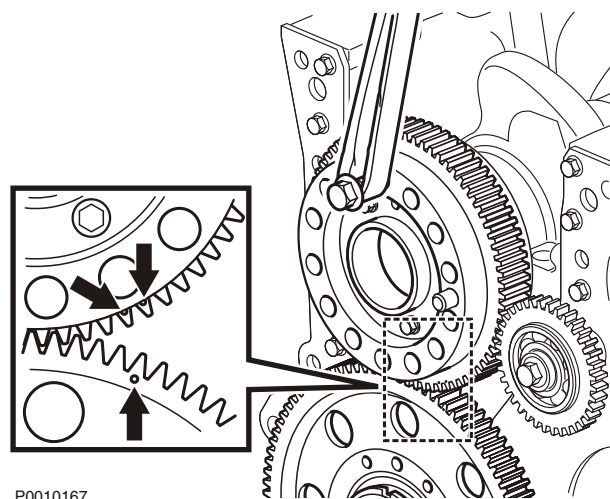
9990013 Slide hammer

- 1 Remove the crankshaft belt pulleys; refer to *Drive Belts* page 290, *Alternator Belts, Change* page 298.
- 2 Remove the crankshaft seal holder.

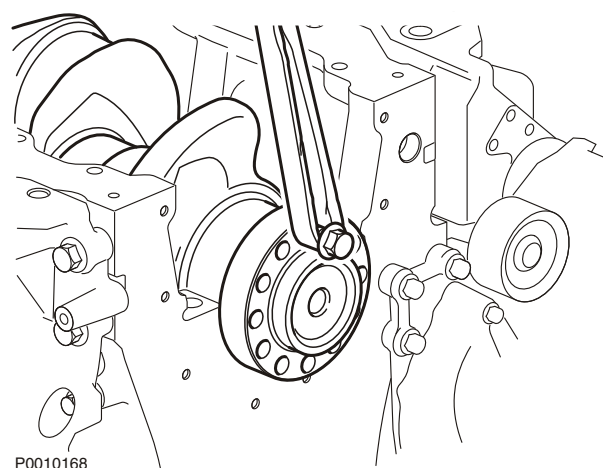




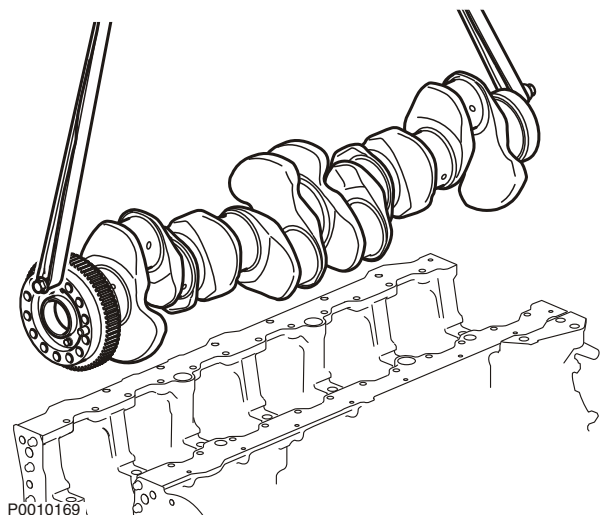
- 3 Remove the main bearing cap bolts.  
Use 9990114 Puller together with 9990013 Slide hammer to rock the main bearing caps loose.  
Keep the main bearing halves safe.
- 4 Remove the front engine mounts if they were not removed earlier.  
Attach a suitable lifting strap to the front and rear end of the crankshaft according to the following steps.



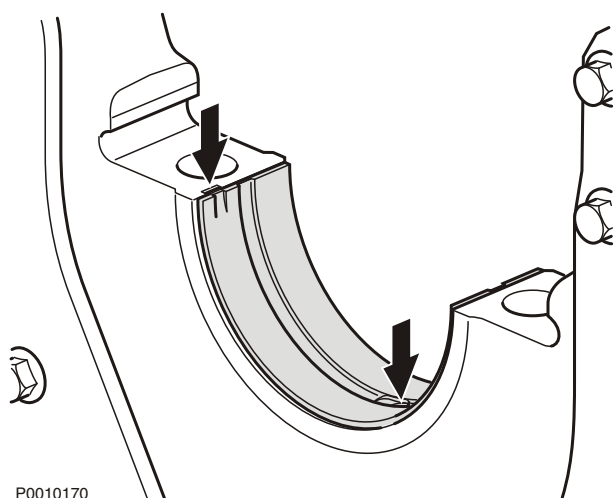
- 5 Crank the crankshaft so that the timing mark ends up exactly as illustrated. The crankshaft can only be removed in this position.  
Insert a bolt in the top hole in the timing gear.



- 6 In the same manner, insert a bolt into the other end of the shaft and attach the lifting strap.



- 7 Lift the crankshaft and make sure that the connecting rods and main bearing cups do not come out with the crankshaft.



- 8 Remove the thrust washers. Remove the main bearing cups and wipe the bearing seats dry. Fit new bearings. Make sure the tabs fit into the notch in the bearing seat and that the oil holes correspond to each other. Oil the bearings with engine oil.

## Engine Assembly

### Crankshaft, Installation

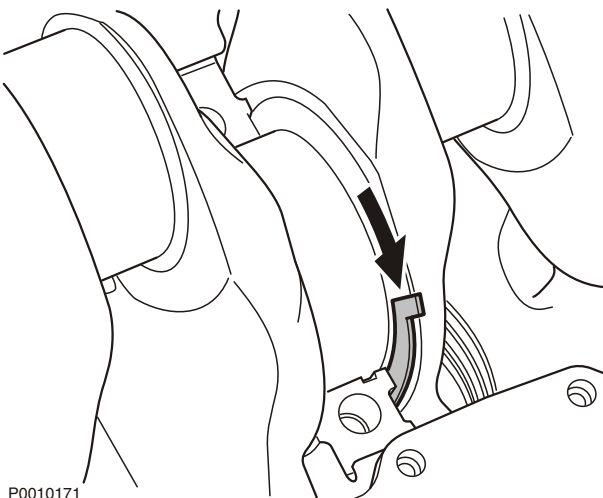
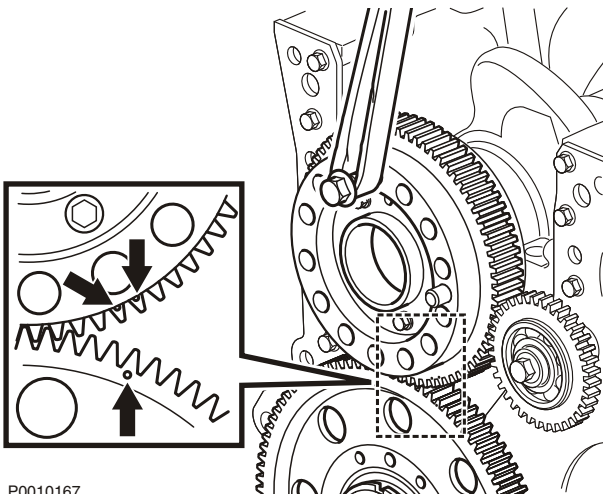
Tools:

885811 Timing tool  
885633 Torque multiplier  
885648 Counterhold  
9999696 Magnetic stand  
9989876 Dial indicator  
9998511 Lever

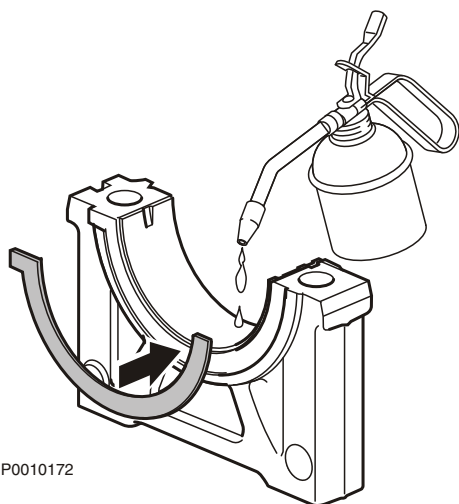
- 1 Inspect the crankshaft; refer to *Crankshaft, Inspection* page 224.
- 2 Check that the crankshaft is clean, that all bearing surfaces are fault free and that the oil channels are open. Install the crankshaft gear with a new O-ring. Suspend the crankshaft in a lifting strap; refer to *Crankshaft, Removal* page 135. Lubricate all bearing surfaces with engine oil.
- 3 Lower the crankshaft carefully into position. Align the gearwheel markings with each other.

**IMPORTANT!**

Make sure that no connecting rod ends up in the wrong position. The connecting rod separation planes are very sensitive.

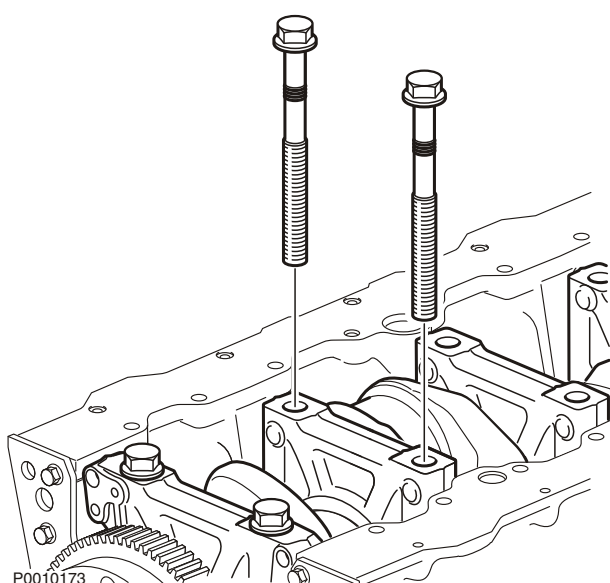


- 4 When the crankshaft has been lowered onto the main bearings, check that they are still correctly positioned. Install the thrust washers so that the locator tabs end up in the intended notches.



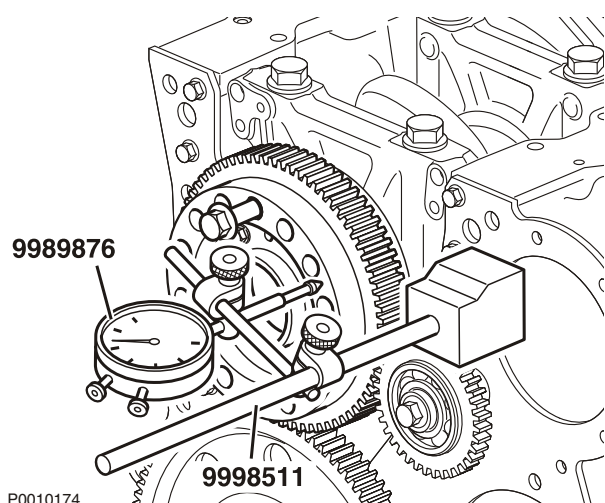
P0010172

- 5 Wipe the main bearing caps dry and install new bearings. Lubricate the bearing surfaces with engine oil.  
Install the thrust washers on the center main bearing cap (fit the locator tab into the notch). The center cap has a groove that must fit against a locator tab in the engine block.



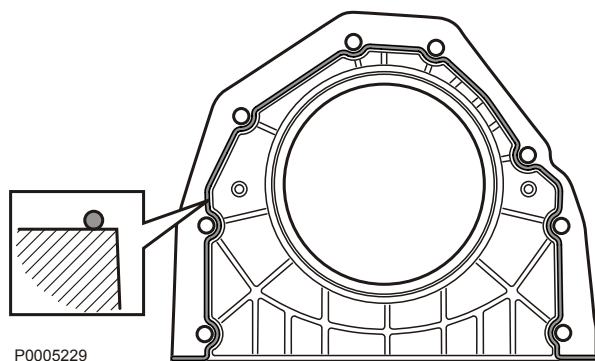
P0010173

- 6 Install the cap according to the marking. Use the bolts to guide the caps straight. Tighten the bolts so that the caps are pulled down onto the engine block.  
Check that the crankshaft can be rotated.  
Torque and angle tighten the main bearing cap bolts using 885811 Timing tool, 885633 Torque multiplier and 885648 Counterhold according to *Special Tightening Torques* page 8.  
Check once more that the crankshaft can be rotated

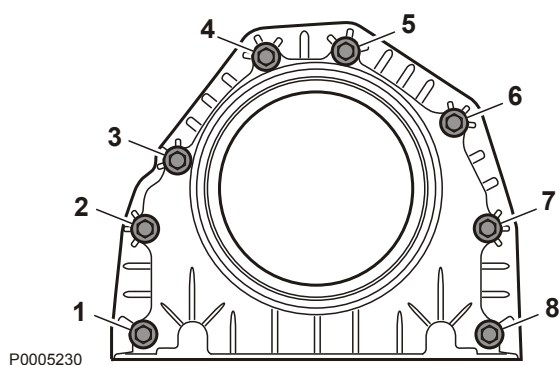


P0010174

- 7 Check crankshaft end float with the aid of 9999696 Magnetic stand and 9989876 Dial indicator.  
Use 9998511 Lever move the crankshaft back and forth. Read off the value on the dial indicator and compare to *Technical Data* page 27.
- 8 Install new bearings in the connecting rods and big end bearing caps and install all connecting rods; refer to *Pistons, Removal* page 130.  
Check that it is still possible to rotate the crankshaft
- 9 Install the piston cooling nozzles if they were removed.



- 10 Remove the front crankshaft seal from the cover. Clean the cover and engine block where the cover is to be installed. Apply sealant to the cover; refer to *Special Tightening Torques* page 8. Install the cover and tighten the bolts in sequence; refer to *Special Tightening Torques* page 8.
- 11 Install a new crankshaft seal and belt pulley; refer to *Crankshaft seal, replace (front)* page 211.

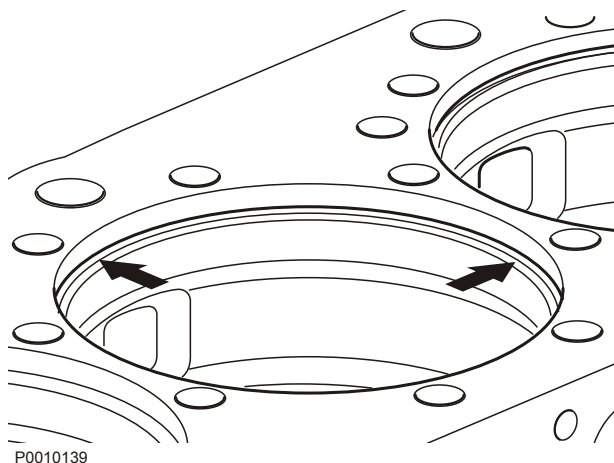


## Cylinder Liner, Installation

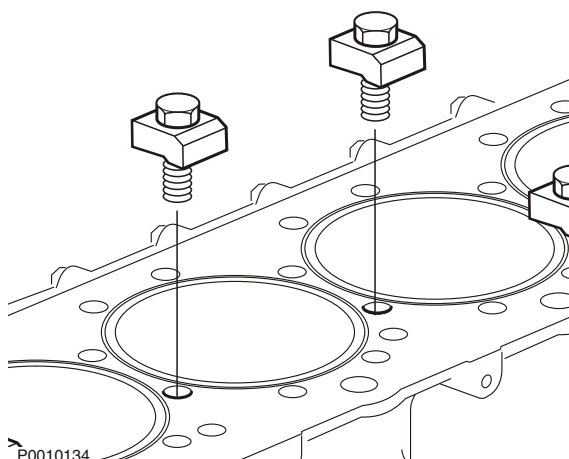
### Tools:

9996966 Press tool  
 9992479 Holder for dial indicator  
 9989876 Dial indicator  
 9998511 Lever  
 9992955 Plate

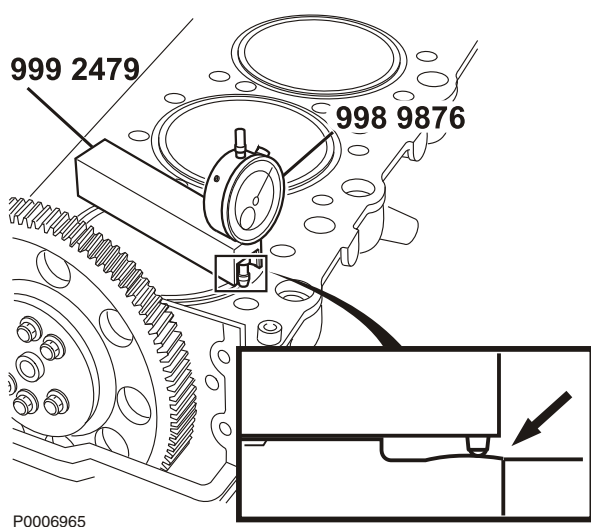
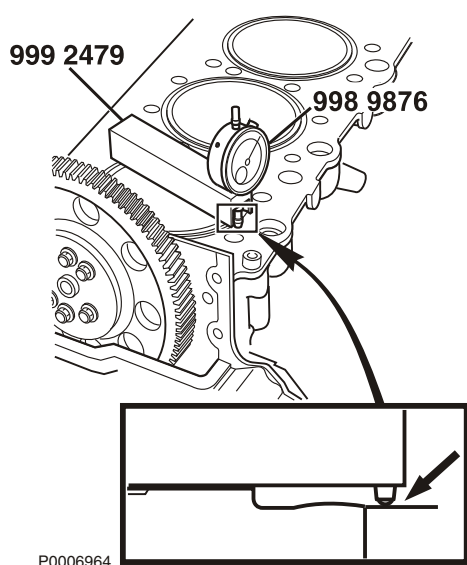
- 1 Check the engine block liner seat for damage. If the liner seat is damaged it must be repaired.



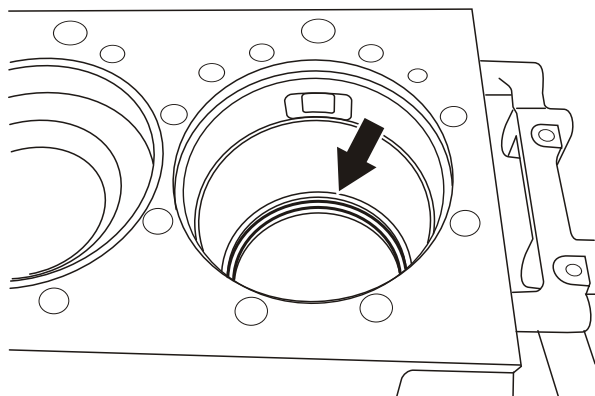
- 2 Install the liner without O-rings and press the liner down using two 9996966 Press tool.



- 3 Measure the height between the liner and the cylinder block plane. Measure the height of the liner in two places, diagonal to each other. Calculate the average of the two measurements. For correct liner height above block plane, refer to specifications. If the liner height is outside specified tolerances, the liner seat must be repaired (milled). Always measure the highest point on the liner sealing surface. Mark the liner's position with a felt pen in order to re-install it in the exact same position.

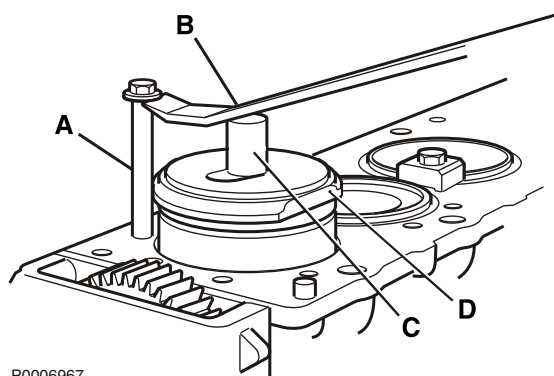






P0010140

- 4 Remove the press tool and pull out the liner. Clean the O-ring grooves in the engine block. Lubricate new O-rings and insert them in the grooves in the engine block; black uppermost, then purple in the lower groove. Use the oil supplied. Install the O-ring on the cylinder liner. Oil the lower part of the cylinder liner with the lubricating oil supplied.



P0006967

- A Cylinder head bolts
- B 9998511 Lever
- C Socket
- D 9992955 Plate

- 5 Press the liner down according to the earlier marking; if necessary use 9992955 Plate, a suitable socket and 9998511 Lever against a cylinder head bolt. Press the liner down using two 9996966 Press tool.
- 6 Install the remaining liners the same way

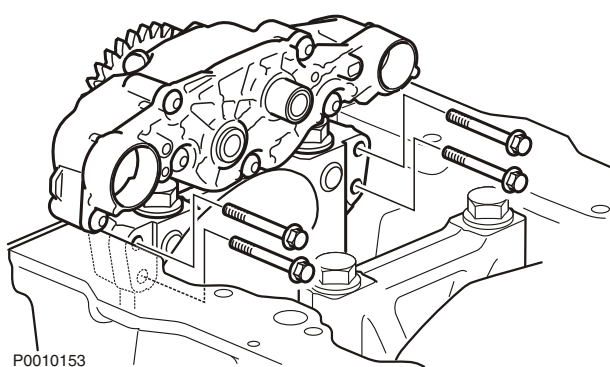
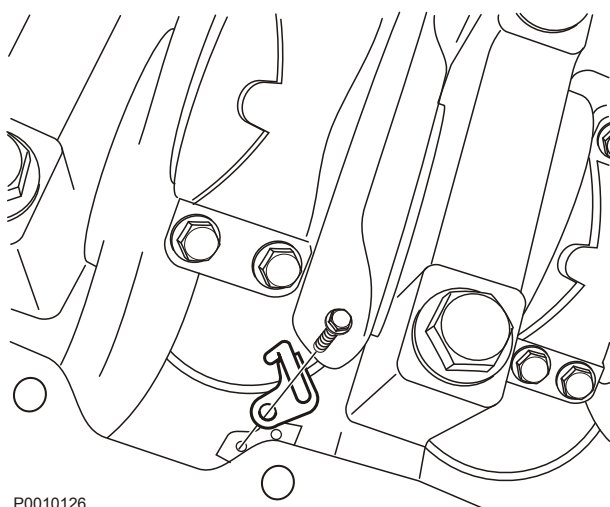
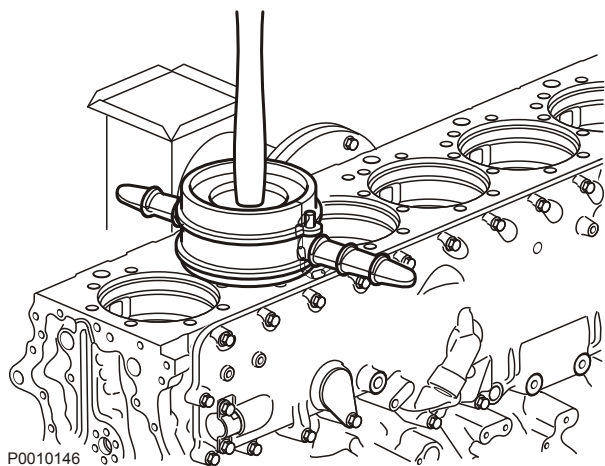
## Pistons, Installation

### Tools:

9996966 Press tool  
9998531 Piston ring compressor

- 1 Rotate the crankshaft so that the big end journal for the piston to be installed ends up as low as possible. Remove the two press tools for the liner where the piston is to be installed.





- 2 Lift the piston into place with the piston ring clamp and connecting rod (big end bearing lubricated). Make sure the piston is facing the right direction (so that the connecting rod is in the right position on the crankshaft). Tap down the piston with a hammer shaft. Remove the piston ring clamp when the piston is below it. Re-install the press tools for the cylinder liner. Press down the piston so that the connecting rod touches the crankshaft. Install the big end bearing caps and align it precisely with the crankshaft (big end bearing oiled). Install the bolts. Torque the bolts and check that the crankshaft can be rotated.
- 3 Install the remaining pistons the same way.
- 4 Clean the piston cooling nozzles and check that they are not damaged. Install the nozzles using new bolts. Check that the nozzles are aimed directly at the piston oil cooling hole.

## Lube Oil Pump, Installation

- 1 Install the oil pump, reinforcing plate, pipe and suction strainer; refer to *Lubrication Oil Pump, Change* page 229.

## Timing Gear, Installation

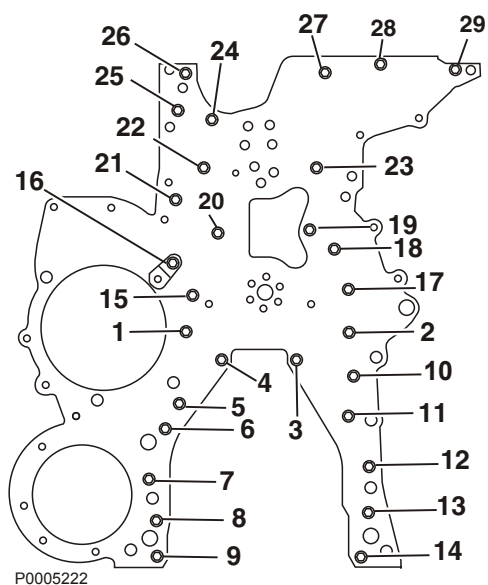
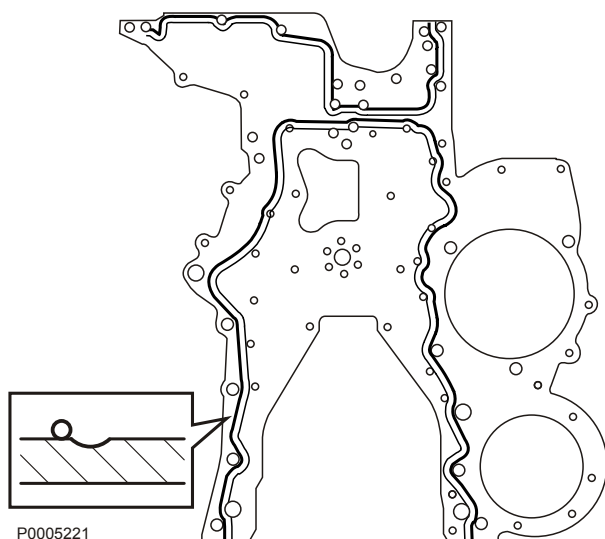
### Tools:

9998267 Guide sleeve

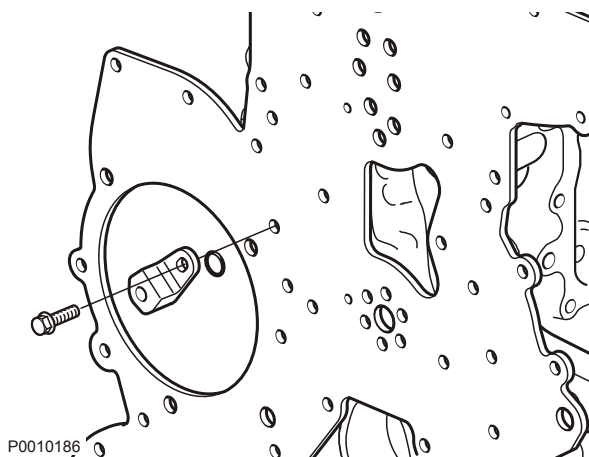
9999683 Dial indicator (short probe)

9999696 Magnetic stand

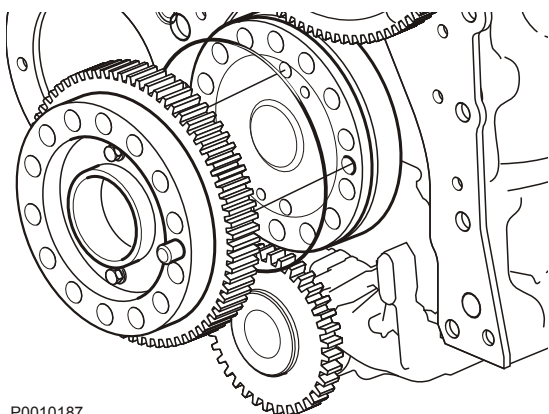
- 1 Apply a 2 mm (0.08") bead of sealant precisely outside the groove on the timing plate, max 20 min. before installation.



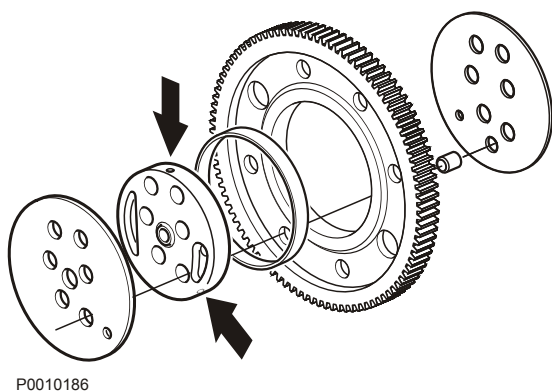
- 2 Align the plate with the locator sleeves. Install all the bolts and tighten them in sequence according to *Special Tightening Torques* page 8.



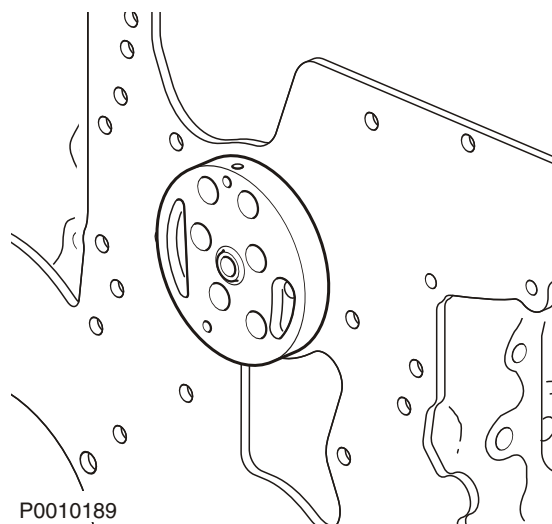
- 3 Install a new O-ring under the holder. Remove 9998267 Guide sleeve.



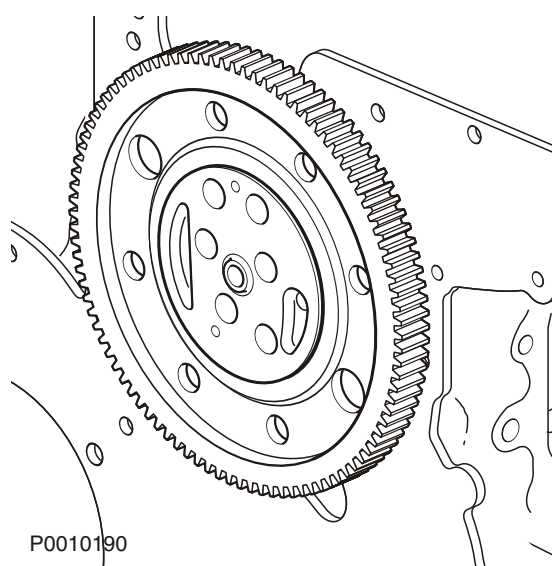
- 4 Install a new O-ring on the crankshaft and lubricate it.  
Lubricate the inside of the gearwheel with the same lubricant. Fit the gearwheel locator tab into the crankshaft hole and make sure the oil pump gear meshes with the crankshaft gear. Install the bolts and tighten them alternately so that the gearwheel is not skewed. Torque according to *Special Tightening Torques* page 8.



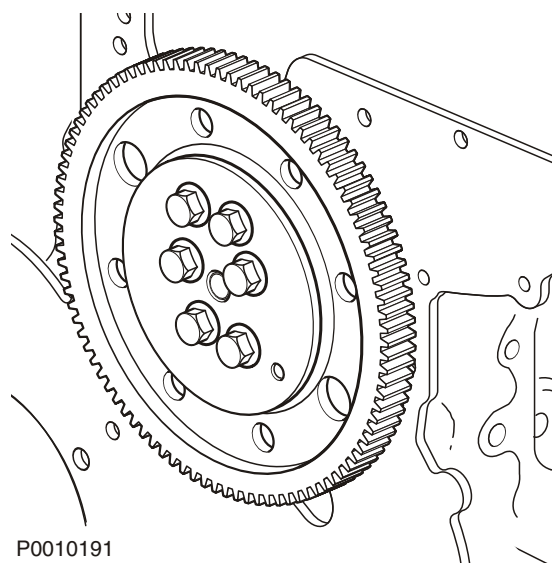
- 5 Clean the upper intermediate gear hub. Check the oil holes are open.  
Fit the washer onto the locator sleeve. Check that the bolt holes align.



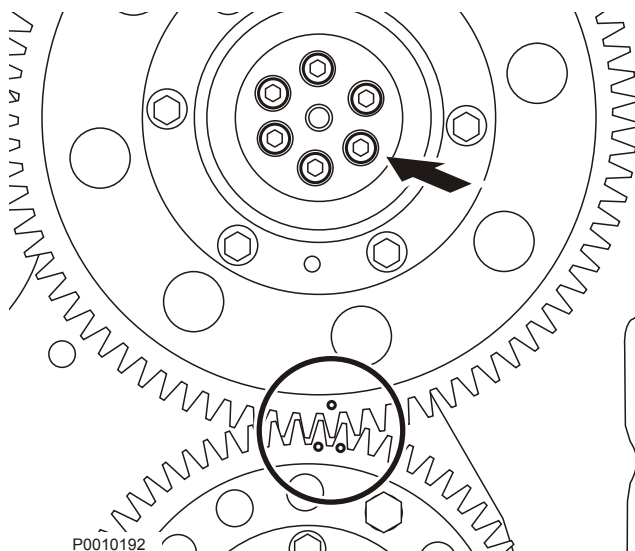
- 6 Fit the hub onto the engine by aligning the locator sleeve. Lubricate the thrust bearing with engine oil.



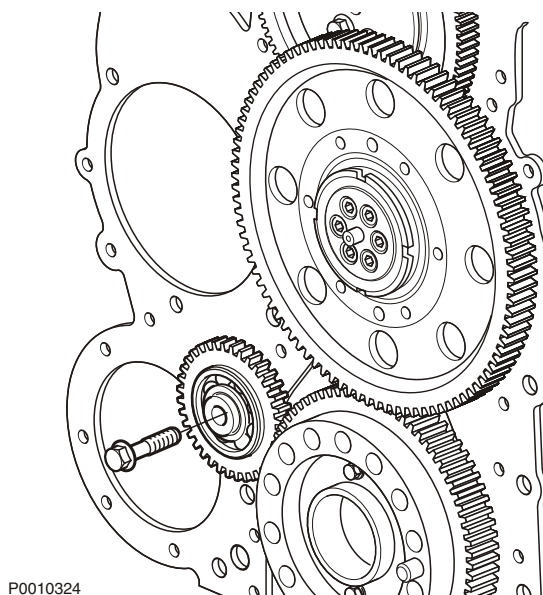
- 7 Check that the bearing is fault free. Lubricate the bearing with engine oil. Install the intermediate gear turned so that the bearing is located outward.
- 8 Check that the plate lubricating hole is open. Lubricate the rear of the plate.



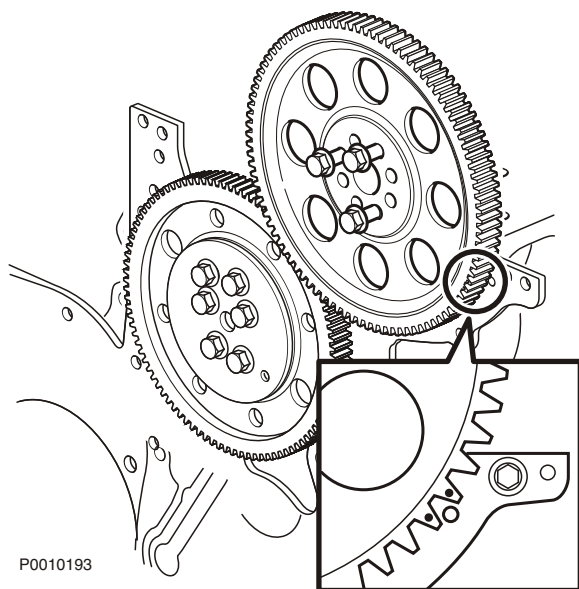
- 9 Fit the plate onto the centering guide and install the bolts. Tighten the bolts until they touch. Check that the gearwheel rotates easily.



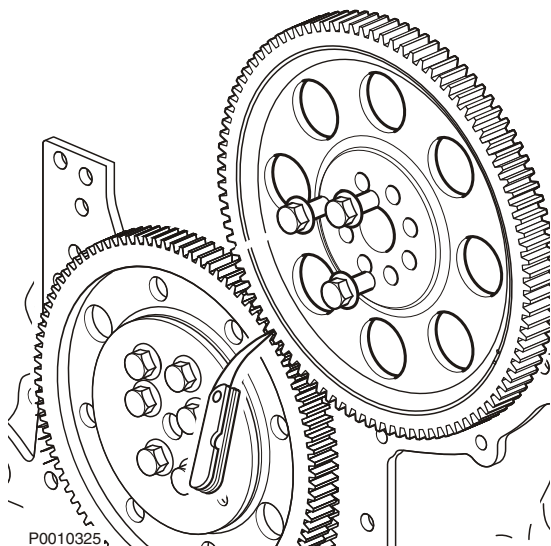
- 10 Check the double gear bearing.  
Align the marking on the double gear against the marking on the crankshaft. Align the upper intermediate gear teeth and fit the locator pin into the center hole. Turn the hub so the bolt holes align. Install the bolts and tighten according to *Special Tightening Torques* page 8.



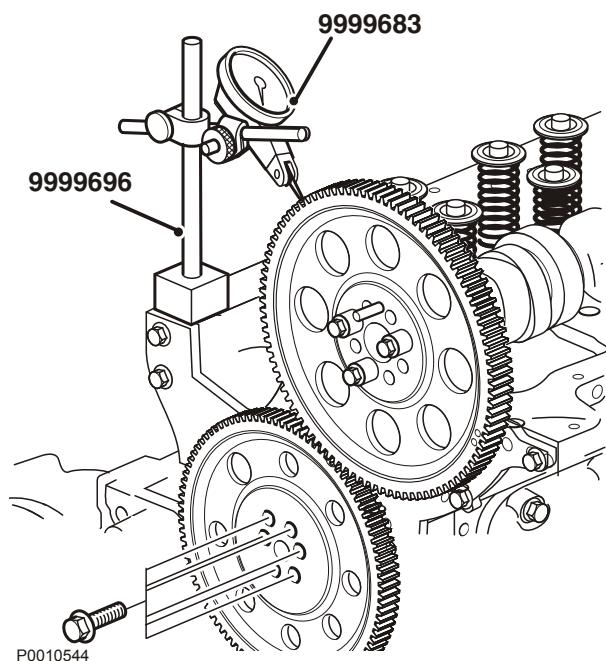
- 11 Install the lower intermediate gear.



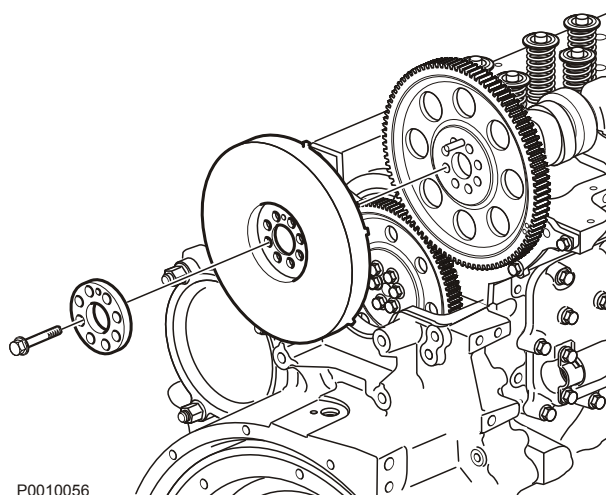
- 12 Install the camshaft gear without the oscillation damper. Align the marking with the hole in the timing plate.  
Allow suitable spacers under the bolts to act as a replacement for the vibration damper.



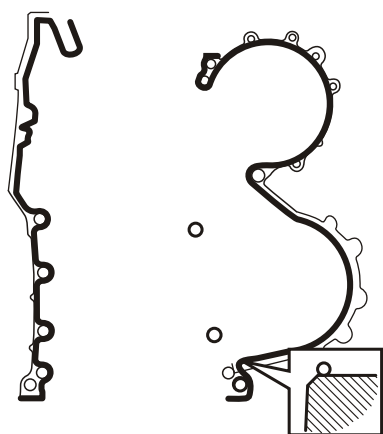
- 13 **Adjust the gear lash as follows:**  
Undo the bolts to the upper intermediate gear so that it is moveable. Check by rotating the camshaft gear back and forth.  
When the camshaft gear is rotated clockwise until it stops the intermediate gear is moved to the left so that a large gear lash measurement between the camshaft gear and the intermediate gear is obtained.  
When the camshaft gear is rotated counterclockwise until it stops the intermediate gear is moved to the right so that a no gear lash measurement between the camshaft gear and the intermediate gear is obtained.  
In order to adjust gear lash to the correct value, insert a 0.10 mm (0.0039") feeler gauge between the gearwheels while the camshaft gear is rotated clockwise until it stops. Then tighten the intermediate gear bolts and remove the feeler gauge.



- 14 Check gear lash measurement using 9999683 Dial indicator (short probe) and 9999696 Magnetic stand. The upper intermediate gear must be held secure when checking gear lash. Compare to *Technical Data page 27*. Torque the bolts to the upper intermediate gear; refer to *Special Tightening Torques page 8*.

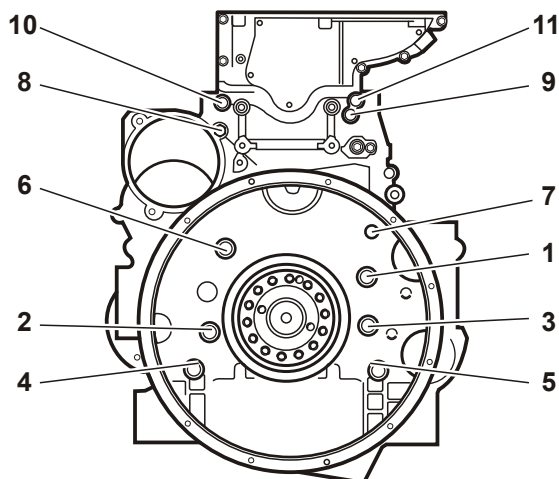


- 15 Remove the bolts and spacers from the camshaft gear. Install the vibration damper, bolts and washer. Tighten the bolts; refer to *Special Tightening Torques page 8*.
- 16 Remove the crankshaft seal from the flywheel housing. Clean the flywheel housing contact surfaces. Check that the locator sleeves are in place.



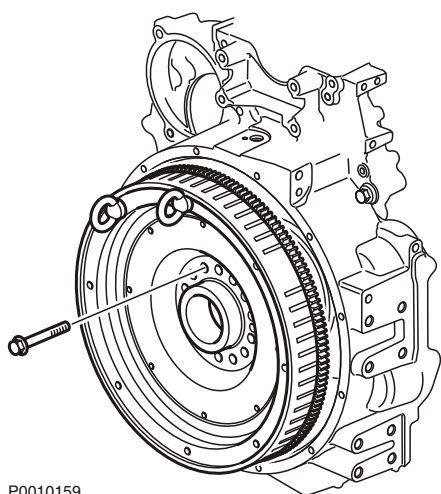
- 17 Apply a 2 mm (0.08") bead of sealant according to *Special Tightening Torques page 8* (must be torqued within 20 mins.).





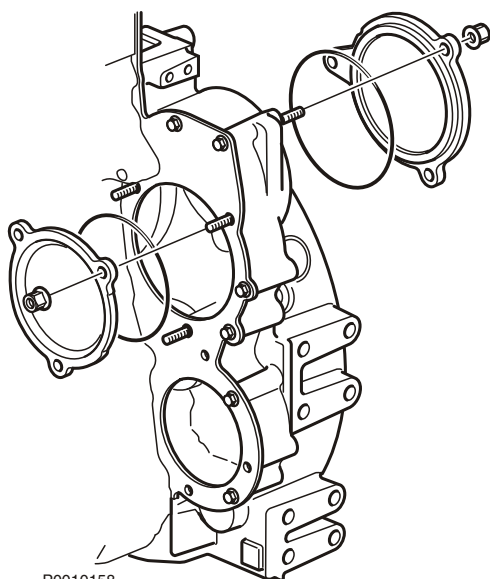
P0005225

- 18 Lift the cover into place and align the locator sleeves. Install all the bolts and torque according to *Special Tightening Torques* page 8 (M14 first according to chart).
- 19 Inspect the flywheel. Where necessary, replace the ring gear; refer to *Gear Ring, Flywheel: Replace* page 204.



P0010159

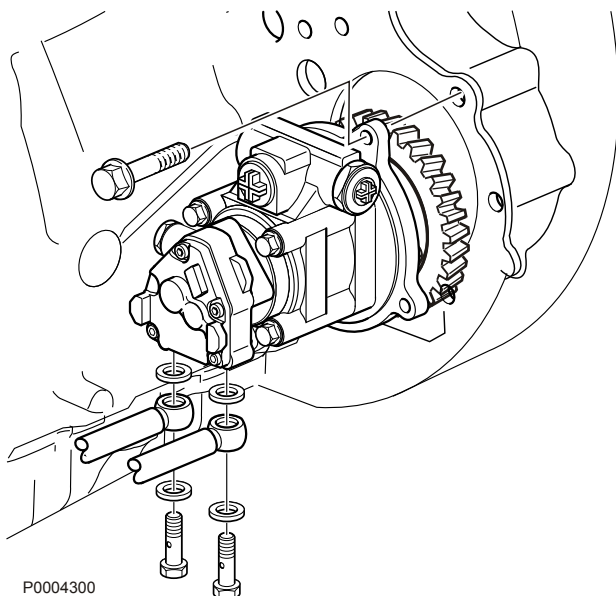
- 20 Install a new crankshaft seal; refer to *Crankshaft Sealing, Change (rear)* page 219. Install the flywheel. Check the flywheel with regard to distortion; refer to *Flywheel, Indication* page 203.



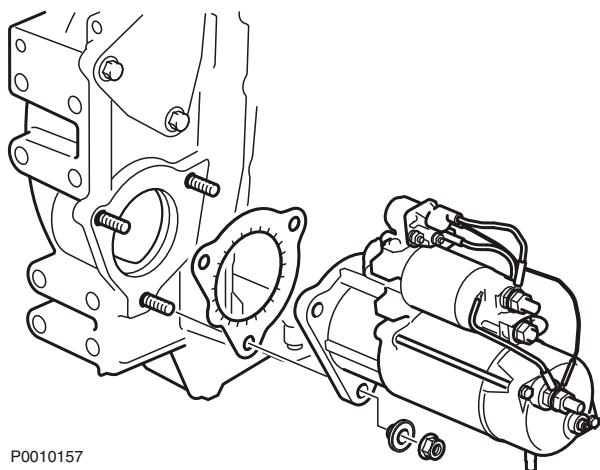
P0010158

- 21 Install the covers with new seals. Install the crankshaft sensor with a new seal; refer to *Sensors, Adjustment* page 113.

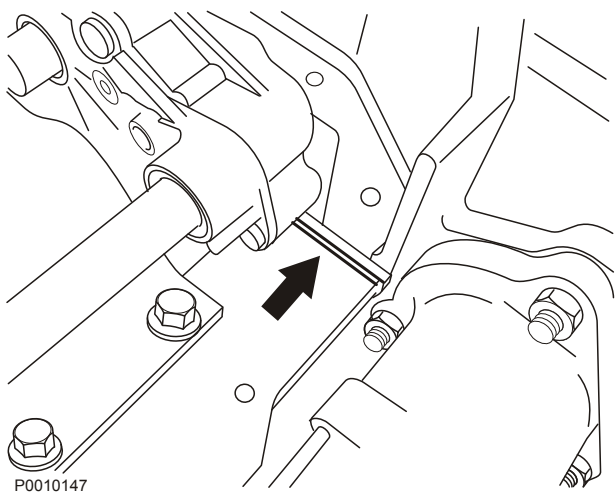




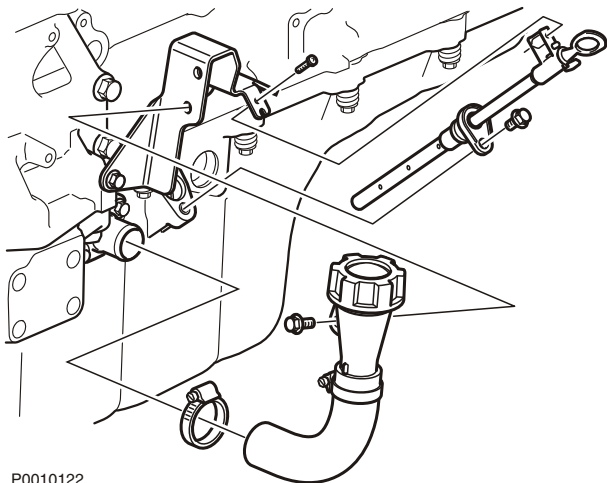
- 22 Install the fuel pump with drive unit and new seal. Install new fuel line seals.



- 23 Install the starter motor.

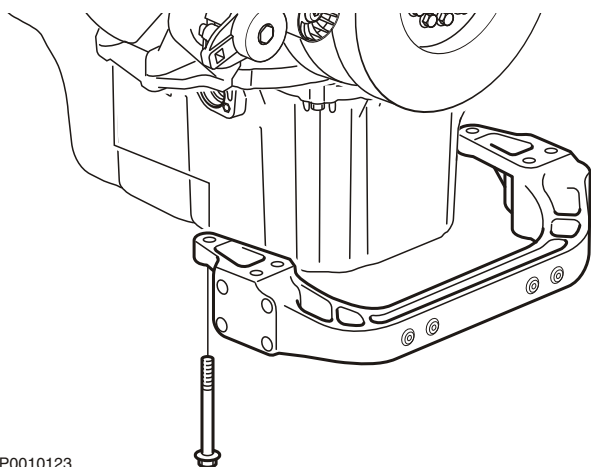


- 24 Clean the oil sump thoroughly. Check to see if the oil sump rubber seal requires replacement. Cut away excess sealant from the front crankshaft seal cover. Cut away excess sealant from the timing plate and the flywheel housing. Apply new sealant to the joints and install the oil sump within 20 min.



P0010122

- 25 Install the oil filler with attachment and the oil dipstick.



P0010123

- 26 Install the front engine mount and tighten the bolts according to *Special Tightening Torques* page 8.
- 27 Install the cylinder head according to *Cylinder Head, Installation* page 162.

## 21-1 Cylinder Head

### Cylinder Head, Removal

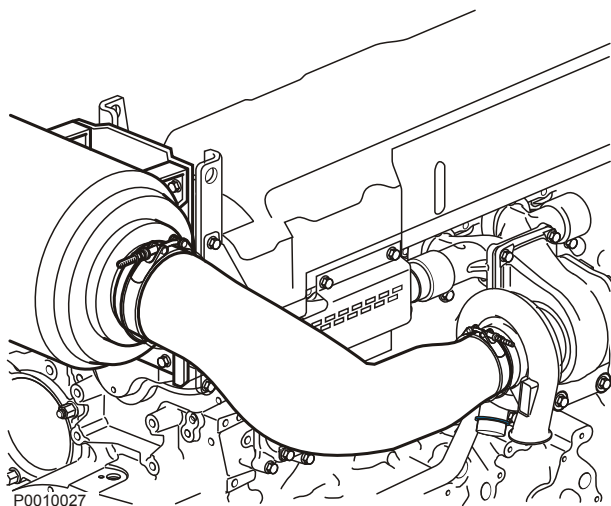
Engine in stand; refer to *Engine with mounting and equipment page 120*.

Oil and coolant drained.

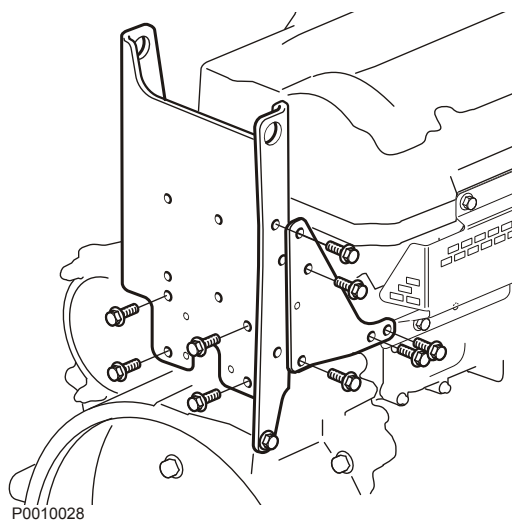
Tools:

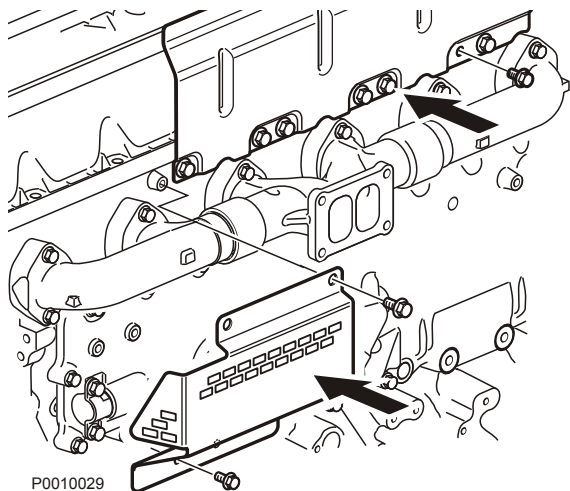
9990185 Lifting tool  
9996400 Slide hammer  
9998674 Adapter  
9990006 Puller  
9990013 Slide hammer  
885822 Magnetic pen  
9998249 Protective sleeve  
9998251 Protection plug  
9996239 Lifting tool  
9996966 Press tool  
9998264 Lifting tool

- 1 Remove the air cleaner with attachment plate and the turbocharger pipe.

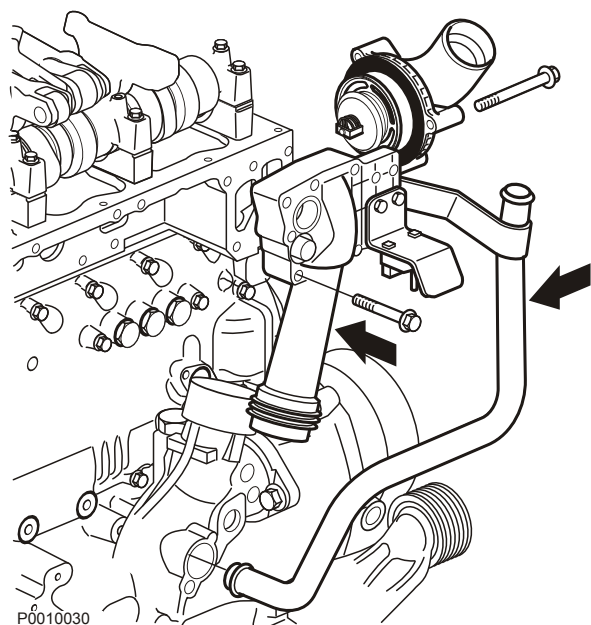


- 2 Remove the rear engine lifting eye.
- 3 Remove the turbocharger; refer to *Turbo, Change page 275*.

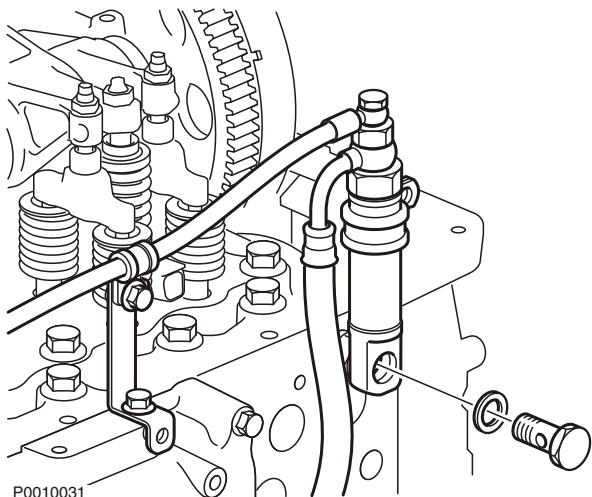




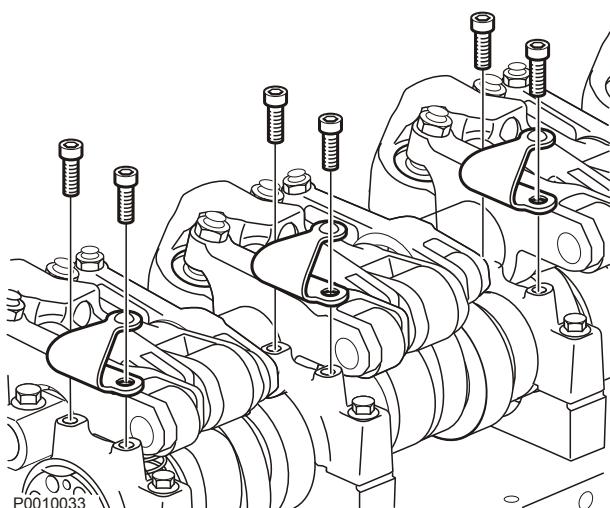
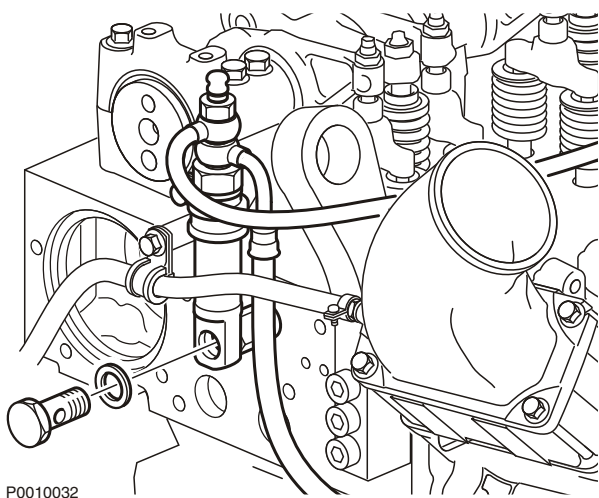
- 4 remove the heat shield and manifold.



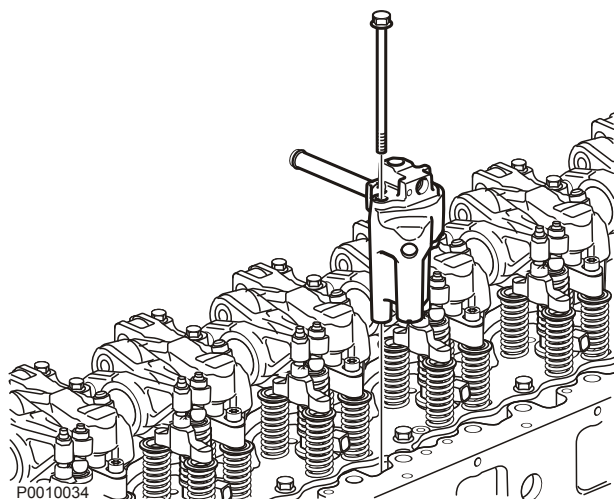
- 5 Remove the water pipes (2 pcs.). Remove the thermostat cover and thermostat; refer to *Thermostat, Change page 288*.
- 6 Remove the ventilation pipe and valve cover.
- 7 Remove the wire harness. Begin with the wires under the valve cover.



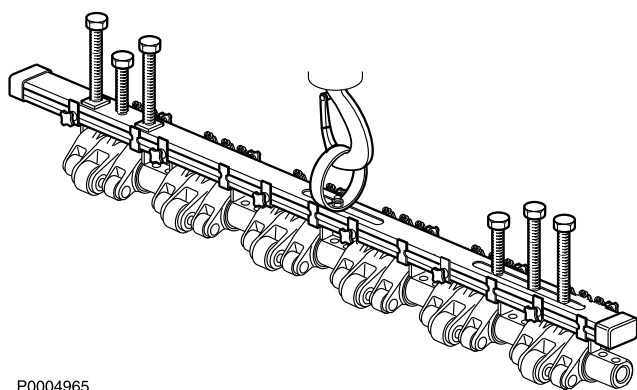
- 8 Remove the fuel lines from the cylinder head.
- 9 Remove the inlet manifold; refer to *Inlet Manifold, Change page 269*.



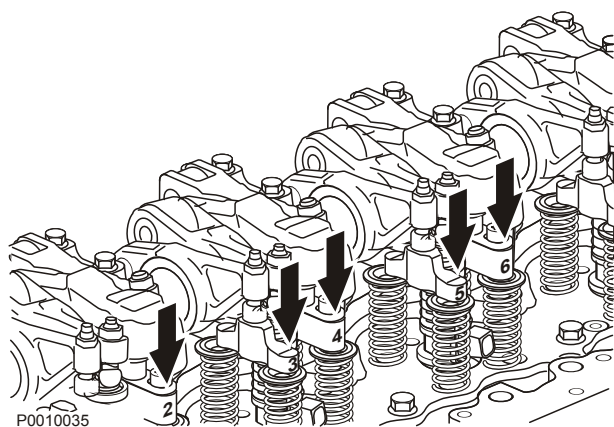
- 10 TAD1350–53GE:  
Remove the springs from the EGR rocker arms.  
**NOTICE!** Do not drop the bolts into the timing gear.



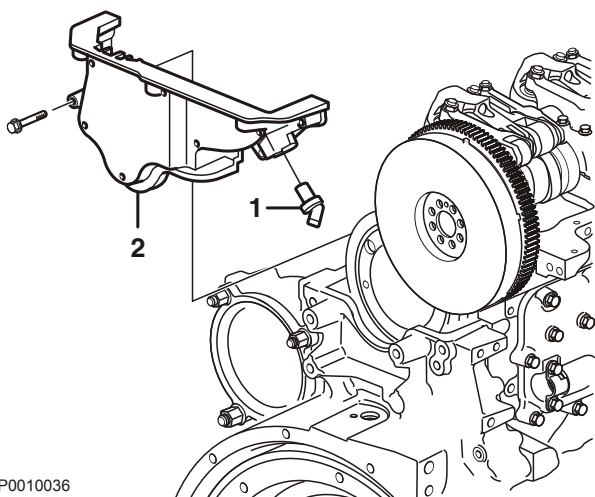
- 11 Remove the rocker arm lubrication valve and oil pipe. Remove the rocker arm shaft. Undo the bolts alternately so the shaft is not bent.



- 12 Install 9990185 Lifting tool and adjust the rocker arm holders. This is done so that the rocker arms can be kept together per cylinder. The higher holders must be used. Lift the rocker arm bridge away. Make sure the pistons in the exhaust rocker arms and the adjuster screw ball do not fall out.

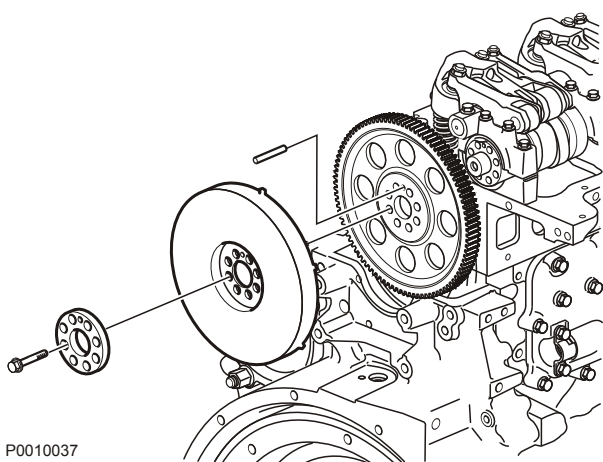


- 13 Mark and then remove the valve yokes.



P0010036

- 14 Remove the camshaft sensor (1) and then the upper timing cover (2).



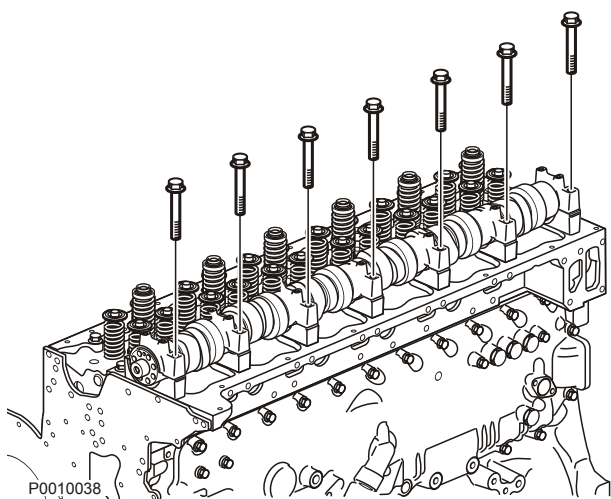
P0010037

- 15 Remove the camshaft gear and vibration damper bolts.  
Lift away the vibration damper.

**IMPORTANT!**

make sure the vibration damper is protected from impact and shocks.

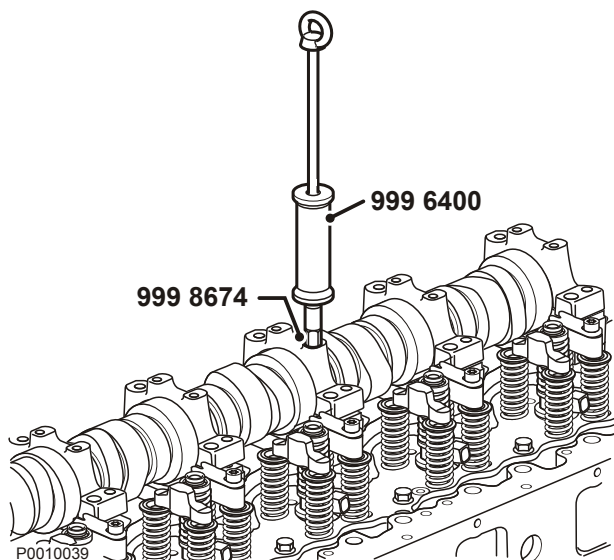
Remove the camshaft gear.



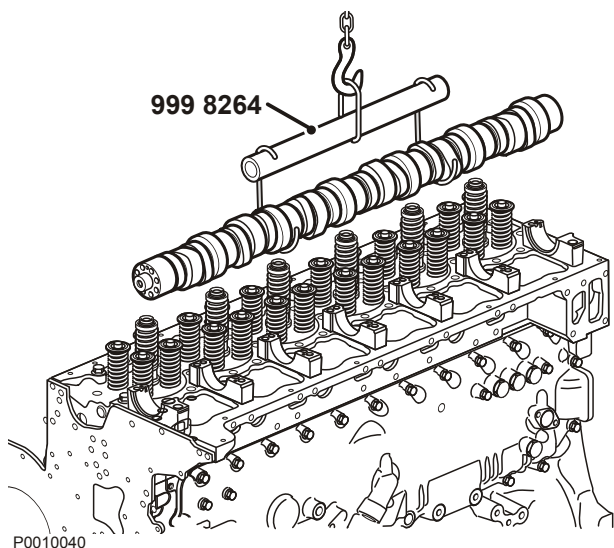
P0010038

- 16 Remove the camshaft cap bolts. Check that the caps are marked.





- 17 Use 9996400 Slide hammer and 9998674 Adapter to rock the caps loose.

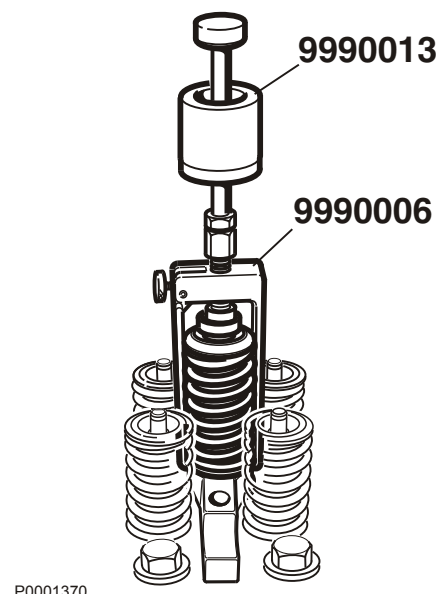


- 18 Use 9998264 Lifting tool to lift the camshaft.

### ⚠ CAUTION!

Cutting hazard! Protect your hands!

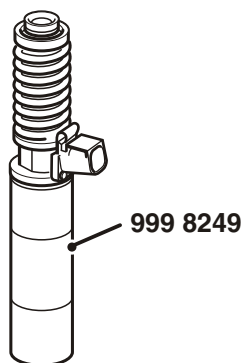
- 19 Remove the unit injector bolts.



- 20 Rock a unit injector loose using 9990006 Puller and 9990013 Slide hammer. Check that the seal washer (steel washer) comes out with the injector. If it is still in the copper sleeve, remove it using 885822 Magnetic pen.

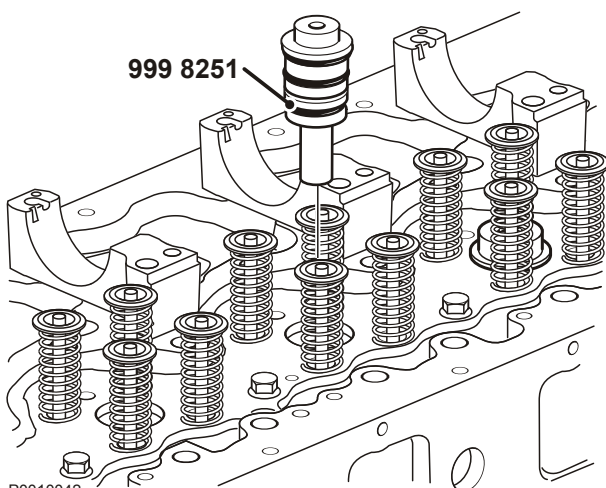
**NOTICE!** The seal washer must always be replaced when installing an injector.





P0010041

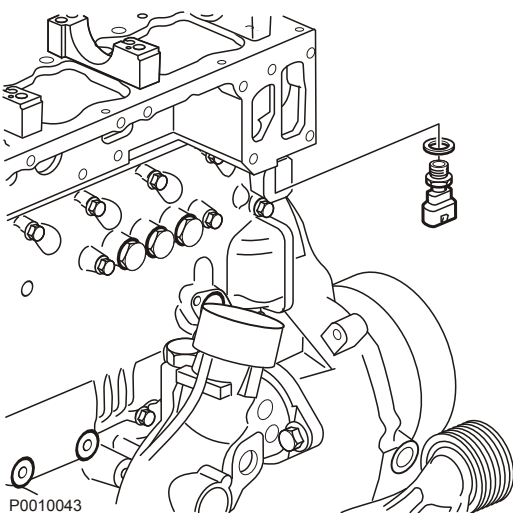
- 21 Put the injector in 9998249 Protective sleeve.



P0010042

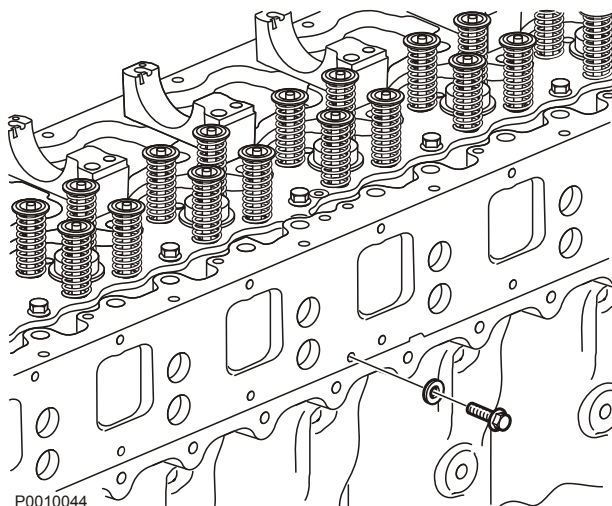
- 22 Insert 9998251 Protection plug in the cylinder head.

- 23 Remove the remaining injectors the same way.

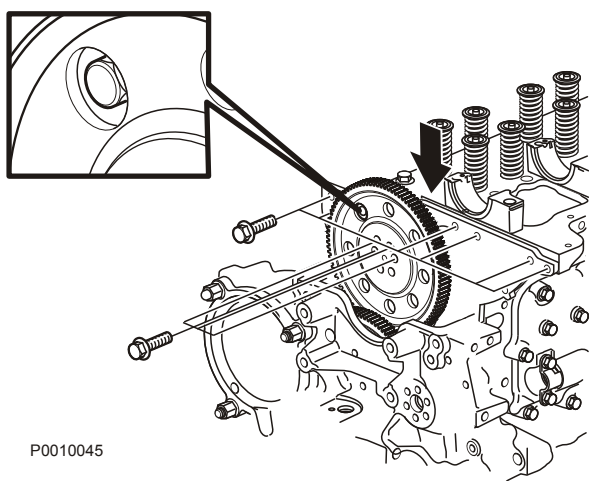


P0010043

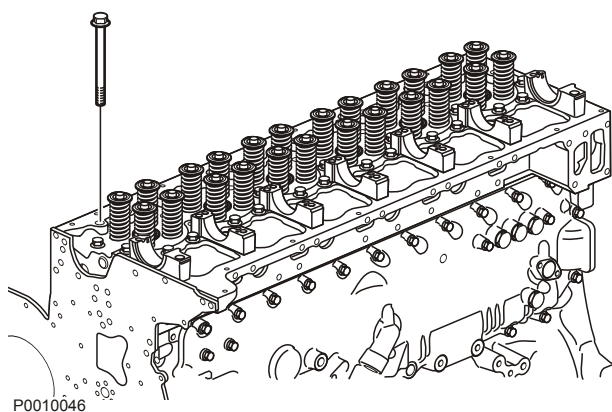
- 24 remove the coolant temperature sensor.



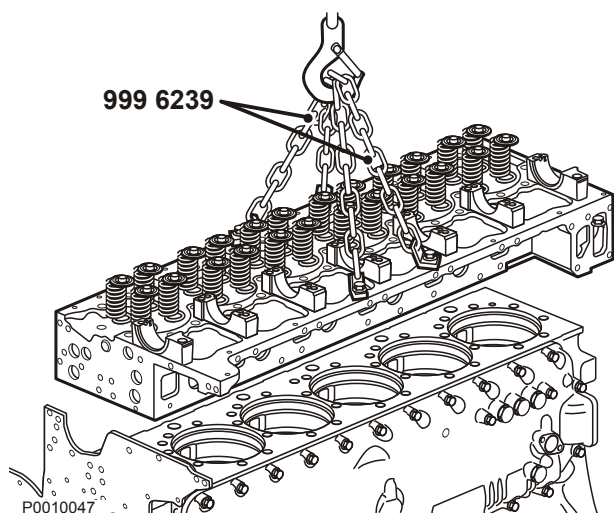
25 remove the bolt and washer.



26 Turn the crankshaft so that the timing gear is in the same position as illustrated. Remove the bolts that hold the intermediate plate against the cylinder head (6 pcs.). Remove the upper bolts from the timing gear (4 pcs.).



27 Remove the cylinder head bolts.



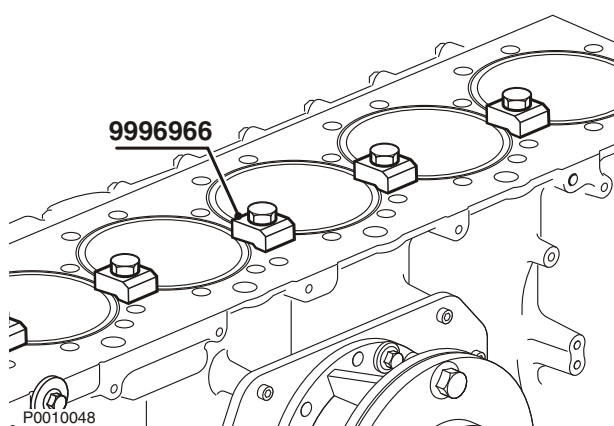
- 28 Install two 9996239 Lifting tool on the cylinder head and lift it away.

**NOTICE!** The timing gear sealant may make it necessary to carefully prise the cylinder head away until it is free.

Lower the cylinder head onto a clean surface.

**IMPORTANT!**

The sealing surface must not be damaged.



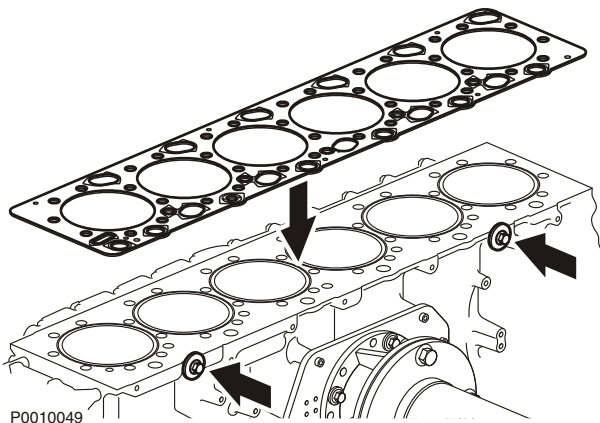
- 29 Remove the cylinder head gasket.  
Install 9996966 Press tool to keep the liners in place. Make sure the press tools are not able to damage the pistons if they are to be removed.

## Cylinder Head, Installation

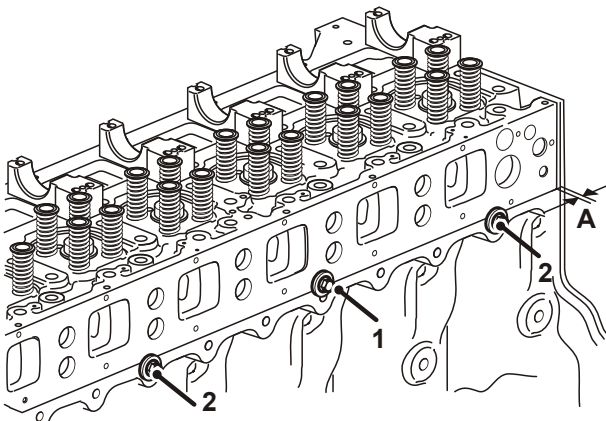
### Tools:

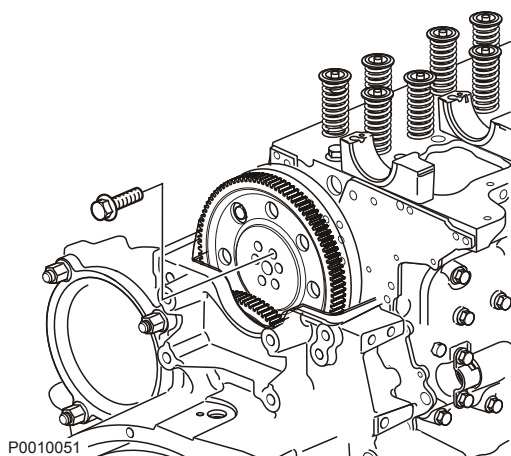
9990185 Lifting tool  
 9996400 Slide hammer  
 9998264 Lifting tool  
 9999696 Magnetic stand  
 9999683 Dial indicator (short probe)  
 885810 Fixture  
 9998601 Fixture  
 9998599 Cleaning kit  
 9998250 Sealing ring  
 9990156 Adapter  
 3883671 Protective sleeve  
 3883672 Protective sleeve

- 1 Check the liner height (refer to *Cylinder Liner, Installation page 140*) and clean the engine block and liner sealing surfaces.  
Clean the timing plate free from sealant.  
Dip all the cylinder head bolts in anti corrosion agent and let them run off through a net.
- 2 Thoroughly clean the cylinder head internally and externally. Also clean the fuel channels and unit injector copper sleeves. Install protection plugs immediately after cleaning.
- 3 Install a new cylinder head gasket and align it with the liners. Make sure the two bolts and washers are in place and tightened.
- 4 Apply sealant outside the timing plate groove (2 mm (0.08") wide bead). The cylinder head must be finally tightened 20 min after the application of sealant.

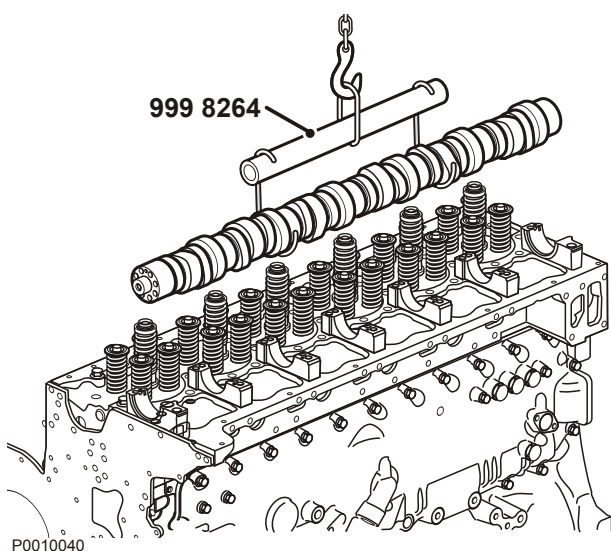
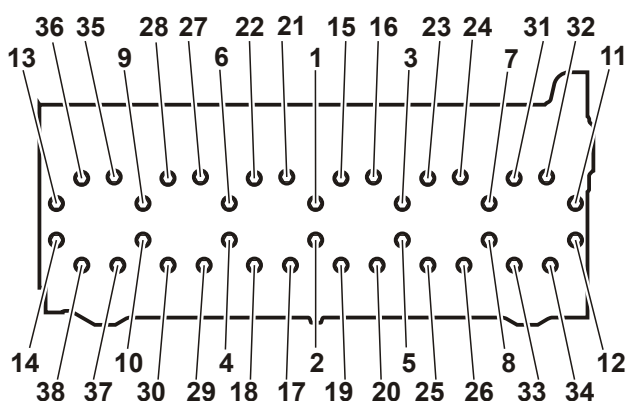


- 5 Make sure that the bolt and washer (1) are in place on the cylinder head. The bolt must only be tightened a few turns.  
Lower the cylinder head down onto the gasket. Leave a 5–10 mm (0.2–0.4") gap (A) to the timing plate.  
Make sure the washer (1) ends up outside the engine block edge. Then tighten the bolt so that the washer pulls the cylinder head sideways until it touches the two washers (2) on the engine block side.





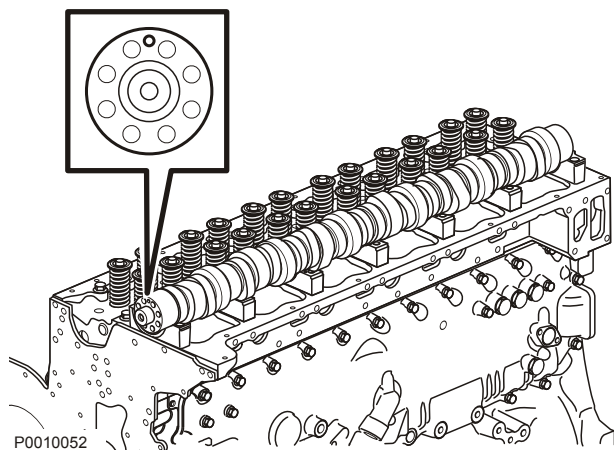
- 6 Install a bolt in the upper timing gear and tighten it so that the cylinder head is pulled toward the timing plate.  
Undo the bolt a little. The cylinder head is now in the correct position for tightening with the cylinder head bolts (the raised portions of the gasket will be flattened).  
Install all cylinder head bolts and tighten according to the chart (sequence, torque and angle tightening) in *Special Tightening Torques* page 8.  
When all the cylinder head bolts have been tightened, install the six bolts for the timing plate and tighten them.



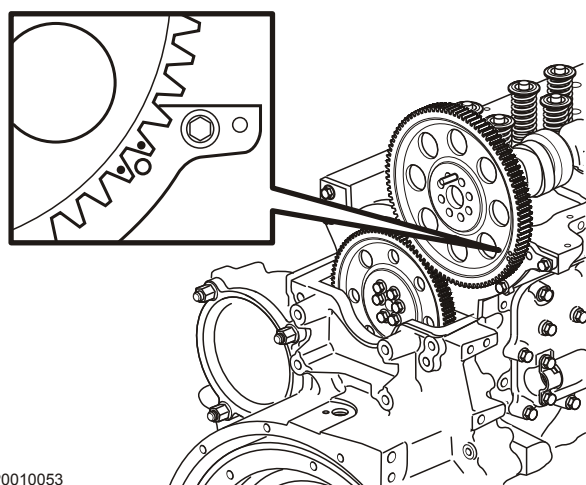
- 7 Check that the cam bearings are in position and fault free. Oil the cam bearings.  
Use 9998264 Lifting tool to lift the camshaft into position.

**CAUTION!**

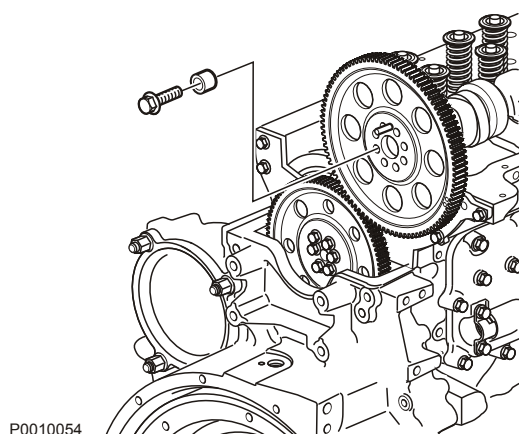
Cutting hazard! Protect your hands!



- 8 Rotate the camshaft so that the guide hole faces straight up.
- 9 Check that the cam bearings are fault free and correctly installed in the caps. Install the caps according to the markings. Install M10X80 bolts instead of the rocker arm bridge. Tighten the caps according to *Special Tightening Torques* page 8. Check that the camshaft can be rotated.

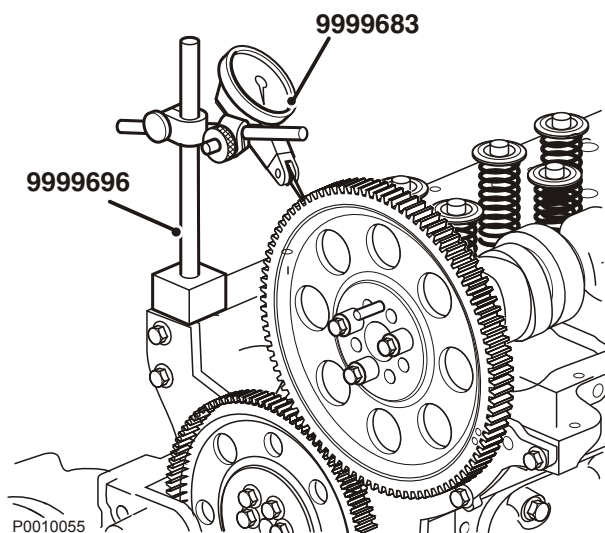


- 10 Check that the flywheel marking is at zero. Install the camshaft gear so that the locator pin aligns with the hole in the camshaft and the gear marking against the hole in the timing plate.

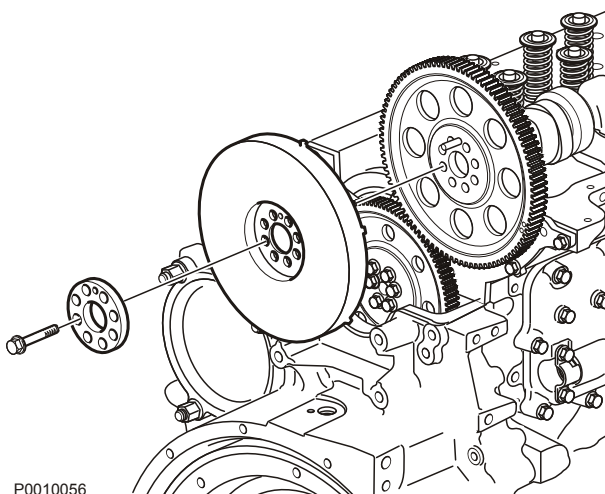


- 11 Install at least three bolts with suitable spacers in the gear and tighten them.

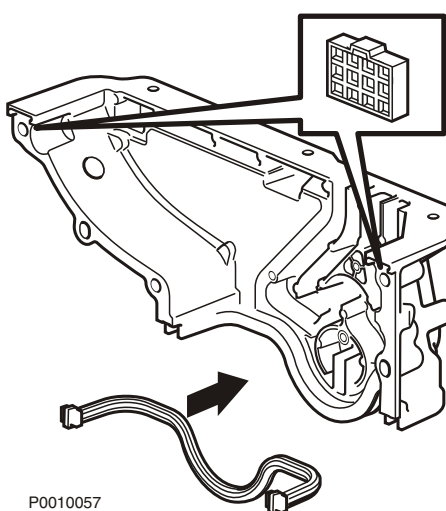




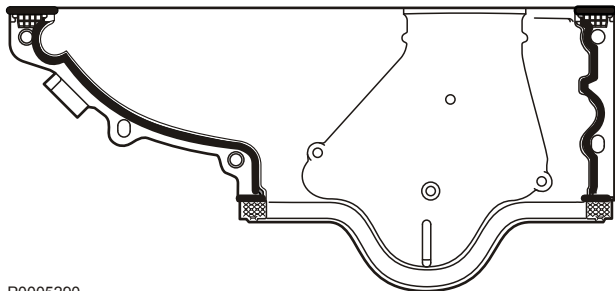
- 12 Use 9999696 Magnetic stand and 9999683 Dial indicator (short probe) to check gear lash measurement. Hold the intermediate gear secure and rotate the camshaft gear back and forth to check the gear lash; refer to *Technical Data* page 27. If the measurement must be adjusted, refer to *Timing Gear, Installation* page 144.



- 13 Remove the bolts and spacers from the camshaft gear. Install the vibration damper, bolts and washer. Torque according to *Technical Data* page 27.

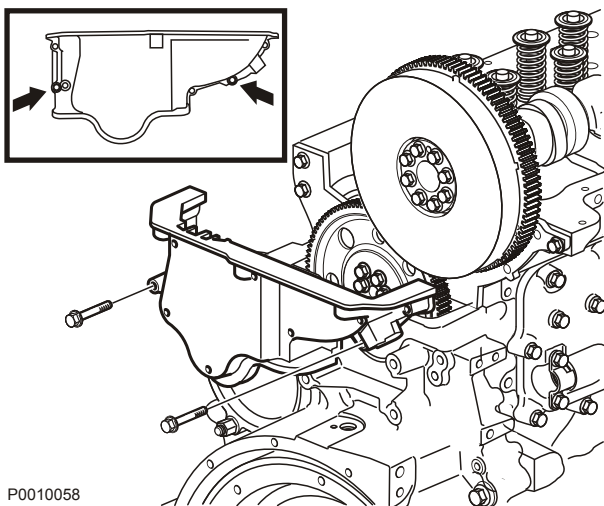
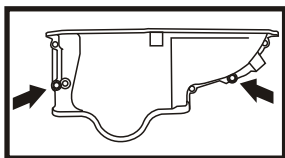


- 14 Clean the upper timing cover. Install new rubber seals on the cover.



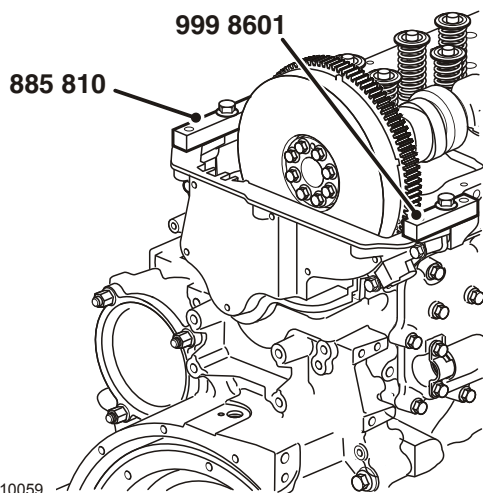
P0005290

- 15 Apply a 2 mm (0.08") bead of sealant as illustrated (must be torqued within 20 mins.).



P0010058

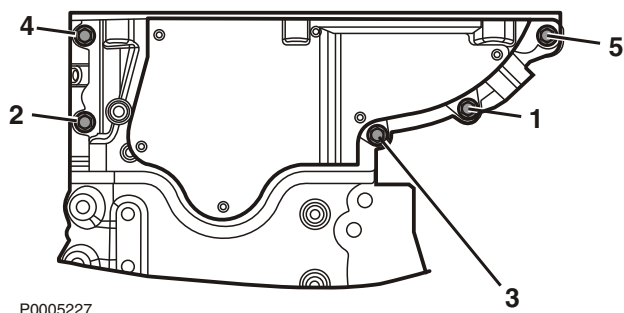
- 16 Install the cover with the two bolts located in the oval holes. Torque to **4 Nm** (3 lbf.ft).



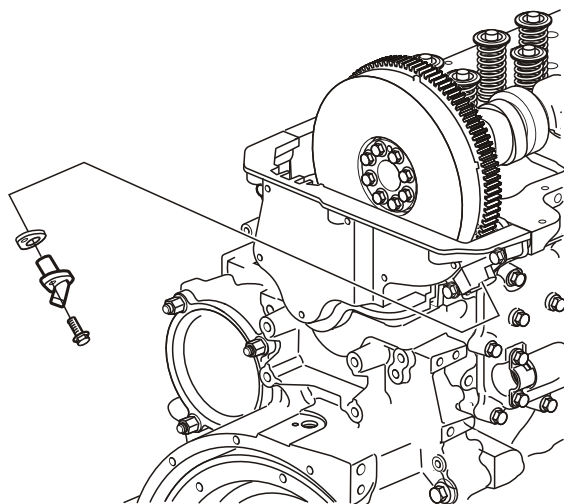
P0010059

- 17 Fit 885810 Fixture and 9998601 Fixture. Press down the cover so that it arrives at the same height as the upper side of the cylinder head.

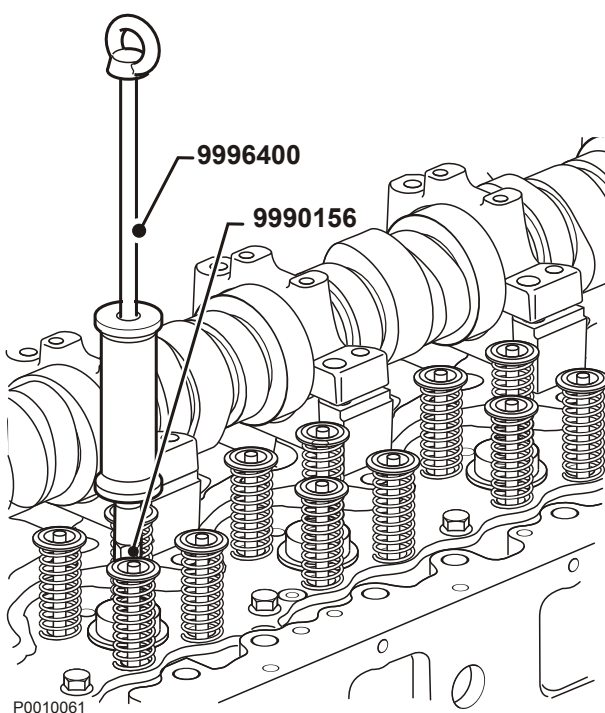




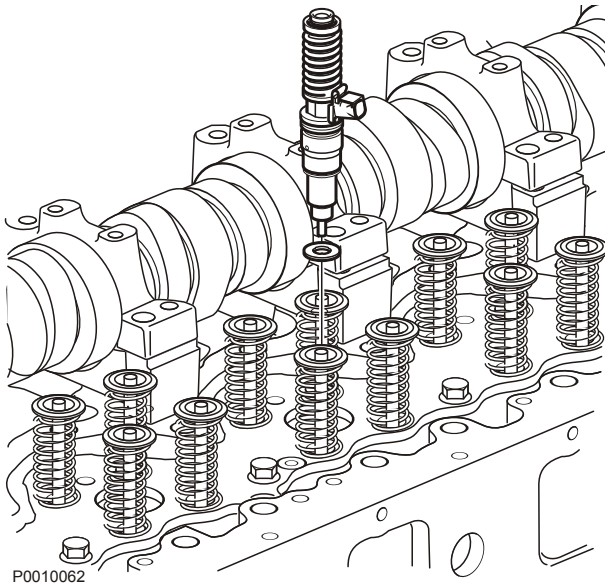
- 18 Install the remaining bolts and tighten them in sequence according to *Special Tightening Torques page 8*.  
Remove the press tools.



- 19 Install the camshaft sensor with a new seal and heat shield; refer to *Sensors, Adjustment page 113*.



- 20 Remove the protective plug for one unit injector (where necessary use 9990156 Adapter and 9996400 Slide hammer).  
Clean the copper sleeve with 9998599 Cleaning kit. Protect the fuel channel with two 9998250 Sealing ring.



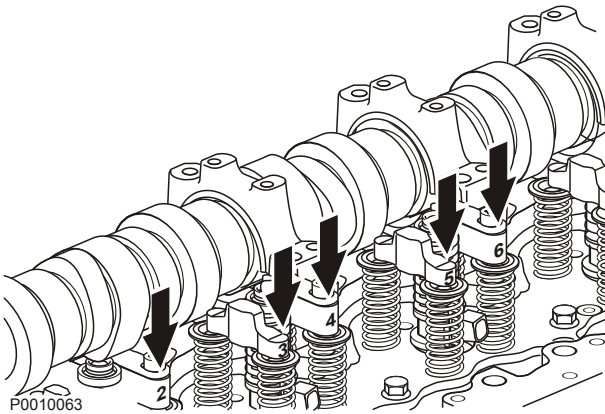
- 21 Remove the unit injector from the protective sleeve. Replace the O-rings on the unit injector by using 3883671 Protective sleeve and 3883672 Protective sleeve. Install a new steel washer on the injector sealing surface

### IMPORTANT!

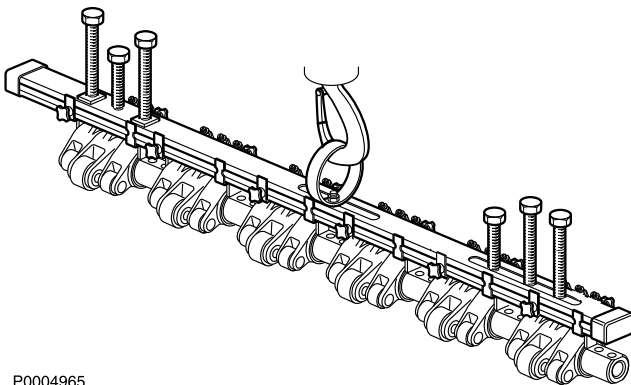
The steel washer must be replaced new every time an injector is installed.

Install the injector and injector yoke. Turn the injector so that the wiring connections are exactly opposite the valve springs. Install the retaining bolt and torque it.

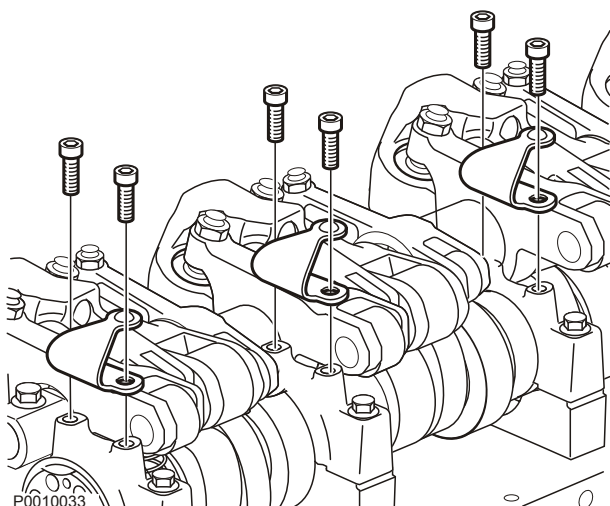
- 22 Install the remaining unit injectors in the same way.



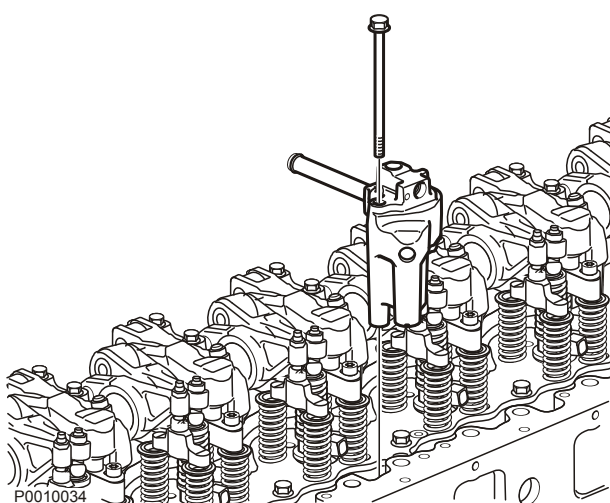
- 23 Install the valve yoke according to the marking made at removal.



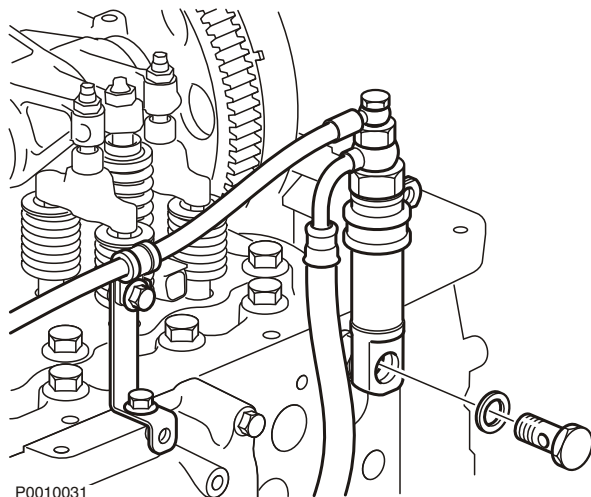
- 24 Remove the extra bolts located in the rocker arm bridge position. Lubricate the valve yokes and the unit injector ball seats. Lift the rocker arm bridge into place. Guide all rocker arms so they arrive in the correct positions. Make sure that the exhaust rocker arm pistons and the adjuster screw balls are in place. Remove the lifting tool from the rocker arm bridge. Install the rocker arm shaft bolts. Check that the valve yokes are positioned correctly on the valve stem. Tighten the bolts alternately so that the rocker arm shaft is not bent. Make sure the shaft guides the locator sleeves on the bearing caps. Torque according to *Special Tightening Torques* page 8.



- 25 TAD1350-55GE:  
Install the EGR rocker arm springs. Make sure the springs are positioned correctly on the rocker arm ball tappet, but do not tighten the bolts (the bolts are tightened after valve adjustment).



- 26 Install the valve and rocker arm lubrication oil pipe with new seals.
- 27 Adjust the valves and unit injectors; refer to *Valves and Unit Injectors, Adjustment* page 177.
- 28 Install the inlet manifold; refer to *Inlet Manifold, Change* page 269.

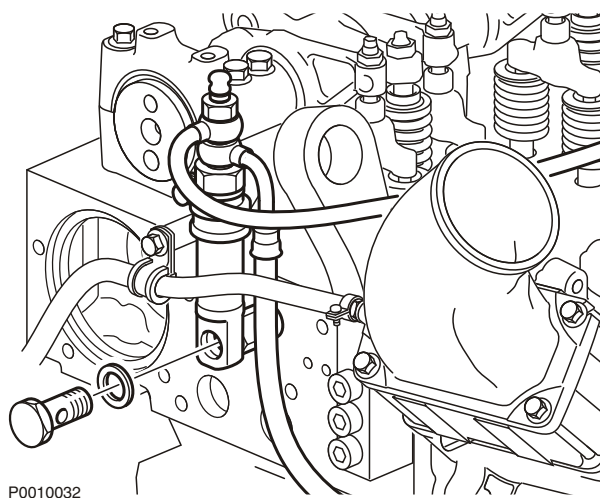


- 29 Install the fuel lines on the cylinder head with new seals.

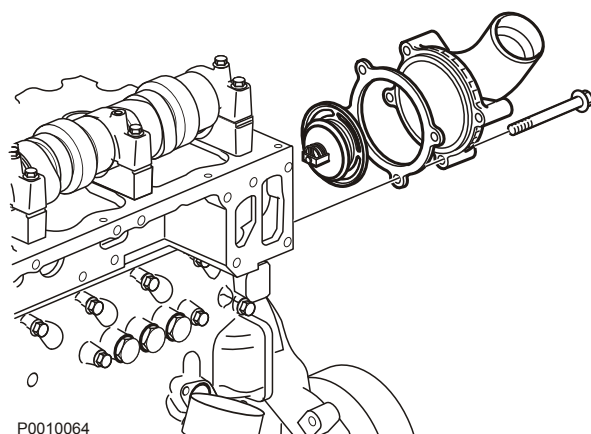
**IMPORTANT!**

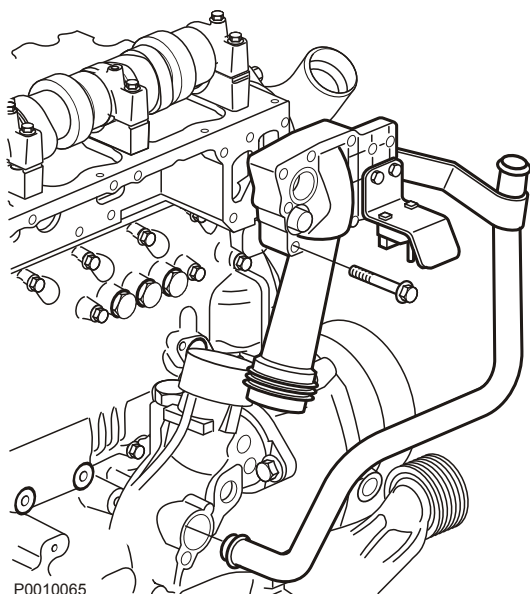
Take great care to keep fuel unions clean. Even minimal amounts of dirt in the fuel system can cause engine breakdown.

- 30 Install the coolant temperature sensor if it was removed.

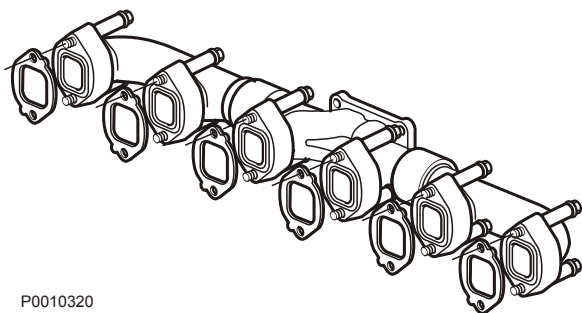


- 31 Install the thermostat and cover with a new seal.

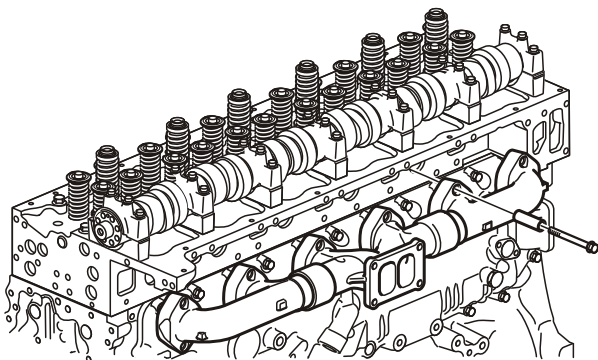




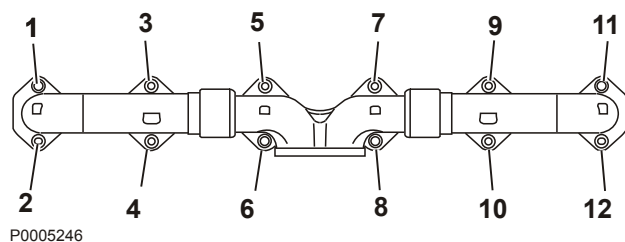
- 32 Install the water pipes with new seals.

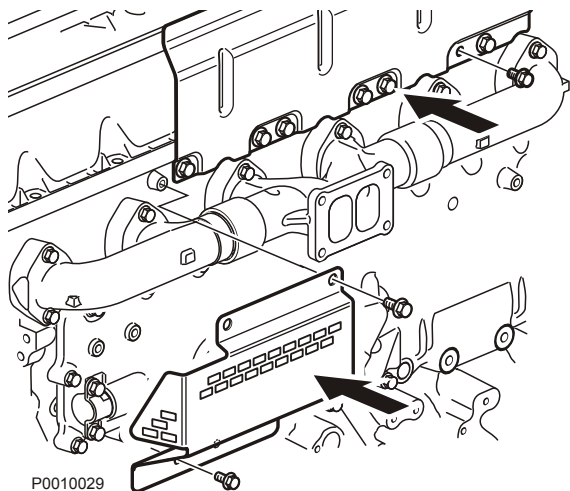


- 33 Clean the cylinder head exhaust manifold sealing surface. Clean the manifold gasket plane and blow any carbon flakes out of the manifold. Bolt the new exhaust manifold gaskets onto the manifold (the gaskets are marked Up and Manifold side).

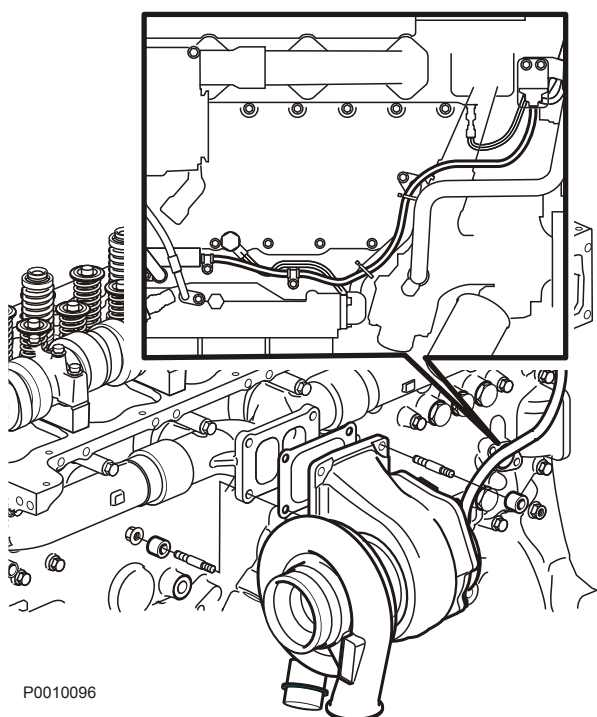


- 34 Lift the manifold into position. Tighten the bolts. Make sure the gaskets do not come awry. Tighten according to *Special Tightening Torques* page 8.





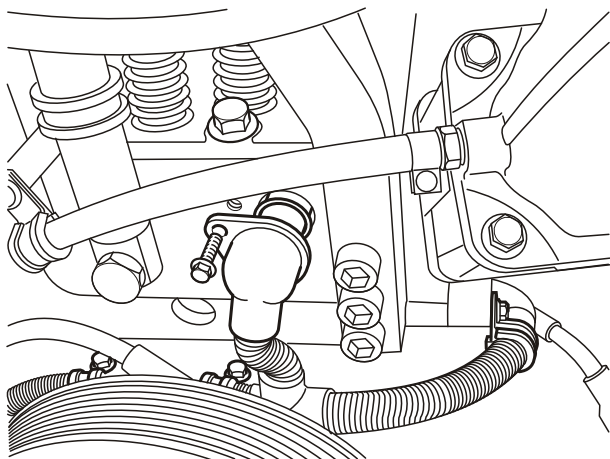
35 Install the heat shield.



36 Clean the turbocharger gasket planes. Fit a new gasket to the exhaust manifold and install the turbocharger. Install spacers and tighten the bolts. Install the oil return pipe with new seals. Fill the turbocharger with clean engine oil before the pressure hose is installed on the turbocharger. Install the hose and actuator heat shield on the turbocharger and clamp it as illustrated.

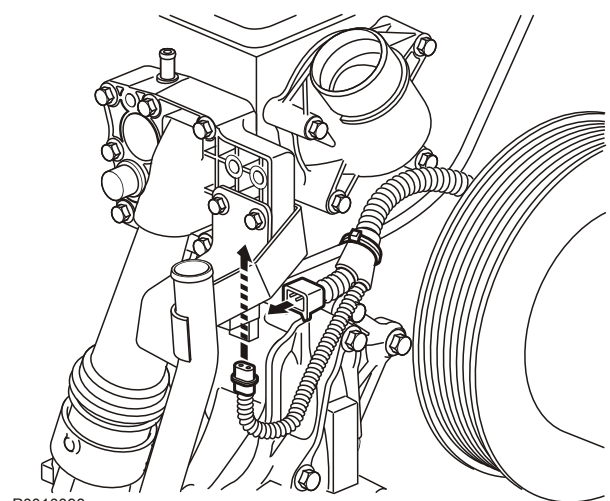
**NOTICE!** Do not tighten too hard.





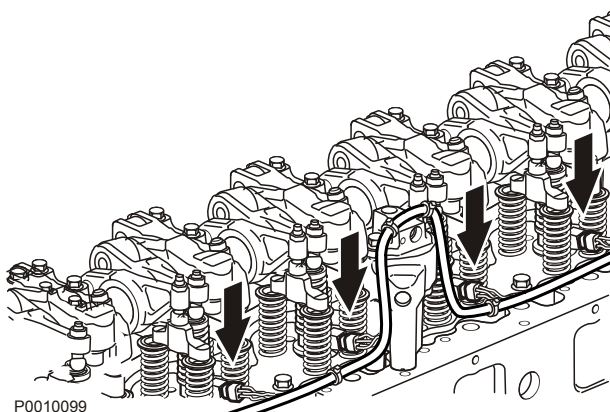
P0010097

- 37 Install a new O-ring on the wire harness to seal against the cylinder head. Install the wire harness. Begin by running the part for the unit injectors through the hole in the front side of the cylinder head. Make sure the O-ring is not damaged when it is pressed into the hole in the cylinder head. Tighten the bolt. Attach the wire harness with two clamps behind the belt pulley and one clamp on the inlet manifold.



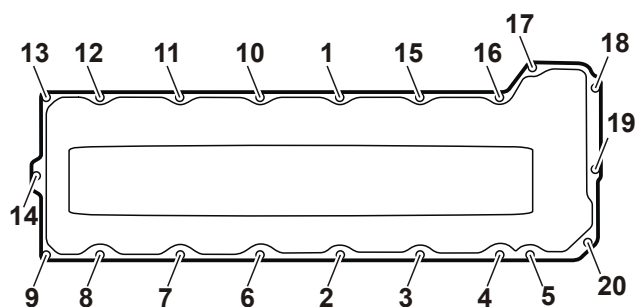
P0010098

- 38 Install the connectors to the temperature sensor and wastegate control valve. Secure the wire harness with cable ties. Make sure the wire harness does not touch the rear of the belt pulley.



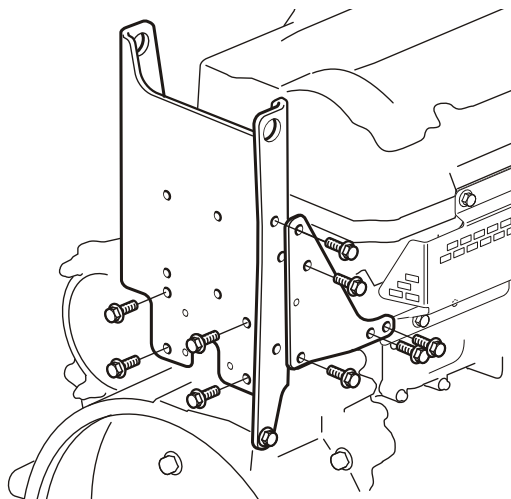
P0010099

- 39 Install the connectors to the unit injectors and oil valve. Clamp the wire harness under the valve cover with original cable ties (these are heat and oil resistant).



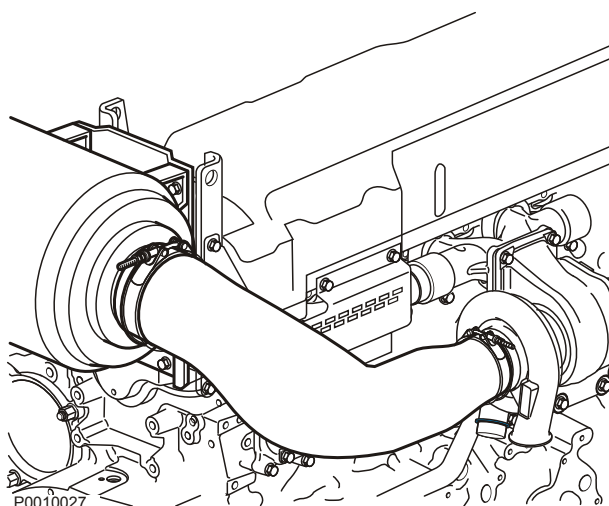
p0005236

- 40 Check to see if the valve cover gasket needs to be changed.  
Install the valve cover and tighten according to *Special Tightening Torques* page 8.
- 41 The remaining wire harness is secured after the engine fixture has been removed.



P0010028

- 42 Install the rear lifting eye.



P0010027

- 43 Install air filters with holders and turbocharger pipes.
- 44 Install new oil filters and fill with engine oil.



## 21-3 Cylinder Liner, Pistons

### Cylinder Liner and Pistons, Inspection

**Clean the cylinder liners carefully before inspection and measurement.**

#### IMPORTANT!

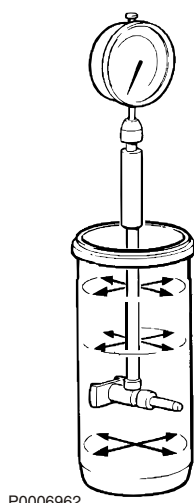
Cylinder liners and pistons are classed together. This means that cylinders and liners must not be mixed.

The piston and cylinder liner sets are only available as a single, complete unit.

#### Cylinder Liner

Measurement of cylinder liner wear can be done with the liner installed in the cylinder block.

**NOTICE!** The cylinder liners must be taken out of the engine block, to do a careful crack check.



P0006962

- 1 Measure the cylinder liners with a cylinder indicator. In order to obtain the greatest possible accuracy in the wear measurement, the cylinder liner must first be set up with a gauge ring or micrometer. Use the original diameter of the cylinder liner as the base value.
- 2 Measure the cylinder liner at top and bottom dead centers, and at several places vertically. At each measurement location, measurement must be lengthwise and crosswise in relation to the engine.
- 3 If wear is greater than 0.45–0.50 mm, a new complete lining kit must be used (piston, liner, piston rings, piston pin and seals). Oil consumption also affects when cylinder liners must be changed.
- 4 Remove the cylinder liner and do a crack check. Be specially careful when checking the liner collars. The Magnaflux method may be used for this check.

#### Pistons

- 5 Check for worn piston ring grooves, damaged retainer ring grooves, cracks and other damage to the pistons.  
If the piston has deep scratches on its skirt, the piston (liner kit) must be scrapped. The same applies if the piston has one or more cracks in the piston pin hole or in the bottom of the combustion chamber.  
Crack tests must be done using the chalk powder method.

## Connecting Rod, Check

**Important consideration when removing/installing fracture-split connecting rods.**

### Installing a NEW connecting rod:

Carefully fix the connecting rod in a vise with soft jaw pads.

Undo the connecting rod bolts a few turns and carefully tap the bearing cap with a plastic faced hammer until it loosens.

The split line can be difficult to find when the connecting rod is assembled.

When the cap is separated from the connecting rod, it may occur that a chip is missing or comes loose. This does not affect the function of the connecting rod adversely.

Handle the connecting rod and bearing cap carefully. If any strike marks occur on the split line, this may affect strength after torquing.

### IMPORTANT!

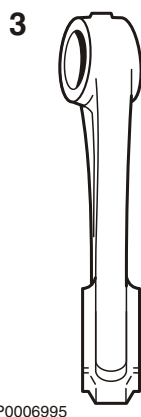
If the connecting rod or bearing cap are damaged, change the connecting rod.

## Connecting Rod Bushing, Check up

- 1 Check the connecting rods for cracking, straightness and twist before any piston pin bush replacement. Scrap the connecting rod if it is cracked, bent or twisted.  
When the piston pin bush is changed, the bush must be machined (trapezoid piston pin end).  
When the clearance is correct, an oiled piston pin should slowly slide through the bush under its own weight.

### IMPORTANT!

Regarding max. allowed straightness and twist deviations, refer to *Technical Data* page 27.



- 2 Use a new piston pin and measure the straightness of the connecting rod, using a fixture.
- 3 Measure connecting rod twist.

## 21-4 Valve Mechanism

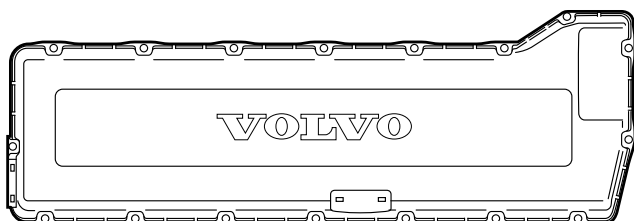
### Valves and Unit Injectors, Adjustment

TAD1340VE, TAD1341GE, TAD1341VE,  
TAD1342GE, TAD1342VE, TAD1343GE,  
TAD1343VE, TAD1344GE, TAD1344VE,  
TAD1345GE, TAD1345VE

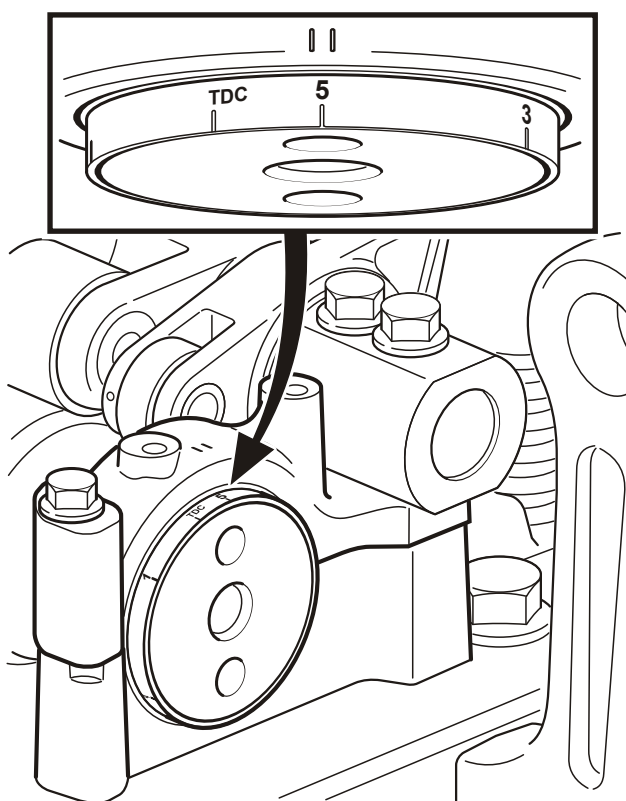
Tools:

9993590 Rotation tool

- 1 Remove the valve cover.



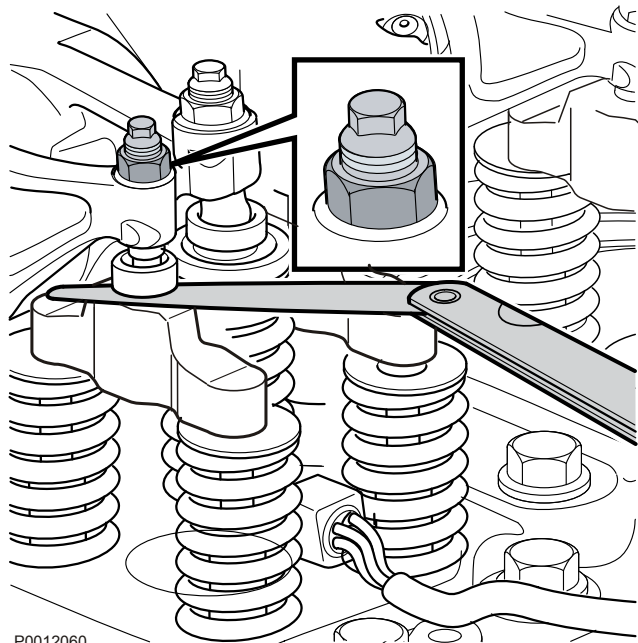
P0004806



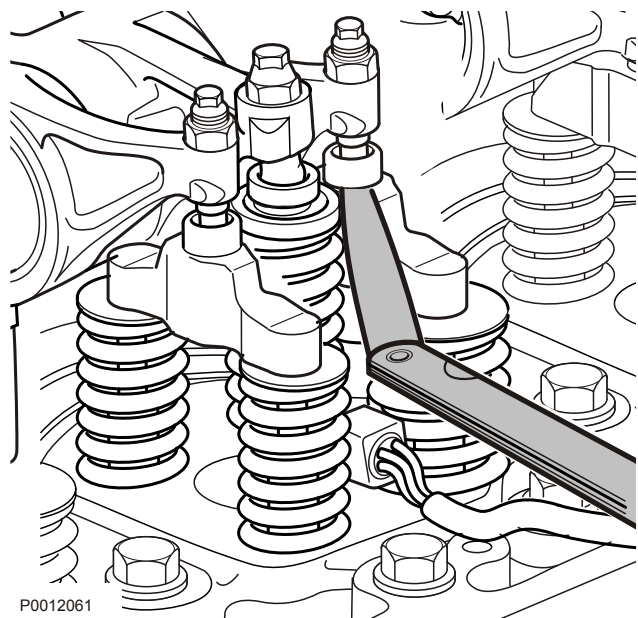
P0002568

- 2 Rotate the crankshaft with tool 9993590 Rotation tool until the camshaft mark is located centrally between the marks on the bearing cap (the marks for the cylinder to be adjusted).

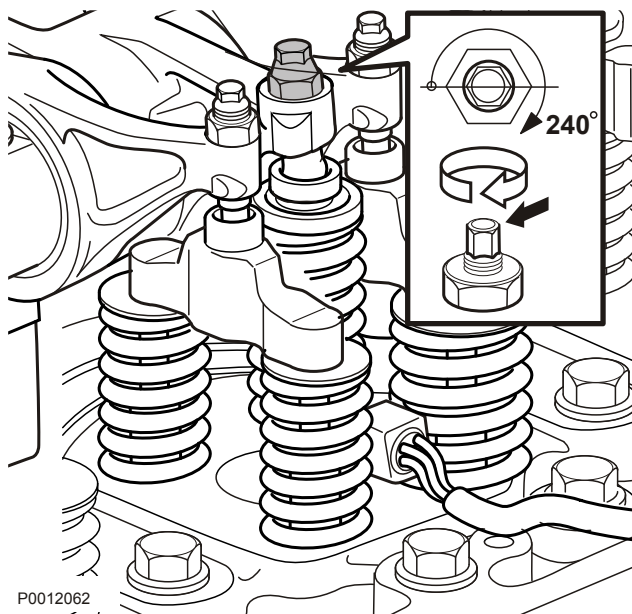
**NOTICE!** It is important that the line marked on the camshaft is centered between the two marks on the bearing cap when adjustment is carried out.



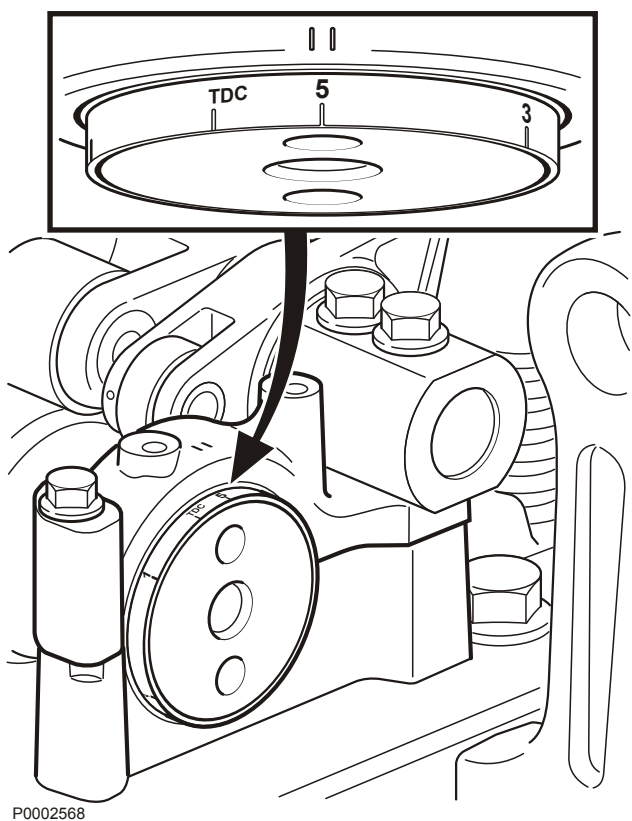
- 3 Adjust the valve play for the inlet valves to **0.2 mm** (0.0079") with the aid of a feeler gauge. Tighten the lock nut.



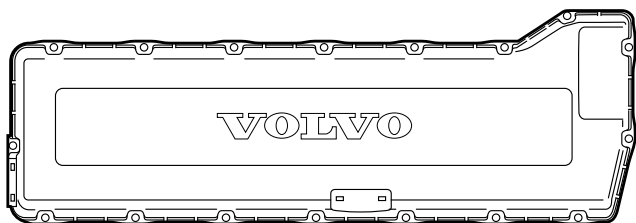
- 4 Check the valve play for the exhaust valves with the aid of a feeler gauge. The play must be **0.8 mm** (0.0315"). Tighten the lock nut.



- 5 Adjust the unit injector setting by loosening the adjuster screw until play is attained on the injector.  
Adjust the screw until the play disappears (by feel until the roller can no longer be rotated).  
Tighten the adjuster screw a further 240° (4 sides of the hexagon). Tighten the lock nut.



- 6 Rotate the crankshaft to the next camshaft mark and adjust the remaining valves in the same manner.



P0004806

- 7 Check the valve cover gasket. Change as necessary.  
Install the valve cover.
- 8 Remove tool 9993590 Rotation tool from the toothed rim.

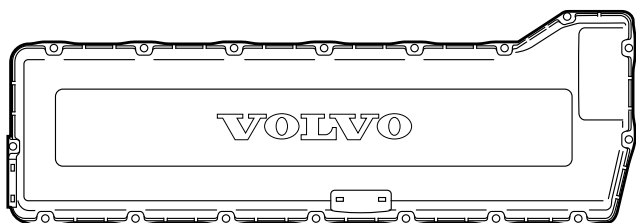
### Valves and Unit Injectors, Adjustment

TAD1350GE, TAD1351GE, TAD1352GE,  
TAD1353GE, TAD1354GE, TAD1355GE

Tools:

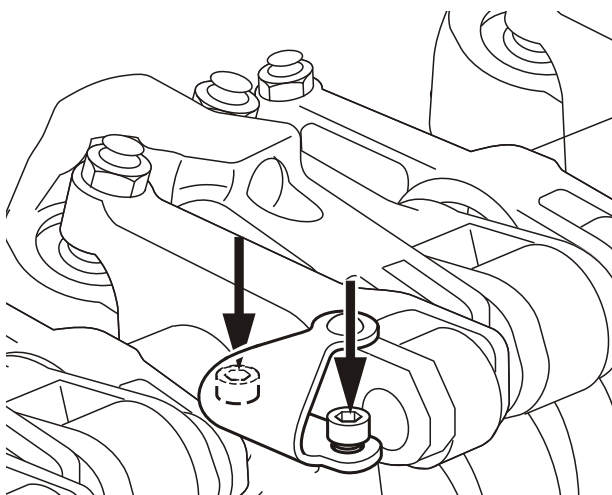
9993590 Rotation tool

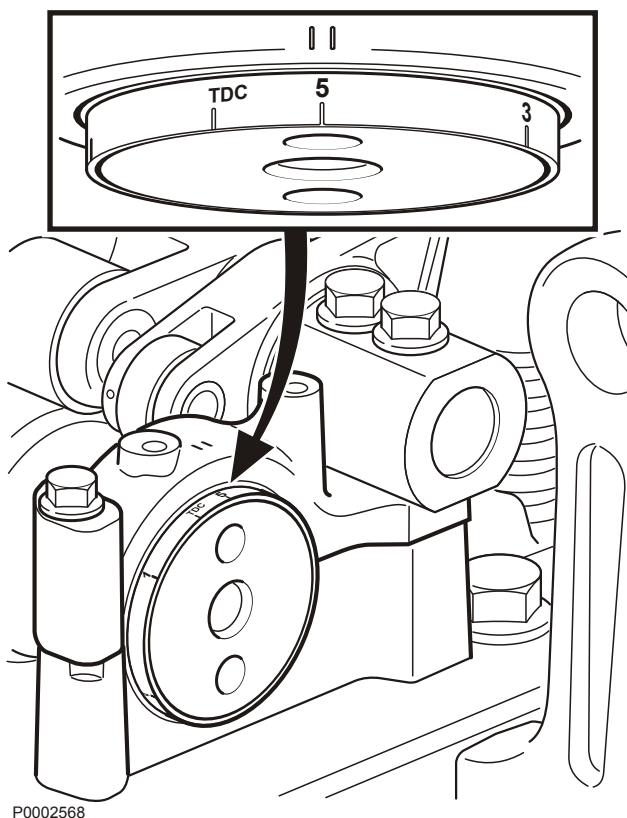
- 1 Remove the valve cover.



P0004806

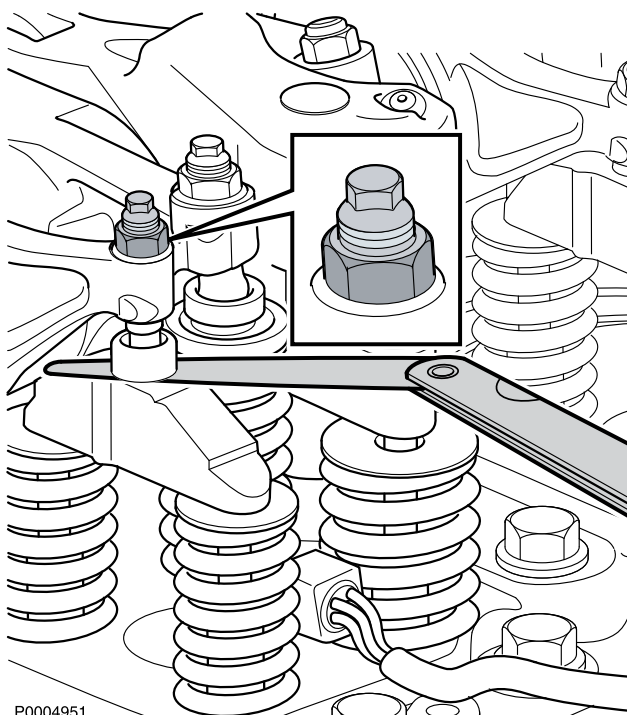
- 2 Loosen all hexagon socket cap screws to the EGR rocker arm springs.



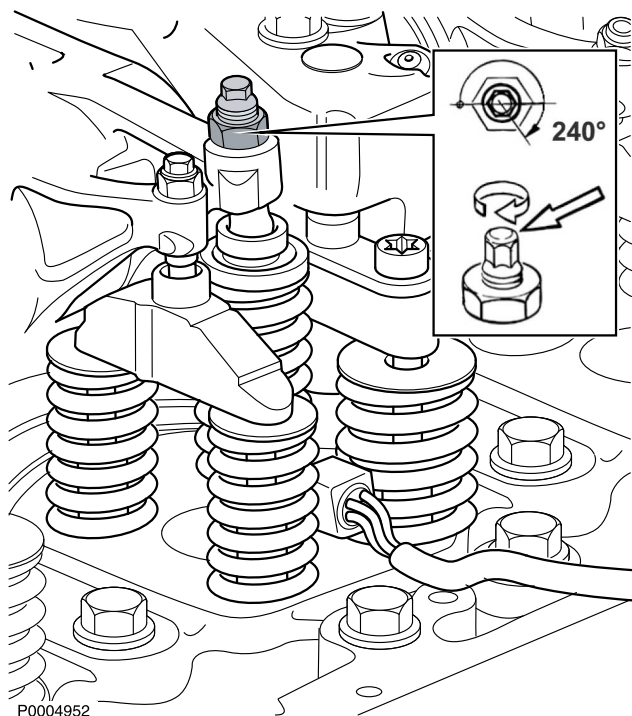


- 3 Rotate the crankshaft with tool 9993590 Rotation tool until the camshaft mark is located centrally between the marks on the bearing cap (the marks for the cylinder to be adjusted).

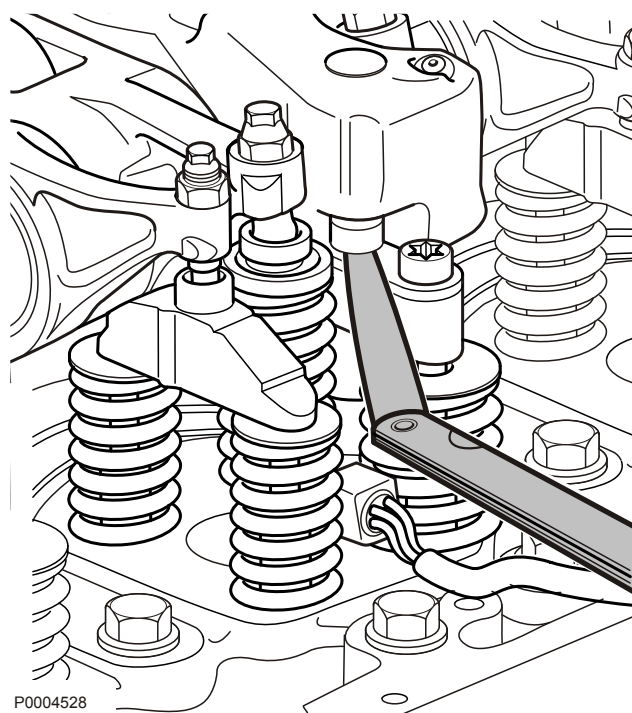
**NOTICE!** It is important that the line marked on the camshaft is centered between the two marks on the bearing cap when adjustment is carried out.



- 4 Adjust the valve play for the inlet valves to **0.2 mm (0.0079")** with the aid of a feeler gauge.

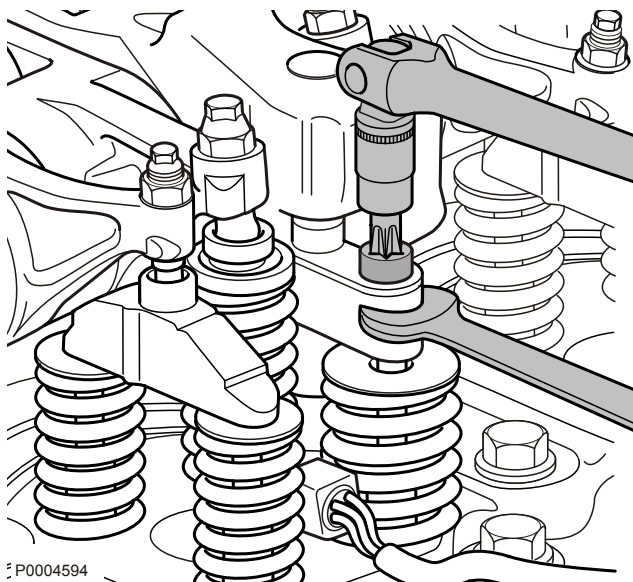


- 5 Adjust the unit injector setting by loosening the adjuster screw until play is attained on the injector. Adjust the screw until the play disappears (by feel until the roller can no longer be rotated). Tighten the adjuster screw a further 240° (4 sides of the hexagon). Tighten the lock nut.



- 6 Check the valve play for the exhaust valves with the aid of a feeler gauge. The play must be **0.8 mm** (0.0315").



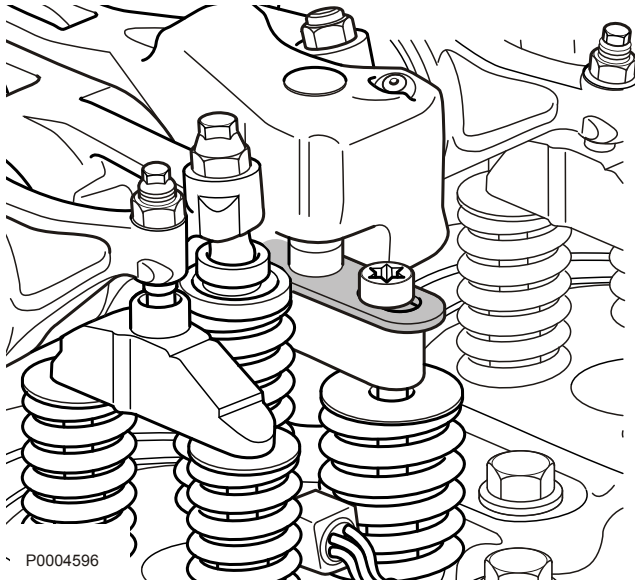


- 7 **NOTICE!** Ensure that no loose parts fall into the camshaft drive.

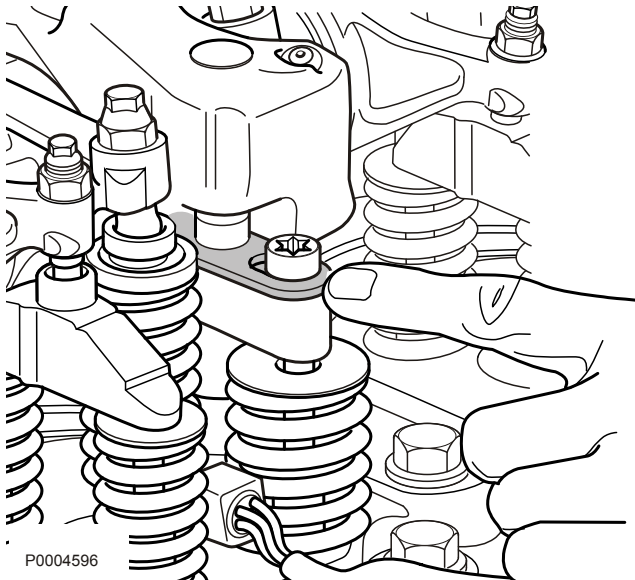
**NOTICE!** Use a wrench on the yoke as a counterhold during removal.

If the shims must be replaced, undo the screw on the yoke while holding the yoke fast with a wrench so that the valves are not bent.

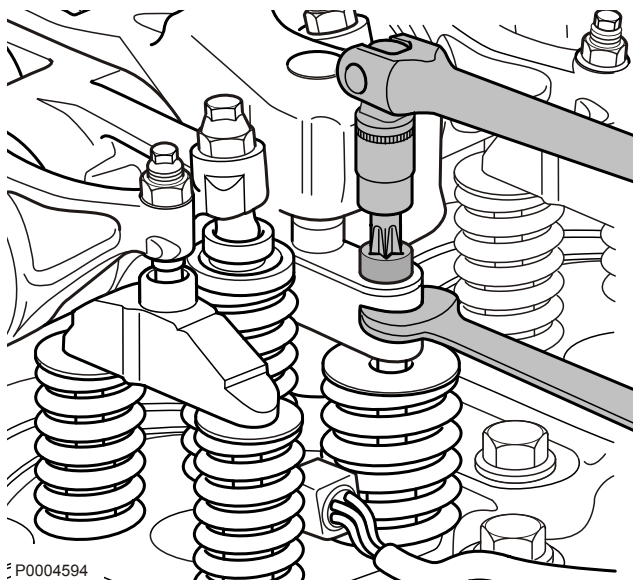
- 8 When replacing shims, press them home firmly.



Example showing incorrectly installed shims.

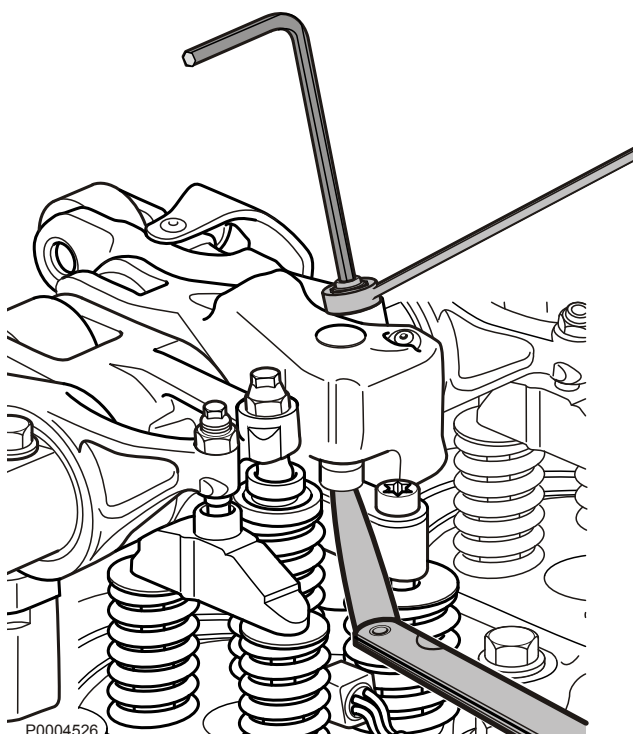


Example showing correctly installed shims.

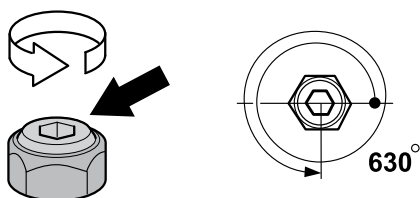


- 9 **NOTICE!** Use a wrench on the yoke as a counterhold also when tightening.

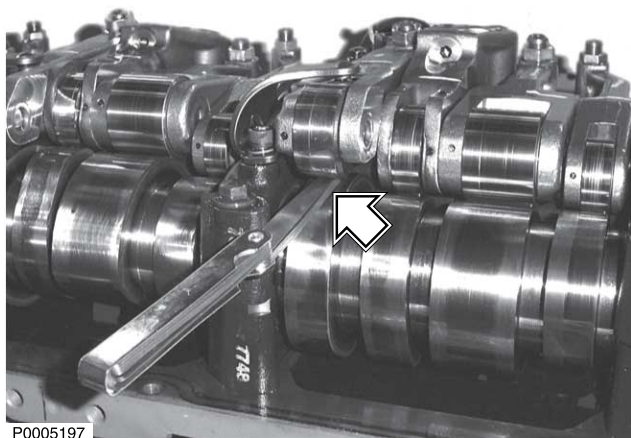
Tighten the shims with a wrench, and hold the yoke fast so that the valves are not bent. Using a feeler gauge, check that the play is **0.8 mm (0.0315")**.



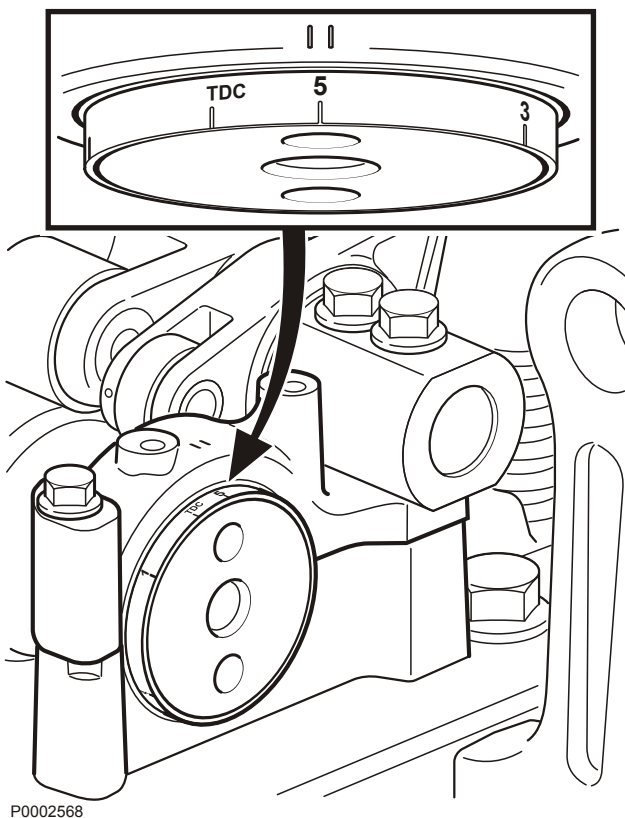
- 10 Allow the feeler gauge to remain in place after adjustment and adjust the EGR rocker arm by loosening the locknut and adjusting the screw until no play is attained. Check by rotating the rocker arm roller at the camshaft.



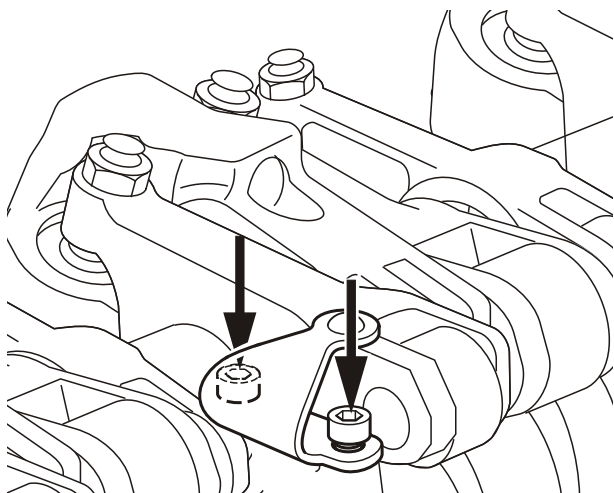
- 11 Undo the adjuster screw 1 and 3/4 turns (630°). Tighten the lock nut. Remove the feeler gauge from the exhaust valve.



- 12 Where necessary, check the EGR rocker arm adjustment with a feeler gauge. Check the play between the camshaft and the roller on the EGR rocker arm. The play must be between **3.7 mm (0.146")** and **3.9 mm (0.154")**.

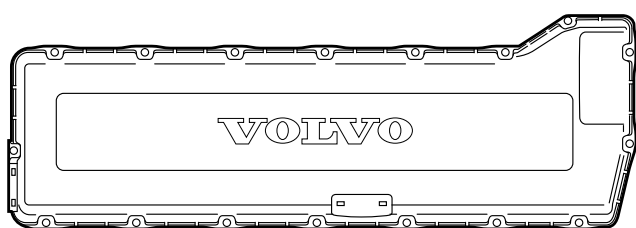


- 13 Rotate the crankshaft to the next camshaft mark and adjust the remaining valves in the same manner.



- 14 Tighten the retaining screws to the EGR rocker arm springs.

**NOTICE!** Ensure that the springs position correctly on the pressure points.



P0004806

- 15 Check the valve cover gasket. Change as necessary.  
Install the valve cover.
- 16 Remove tool 9993590 Rotation tool from the toothed rim.

## Valve Guides, Inspection

Tools:

9989876 Dial indicator

9999696 Magnetic stand

### Cylinder head removed

Refer to removal in 21-1, *Cylinder Head, Change*.

- 1 Remove the valve stem seals from the valve guides.

2

#### **IMPORTANT!**

The cylinder head must not be put down so its entire weight rests on the valve guides (see illustration).

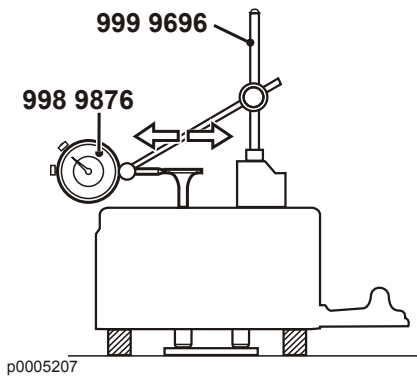
Put the cylinder head on the bench with the valve discs facing upwards.

- 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 tool 9989876 Dial indicator and tool 9999696 Magnetic stand, so that the dial indicator tip is touching the valve disc edge.

Move the valve sideways, in the direction of the exhaust or inlet duct. 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 page 27*.



p0005207

## Valve Guides, Replacing

Cylinder head removed.

**NOTICE!** If the valve seats must also be changed, this must be done before the valve guides are removed.

### CAUTION!

Risk of eye injury. Eye protection required.

#### Option 1

Tools:

9809726 Pneumatic hydraulic pump

9809729 Hydraulic cylinder

9990176 Press tool

9996159 Adapter

88800147 Drift

88800062 Drift

#### Optional tools

Tools:

9992670 Hand pump

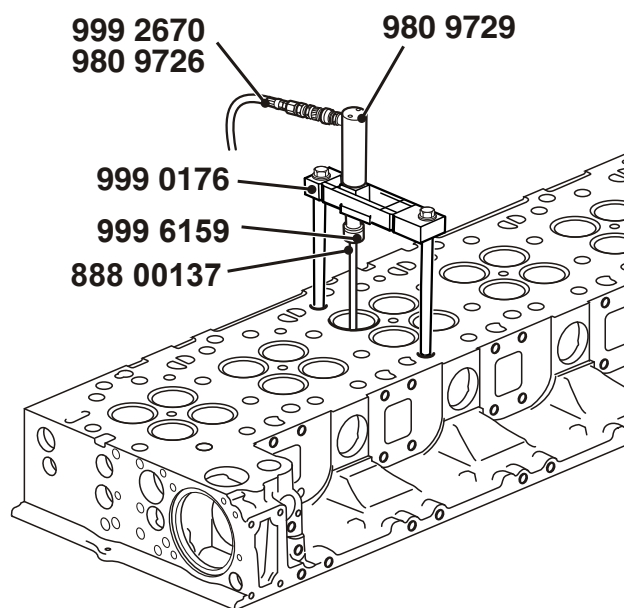
Note: 9992670 is alternative to 9809726.

#### Removal

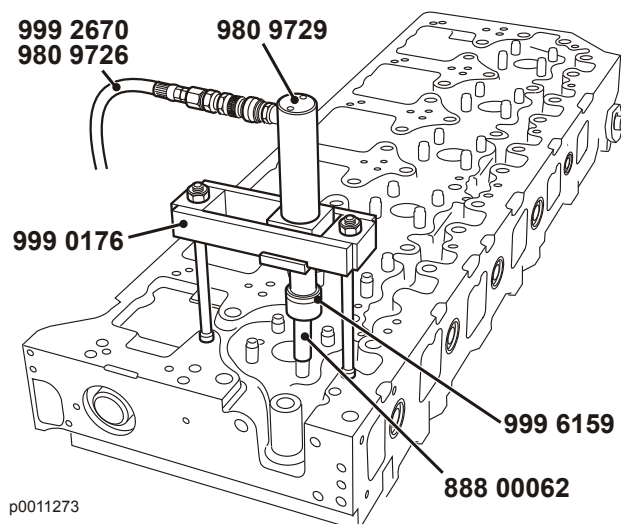
- 1 Install tool 9990176 Press tool into the cylinder head retaining bolt holes.

**NOTICE!** Put washers between the nuts and the cylinder head plane.

- 2 Tighten the nuts of the tool.
- 3 Install tool 9996159 Adapter in the hydraulic cylinder.
- 4 Fit tool 9809729 Hydraulic cylinder into tool 9990176 Press tool and press out the valve guide using tool 88800147 Drift and 9809726 Pneumatic hydraulic pump, alternatively 9992670 Hand pump.
- 5 Press the other valve guides out in the same way.



p0003637



## Installation

- 6 Heat the cylinder head with hot water while cooling the valve guides with e.g. carbon dioxide snow.  
Lubricate the cylinder head valve guides with engine oil.

### IMPORTANT!

Wear protective goggles when pressing.

- 7 Press in the valve guide for the inlet valve using tool 88800062 Drift. Press in the exhaust valve guide using the same tool.
- 8 Press until the tool bottoms against the cylinder head plane.
- 9 Remove the tool from the cylinder head.

### IMPORTANT!

After the valve guides have been changed, the cylinder head must be cleaned carefully to prevent dirt particles from getting into the fuel and oil ducts. Contamination may cause failure or malfunction of the unit injectors.

### Option 2

Tools:

9992000 Handle  
88800147 Drift  
88800062 Drift

**NOTICE!** If the valve seats must also be changed, this must be done before the valve guides are removed.

### CAUTION!

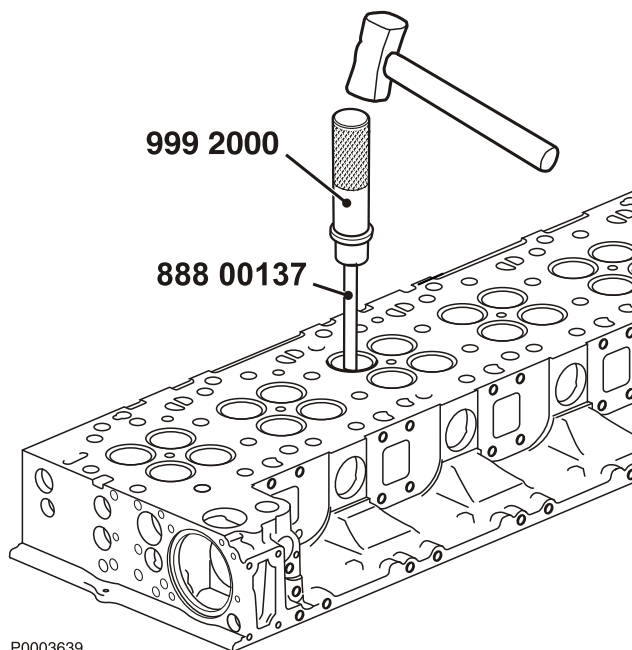
Risk of eye injury. Eye protection required.



## Removal

**NOTICE!** Take out the valve guides from beneath the cylinder head.

- 1 Tap out the valve guides with tool 88800147 Drift together with 9992000 Handle.
- 2 Tap the other valve guides out in the same way.



P0003639

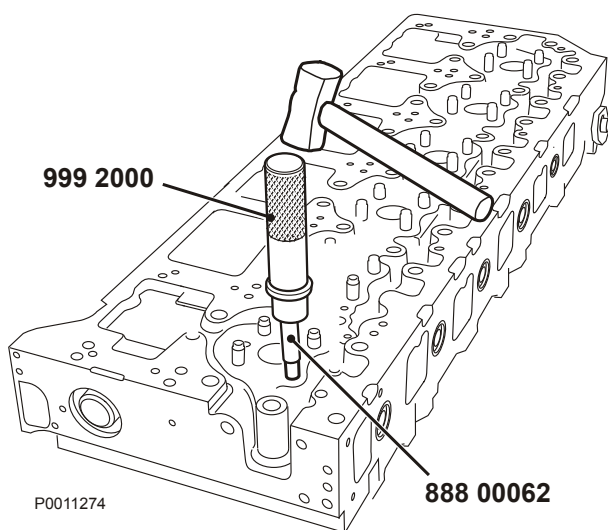
## Installation

- 3 Heat the cylinder head with hot water while cooling the valve guides with e.g. carbon dioxide snow. Lubricate the cylinder head valve guides with engine oil.

### CAUTION!

Risk of eye injury. Eye protection required.

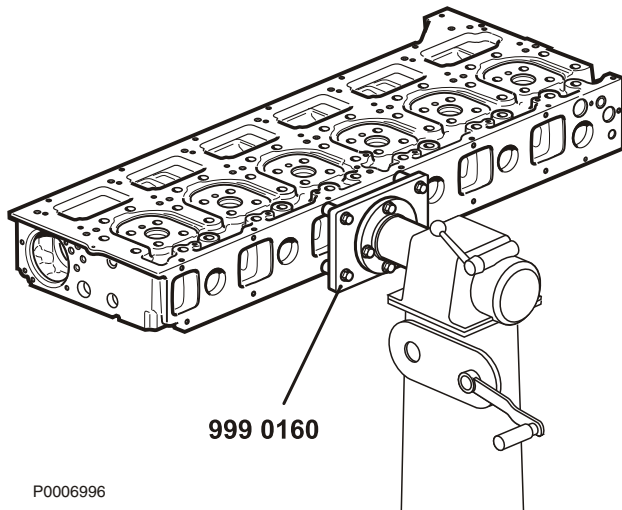
- 4 Tap in the valve guide for the inlet valve using tool 88800062 Drift. Tap in the exhaust valve guide using the same tool.
- 5 Tap until the tool bottoms against the cylinder head plane.
- 6 Repeat the procedure for the remaining valve guides.



P0011274

### **IMPORTANT!**

After the valve guides have been changed, the cylinder head must be cleaned carefully to prevent dirt particles from getting into the fuel and oil ducts. Contamination may cause failure or malfunction of the unit injectors.



## Valves, Removal

Work is made easier if the cylinder head is fixed in an equipment stand using tool 9990160 Fixture. Use 4 pcs. bolts M8 x 25.

**NOTICE!** It is important that the greatest possible cleanliness is observed during work on the cylinder head. Dirt particles in the fuel ducts can cause failure or malfunction of the unit injectors.

### Alternative 1

Tools:

9809726 Pneumatic hydraulic pump  
 9809729 Hydraulic cylinder  
 9990160 Fixture  
 9990174 Drift  
 9992670 Hand pump  
 9996159 Adapter  
 9998246 Drift

Note: 9992670 Hand pump is alternative to 9809726 Pneumatic hydraulic pump .

### Alternative 2

Tools:

9990210 Valve spring compressor

### Alternative 1

- 1 Fit tool 9809729 Hydraulic cylinder into tool 9990176 Press tool.
- 2 Install tool 9996159 Adapter and tool 9998246 Drift (inlet) or tool 9990174 Drift (outlet) on the hydraulic cylinder. Place the tool in the holes for the cylinder head retaining bolts. Tighten the tool nuts.
- 3 Connect tool 9809726 Pneumatic hydraulic pump (alternatively 9992670 Hand pump).
- 4 Press the valve spring washer down and remove the collets.

**NOTICE!** Check that the tool does not damage the unit injector electrical connector, if the injector is left in place.

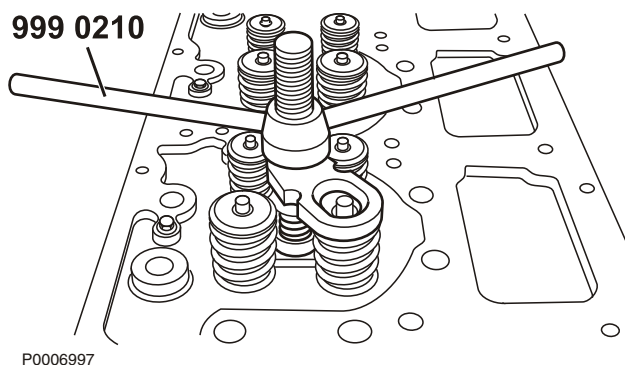
**NOTICE!** Put the valves and springs in a marked stand, to facilitate putting components back in the same places in the cylinder head.

- 5 Remove the remaining valves in the same way as above, using the press tool.
- 6 Remove the oil seals from the valve guides.

## Alternative 2

Tools:

9990210 Valve spring compressor



- 1 Lay the cylinder head on a flat, clean surface. Make sure the cylinder head is not damaged when the valves are to be removed.
- 2 Fit tool 9990210 Valve spring compressor in the unit injector hole. Fix the tool in the bolt hole for the unit injector yoke, M10 x 30.
- 3 Place the moving part of the tool over the valve spring to be removed. Screw down the "wing nut" on the tool until the valve washer has been pressed down so far that the collets can be removed.

**NOTICE!** Put the valves and springs in a marked stand, to facilitate putting components back in the same places in the cylinder head.

- 4 Remove the remaining valves in the same way as above.
- 5 Remove the oil seals from the valve guides.

## Valves, Installation

### Alternative 1

Tools:

9809726 Pneumatic hydraulic pump  
 9990165 Guide sleeve  
 9990174 Drift  
 9990176 Press tool  
 9990210 Valve spring compressor  
 9992670 Hand pump  
 9996159 Adapter  
 9998246 Drift  
 88800151 Drift

Note: 9992670 Hand pump is alternative to 9809726 Pneumatic hydraulic pump .

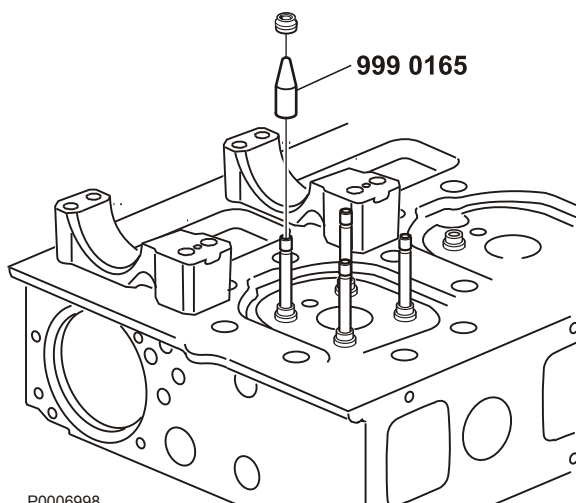
### Alternative 2

Tools:

9990210 Valve spring compressor

- 1 Oil the valve stems and install the valves.  
Oil the oil seals.
- 2 Install tool 9990165 Guide sleeve on the valve stem and press the new oil seals down over the valve guides.

**NOTICE!** Check that the oil seals are pressed down properly. If necessary, use 88800151 Drift and tap carefully with a plastic mallet.



P0006998

### Alternative 1

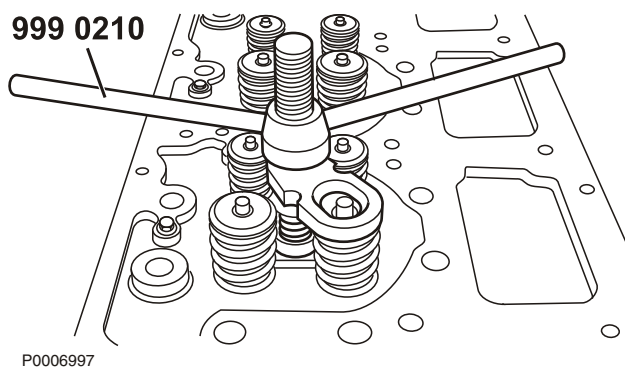
- 3 Install the valve caliper guide pins.  
Install the springs and valve spring washers.  
Carefully press down the valve spring washer and install the collets. Use tool 9990176 Press tool together with 9809726 Pneumatic hydraulic pump , 9996159 Adapter and 9998246 Drift (inlet) or 9990174 Drift (outlet), in the same way as for Valves, Removal.

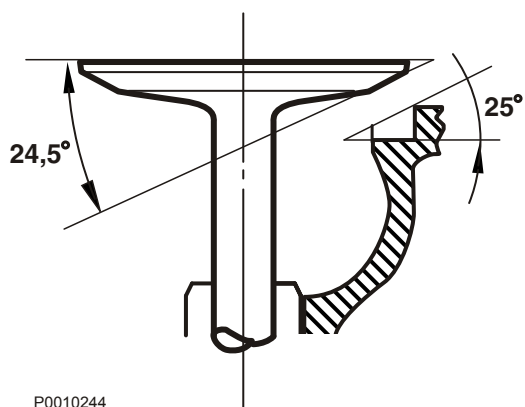
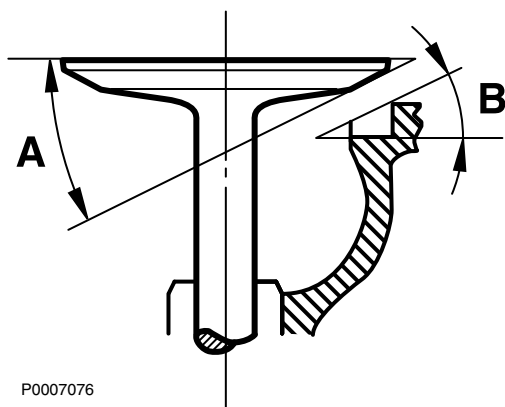
**Alternative 2**

Tools:

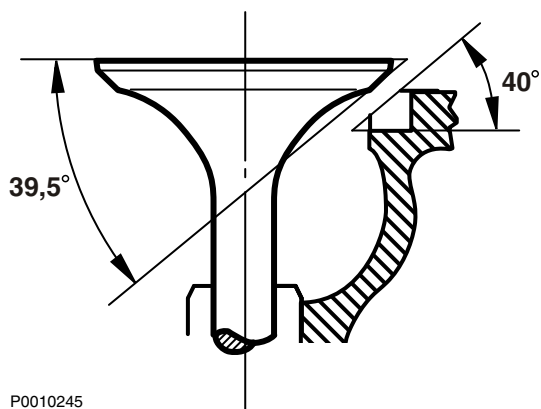
9990210 Valve spring compressor

- 1 Alternatively, tool 9990210 Valve spring compressor may be used instead of the hydraulic cylinder, in the same way as for Valves, Removal.





Inlet valve



Exhaust valve

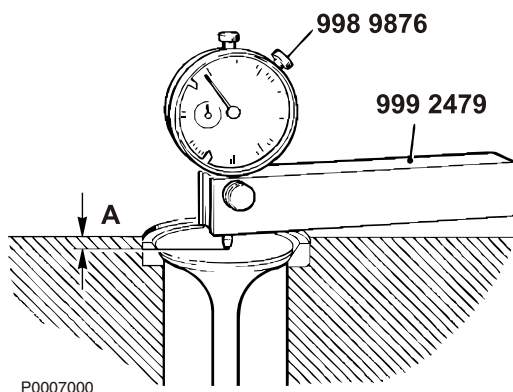
## Valve Seats and Valve, Grinding

For valve sealing angles, refer to *Technical Data* page 27.

**NOTICE!** Spare part valve seats are already machined, and do not need further grinding.

### Valve seat, grinding

- 1 Before the valve seats are ground, the valve guides must be checked and changed if wear tolerances have been exceeded.
- 2 When grinding valve seats, do not remove an unnecessary amount of material; only remove enough material to give the valve seat the correct shape and a good mating surface.
- 3 Grind new seats down so far that the dimension between the cylinder head plane and the valve disc surface, is in accordance with specifications; refer also to *Technical Data* page 27.
- 4 Check the valve seat angle with a valve seat gauge, once the seat mating surface has been coated with a thin layer of marker dye.



**NOTICE!** Spare part valves are already machined, and do not need further grinding.

**NOTICE!** The sealing surface must be ground as little as possible; however, enough to grind away all damage.

### Valves, grinding

- 1 Check dimension (A). If the dimension is greater than the wear tolerance as specified in *Technical Data page 27*, the valve must be changed.

**NOTICE!** Always change a valve with a bent valve stem.

- 2 Check valve sealing with marker dye. If there is any leakage, grind the **valve seat** again; refer to Valve Seat, Grinding, then do a new check. Once the results of grinding are acceptable, the valve and seat may be lapped in with fine grinding paste.

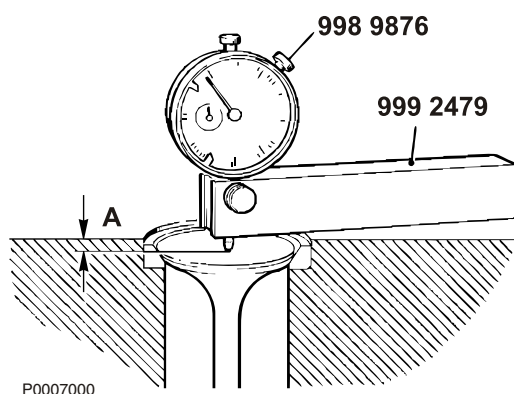
## Valve Seat, Change

Cylinder head and valves removed.

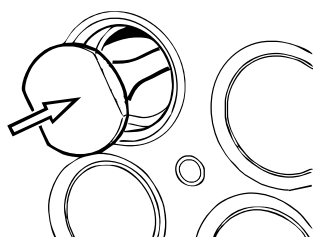
Tools:

9989876 Dial indicator

9992479 Holder for dial indicator



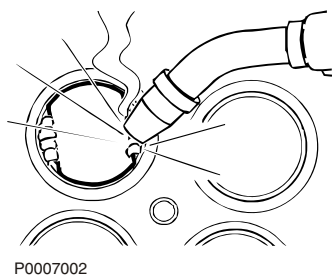
- 1 The valve seats must be changed if a satisfactory seal cannot be obtained or when the distance (A) exceeds the value stated in the specification; refer to *Technical Data* page 27.



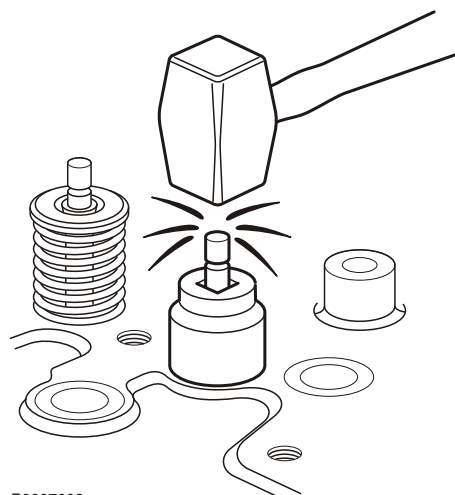
- 2 Grind the head off an old valve and weld it onto the valve seat. Use a MAG welder, or a conventional arc welder (with a stainless welding electrode).

### IMPORTANT!

Carefully cover the other surfaces on the cylinder head to prevent any weld spatter from fastening.







P0007003

- 3 Place a suitable socket over the valve/valve guide and carefully tap the valve seat out.

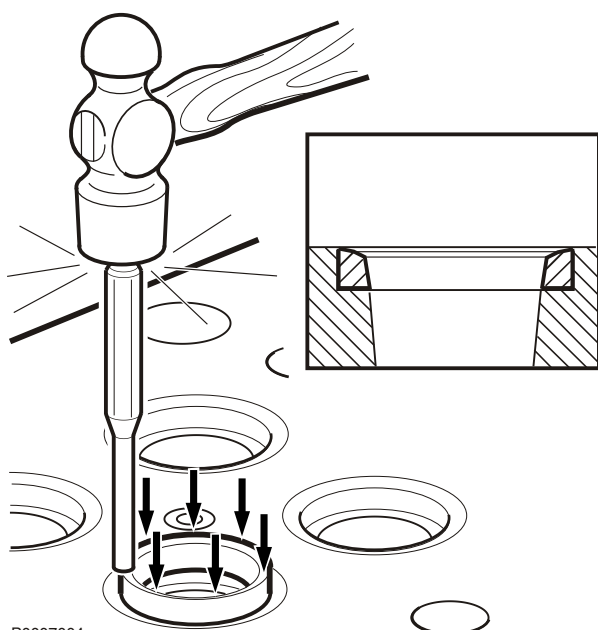
**IMPORTANT!**

Be careful not to damage the cylinder head.

**⚠ CAUTION!**

Risk of eye injury. Eye protection required.

- 4 Clean the seat bed carefully and check the cylinder head for cracks.
- 5 Measure the diameter of the valve seat bed in the cylinder head. Determine whether a standard or oversize dimension valve seat must be used. Carry out any necessary machining to the valve seat bed; refer to *Technical Data* page 27.



P0007004

- 6 Cool the seat in carbon dioxide snow between  $-60^{\circ}\text{C}$  ( $-76^{\circ}\text{F}$ ) and  $-70^{\circ}\text{C}$  ( $-94^{\circ}\text{F}$ ) and heat the cylinder head by flushing with hot water, or by some other method. Install the new valve seat using a drift.

**NOTICE!** Align the seat with the seat angle facing the tool. Check sealing against the valve.

## Valve Stem Sealings, Replace

### Tools:

9990165 Guide sleeve  
9990210 Valve spring compressor  
9993590 Rotation tool

### Removal

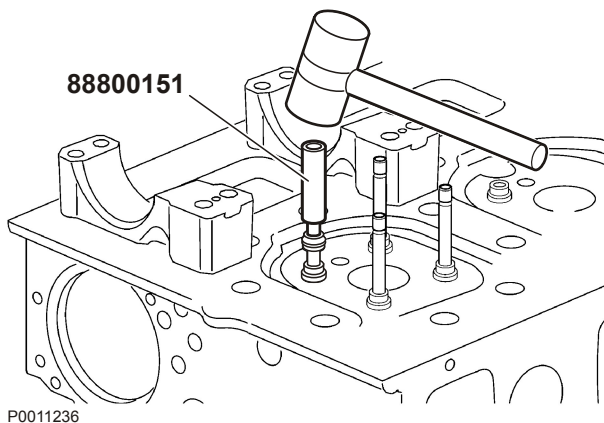
- 1 Disconnect all current to the engine, by switching off the main switch.
- 2 Remove the unit injectors; refer to the removal section in *Unit Injector, Replace* page 255.
- 3 **NOTICE!** The piston must be at top dead center when the valves are removed. This is to prevent the valves from falling down into the cylinder. Use tool 9993590 Rotation tool.
- 4 Compress the valve springs for no. 1 cylinder. Use tool 9990210 Valve spring compressor.
- 5 Remove the valve washers, valve springs and collets.
- 6 Remove the old valve stem seals.

### Installation

- 7 Lubricate the valve stem with engine oil. Fit tool 9990165 Guide sleeve to the valve stem. Thread the new seal on and put it over the mandrel. Slide tool 88800151 Drift over the valve stem and tap the seal down carefully with a plastic mallet.
- 8 Install the valve springs, valve spring washers and collets. Carefully tap with a plastic mallet to make sure the collets end up in the right position.
- 9 Transfer the valve spring compressor to no. 6 cylinder and repeat the tasks as above. Then crank the engine so that no.3 and no.4 cylinder are at TDC.  
Repeat the procedure. Then continue with cylinders 2 and 5.

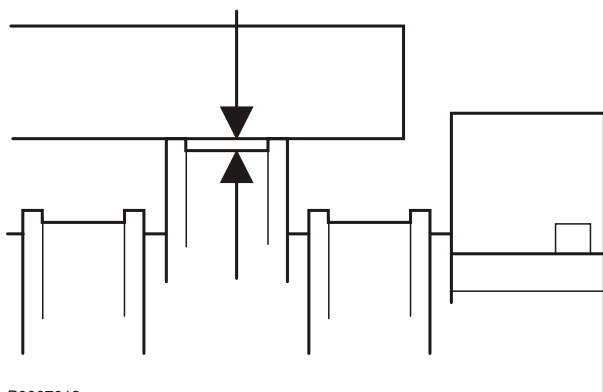
**NOTICE!** The piston must be at top dead center when the valves are removed. This is to prevent the valves from falling down into the cylinder. Use tool 9993590 Rotation tool.

- 10 Install the unit injectors; refer to the installation section in *Unit Injector, Replace* page 255.
- 11 Adjust the valves and unit injectors; refer to *Valves and Unit Injectors, Adjustment* page 177.
- 12 Vent the fuel system; refer to *Fuel system, bleeding* page 245. Perform a function and leakage check.



P0011236

## 21-5 Timing Gears and Shaft



P0007013

### Camshaft, Wear Check

#### Rocker bridge removed.

Put a steel rule across the camshaft lobes, parallel with the camshaft axis, to check whether the cam profiles have been worn.

Measure the wear with a feeler gauge or wire gauge. Alternatively, a digital caliper gauge can be used.

Compare the measured values with those specified in *Technical Data* page 27.

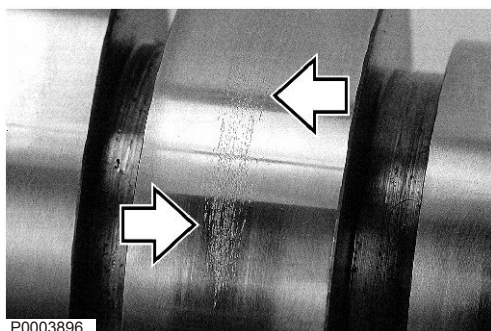
#### Guidelines for replacement

In normal conditions, unevenness may occur on the surface of engine camshaft lobes. This does not mean that the camshaft has to be changed. These marks do not have any negative influence on either engine performance or the durability of the engine and its components.

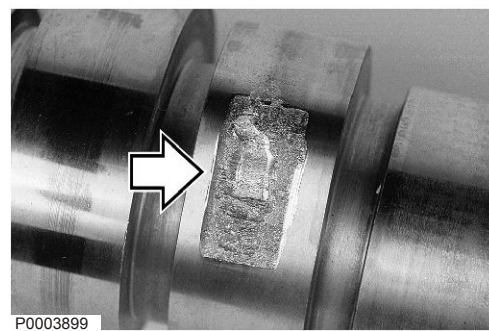
Examples of acceptable wear and **unacceptable** wear are shown below.

#### Lighter scratches:

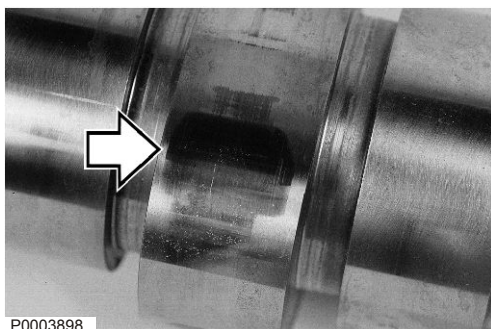
The camshaft does not need to be changed.



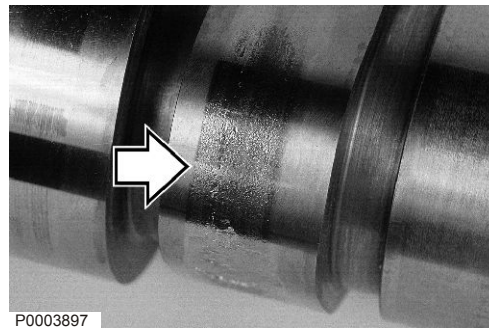
P0003896



P0003899



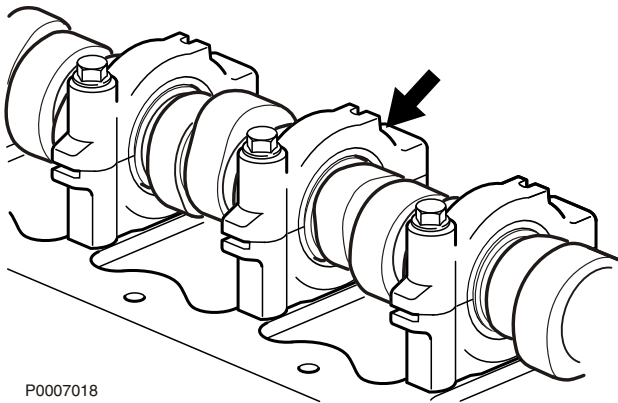
P0003898



P0003897

## Camshaft Bearing Housing, Replace

The factory-installed bearing housings are machined with the cylinder head and are therefore not replaceable. If a bearing housing is damaged the complete cylinder head must be replaced.



P0007018

## Flywheel, Indication

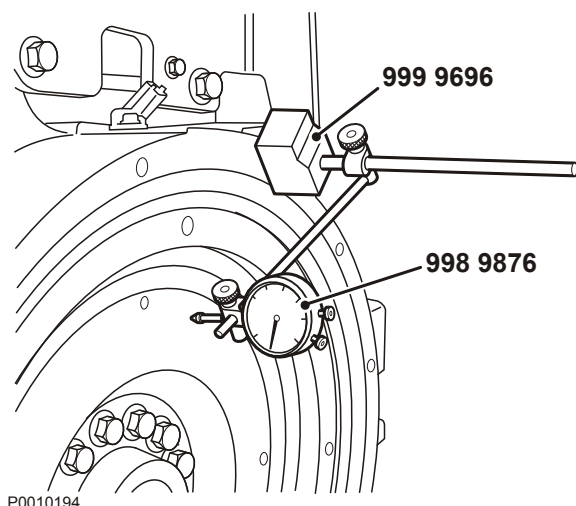
**Flywheel exposed; refer to *Timing Gear, Removal* page 124.**

Tools:

9993590 Rotation tool

9989876 Dial indicator

9999696 Magnetic stand



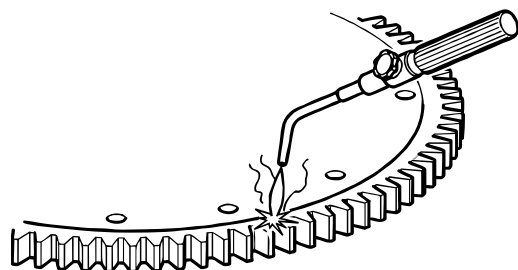
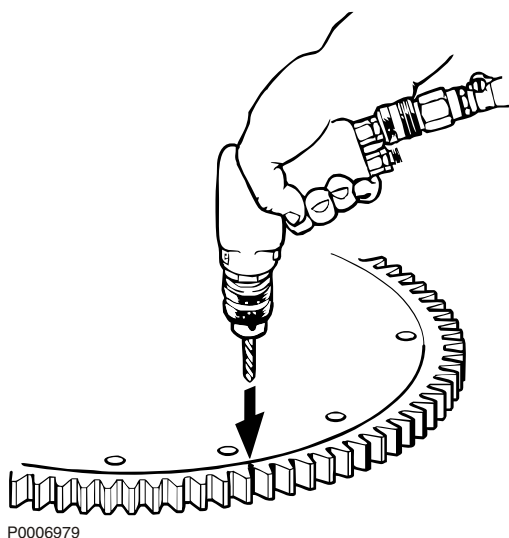
P0010194

- 1 Install 9993590 Rotation tool in order to rotate the flywheel.
- 2 Install 9999696 Magnetic stand and 9989876 Dial indicator with the measuring tip against the flywheel at a measuring radius of around 150 mm (5.9").  
Rotate the flywheel at least one revolution and check the min and max deflections on the dial indicator. The value should not exceed **0.20 mm** (0.0079").
- 3 If the distortion is greater, and this is not the result of a damaged surface where the dial indicator is applied, remove the flywheel and check that there is no waste material or damage to the contact flange on the flywheel and crankshaft.  
Clean the flanges or change the flywheel if it is damaged.  
Torque the bolts; refer to *Special Tightening Torques* page 8.
- 4 Check using the dial indicator and magnetic stand again.  
Remove the tool.

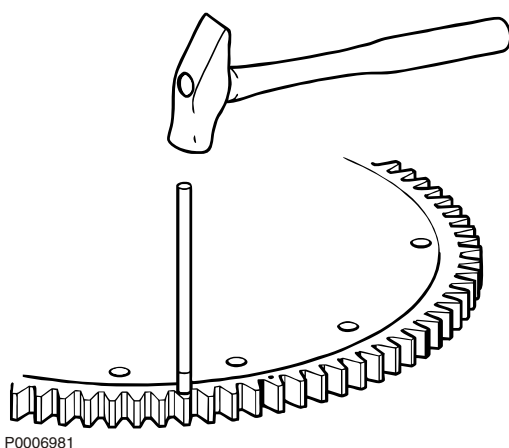
## Gear Ring, Flywheel: Replace

### Flywheel removed.

- 1 Drill 1–2 holes between teeth on the ring gear. Split the gear ring at the drilled hole, using a cold chisel. Lift the gear ring away from the flywheel.
- 2 Brush the flywheel contact surface clean with a steel wire brush.



- 3 Heat the new gear ring up to 180–200°C (356–392 °F) with a welding torch or in an oven. The gear ring must be evenly heated. Be careful not to heat the gear ring up far with annealing as a result. Check the heat by polishing the ring bright at several places. Stop heating when the polished surfaces become blued.



- 4 Put the heated gear ring onto the flywheel and tap it into place with a soft mandrel and hammer. Leave the gear ring to cool.

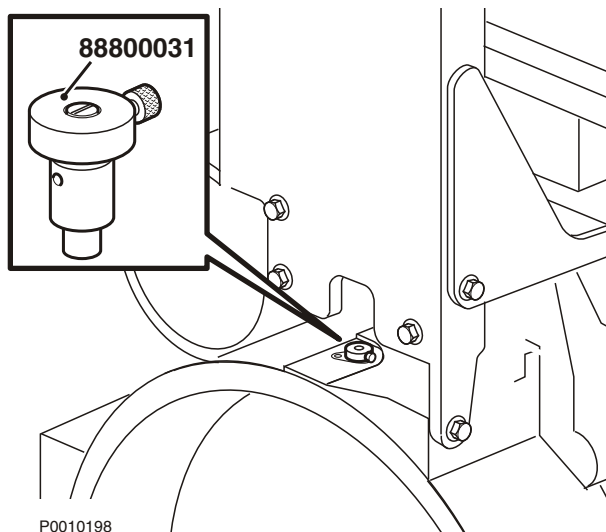
## Sensors, Adjustment

### Sensor removed.

#### Tools:

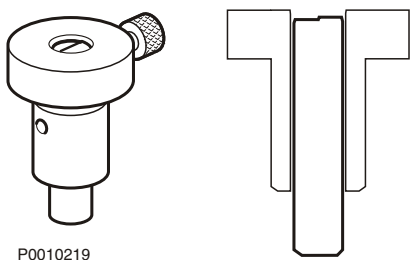
88800031 Measuring tool

- 1 If the camshaft sensor needs to be adjusted, rotate the crankshaft so that one tooth on the camshaft vibration damper is centered in front of the sensor hole.
- 2 Remove any shims beneath the sensor. Clean the tool's contact surface on the engine.
- 3 Insert 88800031 Measuring tool without tightening the lock screw. Press in the tool firmly so that it is in contact with the cover. Press in the center part of the tool until it contacts the gearwheel and tighten the lock screw. Rove the tool and inspect the center section position in its sleeve.

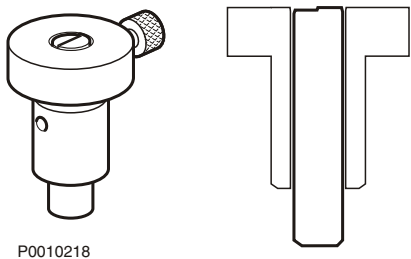


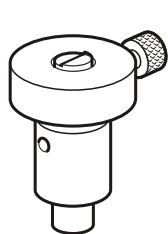
- 4 **Determine further actions according to the following:**

If the center section of the tool is entirely below the sleeve's upper edge, no shims are required.

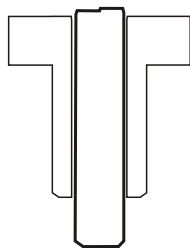


If only the center section upper surface is above the sleeve's top edge, one shim is required.





P0010220



If the two center section surfaces are above the sleeve's top edge, two shims are required.

- 5 Install the sensor with a new seal and any shims.



## Main bearing, Change

### Oil pan removed

The method describes replacement of main bearings with the crankshaft in place in the engine

#### Tools:

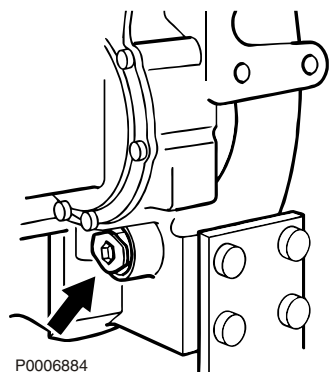
9990013 Slide hammer

9990114 Puller

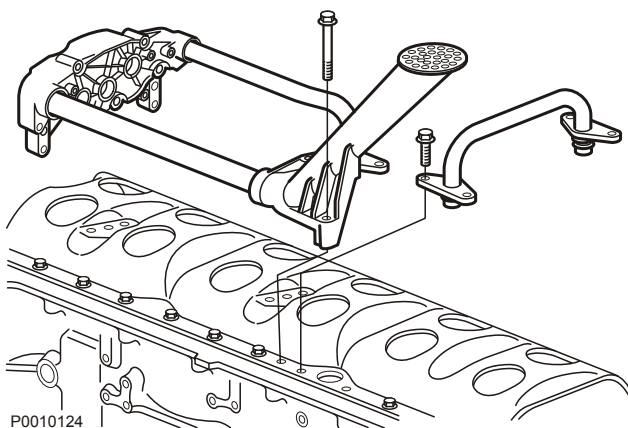
9993590 Rotation tool

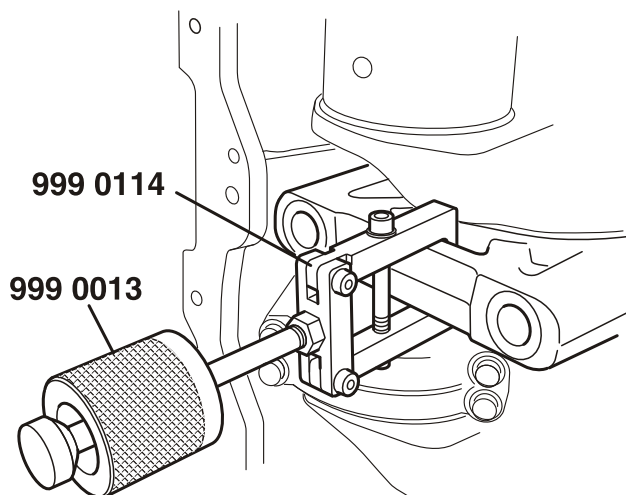
### Removal

- 1 Fit tool 9993590 Rotation tool.



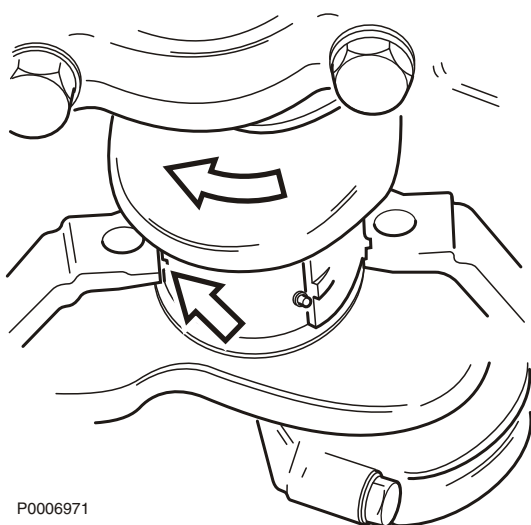
- 2 Remove the oil suction pipe and oil pump.  
Remove the bracing frame.





P0006970

- 3 Remove one bearing cap.



P0006971

- 4 Remove the upper main bearing shell by putting a pin in the crankshaft oil hole and rolling the bearing shell out by turning the crankshaft in the direction of rotation with tool 9993590 Rotation tool.
- 5 Clean and check the bearing seat, bearing cap, shaft journal and bearing shell.  
If the bearing has seized, the reason must be determined before a new bearing is installed.
- 6 Check that the correct bearing dimension is used when the bearing shells are changed.

**NOTICE!** If case of uncertainty, check in *Technical Data page 27* which oversize dimensions are available.

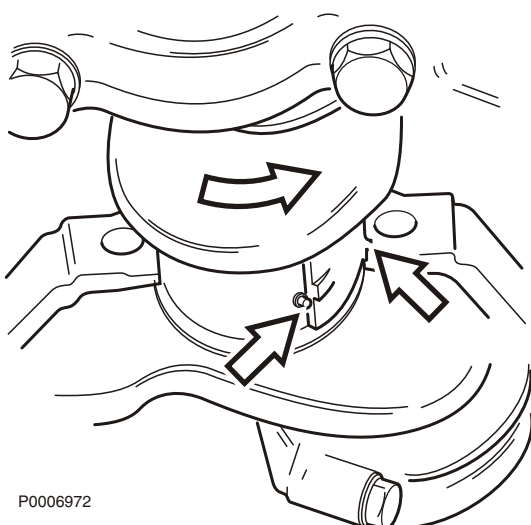
## Installation

- 7 Lubricate the shaft journal and the new bearing shells with engine oil.
- 8 Install the upper bearing shell by turning the crankshaft using tool 9993590 Rotation tool against the direction of rotation with the pin in the oil hole.

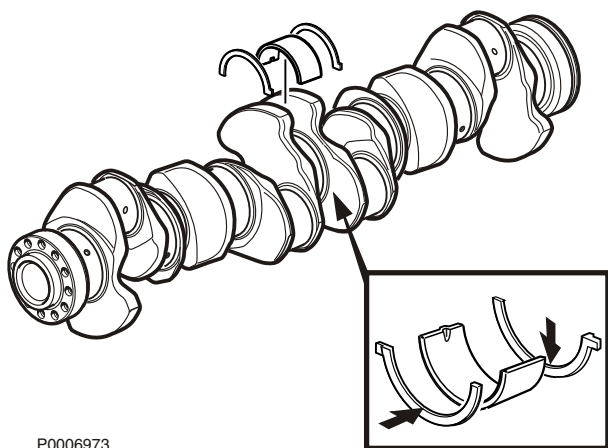
**NOTICE!** Check that the pressed-out bearing shell heel is correctly aligned in the bearing seat cutout.

Make sure that the upper bearing shells (those to be located in the engine block) are equipped with oil holes.

**NOTICE!** Remove the pin when done.



P0006972



P0006973

- 9 Fit the main bearing cap together with the lower bearing shell.

**NOTICE!** The main bearing caps are asymmetric and can only be installed in one position. Note the main bearing cap numbers showing their locations if several caps are removed simultaneously.

Torque the caps in two steps as specified; refer to *Technical Data page 27*.

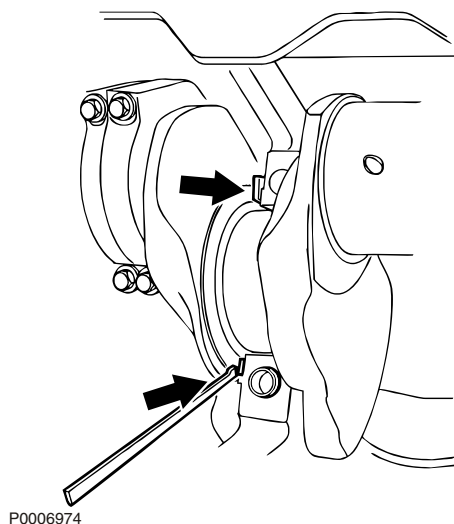
- 10 Change the other bearing shells, one a time, in the same way as the first one. Each time a changed is made, check that the crankshaft does not seize by turning it using tool 9993590 Rotation tool.
- 11 Check crankshaft end float and replace the thrust washers if the clearance is too great or if the thrust washers are damaged.

**NOTICE!** Measure the end float with a dial gauge. Thrust bearings are available in a number of over-size dimensions. Refer to *Technical Data page 27* for oversize dimensions and axial play.

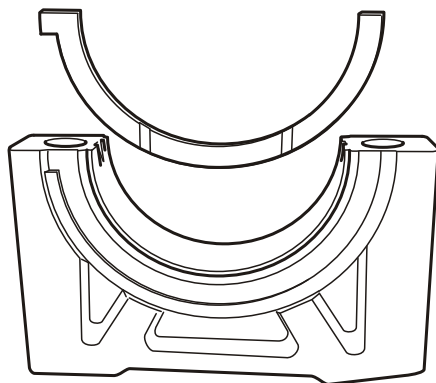
The crankshaft thrust bearing is located in the center main bearing.

- 12 Use a narrow plastic or wood stick to remove the thrust bearing washers from the cylinder block bearing seat.

**NOTICE!** The thrust washers can only be placed in one position.



P0006974



P0006975

- 13 Check the axial play of the crankshaft when all main bearing caps have been torqued; refer to *Technical Data page 27* for specification.
- 14 Install the bracing frame and torque according to the tightening chart; refer to *Technical Data page 27*.
- 15 Install the oil pump and oil suction pipe.
- 16 Remove tool 9993590 Rotation tool from the fly-wheel housing and install the cover.
- 17 Install the oil pan.  
Add oil and change the oil filter.  
Check the oil pressure.

## 21-6 Crank Mechanism

### Crankshaft seal, replace (front)

#### Tools:

9990192 Puller  
 9992000 Handle  
 9993590 Rotation tool  
 9996400 Slide hammer  
 88800021 Drift

#### Removal

- 1 Drain the coolant; refer to *Draining the Cooling System* page 278.
- 2 Remove the radiator, where fitted.

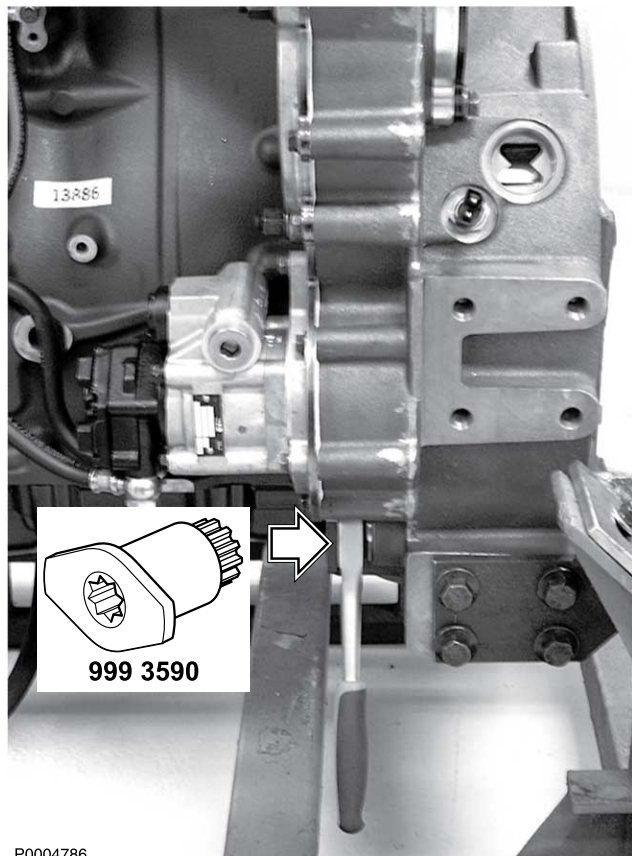
#### IMPORTANT!

Do not lay the fan down. Oil may run out that cannot run back in again.

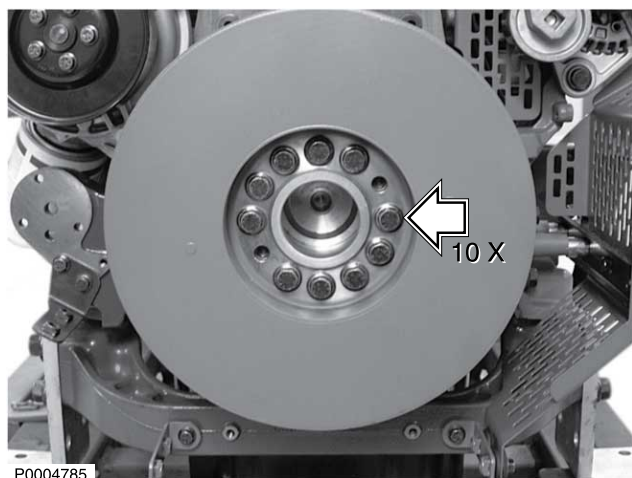
- 3 Remove the cooling fan.
- 4 Remove the right belt guard; refer to *Belt Protector* page 296.
- 5 Remove the belts. For the drive belt, refer to *Drive Belts* page 290.  
 For the alternator belt, refer to *Alternator Belts, Change* page 298.
- 6 Remove the automatic belt tensioner.



P0004682

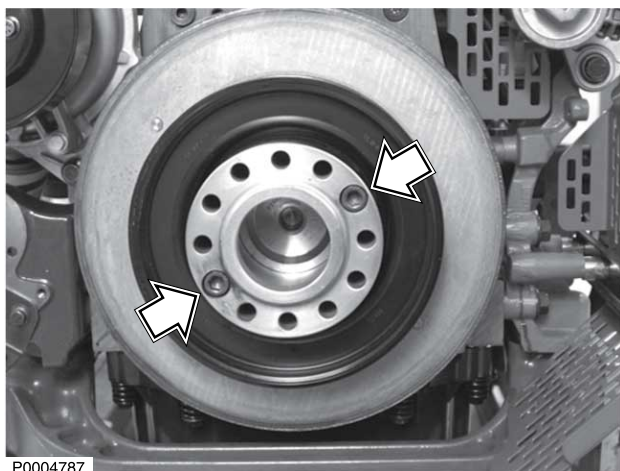


- 7 Where necessary, use tool 9993590 Rotation tool as a counterhold.



- 8 Remove the bolts to the outer oscillation damper.
  - 9 **NOTICE!** The oscillation damper weighs approx. 15 kg. Make sure that it is not damaged.
- Carefully remove the outer vibration damper.

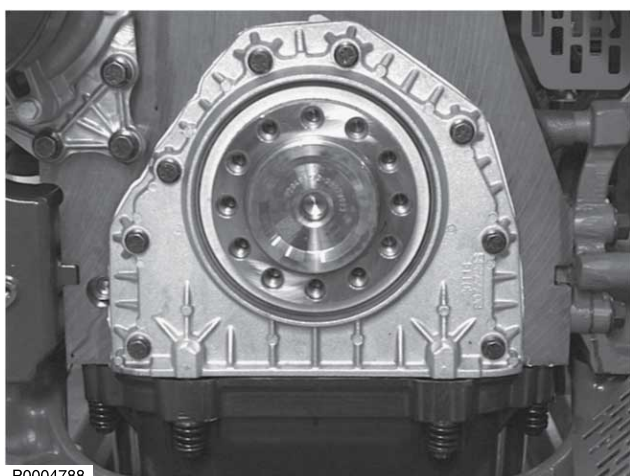




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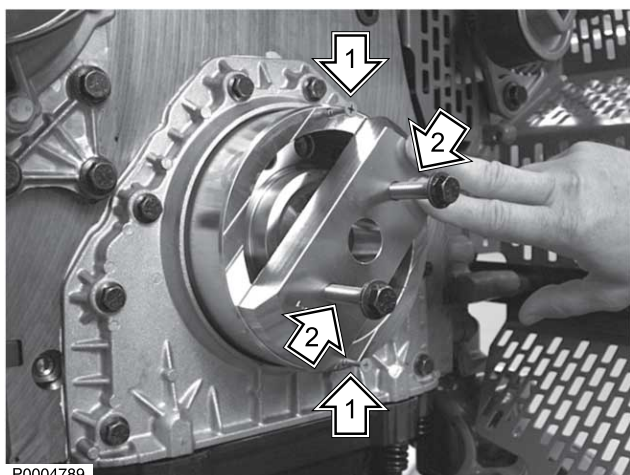
- 10 **NOTICE!** The inner belt pulley / vibration damper is heavy. Handle with care.

Remove the two bolts to the hub and belt pulley.



P0004788

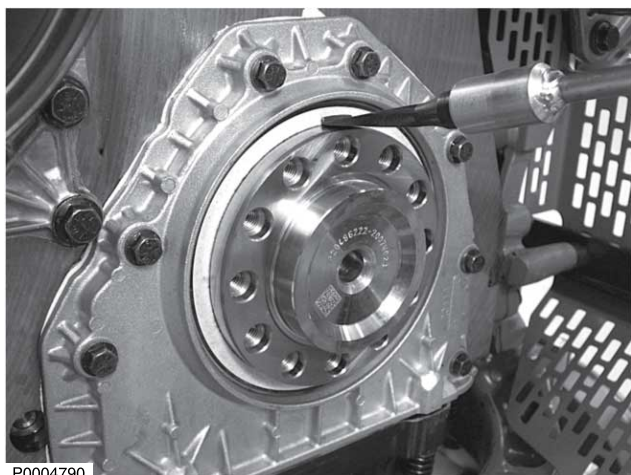
- 11 Remove the hub and outer and inner belt pulley / vibration damper.



P0004789

### Alternative 1, seal removal

- 12 Fit tool 88800021 Drift.
- 13 Drill two holes  $\varnothing 3.5$  mm in the seal with the aid of the guide hole in the tool. Bush grease on the drill to prevent dirt from getting into the engine.
- 14 Screw in two suitable sheet metal screws (1), length approx. 50 mm, through the holes in the tool, so that they fasten firmly in the seal.
- 15 Fit two long-threaded M10x60 bolts (2) and screw them in until the seal releases.



P0004790

### Alternative 2, seal removal

- 16 **NOTICE!** Incline the tool to ensure that the crankshaft is not damaged.

Assemble tool 9996400 Slide hammer and tool 9990192 Puller.

Remove the old seal by tapping in a puller inside the seal and pulling it out with a slide hammer.

### Installation

9992000 Handle

9993590 Rotation tool

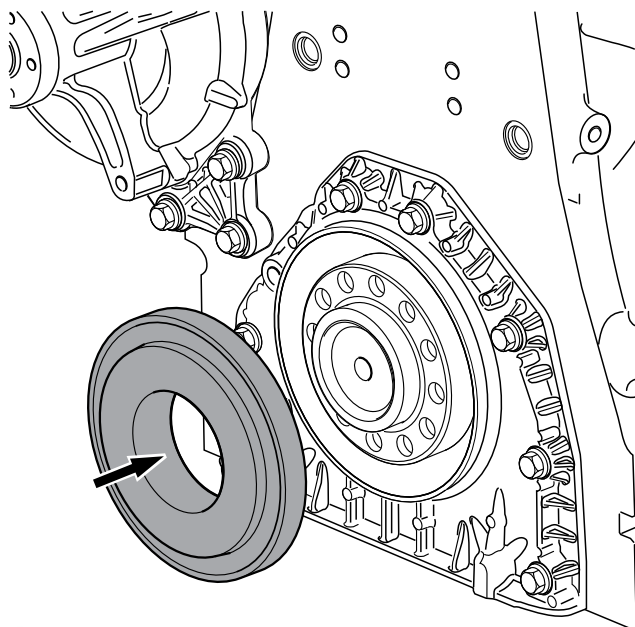
88800021 Drift.

- 17 Check that the plastic ring is correctly in place in the new seal.

**NOTICE!** If the plastic ring is not in place in the new seal, the seal ring may be damaged and must not be used.

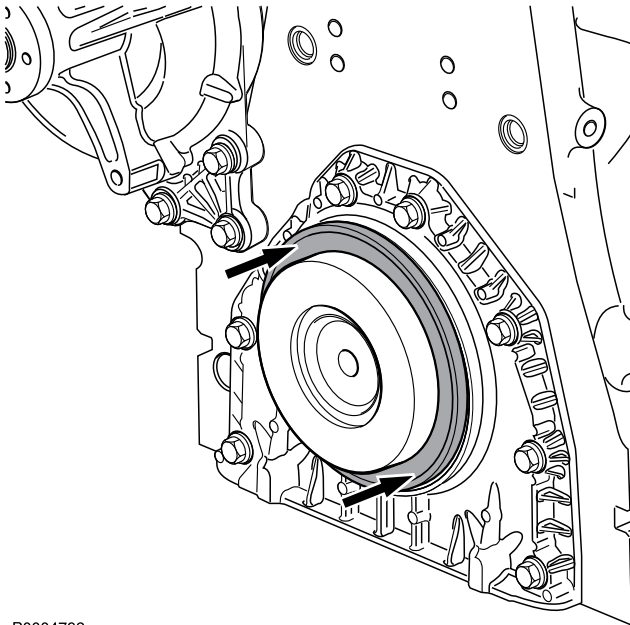
- 18 Clean the crankshaft sealing surface and cover. Check that these are damage free.

- 19 Install the new seal ring and plastic ring onto the crankshaft journal.



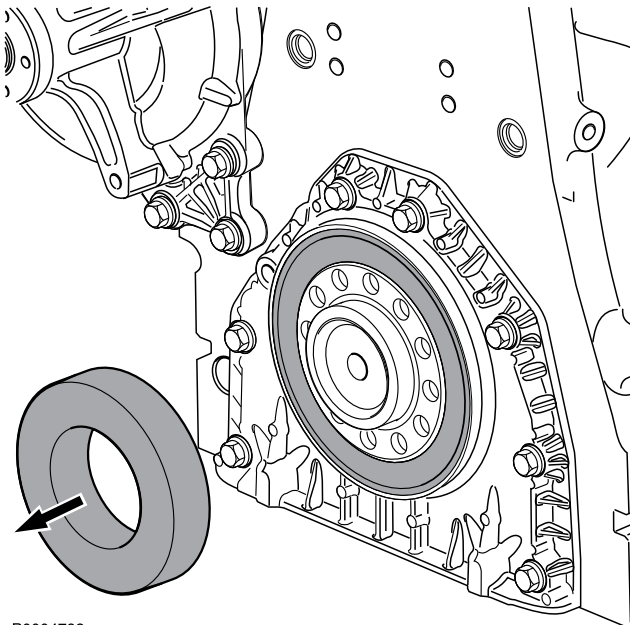
P0004791





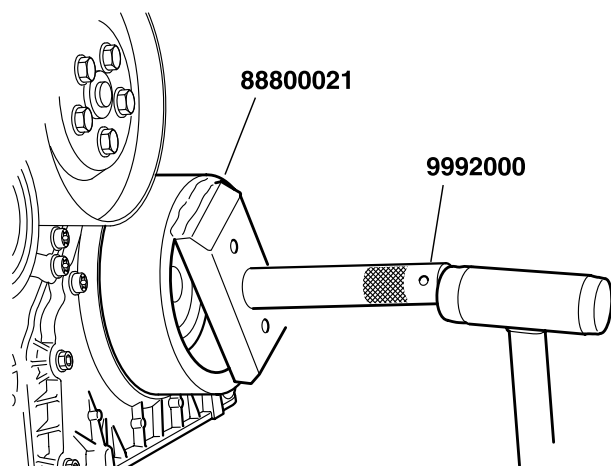
P0004792

20 Press the seal toward the cover by hand.



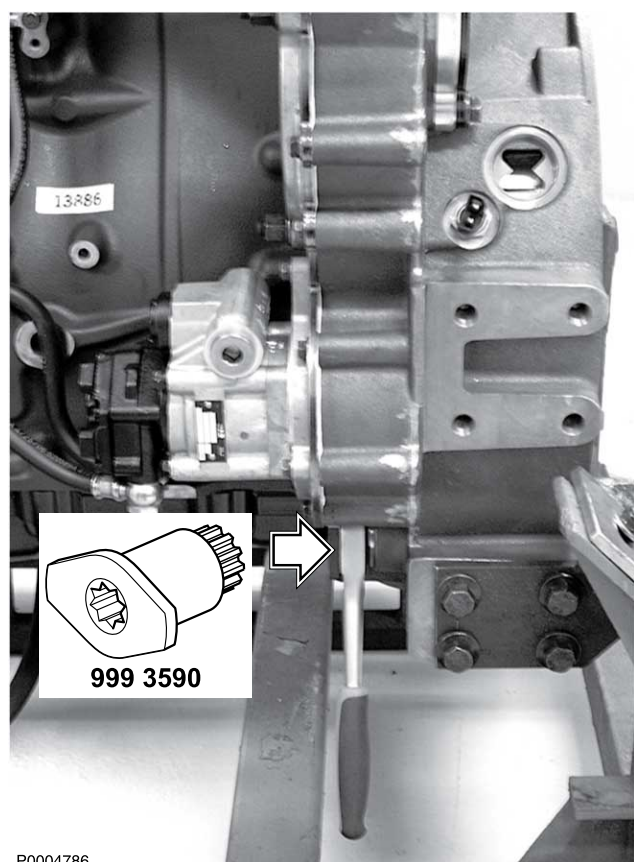
P0004793

21 Remove the plastic ring.



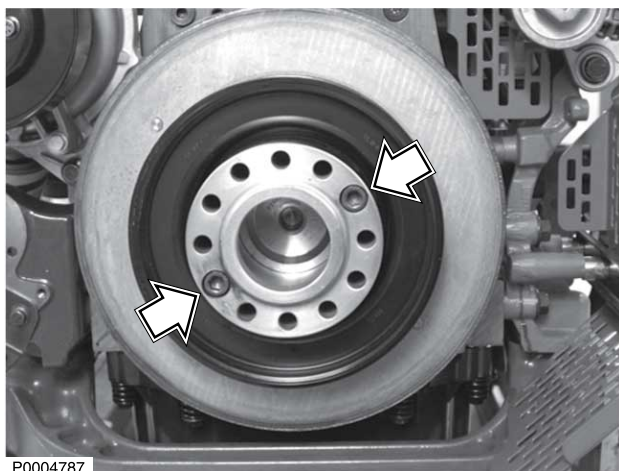
P0004794

- 22 Carefully tap in the new seal until it bottoms against the crankshaft journal. Remove the tool.
- 23 Make sure that the crankshaft, belt pulleys and hub mating surfaces are clean and damage free.
- 24 Fit the inner belt pulley / vibration damper.
- 25 Install the outer belt pulley.
- 26 Install the hub.



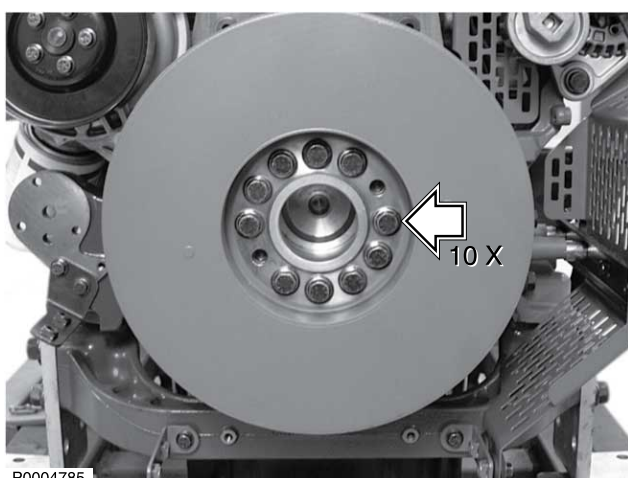
P0004786

- 27 Where necessary, use tool 9993590 Rotation tool as a counterhold.



P0004787

- 28 Install the two bolts to the hub.  
Torque the bolts according to specifications:  
Refer to *General Tightening Torques* page 7.
- 29 Ensure that the outer oscillation damper surfaces are clean and damage free.



P0004785

- 30 Install the outer oscillation damper.
- 31 Torque the oscillation damper bolts according to specifications: Refer to *General Tightening Torques* page 7.



- 32 Install the belt tensioner.
- 33 Install the alternator belt: Refer to *Alternator Belts, Change* page 298.
- 34 Install the drive belt: Refer to 703, *Drive Belt, Change*.
- 35 Ensure the belts track in their grooves.
- 36 Install the right belt guard: Refer to *Belt Protector* page 296.
- 37 Install the cooling fan.
- 38 Install the radiator, where fitted.
- 39 Refill with coolant: Refer to *Coolant Level, Checking and Topping Up* page 280.

## Crankshaft Sealing, Change (rear)

### Tools:

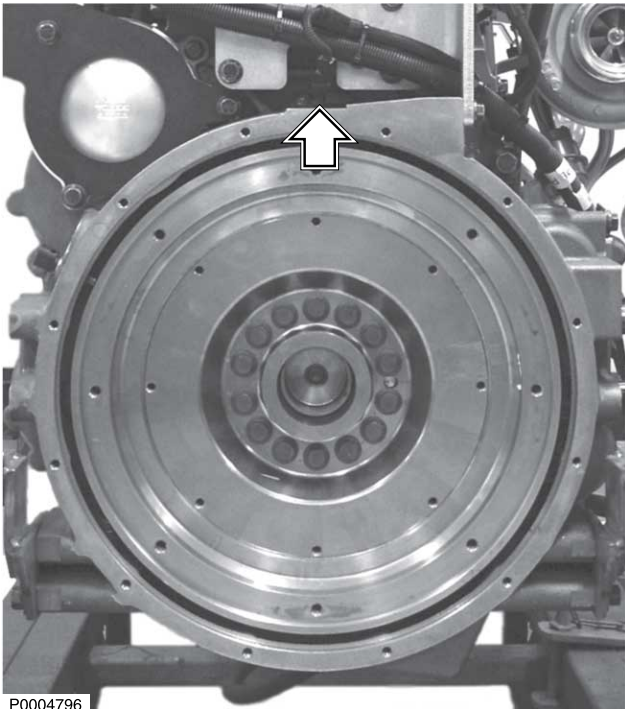
9990166 Mounting tool

9990192 Puller

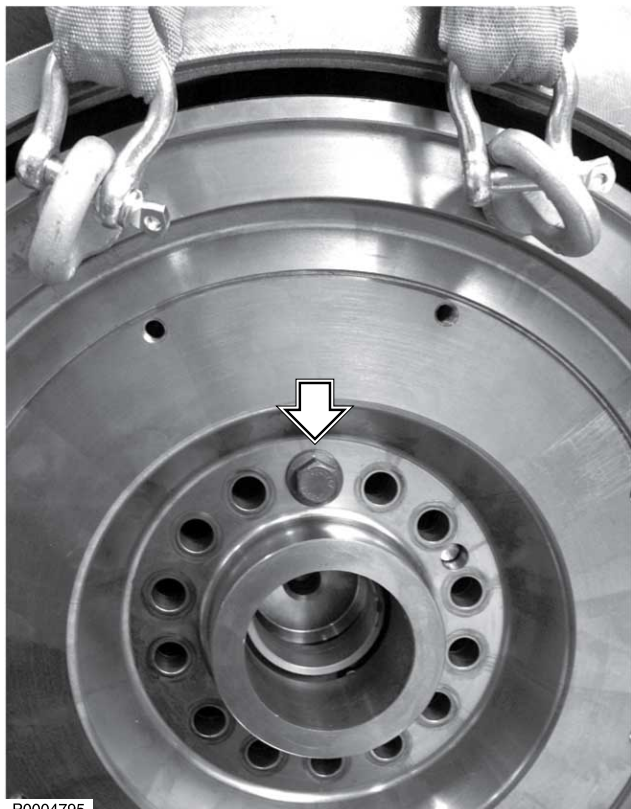
9996400 Slide hammer

### Removal

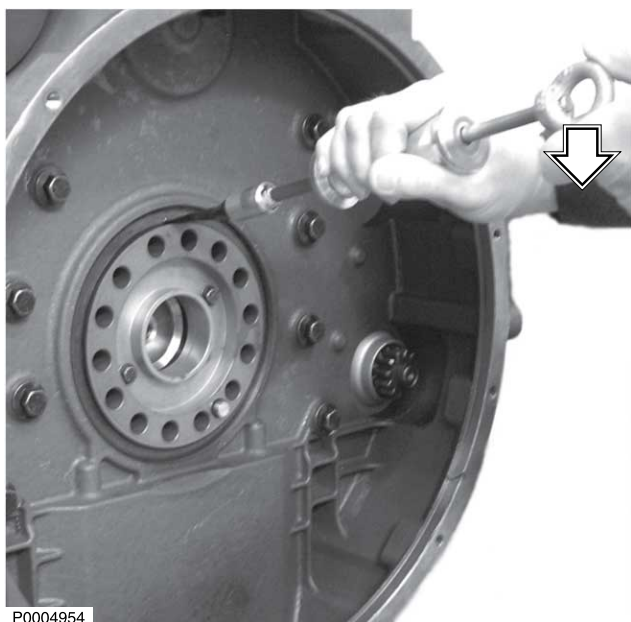
- 1 Remove the flywheel sensor.



P0004796

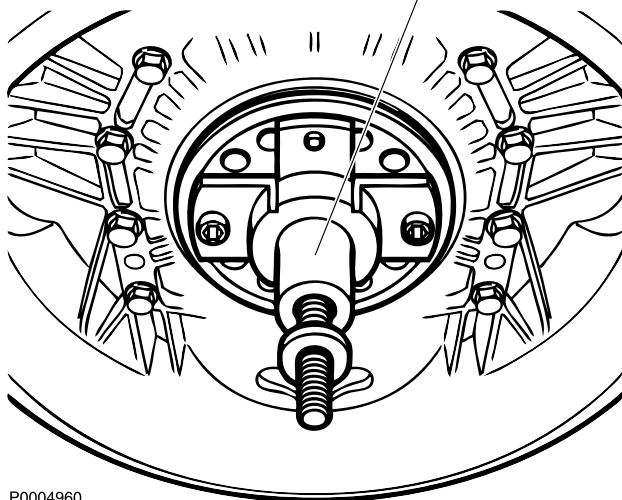


- 2 Remove all bolts from the flywheel, with the exception of the upper bolt.
- 3 Install lifting eyes and straps to the flywheel.  
**NOTICE!** Lock the lifting device.
- 4 Remove the last bolt and lift away the flywheel.



- 5 Fit 9996400 Slide hammer and 9990192 Puller. Check that the tools are free from burrs and grime.
- 6 **NOTICE!** Be careful not to damage the crankshaft. Incline the tool inwards to ensure a good grip in the seal.  
Knock out the seal.



**9990166**

P0004960

**Installation**

9990166 Mounting tool

- 7 **NOTICE!** Clean the seal seat in the flywheel housing and the sealing surface on the crankshaft.

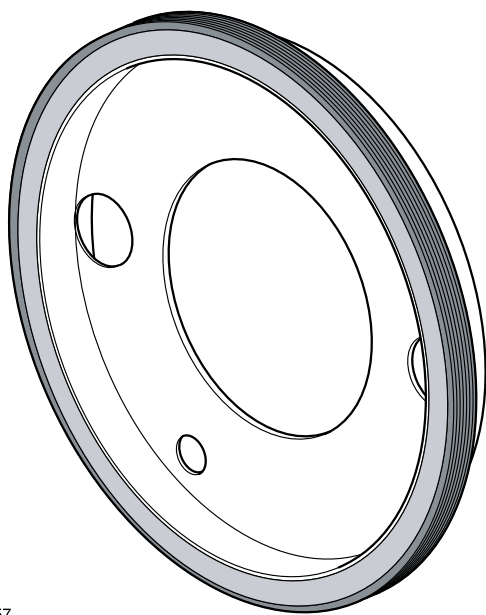
**NOTICE!** Ensure that the plate locates correctly on the crankshaft guide pin and bottoms firmly against the crankshaft **before** the bolts are tightened.

Fit 9990166 Mounting tool onto the crankshaft and screw it in place.

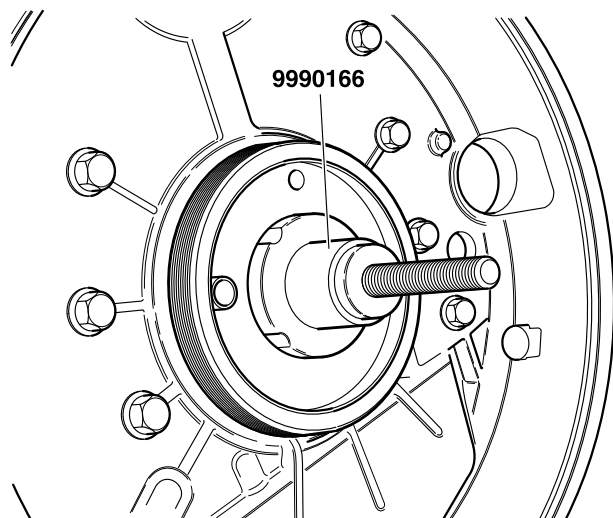
- 8 Fit the spacer ring to the pin bolt.

**NOTICE!** The spacer ring determines how far in the seal must be.

- 9 The seal is supplied with a plastic installation ring. The plastic ring must **not** be removed from the seal.

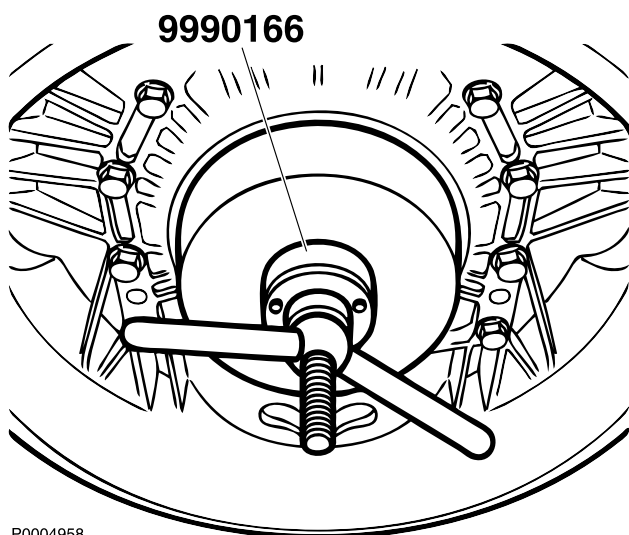


P0004957



P0004959

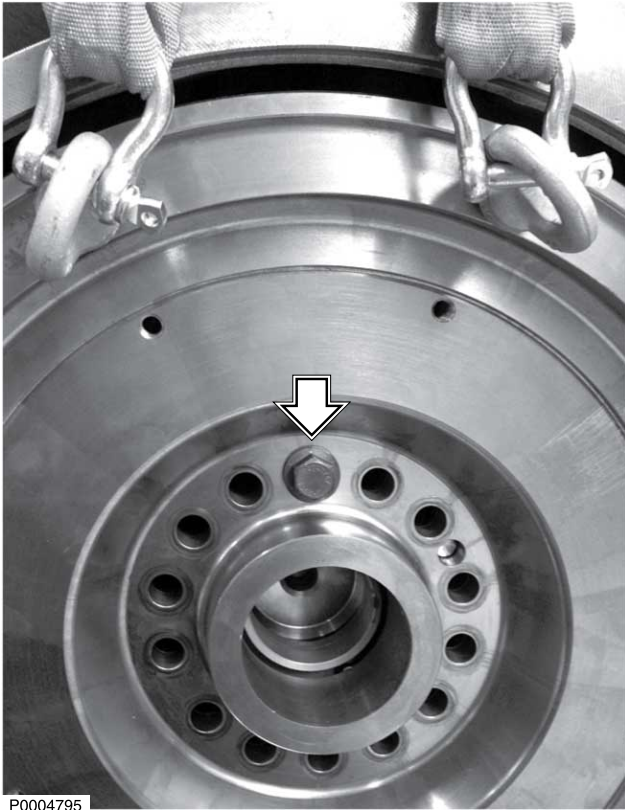
- 10 Install the seal without removing the installation ring.



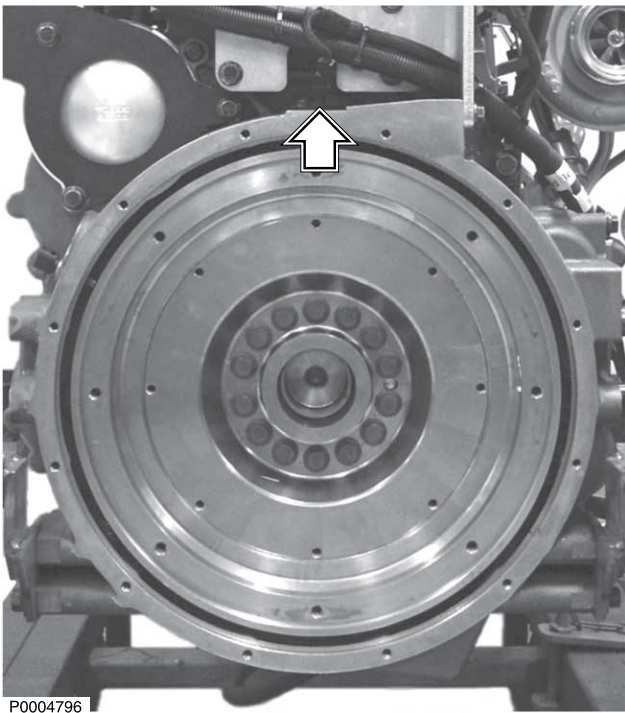
P0004958

- 11 Install the cover together with its handle. Press in the seal by rotating the handle.
- NOTICE!** When the cover bottoms the seal is in the correct position.
- 12 Remove the tool and the installation ring.





- 13 Offer the flywheel into place and fit the key in the keyway.  
Install one bolt to render the lift safe.
- 14 Install the remainder of the bolts.  
Torque according to specifications: Refer to *General Tightening Torques* page 7.



- 15 Install the flywheel sensor.

## Crankshaft, Inspection

**The crankshaft is induction hardened.**

Inspect the crankshaft very carefully to avoid unnecessary overhaul.

The following applies when the need for overhaul is checked:

- 1 Clean the crankshaft carefully.  
Measure the bearing journals' out-of-round, wear and taper. Refer to *Technical Data page 27* for specifications.
- 2 Check whether there is any surface damage on the bearing journals. If there is any damage on the surface layer, the shaft must be re-ground.
- 3 Place the shaft pair of V-blocks, under 1st and 7th main bearing journals. Alternatively, hold the crankshaft between the two centers.
- 4 Measure crankshaft axial displacement (throw) on the 4th main bearing.  
For maximum permissible values, refer to *Technical Data page 27*.

### **IMPORTANT!**

Crankshaft straightening is not permitted.

- 5 Check for cracks before and after any grinding.  
Magnetic powder testing is used for this test, i.e. fluorescent powder which is viewed under ultra-violet light.

## Main bearing, Change

### Oil pan removed

The method describes replacement of main bearings with the crankshaft in place in the engine

#### Tools:

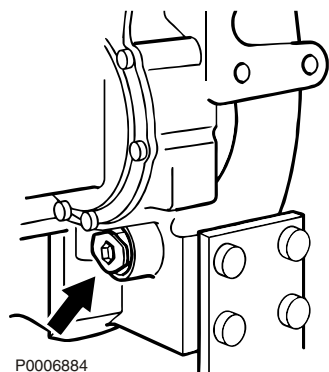
9990013 Slide hammer

9990114 Puller

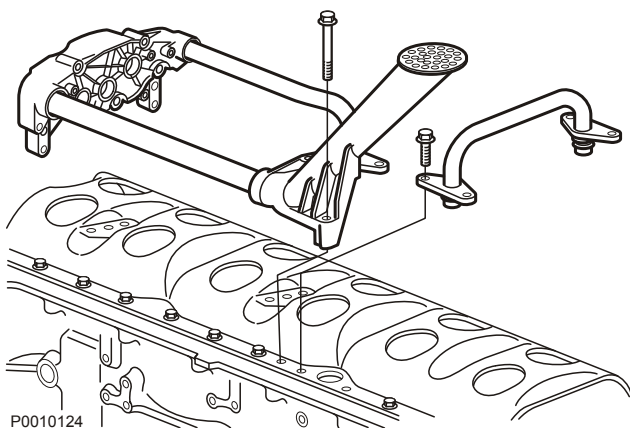
(missing tool)

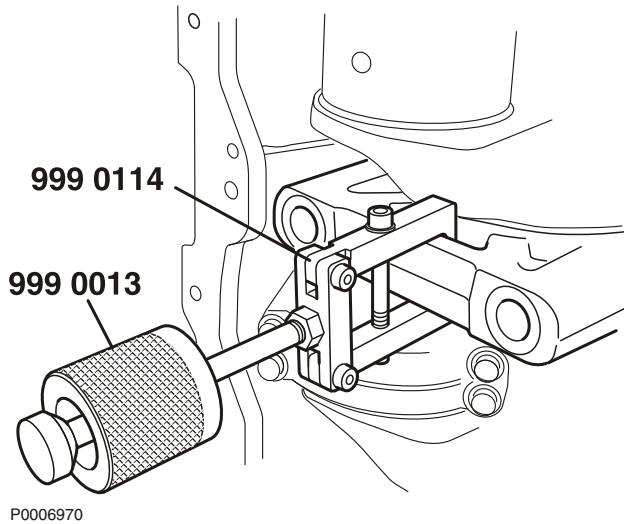
### Removal

- 1 Fit tool (missing toolreference).

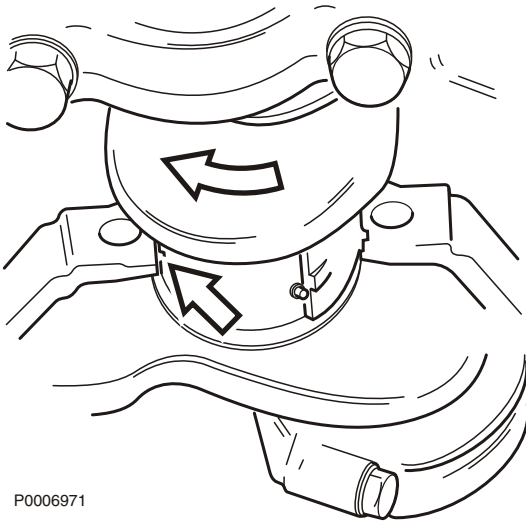


- 2 Remove the oil suction pipe and oil pump.  
Remove the bracing frame.





3 Remove one bearing cap.



4 Remove the upper main bearing shell by putting a pin in the crankshaft oil hole and rolling the bearing shell out by turning the crankshaft in the direction of rotation with tool (missing toolreference).

5 Clean and check the bearing seat, bearing cap, shaft journal and bearing shell.  
If the bearing has seized, the reason must be determined before a new bearing is installed.

6 Check that the correct bearing dimension is used when the bearing shells are changed.

**NOTICE!** If case of uncertainty, check in *Technical Data page 27* which oversize dimensions are available.

## Installation

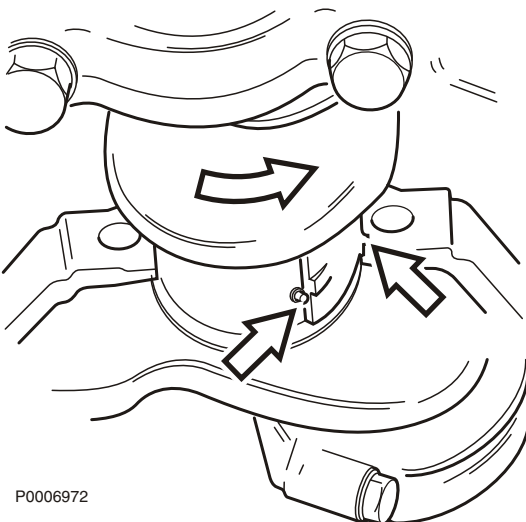
7 Lubricate the shaft journal and the new bearing shells with engine oil.

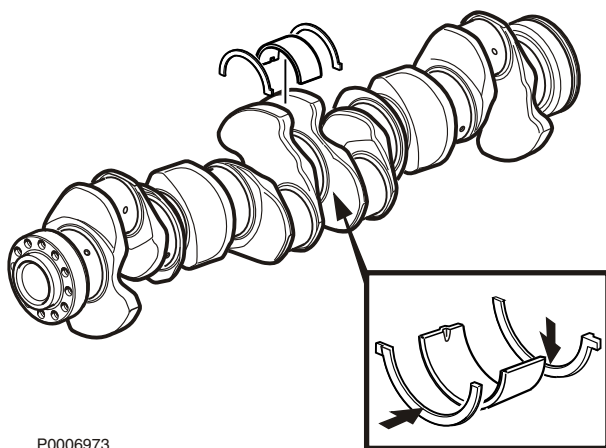
8 Install the upper bearing shell by turning the crankshaft using tool (missing toolreference) against the direction of rotation with the pin in the oil hole.

**NOTICE!** Check that the pressed-out bearing shell heel is correctly aligned in the bearing seat cutout.

Make sure that the upper bearing shells (those to be located in the engine block) are equipped with oil holes.

**NOTICE!** Remove the pin when done.





- 9 Fit the main bearing cap together with the lower bearing shell.

**NOTICE!** The main bearing caps are asymmetric and can only be installed in one position. Note the main bearing cap numbers showing their locations if several caps are removed simultaneously.

Torque the caps in two steps as specified; refer to *Technical Data* page 27.

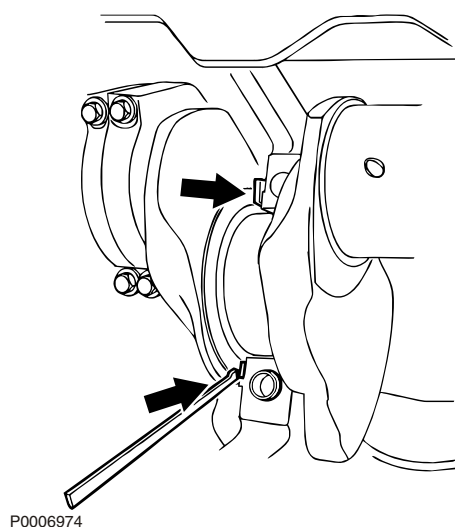
- 10 Change the other bearing shells, one a time, in the same way as the first one. Each time a changed is made, check that the crankshaft does not seize by turning it using tool (missing tool-reference).
- 11 Check crankshaft end float and replace the thrust washers if the clearance is too great or if the thrust washers are damaged.

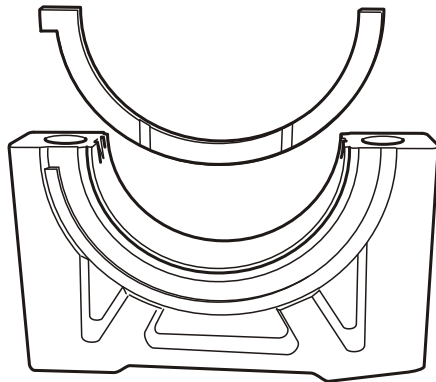
**NOTICE!** Measure the end float with a dial gauge. Thrust bearings are available in a number of over-size dimensions. Refer to *Technical Data* page 27 for oversize dimensions and axial play.

The crankshaft thrust bearing is located in the center main bearing.

- 12 Use a narrow plastic or wood stick to remove the thrust bearing washers from the cylinder block bearing seat.

**NOTICE!** The thrust washers can only be placed in one position.





P0006975

- 13 Check the axial play of the crankshaft when all main bearing caps have been torqued; refer to *Technical Data page 27* for specification.
- 14 Install the bracing frame and torque according to the tightening chart; refer to *Technical Data page 27*.
- 15 Install the oil pump and oil suction pipe.
- 16 Remove tool (missing toolreference) from the fly-wheel housing and install the cover.
- 17 Install the oil pan.  
Add oil and change the oil filter.  
Check the oil pressure.

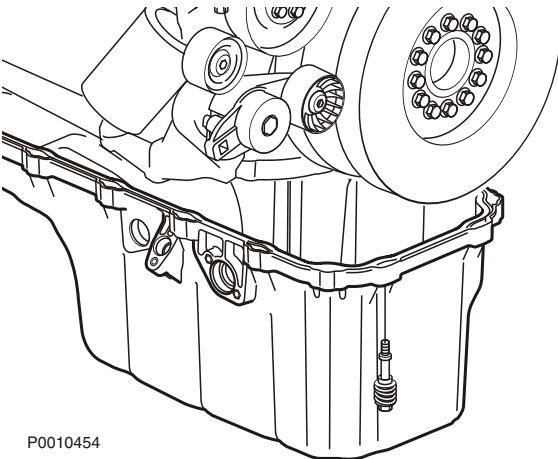
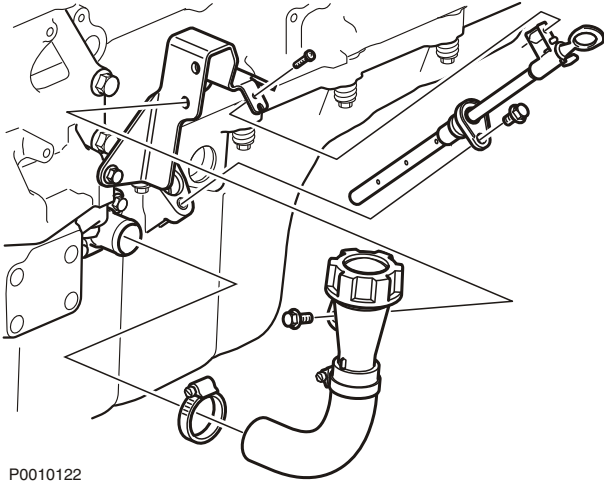
## 22-1 Oil pump and Line

### Lubrication Oil Pump, Change

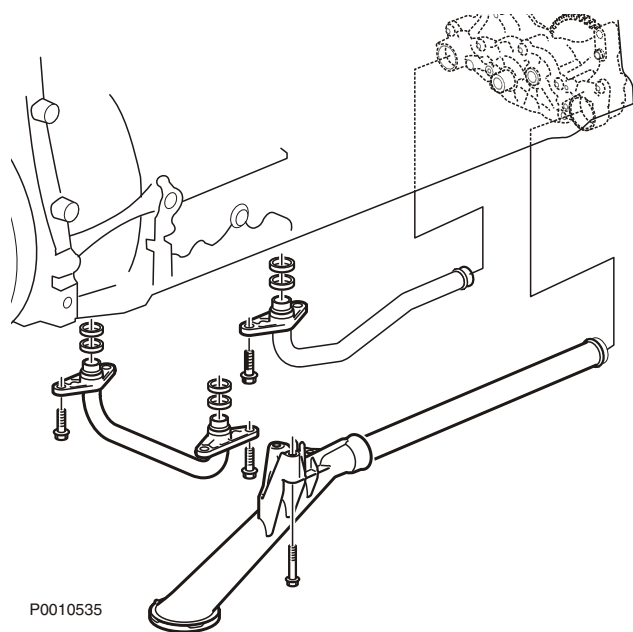
Engine oil drained.

#### Removal

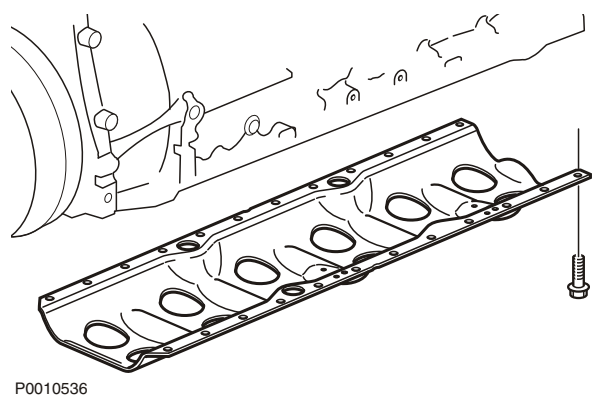
- 1 Remove the oil filler with attachment and the oil dipstick.  
Remove the oil level sensor connector.



- 2 Remove the oil sump bolts and remove the sump.
- 3 Remove the oil filters.



- 4 Remove the suction strainer and the pipe to the pump. remove the delivery pipe from the pump. Remove the connection pipe.

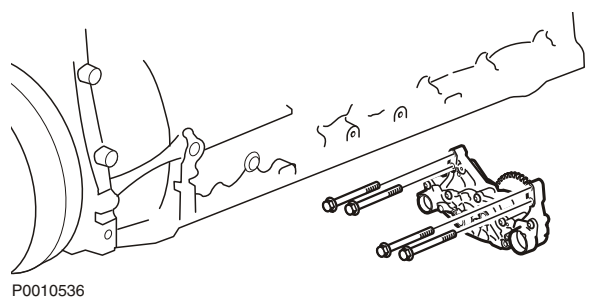


- 5 Remove the reinforcement plate.



**CAUTION!**

Cutting hazard! Protect your hands!



- 6 Remove the oil pump.

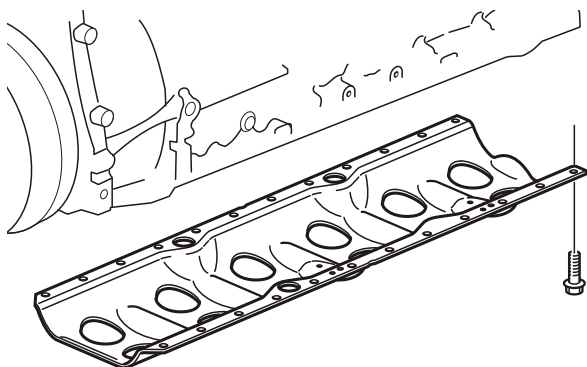


## Installation

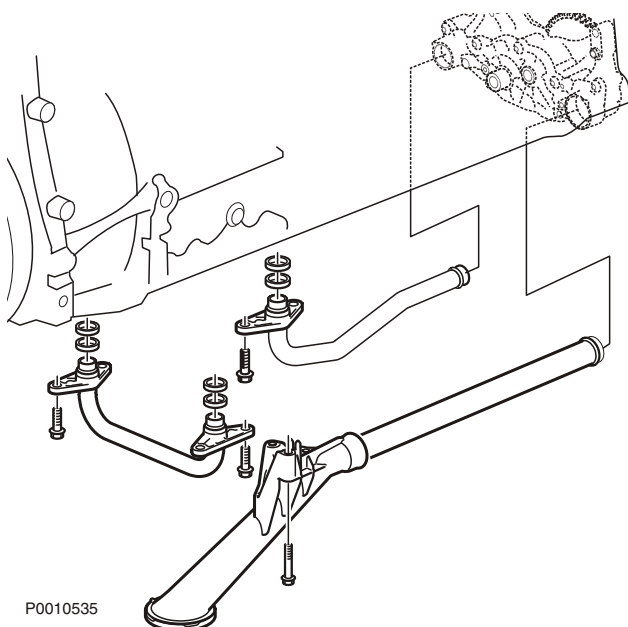
- 7 Install the oil pump by meshing the gearwheels and tightening the bolts.
- 8 Install the reinforcement plate with new bolts.

### **CAUTION!**

Cutting hazard! Protect your hands!

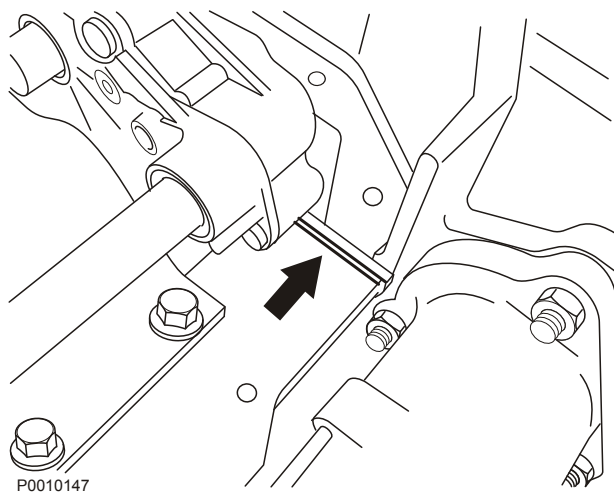


P0010536



P0010535

- 9 Use new seals for all pipes. Install the delivery pipe from the pump. Install the connection pipe. Tighten all bolts to the reinforcement plate in the sequence and torques according to *Special Tightening Torques* page 8. Install the suction strainer and pipe to the oil pump.



- 10 Clean the oil sump thoroughly. Check to see if the oil sump rubber seal requires replacement. Cut away excess sealant from the front crankshaft seal cover. Cut away excess sealant from the timing plate and the flywheel housing. Apply new sealant to the joints and install the oil sump within 20 min.
- 11 Tighten the oil sump bolts and install the engine mount and tighten according to *Special Tightening Torques* page 8. Install new oil filters. Fill with engine oil.

## 22-2 Oil filter

### Oil Pressure Sensor, Check

If you suspect that the oil pressure sensor reads incorrectly, check the oil pressure with an **external pressure sensor**.

The pressure sensor is located behind the control unit; refer to *Engine Placement*.

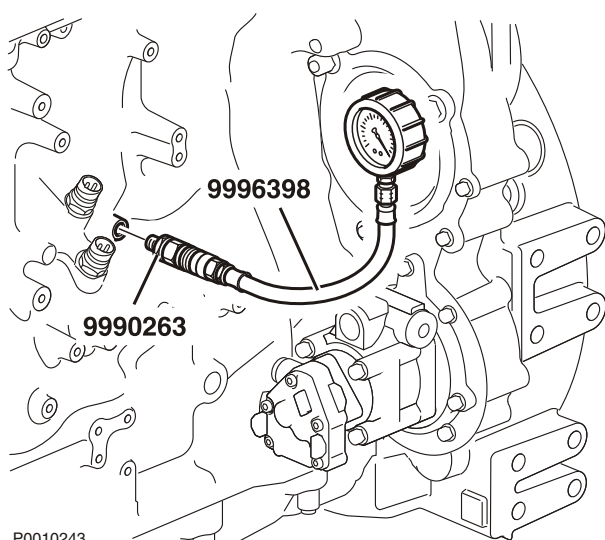
**Tools:**

9996398 Manometer

9998493 Hose

9990263 Nipple

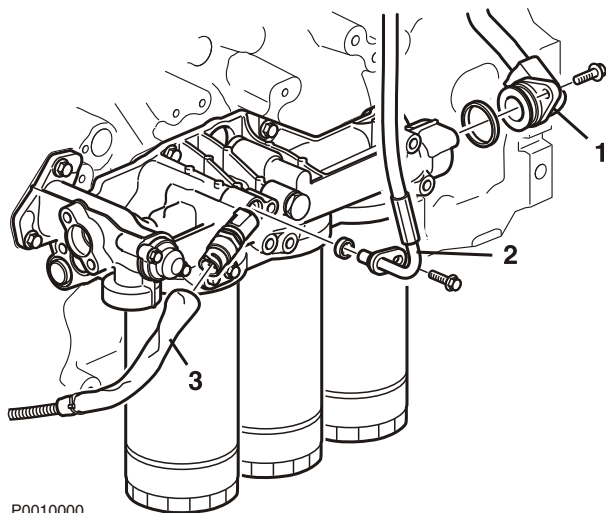
- 1 Check the oil pressure with an external pressure gauge and compare values with the specification in *Technical Data* page 40.
- 2 Remove the plug and attach 9990263 Nipple.
- 3 Install 9996398 Manometer.
- 4 Start the engine and check the oil pressure.  
If the oil pressure measurement shows that the pressure is below the minimum value as specified, continue troubleshooting by checking the oil filters.  
If the oil pressure measurement using an external pressure sensor shows that the pressure is within tolerance, but the engine's regular pressure sensor does not, replace the pressure sensor.
- 5 Remove the hose and pressure gauge.
- 6 Install the plug with a new seal washer



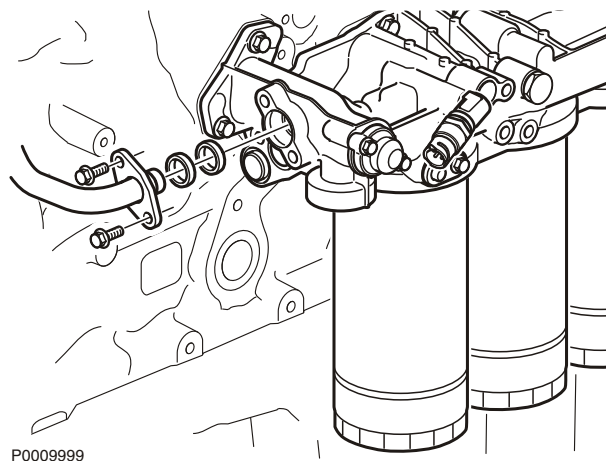
## Oil Filter Bracket, Change

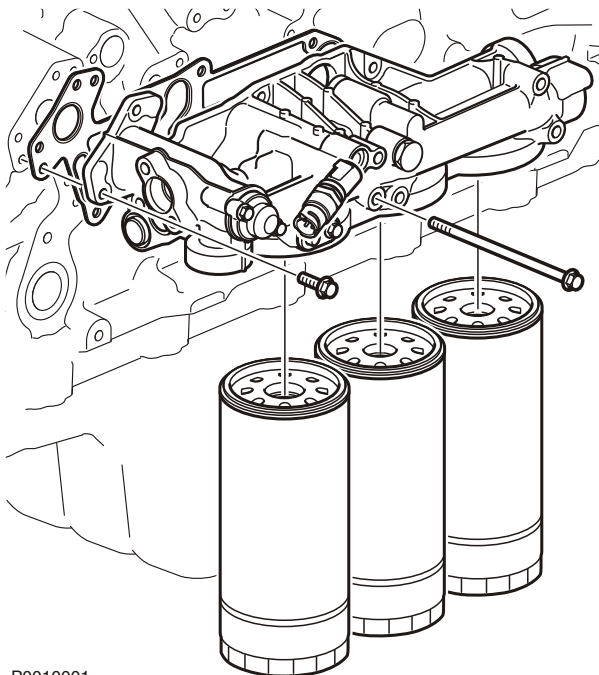
### Removal

- 1 Clean the oil filter bracket and surrounding surfaces.
- 2 Remove the front oil pipe (1) located between the oil cooler and filter bracket. Remove the oil hose (2) to the turbocharger. Remove the pressure sensor connector (3).



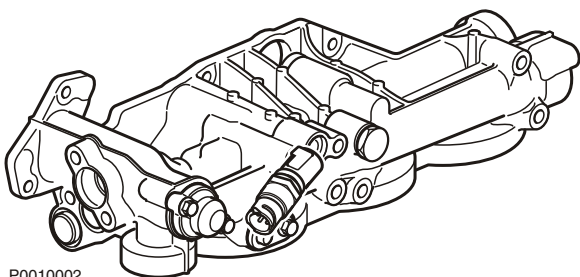
- 3 Remove the rear oil pipe located between the oil cooler and filter bracket.





P0010001

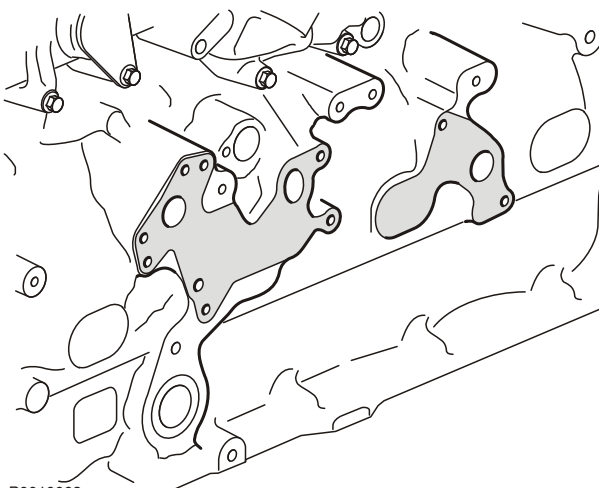
- 4 Remove the oil filters.
- 5 Remove the bolt to the coolant drain line. Remove the bolts on the filter bracket (7 pcs.). Remove the bracket. Remove the gasket.



P0010002

### Installation

- 6 Move over the parts that are to be reused to the new bracket.

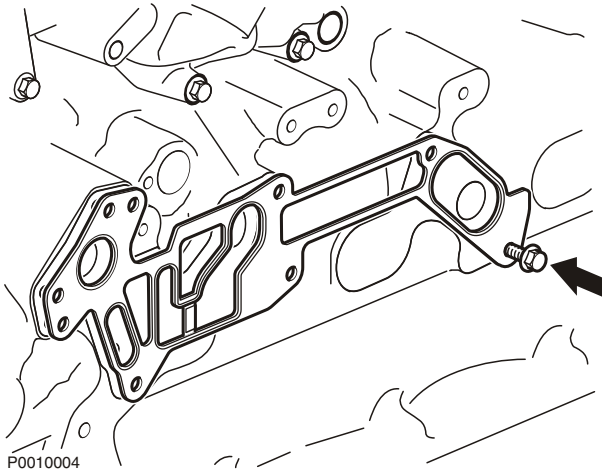


P0010003

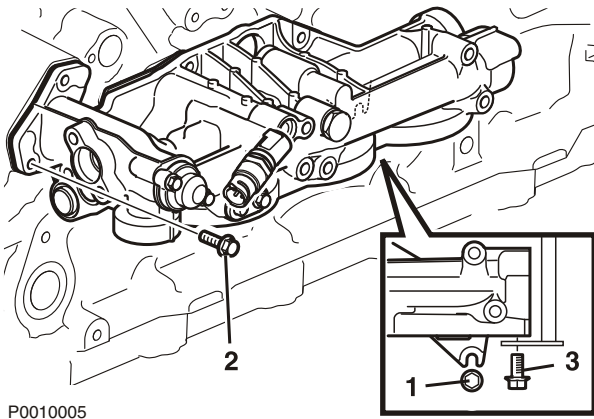
- 7 Thoroughly clean the engine block contact surfaces for the bracket.

### IMPORTANT!

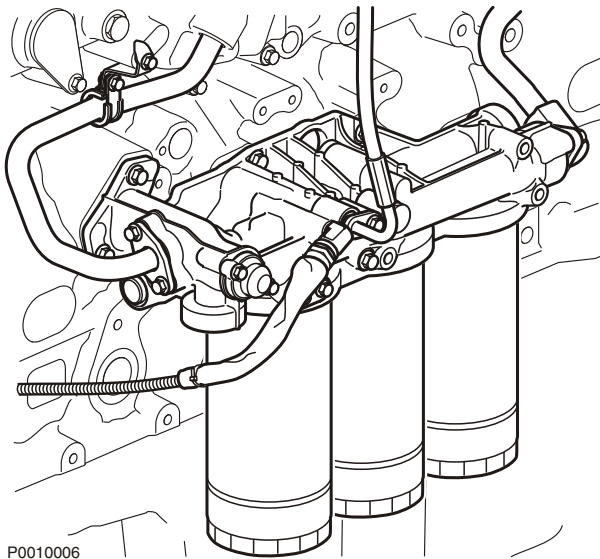
Sealant may absolutely not be used. The use of sealant may result in engine breakdown.



- 8 Install a new gasket and screw in the lower front bolt a couple of turns.



- 9 Lift up the back edge of the sea; and suspend the bracket from the front bolt (1). Fit a bolt (2) to the rear end.  
Install the remaining bolts and tighten them.  
Install the bolt (3) to the coolant drain line.



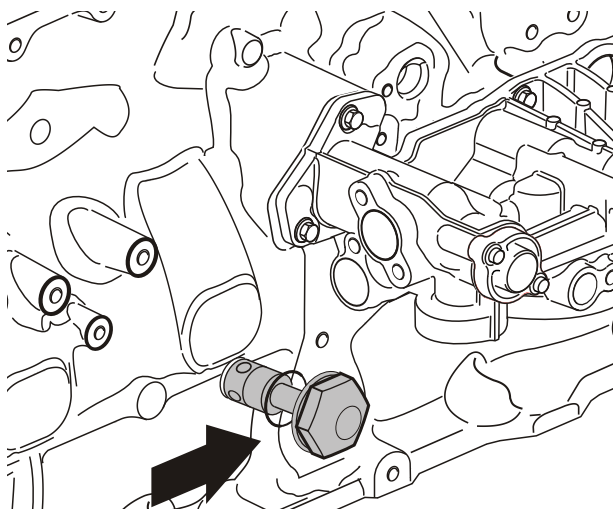
- 10 Install the front and rear pipes to the oil cooler with new seals. Install the hose to the turbocharger with a new seal.  
Install the pressure sensor connector. Clamp the heat shield to the pressure sensor.  
Install new oil filters.  
Clamp the hose to the waste gate controller.
- 11 Replenish or change the oil.
- 12 Start the engine and check oil system function and integrity.
- 13 Switch the engine off and check the oil level.

## Safety Valve, Oil Pressure, Replace

Tools:

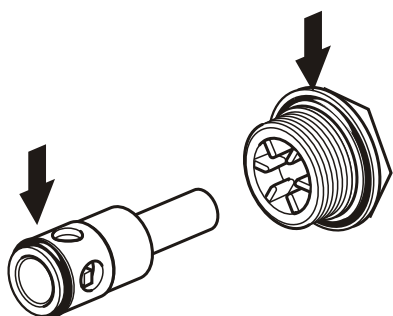
9998598 Sleeve

- 1 Clean round the safety valve.
- 2 Remove the safety valve cover using 9998598 Sleeve.
- 3 Remove the safety valve and make sure the O-rings come with it. Check that there is no dirt on the valve sealing surface on the engine block.



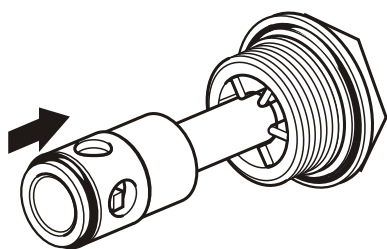
P0010334

- 4 Install a new O-ring on the valve cover. Brush a little grease on the O-ring and press it in place so that it is secure.

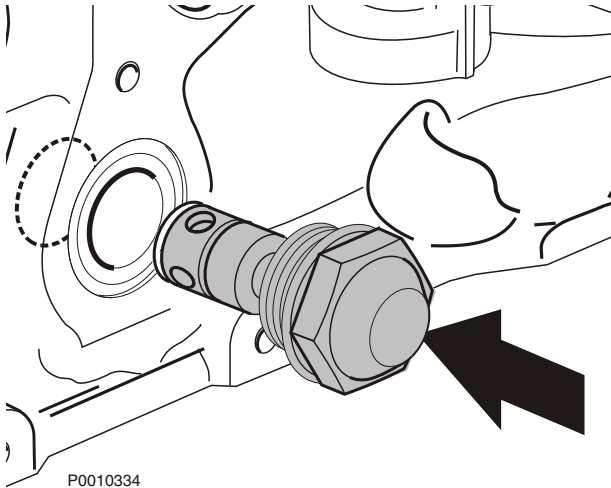


P0010335

- 5 Install the valve half way into the cover.

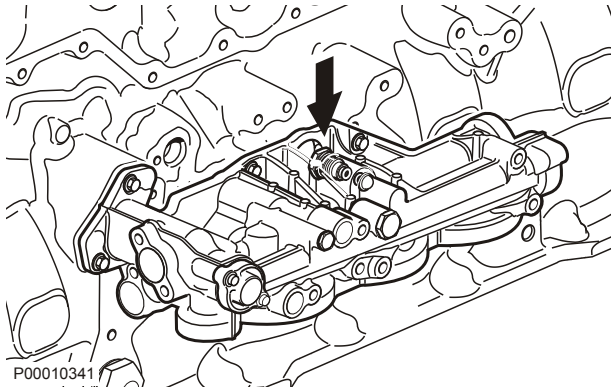


P0010336

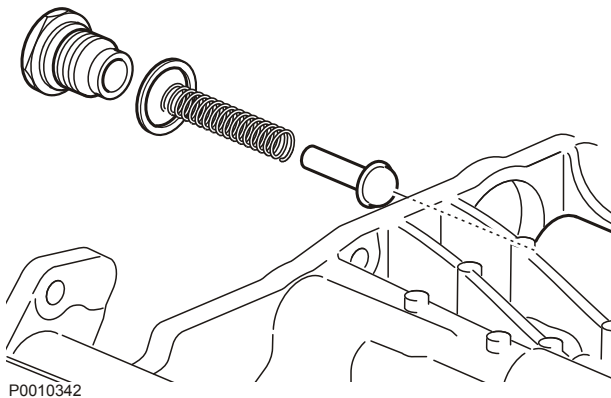


- 6 Guide the valve into the engine block and fasten the cover. The cover should be easy to screw down all the way until the O-rings bottom. Tighten according to *Special Tightening Torques page 8*.
- 7 Start the engine and check that no oil leakage is present.

## Bypass Valve, Oil Filter Bypass, Replace



- 1 Remove the oil filter bracket (refer to *Oil Filter Bracket, Change page 234*) in order to gain access to the overflow valve.



- 2 Remove the overflow valve plug. Remove the seal washer, spring and valve body and replace with new parts. Clean the oil channels and check the seal seat in the bracket. Install the valve body with the spring and the plug with the seal washer.
- 3 Install the oil filter bracket with a new seal; refer to *Oil Filter Bracket, Change page 234*.

### IMPORTANT!

No sealant may be used. The use of sealant may result in engine breakdown.



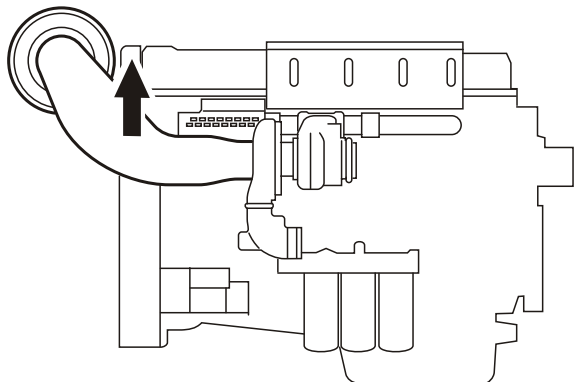
## 22-3 Oil cooler

### Oil Cooler, Replace

Coolant drained.

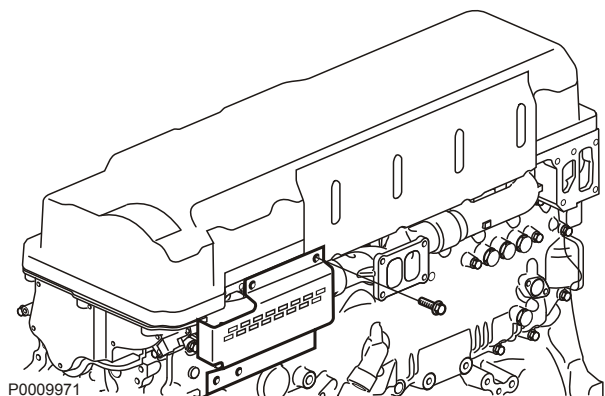
#### Removal

- 1 Remove the pipe between the air cleaner and the turbocharger.



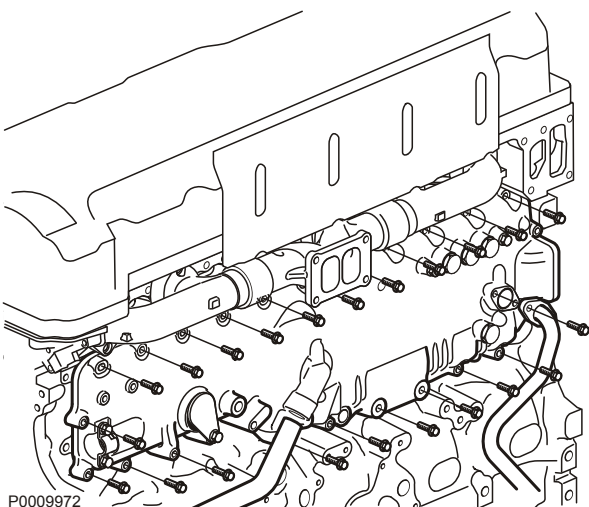
P0009970

- 2 Remove the heat shield.

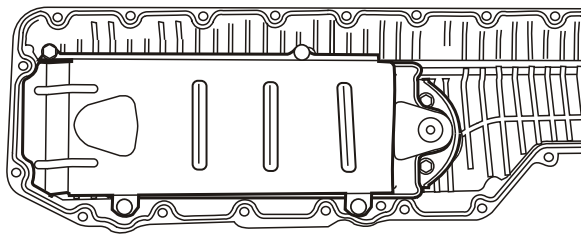


P0009971

- 3 Remove the oil pipe to the oil cooler. Remove the coolant drain pipe. Remove the thermostat housing bolts. One of the rear bolts is saved until last. One bolt behind the water pump must remain in place in the cover when the former is removed. Carefully prise the cover away from the engine block. Lift the cover and oil cooler away to the rear.

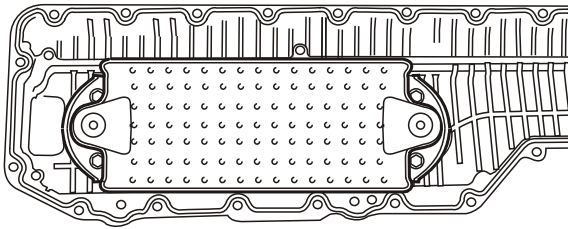


P0009972



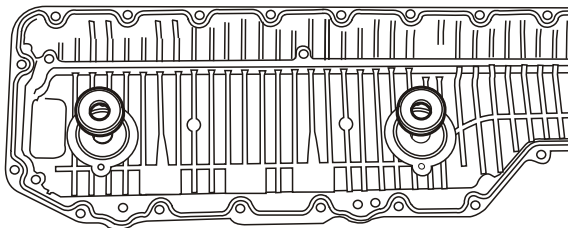
P0009973

- 4 Remove the oil cooler cover plate.



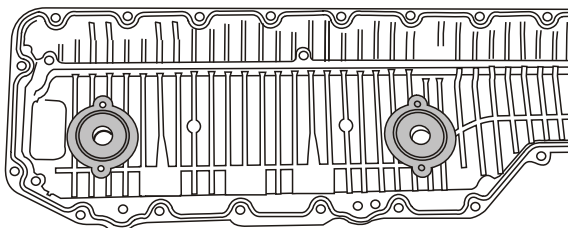
P0009974

- 5 Remove the oil cooler.



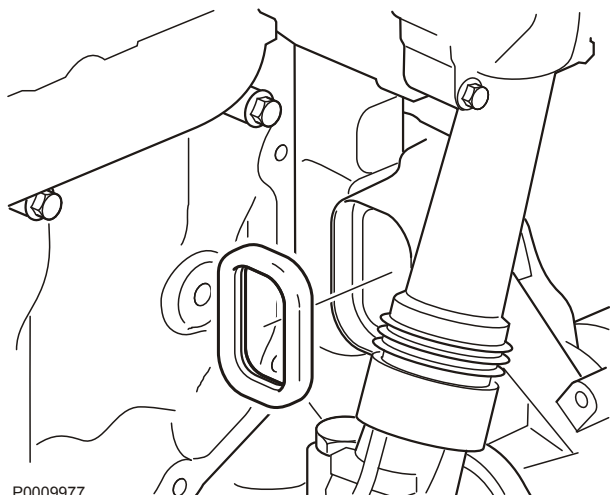
P0009975

- 6 Remove the two seal rings.



P0009976

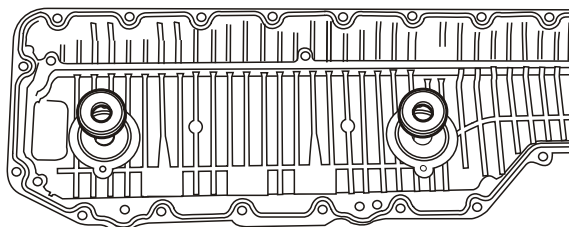
- 7 Clean all sealing surfaces.



- 8 Check the front seal against the water pump and replace as necessary.

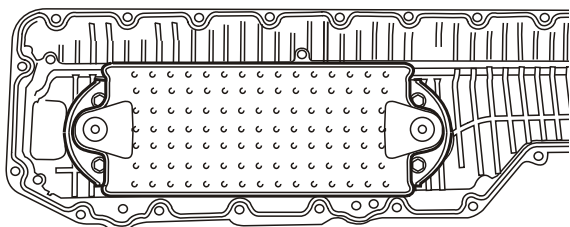
### Installation

- 9 Install new seal rings on the oil cooler.



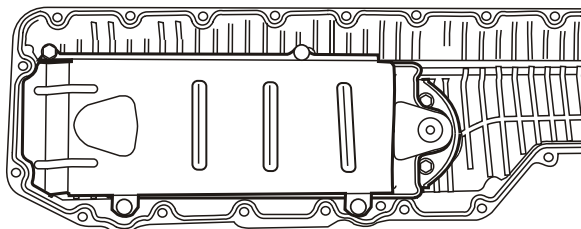
P0009975

- 10 Install the oil cooler.

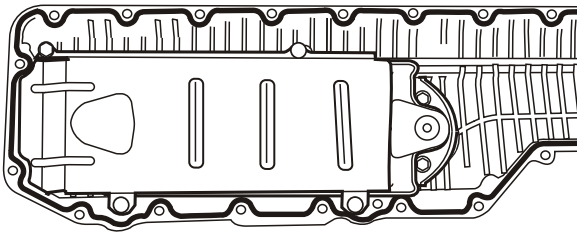


P0009974

- 11 Install the oil cooler plate.

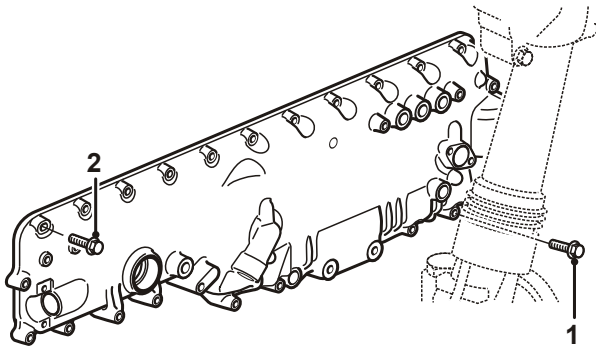


P0009973



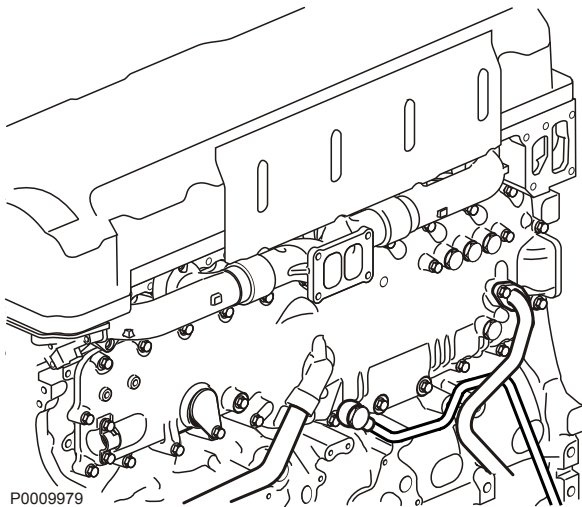
P0010538

- 12 Check the cover seal. If it needs to be replaced, then:  
Clean the groove for the seal thoroughly. Apply a thin bead of sealant 1161771 in the groove, max 20 min. before the cover is installed. Spread out the sealant with a finger so that only a thin layer is in the groove.  
Press the new seal into the groove. Make sure the seal's flat surface reaches the bottom of the groove.



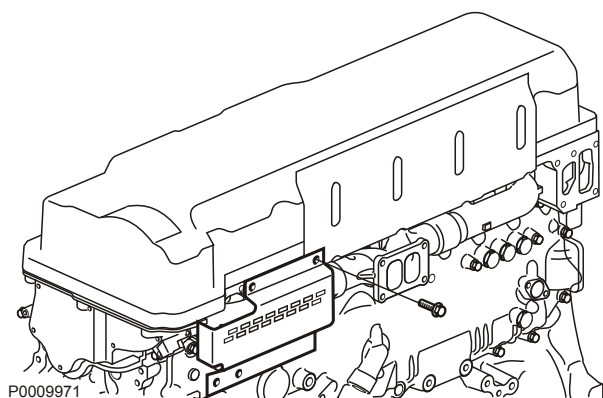
P0009978

- 13 Install bolt (1) which will end up behind the water pump in the cover. Lift the cover into place. Install a bolt (2) in the oval hole.
- 14 Press the cover forward and install another bolt. Install the remaining bolts and tighten them according to the chart in *Special Tightening Torques* page 8.



P0009979

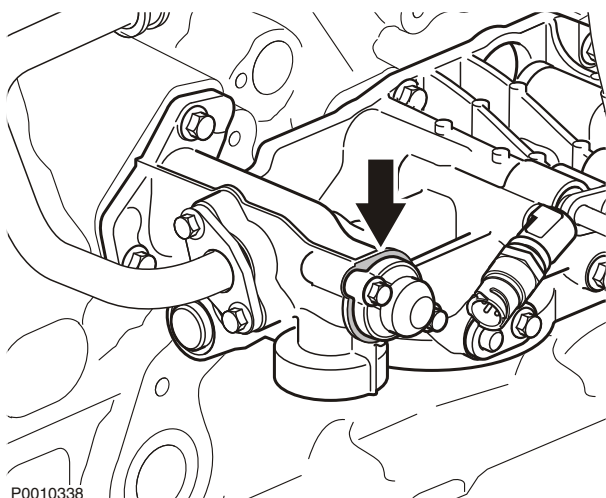
- 15 Install the oil pipes with new seals and tighten them. install the coolant drain pipe.
- 16 Fill the cooling system, pressure test and check integrity; refer to *Cooling System, Pressure Testing* page 108.



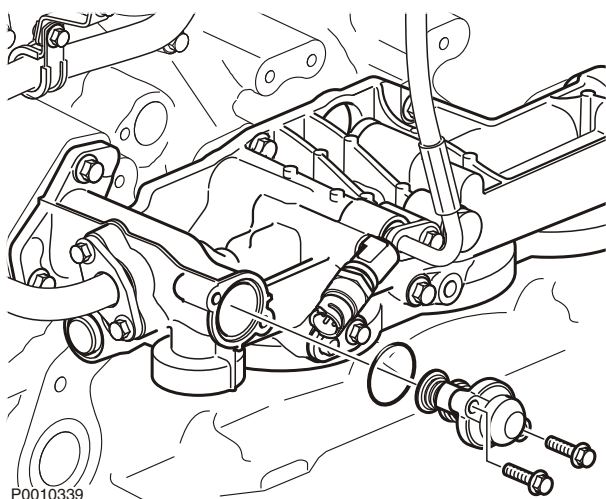
- 17 Install the heat shield.
- 18 Install the pipe between the turbocharger and the air cleaner. Check the engine oil level and top up if necessary.

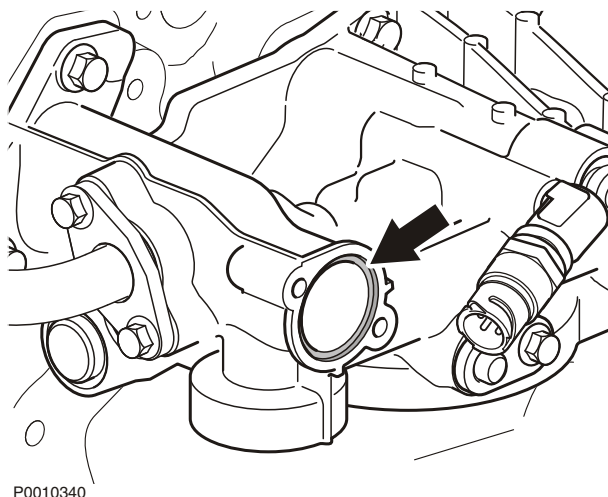
## Thermostat Oil Cooler, Change

- 1 Clean the surface around the thermostat.



- 2 Remove the thermostat housing bolts. Remove the thermostat and O-ring.



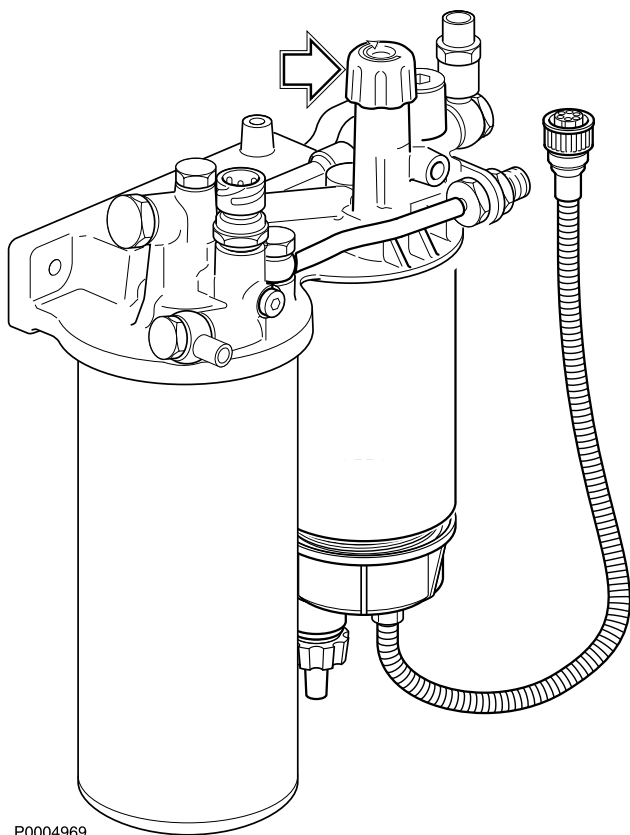


- 3 Check that there is no dirt in the oil ducts.  
Clean the O-ring groove.
- 4 Install a new O-ring in the groove. Install a new thermostat.  
Tighten the bolts.
- 5 Start the engine and check that no oil leakage is present.

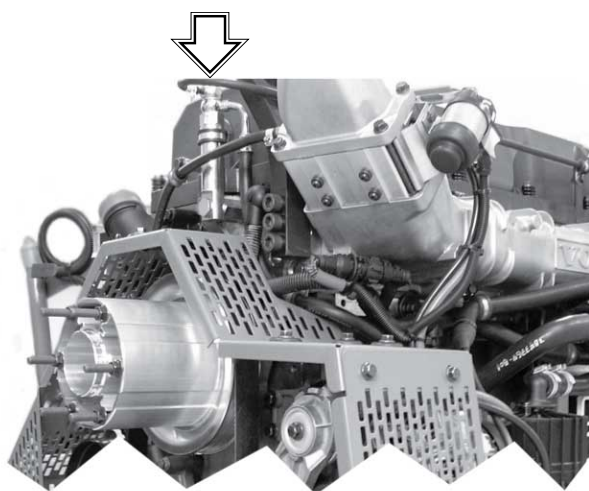
## 23-0 Fuel System, General

### Fuel system, bleeding

- 1 Check that there is sufficient fuel in the tank, and that any fuel taps are open.
- 2 Twist the hand pump free from the fuel filter bracket.



P0004969



P0004970

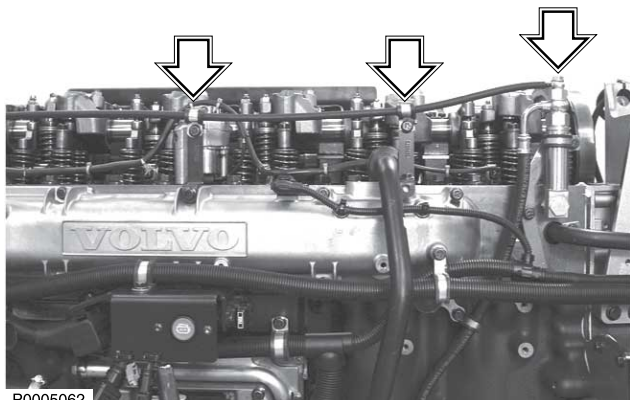
- 3 Open the nipple on the front fuel connection. Connect a drain hose.
- 4 Purge the fuel system by pumping with the hand pump until fuel flows. Close the nipple and secure the hand pump.
- 5 Start the engine and allow it to idle fast for about 10 minutes.
- 6 Perform a leakage and function check.

## Draining, Fuel Duct in Cylinder Head

### IMPORTANT!

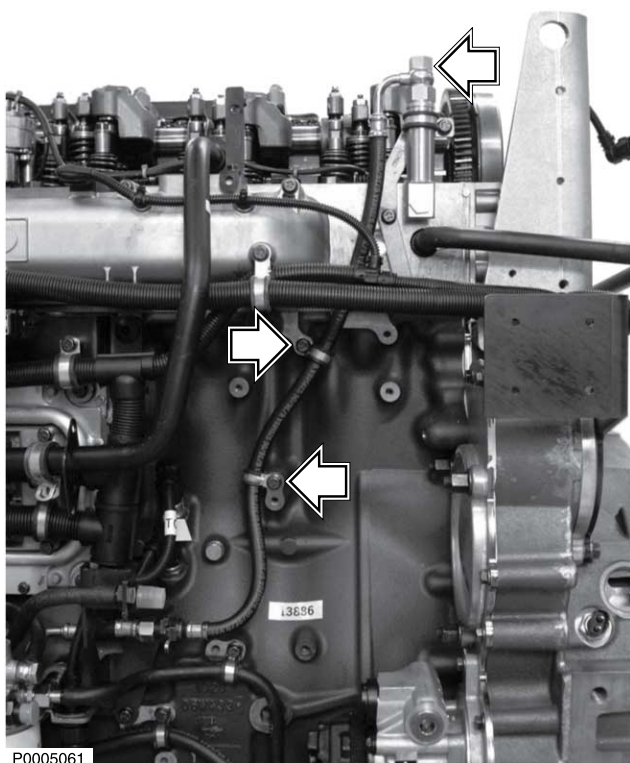
Make sure that dirt does not enter the fuel channels and hoses.

- 1 Clean around the fuel connections at the cylinder head rear end.
- 2 Remove the purging hose screw.  
Remove the two clamps.



- 3 Remove the fuel supply line on the engine topside (coming from the filter bracket).  
Remove the two clamps

**NOTICE!** Do **not** remove the lower union at the filter bracket.

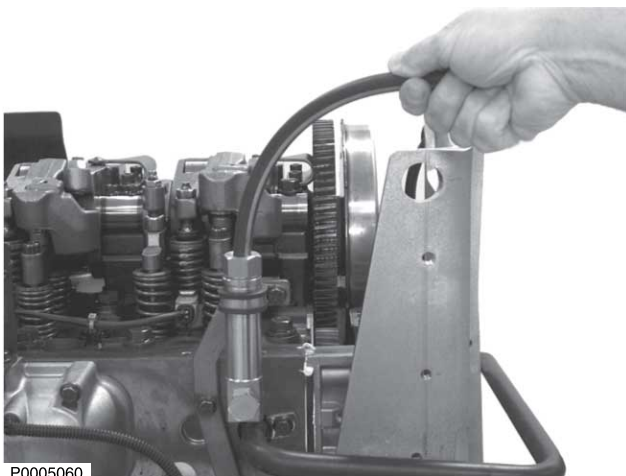






P0005059

- 4 Allow the hoses to hang into a receptacle.



P0005060

- 5

**IMPORTANT!**

Take great care to ensure that dirt does not enter the fuel channel.

Use a suitable hose and blow the fuel through the fuel channel in the cylinder head, so that it runs out into the receptacle.

- 6 **NOTICE!** If a compression test must be carried out, do not connect the fuel lines until the test has been completed. Otherwise the cylinder head fuel channels will fill with fuel again.
- 7 When installing the fuel hoses, use new seals.

## 23-3 Fuel Feed Pump and Filter

### Fuel Feed Pressure, Check

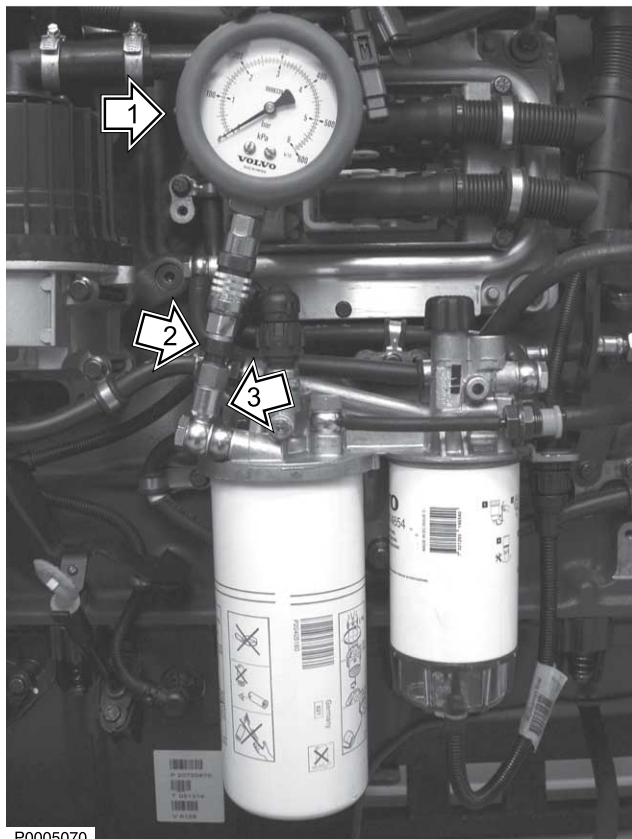
Tools:

9990124 Nipple

9996666 Nipple

9998339 Manometer

- 1 Install tool:
  - 1 9998339 Manometer
  - 2 9996666 Nipple
  - 3 9990124 Nipple
- 2 Check that the fuel feed pressure is according to specifications: Refer to *Engine, General* page 26.
- 3 Remove the tool.  
Install new fuel line seals.



P0005070

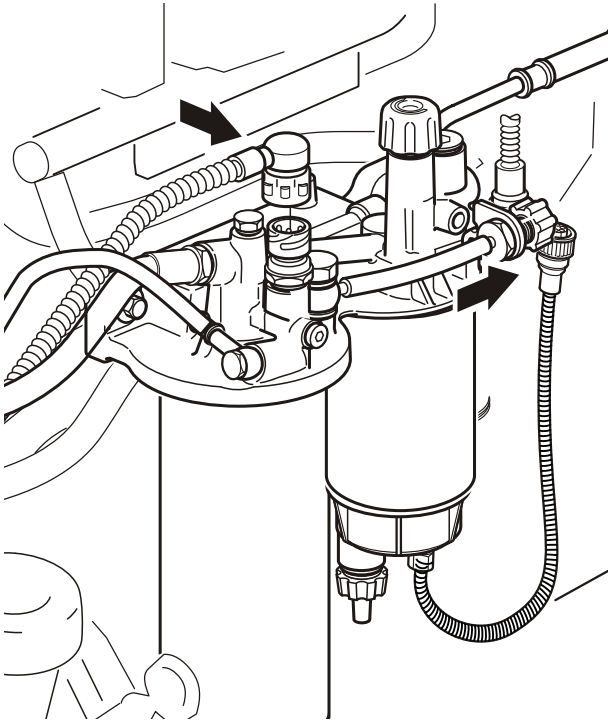
### Fuel Filter Bracket, Change

#### IMPORTANT!

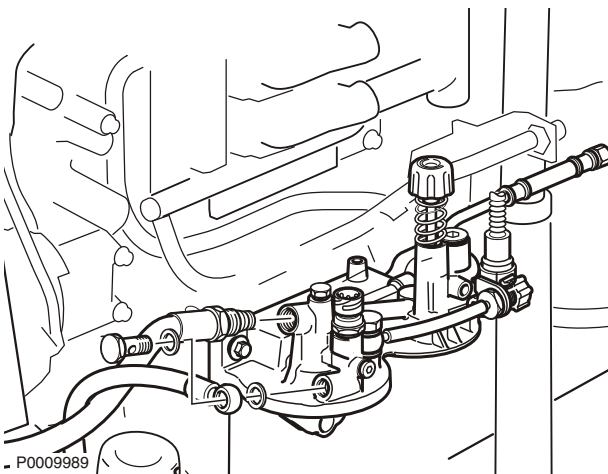
Take great care to keep fuel system unions clean. Even minimal amounts of dirt can cause engine breakdown.

#### Removal

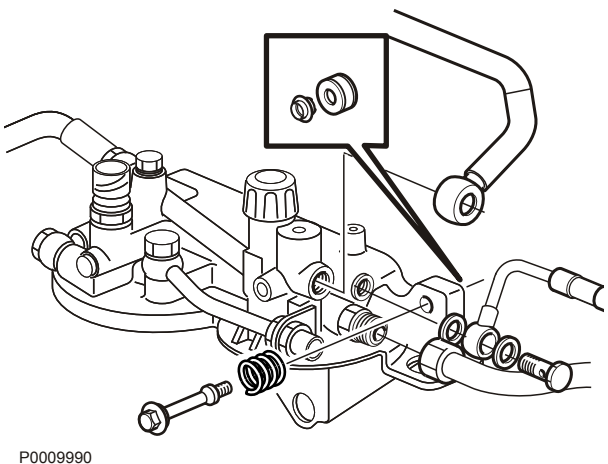
- 1 Switch off battery power.
- 2 Thoroughly clean the fuel filter bracket, fuel hoses and unions, and the area around the bracket.



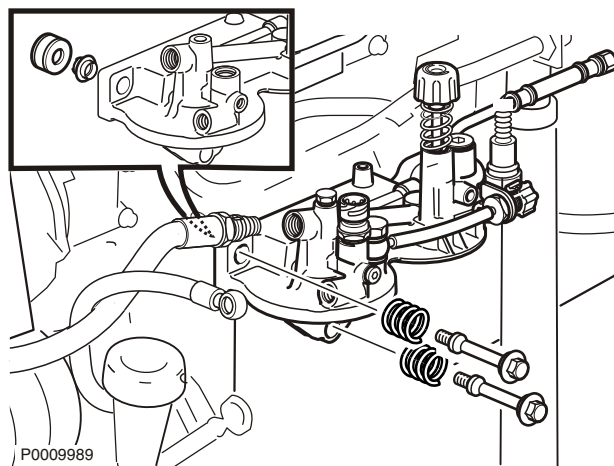
- 3 Drain the pre-filter and water separator. Remove both fuel filters.  
Remove the electrical connectors to the pressure sensor and water sensor.



- 4 Remove the return fuel line from the bracket.  
Remove the pump supply line from the bracket.

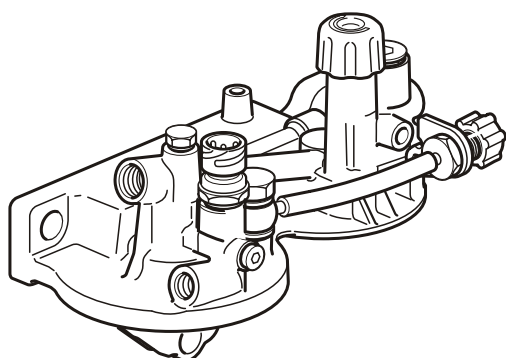


- 5 Remove the inlet line to the bracket. Remove the pump line from the bracket. Remove the bracket's rear attachment bolt.  
Retain the rubber bushing located behind the bracket. Remove the supply line banjo bolt.

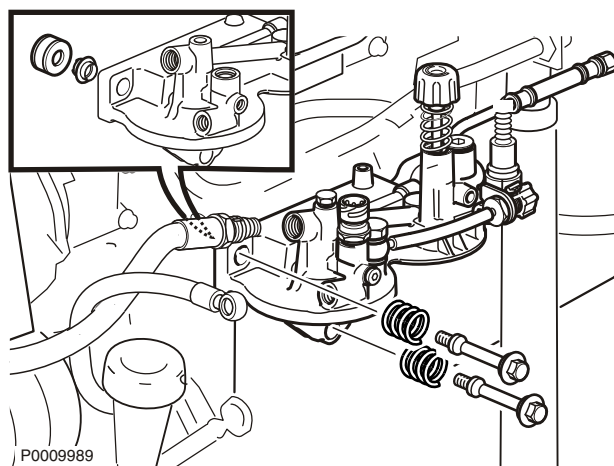


- 6 Remove the two remaining bracket bolts. Retain the rubber bushings located behind the bracket. Lift away the bracket.

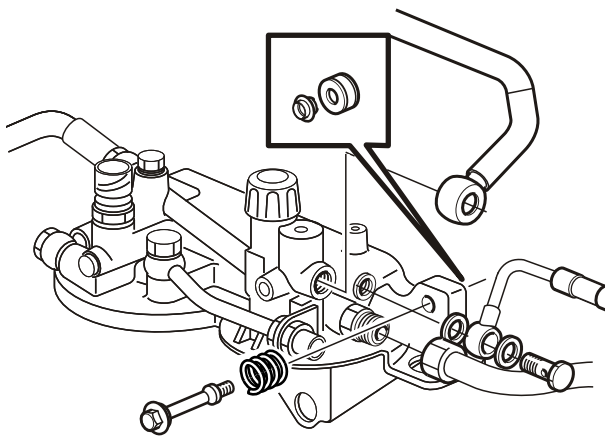
## Installation



- 7 Move over any parts that are to be reused to the new bracket.

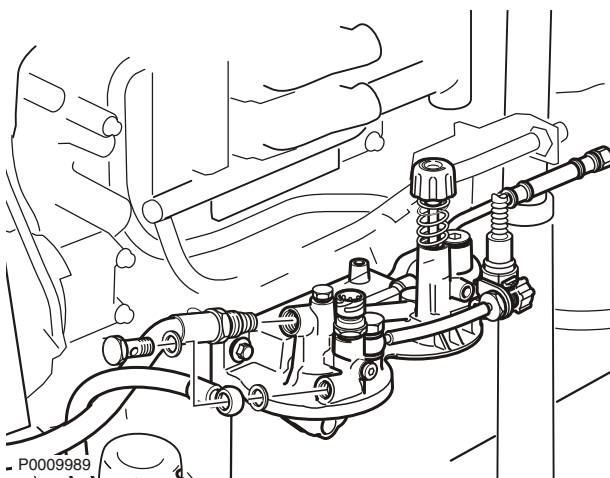


- 8 Install two retaining bolts and the rubber bushings to the bracket (the lower one and the front one).



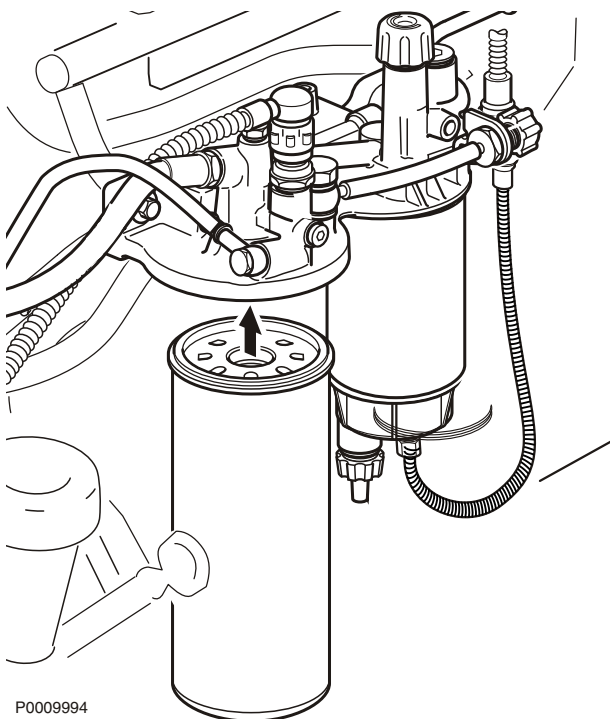
P0009990

- 9 Install and tighten the supply line banjo bolt with new seals. Install the rubber bushing and the bracket's rear bolt.



P0009989

- 10 Install the upper fuel lines with new seals.



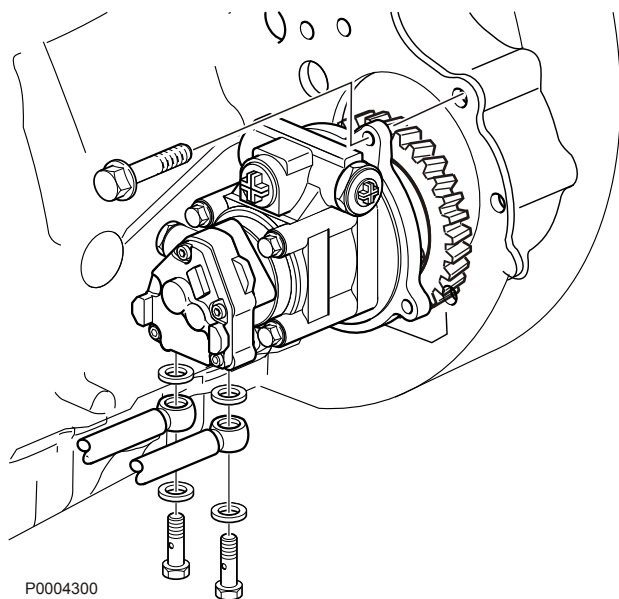
P0009994

- 11 Install new fuel filters and connect the connector. Vent the fuel system. Start the engine and check fuel system integrity.

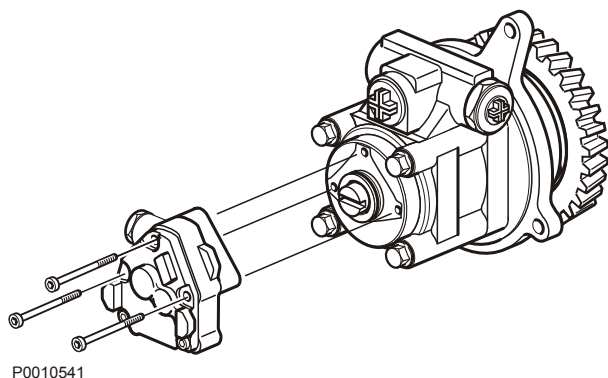
## Fuel Feed Pump, Change

### Removal

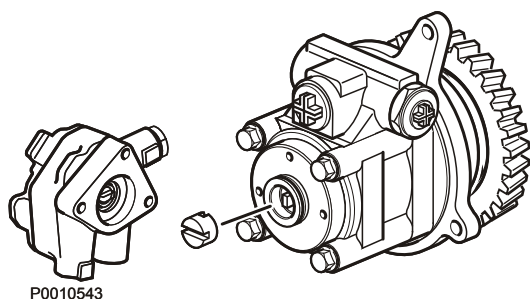
- 1 Clean the fuel pump and fuel lines, and the fuel pump drive device
- 2 Position a collection container underneath the pump. Undo the fuel lines at the pump and allow the fuel to run out into the container. Remove the bolts that attach the entire unit to the engine
- 3 Lift away the pump and drive.



- 4 Remove the bolts that attach the pump to the drive device. Remove the pump.

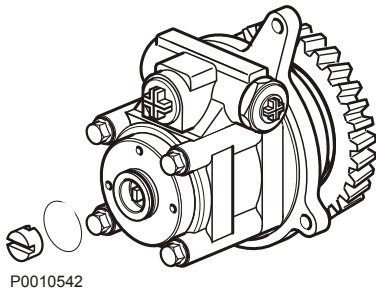


- 5 Retain the intermediate section to the drive. Check that the drive bearings feel serviceable and that the gearwheel is not damaged.

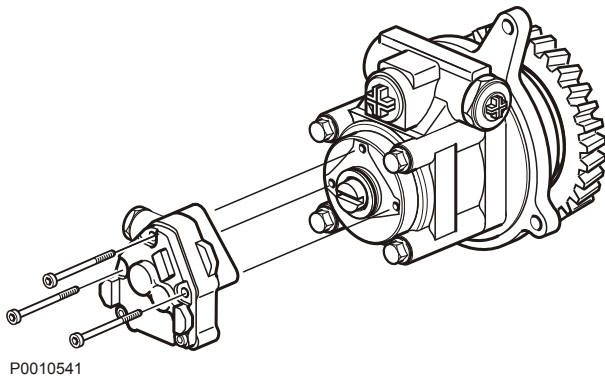


## Installation

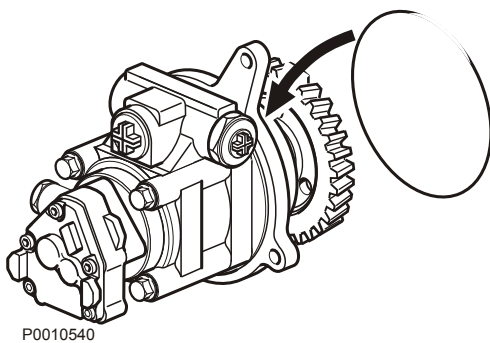
- 6 Install a new O-ring for the pump.  
Install the intermediate section.



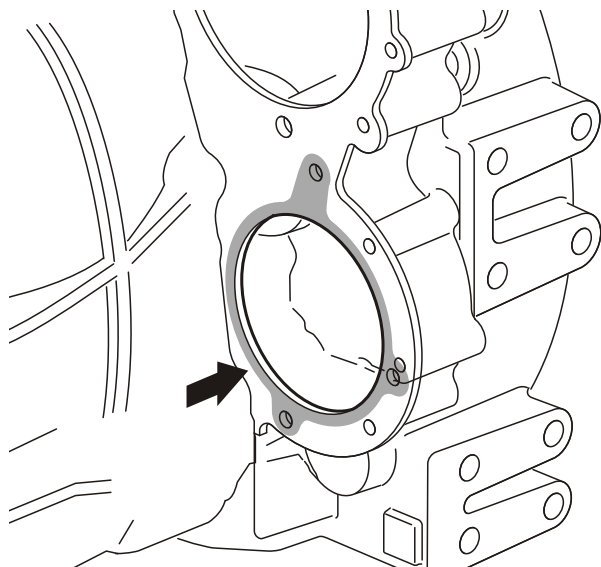
- 7 Install the new pump. Turn the gearwheel so that the intermediate piece fits against the pump and tighten the pump bolts; refer to *General Tightening Torques* page 7.



- 8 Clean the sealing surfaces and install a new O-ring on the drive unit.

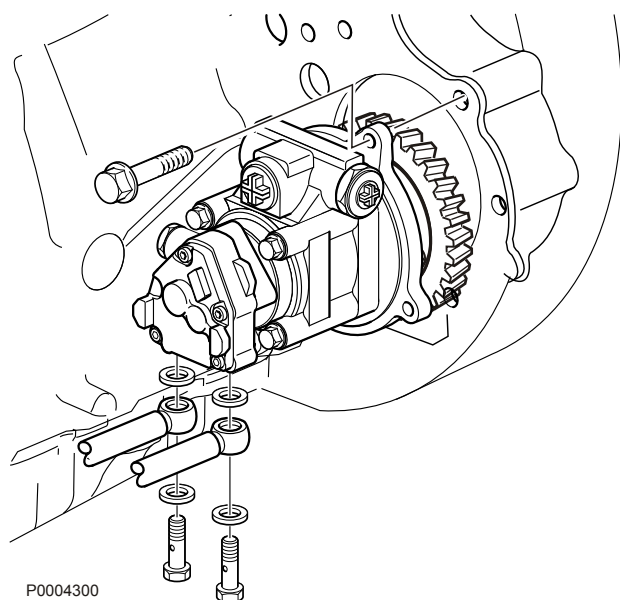






P0010539

- 9 Clean the engine sealing surface.



P0004300

- 10 Install the fuel pump on the engine by aligning the gearwheel into the timing and then tighten the bolts.  
Install the fuel lines with new seals
- 11 Vent the fuel system; refer to *Fuel system, bleeding* page 245.
- 12 Start the engine and check fuel system integrity.



## 23-7 Injectors and Delivery Pipes

### Unit Injector, Replace

#### Tools:

9988539 Compression meter  
 9990006 Puller  
 9990013 Slide hammer  
 9990185 Lifting tool  
 9998248 Adapter  
 9998249 Protective sleeve  
 9998251 Protection plug  
 9998599 Cleaning kit

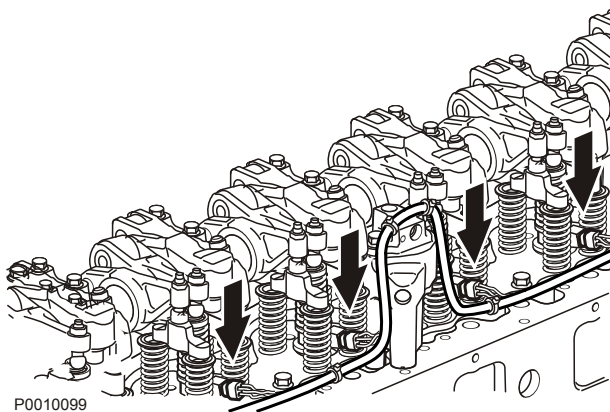
The tool kit 9998599 Cleaning kit includes:

- 9808570 Brush
- 9808616 Extender
- 9998580 Protective sleeve

For valves and unit injector adjustment; refer to *Valves and Unit Injectors, Adjustment* page 177.

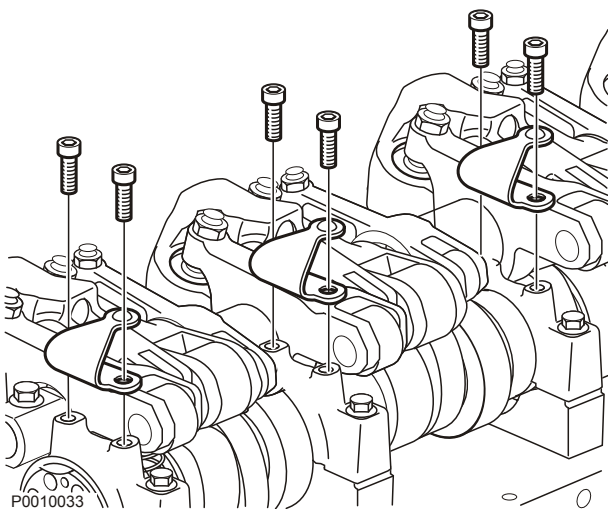
### Removal

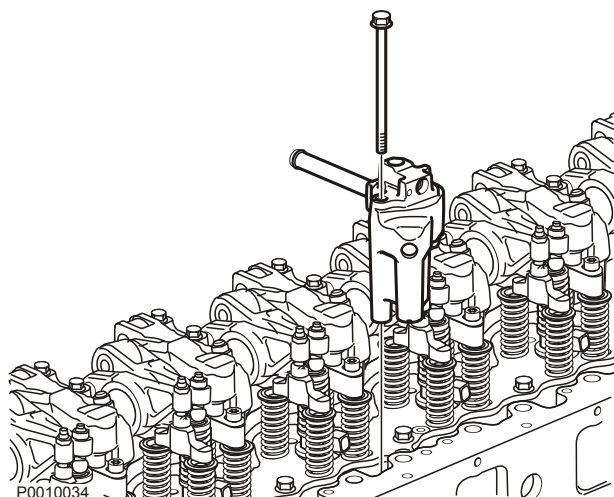
- 1 Remove the ventilation pipe and valve cover.
- 2 Undo the connectors to the unit injectors and oil valve.



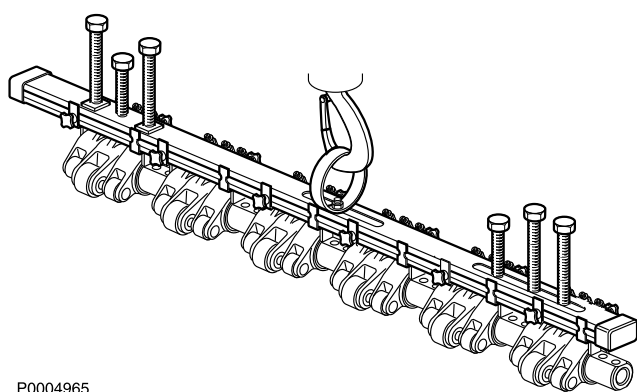
- 3 Remove the EGR rocker arm springs.

**NOTICE!** Do not drop the bolts into the timing gear.

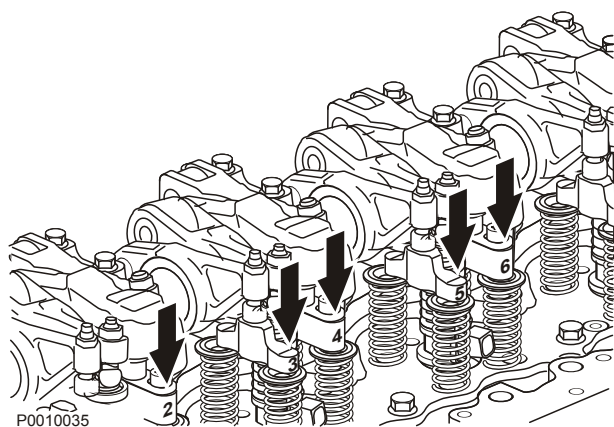




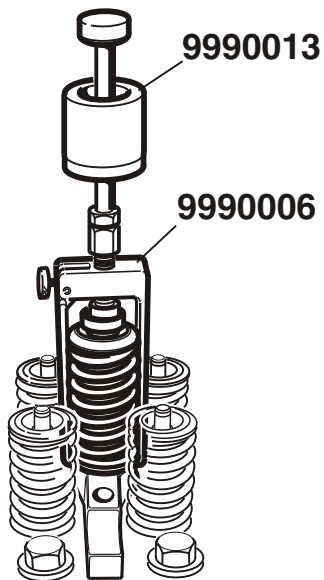
- 4 Remove the rocker arm lubrication valve and oil pipe.  
Undo the rocker arm bridge bolts in stages, equal amounts each time, to avoid bending the rocker shaft.



- 5 Install 9990185 Lifting tool and adjust the holes for the rocker arms (to keep the rocker arms together for each cylinder). The higher holders must be used  
Lift the rocker arm bridge away. Make sure the pistons in the exhaust rocker arms and the adjuster screw ball do not fall out.



- 6 Mark and remove the valve yokes.
- 7 Empty the cylinder head fuel channels; refer to *Draining, Fuel Duct in Cylinder Head* page 246.
- 8 Remove the bolts for the unit injector retaining yoke.

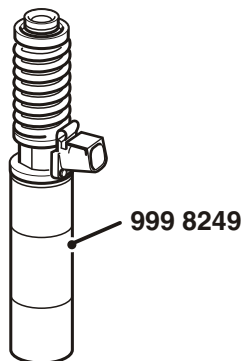


P0001370

- 9 Rock a unit injector loose using 9990006 Puller and 9990013 Slide hammer. Check that the seal washer (steel washer) comes out with the injector. If it is still in the copper sleeve, remove it using 885822 Magnetic pen.

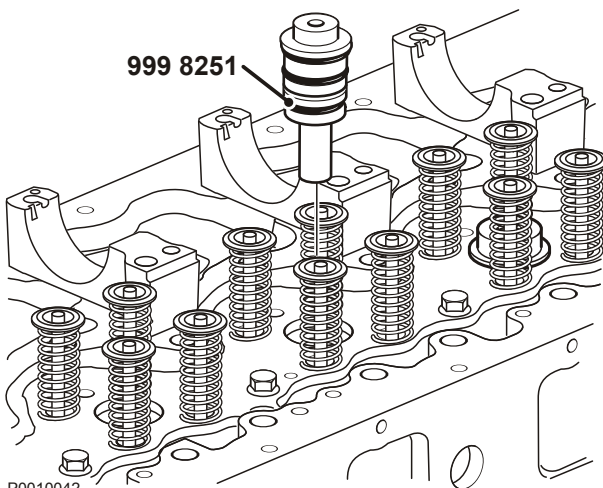
**IMPORTANT!**

The seal washer must always be replaced when installing an injector.



P0010041

- 10 Put the injector in 9998249 Protective sleeve.



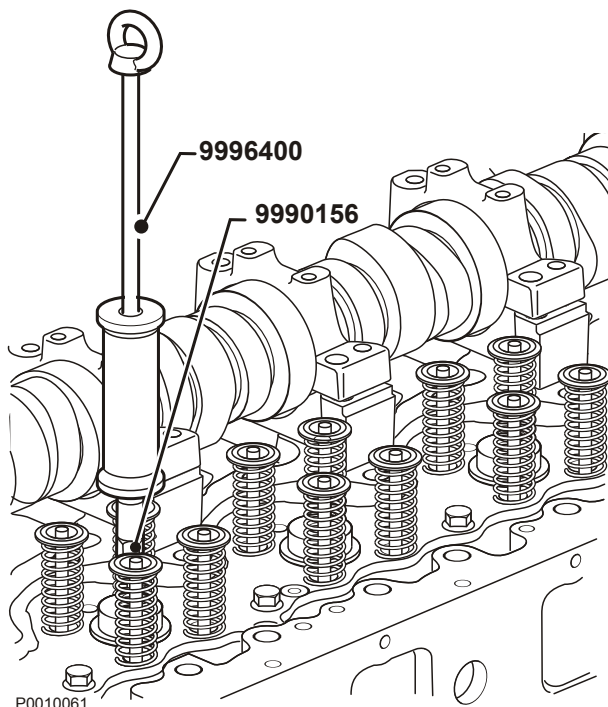
P0010042

- 11 Insert 9998251 Protection plug in the cylinder head. Clean the copper sleeves thoroughly with the aid of 9998599 Cleaning kit.

## Installation

9990156 Adapter  
 9996400 Slide hammer  
 9990185 Lifting tool  
 3883671 Protective sleeve  
 3883672 Protective sleeve

- 12 Remove the protective plug for one unit injector (where necessary use 9990156 Adapter and 9996400 Slide hammer).



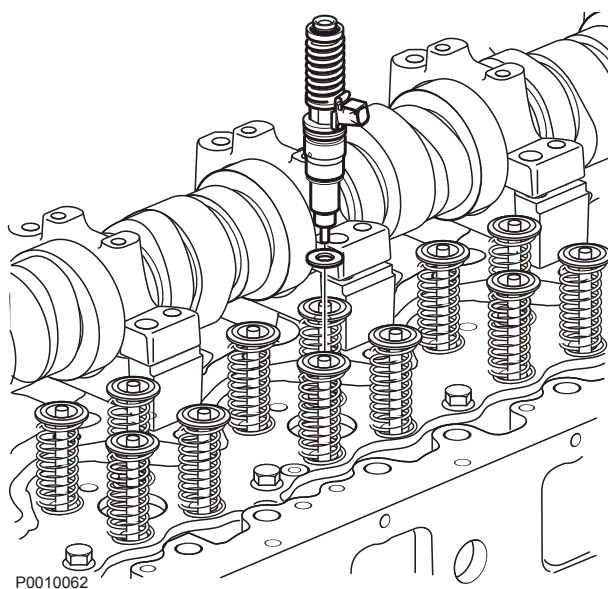
- 13 Remove the injector from the protective sleeve. Replace the unit injector O-rings (use 3883671 Protective sleeve and 3883672 Protective sleeve) and install a **new** steel washer on the injector sealing surface.

### IMPORTANT!

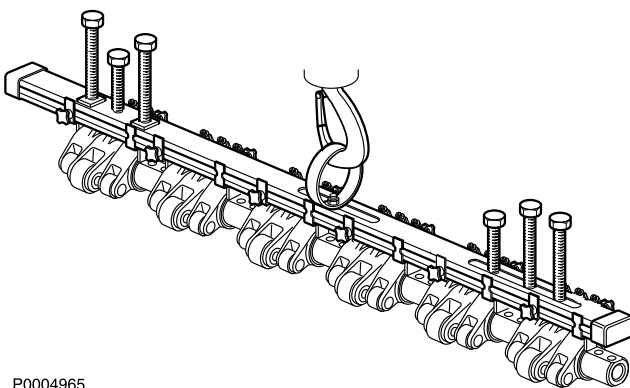
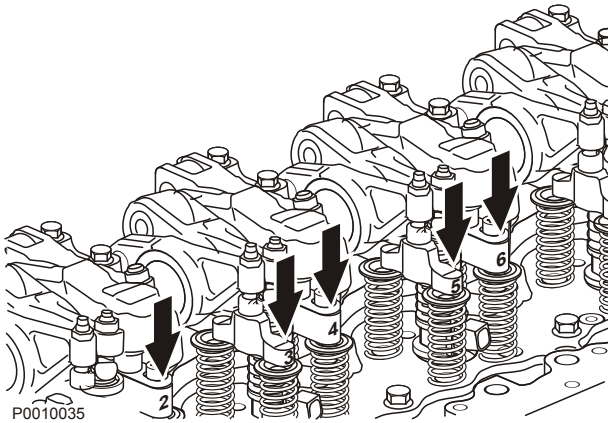
The steel washer must be replaced every time an injector is installed.

Install the injector and injector yoke. Turn the injector so that the wiring connections are exactly opposite the valve springs.  
 Install the retaining bolt and tighten according to *Special Tightening Torques page 8*.

- 14 Install the remaining injectors the same way.



- 15 Put the valve yoke back in accordance with the previous marking.



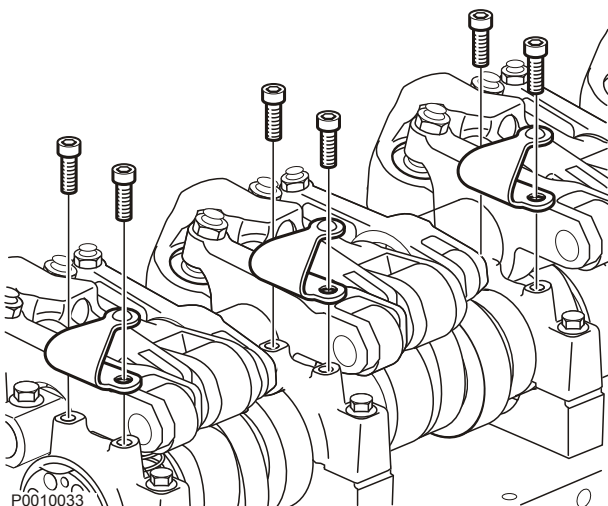
- 16 Lubricate the valve yokes and the unit injector ball seats.

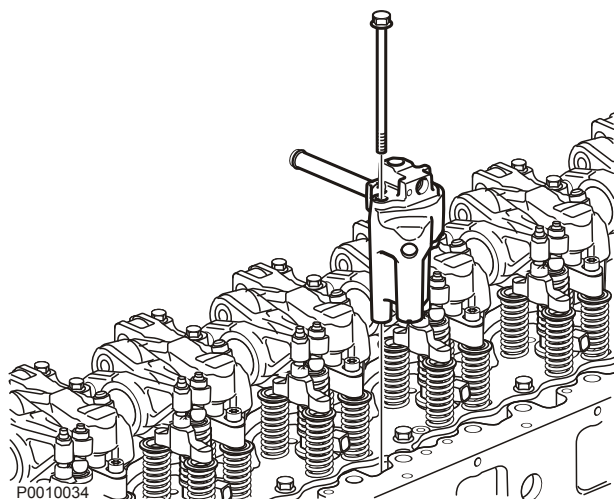
Lift the rocker arm bridge into place. Guide all rocker arms so they arrive in the correct positions. Make sure that the exhaust rocker arm pistons and the adjuster screw balls are in place. Remove the lifting tool from the rocker arm bridge. Install the rocker arm shaft bolts. Check that the valve calipers are positioned correctly on the valve stem.

Tighten the bolts alternately so that the rocker arm shaft is not bent. Make sure the shaft guides the locator sleeves on the bearing caps.

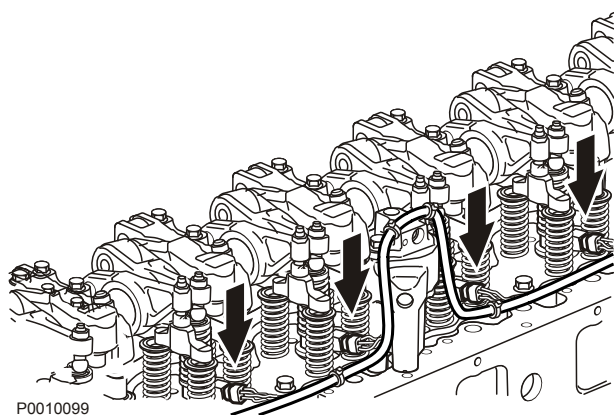
Tighten the bolts; refer to *Special Tightening Torques* page 8.

- 17 Install the EGR rocker arm springs. Make sure the springs are positioned correctly on the rocker arm ball tappet, but do not tighten the bolts (the bolts are tightened after valve adjustment).

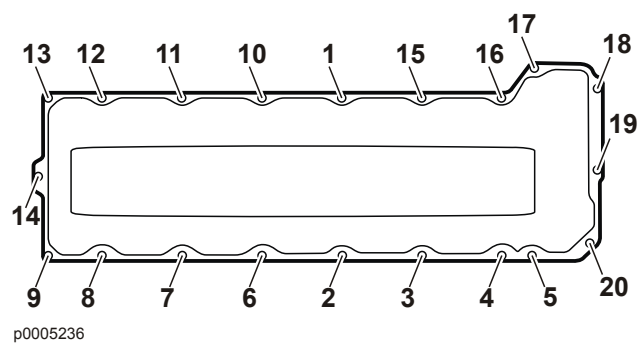




- 18 Install the valve and rocker arm lubrication oil pipe with new seals.
- 19 Adjust the valves and unit injectors; refer to *Valves and Unit Injectors, Adjustment page 177*.



- 20 Install the connectors to the unit injectors and oil valve. Clamp the wire harness under the valve cover with original cable ties (heat and oil resistant).



- 21 Install the valve cover. Replace gasket as necessary. Tighten according to *Special Tightening Torques page 8*.
- 22 Vent the fuel system; refer to *Fuel system, bleeding page 245*.



## Copper sleeve for unit injector, replace

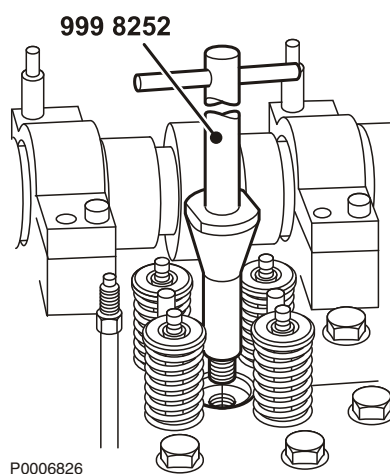
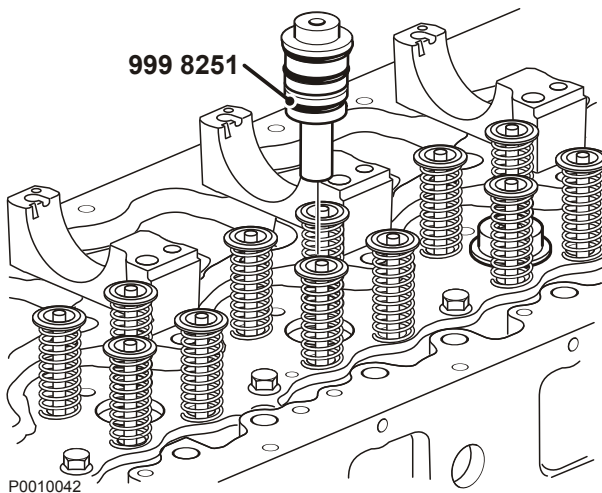
Unit injector removed; refer to *Unit Injector, Replace* page 255.

### Tools:

1159794 Torque wrench  
 9809668 Extractor  
 9809667 Thread tap  
 9998580 Protective sleeve  
 9996049 Draining hose  
 9998250 Sealing ring  
 9998251 Protection plug  
 9998252 Thread cutting tool  
 9998599 Cleaning kit  
 88800191 Extractor  
 88800196 Drift

- 1 Drain the coolant with the aid of a hose, tool 9996049 Draining hose; refer to *Draining the Cooling System* page 278.
- 2 If necessary, remove tool 9998251 Protection plug.
- 3 Install 2 seal rings, tool 9998250 Sealing ring, to prevent dirt from getting into the fuel ducts when the copper sleeve is removed.

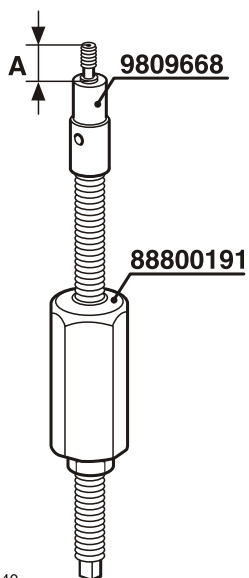
**NOTICE!** Ensure that the piston is in its lower position.



- 4 Lubricate the tap, tool 9809667 Thread tap (M9) with grease in order to prevent swarf from falling into the cylinder. Screw the tap at least 20 mm (0.8") into the copper sleeve, using tool 9998252 Thread cutting tool.

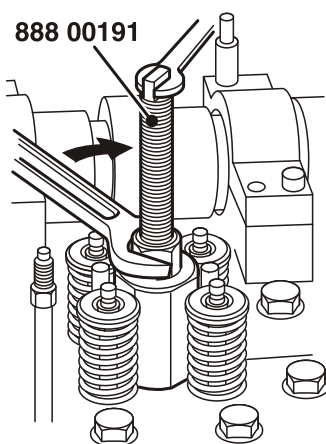
**NOTICE!** Use thread tap 9809667.

- 5 Remove tool 9998252 Thread cutting tool and the tap.



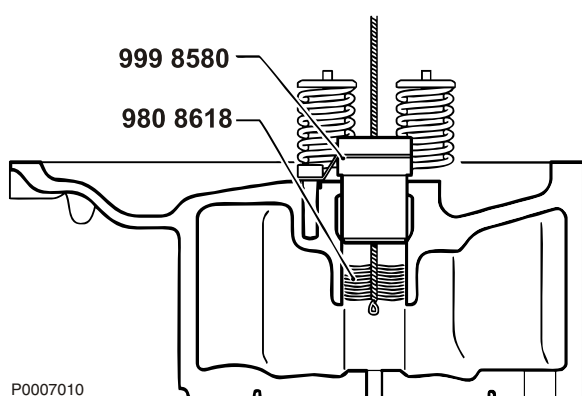
P0010240

- 6 Check that the tap, tool 9809668 Extractor (M9) is installed on tool 88800191 Extractor. Screw the tap in on tool 88800191 Extractor **17 mm (0.67") (A)**. Screw the tool all the way to the bottom of the copper sleeve.



P0007009

- 7 Remove the copper sleeve by turning the nut at the same time as the pin is held secure.



P0007010

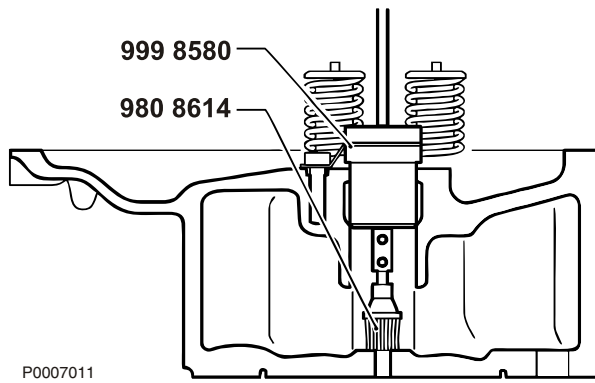
- 8 Use cleaning kit, tool 9998599 Cleaning kit and a power drill before fitting the new copper sleeve. Install tool 9998580 Protective sleeve in the injector hole and secure it with a holder.

### IMPORTANT!

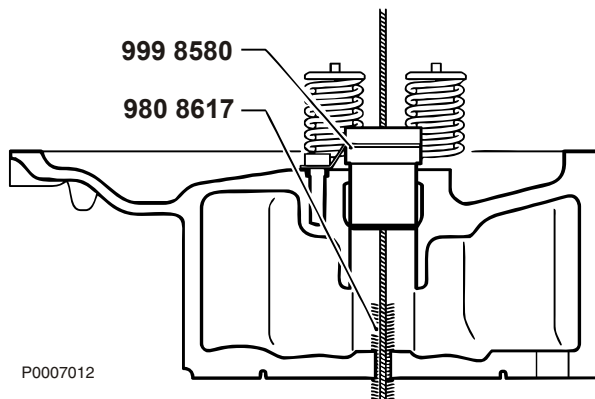
Tool 9998580 Protective sleeve must be used to prevent dirt from getting into the fuel duct.

- 9 Clean the cylinder head walls for the copper sleeve with part no. 9808618.





- 10 Clean the copper sleeve seat with brush no. 9808614 together with the handle and holders.



- 11 Clean the cylinder head hole with brush no. 9808617.
- 12 Remove tool 9998580 Protective sleeve. Make sure the O-ring is removed.
- 13 Check that the piston is at bottom dead center.

**IMPORTANT!**

This must be done so that tool no. 9998688 does not damage the piston due to its length.



- 14 Always use the **new version** copper sleeve with two grooves at the upper edge, when replacing.

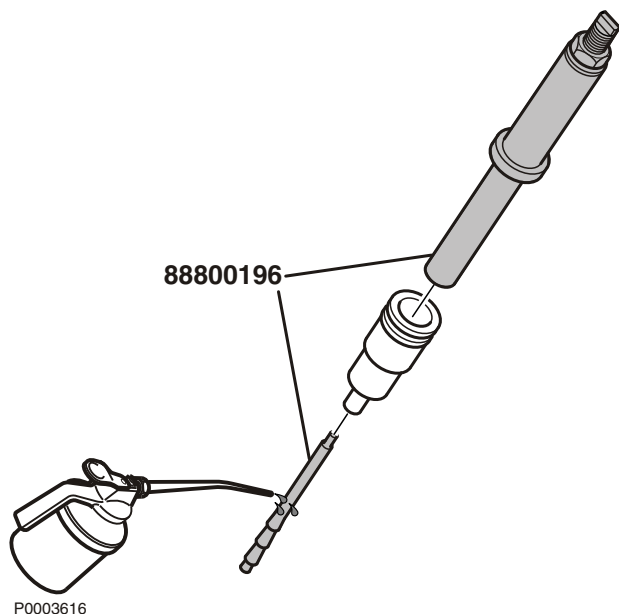
**IMPORTANT!**

The steel gasket supplied with the new copper sleeve must be used when installing the unit injector.

Lubricate the O-ring on the copper sleeve with soapy water.

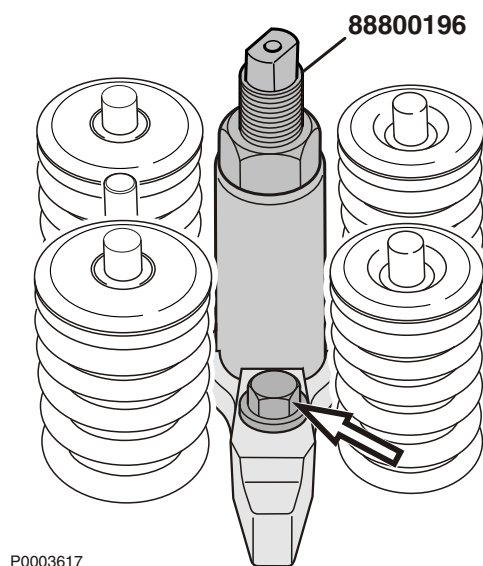
**IMPORTANT!**

Always use a new O-ring.

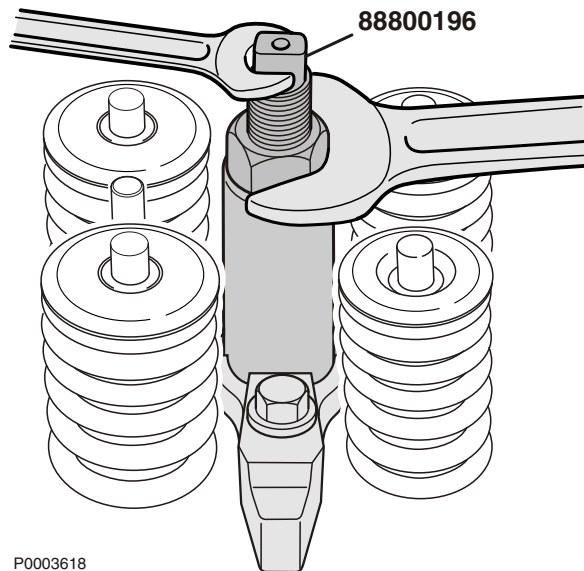


- 15 Put the copper sleeve on tool no. 88800196. The steel gasket may **not** be used when installing the copper sleeve. It may **only** be used when installing the unit injector. Oil the pin on the tool.

**NOTICE!** The tool only fits the new version copper sleeve.

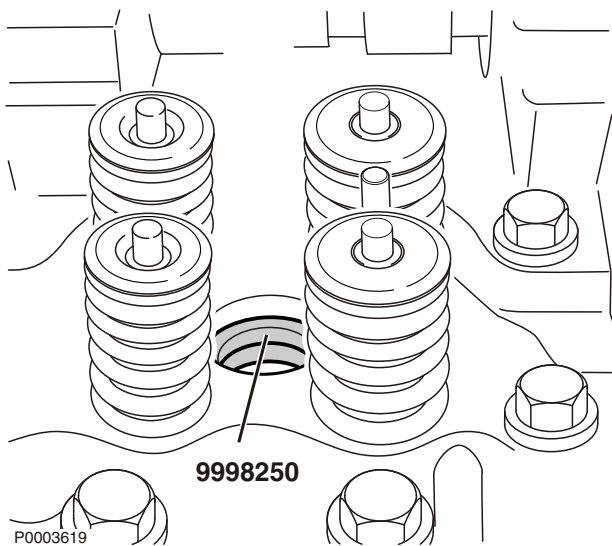


- 16 Place 88800196 together with the copper sleeve in the cylinder head. Make sure the copper sleeve bottoms in the cylinder head. Install the unit injector yoke. Use tool 1159794 Torque wrench to press in the copper sleeve; torque 80 Nm (59 lbf ft).



P0003618

- 17 By holding the tap and turning the nut, the tap is drawn onto tool 88800196 through the copper sleeve tip.  
Remove tool 88800196.



P0003619

- 18 Remove the protective rings, tools (2 pcs.) 9998250 Sealing ring.
- 19 Install the unit injectors with washer; refer to *Unit Injector, Replace* page 255.
- 20 Put the valve yoke back in accordance with the marking.
- 21 Install the rocker arm bridge and check the clearance of the valves and unit injectors.
- 22 Install the valve cover.
- 23 Fill up with coolant and check that no leakage occurs. Refer also to *Coolant Level, Checking and Topping Up* page 280.

## 23-8 Control System, ECM, Data Sets

### Control Unit, Replace

**NOTICE!** Before the control unit is replaced and any warranty claim made, all checks in the check list must be performed, to exclude any defect in the engine control system. If the measurements of the cable harness show defects, it is highly likely that the control unit is fault free. Refer to the "Service Manual, EMS 2".

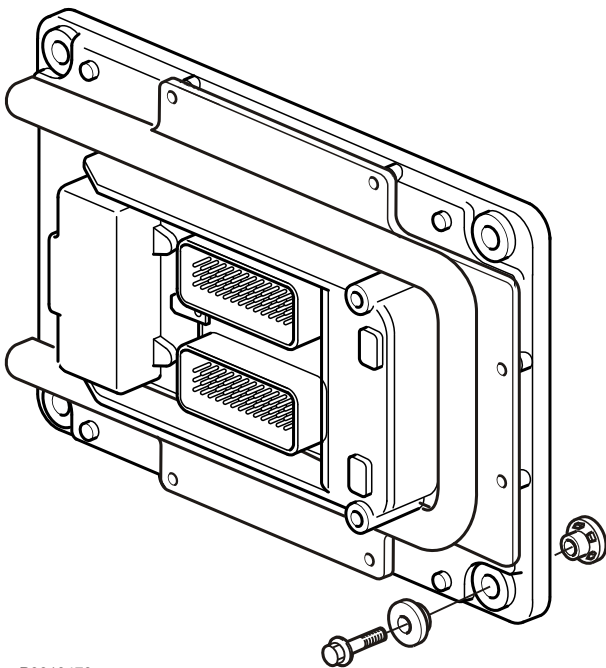
### **WARNING!**

Faulty individual control unit settings may result in injury to persons or damage to the engine. For information about reprogramming and reading of software, refer to "Service manual, EMS 2"

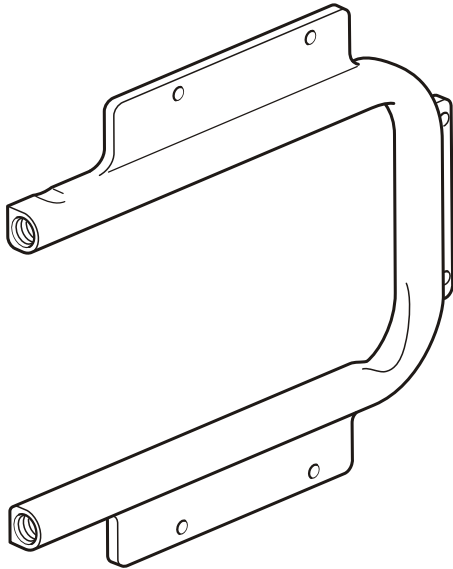
### **IMPORTANT!**

Exchange of control units between engines, during fault tracing or repair, must never be performed under any circumstances.

- 1 Clean thoroughly around the control unit fuel connections.
- 2 Disconnect power from the engine by disconnecting the negative battery terminal.
- 3 Remove the lower part of the crankcase breather pipe.
- 4 Remove the upper and lower cable harness clamps.
- 5 Remove the control unit cable harness by moving the connector block retaining clips outwards.
- 6 Remove the upper and lower fuel connections to the cooling element; plug the fuel lines.
- 7 Remove the control unit retaining bolts and remove the control unit.



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- 8 Transfer the cooling element to the new control unit. Make sure that the surface between the cooling element and the control unit is clean.
- 9 Install the new control unit.
- 10 Connect the upper and lower fuel connections to the cooling element with new sealing washers.
- 11 Install the harness and clamps.
- 12 Install the crank case breather lower pipe.
- 13 Bleed the fuel system. Refer to *Fuel system, bleeding page 245*.  
Start the engine and check for error codes. Refer to the "Service Manual, EMS 2".

## 25-0 Inlet and Exhaust System, General

### Charge Air Pipe, Leakage Check

- 1 Inspect the charge air pipes for visible cracks and external damage.
- 2 Check that there is no oil in the charge air pipes. If the pipes are damaged or the union seal rings leak, the charge pressure will be too low and engine performance will be affected. If the pipes are contaminated with oil on the inside, this indicates oil leakage in the turbocharger turbine shaft seal. In this case, the turbocharger should be changed as a unit.

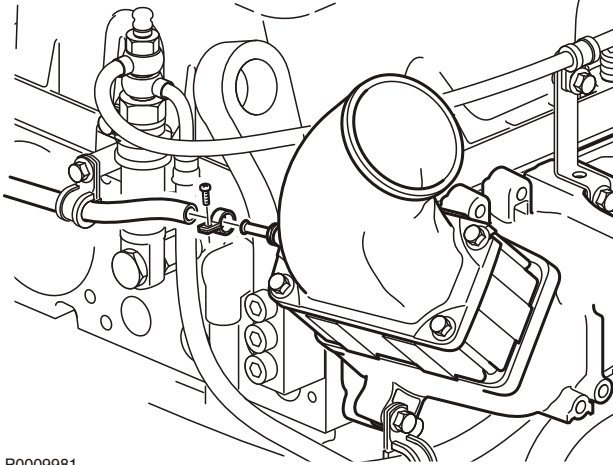
**NOTICE!** If there is any oil in the charge air pipes and charge air hoses, the charge air cooler and all pipes and hoses in the charge air system must be cleaned very carefully before the engine is started.

## 25-1 Inlet and Exhaust Manifolds

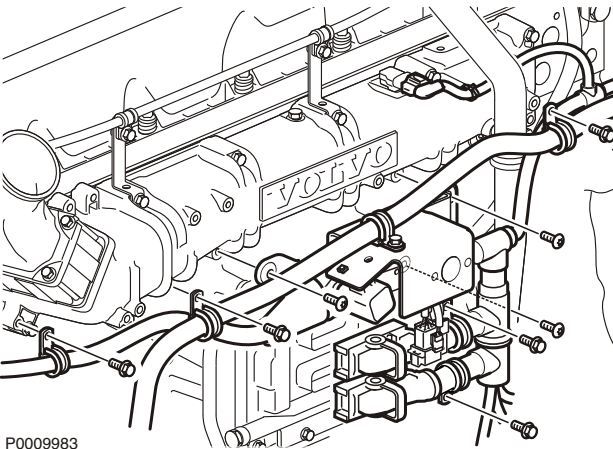
### Inlet Manifold, Change

#### Removal

- 1 Switch off battery power to the engine.  
Remove the hose between the inlet pipe and the charge air cooler.
- 2 Remove the hose to the waste gate actuator.

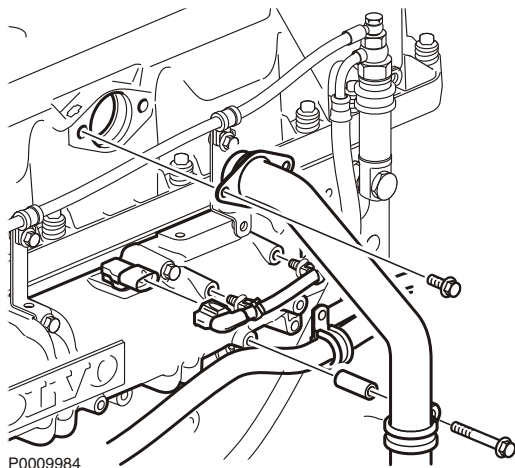


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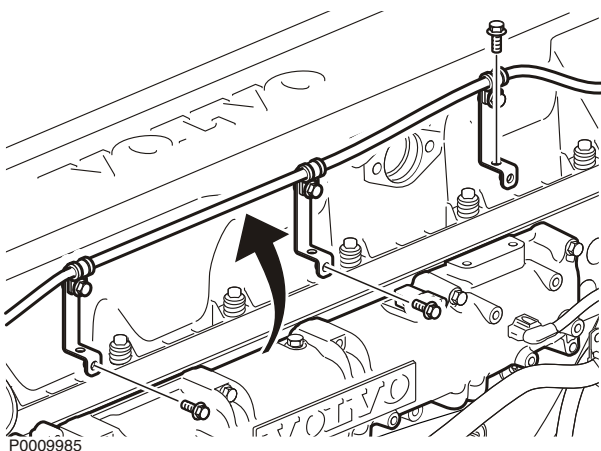


P0009983

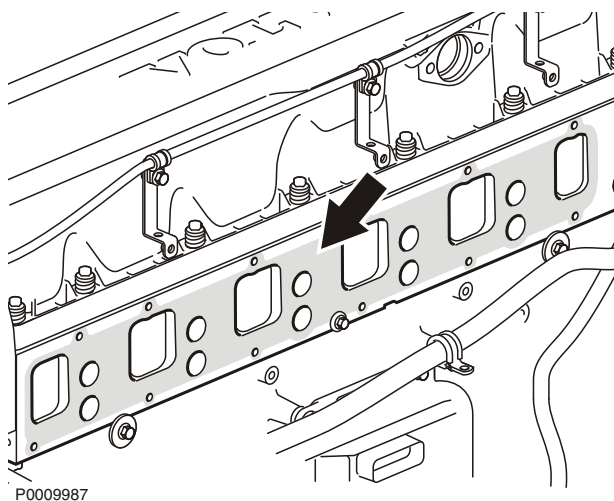
- 3 Remove the connection to the engine control unit and the wire harness clamps.  
Remove the relay holder and stop button bolts.  
Remove the wire harness clamp bolts.



- 4 Remove the connector to the charge air pressure sensor and undo the cable ties. Remove the crankcase ventilation pipe.



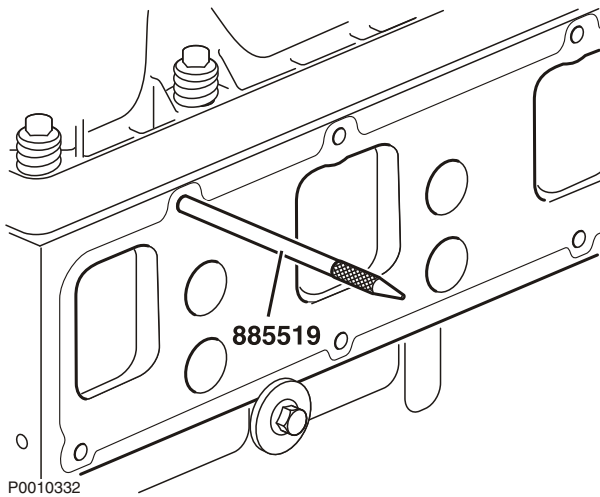
- 5 Remove the bolts for the fuel hose holders and place the holders on the valve cover. Remove the inlet pipe bolts and lift away the pipe.



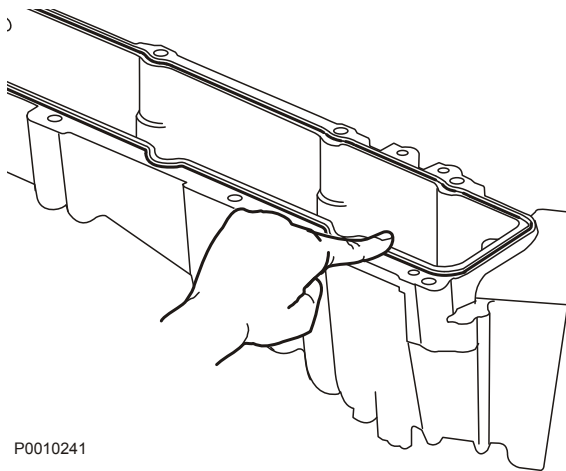
### Installation

- 6 Inspect and clean the sealing surfaces on the cylinder head and inlet manifold.

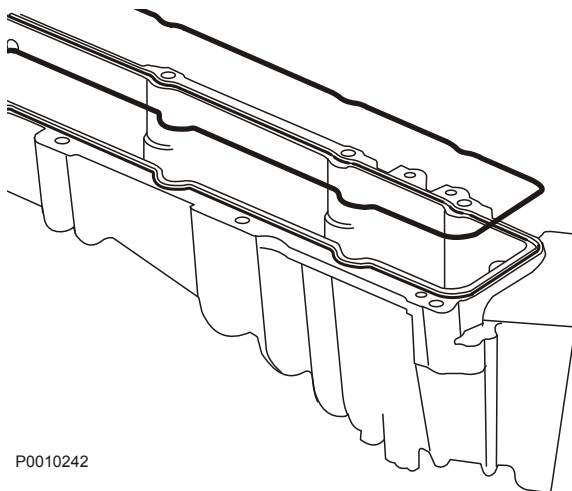




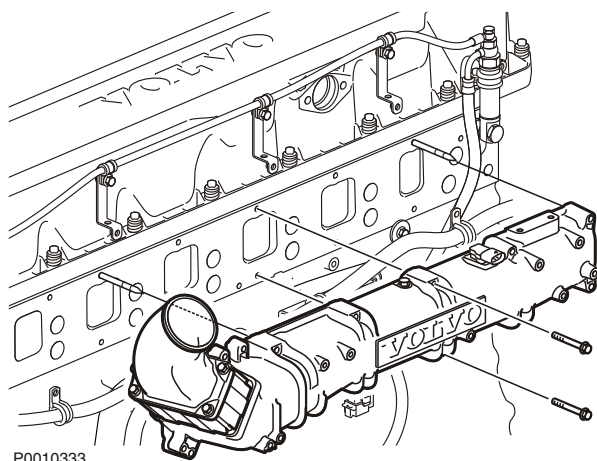
- 7 Install two pcs. 885519 Guide pin on the cylinder head.
- 8 If the seal on the inlet manifold needs replacing; scrape away all of the old sealant and carefully clean the groove for the new sealant so that no oil or sealant residue remains. Apply a thin bead of sealant 1161771 in the groove max. 20 mins. before the inlet manifold is installed.



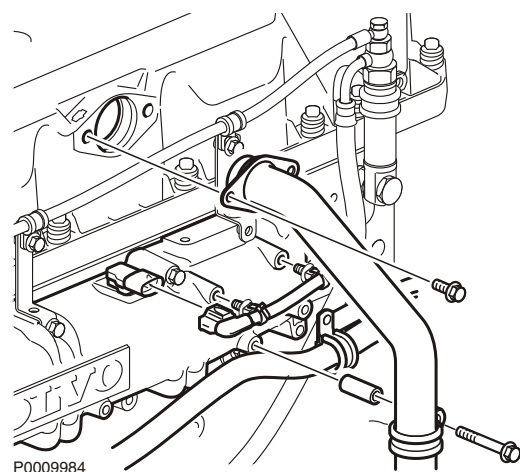
- 9 Spread out the sealant with a finger so that only a thin layer is in the groove.



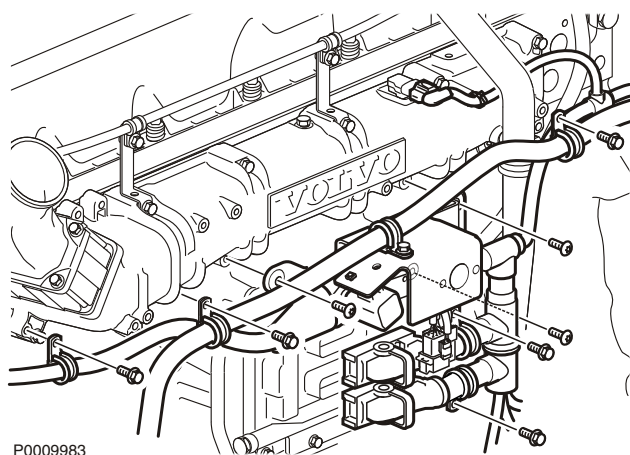
- 10 Press the new seal into the groove. Make sure that the seal joint arrives in the intended notch and that the seal's flat surface reaches the bottom of the groove.



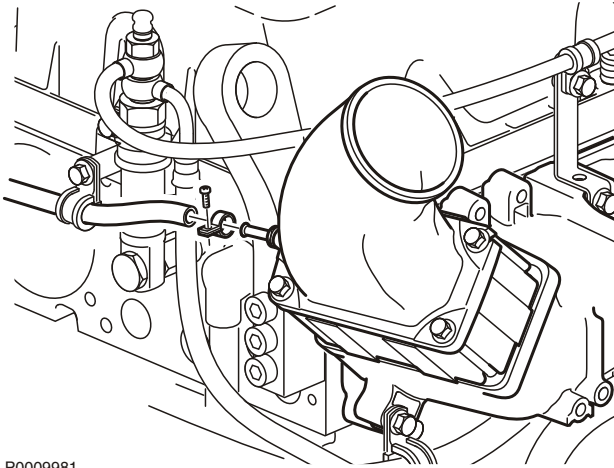
- 11 Guide the inlet manifold on the locator pins and fasten the manifold together with the fuel line holders.



- 12 Install the crankcase ventilation pipe. Install the connector for the charge air pressure sensor and secure the wiring with cable ties.



- 13 Install the relay holder on the engine block and bolt the wire harness to the inlet manifold. Install the connectors to the engine control unit and the wire harness clamps.



P0009981

- 14 Install the waste gate actuator hose.
- 15 Install the hose between the charge air cooler and the inlet pipe.
- 16 Switch on battery power and start the engine.
- 17 Check inlet manifold airtight integrity.

## 25-5 Turbocharger

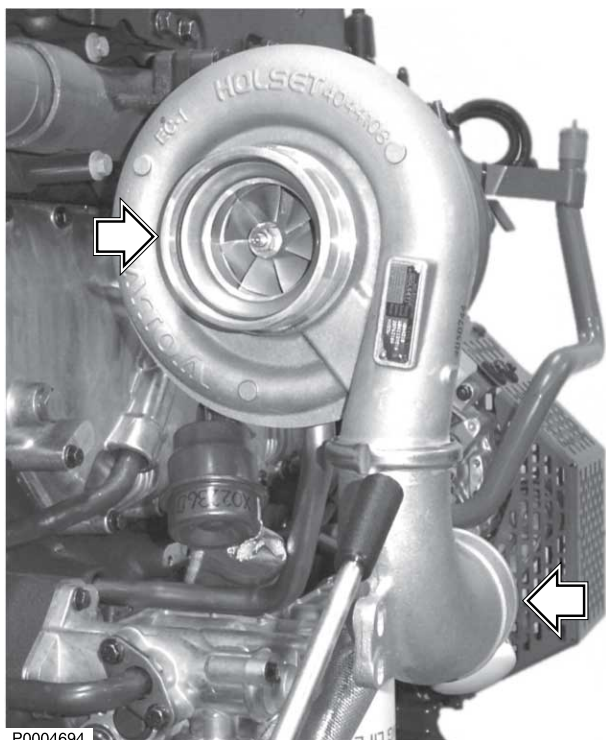
### Turbocharger, Inspection

- 1 Check that the turbocharger part number is correct for the engine variant. The wrong turbocharger for the engine variant might not provide enough charge pressure, which would reduce engine power.
- 2 Check that the turbocharger has the correct compressor housing. If the wrong compressor housing is installed on the turbocharger, the compressor wheel might have been damaged or have too much clearance between wheel and housing. In both cases, charge air pressure will be too low.
- 3 Remove the inlet manifold from the turbocharger.
- 4 Check the turbocharger for damage to the compressor wheel and excessive end float on the turbine shaft.
- 5 If there is any damage on the compressor wheel or excessive end float on the turbine shaft, the turbocharger must be changed as a unit.
- 6 Remove the exhaust pipe (muffler) from the turbocharger and check the turbine disc.
- 7 Check the turbine wheel for damage. If the turbine wheel is damaged, the turbocharger must be changed as a unit.

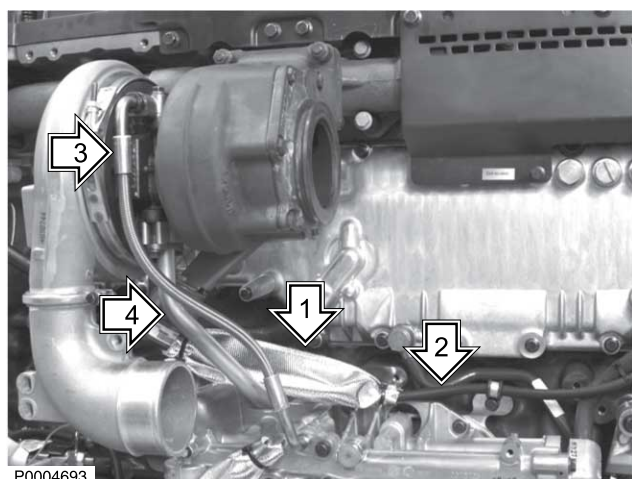
## Turbo, Change

### Removal

- 1 Remove the heat shield, if fitted.
- 2 Remove the pipe between the air filter and the turbocharger.
- 3 Remove the pipe between the turbocharger and the charge air cooler.
- 4 Remove the exhaust pipe/muffler.

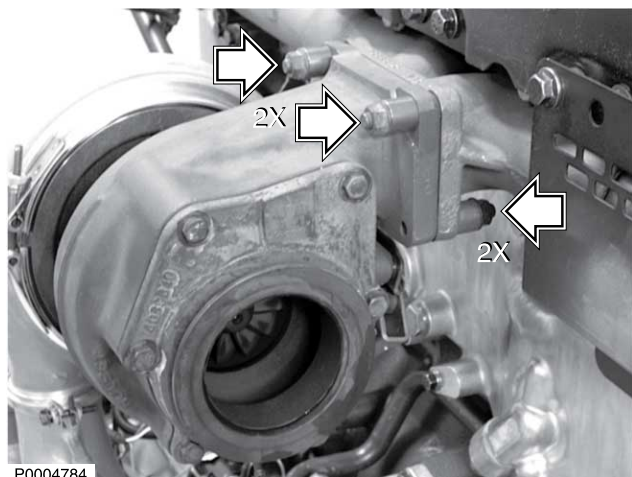


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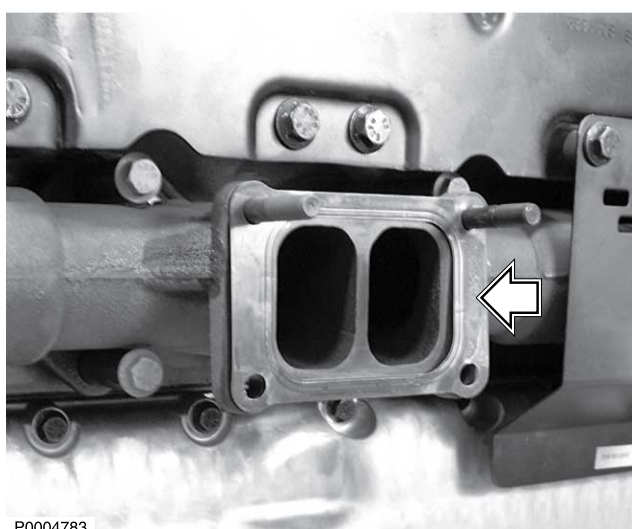


P0004693

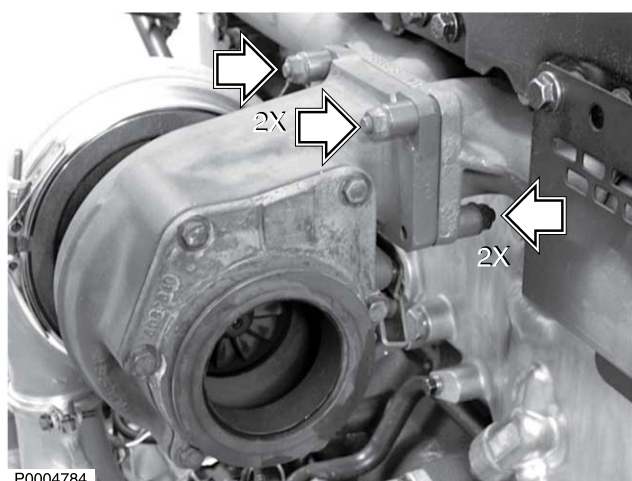
- 5 Remove the hose heat shield (1) and lay it to one side.
- 6 Remove the hose (2) to the waste gate actuator.
- 7 Remove the oil supply pipes (3) from the turbocharger.
- 8 Remove the oil supply pipe (4) and the union by undoing the bolts beneath the turbocharger. Pull the pipe from the engine block.



- 9 Remove the nuts and spacers from the turbocharger.
- 10 Lift away the turbocharger.

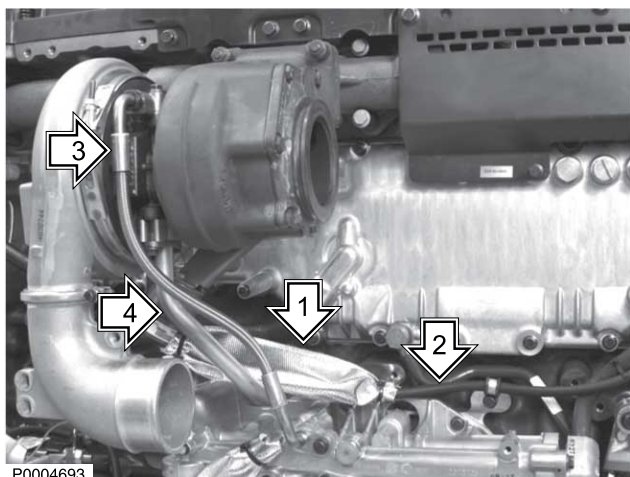


- 11 Remove the gasket and check the exhaust manifold sealing surface. Blow through the manifold and check that there is no contamination in the pipe. Install a new gasket on the exhaust manifold



## Installation

- 12 Lift the turbocharger into position. Install the spacer sleeves and nuts and fasten the turbocharger; refer to *General Tightening Torques* page 7.



- 13 Replace the seals on the oil return pipe (4) and re-install it.
- 14 Fill the turbocharger with new, clean engine oil and install the oil delivery hose (3) with a new gasket.
- 15 Install the hose (2) to the waste gate actuator. Move the heat shield (1) to its correct position and clamp in place.
- 16 Check that the turbocharger inlet pipe is thoroughly clean internally before it is installed between the air filter and turbocharger. Check that the pipe between the turbocharger and charge air cooler is clean internally. if there is contamination in the pipe, the charge air cooler also requires internal cleaning. Install the pipe between the turbocharger and the charge air cooler. Install the exhaust system. Start the engine and check that no leakage is evident.



## 26-0 Cooling System, General

### Draining the Cooling System

#### **WARNING!**

Do not open the coolant filler cap when the engine is warm, except in emergencies, this could cause serious personal injury. Steam or hot fluid could spray out.

#### **IMPORTANT!**

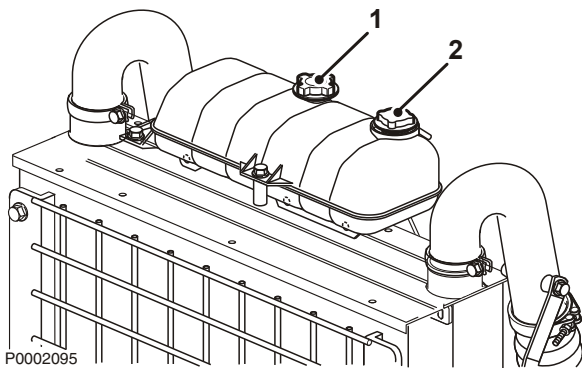
On engines which are to be laid up or put in storage, the engine cooling system must **not** be drained. The coolant contains corrosion-inhibiting additives.

Tools:

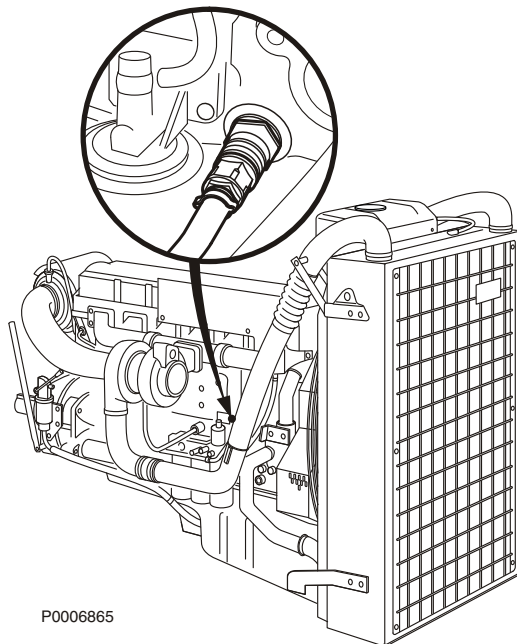
9996049 Draining hose

**NOTICE!** Do not open the pressure cap (2).

- 1 Remove the filler cap (1).



- 2 Open all drain points. Drain the coolant from the radiator and engine block, using tool 9996049 Draining hose. The drain nipples are situated under the radiator on the right side of the engine block.
- 3 Check that all coolant drains out. Deposits may be found inside the drain plug/tap, and need to be cleared away. There is otherwise a risk that coolant could remain and cause frost damage. Check whether the installation has any further taps or plugs at the lowest points of the cooling water lines.
- 4 Shut any taps and check that the spring-loaded covers on the nipples close completely. Install the rubber plugs.





## Cooling System, Cleaning

### **WARNING!**

All coolant is hazardous and harmful to the environment. Do not consume. Coolant is flammable.

Cooling performance is reduced by deposits in the radiator and cooling galleries. The cooling system should be cleaned out when the coolant is changed.

### **IMPORTANT!**

Cleaning must not be done if there is any risk of the cooling system freezing, since the cleaning solution does not have antifreeze properties.

### **IMPORTANT!**

It is extremely important that the correct concentration and volume of coolant is added to the system. Mix in a separate clean vessel before filling the cooling system. Make sure that the liquids mix.

- 1 Drain the cooling system. Refer to *Draining the Cooling System* page 278.
- 2 Put a hose into the expansion tank filling hole and flush with clean water, according to specifications in *Technical Data* page 44, until the water draining out is completely clear.
- 3 Should there still be some contamination left after flushing for a long time, cleaning may be done with coolant. Otherwise, continue as in stage 8 below.
- 4 Fill the cooling system with 15-20% mixture of concentrated coolant. Use only Volvo Penta recommended concentrated coolant mixed with clean water.
- 5 Drain the coolant after 1–2 days of operation. Remove the filler cap and the lower radiator hose if necessary to increase emptying speed. To prevent suspended material from settling back in the system, emptying should be done rapidly, within 10 minutes, without the engine having been at a standstill for a long time.
- 6 Flush the system immediately and thoroughly with clean hot water to prevent dirt from settling on the inner surfaces. Flush until the water running out is completely clean. Make sure that any heater controls are set to full heating during emptying.
- 7 Should contamination still remain after a long period of flushing, a clean-out may be done using Volvo Penta radiator cleaner, followed by treatment with Volvo Penta neutralizer. Carefully follow the instructions on the package. Otherwise, continue as in stage 8 below.
- 8 When the cooling system is completely free from contamination, close the drain taps and plugs.

- 9 Refill with new, Volvo Penta-recommended cooling fluid. Refer to *Technical Data page 44* and *Coolant Level, Checking and Topping Up page 280*.

## Coolant Level, Checking and Topping Up

### **WARNING!**

Do not open the coolant filler cap when the engine is warm, except in emergencies, this could cause serious personal injury. Steam or hot fluid could spray out.

### **IMPORTANT!**

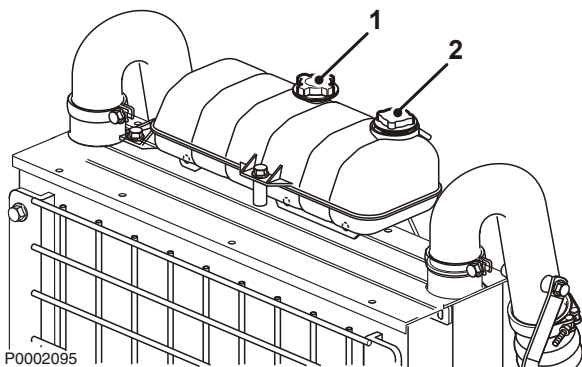
Filling of coolant must be performed with the engine stopped. Fill slowly, to allow air to flow out.

## Coolant Level, Checking and Topping Up

### **IMPORTANT!**

Only use the coolant recommended by Volvo Penta.

- 1 **NOTICE!** Open only the filler cap (1). Do not open the pressure cap (2).
- 2 Check that the coolant level is above the MIN mark on the expansion tank.
- 3 Top up with coolant as required, so that the level is between the MIN and MAX marks.



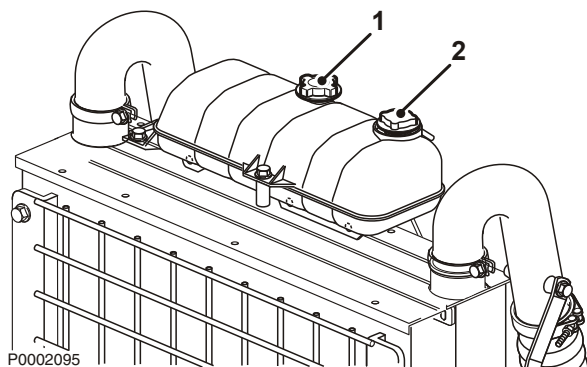
## Filling a completely empty system

**NOTICE!** Mix the correct amount of coolant in advance, to ensure that the cooling system is completely filled. Refer to *Technical Data page 44* for the correct coolant volume.

### **IMPORTANT!**

Do not start the engine until the system is vented and completely filled.

- 1 Check that all drain points are closed.



- 2 Open the filler cap (1). Do not open the pressure cap (2).
- 3 Fill up with coolant, so that the level is between the MIN and MAX marks.
- 4 Start the engine when the cooling system has been completely filled and vented. Open any venting taps a short while after starting, to allow trapped air to escape.  
If a heating unit is connected to the engine cooling system, the heat control valve should be opened and the installation vented during filling.
- 5 Stop the engine after about an hour and check the coolant level. Top up as necessary.

## Cooling System, Pressure Testing

### Alternative 1

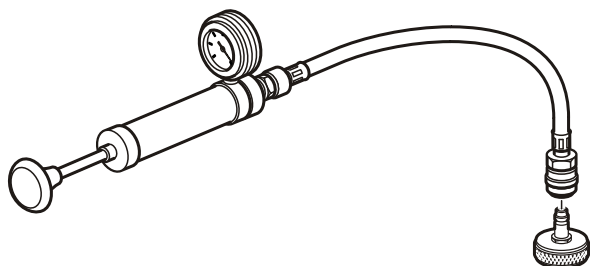
#### **WARNING!**

Do not open the coolant filler cap when the engine is warm. Steam or hot fluid could spray out, causing severe burns.

Tools:

3849613 Pressure testing kit

- 1 Check that all hoses and clamps are undamaged and intact.
- 2 Check the coolant level in the expansion tank.
- 3 Replace the filler cap on the expansion tank with a suitable cover from 3849613 Pressure testing kit.
- 4 Connect the pump and pump up a pressure of 70 kPa (0.7 bar).
- 5 Pressure must not drop for a **two minute** test period, for the cooling system to be regarded as being free from leakage.
- 6 Release the excess pressure and remove the pressure testing unit.
- 7 Check the coolant level in the expansion tank. Install the regular filler cap.
- 8 Start the engine and check that no leakage occurs.



### Alternative 2

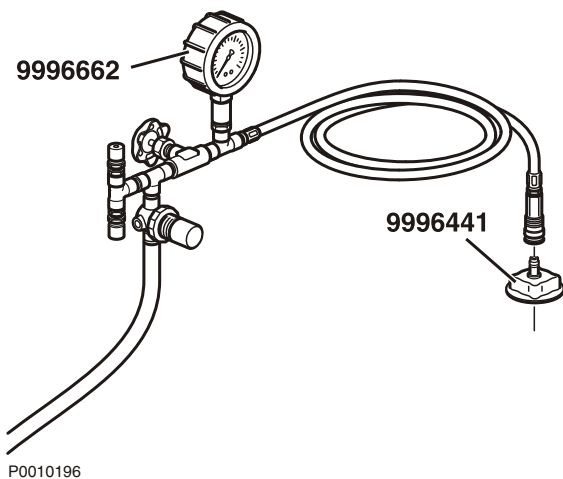
#### **WARNING!**

Do not open the coolant filler cap when the engine is warm. Steam or hot fluid could spray out, causing severe burns.

Tools:

9996441 Cover, with connecting nipple

9996662 Pressure testing kit



- 1 Check that all hoses and clamps are undamaged and intact.
- 2 Check the coolant level in the expansion tank.
- 3 Replace the filler cap with 9996441 Cover, with connecting nipple. Connect 9996662 Pressure testing kit to the cap. Connect compressed air to the equipment and open the cock. Adjust the pressure to 70 kPa (0.7 bar) with the adjuster knob. Then close the tap.
- 4 Pressure must not drop for a **two minute** test period, for the cooling system to be regarded as being free from leakage.
- 5 Release the excess pressure and remove the pressure testing unit.
- 6 Check the coolant level in the expansion tank. Install the regular filler cap.
- 7 Start the engine and check that no leakage occurs.

### Alternative 3

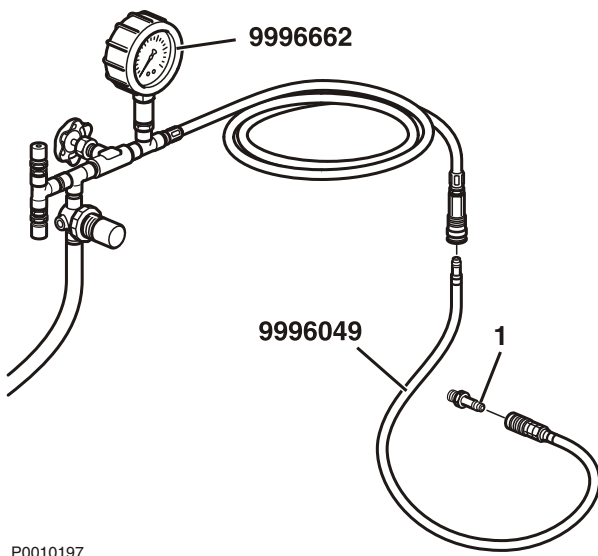
#### **WARNING!**

Do not open the coolant filler cap when the engine is warm. Steam or hot fluid could spray out, causing severe burns.

#### Tools:

9996662 Pressure testing kit

9996049 Draining hose



- 1 Check that all hoses and clamps are undamaged and intact.
- 2 Check the coolant level in the expansion tank.
- 3 Connect 9996662 Pressure testing kit to 9996049 Draining hose and close the cock. Connect the hose to the engine drain valve (1). Open the cock and adjust the pressure to 70 kPa (0.7 bar) with the adjuster knob. Then close the tap.
- 4 Pressure must not drop for a **two minute** test period, for the cooling system to be regarded as being free from leakage.
- 5 Open the cock and increase the pressure until the filler cap opens (must correspond to opening pressure according to *Technical Data page 44*). Reduce the pressure to 50 kPa (0.5 bar) and then increase to 70 kPa (0.7 bar) and check that pressure is maintained.
- 6 Remove the compressed air connection. Open the control valve so that the pressure drops and shut the cock when coolant runs into the drain hose. Remove the drain hose from the engine. Then remove the drain hose from the test equipment and empty the coolant from the hose.

Re-install the rubber plug in the engine drain valve.

- 7 Check the coolant level in the expansion tank.
- 8 Start the engine and check that no leakage occurs.

## 26-2 Coolant Pump, Thermostat

### Coolant Pump, Change

Tools:

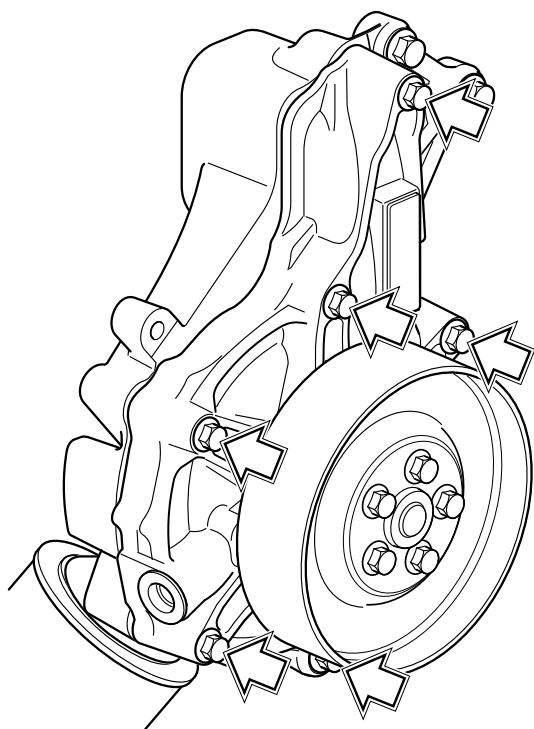
9996049 Draining hose

#### Removal

- 1 Drain the coolant: Refer to *Draining the Cooling System* page 278.
- 2 Remove the right belt guard. Refer to *Belt Protector* page 296.
- 3 Wind off the belt. Refer to *Drive Belts* page 290.
- 4 Remove the three bolts to the automatic belt tensioner.



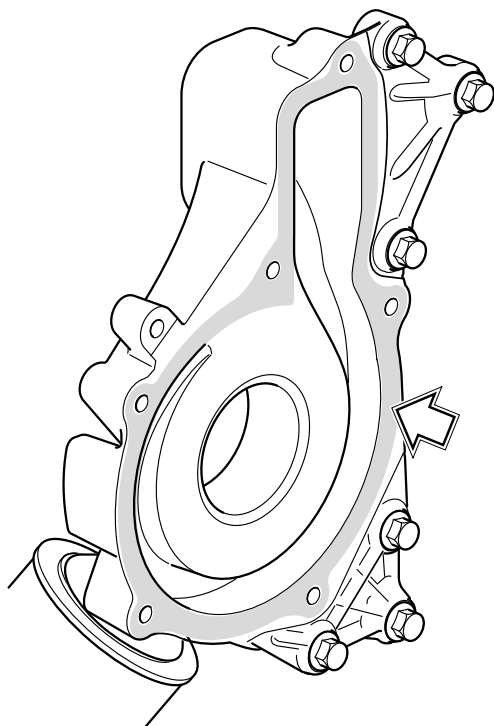
- 5 Remove the six bolts to the coolant pump.  
Remove the coolant pump.



P0004683

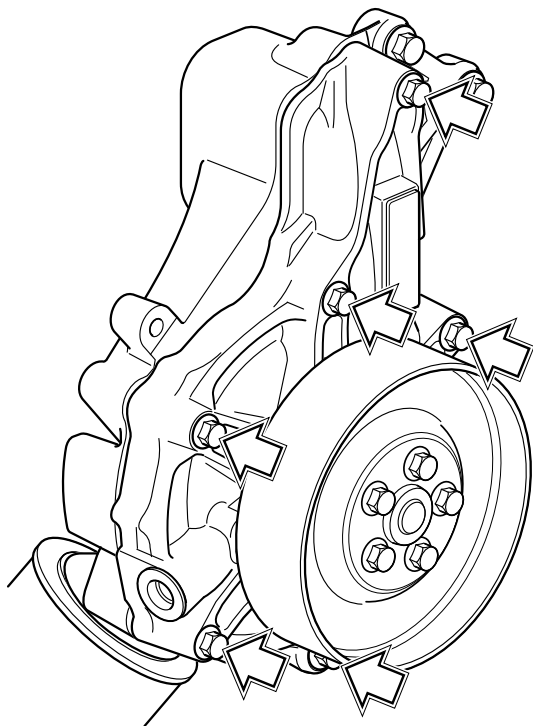
### Installation

- 6 Clean and check the sealing surfaces.
- 7 Where necessary, transfer the belt pulley to the new pump.
- 8 Install a new rubber gasket.



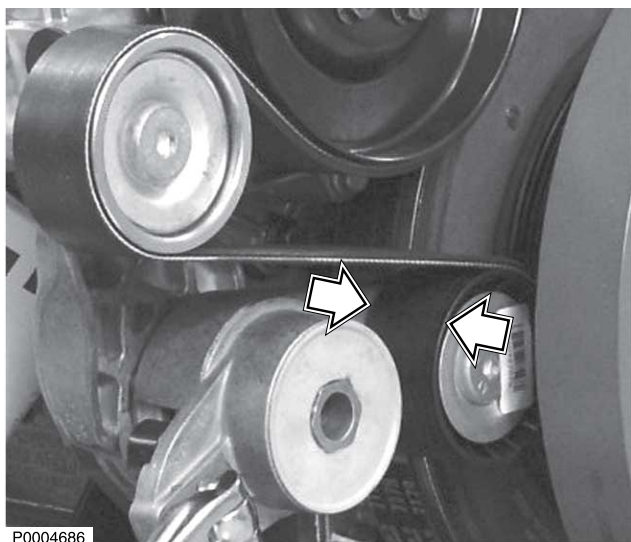
P0004684

- 9 Install the pump and the six bolts.



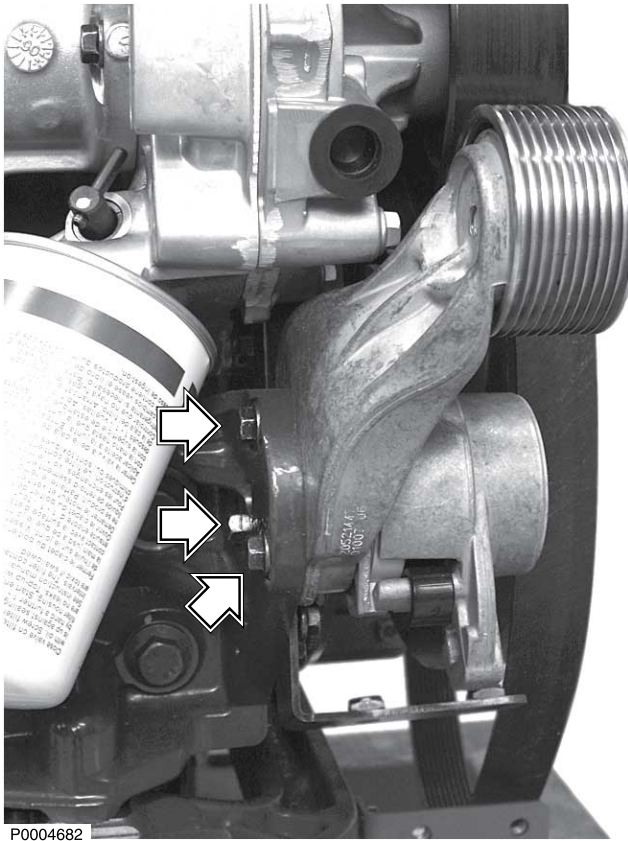
P0004683

- 10 Check the idler and tensioner pulleys on the automatic belt tensioner.



P0004686





- 11 Install the automatic belt tensioner.

**NOTICE!** Make sure the key engages in the keyway.

Tighten the bolts.

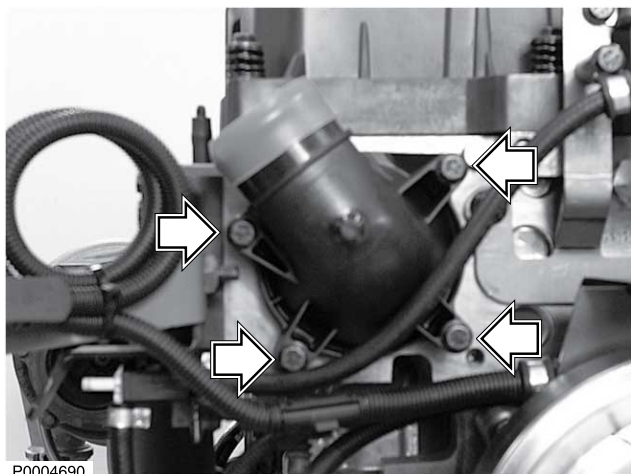
- 12 Wind on the belt. Refer to *Drive Belts* page 290.
- 13 Install the right belt guard. Refer to *Belt Protector* page 296.

## Thermostat, Change

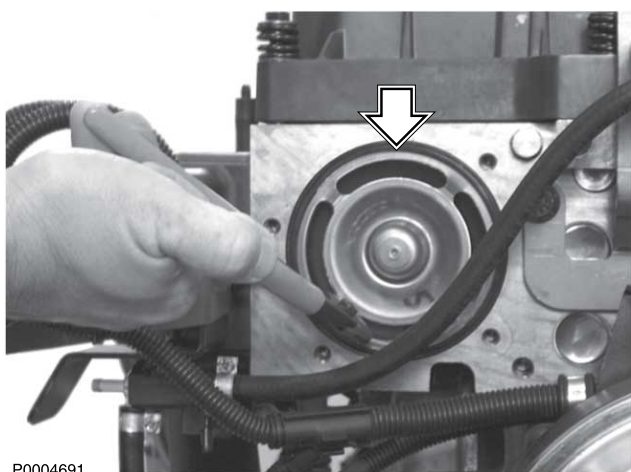
Tools:  
9996049 Draining hose

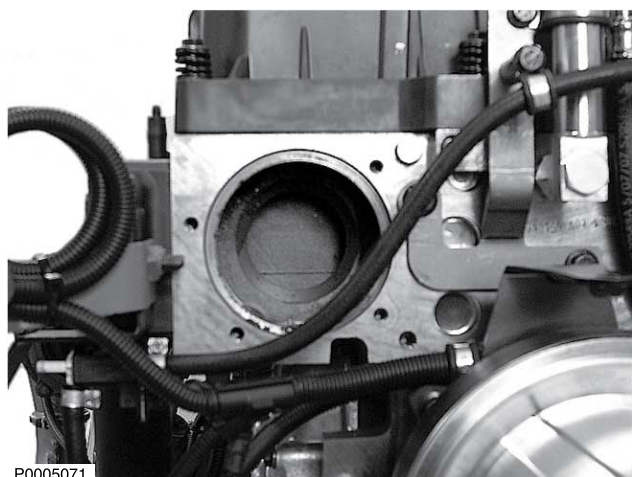
### Removal

- 1 Drain the cooling system; refer to *Draining the Cooling System* page 278.  
Drain off coolant sufficient for its level to drop below the thermostat housing.
- 2 Remove the upper belt guard; refer to *Belt Protector* page 296.
- 3 Remove the thermostat housing cover.



- 4 Remove the thermostat.

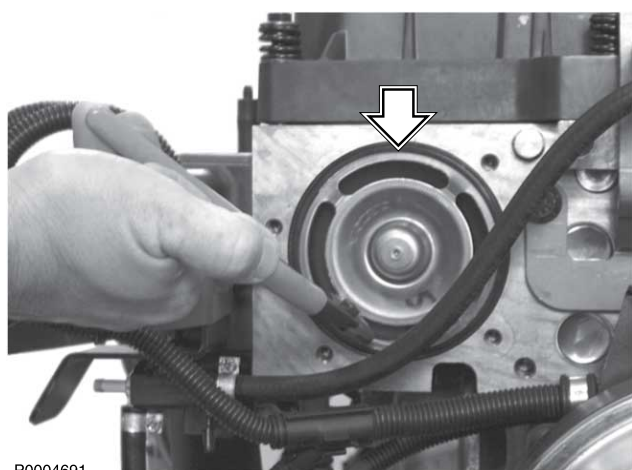




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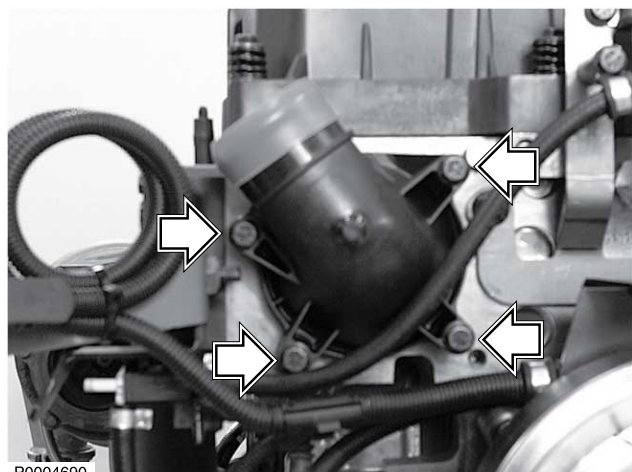
## Installation

- 5 Clean and inspect the mating surfaces for both the thermostat and the thermostat housing cover.



P0004691

- 6 Install the new thermostat and a new gasket.



P0004690

- 7 Install the thermostat housing cover and the bolts.
- 8 Install the upper belt guard: Refer to *Belt Protector* page 296.

### IMPORTANT!

Ensure that engine wiring is not pinched.

- 9 Refill with new coolant; refer to *Coolant Level, Checking and Topping Up* page 280.
- 10 Start the engine and check for leaks. Pressurize the cooling system; refer to *Cooling System, Pressure Testing* page 108.

## Drive Belts

Right belt guard removed; refer to *Belt Protector* page 296.

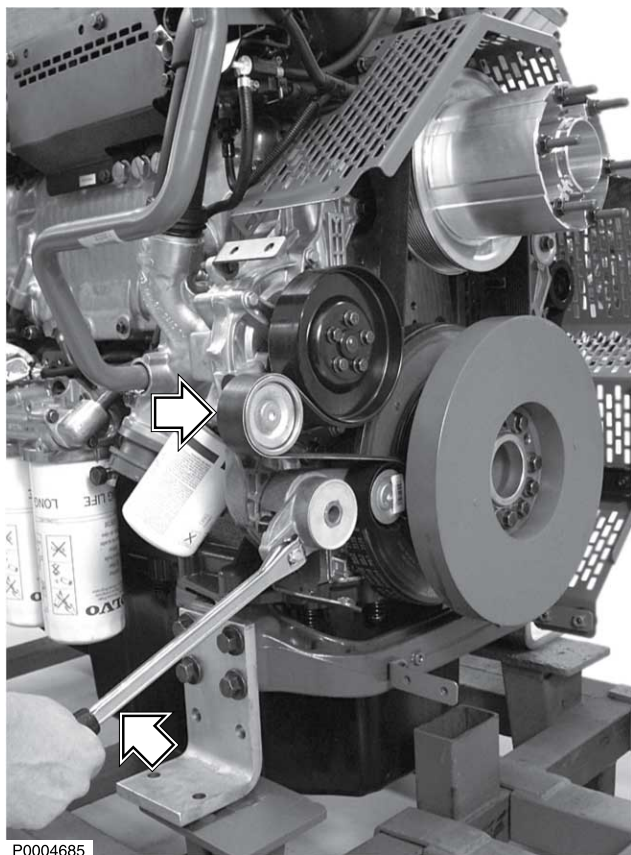
### Removal

- 1 Lift the lever.

#### **CAUTION!**

Pinch hazard. Keep fingers clear.

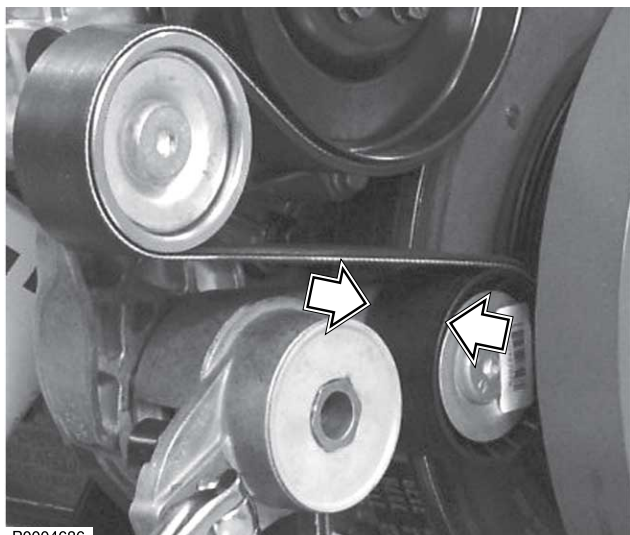
Wind off the belt.



P0004685

## Installation

- 1 Check the belt tensioner pulleys.



- 2 Lift the lever.

### **CAUTION!**

Pinch hazard. Keep fingers clear.  
Wind on the belt.





## Belt Tensioner, Change

Right belt guard removed; refer to *Belt Protector* page 296.

Drive belt removed; refer to *Drive Belts* page 290.

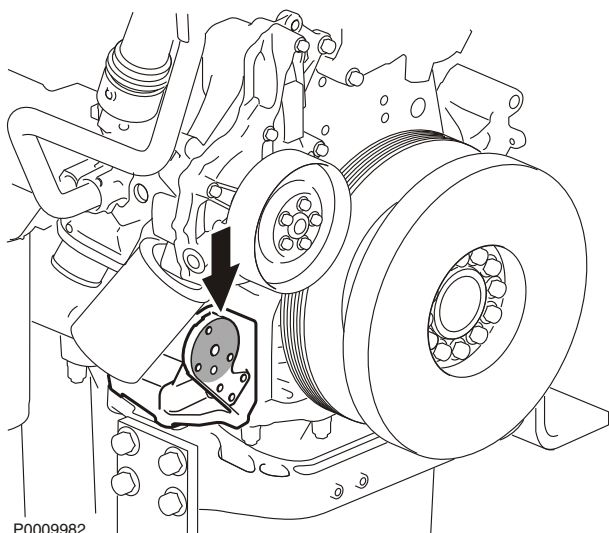
### Removal

- 1 Undo the three bolts that retain the belt tensioner and return wheel. Remove the unit.
- 2 Unbolt the return wheel or tensioner, or replace the complete unit.



### Installation

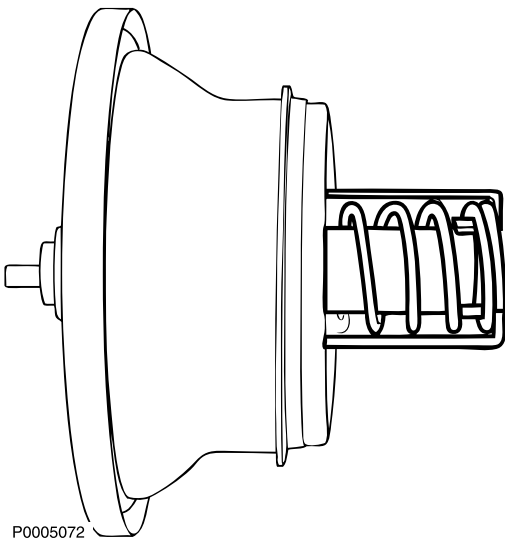
- 3 Install the tensioner complete with attachment. Align the guide pin on the attachment to the installation hole and tighten the bolts. Check the condition of the drive belts.
- 4 Re-install the belts; refer to *Drive Belts* page 290.



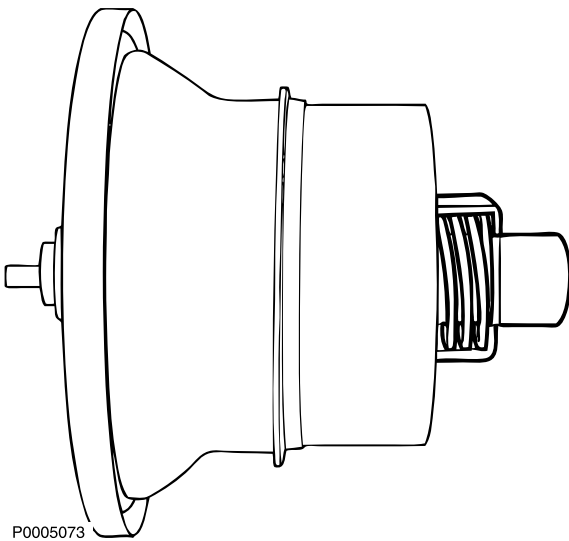
## Thermostat, Function Check

Remove the thermostat, see *Thermostat, Change page 288*.

- 1 Place the thermostat in a big pot with water and heat it to the opening temperature as specified in *Engine, General page 26*.



Closed thermostat.



Open thermostat.

- 2 If the thermostat does not open at specified temperature, it should be replaced.
- 3 Install the thermostat, see *Thermostat, Change page 288*.

**NOTICE!** Always use a new seal, even if the thermostat is not replaced.

## Coolant Filter, Change

Tools:

9999179 Extractor oil filter

**NOTICE!** The coolant filter must be replaced at the prescribed intervals.

Failure to follow these intervals may result in significantly reduced engine life. In respect of engine work requiring more than five liters of new coolant to be added, a new coolant filter must always be installed.

### Removal

- 1 Shut the filter housing tap.
- 2 Clean around the filter and remove it with the aid of tool 9999179 Extractor oil filter.



P0004963

Closed tap.



## Installation

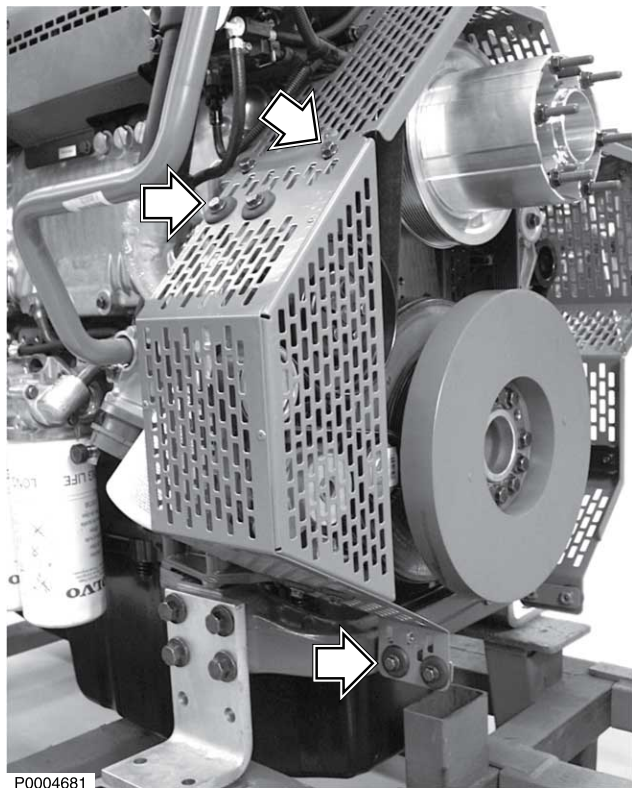
- 3 Lubricate the filter gasket with petroleum jelly or soapy water. Install the new filter. Screw the filter down until the gasket touches the sealing surface. Then tighten a further ½ turn.
- 4 Open the tap on the filter housing.
- 5 Start the engine and check for leaks.



P0004962

Open tap.

## 26-3 Fan, Fan Shroud



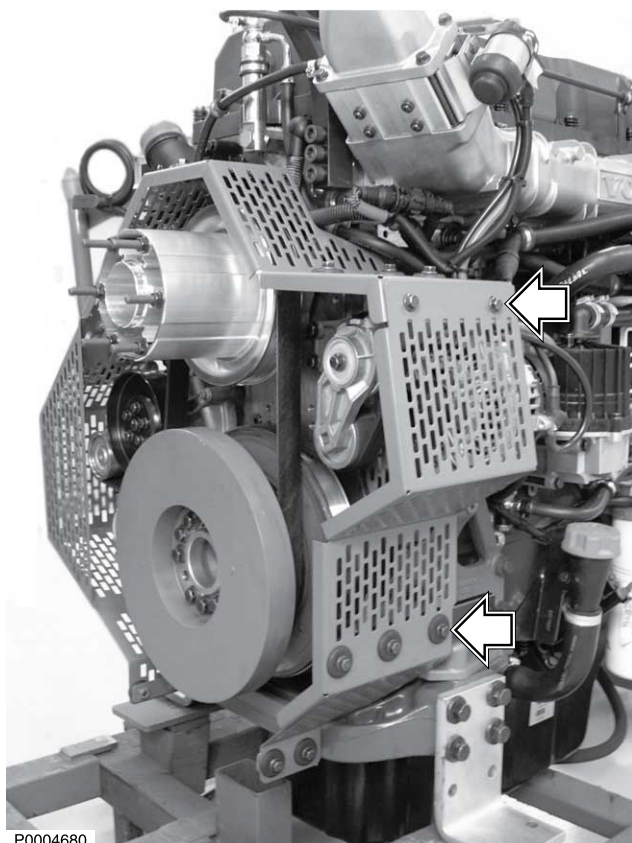
### Belt Protector

#### Right belt guard

- 1 **Removal:** Undo and remove the bolts. Remove the guard.
- 2 **Installation:** Install the guard and the bolts. Tighten the bolts.

#### **IMPORTANT!**

Never lay the fan down. Oil will run out that cannot run back, which will result in the fan seizing.



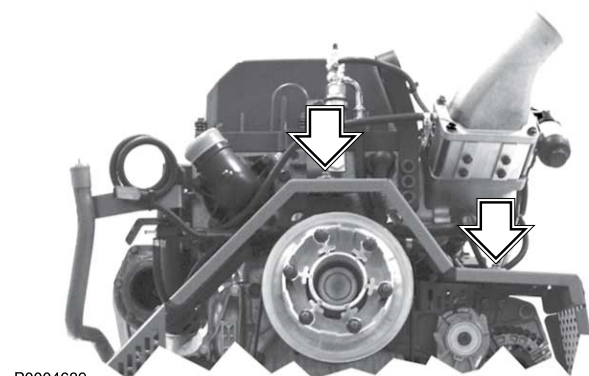
P0004680

### Left belt guard

- 1 **Removal:** Undo and remove the bolts. Remove the guard.
- 2 **Installation:** Install the guard and the bolts. Tighten the bolts.

#### **IMPORTANT!**

Never lay the fan down. Oil will run out that cannot run back, which will result in the fan seizing.



P0004689

### Upper belt guard

- 1 **Removal:** Undo and remove the bolts. Remove the guard.
- 2 **Installation:** Install the guard and the bolts. Tighten the bolts.

#### **IMPORTANT!**

Never lay the fan down. Oil will run out that cannot run back, which will result in the fan seizing.

## 32-1 Alternator

### Alternator Belts, Change

Left belt guard removed; refer to *Belt Protector* page 296.

Coolant pump belt removed; refer to *Drive Belts* page 290.

#### Removal

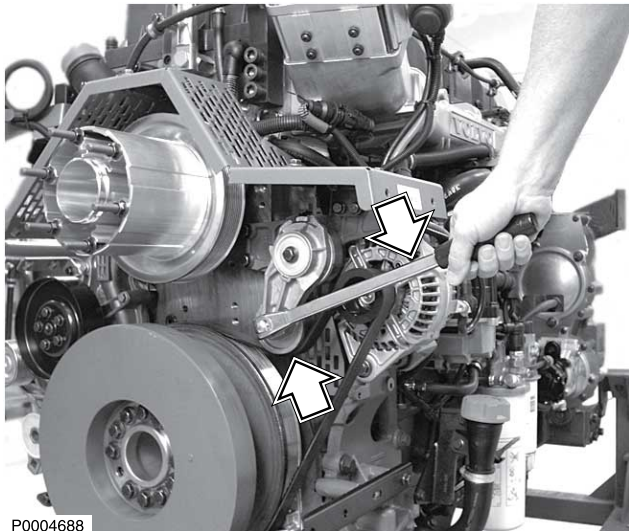
- 1 Depress the lever.



#### CAUTION!

Pinch hazard. Keep fingers clear.

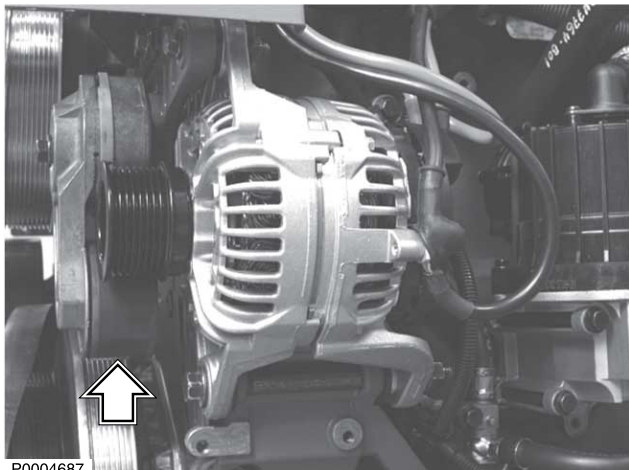
Wind off the belt.



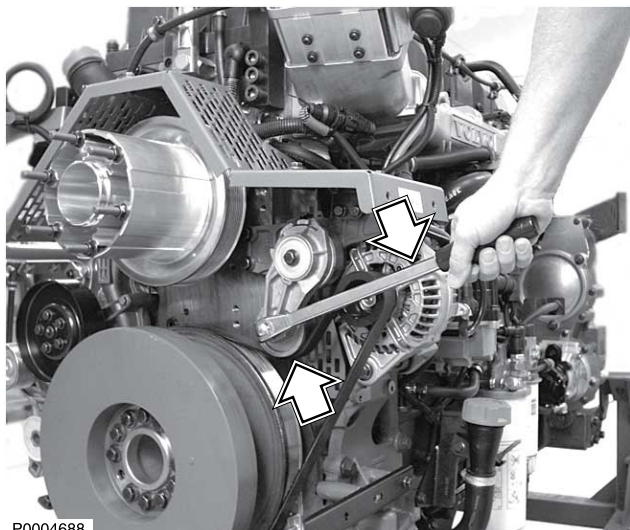
P0004688

#### Installation

- 1 Check the belt tensioner pulleys.



P0004687



- 2 Depress the lever.

**⚠ CAUTION!**

Pinch hazard. Keep fingers clear.

Wind on the belt.

## Belt Tensioner, Change

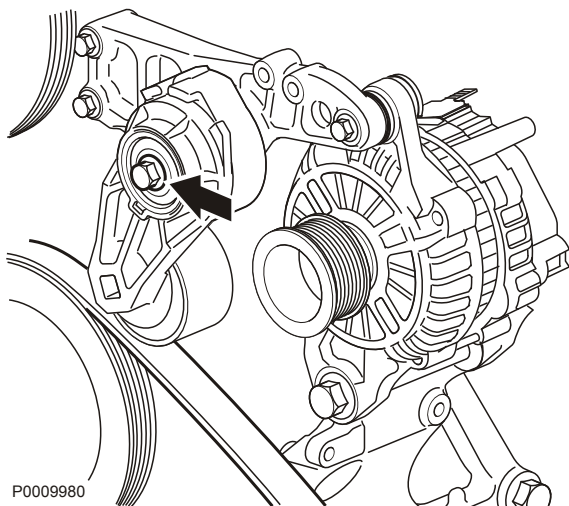
Left belt guard removed; refer to *Belt Protector* page 296.

Coolant pump belt removed; refer to *Drive Belts* page 290.

Alternator belt removed; refer to *Alternator Belts, Change* page 298.

### Removal

- 1 Remove the tensioner retaining bolt and remove the tensioner.



### Installation

- 2 Install the tensioner. Align the guide pin on the attachment with the installation hole and tighten the bolts.  
Check the condition of the drive belts.
- 3 Install the alternator belt; refer to *Alternator Belts, Change* page 298.
- 4 Check that the belt is correctly positioned on the belt pulleys.



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