Workshop Manual

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Group 21-26

TAD940GE, TAD941GE
TAD940VE, TAD941VE, TAD942VE, TAD943VE
TAD950VE, TAD951VE, TAD952VE

Workshop Manual

Group 21-26

Industrial engine

TAD940GE, TAD941GE
TAD940VE, TAD941VE, TAD942VE, TAD943VE
TAD950VE, TAD951VE, TAD952VE

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Safety information

Introduction

This Workshop Manual contains descriptions and instructions for the repair of the Volvo Penta products or product versions. Check that you have the correct Workshop Manual for your engine.

Before starting work on the engine, read these safety precautions with care as well as ”General information” and ”Service procedures”.

Important

In this book and on the product you will find the following special warning symbols.

WARNING! Possible danger of personal injury, extensive damage to property or serious mechanical malfunction if the instructions are not followed.

IMPORTANT! Used to draw your attention to something that can cause damage or malfunctions on a product or damage to property.

NOTE: Used to draw your attention to important information that will facilitate the work or operation in progress.

Below is a summary of the risks involved and safety precautions you should always observe or carry out when operating or servicing the engine.

Immobilize the engine by turning off the power supply to the engine at the main switch (switches) and lock it (them) turned off before starting work. Set up a warning notice at the engine control point.

As a general rule all service operations must be carried out with the engine stopped. However, some work, for example
certain adjustments require that the engine is running when they are carried out. Approaching an engine which is operating is a safety hazard. Loose clothing or long hair can fasten in rotating parts and cause serious personal injury.

If working in proximity of an engine which is operating, careless movements or a dropped tool can result in personal injury.
Take care to avoid contact with hot surfaces (exhaust pipes, Turbocharger (TC), air intake pipe, starter heater etc.) and hot liquids in lines and hoses on an engine which is running or which has just been stopped. Reinstall all protective parts removed during service operations before starting the engine.

Check that the warning or information labels on the product are always clearly visible. Replace labels which have been damaged or painted over.

Never start the engine without installing the air cleaner (ACL) filter. The rotating compressor in the Turbo can cause serious personal injury. Foreign objects entering the intake ducts can also cause mechanical damage.

Never use start spray products or similar when starting the engine. They may cause an explosion in the inlet manifold. Danger of personal injury.

Only start the engine in a well- ventilated area. If operating the engine in an enclosed area ensure that there is exhaust ventilation leading out of the engine compartment or workshop area.

Avoid opening the coolant filler cap when the engine is hot. Steam or hot coolant can spray out and the system pressure will be lost. When needed, open the filler cap slowly and release the pressure in the system. Be very careful if a cock or plug or engine coolant line must be removed when the engine is hot. It is difficult to anticipate in which direction steam or hot coolant can spray out.

Hot oil can cause burns. Avoid getting hot oil on the skin. Ensure that the lubrication system is not under pressure before carrying out any work. Never start or operate the engine with the oil filler cap removed, otherwise oil could be ejected.

Stop the engine before carrying out operations on the engine cooling system.

⚠ Always use protective glasses or goggles when carrying out work where there is a risk of splinters, grinding sparks, acid splashes or where other chemicals are used. The eyes are extremely sensitive. An injury could result in blindness!

⚠ Avoid getting oil on the skin! Repeated exposure to oil or exposure over a long period can result in the skin becoming dry. Irritation, dryness and eczema and other skin problems can then occur. Used oil is more dangerous than fresh oil from a health aspect. Use protective gloves and avoid oil soaked clothes and shop rags. Wash regularly, especially before eating. There are special skin creams which counteract drying out of the skin and make it easier to clean off dirt after work is completed.

⚠ Many chemicals used on the product (such as engine and transmission oils, glycol, gasoline and diesel oil), or chemicals used in the workshop (such as degreasers, paint and solvents) are hazardous to health. Read the instructions on the product packaging with care! Always follow the safety precautions for the product (for example use of protective mask, glasses, gloves etc.). Make sure that other personnel are not exposed to hazardous chemicals, for example in the air. Ensure good ventilation in the work place. Follow the instructions provided when disposing of used or leftover chemicals.

⚠ Exercise extreme care when leak detecting on the fuel system and testing the fuel injector nozzles. Use eye protection. The jet from a fuel injector nozzle is under extremely high pressure and has great penetrative energy, so the fuel can penetrate deep into the body tissue and cause serious personal injury. Danger of blood poisoning.

⚠ **WARNING!** The delivery pipes must under no circumstances be bent. Damaged pipes should be replaced.

⚠ All fuels and many chemical substances are flammable. Do not allow naked flame or sparks in the vicinity. Certain thinner products and hydrogen from batteries can be extremely flammable and explosive when mixed with air in the right proportions. No Smoking! Ensure that the work area is well ventilated and take the necessary safety precautions before starting welding or grinding work. Always ensure that there are fire extinguishers at hand when work is being carried out.

⚠ Ensure that rags soaked in oil or fuel and used fuel or oil filters are stored safely. Rags soaked in oil can spontaneously ignite under certain circumstances. Used fuel and oil filters are environmentally dangerous waste and must be deposited at an approved site for destruction together with used oil, contaminated fuel, left over paint, solvents, degreasers and waste from washing parts.

⚠ Never expose a battery to naked flame or electrical sparks. Never smoke close to the batteries. The batteries give off hydrogen gas during charging which when mixed with air can form an explosive gas - oxyhydrogen. This gas is easily ignited and highly volatile. Incorrect connection of the battery can cause a single spark which is sufficient to cause an explosion with resulting damage. Do not shift the connections when attempting to start the engine (spark risk) and do not lean over any of the batteries.

⚠ Always ensure that the Plus (positive) and Minus (negative) battery cables are correctly installed on the corresponding terminal posts on the batteries. Incorrect installation can result in serious damage to the 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 off immediately using plenty of water and soap. If battery acid comes in contact with the eyes, immediately flush with plenty of water and obtain medical assistance at once.

⚠ Turn the engine off and turn off the power at the main switch(es) before carrying out work on the electrical system.

⚠ Clutch adjustments must be carried out with the engine stopped.

⚠ Use the lifting eyes fitted on the engine when lifting the drive unit. Always check that the lifting equipment used is in good condition and has the load capacity to lift the engine (engine weight including gearbox, if fitted, and any extra equipment installed). Use an adjustable lifting beam or lifting beam specifically for the engine to raise the engine to ensure safe handling and to avoid damaging engine parts installed on the top of the engine. All chains and cables should run parallel to each other and as perpendicular as possible in relation to the top of the engine. If extra equipment is installed on the engine which alters its center of gravity a special lifting device is required to obtain the correct balance for safe handling.

Never carry out work on an engine suspended on a hoist.

⚠ Never work alone when removing heavy engine 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 another to ensure that components are lifted clear and not damaged during the lifting operations.

Always check before starting work if there is enough room to carry out removal work without risking personal injury or damage to the engine or parts.

⚠ **WARNING!** The components in the electrical system and in the fuel system 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.

⚠ Always use the fuels recommended by Volvo Penta. Refer to the Instruction Book. Use of fuels that are of a lower quality can damage the engine. On a diesel engine poor quality fuel can cause the control rod to seize and the engine to overrev with resulting risk of damage to the engine and personal injury. Poor fuel quality can also lead to higher maintenance costs.

⚠ Remember the following when washing with a high pressure washer: Never direct the water jet at seals, rubber hoses, electrical components or the radiator. Never use the high pressure feature when cleaning an engine.

General information

About this Workshop Manual

This Workshop Manual contains descriptions and instructions for the repair of standard engine version TAD940GE, TAD941GE, TAD940VE, TAD941VE, TAD942VE, TAD943VE, TAD950VE, TAD951VE and TAD952VE.

The Engine Designation and Engine Numbers can be found on the product plate.
Please always include both the engine designation and the engine number in all correspondence.

The Workshop Manual is produced primarily for the use of Volvo Penta workshops and service technicians. For this reason the manual presupposes a certain basic knowledge and that the user can carry out the mechanical/electrical work described to a general standard of engineering competence.

AB Volvo Penta products are under a continual process of development and we therefore reserve all rights regarding changes and modifications. All the information in this manual is based on product specifications available at the time the book was published. Any essential changes or modifications of the product or revised service methods introduced after the date of publication will be provided in the form of Service Bulletins.

Flat Rates

Operation numbers that show in instruction headings refer to Volvo Penta Flat Rates"

Spare parts

Spare parts for the electrical and fuel systems are subject to various national safety requirements. Volvo Penta Original Spare Parts meet these specifications. Any type of damage which is the result of using spare parts that are not original Volvo Penta parts for the product in question will not be covered under any warranty or guarantee provided by AB Volvo Penta.

Certified engines

Manufacturer warrants that both new and currently operating engines that are certified to national and regional environmental regulations meet environmental requirements. The product must correspond to the engine that was approved during certification. In order that Volvo Penta, as manufacturer, will be able to warrant that engines in operation meet environmental requirements, the following requirements for service and spare parts must be met:

- Service and maintenance intervals recommended by Volvo Penta must be followed.
- Only Volvo Penta Original Spare Parts intended for the certified engine version may be used.
- Service work that covers injection pumps, pump settings, and injectors must always be carried out by an authorized Volvo Penta workshop.
- The engine must not be altered or modified in any way, except for accessories and service kits developed by Volvo Penta for that engine.
- No modifications to the exhaust pipes and engine room air intake pipes are allowed.
- Any seals on the engine may not be broken by unauthorized persons.

⚠ **IMPORTANT!** When spare parts are required, use only Volvo Penta original parts.

Use of non-original parts will result in AB Volvo Penta being unable to warrant that the engine corresponds to the certificated engine version.

Any type of damages or costs which are the result of using spare parts that are not original Volvo Penta parts for the product in question will not be paid for by AB Volvo Penta.

Repair instructions

The working methods described in the Workshop Manual apply to work carried out in a workshop. The engine has been removed and is installed in an engine fixture. Unless otherwise stated reconditioning work which can be carried out with the engine in place follows the same working method.

Warning symbols used in this Workshop Manual (for full explanation of the symbols refer to the section; "**Safety Precautions**"

WARNING!

IMPORTANT!

NOTE:

are not in any way comprehensive since it is impossible to predict every circumstance under which service work or repairs may be carried out. AB Volvo Penta can only indicate the risks considered likely to occur as a result of incorrect working methods in a well equipped workshop using working methods and tools tested by AB Volvo Penta.

All operations described in the Workshop Manual for which there are Volvo Penta Special Tools available assume that these tools are used when carrying out the repair. Volvo Penta Special Tools have been specifically developed to ensure as safe and rational working methods as possible. It is therefore the responsibility of anyone using other tools or other working methods than we recommend to determine that there is no risk of personal injury or mechanical damage or malfunction as a result.

In some cases special safety precautions and user instructions may be required in order to use the tools and chemicals mentioned in the Workshop Manual. Always follow these precautions. There are no specific instructions given in the Workshop Manual.

By following these basic recommendations and using common sense it is possible to avoid most of the risks involved in the work. A clean work place and a clean engine will eliminate many risks of personal injury and engine malfunction.

Especially when working on the fuel system, engine lubrication system, air intake system, turbocharger unit, bearing seals and seals, it is extremely important to avoid dirt or foreign objects entering the parts or systems, since this can result in reduced service life or malfunctions.

Our joint responsibility

Every engine consists of many systems and components that work together. If one component deviates from the technical specifications this can have dramatic consequences on the environmental impact of the engine even if it is otherwise in good running order. It is therefore critical that the stated wear tolerances are observed, that systems which can be adjusted are correctly set up and that only Volvo Penta Original Parts are used on the engine. The stated service intervals in the Maintenance Schedule must be followed.

Some systems, such as the components in the fuel system, require special expertise and special testing equipment for service and maintenance. Some components are factory sealed for environmental and product specific reasons. Under no circumstances attempt to service or repair a sealed component unless the service technician carrying out the work is authorized to do so.

Bear in mind that most chemical products, incorrectly used, are hazardous to the environment. Volvo Penta recommends the use of bio-degradable degreasing agents for all cleaning of engine components unless otherwise stated in the Workshop Manual. Pay special attention to make sure that oils and washing residue etc are handled correctly for destruction, and do not unintentionally end up in nature.

Torque

Correct torque for critical joints which must be tightened using a torque wrench are listed under "Technical Data - Torque" and stated in the method descriptions in the Workshop Manual. All torque data apply to cleaned threads, bolt heads and mating surfaces. Torque data stated apply to lightly oiled or dry threads. Where grease, locking or sealing agents are required for screwed joints this is stated in both the operation description and in "torque". Where no torque is stated for a joint use the general torque shown in the following table. The torques stated are a guide and the joint does not have to be tightened using a torque wrench.

Dimension	Torque	
	Nm	lbf ft
M5	6	4.4
M6	10	7.4
M8	25	18.4
M10	50	36.9
M12	85	62.3
M14	140	103.3
M16	220	162.3

Torquing with Protractor tightening (angle tightening)

When torquing with protractor (angle tightening), the fastener is tightened to a predetermined torque and then turned a predetermined angle. Example: a 90° protractor tightening means that the joint is tightened a further 1/4 turn in one operation after the stated torque has been applied.

Lock nuts

Do not re-use lock nuts that have been removed during disassembly operations as these have reduced service life when re-used. For lock nuts with a plastic insert such as Nylok® the torque stated in the table is reduced if the Nylok® nut has the same head height as a standard hexagonal nut without plastic insert. Reduce the torque by 25% for bolt size 8 mm (0,3150 “) or larger. Where Nylok® nuts are higher, where the metallic thread is of the same height as a standard hexagonal nut, the torques given in the as shown in table apply.

Strength classes

Bolts and nuts are divided up into different classes of strength; the class is indicated by the number on the bolt head. A higher number indicates a material with greater strength. It is therefore important that bolts removed during the disassembly of a bolted joint must be reinstalled in their original position when assembling the joint. If a bolt must be replaced check in the spare parts catalogue to make sure the correct bolt is used.

Sealant

A number of sealants and locking liquids are used on the engines. The agents have varying properties and are used for different types of jointing strengths, operating temperature ranges, resistance to oil and other chemicals and for the different materials and gap sizes in the engines.

To ensure service work is correctly carried out it is important that the correct sealant and locking fluid type is used on the joint where the agents are required.

In this Volvo Penta Workshop Manual the user will find that each section where these agents are applied in production states which type was used on the engine.

During service operations, use the same agent or an alternative from a different manufacturer.

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 for use regarding temperature range, curing time and any other instructions for the product

Two different basic types of agent are used on the engine and these are:

RTV agent (Room temperature vulcanizing). Used for gaskets, sealing gasket joints or coating gaskets. RTV is visible when a part has been disassembled; old RTV must be removed before resealing the joint.

The following RTV agents are mentioned in the Workshop Manual: Loctite® 574, Permatex® No. 3, Permatex® No 77. Old sealant can be removed using denatured alcohol in all cases.

Anaerobic agents. These agents cure in an absence of air. They are used when two solid parts, for example cast components, are installed face-to-face without a gasket. They are also commonly used to secure plugs, threads in stud bolts, cocks, oil pressure switches etc. The cured material is glass-like and it is therefore colored to make it visible. Cured anaerobic agents are extremely resistant to solvents and the old agent cannot be removed. When reinstalling the part, degrease it carefully and then apply new sealant.

The following anaerobic agents are mentioned in the Workshop Manual: Loctite® 572 (white), Loctite® 241 (blue).

NOTE: Loctite® is a registered trademark of Loctite Corporation, Permatex® is a registered trademark of the Permatex Corporation.

Safety rules for fluorocarbon rubber

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

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

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

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

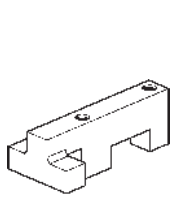
The following seals are probably made from fluorocarbon rubber:

Seal rings for the crankshaft, camshaft, intermediate shafts.

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

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

Special tools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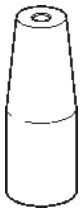
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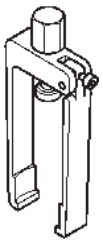
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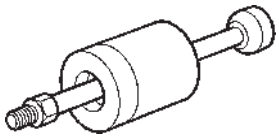
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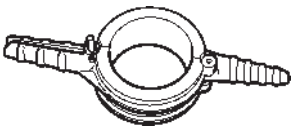
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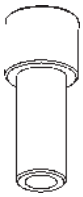
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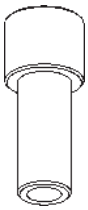
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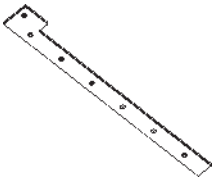
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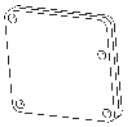
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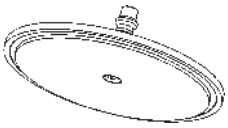
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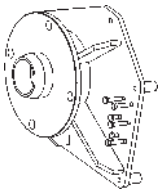
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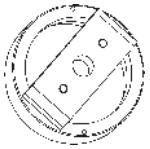
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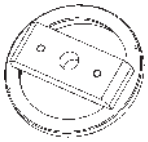
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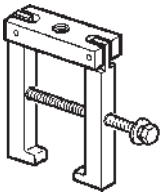
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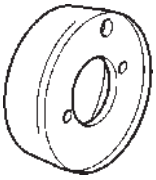
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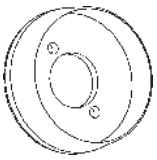
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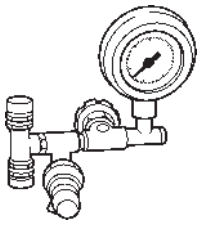
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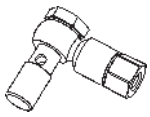
885810	Fixture for upper gear case
3883671	Installation sleeve, upper O-ring, injector
3883672	Installation sleeve, lower O-ring, injector
9809699	Sealing washer for temperature sensor during pressure testing of cylinder head
9990006	Puller, unit injector
9990013	Slide hammer
9990044	Piston ring compressor
9990049	Drift for replacement of valve guides, inlet
9990050	Drift for replacement of valve guides, outlet
9990104	Plate for cylinder liner removal/refitting
9990105	Sealing washer for cylinder head pressure testing
9990106	Thermostat housing sealing washer
9990107	Connection washer for thermostat housing at cylinder head pressure testing
9990109	Engine fixture
9990112	Drift, removal of front crankshaft seal
9990113	Drift, removal of rear crankshaft seal
9990114	Puller for main bearing caps
9990117	Cone, refitting rear crankshaft seal
9990118	Cone, refitting front crankshaft seal
9990123	Pressure testing device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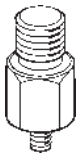
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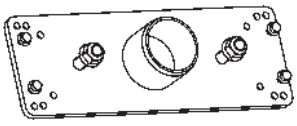
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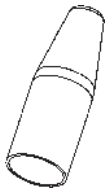
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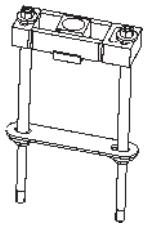
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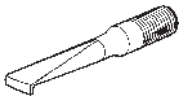
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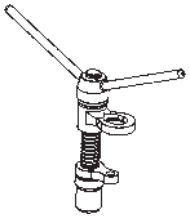
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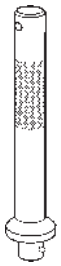
9991821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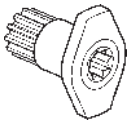
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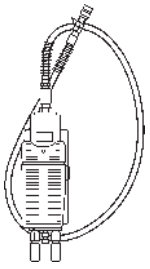

9996222

9990124 Nipple for checking of the fuel delivery pipes

9990125 Nipple for checking of boost pressure gauge, with 4 mm hose

9990156 Sealing plug adapter 9998251

9990160 Cylinder head fixture

9990165 Guide sleeve for valve stem seal

9990176 Press tool for removal/refitting of valve springs and valve guides

9990185 Lifting tool for rocker arm shaft

9990192 Puller for rear crankshaft seal, is used together with 9996400

9990210 Valve spring compressor

9991801 Handle, replacing flywheel bearing

9991821 Slide hammer, replacing flywheel bearing

9992000 Drift

9992063 Puller, crankshaft drive

9992479 Holder for dial indicator

9992564 Drift, replacing flywheel bearing

9992620 Drift, refitting of crankshaft drive

9992873 Connecting nipple for pressure checking

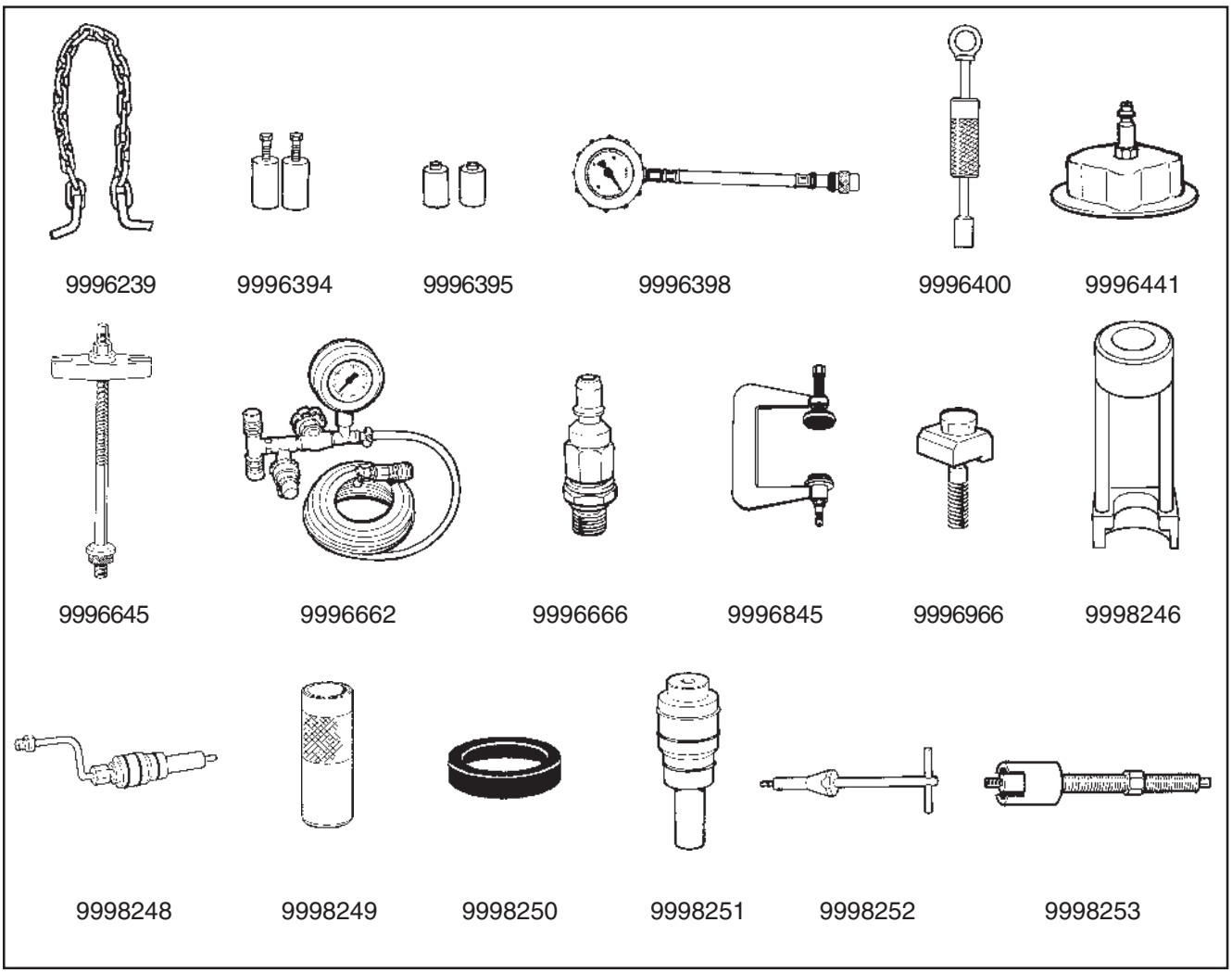
9993590 Turning tool

9996049 Coolant drain tube

9996159 Adapter for hydraulic cylinder, is used with 9996161

9996161 Hydraulic cylinder, used with 9990176

9996222 Pneumatic hydraulic pump, used with 9996161



9996239 Lifting chain, removal/refitting of cylinder head and flywheel casing, 2 ea required

9996394 Spacer for removal of cylinder liner, 2 ea are used with 9996645

9996395 Spacer for removal of cylinder liner, 2 ea are used with 9996645

9996398 Pressure gauge with quick-connect, 1.5 MPa

9996400 Slide hammer for removal of protection plug 9998251 for cylinder head. [3] Also for removal of rear crankshaft seal together with 885341.

9996441 Cover with connecting nipple for cooling system leakage test

9996645 Cylinder liner puller

9996662 Pressure testing device

9996666 Connecting nipple for pressure checking

9996845 Screw clamp for oil cooler pressure testing, 2 ea required

9996966 Cylinder liner press tool (7 ea are required)

9998246 Drift, removal/refitting of valve springs

9998248 Adapter for measuring compression pressure (6 pcs needed).

9998249 Protective sleeve for unit injector (6 ea required)

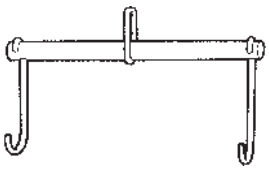
9998250 Sealing ring for fuel channel in the cylinder head when replacing copper sleeve, 2 ea required

9998251 Protection plugs for cylinder head (6 ea required)

9998252 Thread cutting tool. Consists of: **9809667** (M9) and **9987009** (M8). For D9, only **9809667** is used for removal of unit injector copper sleeve

9998253 Copper sleeve puller. Consists of: 9809746 (M8) and 9809668. For D9, only 9809668 is used


9998263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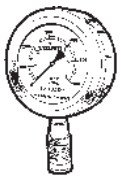
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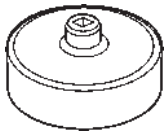
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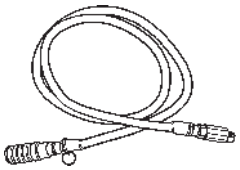
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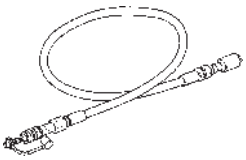
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9998502


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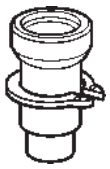
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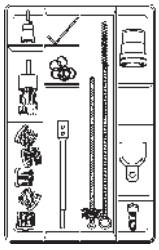
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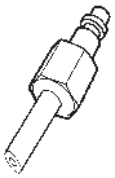
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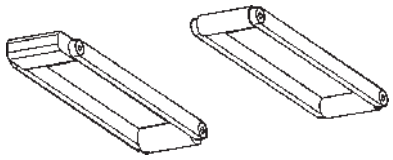

88820016


88880003

9998263 Drift for removing valve guide

9998264 Lifting yoke for camshaft

9998339 Pressure gauge

9998487 Socket for removal of oil filters

9998493 Hose for checking boost pressure

9998494 Hose (red) with nipple for measuring of the fuel delivery pipes, used with 9990123

9998502 Hose (green) for cooling system pressure testing, used with 9990123

9998511 Crowbar

9998517 Tool for checking/adjustment of flywheel and camshaft wheel sensor distance.

9998599 Cleaning kit for unit injectors. Consists of:

959239	Screw M10
9808570	Brush, white
9998580	Sleeve with holder and O-ring
276948	O-ring kit
9808634	Brush set, comprising:
	Storage box
	Holder
	Holder
	Handle
9808614	Brush, yellow 10 pcs
9808617	Wire brush, narrow
9808618	Wire brush, course

9998601 Fixture for upper gear case

9998688 Expander, replacing copper sleeve

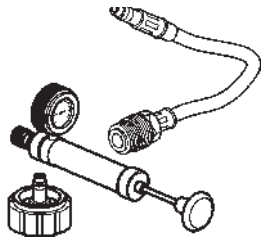
9999179 Filter puller

9999314 Hose fitting

88820016 Gauges, for adjusting the double rocker arm

88880003 Holder kit, used together with 9990185 for TAD950-952VE

Other special equipment



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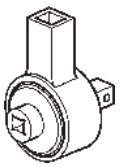

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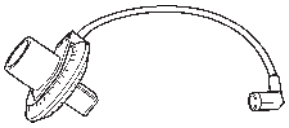

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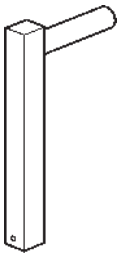

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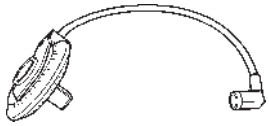

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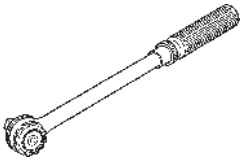

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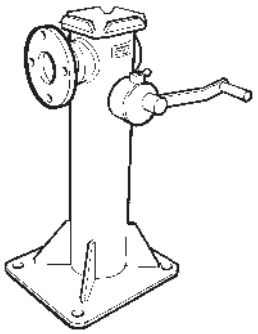
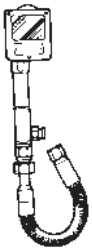
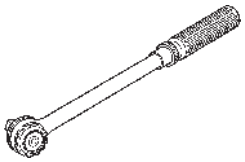


998 6485



998 8539

998 9876



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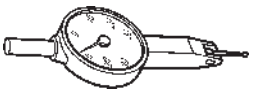

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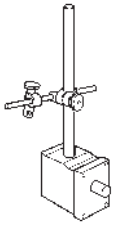


999 9696

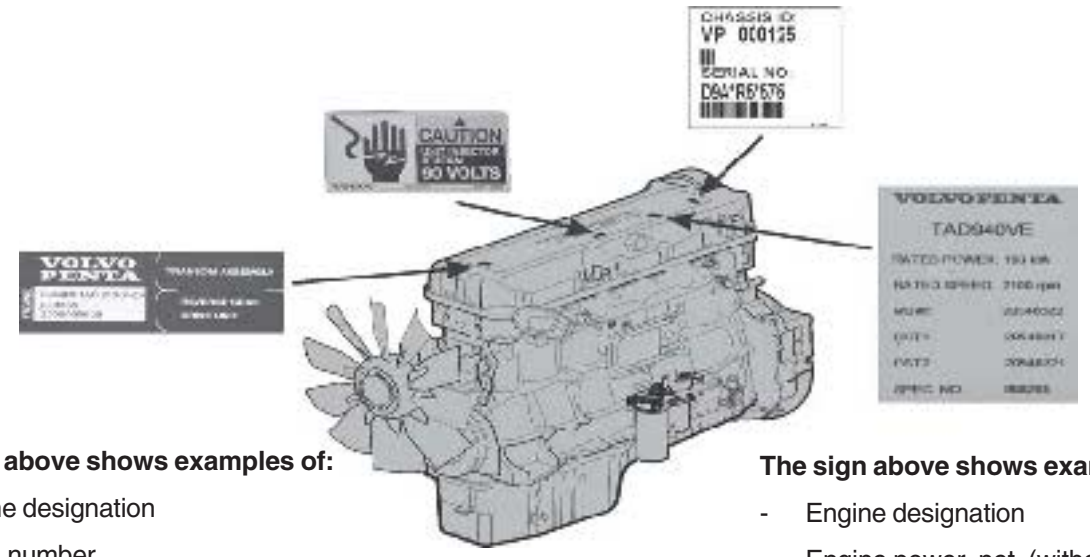
885531	Pressure-testing equipment, cooling system
885633	Torque amplifier 1/2" - 3/4"
885648	Counterhold, used together with 885633
885811	Angle gauge 3/4"
885812	Angle gauge 1/2"
1159794	Torque wrench 3/8, 10 - 100 Nm (7.4 - 74 lbf ft)
998 6485	Assembly stand
998 8539	Compression gauge
998 9876	Dial indicator
9999881	Torque wrench
9999683	Dial indicator
9999696	Magnetic stand

Introduction

TAD940GE, TAD941GE, TAD940VE, TAD941VE, TAD942VE, TAD943VE, TAD950VE, TAD951VE and TAD952VE are in-line, direct injected, 6-cylinder industrial diesel engines. TAD950VE, TAD951VE have TAD952VE have internal EGR (Exhaust Gas Recirculation).

All engines are equipped with electronically controlled fuel management (EMS 2), turbocharger, intercooler, thermostatically controlled cooling systems and electronic speed control.

Identification numbers



The sign above shows examples of:

- Engine designation
- Serial number
- Specification number

The sign above shows examples of:

- Engine designation
- Engine power, net, (without fan)
- Max. engine speed
- Main software
- Data set 1
- Data set 2
- Product number

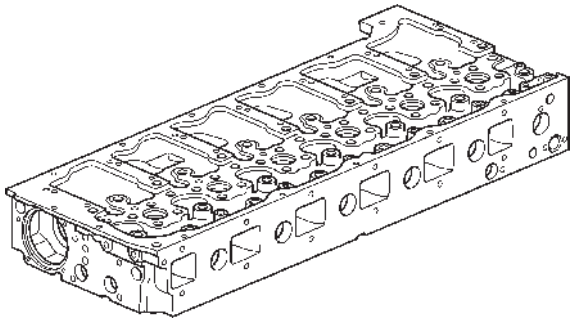
Explanation of engine designation:

E.g. TAD940GE/TAD940VE

T – Turbo
A – Air to air intercooler
D – Diesel engine
9 – Cylinder volume, liter
4 – Generation
0 – Version
G – Generator unit engine
V – Stationary and mobile operation
E – Emission control

Design and function

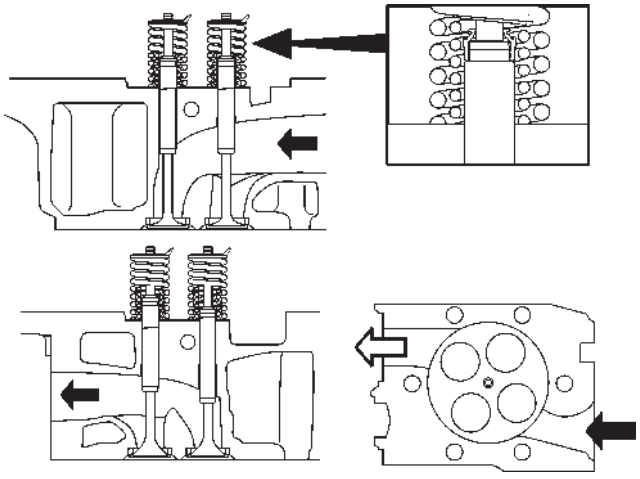
Group 21: Engine body



Cylinder head

The cylinder head is cast in one piece of alloyed cast iron and covers all cylinders

It is equipped with an overhead camshaft and is held by 26 ea M16 screws that are evenly spaced around the cylinder.

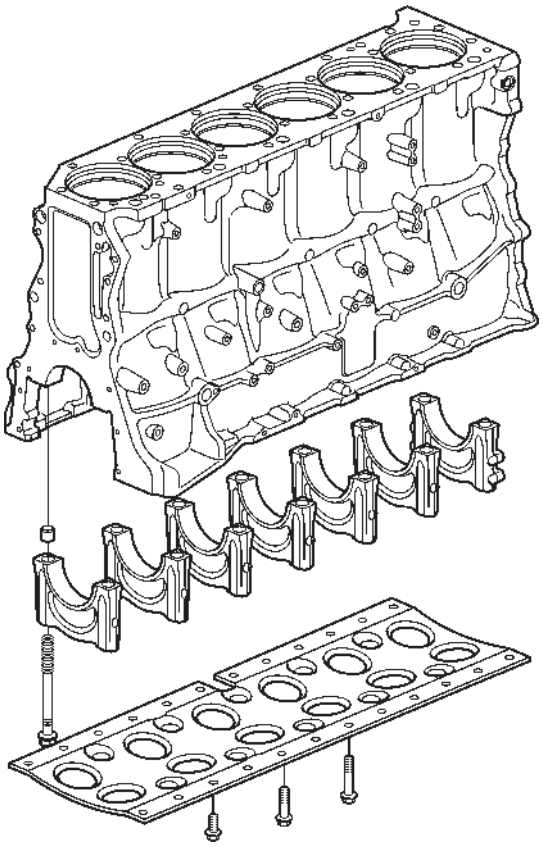


The cylinder head has separate inlet- and outlet channels with cross-flow for each cylinder.

The valve guides are made of alloyed cast iron and all valve guides have oil seals. The valve seats are replaceable and made of steel.

The four valve system and valve placements are turned 12 ° in relation to the cylinder head cross-section.

The engine is a low exhaust emission engine and no machining may be performed that will change the position of the injectors in relation to the combustion chamber, such as cylinder head face-grinding or copper sleeve seat milling.



Cylinder block

The cylinder block is made of alloyed cast iron and cast in one piece. It is equipped with wet, replaceable cylinder liners.

The cylinder block sides are cup-shaped around each cylinder in order to obtain high rigidity and good sound proofing.

At the lower level of the block, a bracing frame of 5 mm steel plate is mounted to decrease vibrations and thus also engine noise.

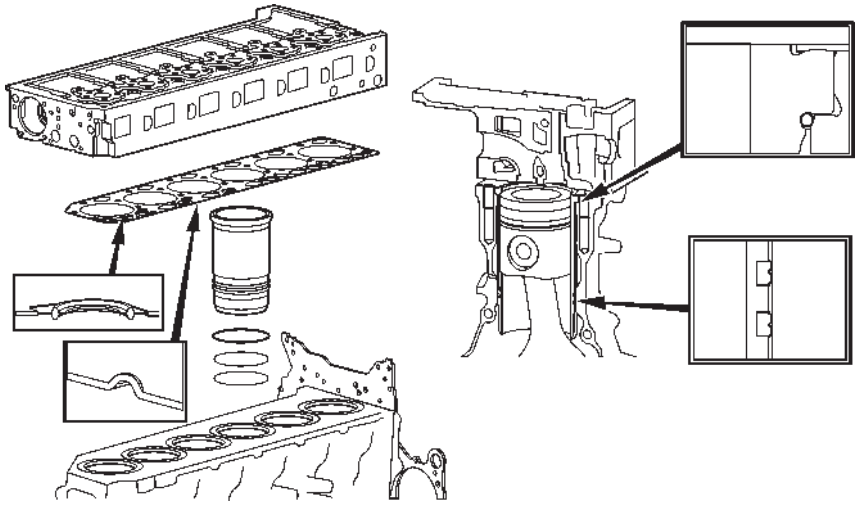
The oil pan is made of plastic and mounted with 18 spring loaded screws in the cylinder block foot.

The cylinder block main bearing caps are made of ductile cast iron and machined together with the cylinder block. In order to avoid incorrect placement the thrust bearing caps 1-3, 5 and 6 are numbered and feature cast bosses in both caps and blocks. The thrust bearing caps are also controlled by sockets that are pressed into the block screw holes.

The lubricating oil pump is secured to the rear main bearing cap, no. 7. The thrust bearing is placed on the middle one, no. 4.

The cylinder head gasket is made of massive steel in one piece, for the whole engine. The gasket incorporates vulcanized rubber seals for oil and coolant passthrough. The gasket also has a number of convex embossings in order for the cylinder to slide on the gasket during the fitting, and not damage the rubber rings in the gasket.

The cylinder head is lowered towards the guide pins in the cylinder block leaving a small distance to the transmission plate. The cylinder head is then pulled horizontally towards the transmission plate. When in place, it is screwed against the cylinder block and the embossings are flattened out.

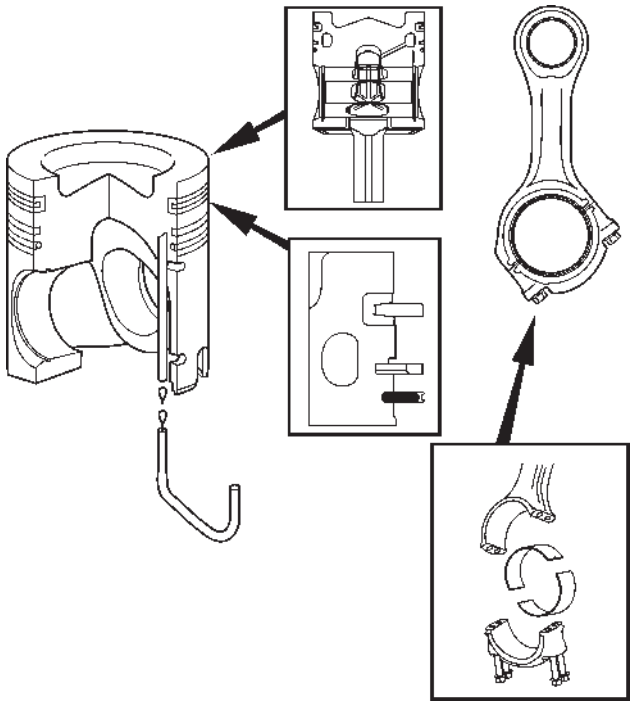


Cylinder liner

The cylinder block is equipped with wet, replaceable cylinder liners.

The coolant space around the cylinder liners is sealed against the cylinder block with three sealing rings. The upper part of cylinder liner is sealed with a ring placed under the liner collar. This ring is made of EPDM rubber.

The lower part of cylinder liner is sealed using two rubber rings. The top one, closest to the coolant, is made of EPDM rubber (black) and the lower one towards the oil side is made of fluorocarbon rubber(purple).



Pistons and connecting rods

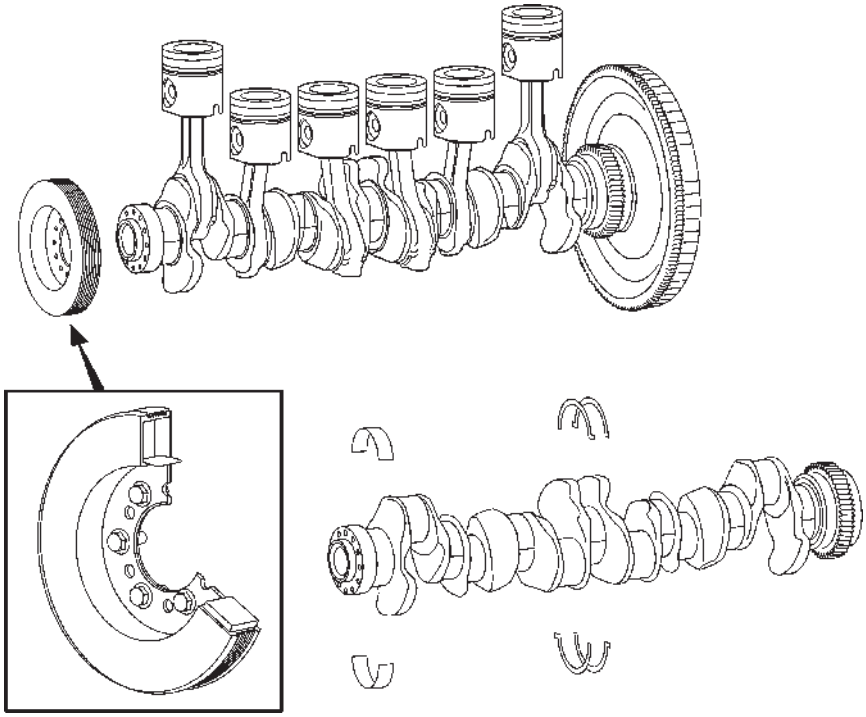
The pistons are made of aluminum and are cooled by lubricating oil that via piston cooling nozzles in the cylinder block is sprayed up through a channel in the piston to a cooling coil in the piston head and is drained via a channel between the piston and the connecting rod.

The piston pin bushing is lubricated via a lube channel in the bushing and the piston rings are lubricated in the usual manner.

The piston has three rings; on top a compression ring type ”Keystone”, in the middle a compression ring with a rectangular cross-section and at the bottom a spring loaded oil wiper ring.

The connecting rods are forged from steel. The lower crank bearing is ”split” i.e. divided through a flat unmachined surface.

The upper part of the connecting rod has unmachined sides and its trapezoidal form allows the forces from the piston to spread optimally to the connecting rod.



Crankshaft

The crankshaft is drop-forged in one piece and induction-hardened on the bearing surfaces for increased strength and decreased risk of cracks.

The crankshaft has 7 main bearings, each crank bearing is placed between two main bearings. The thrust bearings are located in the center main bearing. Both main bearings and connecting rod bearings have steel cups that are lead nickel plated and lined with lead bronze.

The crankshaft can be ground and has five undersize dimensions.

In the rear and the front the crankshaft has an integrated hub for attaching a transmission wheel (rear) and a vibration damper/belt pulley (front), respectively.

In the front cover cap, a Teflon seal seals against the crankshaft front end. The Teflon seal features an outer felt coating that protects against dust.

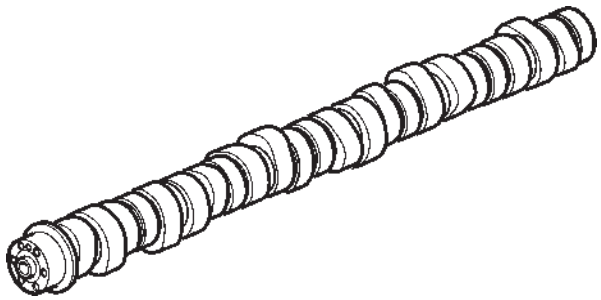
In the vibration damper housing there is a freely rotating steel ring that works as inertial mass. Between the steel ring and the house the damper is filled with a high viscosity silicon oil. The vibrations are reduced by the oil equalizing the crankshaft's pulsating rotation and the steel ring's even rotation.

The crankshaft transmission wheel is placed on the rear end of the crankshaft. A guide pin on the wheel in the crankshaft prevents the wheel from being installed incorrectly. A sealing ring of silicone sealing between the crankshaft and the transmission wheel is situated on the crank shaft end.

The combined gear case/flywheel casing is located around the crankshaft transmission wheel and the flywheel. A Teflon seal seals between the flywheel casing and the crankshaft transmission wheel, with an outer felt coating that protects against dust.

The crankshaft transmission wheel features a guide pin directed towards the back that fits in the flywheel, so that it cannot be installed incorrectly. The flywheel bolts are fastened through the flywheel, the crankshaft drive and into the crankshaft.

The flywheel peripheral surface has a number of milled groves for the injection system speed sensor.



Camshaft

The overhead camshaft is induction-hardened. The bearing pins can be ground with replaceable bearing shells as spare parts.

The camshaft is journalled in seven bearing housings that are machined together and numbered 1-7, viewed from the engine front edge. The rear the bearing is a thrust bearing.

The camshaft has three tappets per cylinder. One for the intake valves, one for the exhaust valves and a tappet in the middle for the unit injector.

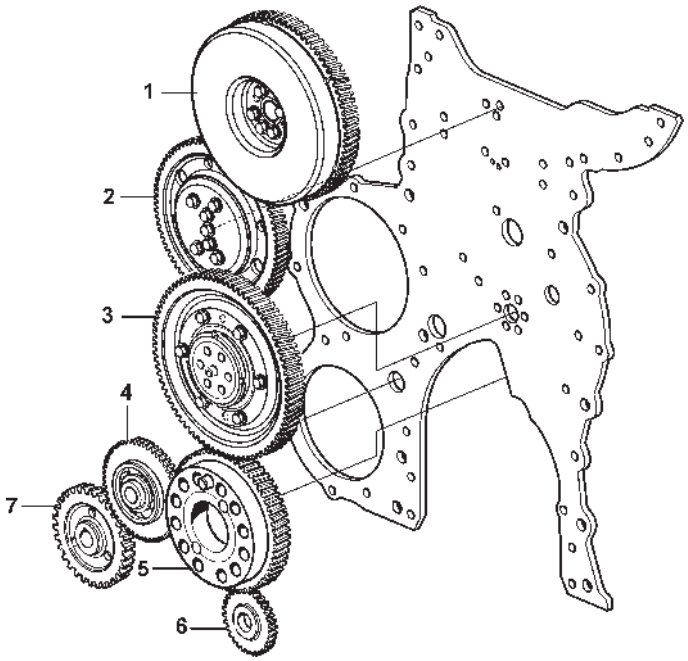
The camshaft drive is installed on the rear flange of the camshaft with a hydraulic vibration damper on the outside. Both the camshaft drive and vibration damper has holes for the guide pin from the camshaft in order to avoid incorrect installation. The vibration damper has teeth that signal the camshaft sensor.

A flange that shows the camshaft's mark, numbers 1-6 and TDC (Top Dead Center) is located in front of the rear bearing housing. TDC is used for the camshaft's initial setting and should be between the two lines on the bearing housing when the flywheel is at the 0° mark. The number marking are used when adjusting valves and injectors.

Screwed onto the camshaft cap is a rocker arm shaft. Journalled on it are rocker arms with pressed-in surface treated steel bushings. A floating valve yoke transfers the rocker arm movement to the valves. The rocker arm contact with the camshaft is carried out via a roller and against the valve yoke with a ball cup and an adjustment screw.

Both inlet and exhaust valves have double springs.

The valve guides are made of alloyed cast iron and the valve seats are made of steel, both are also replaceable as spare parts. All valve guides are equipped with oil seals.



1. Camshaft drive
2. Upper intermediate gear
3. Intermediate gear, double
4. Lower intermediate gear
5. Crankshaft drive
6. Oil pump drive wheel
7. Fuel feed pump / servo pump drive wheel

Transmission

The transmission is placed on the engine's rear edge on a 6 mm thick steel plate that is screwed into the cylinder head and the cylinderblock, fixed with two guide sleeves and a guide pin. All wheels are angle-cut and nitride hardened.

The crankshaft gear (5) also works as a spacers between the crank shaft flange and the flywheel. It is screwed on with 12 ea pass-through screws and fixed to the crankshaft with two socket head cap screws and a guide pin.

Above the crankshaft wheel is a intermediate wheel (3) consisting of two gears screwed together. The wheels are pre-installed on a hub journalled in two conical roller bearings. The inner wheel drives the upper (adjustable) intermediate gear (2) which in turn drives the camshaft wheel (1) and is journalled in a bushing on the hub.

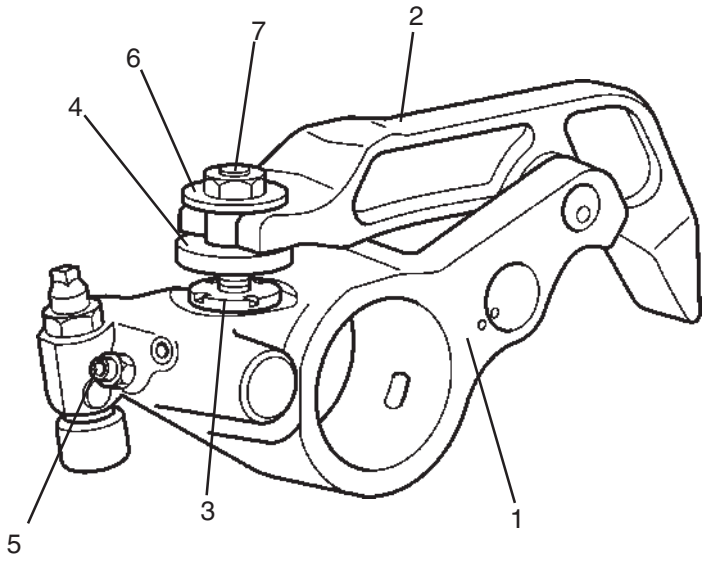
The backlash shall be adjusted between the upper intermediate gear (2) and the camshaft wheel (1) when the transmission has been serviced.

Camshaft wheel (1) is screwed into the camshaft flange and controlled by a guide pin. The vibration damper with teeth for the camshaft sensor is installed on the outside.

The lower intermediate gear (4) is journalled in a two-row ball bearing and drives the combined fuel pump/ servo pump. The wheel is fastened with a screw through the flywheel casing and is threaded into the cylinder block.

Drive wheel (7) is installed on the servo pump pass-through shaft, which also drives the fuel feed pump.

The oil pump drive wheel (6) is powered by the crankshaft gear.



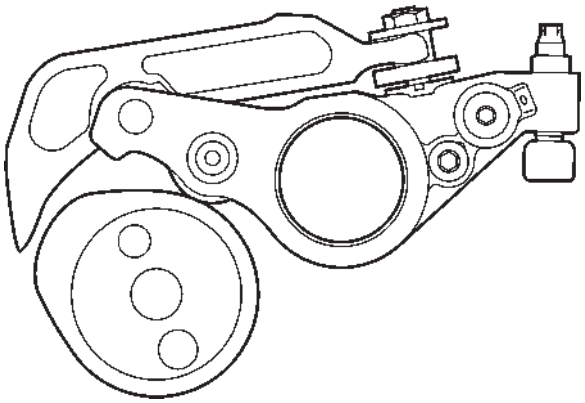
1. Exhaust rocker arm
2. Following arm
3. Stop nut
4. Sleeve
5. Drain nipple
6. Lock nut
7. Piston

Internal EGR

The engines are equipped with internal EGR (Exhaust Gas Recirculation). This means that the double rocker arm has an extra following arm that makes the exhaust valve lift an extra time.

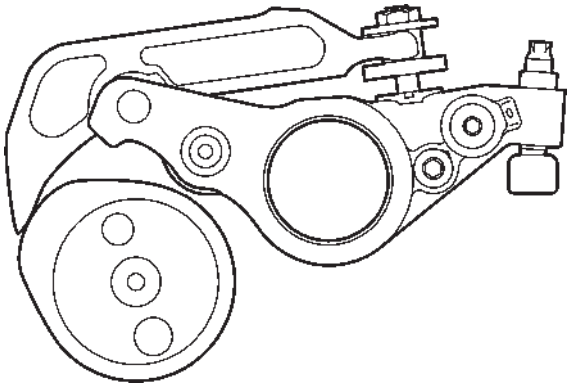
This extra lift allows exhaust gas to flow back into the cylinder at the beginning of each filling phase. The double rocker arm is controlled by the control unit, via oil pressure from the iEGR valve. The iEGR valve is located between the cylinder head and the rocker arm shaft, and supplies the rocker arm shaft with oil.

The double rocker arm consists of two main sections, the exhaust rocker arm (1) on which the following arm (2) is mounted. The control valve in the rocker arm, which is controlled by the iEGR valve, distributes oil pressure to either the upper or the lower side of the piston, and thus either activates or de-activates the iEGR valve.



Inactive

Oil pressure presses the piston to its lower position. The following arm follows it. The camshaft lobe now only contacts the roller but not the following arm.

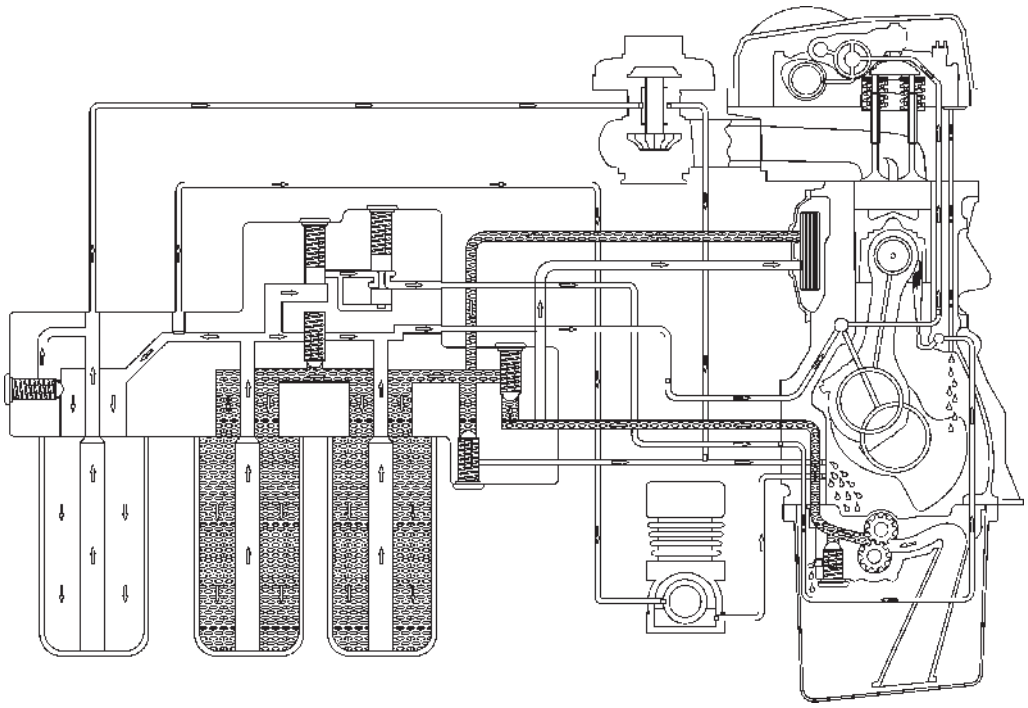


Active

Oil pressure presses the piston to its upper position. The following arm follows it and the rocker is now activated twice by the camshaft lobe; first via the main lobe and then via the following arm.

When the camshaft rotates, the lobe first activates the roller to activate the exhaust valve. Then the lobe comes into contact with the following arm contact surface, which gives the exhaust valve a small lift.

Group 22 Lubrication system



The engine is pressure lubricated by a gear wheel pump connect to the engine's transmission. The oil flow is controlled by 7 valves.

The lubricating oil pump is driven directly by the crankshaft gear and pressures oil to two full-flow filters and one turbo filter (bypass filter). The turbo filter has low through-flow and a high degree of filtration.

Along the cylinder block, two channels are drilled, where the one in the right-hand side of the block is the lubricating oil channel that supplies all bearings on the crank mechanism with oil. The lubricating oil channel is the plugged at the front edge.

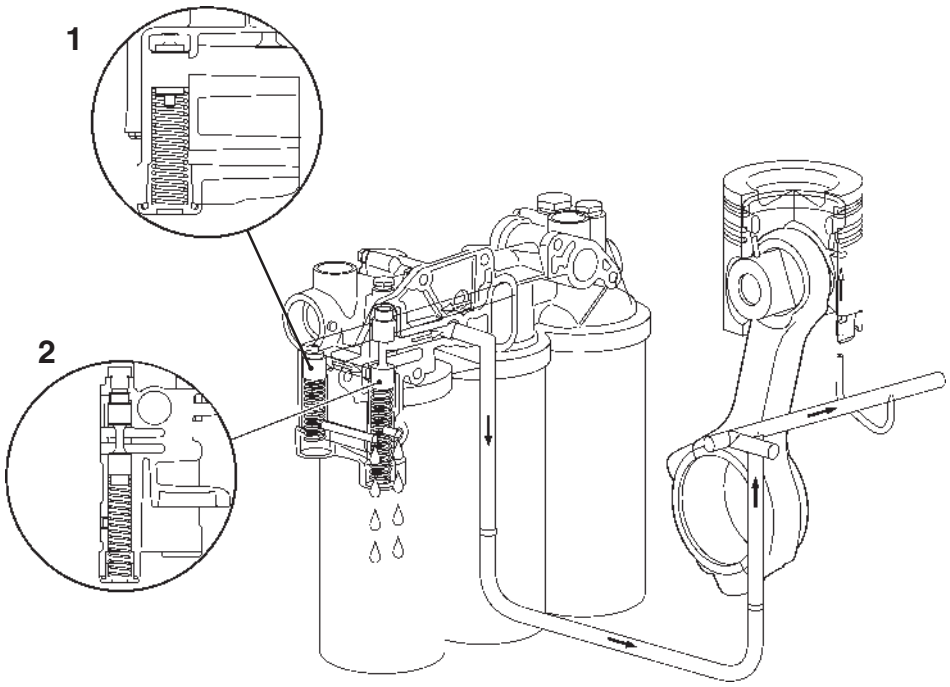
The second channel, in the left side of the block, is the piston cooling duct that supplies the pistons with oil for cooling and lubrication. The piston cooling duct is plugged at both ends.

All bearings in the cylinder head are lubricated from the hollow rocker arm shaft connected with the cylinder block via a cast channel in the block's rear edge.

The oil pump housing is made of aluminum. The pump is installed on the engine's rear main bearing cap and is driven directly by the crankshaft drive. The oil pump housing and the two pump wheels are machined together and cannot be exchanged separately. The pump wheel shafts are journalled directly in the oil pump housing. Suction and delivery pipes are made of steel and are sealed against the pump cover and the oil dispenser house with rubber seals. The suction strainer is made from aluminum.

The oil dispenser house is screwed into the cylinder block foot and acts as a bracket for the suction strainer and oil pump safety valve.

The oil cooler is of a flat type and placed on the right-hand side of the engine, on the inside of the cooling jacket side door and totally enclosed in coolant.



Piston cooling

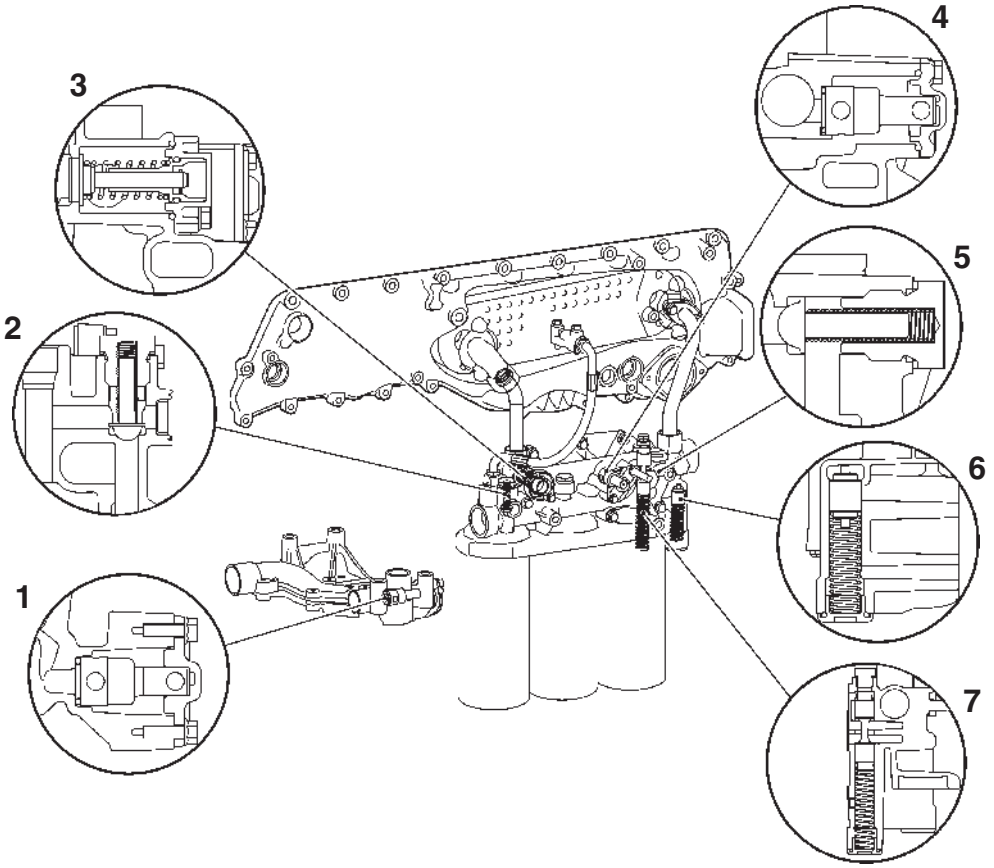
Oil for the piston cooling is filtered through the full-flow filters and is controlled by two spring loaded sleeve valves. Valve (1) senses the pressure to and from the piston cooling valve and is in direct connection with the filtered oil channel. Valve (2) is a control valve and gives a constant piston cooling pressure regardless of engine rpm.

The opening valve (1) is a spring loaded sleeve valve that opens and closes the oil flow. Opens at >2,5 bar (36,26 psi), closes at <2,5 bar (36,26 psi).

The pressure regulating valve (2) for piston cooling is a spring loaded sleeve valve. Oil enters through the lower chamber and passes the hole in the wall to the upper chamber. The pressure from the oil that is led upwards via the channel pushes the sleeve down. The sleeve waist controls the flow through the wall and thus piston cooling pressure, which is held constant.

The piston is cooled by oil using so called cavity cooling. The oil is sprayed vertically up in a channel in the piston via the piston cooling nozzle in the cylinder block. The oil then continues up to a circular channel in the top of the piston and is drained via a channel between the piston and the connecting rod.

Piston pin bushing lubrication is done via groves in the bushings.



1. Safety valve, oil pump

The safety valve opens when oil pressure is too high and the oil escapes back to the oil sump. The valves is a safety valve and is marked purple.

2. Bypass valve, turbo filter (bypass filter)

The bypass valve opens (>1,1 bar (15,95 psi)) if the filter becomes blocked and thus the turbo lubrication is assured.

3. Bypass valve, oil cooler

The valve leads the oil past the oil cooler when the engine oil is cold. The valve senses pressure and opens at high viscosity.

4. Oil pressure limiting valve (reduction valve)

The pressure limiting valve guides the oil pressure by opening at high pressure, allowing excess oil to flow back to the oil pan. The valve is a safety valve and is marked blue.

5. Bypass valve, full-flow filter

The valve opens if the filters become blocked and thus lubrication of the engine is assured.

6. Piston cooling valve

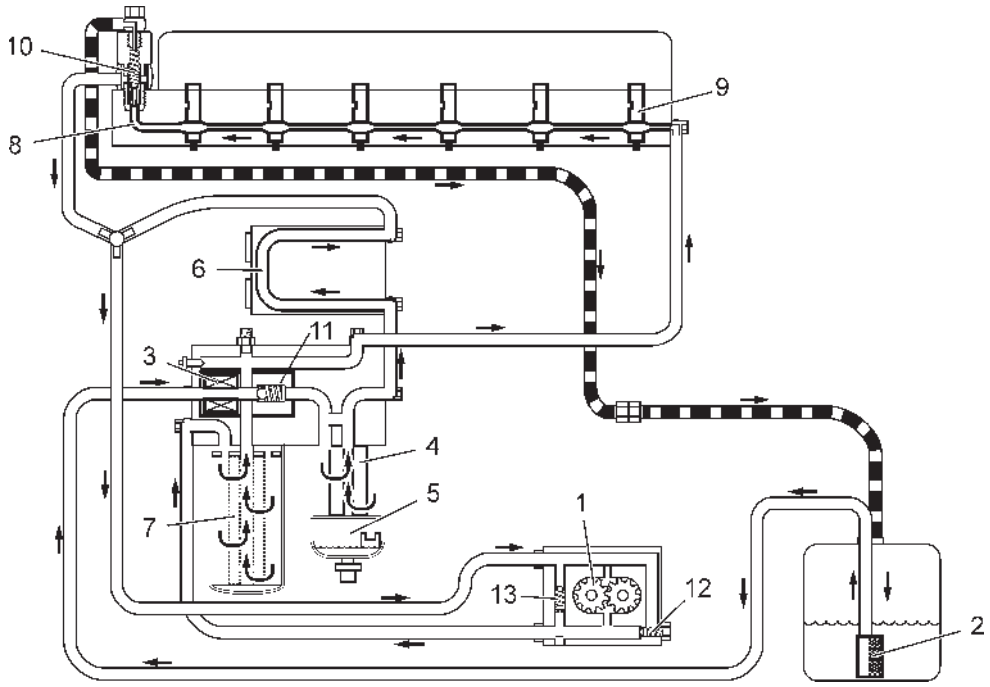
The piston cooling valve opens when engine revs have increased to slightly above idle.

Oil flows through the piston cooling duct to the six piston cooling nozzles. From these, oil sprays up towards the underside of the pistons.

The valve closes oil flow to the piston cooling when the oil pressure falls below 2.5 bar (36 psi).

7. Control valve, piston cooling

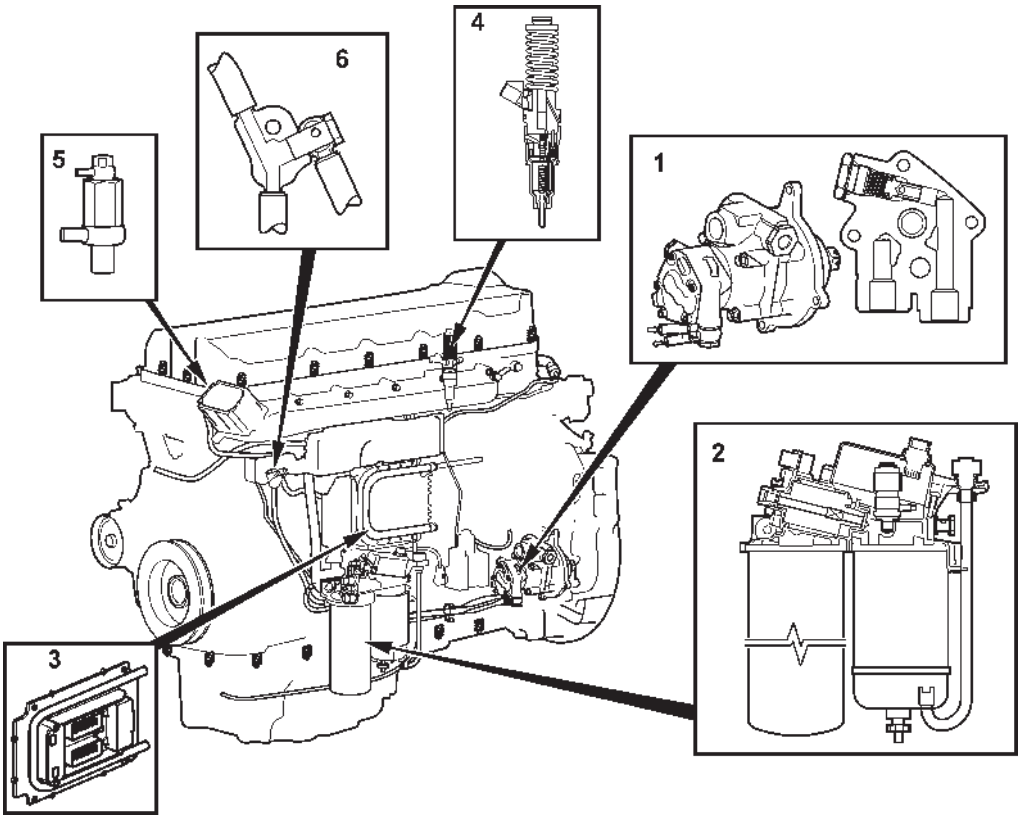
Group 23 Fuel system



Each cylinder has an electronically controlled unit injector that works with very high pressure. The pressure is created mechanically via the rocker arms from the overhead camshaft. The injection itself is electronically controlled from the control module.

The fuel feed pump (1) sucks the fuel through the strainer in the tank (2) and past the electric pump (3) in the fuel filter housing. After the electric pump, the fuel passes the prefilter/water trap (4/5) and from there to the cooling coil on the control module. Through the control module cooling coil (6) the fuel passes up to the manifold housing, where the fuel from the tank is mixed with return fuel from the cylinder head fuel channel and continues to the suction side of the feed pump. The feed pump pushes the fuel to the fuel filter housing, through the main filter (7), to the longitudinal cylinder head fuel channel (8). The fuel channel supplies each unit injector (9) with fuel via a ring-shape space around each unit injector. The bypass valve (10) guides the fuel pressure to the unit injectors. The check valve (11) in the electric pump ensures that the fuel does not flow back when the engine is shut off.

The feed pump has two valves; the safety valve (12) allows the fuel to flow back to the suction side when the pressure rises too high, such as when the fuel filter is clogged. The check valve (13) opens when the electric pump is used.



1. The gear type feed pump is driven by the crankshaft via an intermediate gear. High pressure is needed in order to ensure that the unit injectors are filled. The flow must be sufficient to even out any temperature differences in the cylinder head fuel channel.

2. The fuel filter housing features a built-in electric pump for venting the fuel system and draining water. A built-in check valve (2) in the pump prevents the fuel from flowing back when the engine is shut-down.

3. The control module is screwed to the engine with four vibration absorbing rubber blocks and is cooled by fuel through a cooling coil fastened on the outside of the control module, before the suction side of the feed pump.

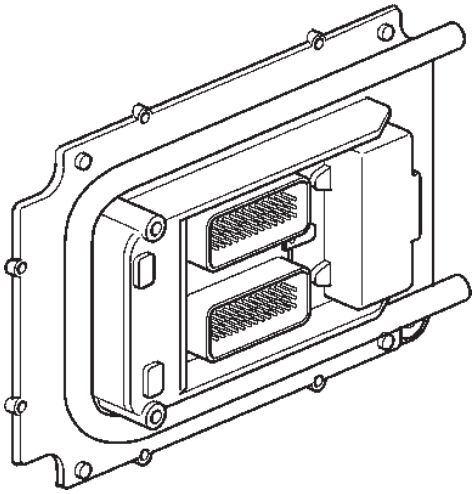
4. The unit injectors are a combination of injection pump and injectors that works with much higher pressure than an ordinary injector. The opening pressure is about 320 bar (4,600 psi). The working pressure can be up to 2000 bar (29,000 psi).

   Injection timing and the amount of fuel to be sprayed is determined by the control module, which signals electromagnetic fuel valves built into the unit injector. The force on the unit injector is transferred via the rocker arm from a ridge on the camshaft.

   The unit injectors are made and classified by tolerance. Each unit injector is marked with a code on the top side of the electric connection. When replacing, the new codes shall be programmed.

5. A hollow screw with an integrated bypass valve, which controls the feed pressure to the fuel system, is located in return line from the cylinder head. The opening pressure is 400-550 kPa (58-80 psi). The high feed pressure is needed to ensure that the unit injectors are filled. The bypass valve also has an integrated vent valve that automatically vents the system, allowing a small volume of fuel back to the tank.

6. Excess fuel from the bypass valve is mixed with fuel from the suction side in the manifold housing, and fed back to the feed pump.



Control module

The control module is the central part of the injection system. It receives information continuously from a number of sensors on the engine in order to determine fuel quantity and time for injection. Control signals are sent through electric wires to the unit injector fuel valves.

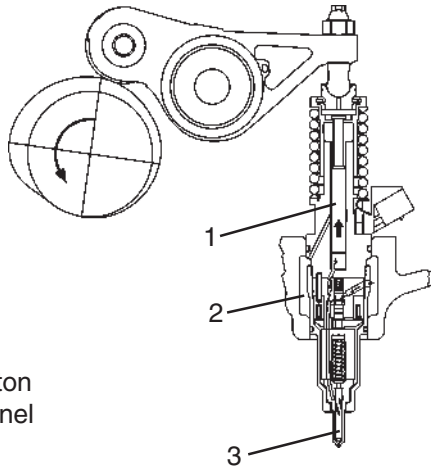
The control module stores any errors and deviations that occur in the system. Store occasional errors as well so you can trace them later.

Unit injector, work phases

The unit injector function can be divided into four phases;

- Filling phase
- Spill phase
- Injection phase
- Pressure reduction phase

The pump piston always pumps the same amount of fuel back and forth through the injector. It is only when the fuel valve is closed that the pressure builds up and injection takes place. The length and timing of the flow impulse determines the amount and timing of the spray, respectively.



1. Pump piston
2. Fuel channel
3. Nozzle

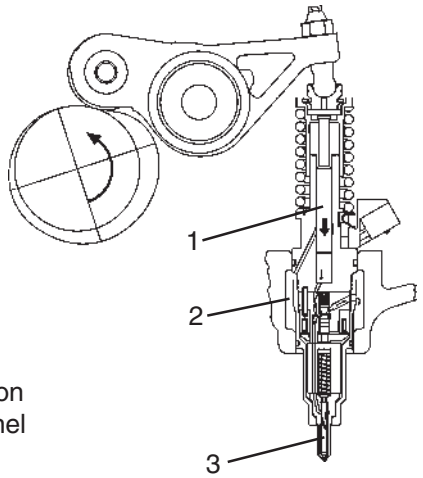
Filling phase

During the filling phase, the pump piston is on the way up to its top position.

The cam shaft ridge's highest point has passed and the rocker arm is on its way towards the camshaft basic circle.

The fuel valve is open since the solenoid valve has no voltage. Therefore, the fuel can be sucked from the fuel channel, past the fuel valve, and into the pump cylinder.

The filling continues until the pump piston has reached its top position.

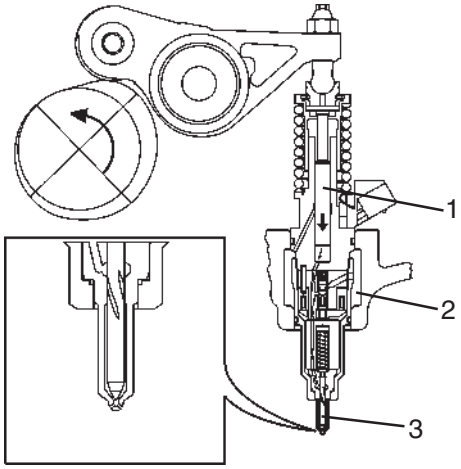


1. Pump piston
2. Fuel channel
3. Nozzle

Spill phase

The spill phase starts when the camshaft has turned to the position when the camshaft ridge starts pressing the pump piston down via the rocker arm. The fuel flows back through the fuel valve and out into the fuel channel.

The spill phase continues as long as the fuel valve is open.



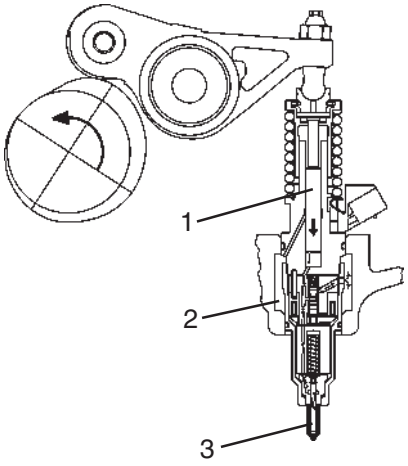
1. Pump piston
2. Fuel channel
3. Nozzle

Injection phase

The injection phase starts when the solenoid valve receives a voltage from the control module and the fuel valve closes.

The camshaft ridge continues to press the pump piston down via the rocker arm. Because the passage through the fuel valve is closed, pressure builds quickly. The pressure lifts the injector needle and injection takes place.

The injection phase continues as long as the fuel valve is closed.

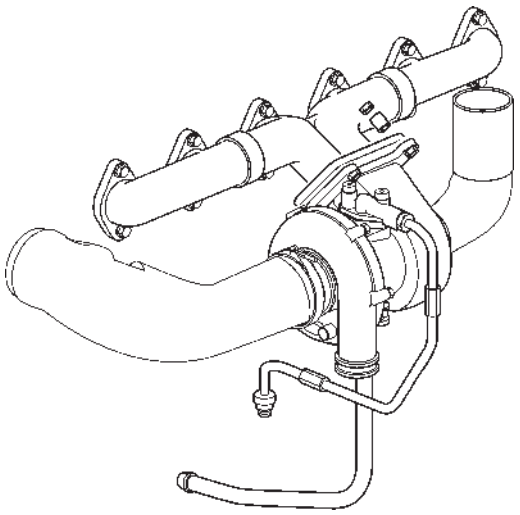


1. Pump piston
2. Fuel channel
3. Nozzle

Pressure reduction phase

The pressure reduction phase starts when the control module determines that the engine has received the volume fuel it needs and then breaks the current impulse to the solenoid valve. The fuel valve opens and the fuel again flows back out into the fuel channel. The pressure drops fast and the injector needle closes so that injection is interrupted.

Group 25 Intake and exhaust system



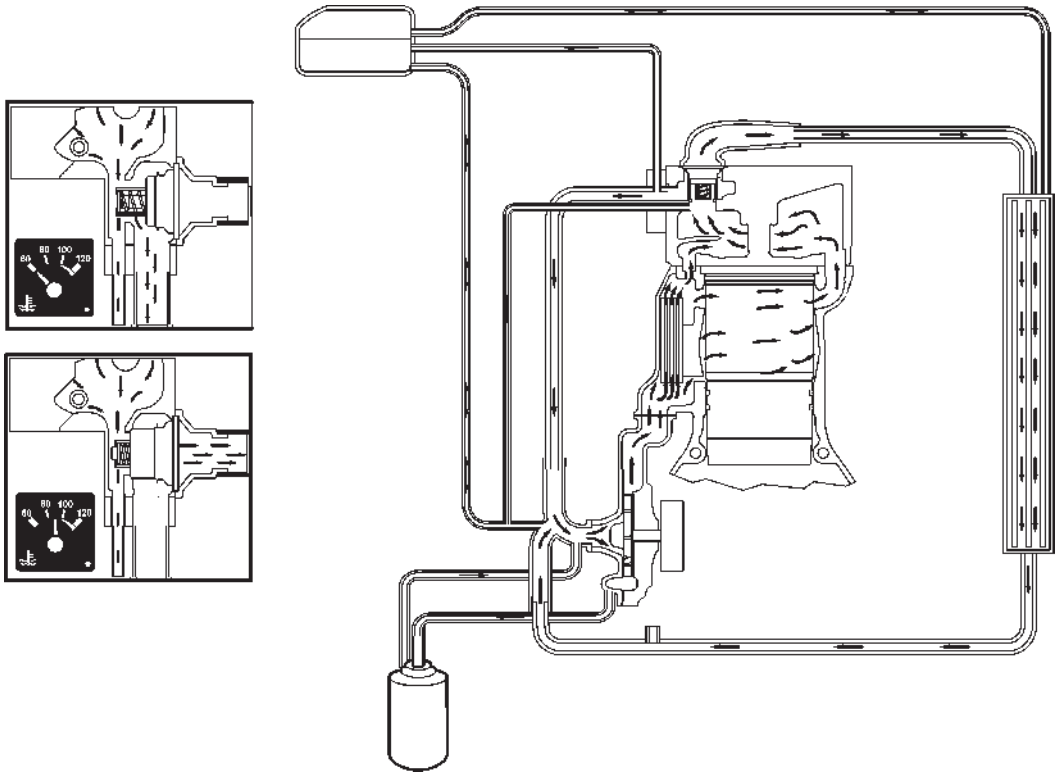
Turbocharger

The turbocharger is powered by the exhaust gases which pass through the compressor turbine housing on their way to the exhaust system.

The exhaust flow turns the turbine wheel and drives the compressor wheel which is installed on the same shaft. The compressor wheel spins in a housing which is connected between the air filter and the engine's inlet manifold.

As the compressor wheel rotates, air is sucked in from the air filter. Air is compressed and pressed into the engine cylinders after it first has been cooled while passing through the charge air cooler.

Group 26 Cooling system



The coolant is pumped directly into the engine by the coolant pump from the pump housing on the right-hand side of the cylinder block. The main part of the coolant is pressed between the oil cooler flanges while some part is pressed into the cylinder liner lower cooling jackets.

After the oil cooler, the coolant is distributed via calibrated holes to the cylinders' upper cooling jackets and to the cylinder head. The cylinder head receives return coolant from the cylinder liner cooling jackets as well. This part of the coolant enters the cylinder head via nozzles that direct the fluid stream towards the outlet channels and the injector sleeves.

The thermostat housing is placed in the front end of the cylinder head. When coolant is cold, the thermostat is closed and the coolant passes directly down through the thermostat housing to the coolant pump and back into the engine.

When the coolant is warm, the coolant is routed to the front outlet on the thermostat housing and to the upper inlet on the radiator. Coolant is pressed down through the radiator while it is cooled, and then flows back to the coolant pump lower inlet. The coolant pump then pushes the coolant into the engine.

When the coolant becomes warm it expands and the excess is pressed up to the expansion tank. Any air in the coolant will be removed.

The thermostat is a so called piston thermostat with piston, transducer, seal and housing in one unit. It starts opening at 85 °C (185 °F) and is fully open at 96°C (204.8 °F).

The coolant pump uses an impeller and is driven by a belt from the crankshaft. The impeller is made from hard plastic. The servo pump shaft is journalled with a maintenance-free, double ball bearing. The seal between pump wheel and bearing is assured by a unit seal. Between seal and bearing there is a space with a drain channel that ends in a drain hole under the servo pump shaft. If the seal leaks, it shows by coolant leaking out through the drain hole. If so, replace the entire pump as a spare part.

Troubleshooting / Test and adjustments

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.

⚠ **WARNING!** Read the safety instructions for handling and service in chapter ”Safety information” before starting work.

Symptoms and possible causes

☼The diagnostic indicator is blinking	See Workshop Manual ”(Group 23) EMS 2”
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
Engine runs roughly	10, 11
High fuel consumption	12, 13, 15, 25
Black exhaust smoke	12, 13
Blue or white exhaust smoke	14, 15, 22
Too low lubrication oil pressure	16
Excessive coolant temperature	17, 18, 19, 20
Too low coolant temperature	20
No, or poor charge	2, 23

1. Flat batteries
2. Poor contact/open circuit in cables
3. Main switch turned off
4. Cable harness box fuse broken
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. Clogged fuel fine filter or pre-filter (due to contamination, or paraffin precipitation in the fuel at low temperature)
10. Air in the fuel system
11. Water/contamination in fuel
12. Faulty unit injector
13. Insufficient air supply to the engine:
   – clogged air filter
   – air leakage between the turbo and the engine’s inlet pipe
   – dirty compressor in the turbocharger
   – faulty turbocharger
   – poor engine room ventilation
14. Excessive coolant temperature
15. Too low coolant temperature
16. Too low oil level
17. Coolant level too low
18. Air in the coolant system
19. Faulty circulation pump
20. Defective thermostat
21. Blocked intercooler
22. Too high oil level
23. Alternator drive belt slips
24. Water entry into engine
25. High back pressure in ex haust system
26. Break in “ Pot+ ” cable to control

Operational disturbances

For additional information and more troubleshooting help, see “Coolant temperature, troubleshooting”. In case of an operational disturbance, check the following points first:

- Check that the coolant level is within markings on the expansion tank (at about 20 °C (68 °F)). If the level is too low in the expansion tank, add coolant 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 blockage (deposits). A clogged cooling system is caused by one or more of the following factors:
- Coolant change has not been done as scheduled.
- Incorrect mix of coolant and water.
- Contaminated water has been used.

Clogging

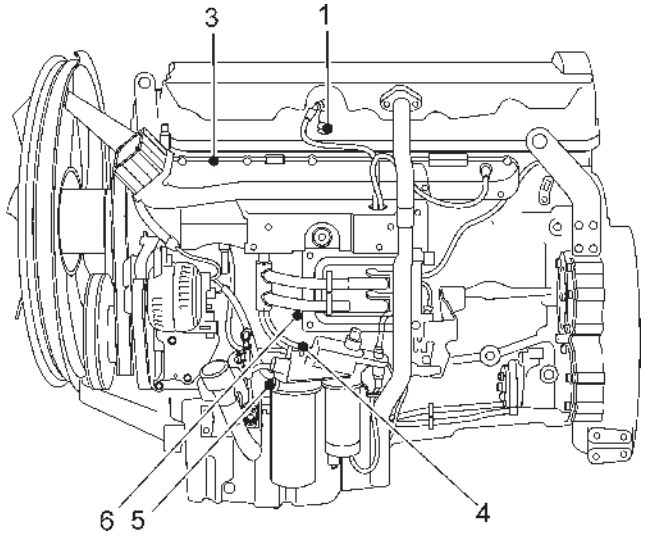
High coolant temperature is most often due to internal or external clogging of the cooling system or a combination of both. If the cooling system is clogged, it must be cleaned. See “Radiator, outside cleaning” and “Cooling system, flushing”

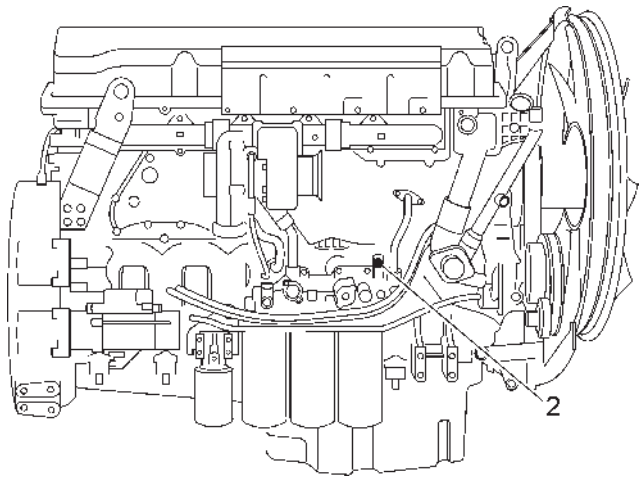
- **External dirt:** Check that the cooler and/or the charge air cooler are not clogged.

  Check for external or internal leakage in the cooling system.
- **Inner contamination:** Check that the cooler and/or the charge air cooler are not clogged.
- **External and internal leakage in the cooling system:** Check for leakage in the system.
- **Coolant circulation:** Check that the coolant circulates by allowing the engine to run at a high rpm. Check that the coolant circulates in the expansion tank too. This may be a clue if there is something wrong with the cooling system.
- **Thermostat:** Check the thermostat function. Drain enough coolant that the thermostat can be removed. Check the thermostat, see “Thermostat, testing”

Placement of instrument socket

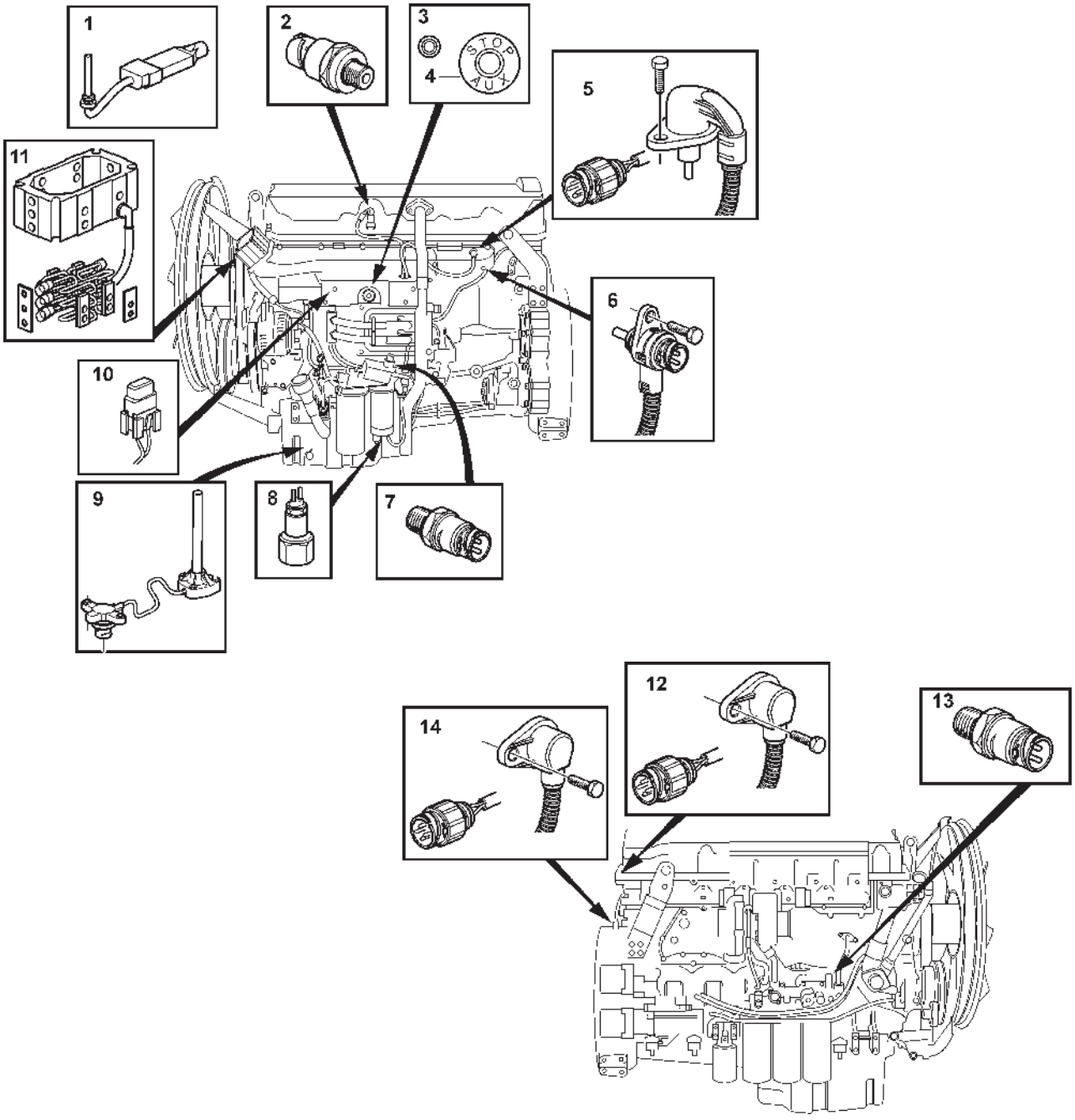
The figures below and on the next page show where instrument sockets may be placed on the engines.





1. Crankcase pressure
2. Oil pressure
3. Charge air pressure or charge / air temperature after charge air cooler.
4. Fuel feed pressure (before filter)
5. Fuel feed pressure (after filter)
6. Piston coolant oil pressure

Component location



1. Coolant level sensor, in the expansion tank
2. Crankcase pressure sensor
3. Fuel venting switch
4. Extra stop
5. Combined charge air pressure and charge air temperature sensor
6. Coolant temperature sensor
7. Fuel pressure
8. Water in fuel sensor

8b. Solenoid valve, drainage, water trap (optional), not shown in illustration

9. Oil level sensor
10. Main circuit breaker 10 A
11. Pre-heater with pre-heating relay
12. Camshaft position
13. Combined oil pressure and oil temperature sensor
14. Flywheel position and engine speed

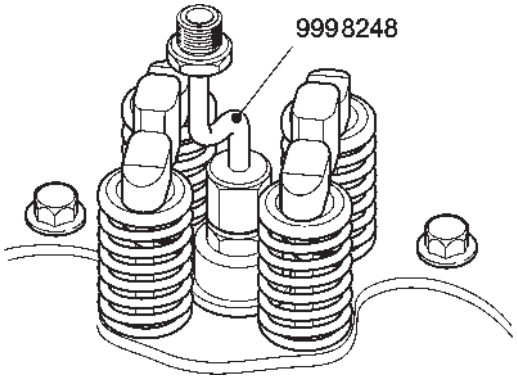
Tests and adjustments

Compression test

21002

The fuel system is emptied and the rocker arm shaft removed.

NOTE! Empty the fuel channel in the cylinder head, see “Draining, fuel channel cylinder head” in chapter “Reconditioning / replacing components”.

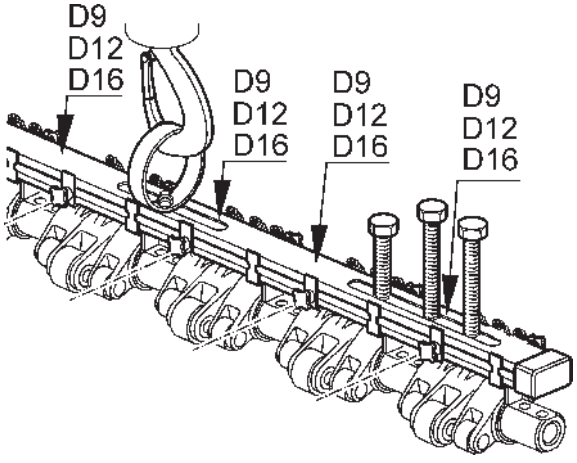


1. Remove the unit injectors and clean the copper sleeves as needed.

⚠ **IMPORTANT!** Make sure that the area around the unit injectors is clean before they are removed.

2. Fit all adapters, 9998248, to the cylinder head. (This in order to avoid repeating removal/refitting of rocker arm shaft and unit injector and performing valve adjustment.)

3. Oil the valve yokes, cam shaft ridges and the rocker arm shaft.



4. Fit the rocker arm shaft with lifting tool 9990185 (for TAD950-952VE also use 88880003).

NOTE! The marks on the tool indicates the fastening points for the rocker arm onto the engine.

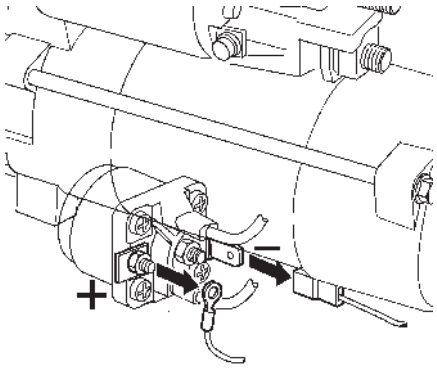
Torque the screws evenly along the rocker arm to avoid that the rocker arm bends or warps.

Make sure that guide pins fit in the camshaft support bearing.

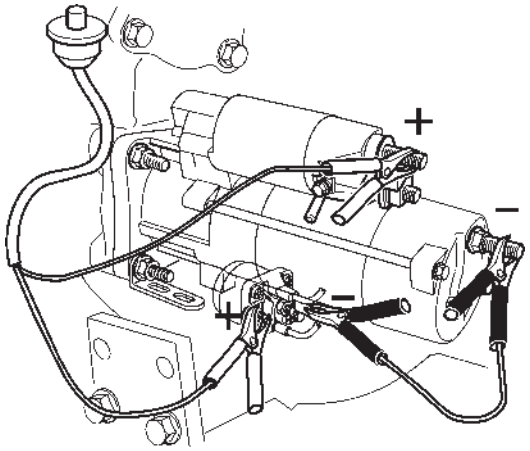
Torque the rocker arm shaft as specified in “Technical data”. Use torque wrench.

5. Install the distribution house and the oil pipe to the rocker arm shaft.

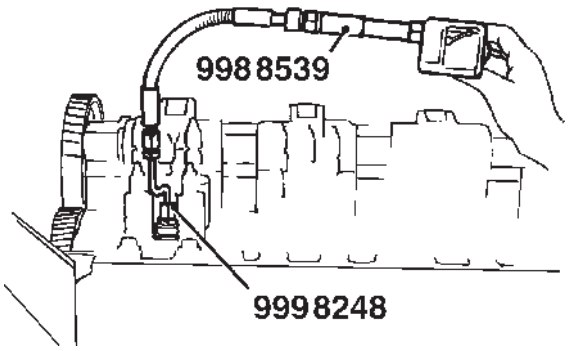
6. Check the valve clearance for all valves as specified.



7. Remove both control wires from the starter motor control connector (the two thin wires).
   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.



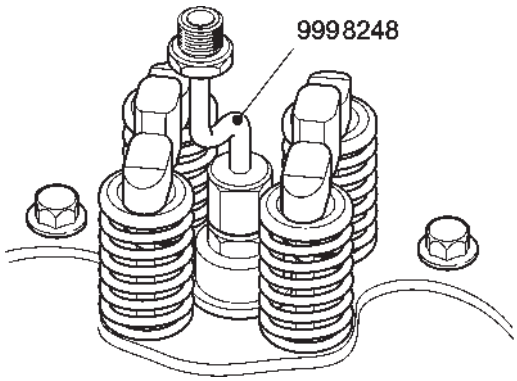
9. Connect compression meter 9988539 to adapter 9998248 on the first cylinder.

10. Run the engine with the starter motor until the compression meter needle has stopped (max compression reading) and read the value.
    Repeat the test on all cylinders.

NOTE: Do not run the engine for more than 15 sec. at a time with intervals of 60 seconds.

11. Remove the distribution house and the oil pipe to the rocker arm shaft.

12. Remove the rocker arm shaft screws equally in stages so that it is not bent.
    Remove the bolts and carefully lift off the rocker arm shaft using lifting tool 9990185.



13. Empty the fuel channel in the cylinder head, see “Draining, fuel channel cylinder head” in chapter “Reconditioning / replacing components”.

14. Remove adapters 9998248 from all cylinders.

15. Fit unit injectors, with new o-rings, see ”Unit injector, replacing”.

    Fit the rocker arm shaft.

    Adjust valves and unit injectors, see ”Valves and unit injectors, adjusting”

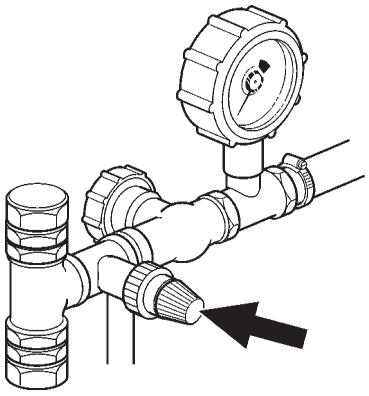
16. Vent the fuel system, refer to “Fuel System, bleeding”

Cooling system, pressure testing

Special tools:
Pressure testiong cap 9996441
Pressure testing device 9996662

⚠ **WARNING!** Open the pressure cap very carefully if the engine is hot. Steam or hot coolant could spray out.

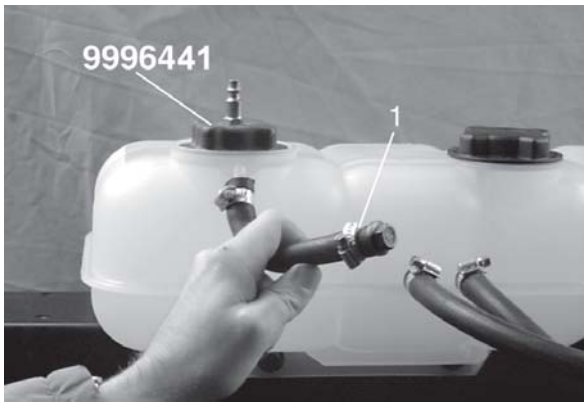
Check pressure testing device 9996662 before it is taken into service.



Alternative 1

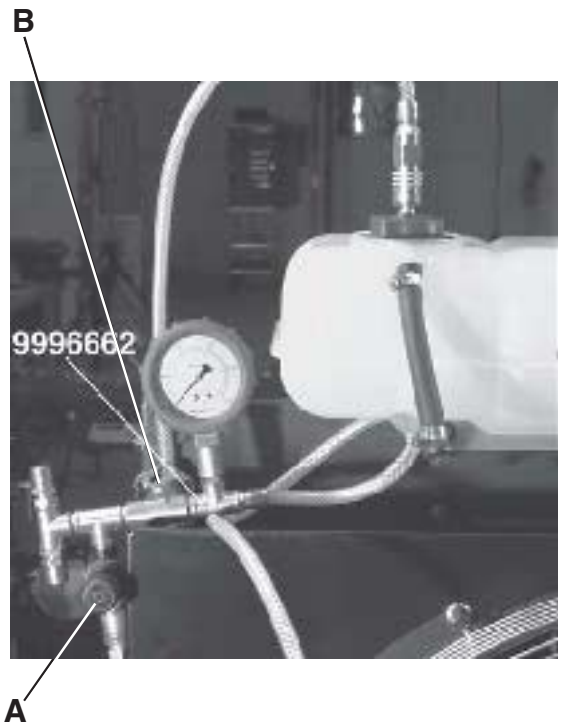
1. Check that all hoses and clamps are undamaged.

2. Check that the tap on the reduction valve is screwed out.



3. Unscrew the filler cap from the expansion tank and screw cap no. 9996441 on. Make sure that the evacuation pipe on the expansion tank is plugged (1).

   Connect the pressure test device to the nipple on the cover.



4. Connect the pressure test device to the compressed air system and open tap (B). Set reduction valve (A) so that a pressure of 0.7 bar is shown on the pressure gauge. Close tap (B).

5. The pressure must not fall for two minutes, for the cooling system to be regarded as being free from leakage.

NOTE! Repeat the pressure test if there is any doubt about whether the cooling system leaks or not.

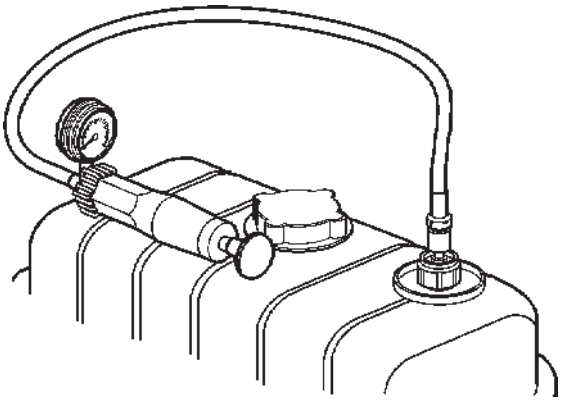
6. Shut the compressed air off after pressure testing. Eliminate excess pressure in the system by unscrewing the valve on the reduction valve and open tap (B).

7. Remove the pressure testing device.
   Remove the plug from the evacuation pipe.

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

9. Start the engine and check carefully that no leakage occurs.

Alternative 2



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 by a suitable tool from kit no. 885531.

4. Pump up a pressure of 0.7 bar.

5. The pressure must not fall during a two minute test, for the cooling system to be regarded as being free from leakage.

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

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

8. Start the engine and check carefully that no leakage occurs.

Boost pressure, troubleshooting

25502

Boost pressure, check

Special tools:

Connecting nipple 9996666
Hose 9998493
Pressure gauge 9998339

1. Connect the nipple with hose and pressure gauge to the measurement outlet on the inlet manifold , see "Location of measurement outlet".

2. Compare the pressure with the value that can be read off from the VODIA tool, see "Workshop manual, EMS 2"
   If the two values differ, the pressure sensor is faulty and must be replaced.

Pressure drop indicator, checking

1. Check that the air filter is clean and that there are no obstructions for the intake air.

2. Remove the pressure drop indicator from the air filter housing

3. Check the pressure drop indicator by sucking air until the dial indicator shows red. Reset the fuse by pressing the yellow top.

4. When the air filter is clogged, for example, and vacuum is created, the pressure drop indicator shows red. Replace dial indicator if it does not work as in point 3, above.

5. Install the pressure drop indicator on the air filter housing

Exhaust system, checking

1. Check that the exhaust system is Penta original.

2. Check if exhaust system has been rebuilt, is bent or has damage that prevents the exhaust from getting out.
   If the exhaust system is not a Penta original, has been rebuilt or damaged, the exhaust back pressure may be too high, which leads to less engine output.

3. If you suspect that the exhaust back pressure is too high the pressure should be checked, see “Exhaust back pressure, measurement

Charge air cooler, checking

1. Check the charge air cooler for damaged cells or connections.
   If it is damaged, replace the charge air cooler.

2. Check the charge air cooler and radiator for external clogging.
   In case of clogging, clean per “Radiator, outside cleaning”.

Inlet pipe, checking

1. Check that the intake manifolds are clean and undamaged inside. Squeezed, damaged or dirty inlet pipes may cause the boost pressure to become lower.

Air intake pipe, checking

1. Check the charge air pipes for visible cracks and external damage.

2. Check for oil in charge air pipes. If the pipes has damage or leakage in sealing rings at connections, the boost pressure will be too low and the engine's output deteriorates.
   If the pipes are contaminated by oil inside, this points to oil leakage at the turbo's turbine shaft seal. In that case, replace the turbo complete.

NOTE: 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 should be very thoroughly cleaned inside, before the engine is started.

Turbo, checking

25507

1. Check that the turbo unit item number is matches the engine version. The wrong turbo unit for the engine version may provide charging pressure that is too low and thus reduce the engine's output.

2. Check that turbo unit has the correct compressor housing. If the wrong compressor housing is installed on the turbo, the compressor wheel may have been damaged or have too big clearance between wheel and housing. In both cases the boost pressure becomes too low.

3. Remove the intake manifold from the turbocharger.

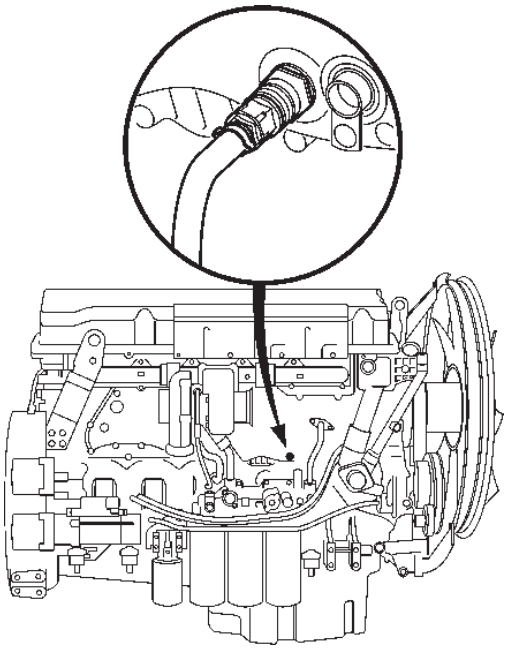
4. Check the turbo for damage on compressor wheel and for big axial play on the turbine wheel shaft.

5. In case of damage to compressor wheel and excessive axial play, the turbo should be replaced complete.

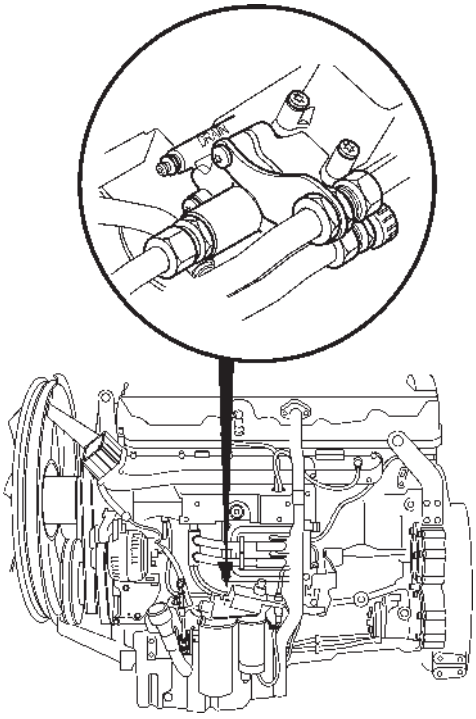
6. Remove exhaust pipe (muffler) from the turbo and check the turbine wheel.

7. Check the turbine wheel for damage. If the turbine wheel has been damaged, replace the entire turbo.

Exposing engine



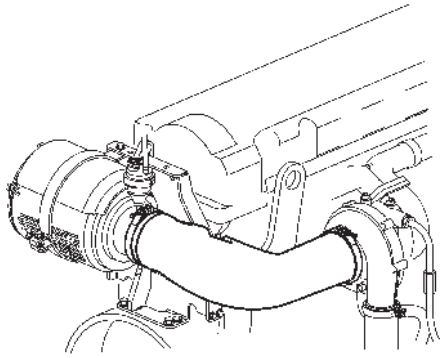
1. Drain the coolant, see ”Cooling system, draining”
   Drain engine oil.



2. Clean around the drain plug for the fuel filter housing. Connect a hose and drain the fuel in a suitable container.
   Loosen the connections on the fuel pump and the water drainage

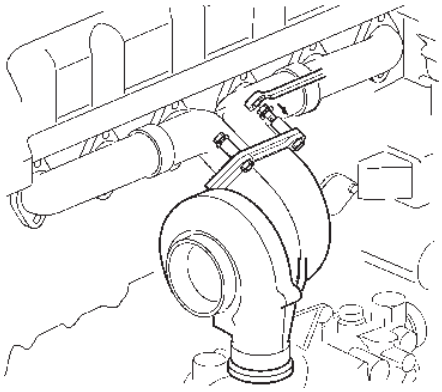
3. Remove the hoses from the radiator and the expansion tank. Remove shield on the right-hand side of engine, if any.

4. Remove heat shield above the turbo, if any.



5. Remove the pipe between the air filter and the turbo. Cover all openings.

   If the filter housing is installed on the engine, remove it and its brackets.



6. Remove muffler and brackets, if any.

   Remove the turbo from the exhaust pipe and the two oil pipes.

   Cover the turbo outlet opening.

7. Remove the crankcase ventilation pipe and extra oil separator, if any.

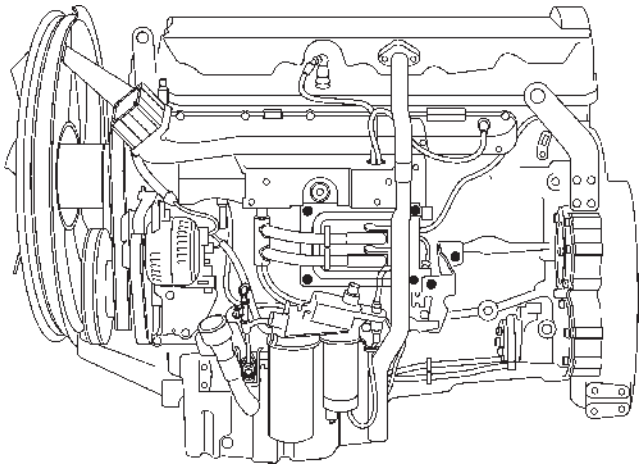
8. Remove the pipe between the charge air cooler and the intake manifold. Cover all openings.

9. Remove safety cover above alternator, if any.

10. Remove the radiator fan safety cover or screen and its brackets towards the cylinder head.

    Remove the drive belts.

Fixture fitting



1. Remove cable harness and fuel lines to the control module. Cover all openings.
   Remove the control module.

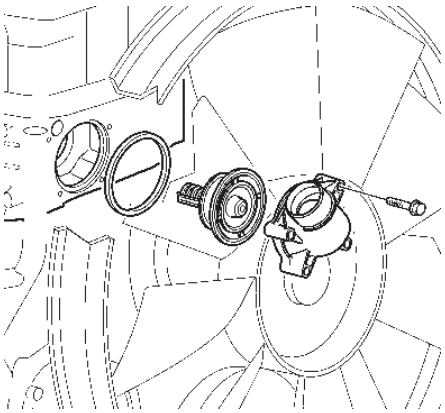
2. Remove fuel and electrical connections. Lift the fuel filter bracket together with the filters.
   Cover all fuel connections.

3. Install fixture 9990109 with 6 screws.

Engine body, general overhaul

Cylinder head, removal

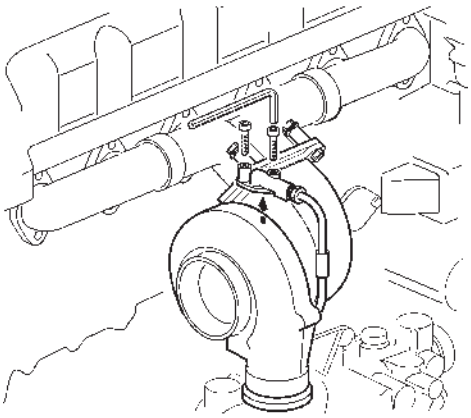
The engine exposed, coolant and fuel drained.



1. Remove the coolant pipes on the right front side of the engine.

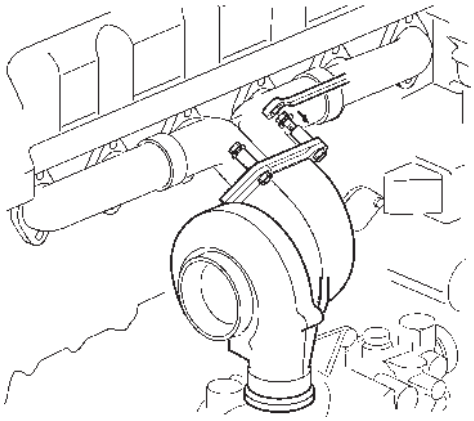
2. Remove the thermostat housing and the front lifting eye.

3. Remove the rear lifting eye, if it is secured to the cylinder head.
   Remove the heat shields.

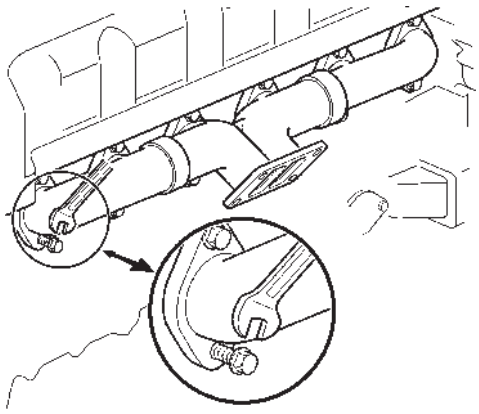


4. Remove the heat shields above the turbo, if this was not done when the engine was exposed.

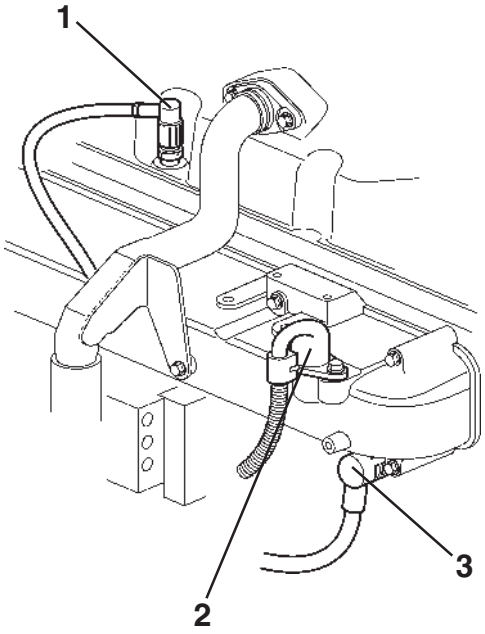
5. Remove the oil pipes between the turbo and the oil filter bracket and the engine block, respectively.
   Cover all openings.



6. Cover the turbo exhaust port and remove the turbo.



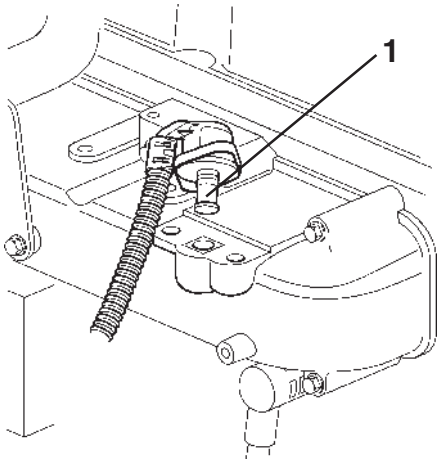
7. Remove the exhaust manifold.



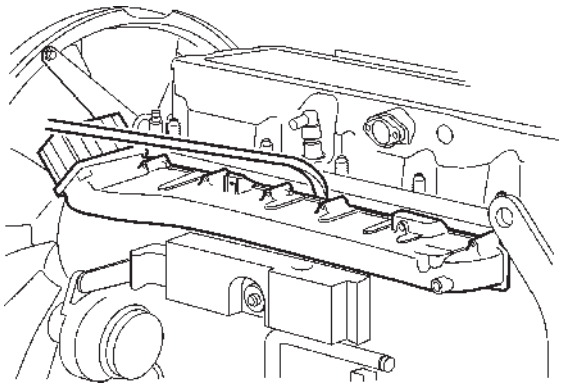
8. Disconnect the contact from sensor in the valve cover (1) and remove its cable harness from the holders in the valve cover.

9. Remove charge air pressure sensor (2) and tape intake manifold opening.

10. Remove the coolant sensor (3).



11. Protect the charge air pressure sensor by placing a protective sleeve, or place a clean plastic bag over the sensor and close the bag's opening around the cable harness.



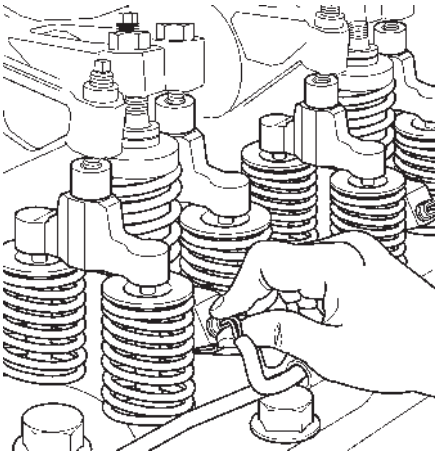
12. Remove fuel line clamps from the intake manifold.

13. Remove the fuel lines from the cylinder head at the front and rear edges.

    Place protection plugs in the holes and cover the hose ends so that they are well protected, to prevent dirt from entering the fuel system.

14. The intake manifold must be removed if you are going to use fixture for cylinder head, 9990160. Remove all screws and remove the intake manifold using crowbar 9998511 against the reinforcement bosses.

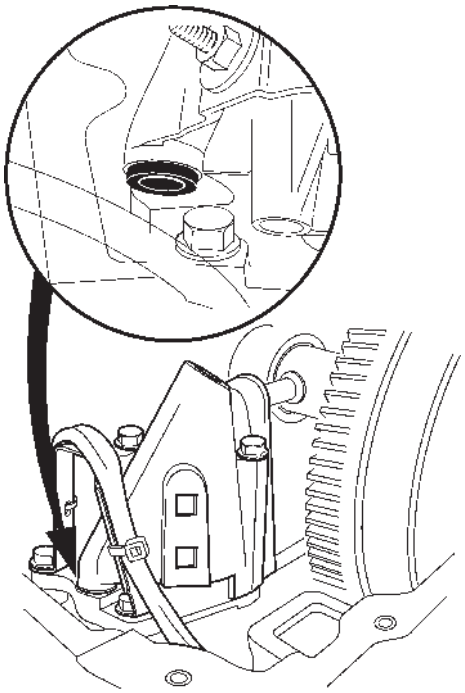
NOTE: The intake manifold may be hard to remove due to sealant.



15. Remove valve cover and crankcase ventilation.

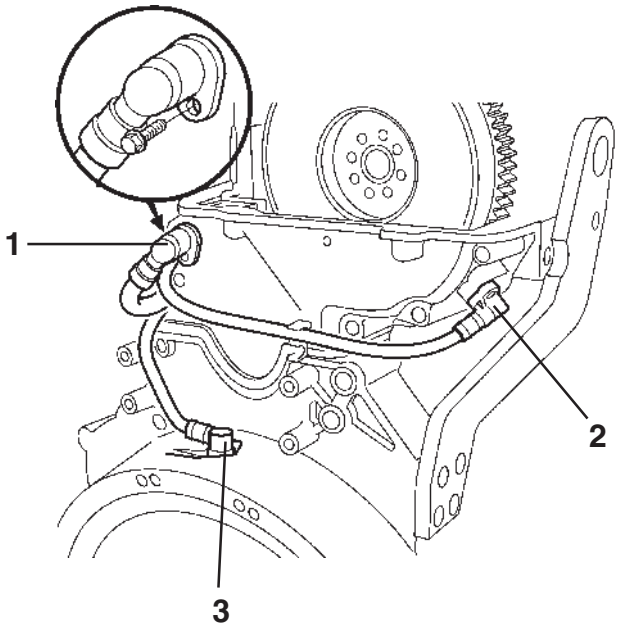
16. Clean around the unit injectors and remove the contacts for the unit injectors. Remove cable holders together with cable harness.

    Cut off cable ties and remove the cable harness from the cable holder.



17. Remove the distribution house for lubrication of the rocker arm shaft (for TAD950-952VE the EGR control valve), together with the delivery pipe.

NOTE: Be careful that the seal under the distribution house does not fall into the transmission gear casing!

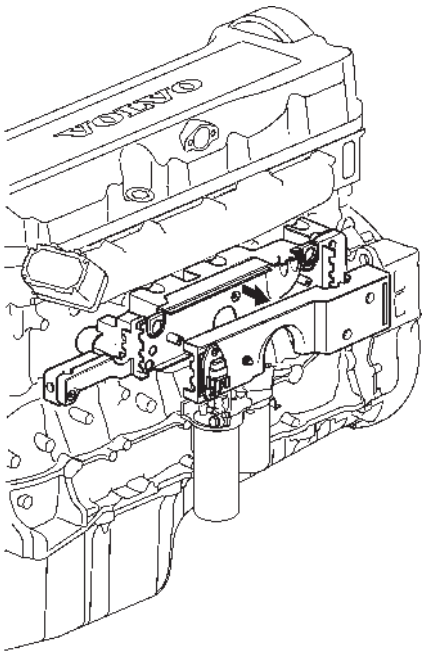


18. Remove the screw for the cable bushing (1) and carefully pull out the cable harness through the cylinder head.

⚠ **IMPORTANT!** Loosen the screw, **not** the cable bushing.

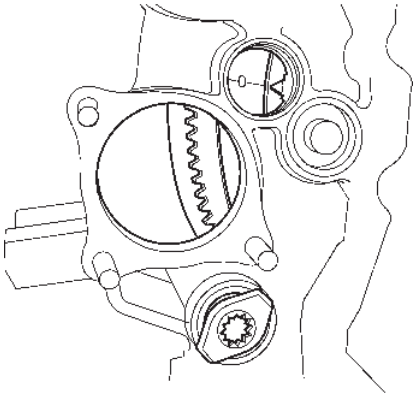
19. Remove camshaft sensor (2) and save any shims.

    If you are going to remove the flywheel casing, remove the flywheel sensor (3) as well. Mark sensors and placement of any shims.

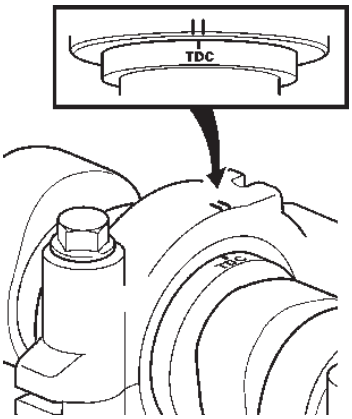


20. Remove the the cover on the electrical box and remove the box's retaining screws.

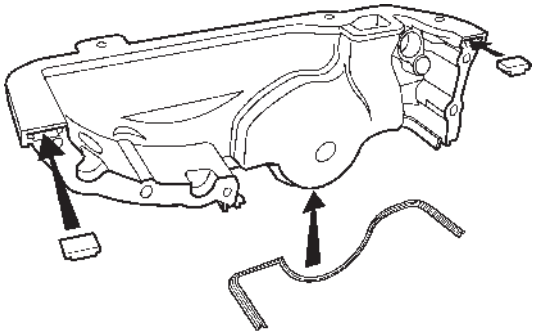
    Remove the extension part and the box together with the cable harness.



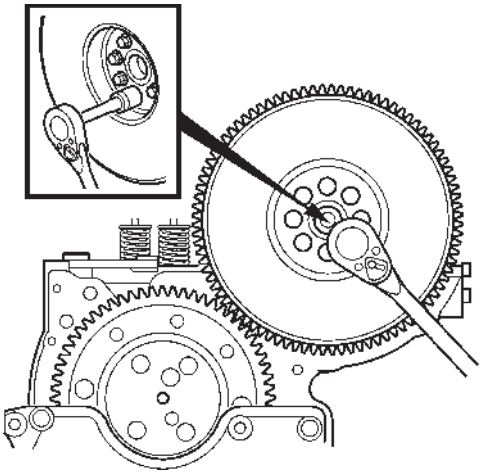
21. Remove the cover plugs in the flywheel casing and attach turning tool 9993590.



22. Turn the engine to TDC on the camshaft, check that the mark on the flywheel is at ”0”.

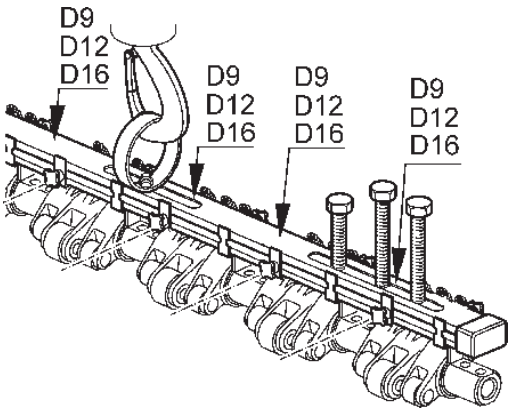


23. Remove the upper transmission gear casing and remove the rubber seals.



24. Remove the camshaft drive together with the vibration damper.

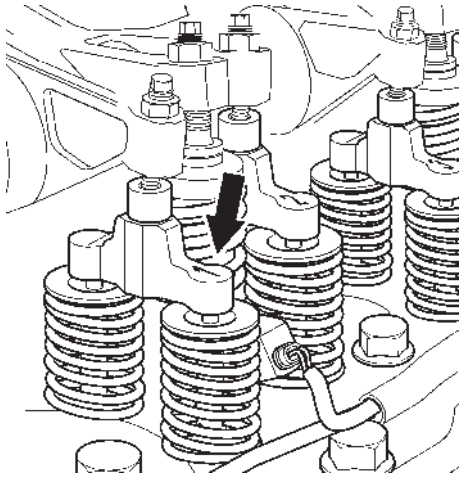
NOTE: The vibration damper is very sensitive to shocks.



25. Remove the rocker arm shaft screws evenly to avoid uneven load.

26. Lift the rocker arm shaft using lifting tool 9990185 (for TAD950-952VE also use 88880003).

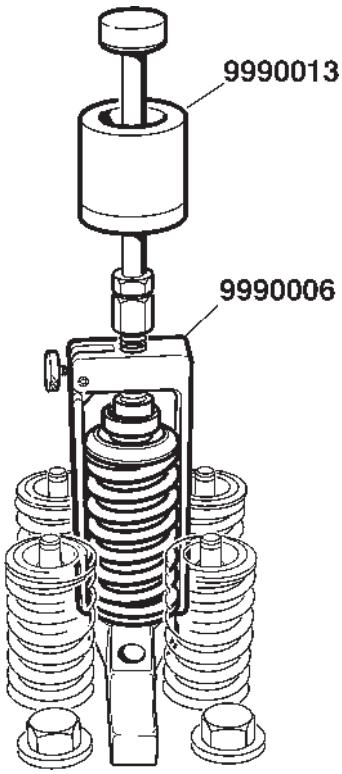
NOTE! The marks on the tool indicates the fastening points for the rocker arm onto the engine.



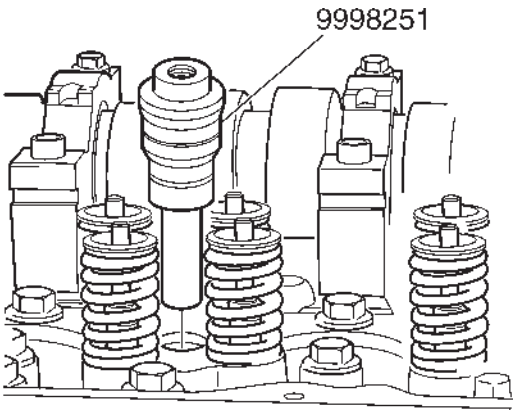
27. Mark and remove the floating valve yokes.

28. Clean around the unit injectors and unscrew the screws for the injector retainers.

    Remove the unit injectors, one at a time.

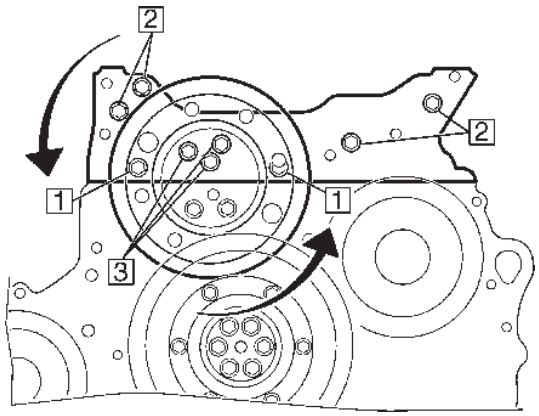


29. Pull up the injector using puller 9990006 and slide hammer 9990013.

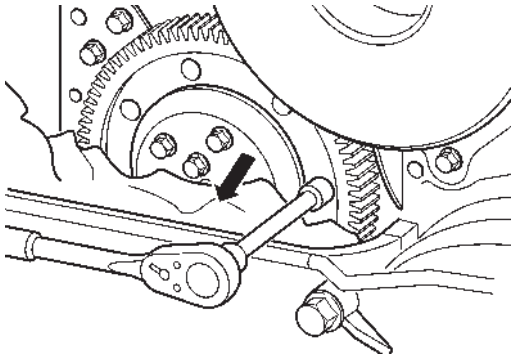


30. Place protection plugs 9998251 in the cylinder head immediately after removal.
Mark the unit injectors and place protective sleeve 9998249 on the injector.

NOTE: Check that the tools are clean.



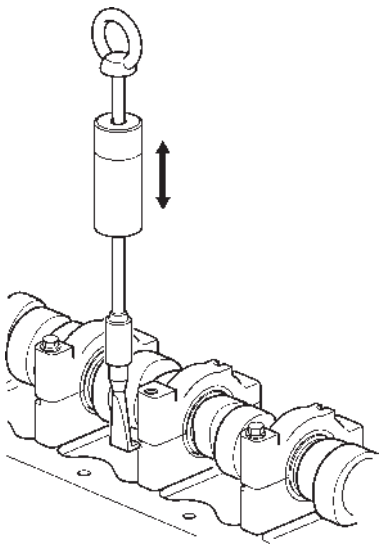
31. Turn the engine so that the two the screws (1) can be reached through the transmission wheel.



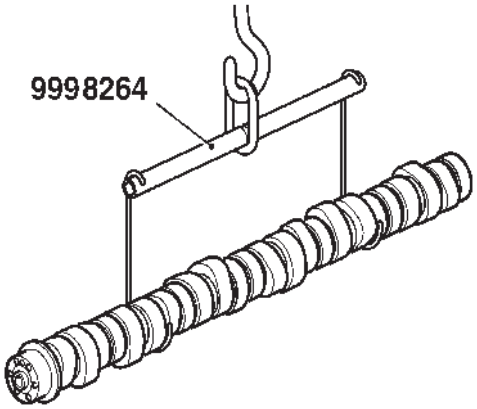
32. Place a rag in front of the drive to prevent screws from falling into the transmission housing.

NOTE: When the engine is turned, the rag must be removed.

33. Remove the remaining four screws (2).
Remove the three upper screws (3) from the transmission wheel hub.



34. Remove the camshaft cap using tools 885341 and 9996400.

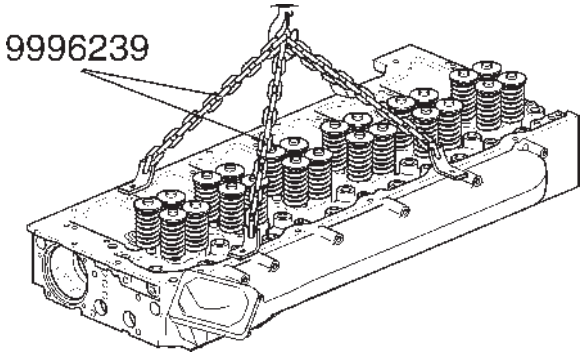


35. Lift the camshaft carefully using tool 9998264.

36. Remove bearing blocks by carefully tapping them with a plastic hammer.

    Remove the bearing blocks with the lower bearing halves and put them in the right order together with their respective camshaft bearing caps, upper bearing halves and screws.

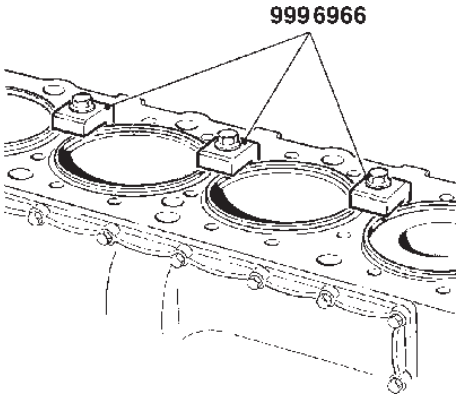
NOTE: The camshaft bearing blocks are held by guide pins marked 1-7.



37. Remove cylinder head screws in the revers sequence as specified in Technical data.

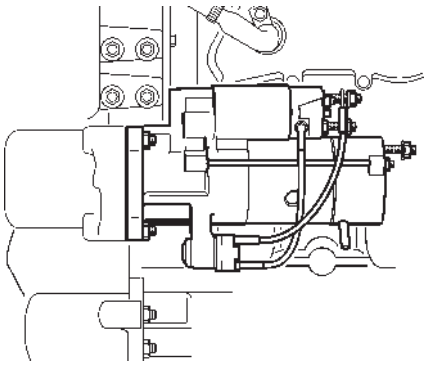
    Use two lifting chains 9996239 to carefully lift the cylinder head away.

NOTE: Place washers between the cylinder head and lifting chains to protect the cylinder head sealing surface.

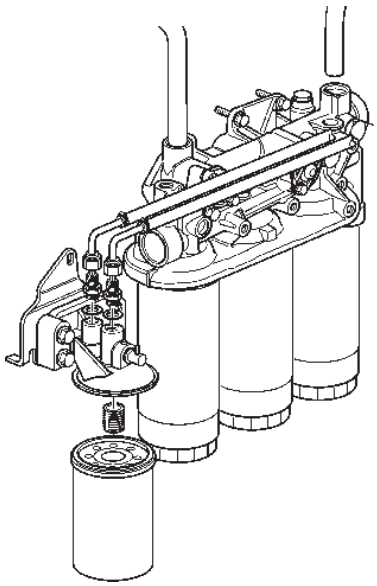


38. Remove the cylinder head gasket and clean contact surface on the cylinder block thoroughly.

NOTE: Secure all cylinder liners using tool 9996966.



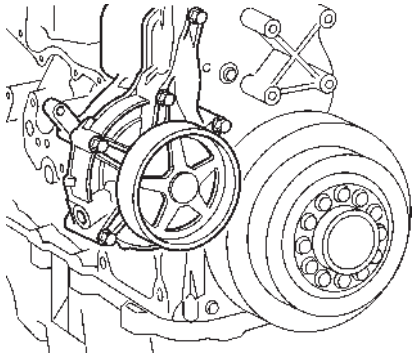
39. Remove the starter motor.



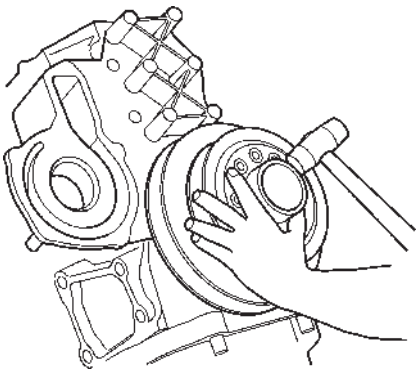
40. Remove the coolant filter with bracket and the fuel lines to the coolant housing behind the coolant pump.

41. Remove the front pipe between filter bracket and oil cooler.

    Remove oil filter bracket and the rear pipe complete together with the oil filters.



42. Remove coolant pump together with the coolant housing and bracket.

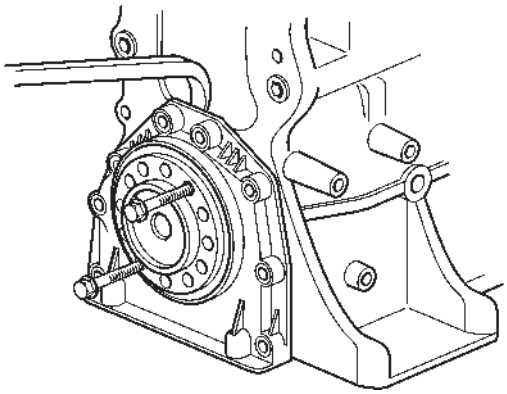


43. Turn the engine up 45°, if it is installed in the stand.

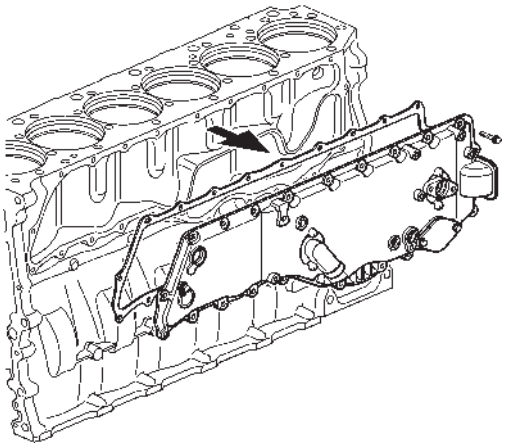
    Remove the screws for belt pulley/vibration damper. Carefully tap and rock the hub and belt pulley to get them loose.

NOTE: Do not disconnect between belt pulley and vibration damper.

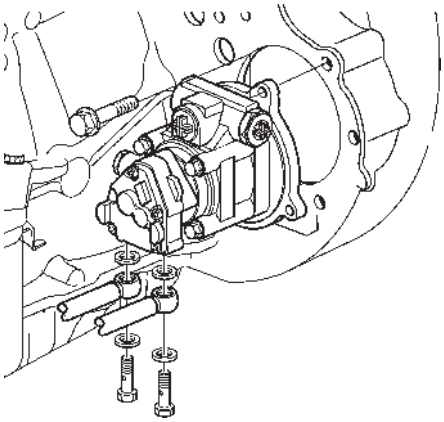
    Lift the vibration damper.



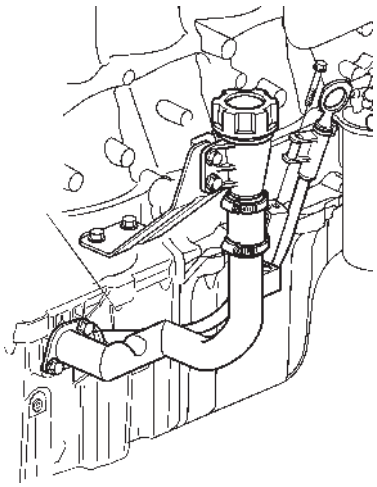
44. Remove the casing for the front crankshaft seal with a crowbar at the reinforcement shown.



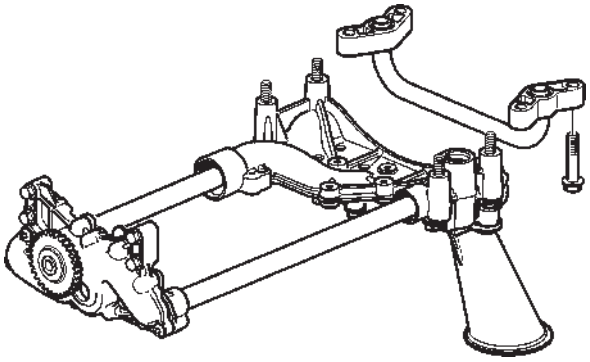
45. Remove the oil cooler casing together with the oil cooler.



46. Remove fuel pump and servo pump complete.



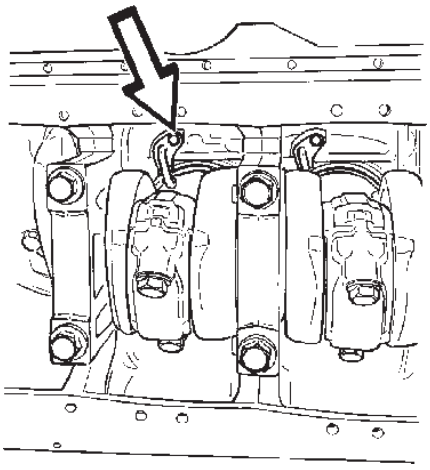
47. Remove engine mounts, oil filler pipe and dipstick.



48. Remove the oil level sensor terminal and remove the oil pan.

49. Remove the connecting pipe and the oil strainer complete with bypass valve and pipe connections.

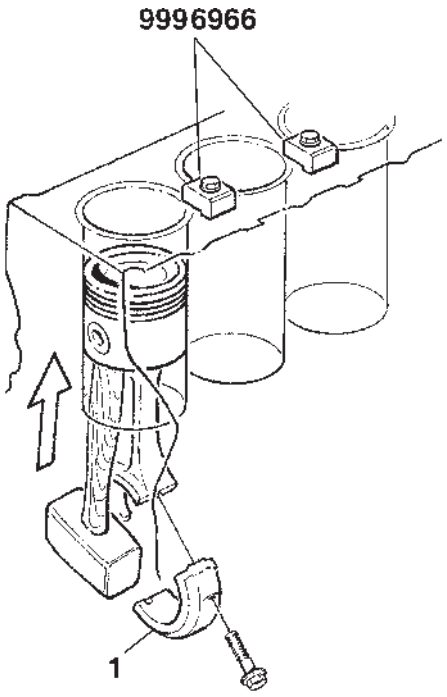
50. Remove bracing frame.



Pistons, removal

51. Remove the piston cooling nozzle. Turn the engine using tool 9993590 so that all become accessible, two at a time.

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



52. Remove main bearing cap and bearing shells, write down the marks.

53. Turn the engine 90° if it is installed in assembly stand 9986485.

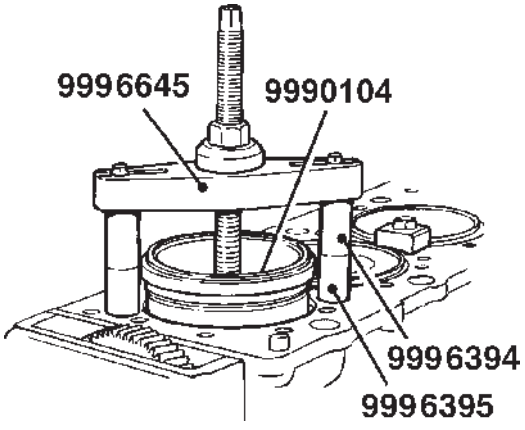
54. Press the piston so far out that the piston rings are outside the edge of the cylinder liner. (Use the handle of a hammer or another object made of wood.)

    Lift out the piston and the connecting rod.

⚠ **IMPORTANT!** Mount the main bearing cap on the connecting rod to prevent damages, the surfaces are very sensitive.

55. Remove the circlip from the piston and press out the piston pin. Disassemble connecting rod and piston.

56. (Mark the connecting rod and piston, if they are to be installed in the same cylinder at assembly.)



57. Mark the cylinder liner position in the block before it is removed to facilitate correct placement if reinstalled.

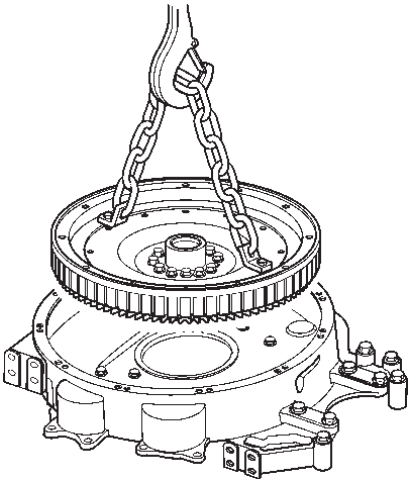
58. Install puller plate 9990104, and support 9996394, on the puller 9996545.

59. Move plate down through the cylinder and place it in correct position under the cylinder liner.

    Pull the impeller off of the pump shaft with the puller. Extend the support legs with 9996395 as needed.

60. Remove the cylinder liner sealing rings.

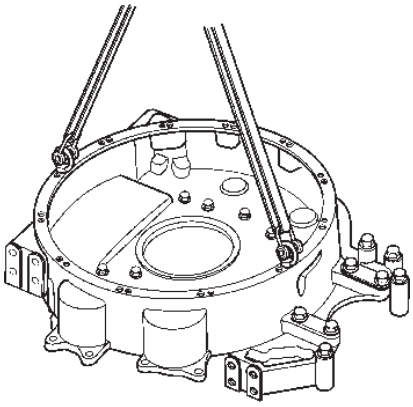
Transmission, removal



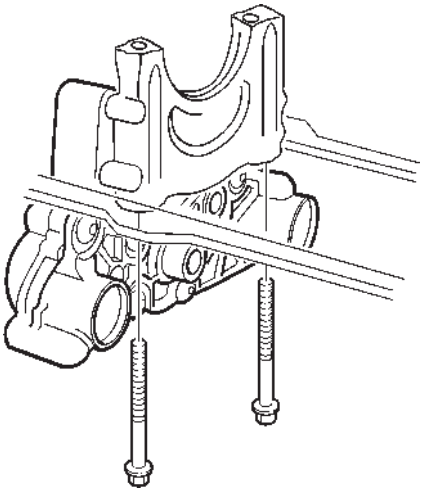
61. Remove the flywheel sensor, if not already done.

62. Secure lifting chain 9996239 in the flywheel with two screws.
    Remove the flywheel.

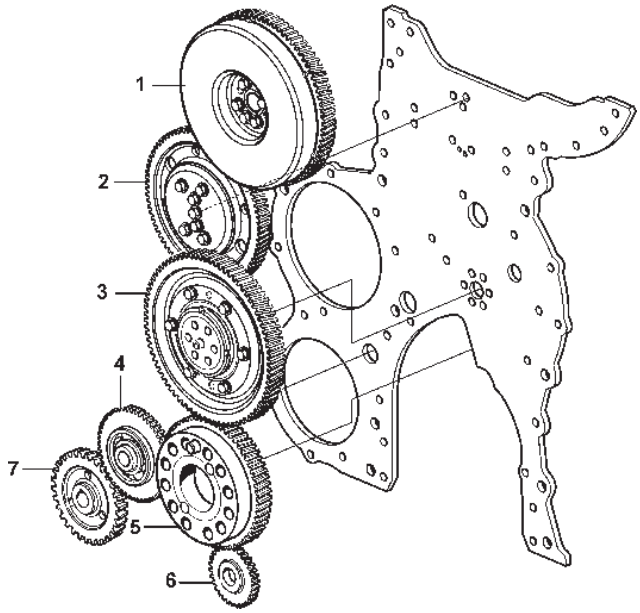
⚠ **WARNING!** Pinching hazard. The flywheel weighs about 40 kg (90 lbs).



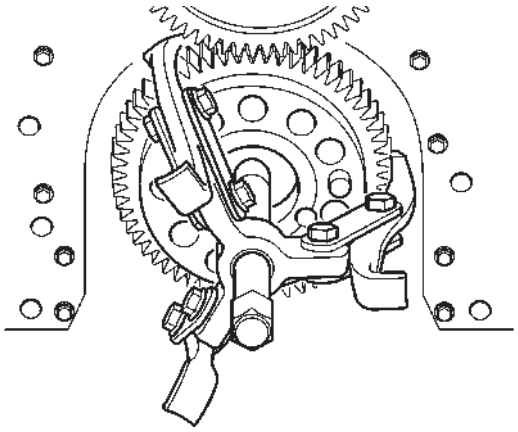
63. Remove the screws in the flywheel casing and remove the flywheel casing using lifting eyes and lifting straps.



64. Remove the lubricating oil pump and the rear main bearing cap. Use puller 9990114 together with slide hammer 9996400, see ”Main bearings, replacing”



1. camshaft drive
2. upper intermediate gear
3. dual drive
4. lower intermediate gear
5. crankshaft drive
6. oil pump drive wheel
7. drive wheel for fuel feed pump / servo pump



65. Remove the lower intermediate gear (4).

66. Remove the two socket head cap screws on the crankshaft drive (5) and remove the drive using a puller.

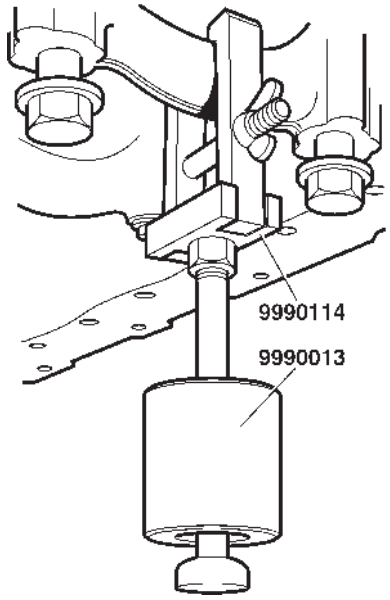
NOTE: To protect the puller thread, place a thick washer between the piston ring tool and the crankshaft.

67. Remove the six socket head cap screws in the hub of the double drive (3) and remove it complete.

68. Remove the upper intermediate gear (2).

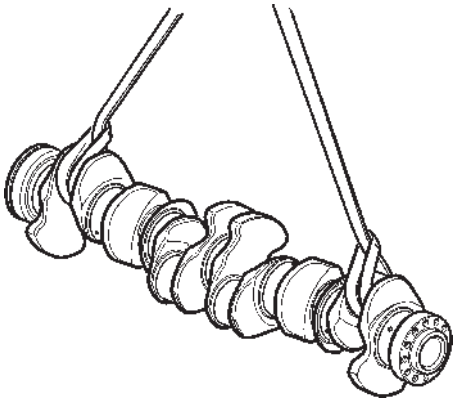
NOTE: Save the spacer plate behind the drive and write down how it is installed.

69. Remove the transmission plate and clean both sides.



Crankshaft, removal

70. Remove the bearing caps. (Rear thrust bearing caps have been removed together with the oil pump.)



71. Carefully lift out the crankshaft.

NOTE: The crankshaft weighs about 80 kg (180 lbs).

72. Before engine block is washed, plugs, screw and remaining brackets should be removed.

73. Clean contact surfaces on parts to be reinstalled.

Crankshaft, refitting

74. Inspect the crankshaft, see ”Crankshaft, inspection”

75. Check the oil channels of crankshaft and its contact surfaces with the bearing shells, cylinder block and caps.

76. Install new main bearing shells.

77. Put the bearing shells in their respective positions in the cylinder block and caps. Make sure that the bearing shells and caps are undamaged.

NOTE: Make sure that the upper bearing shells to be installed into the cylinder block are equipped with oil holes.

78. Smear the bearing pins and bearing shells with engine oil and carefully lift the crankshaft into position.

79. Install the thrust washers for the center main bearing, the axial bearing. The thrust washers can only be placed in one position.

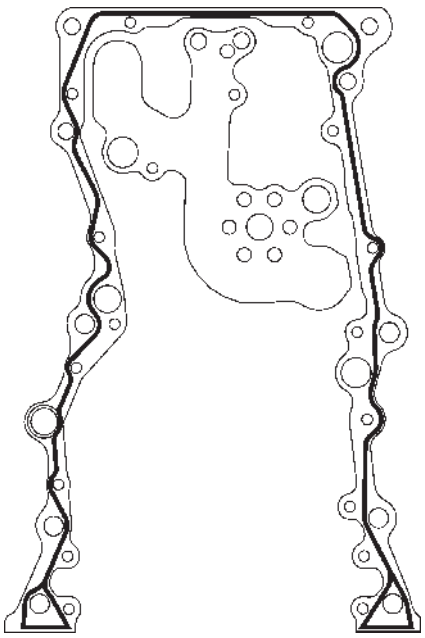
80. Install the main bearing caps with the lower bearing shells. The bearing caps are asymmetric and can only be installed in one position. The middle bearing cap (at the thrust bearing) incorporates a recess which must be turned to fit over the guide studs.

NOTE: Write down the bearing cap markings. 1-7.

81. Oil the main bearing bolts. Allow excess oil to run off before installation.

    Torque as specified in Technical data.

82. Install the front casing at the belt pulley with a new seal.



Transmission, fitting

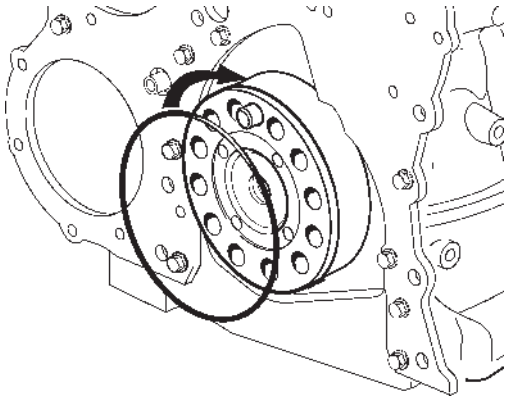
NOTE: Lubricate the inside of the gears before you place them.

83. Apply a 2 mm (0.080") thick bead of sealant on the engine block as illustrated

84. Install the transmission plate. Use new screws that are pre-treated with locking compound. Torque as specified in Technical data.

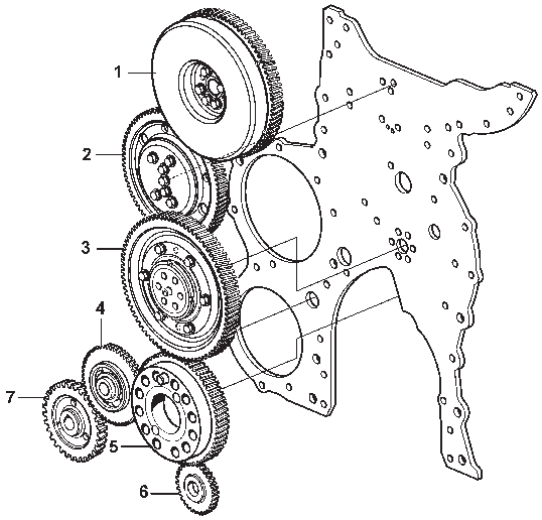
NOTE: Make sure that the plate is aligned with the bottom edge of the block .
NOTE! Torque within 20 minutes after sealant has been applied.

85. Oil the spacer plate and place it together with the upper intermediate gear (2). Torque gently, max 10 Nm (7.38 lbf ft).

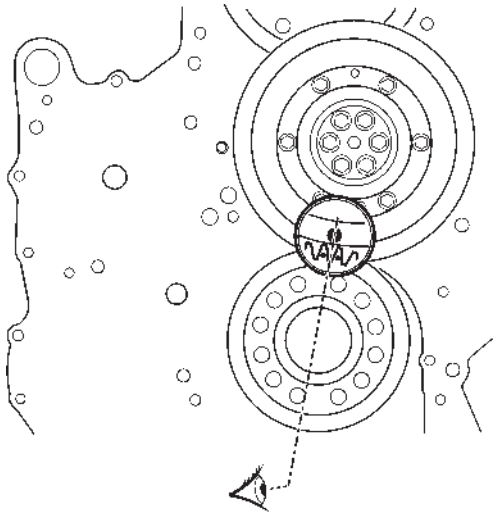


86. Install a new o-ring on the crankshaft.

87. Fit the crankshaft drive (5) and torque socket head cap screws as specified in Technical data.



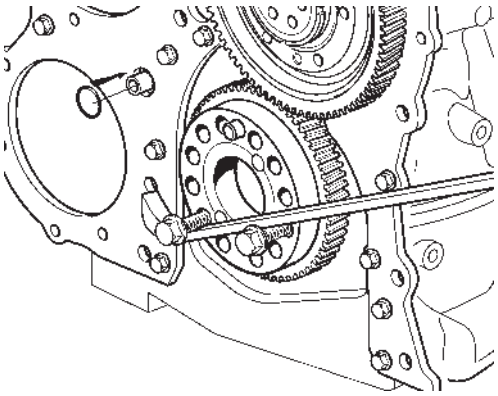
1. camshaft drive
2. upper intermediate gear
3. intermediate gear, double
4. lower intermediate gear
5. crankshaft drive
6. oil pump drive wheel
7. drive wheel for fuel feed pump / servo pump



88. Install the double drive kit (3) with the hole marking between the two hole markings on the crankshaft drive.

NOTE: The double drive inner and outer gears, respectively, have different gear pitch. For the camshaft to be set correctly, the markings must be correct.

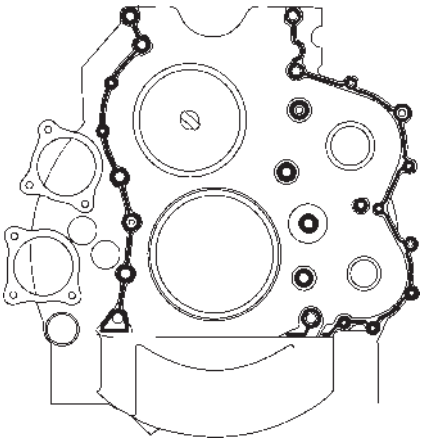
Torque the screws as specified in Technical data.



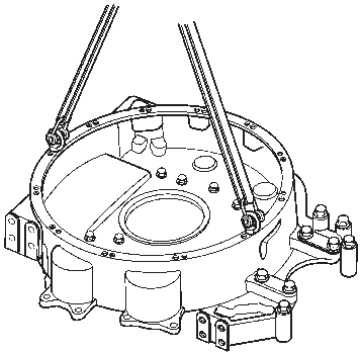
89. Install the bottom intermediate gear (4) with a new O-Ring.

90. Install the lubricating oil pump together with the rear main bearing.

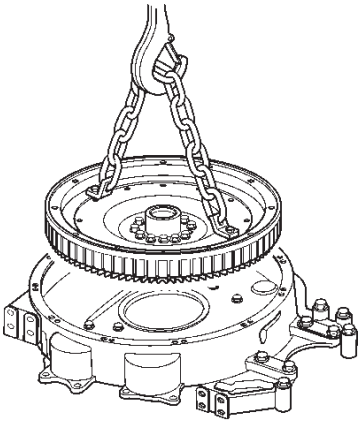
91. Place two screws in the crankshaft drive so you can attach a crowbar and thus be able to turn the crankshaft as needed.



92. Apply new sealing compound to the flywheel casing, towards the engine block.

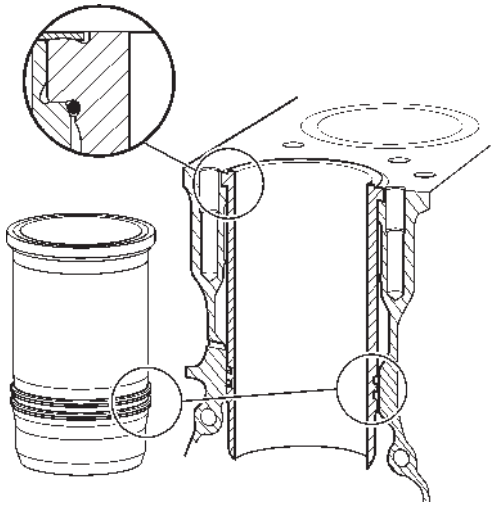


93. Install the flywheel casing. Check that the casing is aligned with the engine block plane.



94. Install a new crankshaft seal.

95. Install the flywheel and torque as specified in Technical data. See ”Flywheel, checking for warp”.

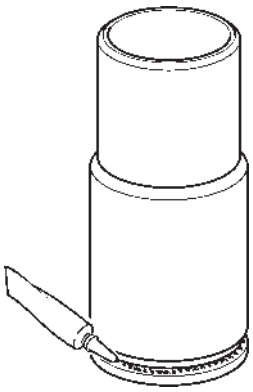


Cylinder liner, fitting

96. Inspect cylinder liner and pistons, see ”Cylinder liner and pistons, inspection”

97. Lubricate the sealing rings, using the lubricant supplied with the lining kit, and install them on the cylinder liner.

NOTE: The purple seal ring belongs in the lowest groove.



without adjustment shims

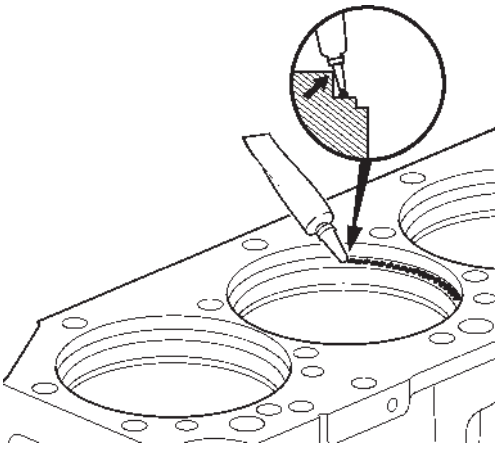
98. When the cylinder liner is installed without shims, an even bead of sealing compound should be applied to the underside of the cylinder liner collar.

NOTE: Do not put the seal around the entire liner. Leave a 2 mm opening.

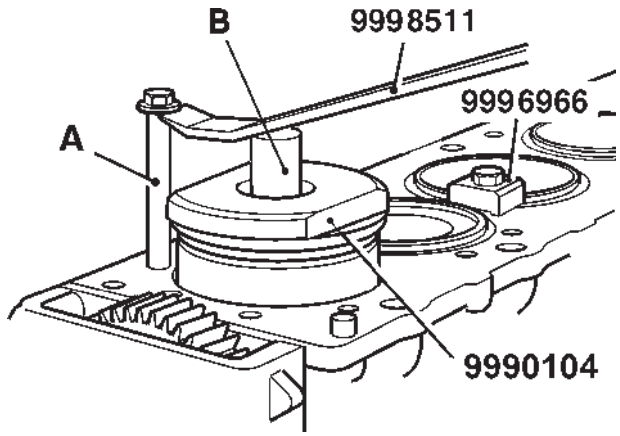
If the liner is fitted with adjustment shims, the sealant compound bead (0.8 mm (0.0315 “)) should be placed on the cylinder block liner seat.

NOTE: Sealing compound must not be used between adjusting shims and the cylinder liner collar.

NOTE: The liner must be positioned **within 5 minutes** after application of sealing compound.

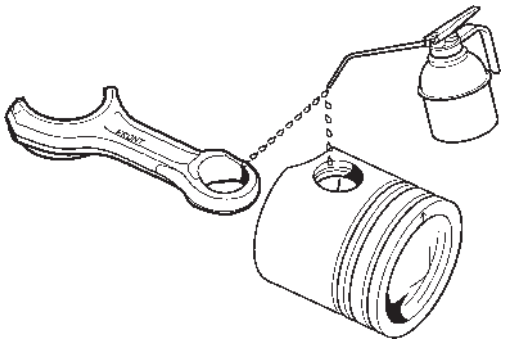


with adjustment shims



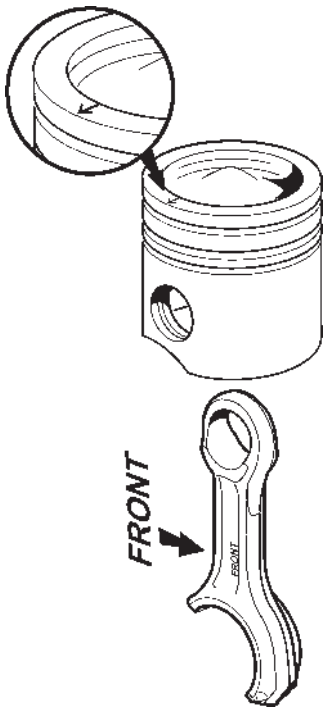
99. Secure one of the cylinder head screws (**A**).
    Place tool 9990104 above the cylinder liner together with appropriate spacer (**B**).
    Press the liner down with crowbar 9998511 and secure it using tool 9996966.

Piston, pre-fitting



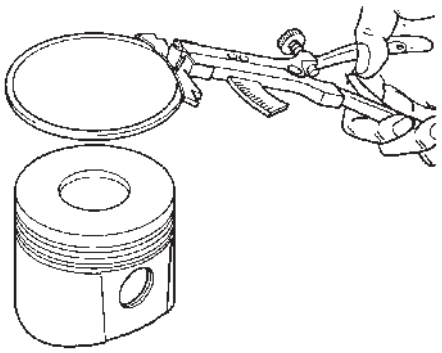
100. Install one of the circlips on the new piston.

101. Oil the piston pin, the piston bearing seat and connecting rod bushing with engine oil.



102. Fit the connecting rod with the arrow on the piston and the word ”Front”- on the connecting rod pointing in the same direction.
    Press in the piston pin.

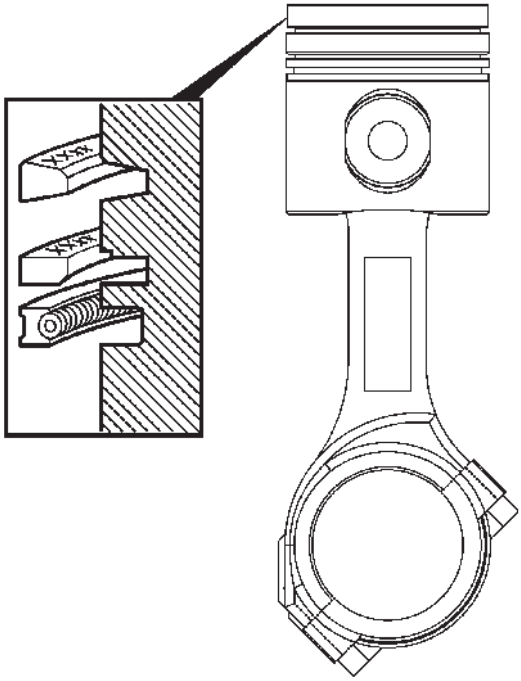
NOTE: The piston pin The piston pin should enter easily, it must **not** be knocked in.



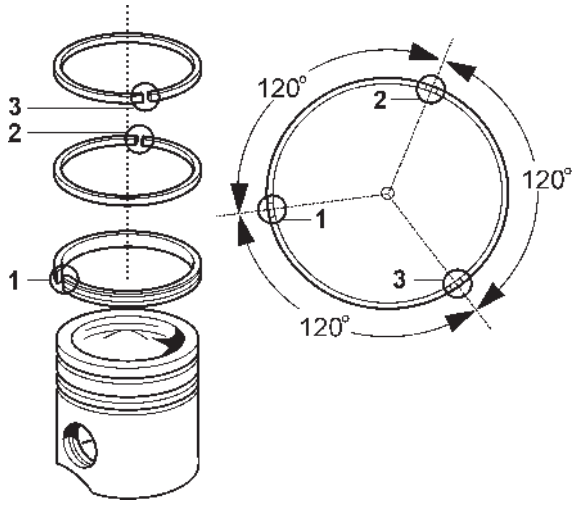
103. Install the other circlip.

104. Check that the piston pin does not move stiffly in the connecting rod bushing but that the piston moves easily.

⚠ **IMPORTANT!** Always use piston ring pliers during installation/removal of the piston rings. The oil scraper rings, especially, are brittle and are easily damaged.



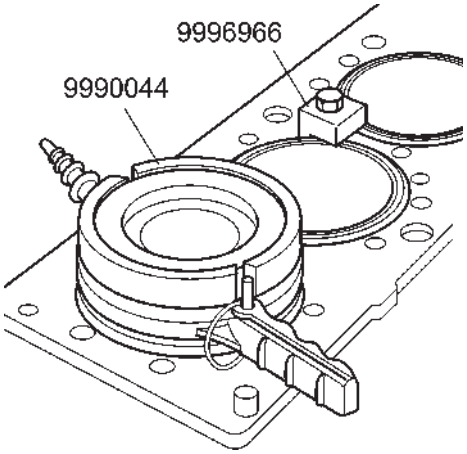
NOTE: The two upper piston rings are marked with letters or point marks. The mark shall be turned up.



105. Place the piston ring gaps offset about 120° offset on the piston. However, the piston ring openings may not end up straight above the piston pin.

NOTE: New cylinder lining kits are delivered complete with pistons and piston rings.

106. Install the bearing shells in the connecting rod.



Pistons, fitting

107. Oil in cylinder liner, the bearing shells and the crank bearing pins.

108. Remove press tool 9996966 temporarily while installing the piston.

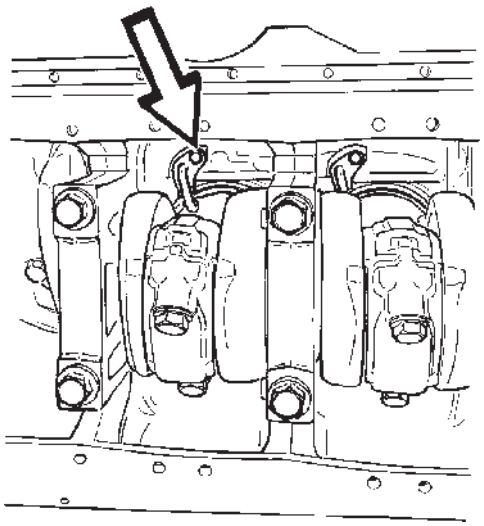
109. Use tool 9990044 and carefully guide the piston with piston rings down into the cylinder. Check that the connecting rod does not damage the crankshaft bearing pin.

NOTE: Be careful. The oil scraper rings are brittle and are easily damaged.

NOTE: The piston ring compressor may not open when the piston has been placed in the tool. The piston rings can be damaged. Press out the piston first, before opening the tool.

110. Reinstall press tool 9996966. All cylinder liners must be locked with the press tool in order to prevent movement between cylinder liner and engine block when the engine is cranked.

111. Install the bearing caps with their bearing halves.



Piston cooling nozzle, fitting

112. Blow the piston cooling nozzle clean and check for damage.

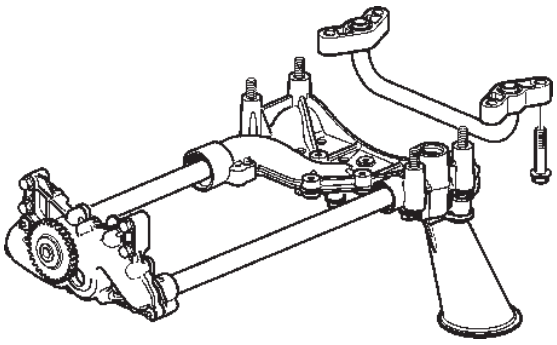
⚠ **WARNING!** Faulty piston cooling results in piston seizure. If you suspect that the piston cooling nozzle may be damaged or deformed, it should be replaced (applies to new nozzles as well).

113. Install piston cooling nozzle.

⚠ **IMPORTANT!** Check that the nozzle is placed correctly in the hole in the cylinder block and is directed towards the recess in the piston and that the retaining plate lies flat against the block. If the piston cooling nozzle is not correctly installed, the engine will immediately break down when loaded.

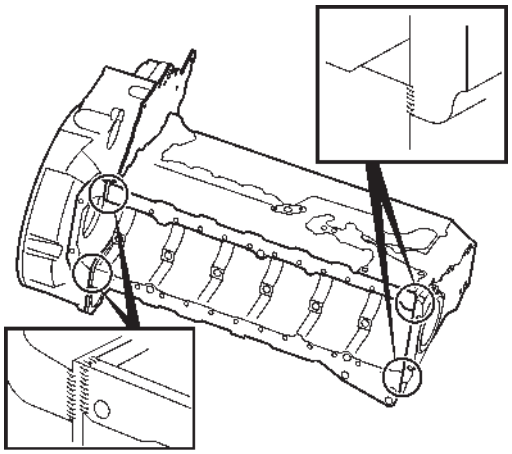
114. Torque as specified in ”Technical data”.

NOTE: The piston cooling nozzle retaining screw has a friction coating and may only be used once.



115. Install bracing frame and connecting pipe.
Torque as specified in Technical data.

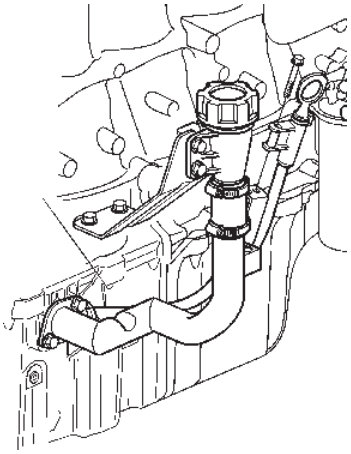
116. Install the oil strainer complete with bypass valve and pipe connections.
Torque as specified in “Technical data”.



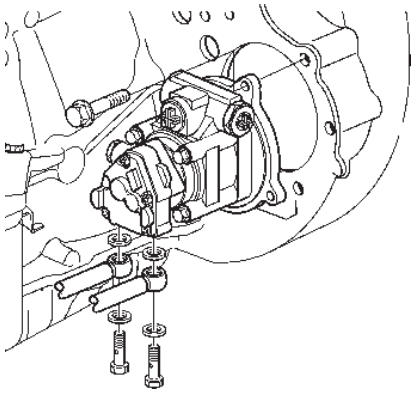
117. Apply a 2 mm (0.080") thick bead of sealant on the parting planes between the transmission gear casing and the lower part of the engine block, and at the front belt pulley casing.
Fit the oil pan
Torque as specified in ”Technical data”.

NOTE: Fit the oil pan within 20 minutes after sealant application.

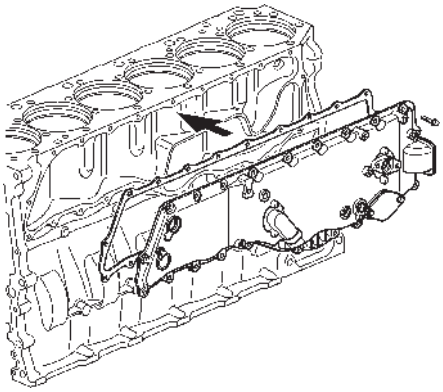
118. Connect the contact to the oil level sensor.



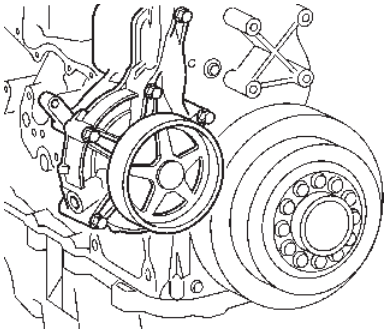
119. Install oil filler pipe and the dip stick pipe together with the bracket.



120. Fit the fuel pump and servo pump complete.

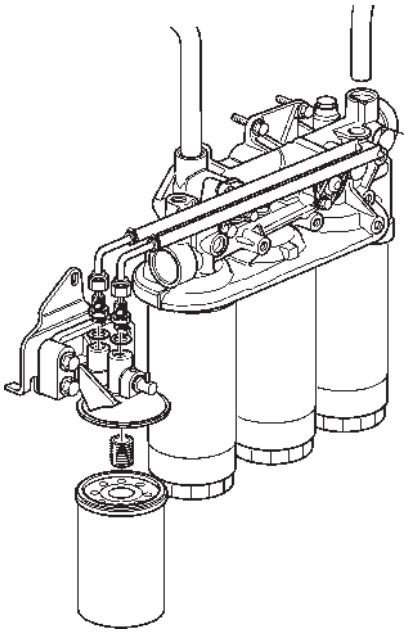


121. Fit oil cooler together with oil cooler cover. See ”Oil cooler cover, fitting”.



122. Fit coolant pump together with the coolant housing and bracket.

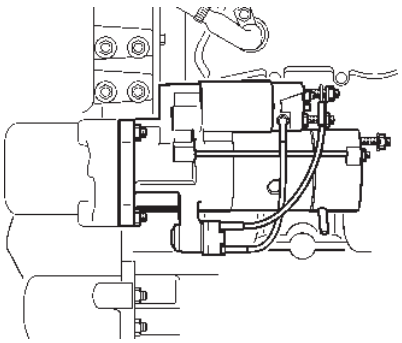
123. Fit the belt pulley and the vibration damper.



124. Fit oil filter bracket and the rear pipe complete.
Fit the front pipe between filter bracket and oil cooler cover.

NOTE: Use new gaskets.

125. Fit the coolant filter with bracket and the fuel lines to the coolant housing behind the coolant pump.



126. Fit the starter motor.

127. Fit the front engine mounts.

128. Fit alternator.

Cylinder head, refitting

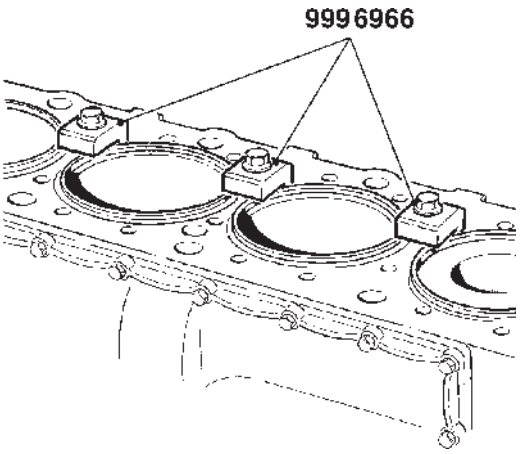
129. Clean the cylinder head thoroughly inside and out before installing.

NOTE: Dirt particles can destroy the unit injectors.

130. Clean the unit injector copper sleeves. See ”Reconditioning/Replacing: Fuel system”

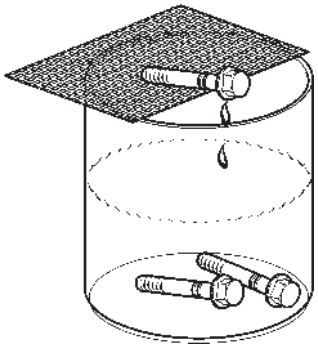
Install protection plugs immediately after cleaning.

131. Remove press tool 9996966 which holds the cylinder liners in place.



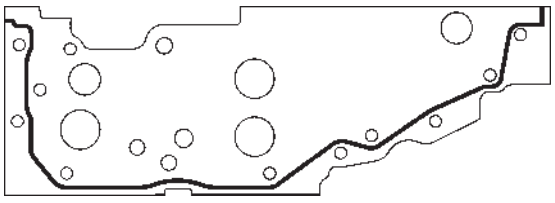
132. Carefully clean the cylinder head and the engine block sealing surfaces, cut away excess sealant.

NOTE: Do **not** pull away dry sealant.



133. Dip the cylinder head bolts completely into a rust-proofing agent.

Then place the screws on a net to remove excess.

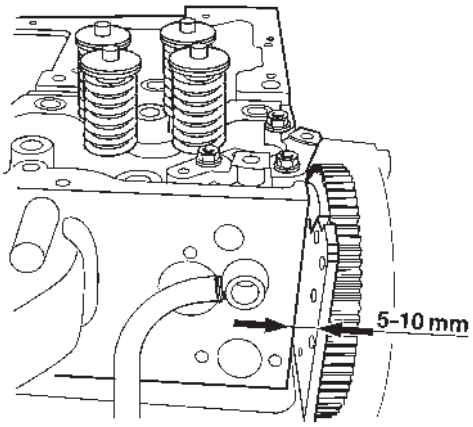


134. Apply a 2 mm (0.080") thick bead of sealant on the rear face of the cylinder head.

NOTE: The cylinder head screws must be torqued within 20 minutes after sealant application.

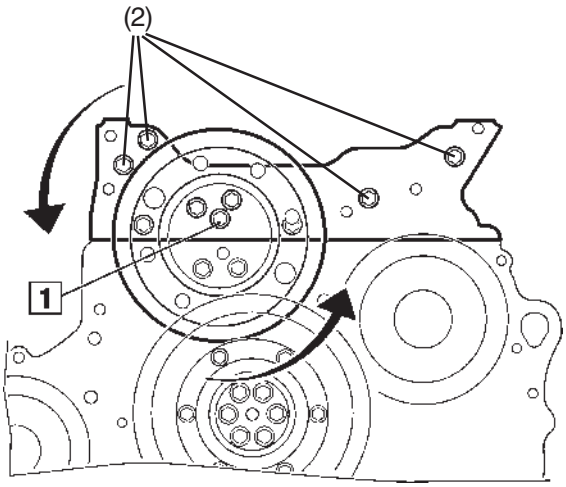
135. Fit a of new cylinder head gasket.

NOTE: Convex embossings prevent damage to the rubber seals.



136. Lower the cylinder head until it rests on the cylinder head gasket.

Maintain a distance to the transmission plate of 5 -10 mm (0.20 – 0.39 “). Locating pins ensure that the cylinder head will be aligned with the engine block.



137. Place a rag in front of the drive to prevent screws from falling into the transmission housing.

NOTE: The rag must be removed before the crankshaft is turned.

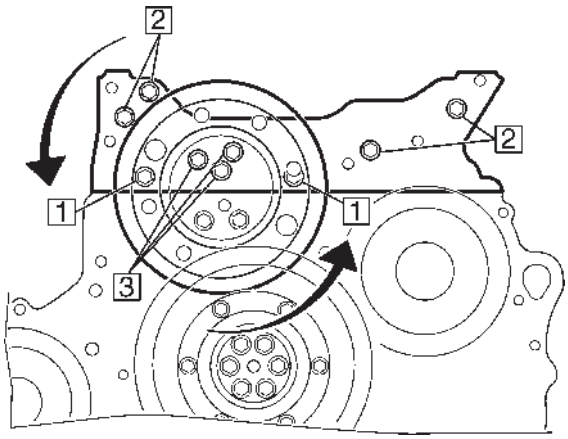
138. Place a screw in the upper intermediate gear hub (1) into the cylinder head, tighten to the cylinder head towards the transmission plate.

Screw in four M8 screws in the transmission plate (2).

139. Torque the screws (1) and (2) as specified in Technical data. Use new screws that are pre-treated with locking compound.

Unscrew all screws (1) and (2) about one turn.

NOTE: The cylinder head is now in the correct position to be secured and must not be moved. If the cylinder head is moved, the screws must again be torqued and loosened as above.

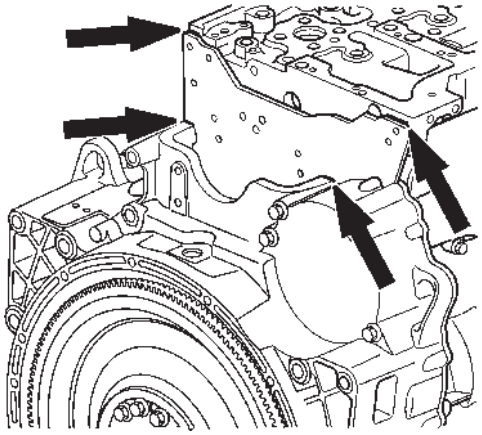


140. Install the cylinder head screws and torque as specified in Technical data. Use torque mutiplier for protractor tightening (angle tightening).

141. Torque the four M8 screws in the transmission plate (2) as specified in “Technical data”.

142. Turn the engine so that the two M8 screws (1) can be installed through the upper intermediate gear. Torque as specified in “Technical data”.

143. Fit the remaining two M10 screws (3) into the upper intermediate gear, without tightening.

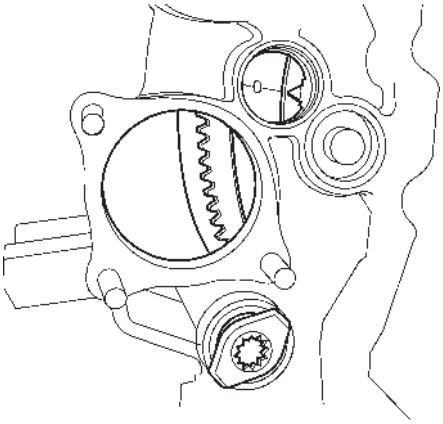


144. Clean the surface of sealant as shown.

NOTE: Cut away the sealant.

145. Remove the lifting tool from the cylinder head.

Camshaft, refitting



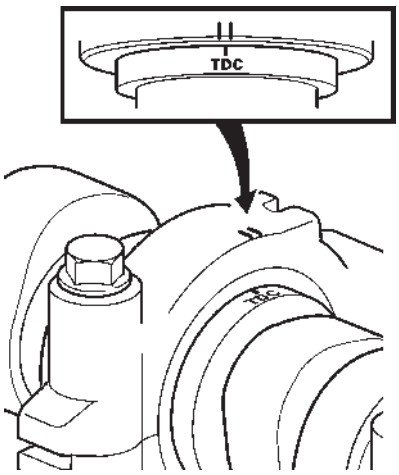
146. Check the camshaft for wear. See ”Camshaft, checking for wear”.

147. Clean surfaces on bearing blocks and the cylinder head.

148. Install the camshaft bearing blocks as marked on the cylinder head, make sure that they rest on the cylinder head.

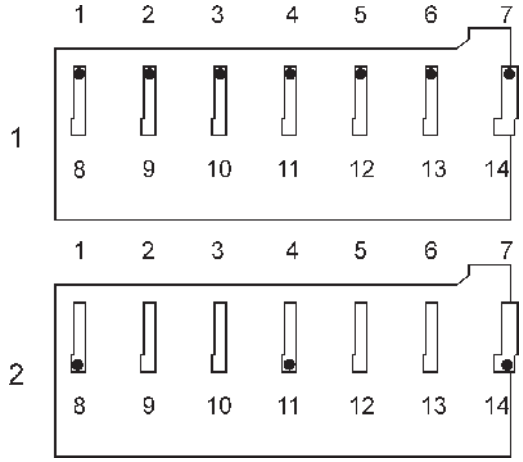
149. Place the bearing shells in the bearing blocks and lubricate the bearing shells with engine oil.

150. Turn the engine with the turning tool so that the flywheel is set exactly to zero, per the marking on the flywheel casing.



151. Carefully lift the camshaft in place. Make sure that the camshaft drive guide pin ends in the straight up position. The camshaft is marked “TDC” and should be in the middle between markings on bearing block no 7.

⚠ **WARNING!** Camshaft ridges are sharp.

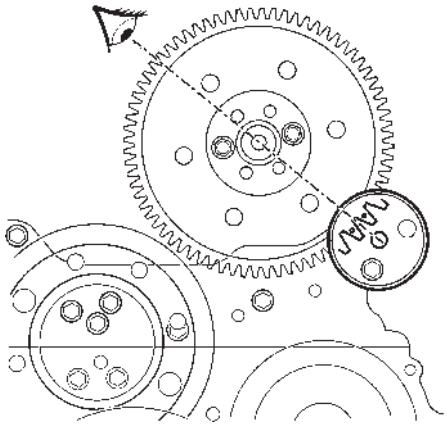


152. Oil the bearing shells and install the bearing caps on the respective bearing blocks.

NOTE: Use a suitable spacer on the rocker arm side.

Torque screws 1-7 per step 1 in Technical data.

Torque screws 8, 11, 14 (with spacers), with the same torque as specified in step 2 in Technical data.

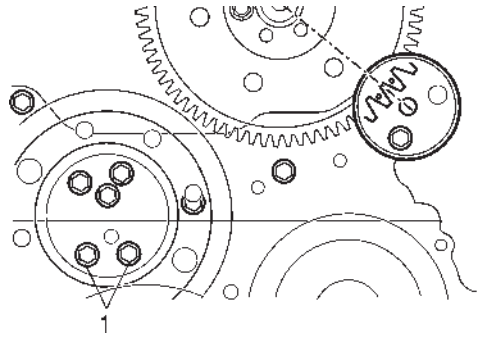


153. Place the drive so that the reference hole in the transmission plate lies between the drive markings.

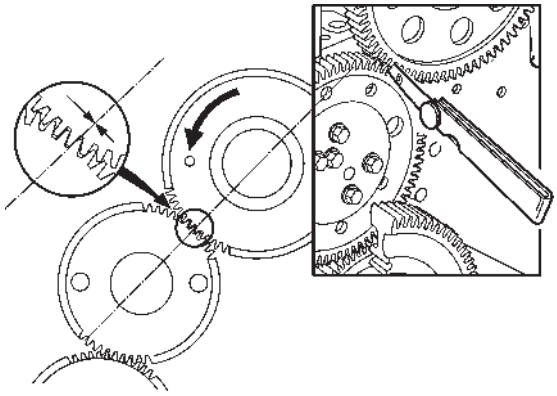
154. Fit the camshaft drive without the vibration damper, use nuts for spacers.

Tighten two screws temporarily with low torque, max 10 Nm (7.4 ft-lb).

Gear backlash, adjusting



155. Loosen the 2 lower screws (1) inside the adjustment wheel. Check that the upper screws are not tightened.

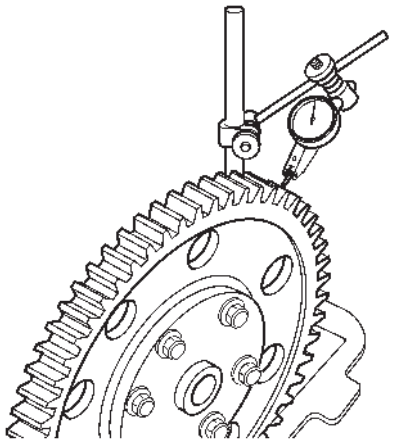


156. Place a 0.1 mm (0.004 in) feeler gauge on the pressure side, at the centerline between the two the gears.

Turn the camshaft drive in the direction shown i figure.

Torque per step 1 in ”Technical data”.

Remove the feeler gauge.



157. Check the clearance as follows:

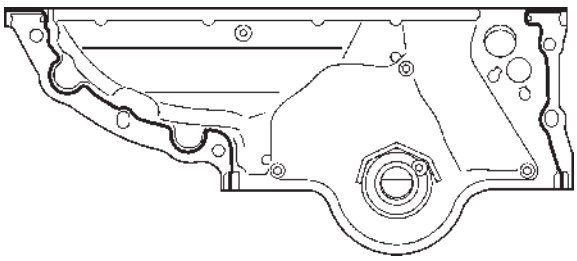
Fix the adjustment wheel.

Place a dial indicator on the camshaft drive, as illustrated.

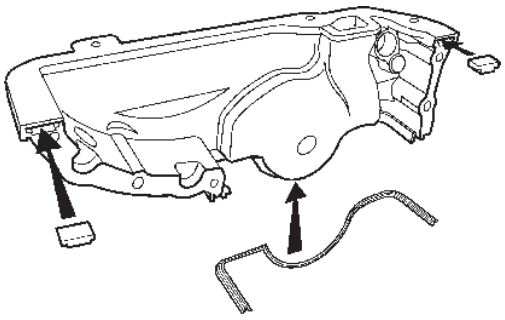
Turn the drive back and forth and compare the result against the specification for gear backlash in ”Technical data”.

158. If gear backlash is correct; torque the screws on the intermediate gear (1) per step 2 in ”Technical data”.

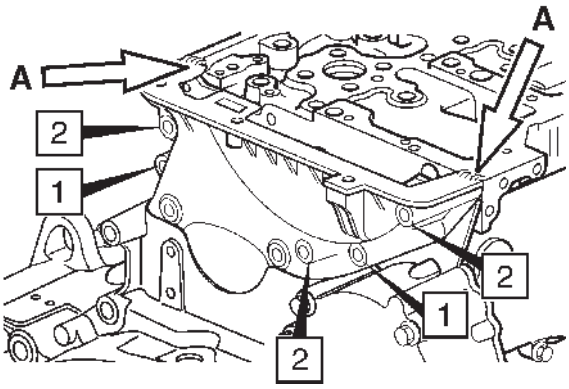
159. Fit the vibration damper. Torque as specified in “Technical data”.



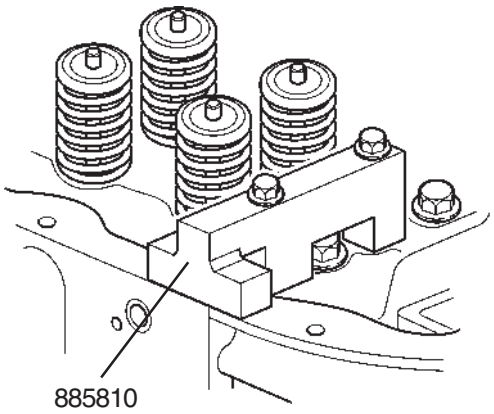
160. Apply a 2 mm (0.080") thick bead of sealant to the upper transmission gear casing contact surface, as shown.



161. Fit the rubber seals and install the upper transmission gear casing.



162. Only fit the screws (1) and tighten by hand. (The holes are oblong so that you can press the casing down towards the rubber seal.)



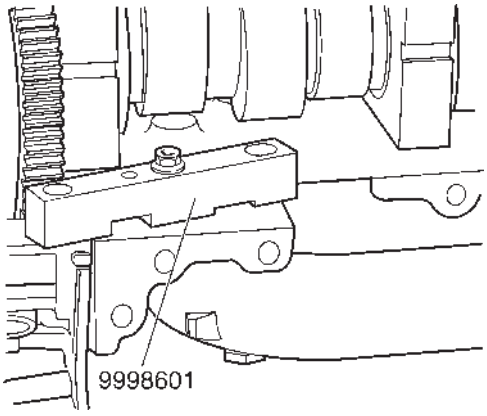
163. Remove the mounting bracket for the distribution house.

Press the casing down with the tools 885810 and 998601 so that the cylinder head and the upper transmission gear casing sealing surfaces are aligned.

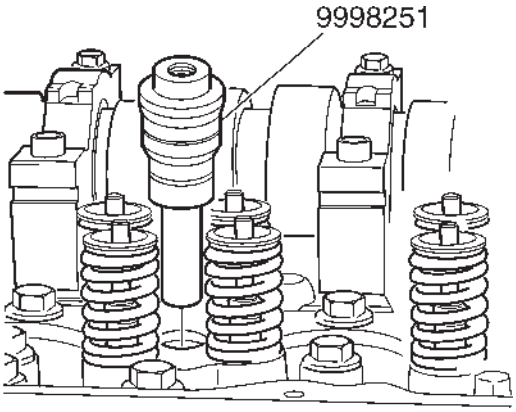
Refit the other bolts (2).

Torque as specified in “Technical data”.

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



164. Install camshaft sensor and adjust per ”Camshaft sensor, checking”.



Unit injector, refitting

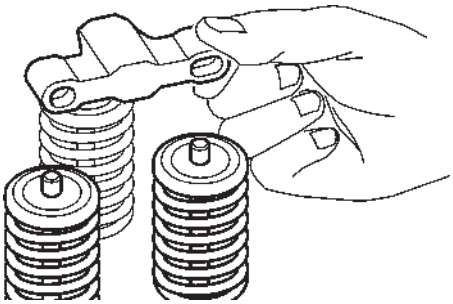
165. Remove protection plugs 9998251 with adapter 9990156 and slide hammer 9996400.

166. Fit new seal rings to the unit injectors. Lubricate the rings with diesel oil.

Install injectors and retainers. Center the injector so it does not touch the valve springs.

Torque as specified in “Technical data”.

NOTE: Install one injector at a time.

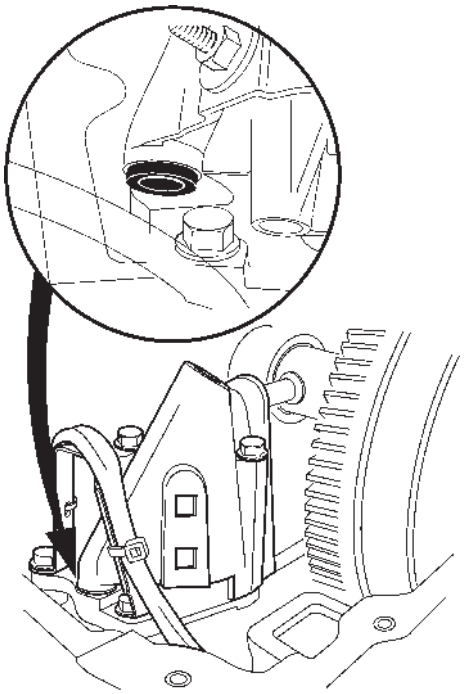


167. Reinstall the floating yokes in their original positions.

NOTE: Make sure that the yoke is directly above the valve stem. The oval hole should be turned away from the camshaft.

168. Lubricate valve yoke and camshaft.

169. Remove the temporary screws with spacers on the main bearing caps.



170. Fit the rocker arm shaft.

Torque the screws alternately along the rocker arm shaft as specified in “Technical data”.

171. Pull the cable harness to the unit injectors through the cylinder head and connect.

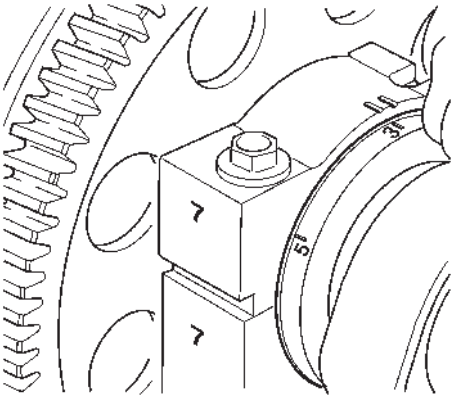
172. Slip on new O-rings over the rocker arm shaft lubricating oil supply pipe. Place the pipe in the distribution house and install the distribution house with its pipe (for TAD950-952VE the EGR control valve). Check that the O-rings on the pipe and ring under the distribution house are positioned correctly.

Fit cable holder and attach cable harness with oil and heat resistant cable ties.

⚠ **IMPORTANT!** Use Volvo Penta Original oil and heat resistant tie wraps (983472) and holders (28429850).

NOTE: Make sure that the wire harness does not get too close to the gear.

Adjustment markings



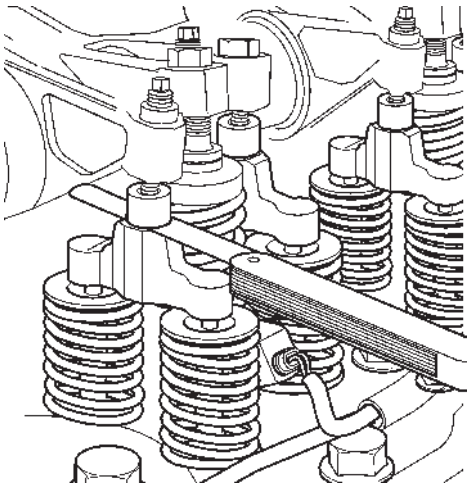
The engine has markings (1-6 for the respective cylinders) for adjusting inlet and outlet valves and the unit injectors.

NOTE: It is important that the line on the camshaft is right between the marks on thrust bearing cap when making the adjustment.

Valves and injectors, adjusting

NOTE: To adjust the valves and injectors on TAD950-952VE, please refer to "Valves, adjustment" and "Double rocker arm, inspection/adjustment" in the "Renovation/Replace components" chapter.

Adjust valves and injectors for the respective cylinders at the same time.



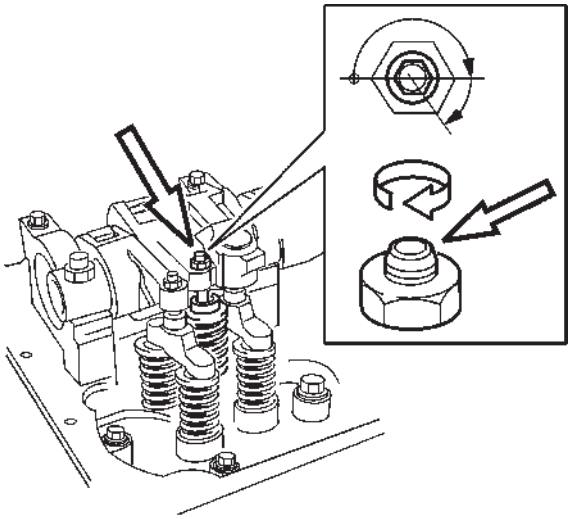
173. Turn the engine to the next camshaft marking.

174. Remove the adjustment screws for the current cylinder rocker arm so that they don't touch valve yokes or unit injectors.

175. Adjust the valve clearance between rocker arm and valve yoke as specified in "Technical data".

    Torque the lock nut as specified in "Technical data".

    Check the valve clearance. Mark the rocker arm when the valve has been adjusted.

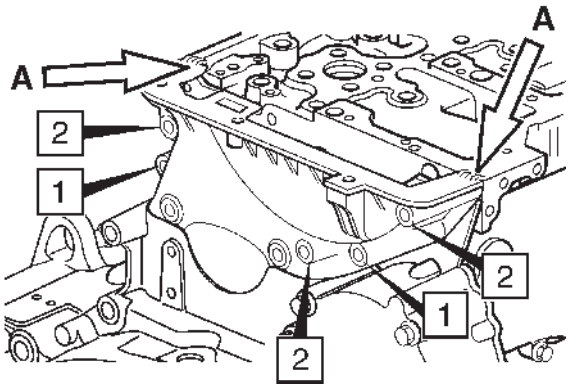


176. Adjust the unit injector rocker arm to zero clearance.

Tighten the adjustment screw a further 3-4 spanner flats (180°-240°).

Tighten the nut on the adjustment screw.

177. Adjust remaining valves and unit injector per the above.

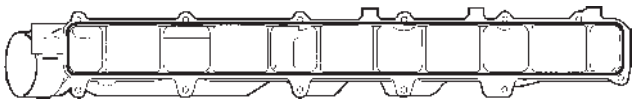


178. Connect the fuel lines to the cylinder head and torque as specified in Technical data.

179. Apply a 2 mm (0.080") thick bead of sealant to parting plane (A) between the transmission gear casing and the cylinder head.

180. Install the valve cover. Torque the screws as specified in ”Technical data”.

NOTE: The valve cover must be installed within 20 minutes after sealant application.



181. Apply a 2 mm (0.080") thick bead of sealant (1161231-4) to the intake manifold.

Install the intake manifold and torque as specified in Technical data.

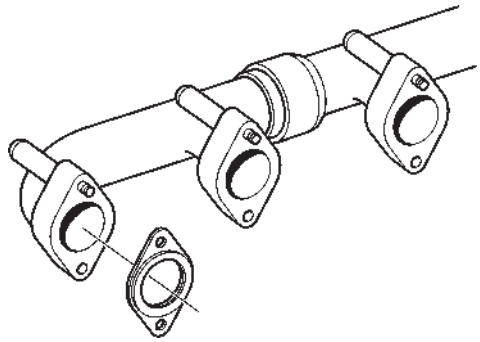
NOTE: The intake manifold must be installed within 20 minutes after sealant application.

182. Install the charge air pressure sensor and the coolant sensor.

Connect the sensor contact in the valve cover and attach the cable harnesses using the holders along the valve cover edge.

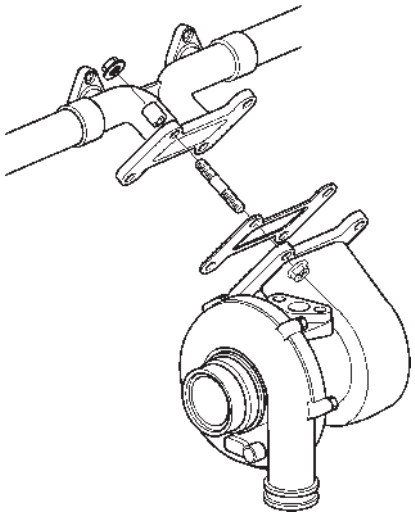
183. Install distributor retaining screws and install the distributor cap.

184. Install the clamps that hold the fuel lines in the intake manifold.



185. Place the gaskets on the exhaust manifold. Turn the gasket so that the side with the text ”Manifold side” is facing the exhaust manifold. ”Thread in” the screws in the gaskets so that they are held in place during installation of the exhaust manifold.

    Install the exhaust manifold and torque as specified in Technical data”.



186. Refit the turbo without tightening.

    Fit oil return pipe. Check that the old seal is not left and that the new one ends up in correct position.

    Install pressure pipe between the oil filter bracket and the turbo.

    Torque as specified in ”Technical data”.

187. Install the heat shields.

188. Install the right lifting eye if it was removed.

189. Fit the thermostat housing and torque alternately. Install the front lifting eye.

190. Fit the coolant pipes on the right front side of the engine. Use new sealing rings and tighten alternately.

191. Remove fixture and replace the parts that were removed.

192. Install the drive belts, fan, alternator and tensioning devices.

193. Install brackets for radiator fan safety cover or screen. Install the shields.

194. Install safety cover above alternator

195. Install the pipe between charge air cooler and inlet pipe.

196. Install the crankcase ventilation pipe and any extra oil separator.

197. Place a new insert in the air filter housing and install it with brackets and the pipe between the air filter housing and the turbo.

198. Install the pipe between the turbo and the charge air cooler.

199. Install muffler with brackets. Connect the exhaust pipe to the turbo.

200. Install heat shield above the turbo, if any.

201. Install belt shield on the right-hand side of engine, if any. Install the hoses to expansion tank and radiator.

202. Replace oil filter. Add engine oil, see “Engine oil, replacing”.

203. Replace coolant filter. Top up with coolant, see “Coolant, filling”.

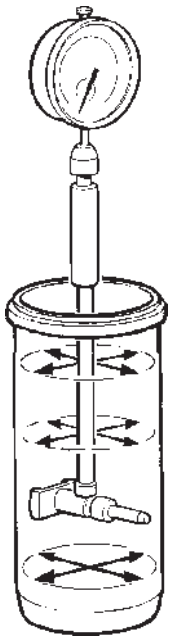
204. Replace fuel filter. Vent the fuel system, see “Fuel System, bleeding”.

205. Start the engine and let it run until it reaches normal operating temperature. Let it idle another 5-10 minutes. When the idle is even, the cylinder balancing system has set the correct amount of fuel for the unit injectors.

NOTE: Do not connect any power consuming device (such as power outlet) while cylinder balancing is underway.

Check that there is no fuel leakage.

Reconditioning / replacing components
Group 21: Engine body



Cylinder liner and pistons, inspection

Clean cylinder liner and pistons carefully before inspection and measurement.

NOTE: Cylinder liner and pistons are classified together. This means that pistons and liners must not be mixed.

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

Cylinder liner

You can measure the cylinder liner collar wear with the liner installed in the cylinder block.

NOTE: In order to thoroughly check for cracks, the cylinder liner must be removed from the cylinder block.

1. Measure the cylinder liner collar wear using a cylinder indicator. To measure the amount of wear as exactly as possible, calibrate the dial indicator first, using a gauge ring or micrometer. Use the cylinder liner original diameter as the basic value.

2. Measure the cylinder liner at the upper and lower turning position and at several points in between.

   At each measurement location, the measurement should be taken in the engine length as well as cross direction.

3. If wear is greater than 0.45–0.50 mm (0.018-0.020 in) a new complete lining kit should be used (piston, liner, piston rings, piston pin and seals).

   Oil consumption is also of importance for determining when to replace cylinder liners.

4. Remove the cylinder liner and check for cracks. Be extra careful when checking the liner collar. The Magnaflux method can be used for this check.

Pistons

5. Check pistons regarding worn piston ring grooves, damaged snap ring grooves, cracks and other damage.

   If the piston has deep scratches in the sleeve surface, the piston (the lining kit) must be discarded. The same applies if the piston has one or several cracks in the piston pin hole or in the bottom of the combustion chamber.

   Crack test is performed using the lime water process.

Cylinder liner and pistons, replacing (all)

Special tools:

Turning tool 9993590
Puller 9996645
Spacer 9996394
Spacer 9996395
Puller plate 9990104
Press tool, 7 ea 9996966
Drift 9996599
Prying tool 9998511
Piston ring compressor 9990044

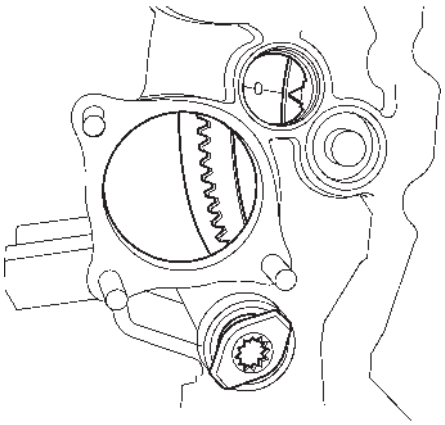
Other special equipment:

Torque wrench, 10 -100 Nm
(7.38 - 73.76 lbf ft) 1159794
Torque wrench, 40 - 340 Nm
(29.50 - 250.77 lbf ft) 1159795
Dial indicator 9999876
Holder 9992479

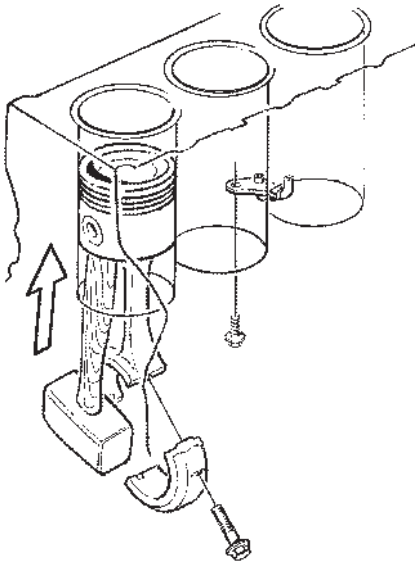
Removal

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

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



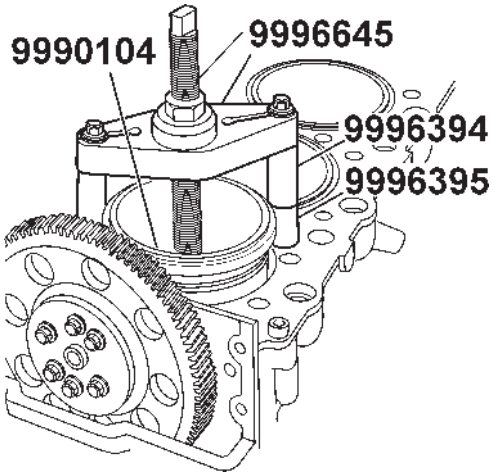
1. Remove the protective cover in the flywheel casing and install tool 9993590.
   Turn the crankshaft so you can access the screws to the connecting rod that is to be removed.



2. Remove main bearing cap and bearing shells.

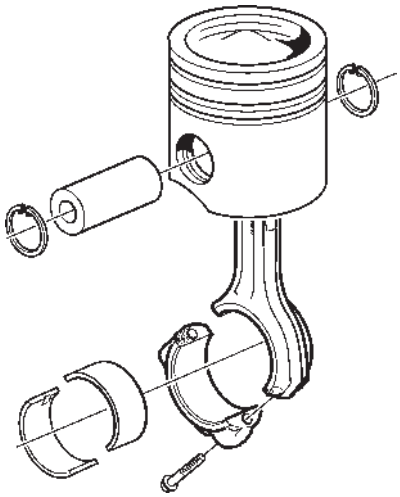
3. Remove the piston together with the connecting rod.

⚠ **IMPORTANT!** Mount the main bearing cap on the connecting rod to prevent damages, the surfaces are very sensitive.



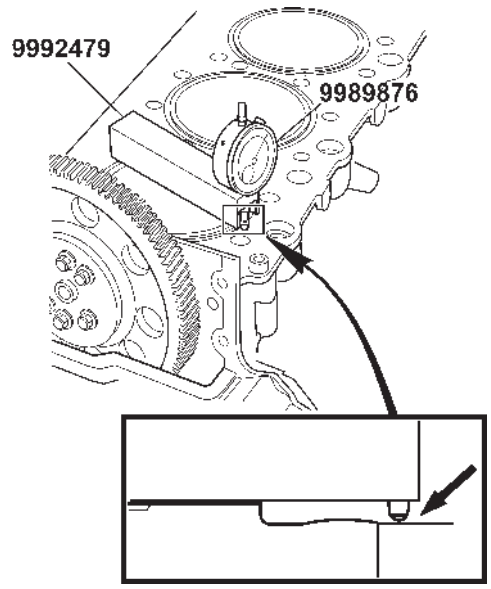
4. Pull the cylinder liners from the block using puller plate 9990104, puller 9996645 and spacer 9996394. If needed, extend using spacer 9996395.

5. Remove the cylinder liner sealing rings.



6. Remove the circlips from the piston and press out the piston pin.
Remove the piston from the connecting rod.

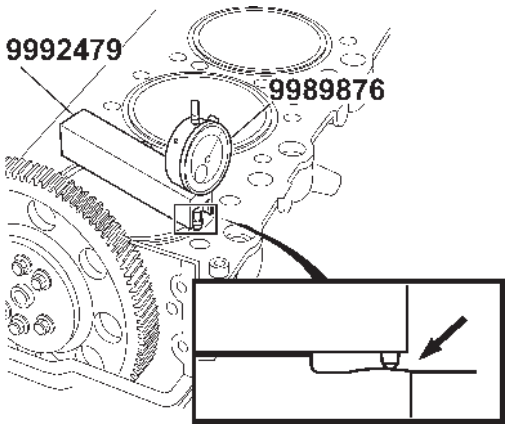
7. Clean the sealing surfaces in the cylinder block and the grooves for the sealing rings. Do not use scrapes or other tools that can damage the sealing surfaces.



Fitting

8. Check the cylinder block liner collar for damage. In case of machining the liner collar see “Cylinder liner seat, machining”. Fit cylinder liner, **without** seal rings. Hold it using **two** press tools. 9996966

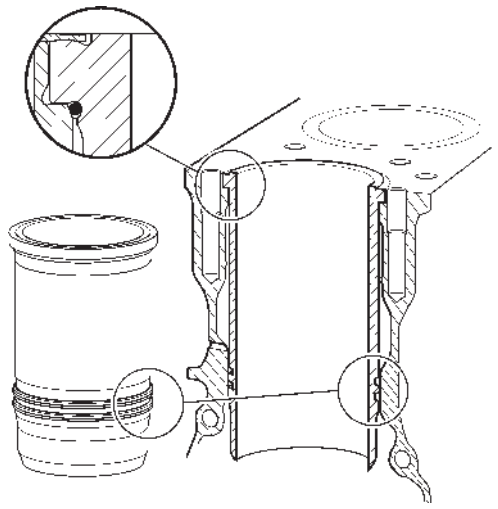
9. Fit dial indicator 9989876 in holder 9992479. Place the container with the dial indicator across the cylinder liners.
Set the dial indicator to zero with a few millimeter pre-load towards the cylinder block plane.



10. Measure the height between the cylinder liner and the cylinder block plane.
Measure the liner height at two different, diagonally opposite places.
Calculate the average of the two measurements. For correct liner height above block plane, see specifications. If the liner height above block plane is outside specified tolerance, the liner collar in the cylinder block should be machined.

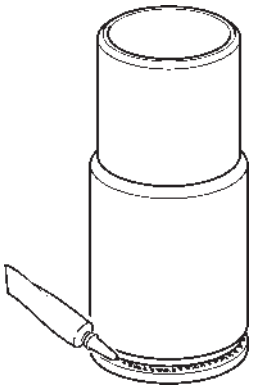
NOTE: Always measure on the highest point of the sealing surface. Mark the liner position in the cylinder block with an India ink pen, so that it is placed in the same position during installation. Repeat the procedure for remaining cylinder liners.

11. Remove the press tool 9996966.
Pull the cylinder liner out of the block.
Place the cylinder liners in the same sequence that they were installed, together with the adjusting shims.



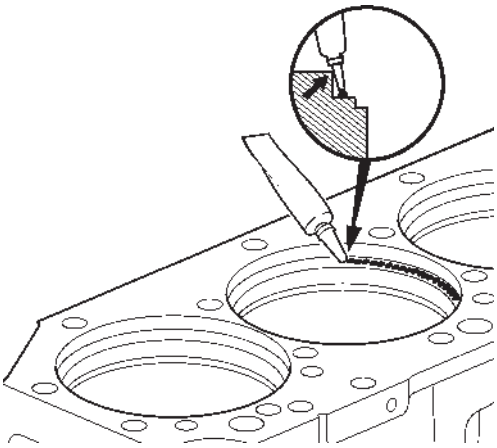
12. Lubricate the sealing rings with the lubricant supplied with the lining kit and install them on the cylinder liners.

NOTE: The purple seal ring belongs in the lowest groove



13. When the cylinder liner is fitted **without** shims, an even, about 0.8 mm (0.003") thick bead of sealing compound should be placed on the underside of the cylinder liner collar.

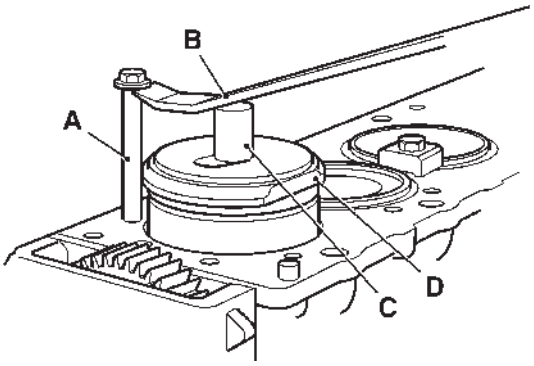
NOTE: Do not put the seal around the entire liner. Leave a 2 mm opening.



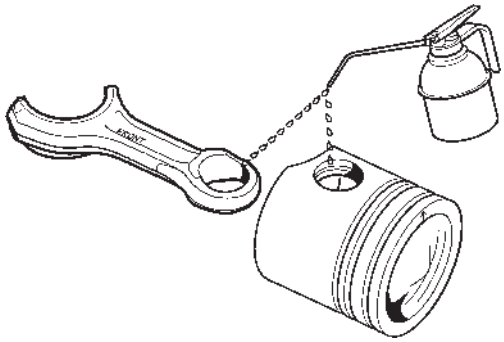
14. If the liner is fitted **with** shims, the sealant bead should be placed on the cylinder block liner seat.

NOTE: Sealant must not be used between the adjusting shims and the cylinder liner collar.

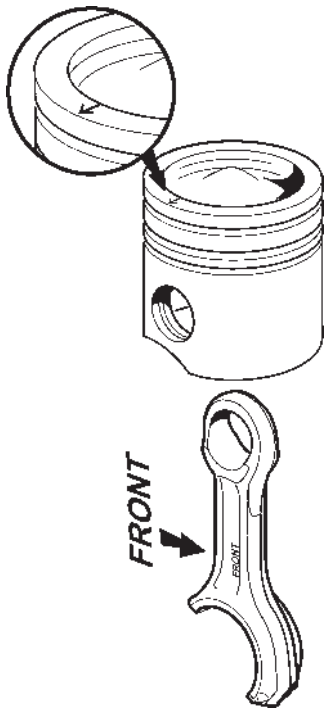
15. **NOTE:** After applying the sealant, the liner must be installed **within 5 minutes**.
If the cylinder head cannot be installed and torqued within 5 minutes, the liner must be held to the engine block with two 9990157 press tools.



16. Install one of the cylinder head screws (A). Place the tool 9990104 (D) above the cylinder liner together with an appropriate spacer (C) and press the cylinder liner down with prying tool 9998511 (B).



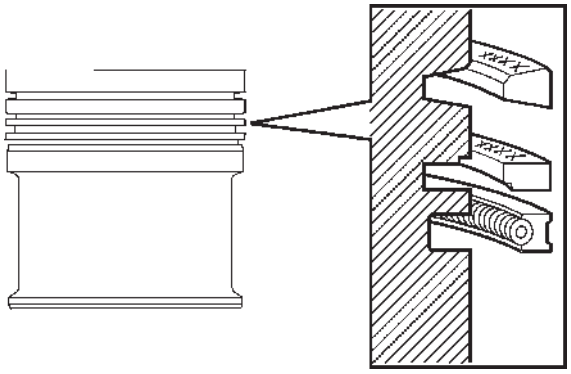
17. Oil the piston pin, the piston bearing seat and connecting rod bushing with engine oil.



18. Install the connecting rod in the piston with the mark “FRONT” on the connecting rod and the arrow on the piston turned in the same direction. Press in the piston pin.

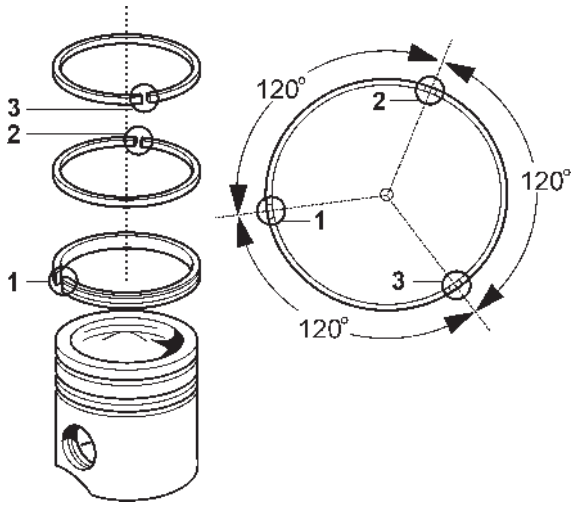
NOTE: You should be able to press the piston pin in without much force. If the resistance is too big, the piston may need to be heated. The connecting rod should turn freely on the piston pin.

Install the circlips.



19. Fit the piston rings. Use piston ring pliers. The piston rings openings should be evenly spaced around the piston.
The oil ring spring opening should be positioned diametrically opposite the seal openings.

NOTE: The two upper piston rings are marked with letters or point marks. The number markings should be turned**up**. The oil ring is symmetric and can be turned either way.



20. Lubricate the piston and the piston rings with engine oil. Check that the piston ring openings are offset in relation to each other.

21. Fit the piston together with the connecting rod.

NOTE: Connecting rods shall be installed in their respective original positions. The arrow on the piston and “FRONT” marking on the connecting rod should point to the front. Use piston ring compressor 9990044.

Temporarily remove the press tool when the piston is fitted. Reinstall the press tool when the piston is in place.

22. Lubricate main bearing caps and the crank bearing pin with engine oil. Fit the big-end bearing shells. Check that they are a correct fit to the connecting rod and caps.
Install the main bearing cap per the number of markings and torque as specified.

23. Clean piston cooling nozzle and check for damage. Install the nozzle and torque as specified.

NOTE: Make sure that the nozzle is aligned with the piston recess.

Crankshaft, inspection

The crankshaft has been induction-hardened.

Inspect the crankshaft thoroughly to avoid unnecessary reconditioning.

To determine reconditioning requirements, the following applies:

1. Thoroughly clean the crankshaft.

   Measure the bearing journals for out-of roundness, wear and taper. See ”Technical data”.

2. Investigate whether surface damage occurs on the bearing races. If the surface layer is damaged, the shaft should be reground.

3. The crankshaft should be placed on either a pair of V-blocks, under 1st and 7th main bearing journals. Alternatively, hold the crankshaft between stocks.

4. Measure crankshaft alignment (throw) on the 4th main bearing.

   Max. allowed values, see ”Technical data”.

NOTE: Straightening of the crankshaft is not allowed.

4. Check for cracks before and after any grinding. To check, use a magnetic powder test, i.e. fluorescent powder which can be seen under ultraviolet light.

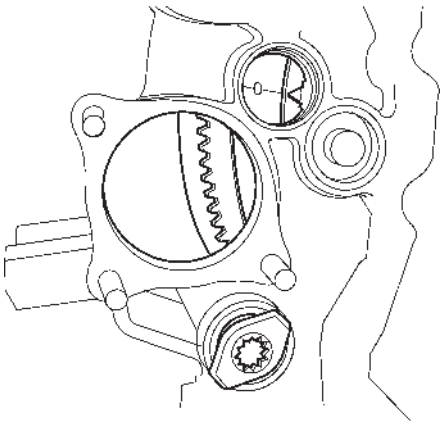
Main bearings, replacing

Pan removed.

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

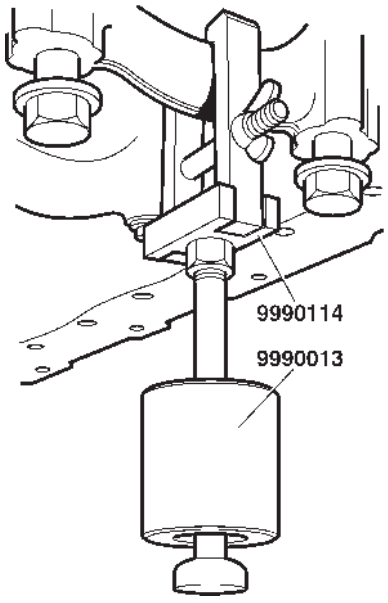
Special tools:
Turning tool 9993590
Puller 9990114
Slide hammer 9990013

Removal

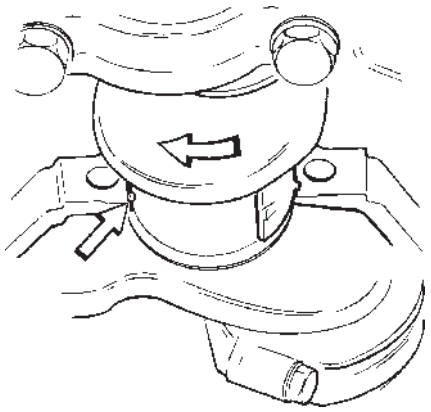


1. Install turning tool 9993590.

2. Remove the connecting pipe plus oil suction and oil pressure pipes with the bracket.
   Remove bracing frame.



3. Remove the oil pump together with the rear main bearing cap.



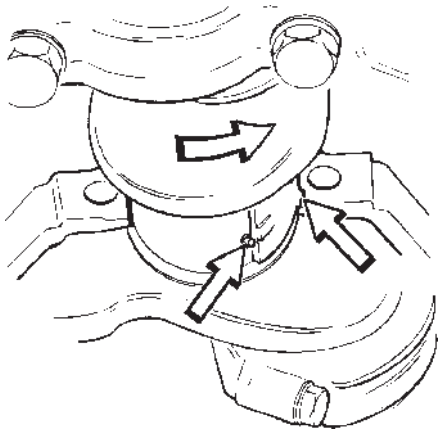
4. Remove the upper bearing shell by placing a pin in the crankshaft oil hole and roll the bearing shell out by turning the crankshaft in the direction of rotation using turning tool 9993590.

5. Clean and check the bearing seat, caps, shaft pivot and bearing shells.

   If the bearing has frozen, the reasons should be determined before a new bearing is fitted.

6. Make sure that the correct bearing size is used for replacement.

NOTE: If you are uncertain, check in Technical data which oversize dimensions are shown.



Fitting

7. Oil the shaft pivot and the new bearing shells with engine oil.

8. Install the upper bearing shell by turning the crankshaft using tool 9993590 against the direction of rotation with the pin in the oil hole.

NOTE: Check that the shoulder pressed out of the bearing shell is placed correctly in the bearing seat recess.

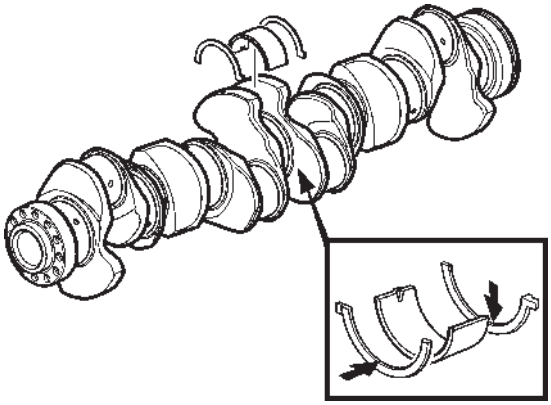
   Make sure that the upper bearing shells (those to be installed into the cylinder block) are equipped with oil holes.

NOTE: Remove the pin when done.

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

NOTE: The main bearing caps is asymmetric and can only be installed in one position. Note the main bearing caps numbers that show their placements if several caps have been removed simultaneously.

   Torque caps in two steps, per Technical data.

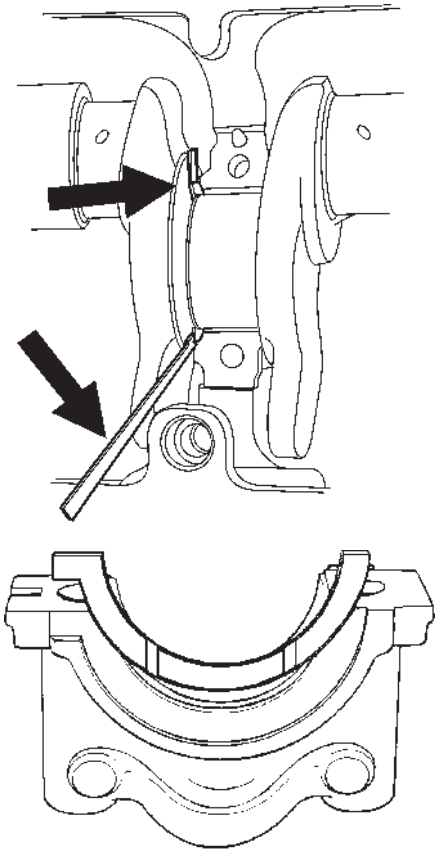


10. Replace the other the main bearings, one at a time, the same way as the first. Every time you replace the crankshaft, check that it does not seize by turning it using the turning tool 9993590.

11. Check the crankshaft axial play and replace the thrust washers if the clearance is too big or if the thrust washers are damaged.

NOTE: Axial play is measured using a dial indicator. The thrust washers are available in a number of oversize dimensions. See ”Technical data” for oversize dimensions and axial play.

12. The crankshaft thrust bearing pin is placed in the middle main bearing.



13. Use a narrow plastic or wood stick to remove the thrust bearing washers in the cylinder block bearing seat.

NOTE: The thrust washers can only be placed in one position.

14. Check the axial play of the crankshaft when all main bearing caps have been torqued, see ”Technical data” for specification.

15. Install bracing frame and torque as specified in ”Technical data”.

16. Fit oil pump with pressure and oil suction pipe and ”the overflow pipe ”.

17. Remove the turning tool 9993590 from the flywheel casing and install the cover.

Crank bearings, replacing (all)

Oil pan, oil suction pipe and bracing frame removed.

Removal

1. Fit turning tool 9993590 and turn the flywheel until the bearing caps on connecting rod 1 and 6 are in a position where you can remove the screws.

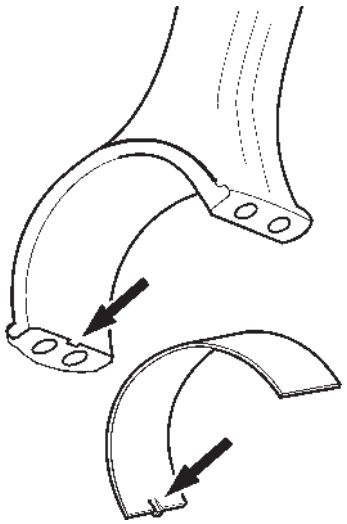
2. Mark and remove thrust bearing caps on connecting rods 1 and 6.

3. Remove the bearing shells and clean the connecting rod and cap bearing seats.

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

4. Check the bearing pins and the bearing shells.

5. Measure the bearing pins. If any of the values exceed the max allowed, the crankshaft should be removed and remedied.



Fitting

6. Fit the new bearing shells and check that the bearing size is correct. Make sure the bearing shell guide pins is aligned with the connecting rod recess.

7. Oil the bearing shells and the crank bearing pins. Fit the bearing caps and torque the screws as specified in ”Technical data”.

8. Turn the flywheel so that connecting rods 5 and 2 are in position to remove the screws and repeat points 2-6.

9. Turn the flywheel so that connecting rods 3 and 4 are in position to remove the screws and repeat points 2-6.

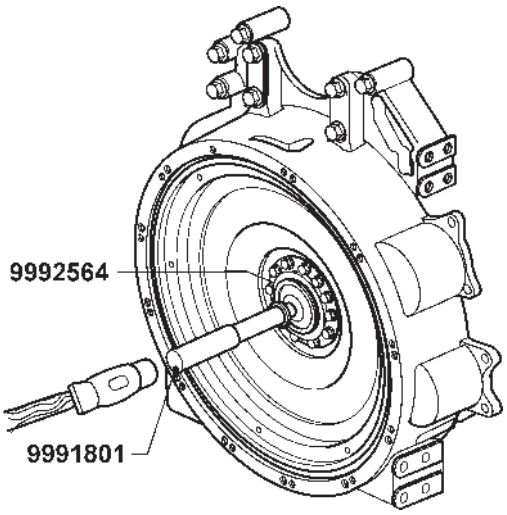
10. Check that no crank bearing seizes.

11. Remove the turning tool from the flywheel casing and install the cover.

Flywheel bearing, replacing

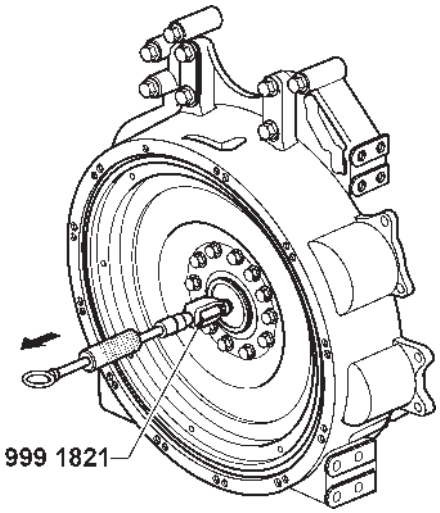
Special tools:

Handle 9991801
Drift 9992564
Slide hammer 9991821



Flywheel removed (recommended):

1. Measure the bearing position in the flywheel.
2. Press the bearing out using a hydraulic press. Use tool 9991801 and 9992564.
3. Clean the flywheel and check for damage.
4. Press in the new bearing to the measured position using tools 9991801 and 9992564.



Flywheel not removed:

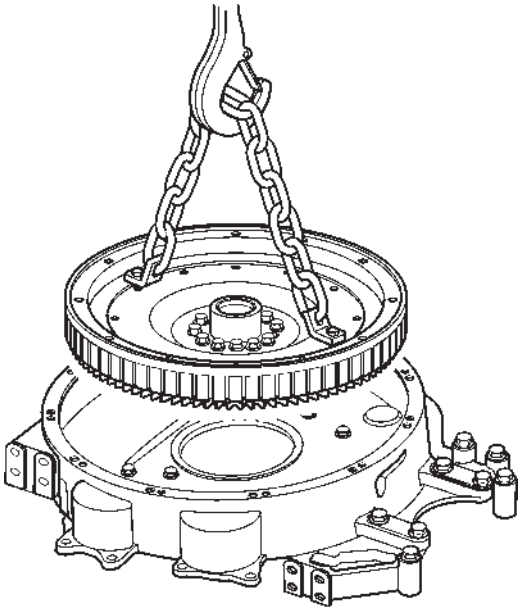
1. Measure the bearing position in the flywheel.
2. Remove the old the bearing using tool 9991821.
3. Drive in the new bearing to the measured position using tools 9991801 and 9992564.

Flywheel, replacing

21661

Special tools:

Turning tool 9993590
Lifting chain, 2 ea 9996239



1. Remove the flywheel sensor.

2. Remove the lid under the starter motor and install turning tool 9993590.

3. Secure lifting chain, 9996239, to the flywheel with two screws.
   Remove the flywheel retaining screws, Use the turning tool as an anvil.
   Lift the flywheel away.

4. Clean the flywheel contact surface which mates with the crankshaft.

5. Clean the flywheel. Check that the tracking surfaces for the flywheel sensor are clean.

6., Check that the flywheel guide pin is correctly inserted into the crankshaft.
   Check for damage.

7. Lift the flywheel into position and install the retaining screws.

8. Torque the retaining screws as specified in Technical data". Use turning tool 9993590 as an anvil.

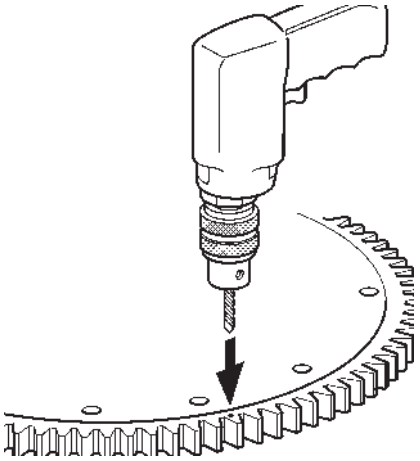
9. Remove turning tool and re-install the cover.

10. Check the flywheel sensor distance, see "Flywheel sensor distance, checking" and install the flywheel sensor.

Ring gear, replacing

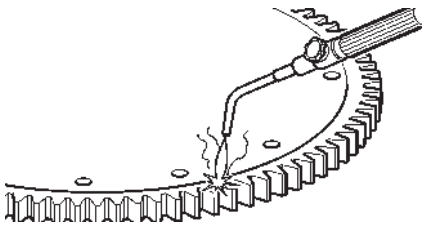
21687

Flywheel removed.

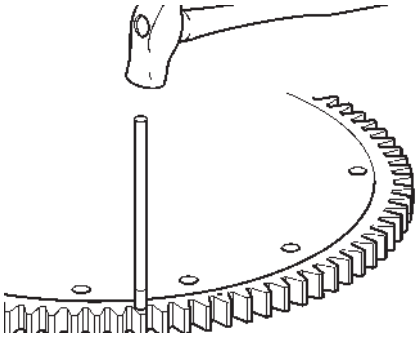


1. Drill a 1–2 hole between teeth on ring gear.
   Crack the ring gear at the drilled the hole using a chisel. Lift the ring gear away from the flywheel.

2. Brush the flywheel contact surface clean with a steel brush.



3. Heat the new the ring gear to 180 - 200 °C (356 - 392 °F) with a welding torch or in an oven. Ring gear should be heated evenly. Take care not to overheat the ring gear since this would make it run out.
   Check the heating by polishing the ring to a shine in a few places. Interrupt the heating when the polished surfaces are blued.

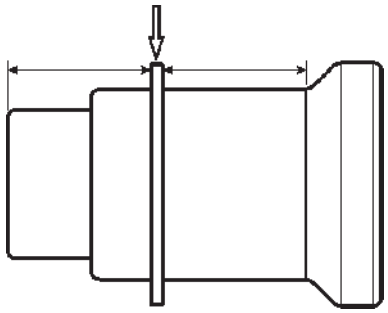


4. Place the heated ring gear on the flywheel and tap it in position with a soft drift and hammer.
   Allow the ring gear to cool down.

Flywheel sensor distance, checking

Special tools:

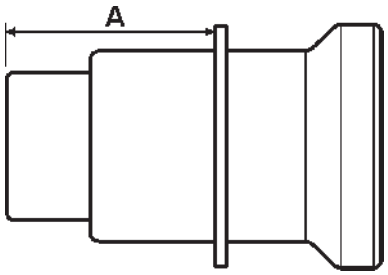
Turning tool 9993590
Measuring instrument 9998517



1. Install turning tool 9993590 and turn the engine's flywheel to 0°.

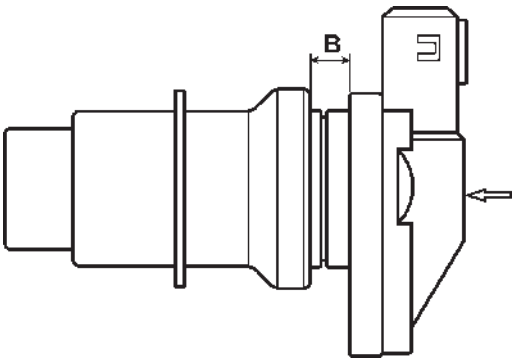
2. Remove the flywheel sensor.

3. Slide the installation tool circlip so that it is placed around the tool's middle.



4. Fit the tool in the sensor hole and press the tool in with care until it touches the flywheel.

5. Remove the tool and measure the distance between the circlip and the end of the tool.
   Write down the value measured (**A**).



6. Place the sensor in the tool and measure the distance between the sensor bracket contact surface and the end of the tool.
   Write down the value measured (**B**).

7. Calculate the existing sensor distance (**D**) as follows:
   D = A - (B + 20 (0,78740157480315 “)) mm.

Example:

Distance A = 28,2 mm (1,11023622047244 “)
Distance B = 8 mm (0,31496062992126 “)
D = 28,2 (1,110 “) - (8 (0,3150 ")+ 20 (0,7874”)) mm
D = 0,2 mm (0,0079 ”)

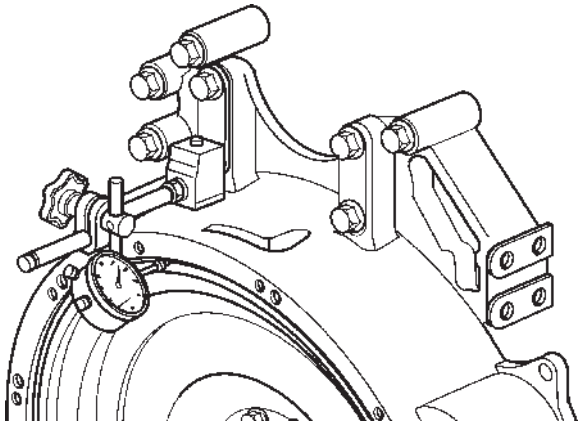
Compare the distance with correct value in ”Technical data”. As needed; adjust using shims, thickness 0.6 mm (0.024 “).

8. Install the sensor on the flywheel casing together with any shims.

9. Remove turning tool and install the cover.

Flywheel, checking for warp

Special tools:
Turning tool 9993590
Dial indicator 9989876
Magnet holder 9999696



Pressure plate removed

1. Place the dial indicator 9989876 with magnetic stand 9999696 with the probe towards the flywheel.

2. Remove the cover from the engine's flywheel casing. Fit turning tool 9993590.

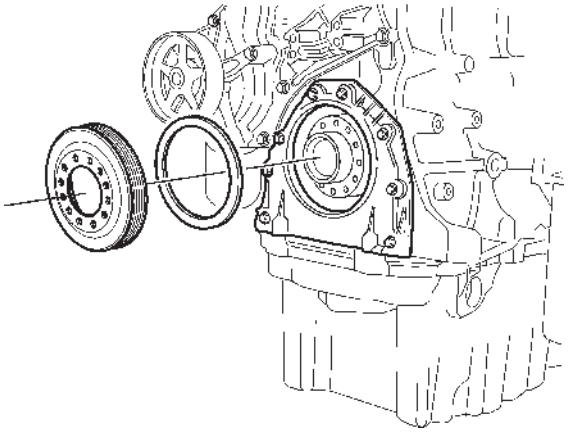
3. Set the dial indicator to zero. Turn the flywheel and note the maximum value that is measured by the dial indicator. The value should not exceed 0.20 mm (0.0080") at a measuring radius of 150 mm (6").
   If the warp is greater, remove the flywheel and check if there is dirt or other irregularities between the flywheel and the crank shaft flange.

4. Remove turning tool 9993590 and install the cover.

Crankshaft seal, front, replacing 21672

Special tools:

Alt 1
Cone 9990118
Drift 9990112
Drift 9992000
Alt 2
Slide hammer 9996400
Puller 9990192



Alternative 1

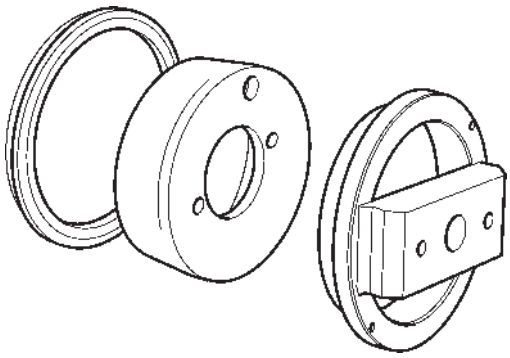
1. Remove crankshaft belt pulley and the vibration damper (12 screws).

2. Drill 2 ∅ 3.5 mm (0.138 “) holes in the seal using the guide holes in drift 9990112. Apply grease to the drill to avoid that dirt enters the engine.

3. Screw in 2 self-tapping screws, 5 mm (0,197 “), in the seal.

4. Install 2 screws, M10 x 60, with long threads in the drift and pull the seal out. Remove the seal and the screws from the tool.

5. Clean the seal position in the flywheel casing and sealing surface against the crankshaft.

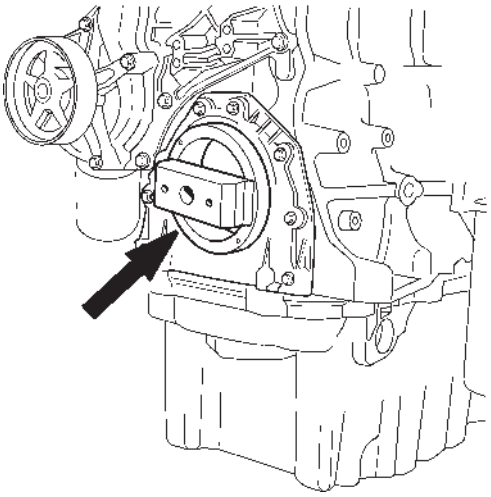


6. Check that the tools are flawless, so you don't destroy the seal.

7. Fit cone 9990118 on drift.

NOTE: No lubrication. Should be installed completely dry.

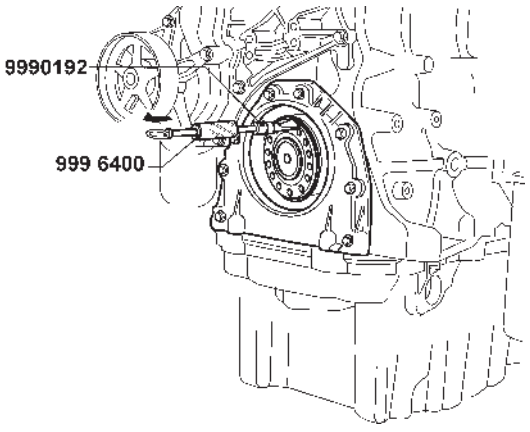
8. Install the seal on tool 9990112 via 9990118.
   Remove tool 9990118.



9. Install handle 9992000 on 9990112 and carefully tap in the new seal until the tool bottoms against the crankshaft.
   Remove the tool and check that the seal was installed correctly.

10. Fit the vibration damper and the belt pulley. Torque as specified in "Technical data".

Alternative 2



1. Knock out the seal using tool 9990192 together with slide hammer 9996400.

2. Install the new seal. See the points 6-11 in "Alternative 1".

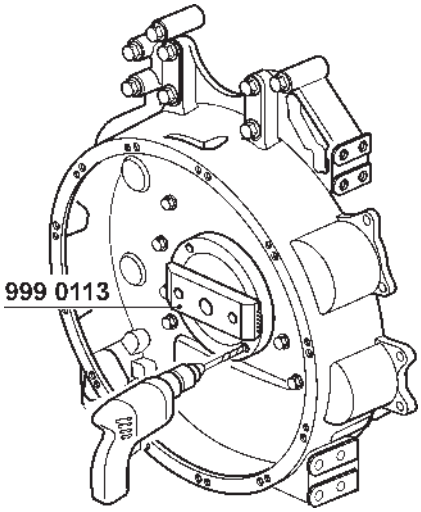
Crankshaft seal, rear, replacing

Flywheel removed.

Special tools:

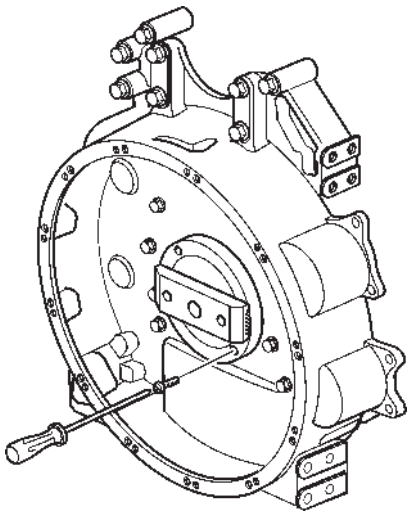
Alt 1
Drift 9990113
Cone 9990117
Drift 9992000
Alt 2
Slide hammer 9996400
Puller 9990192

Alternative 1

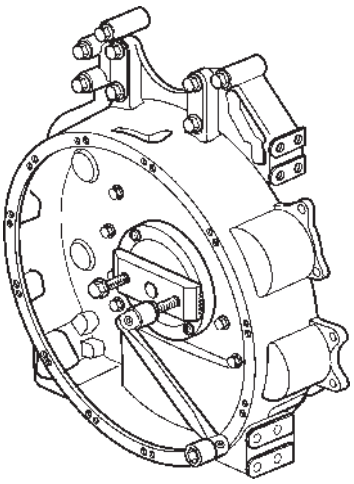


1. Install drift 9990113.

2. Drill 2 ∅ 3.5 mm (0.138 “) holes in the seal’s sheet metal edge, Use the tool’s guide holes as templates. Apply a small amount of grease to the drills to avoid that dirt enters the engine.

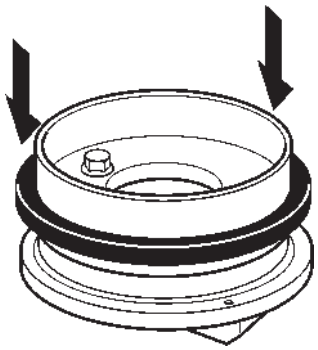


3. Screw two self-tapping, 5 mm (0,197 “), screws into the seal, through the tool’s guide holes.



4. Install 2 screws, M10 x 60, with long threads in the tool's threaded holes and pull the seal out.
   Remove the seal and the screws from the tool.

5. Clean the seal position in the flywheel casing and sealing surface against the crankshaft.

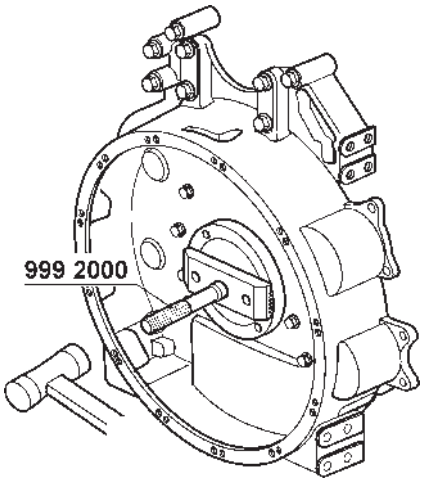


6. Fit the cone 990117 to the bracket 9990113.

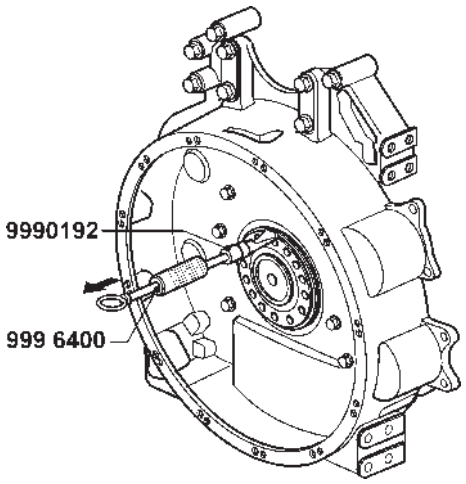
NOTE: Check for damage on the guide or drift. They may damage the seal.

NOTE: No lubrication. Should be installed completely dry.

7. Install the seal on 9990113 via 9990117.
   Remove tool 9990117.



8. Install handle 9992000 on 9990113 and tap in the new seal until the tool bottoms against the crankshaft drive.
   Remove the tool and check that the seal was installed correctly. If needed, use two screws to pull the tool out.



Alternative 2

1. Knock out the seal using tool 9990192 together with slide hammer 9996400.

2. Install the new seal. See the points 4-8 in ”Alternative 1”.

Connecting rod, checking

Important consideration when removing/installing ”cracked” connecting rod.

Fitting NEW connecting rod:

Carefully clamp the connecting rod in a vise equipped with soft jaws.

Unscrew the connecting rod screws a few turns and tap carefully on the bearing cap with a plastic hammer until it comes loose.

The crack line may be hard to find when the connecting rod is assembled.

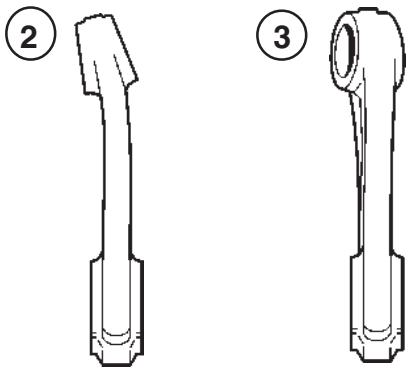
When the bearing cap is separated from the connecting rod, some chip may be missing or come loose. This does not cause any deterioration of the connecting rod function.

Handle connecting rod and caps with care. If impact damage arises on the fracture surface, this may affect the strength following torquing.

NOTE: Clean the connecting rod with compressed air only, never with a rag or equivalent.

⚠ **IMPORTANT!** Replace connecting rod if the stake or cap is damaged.

Connecting rod bushing, check measurement



1. Check the connecting rod with regard to cracks, straightness and twist before any replacement of connecting rod bushing. Discard the connecting rod if it is cracked, bent or twisted.

   When replacing connecting rod bushing, the bushing must be machined (connecting rod of trapezoidal shape).

   When the fit is right, the oiled piston pin will slide slowly of its own weight through the bushing.

⚠ **IMPORTANT!** Regarding max. allowed straightness and twist deviation, see ”Technical data”.

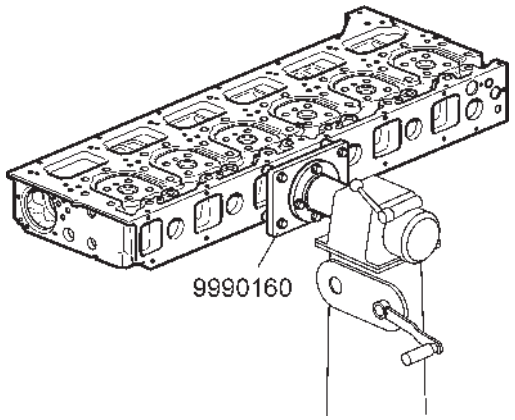
2. Use a new piston pin and measure the connecting rod straightness in a fixture.

3. Measure the connecting rod twist.

Valves, removal

Special tools:

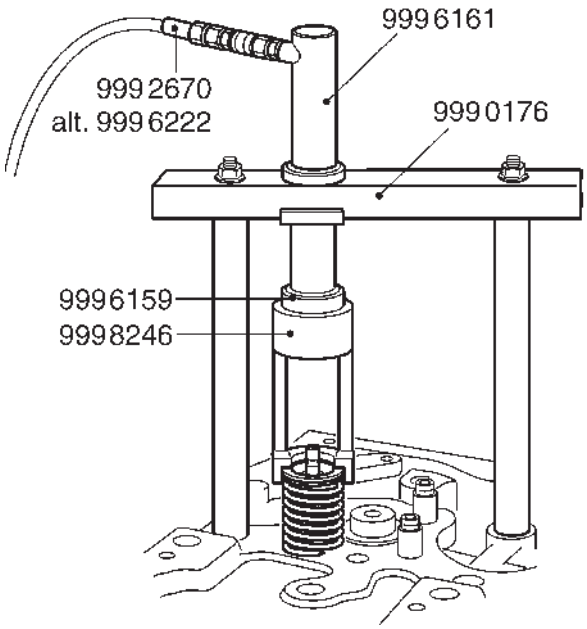
Fixtur	9990160
Hydraulic cylinder	9996161
Press tool	9990176
Adapter	9996159
Drift	9998246
Valve spring compressor	9990210
Hydraulic pump	9992670
alt.	9996222



The work will be facilitated if the cylinder head is held in an assembly stand with fixture 9990160. Use four screws M8x25.

NOTE: It is important to be very clean when working on the cylinder head. Dirt particles in the fuel channels can destroy or cause operational disturbances for the unit injectors.

Alternative 1



1. Install hydraulic cylinder 9996161 in the press tool 9990176.

2. Install pin 9996159 and drift 9998246 on hydraulic cylinder. Place the tool in the holes for the cylinder head retaining screws

   Tighten the tool's nuts.

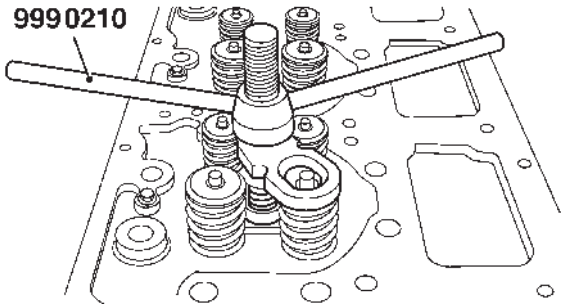
3. Connect a hydraulic pump, 9992670.

4. Press the valve spring washer down and remove the valve collets.

NOTE: Place valves and springs in a marked rack to facilitate reinstallation at the same place in the cylinder head.

5. Remove remaining valves the same way as above using the press tool.

6. Remove the oil seals from the valve guides.



Alternative 2

1. Place the cylinder head on a flat and clean surface. Make sure that the cylinder head is not scratched when the valves are removed.

2. Install press tool 9990120 in the unit injector hole. Attach the tool in the hole for the unit injector retainer, use a screw M10x30.

3. Place the tool's moving part above the valve spring to be removed. Turn down the tool's "wing-nut" until the valve disc has been pressed down and the valve collets can be removed.

NOTE: Place valves and springs in a marked rack to facilitate reinstallation at the same place in the cylinder head.

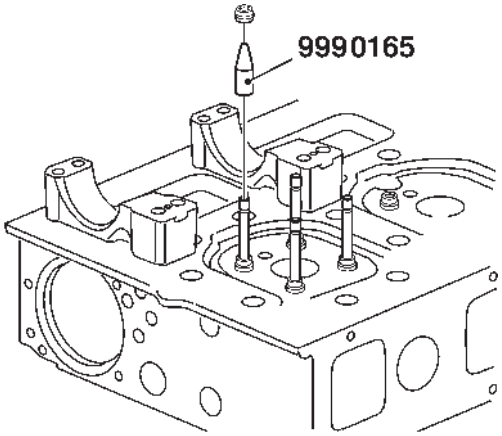
4. Remove remaining valves the same way as above.

5 Remove the oil seals from the valve guides.

Valves, fitting

Special tools:

Guide sleeve 9990165
Valve spring compressor 9990210



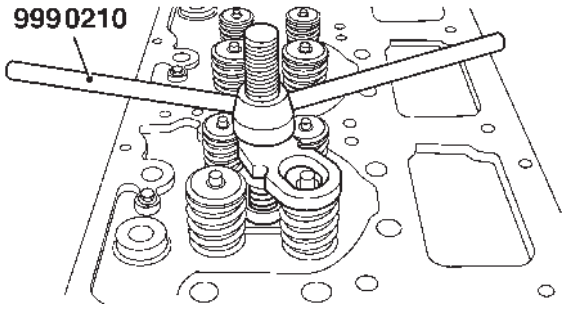
Alternative 1

1. Oil the valve stems and install the valves.
   Oil the oil seals.

3. Install tool 9990165 on valve stem and press down the new oil seals above the valve guides.

NOTE: Check that the oil seals have been pressed down all the way.

4. Fit the valve springs and valve spring washers.
   Press the valve disc down with care and fit the valve collets. Use 9990176 together with hydraulic cylinder 9996161, pin 9996159 and drift 9998246, the same way as during removal.

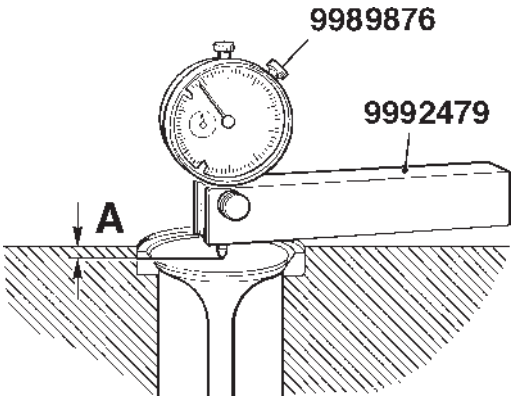


Alternative 2

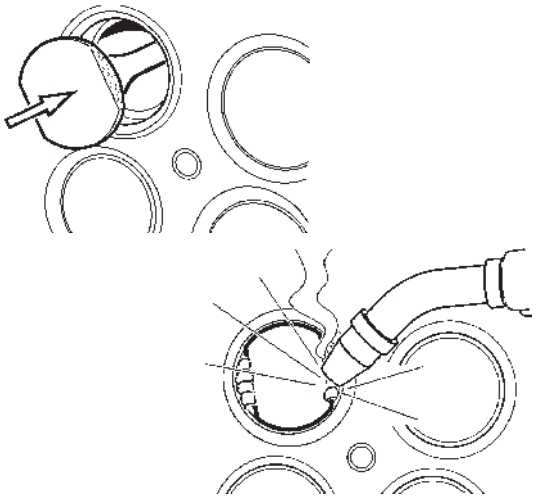
Alternatively, tool 9990120 can be used instead of hydraulic cylinder, the same way as during removal.

Valve seat, replacing

Cylinder head and valves removed

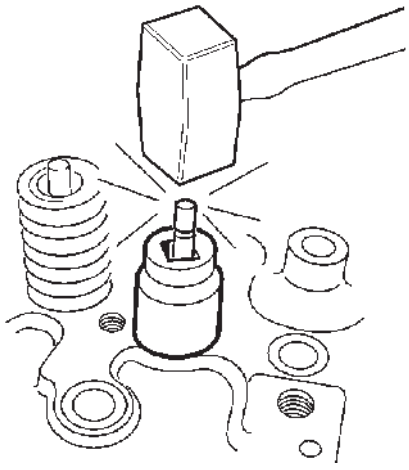


1. The valve seats should be replaced if you cannot get perfect sealing or when the distance "**A**" exceeds the value shown in the specification. See "Technical data".



2. Grind the disc on an old valve and weld it to the valve seat. Use a MAG weld or a conventional arc welder (with stainless welding electrode).

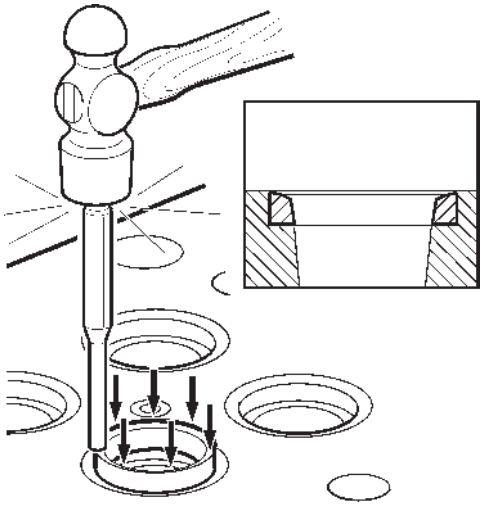
⚠ **IMPORTANT!** Carefully cover other cylinder head surfaces so that any weld splatter will not stick.



3. Place an appropriate socket over the valves/valve guides and **carefully** tap out the valve seat.

NOTE: Be careful not to damage the cylinder head.

NOTE: Use protective goggles.



4. Thoroughly clean the seat location and check the cylinder head for cracks.

5. Measure the diameter of the valve seat location in the cylinder head. With this measurement as a basis, check whether a standard size seat or an oversize seat is required.

   Machine the valve seat location as needed. See ”Technical data”.

6. Cool the seat in dry ice to between –60°C and –70°C (-76 °F and -94 °F) and heat the cylinder head by hosing it with hot water or some other suitable source of heat.

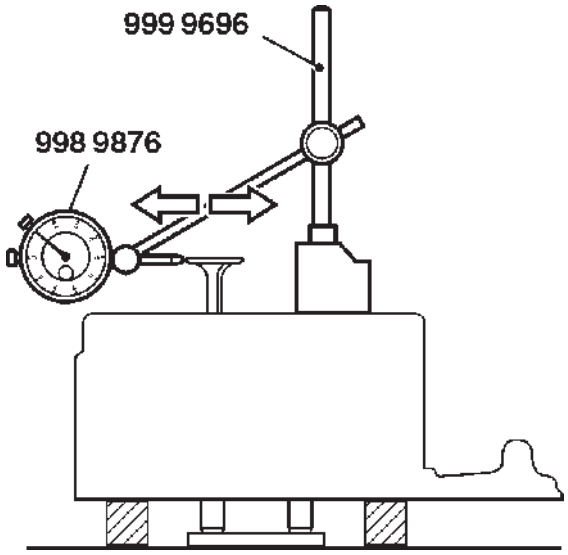
   Install the valve seat with a drift.

NOTE: Turn the seat with the seat angle towards the tool.

Valve guides, inspection

Cylinder head removed

Special tools:
Dial indicator 9989876
Magnetic stand 9999696



1. Remove the valve shaft seals from the valve guides.

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

⚠ **IMPORTANT!** The cylinder head must not be put down so its entire weight rests on the valve guides (see figure under point 4).

3. Place a **new** valve in the valve guides with the valve stem seal end in the same plane as the guides. Use appropriate anvil under valve stem.

4. Use a dial indicator with a magnetic stand, placing the tip of the dial indicator against the valve disc edge.

   Move the valve sideways in the direction of the outlet- or inlet ducts. Note the reading of the dial indicator.

5. Check all valve guides. If the measurements exceed the specifications shown, the valve guides should be replaced. See ”Technical data”.

Valve guides, replacing

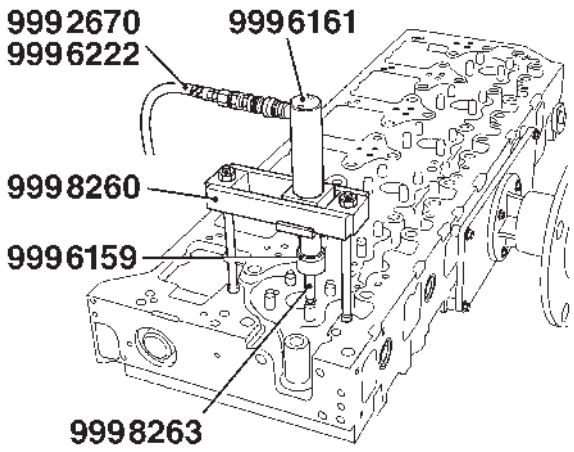
Cylinder head removed

NOTE: If the valve seats too will be replaced, this should be done before the valve guides are removed.

⚠ **IMPORTANT!** Use protective goggles when pressing the valve guides out or in.

Special tools:

Adapter 9996159
Hydraulic cylinder 9996161
Press tool 9990176
Drift, outlet 9990049
Drift, inlet 9990050
Drift 9998263
Hydraulic pump 9996222

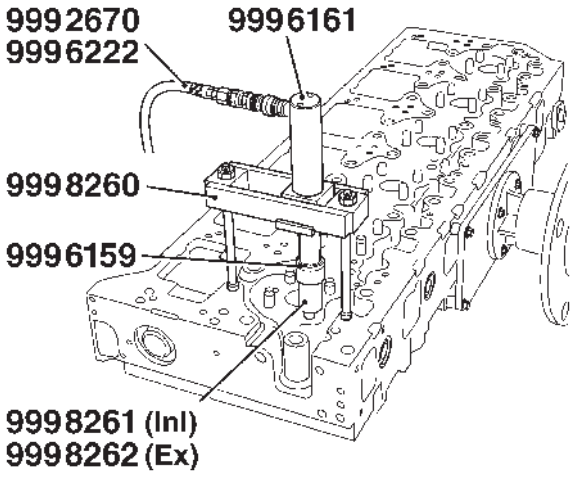


Removal

1. Install hydraulic cylinder 9996161 in tool 9990176.

2. Install pin 9996159 in hydraulic cylinder and press out valve guides with drift 9998263 and hydraulic pump 9996222.

   Press out the other valve guides the same way.



Fitting

3. Oil the valve guide outsides with engine oil before installation.

4. Cool the valve guides.

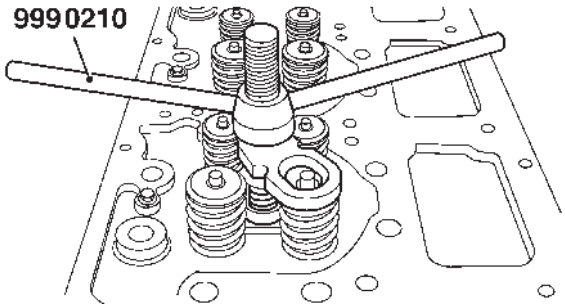
   Press in valve guides for the inlet valve using tool 9990049. The outlet valve guides are pressed in using tool 9990050.

   Press until the tool bottoms against the cylinder head plane.

⚠ **IMPORTANT!** Following replacement of the valve guides, the cylinder head must be cleaned to prevent particles from entering the fuel and oil channels. Contamination can destroy or cause operational disturbances for the unit injectors.

Valve stem seals, replacing

Special tools:
Guide sleeve 9990165
Valve spring compressor 9990210
Turning tool 9993590



1. Remove electricity from the engine by turning off the main circuit breaker.

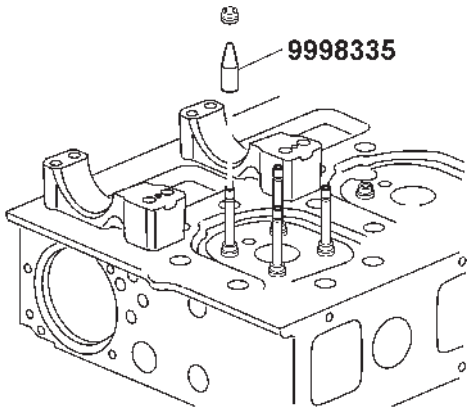
2. Remove unit injector, see “Unit injector, replacing”.

3. **NOTE:** The piston must be TDC when the valves are removed. This so the valves will not fall into the cylinder. Use turning tool 9993590.

4. Press down the valve springs for cylinder no.1. Use tool 9990210.

5. Remove the valve springs and the valve collets.

6. Remove the old valve shaft seals.



7. Oil the valve stem with engine oil.
Fit drift 9990165 on valve stem. Slip on the new seal and place it over the drift.

8. Install valve springs and valve collet. Carefully tap with a plastic hammer so that the valve collets are positioned correctly.

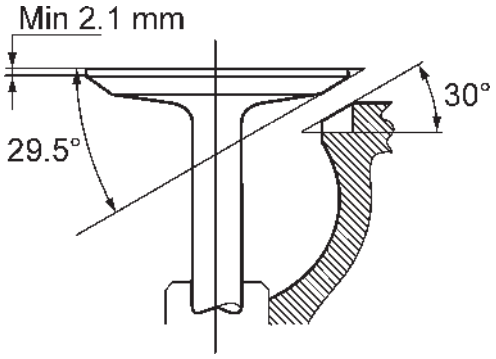
9. Move the valve spring compressor to cylinder no 6 and repeat the moments per above. Then turn the engine so that pistons 3 and 4 are in the TDC position.
Repeat the moments. Continue with cylinders 2 and 5.

NOTE: The piston must be TDC when the valves are removed. This so the valves will not fall into the cylinder. Use turning tool 9993590.

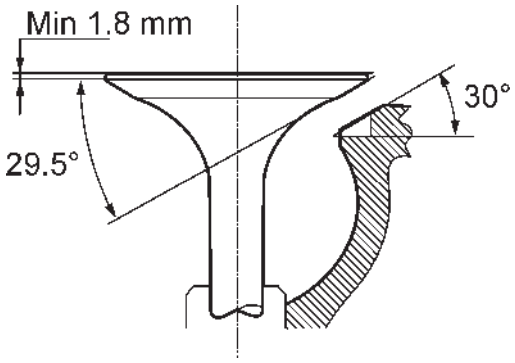
10. Install unit injector, see “Unit injector, replacing”.

11. Adjust valves and unit injectors, see “Valves and unit injectors, adjusting”.

12. Bleed the fuel system. Check for function and leakage.



Intake valve



Exhaust valve

Valve seat, grinding

NOTE: As spare parts, the valve seats are fully machined and should not need additional grinding.

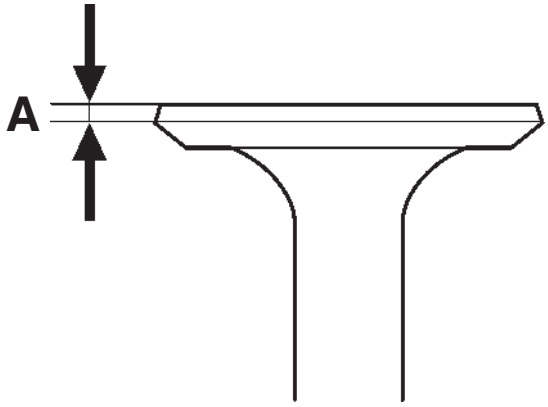
1. Before grinding, check the valve guides and replace them if the wear limits have been exceeded.

2. Grind the valve seat so you don't remove material needlessly, but just enough so the valve seat has the correct form and the valve disc good contact surface.

3. The valve seat is ground so that the dimension between the cylinder head plane and valve disc edge surface conforms to the specification.

4. Valve seat angle is checked with a valve seat gauge after coating the seat contact surface with a light layer of marking paint.

Valves, grinding



Regarding valve sealing angles, See ”Technical data”.

NOTE: As spare parts, the valves are fully machined and should not need additional grinding.

NOTE: Grind the sealing surface as little as possible. But enough that you remove all damage.

1. Check the dimension (A) on valve disc edge. If the dimension is less than the wear tolerance, as specified in ”Valve seat, grinding”, the valve should be replaced.

NOTE: Always replace a valve if the valve stem is bent.

2. Check valve straightness using marking dye. If leakage is found, regrind **the valve seat**, see ”Valve seat, grinding”, and then check again. When the grinding results are acceptable, the valve and seat can be ”lapped” together, with a fine grinding paste.

Cylinder head, pressure testing

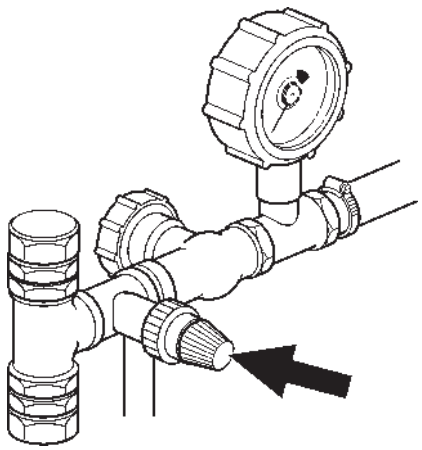
Special tools:

Pressure testing device 9990123
Lifting chain, 2 ea 9996239
Assembly stand 9986485
Fixture 9990160
Connection washer 9990107
Seal plate 9990106
Sealing washer 9809699

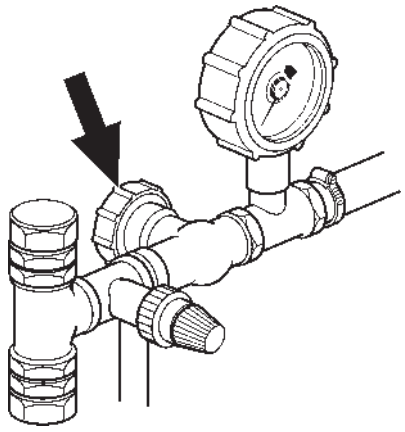
Checking pressure testing device

Check the pressure testing device 9990123 before using it:

1. Connect the pressure testing device to an air supply.



2. Set the pressure gauge to 100 kPa (14.5 psi) with the pressure reduction valve, the knob can be locked using a circlip that is moved axially.



3. Close the shut-off valve. The gauge pressure must not drop for 2 minutes for the device to be considered reliable.

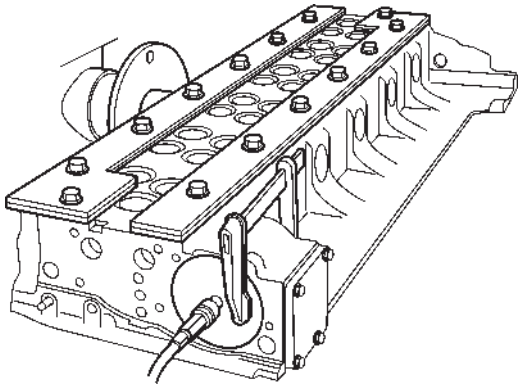
4. Unscrew the pressure reduction valve knob and open the valve.

Pressure testing

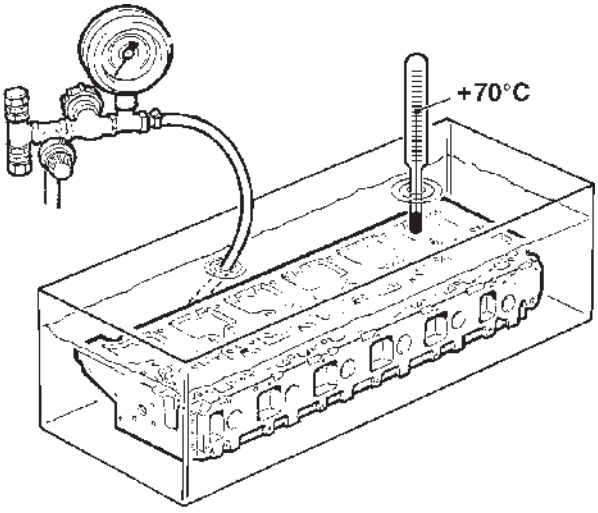
21111

Cylinder head removed.

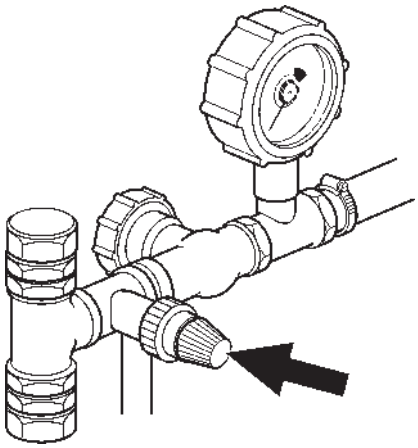
For all lifts of the cylinder head; use 2 lifting chains 9996239, see "Cylinder head, removal"



1. Wash the cylinder head.
2. Attach the cylinder head in assembly stand 9986485 using fixture 9990160 and 4 screws, M8x25.
3. Clean contact surfaces on the cylinder head.
4. Fit seal plates 9990105 on the cylinder head using the cylinder head screws and M16 nuts (14 needed).
5. Fit connection washer 9990107 where the thermostat housing goes. Fix the washer with a c-clamp, see figure.
6. Fit sealing plate 9990106 (if needed) in the thermostat housing.
7. Fit sealing washer 9809699 in the temperature sensor hole.
   Plug any coolant connections for the compressor.



8. Connect pressure gauge hose to connection washer 9990107.
9. Remove the cylinder head including fixture from the assembly stand.
   Remove the fixture.
10. Lower the cylinder head into a water bath, +70 °C (158 °F).
11. Connect air to the pressure testing device.
    Open the shut-off valve.
12. Adjust the pressure reduction valve knob so that pressure gauge shows a pressure of 50 kPa (7.25 psi).
    Maintain the pressure for one minute.



13. Increase the pressure to 150 kPa (22 psi). Lock the pressure reduction valve knob using the circlip.

    Close the shut-off valve.

14. After 1-2 minutes, check whether the pressure has dropped, or if bubbles of air can be seen in the water bath.

    If you see bubbles, check seal plates and inspect the cylinder head for any cracks.

15. Unscrew the knob on the pressure reduction valve to relieve the pressure in the cylinder head and open the cock.

16. Remove the cylinder head from the water bath.

    Attach the fixture.

    Attach the cylinder head in assembly stand.

17. Blow the cylinder head dry. Be extra particular with the fuel channels.

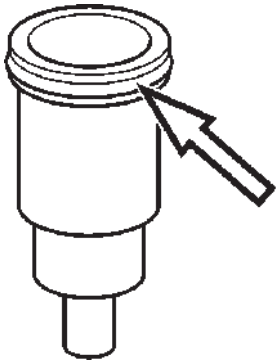
NOTE: Make sure that no dirt enters the fuel channel. This may damage the unit injectors.

18. Remove all the sealing washers and any plugs installed for the pressure testing

19. Remove the cylinder head including fixture from the assembly stand.

    Remove the fixture.

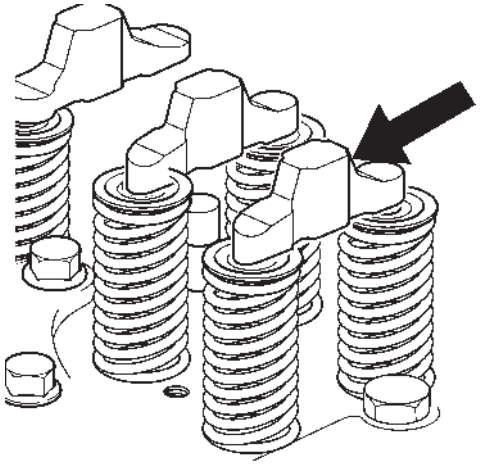
Copper sleeve for unit injector, replacing



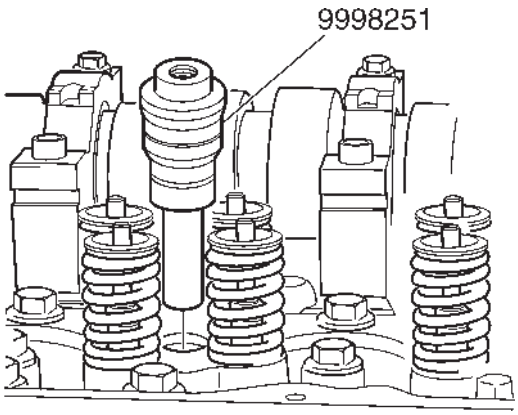
Unit injector removed

Special tools:

Thread cutting tool 9809667
Turning tool 9993590
Protective sleeve 9998249
Sealing ring 9998250
Thread cutting tool 9998252
Puller 9998253
Cleaning kit 9998599
Expander 9998688



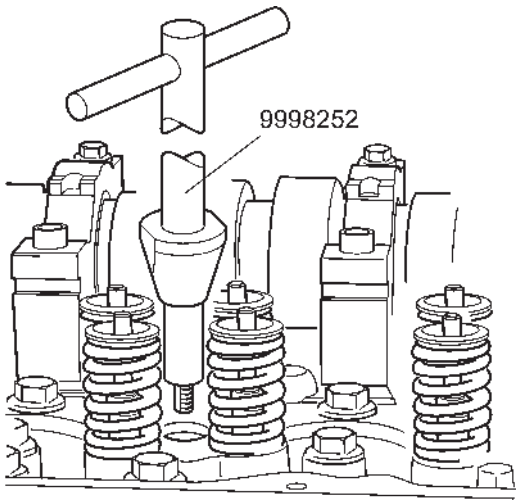
1. Drain the coolant using a hose, 9996049. See "Cooling system, draining".
   Mark and remove the valve yokes.



2. Remove protection plug 9998581.

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

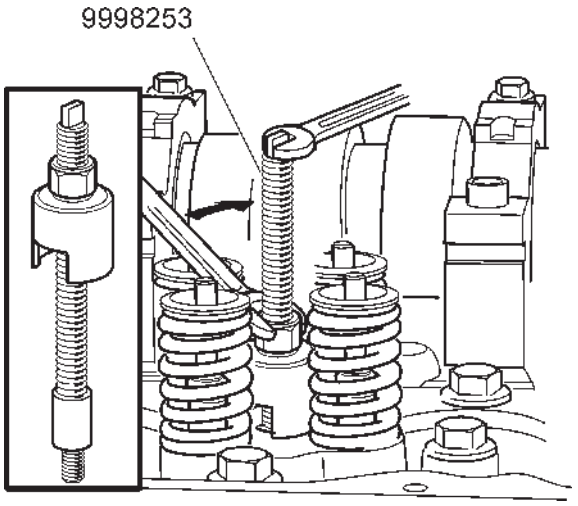
NOTE: Ensure that the piston is in its lower position.



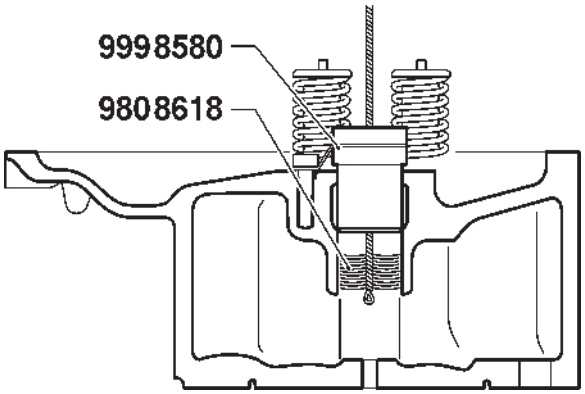
4. Lubricate thread cutting tool, 9809667, with grease in order to prevent chips from falling into the cylinder.
   Screw in thread cutting tool at least 20 mm (0.8 in) in the copper sleeve with tool 9998252.

NOTE: Use thread cutting tool 9809667.

5. Remove tool 9998252 and thread cutting tool.



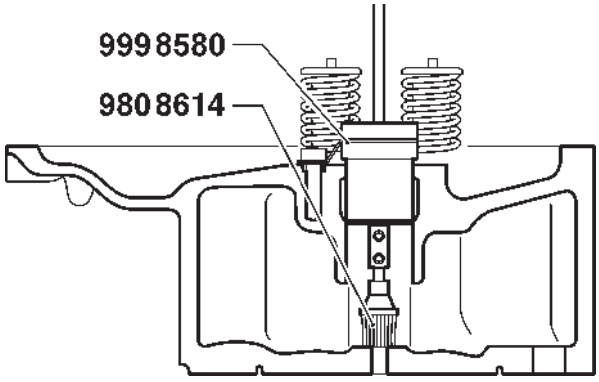
6. Check that the pin 9809668 is installed on 9998253.
   Screw in the pin on tool 9998253 **at least 15 mm (0.6 in)** into the copper sleeve. Remove the copper sleeve by turning the nut while holding the pin.



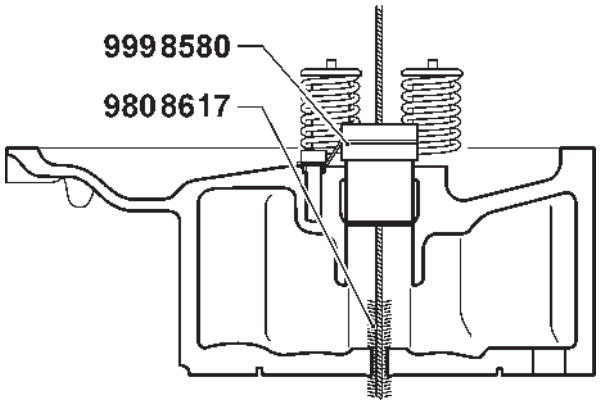
7. Use cleaning kit 9998599 and a power drill before the new copper sleeve is installed.
   Install cleaning sleeve 999,8580 in the injector well and fix with holder (”the ears” must be cut off so the tool will fit).

NOTE: Tools 9808580 should be used to prevent dirt from entering the fuel channel.

8. Clean the cylinder head walls for the copper sleeve using 9808618.

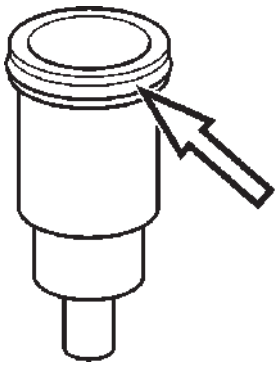


9. Clean the copper sleeve seat with brush 9808614 together with handle and the holders.



10. Clean the cylinder head hole with brush 9808617.

11. Remove the tools 980580.

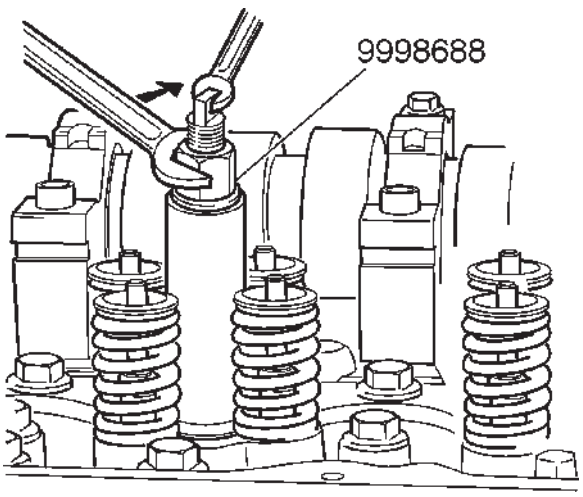


12. Check that the piston is located in its lower position in the cylinder.

NOTE: This should be done so that tool 9998688 does not damage the piston due to its length.

13. Lubricate in the **new** seal ring on copper sleeve with soapy water.

14. Place the copper sleeve on tool 9998688



15. Oil the pin on tool 9998688. Lubricate between nut and tool.

16. Press the copper sleeve down **carefully** so that the drifts are guided towards the unit injector space (the edge) in the cylinder head. Check that copper sleeve bottoms in the cylinder head. Install unit injector yoke and tighten.

17. Enlarge the copper sleeve with a drift by screwing on the nut while the spindle is held steady until the enlarging drift has been pulled all the way through.

NOTE: After fitting new copper sleeve, follow instructions for ”torquing of unit injector yoke” in Technical data

18. Remove the sealing rings 9998250.

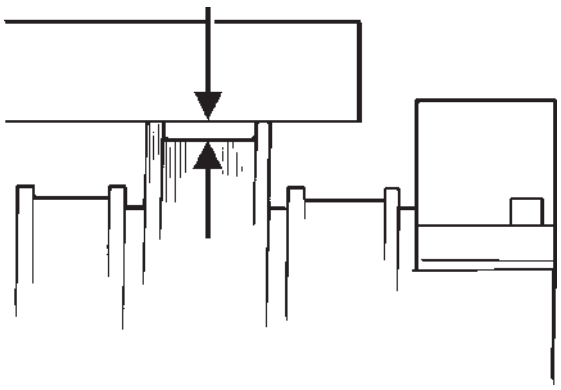
19. Re-install the valve yokes as marked.

20. Install the unit injector. See ”Unit injector, replacing”.

21. Install the rocker arm shaft and check clearances for valves and unit injectors.

22. Install the valve cover.

23. Fill coolant and check for leaks.



Camshaft, checking for wear

Rocker arm shaft removed

Place a steel ruler above the ridges in the camshaft's lengthwise direction in order to check if the cam profiles are worn.

Measure wear using a feeler gauge or wire gauge. As an alternative you can use a digital depth slide gauge.

Compare the measured values with the values shown in "Technical data".

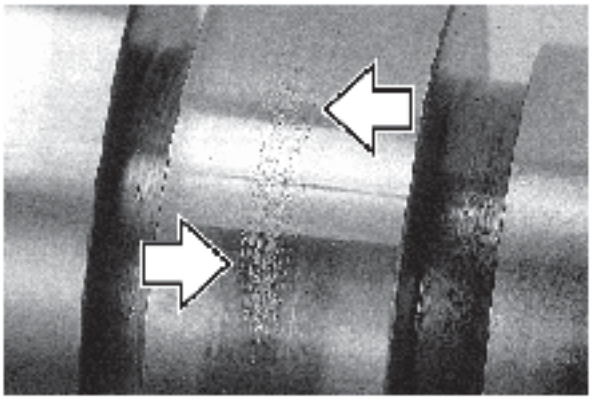
Replacement guidelines

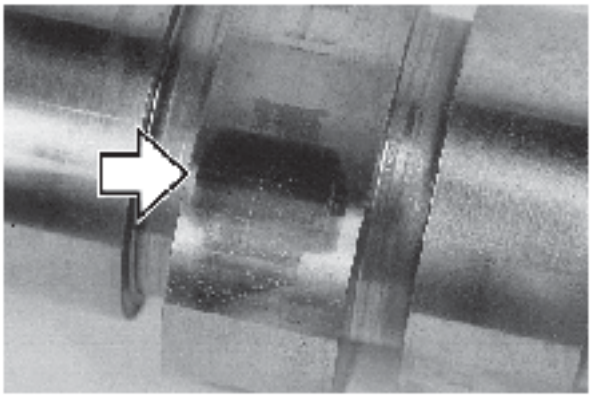
Under normal circumstances, irregularities on the surface of the engine's cam shaft ridges. This does not mean that the camshaft must be replaced. These marks have no detrimental effect on either the engine's performance or durability of the engine and its components.

Examples of acceptable wear and unacceptable wear are shown below.

Acceptable wear.

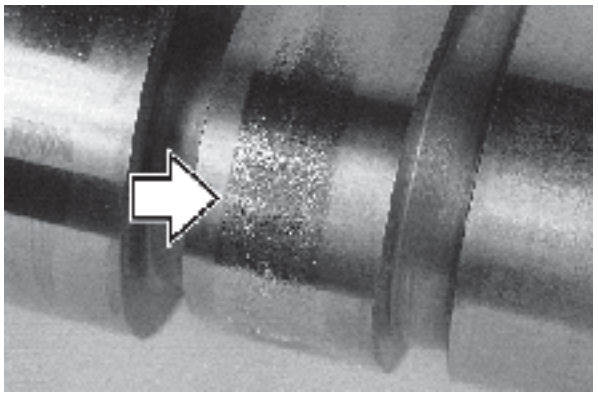
The camshaft does not need to be replaced.

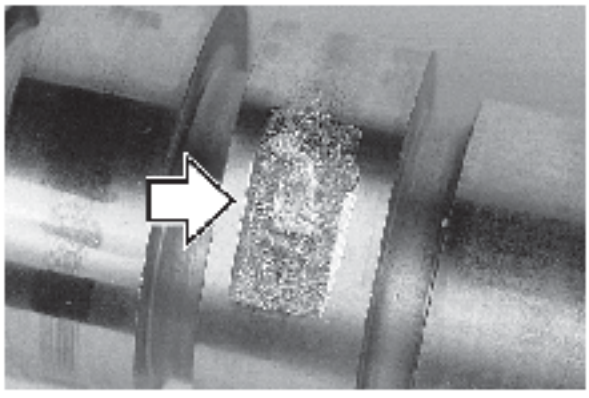




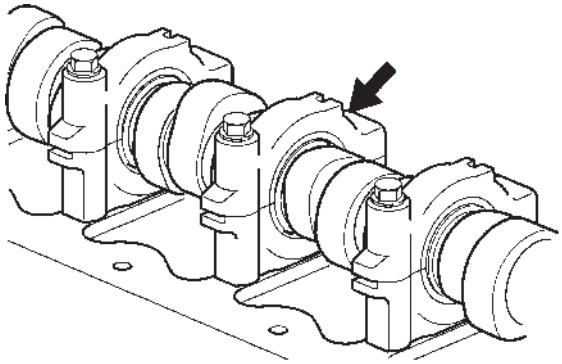
Unacceptable wear.

NOTE: Camshaft with rocker arms must be replaced.



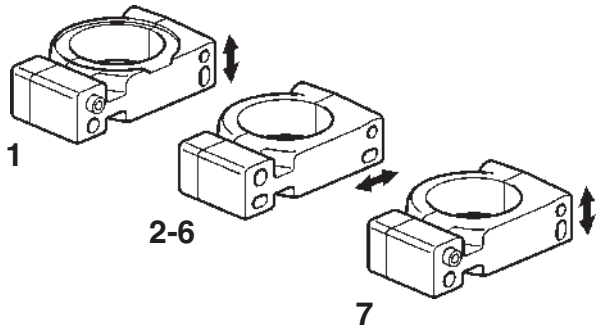


Camshaft bearing housing, replacing



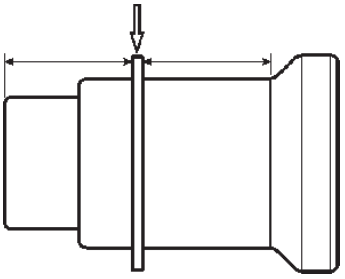
Factory installed bearing housings have been machined with the cylinder head and must not be moved from one cylinder head to another.

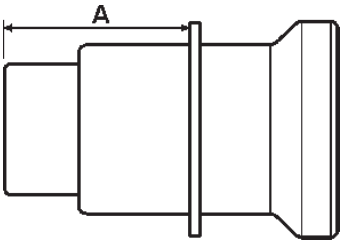
Therefore, the first time one or more bearing housings are replaced, all bearing housings must be replaced so that the positions of the bearing housings can be inscribed. Bearing housings can then be replaced individually.

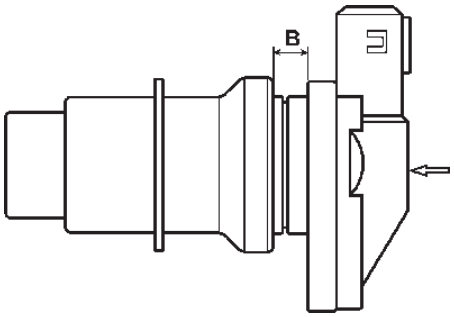


The holes for the guide sleeves are oval in the replacement housings, which allows radial adjustment of the middle bearing housing and axial adjustment of the front and rear bearing housings.

If a replacement housings is being installed, mark them with numbers so that they can be reinstalled in the same place as before if they must be removed.







Camshaft sensor distance, checking

1. Turn the engine so that a tooth on the camshaft drive is aligned with the cam shaft sensor hole on the upper transmission gear casing.

2. Slide the installation tool circlip so that it is placed in the middle of the tool.

3. Place the tool in the camshaft sensor hole and press it in with care until it touches the vibration damper tooth.

4. Remove the tool and measure the distance between the sensor contact surface and the end of the tool.
   Write down the value measured (A).

5. Place the sensor in the tool and measure the distance between the sensor contact surface and the end of the tool (B).

6. Calculate existing sensor distance (D) as follows:
   D = A – (B + 20 (0,78740157480315 “)) mm.
   Example:
   Distance A = 28,2 mm (1,11023622047244 “)
   Distance B = 8 mm (0,31496062992126 “)
   D = 28,2 (1,110 “) – (8 (0,3150 “)+ 20 (0,7874 “)) mm
   D = 0,2 mm (0,0079 “)

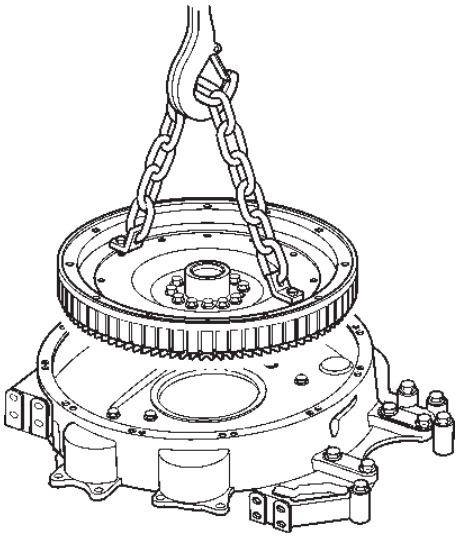
7. Compare the value with correct value per ”Technical data”. Adjust as needed using shims. Install the sensor together with any shims.

Clearance measured	Adjusting shims	
	Quantity	item no.
0,2 - 1,0 mm (0,0787 “ – 0,0394 “)	-	-
-0,3 - 0,3 mm (-0,0118 “ - 0,0118 “)	1	1677894
-0,6 - (-0,3 mm) (-0,0236 “- (- 0,0118 “))	2	1677894

Transmission, replacing

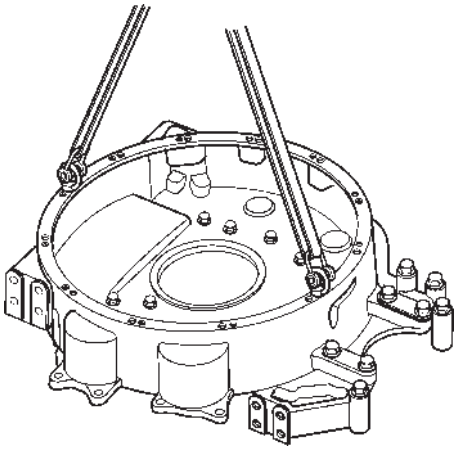
Valve cover, cable harness, upper transmission casing, camshaft sensor and oil pan have been removed.

Removal

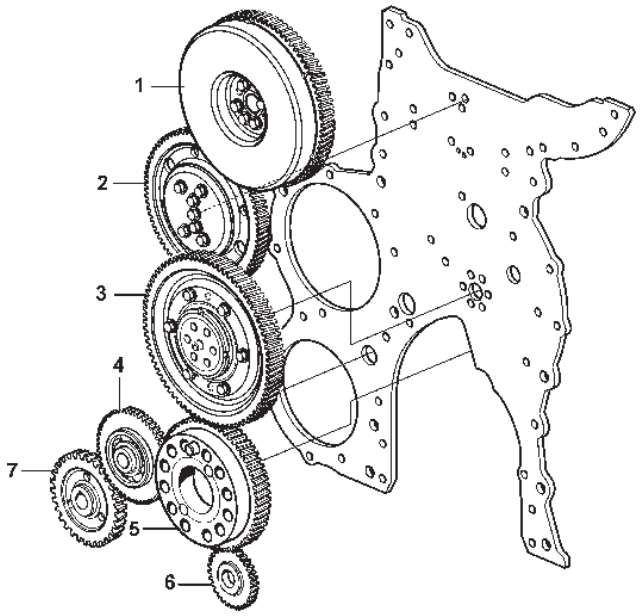


1. Remove the flywheel sensor.
2. Turn the engine to TDC on the camshaft, check that the mark on the flywheel is at ”0”.
3. Secure lifting chain 9996239 in the flywheel. Remove the flywheel.

⚠ **WARNING!** Pinching hazard. The flywheel weighs about 40 kg (90 lbs)



4. Remove the starter motor, rear lifting eyes, fuel pump together with the servo pump, the cover and any rear engine mounts.



1. camshaft drive
2. upper intermediate gear
3. intermediate gear, double
4. lower intermediate gear
5. crankshaft drive
6. oil pump drive wheel
7. drive wheel for fuel feed pump / servo pump

5. Remove flywheel casing screws. Remove the casing using lifting eyes and lifting strap.

6. Remove the lower intermediate gear (4).

7. Remove the two socket head cap screws on the crankshaft drive (5) and remove the drive using puller 11159911.

NOTE: To protect the puller thread, place a thick washer between the piston ring tool and the crankshaft.

8. Remove the six socket head cap screws in the hub of the double intermediate gear (3) and remove it complete.

9. Remove the upper intermediate gear (2).

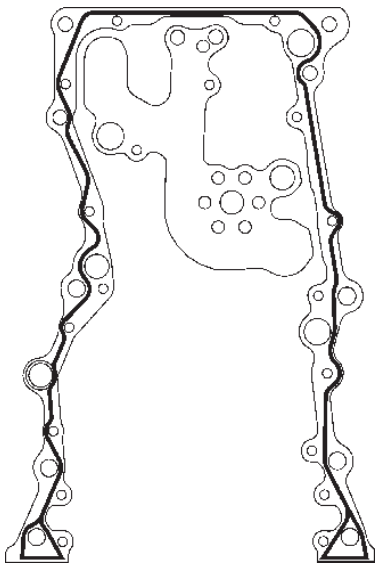
NOTE: Save the spacer plate behind the drive and write down how it is installed.

10. Remove the camshaft drive (1).

11. Remove the transmission plate and clean both sides.

Fitting

NOTE: Lubricate the inside of the gears before you place them.

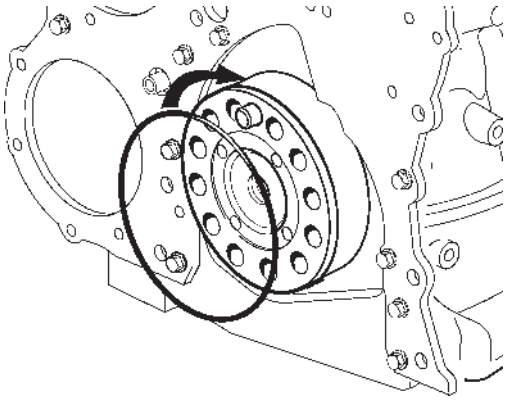


1. Apply a 2 mm (0.080") thick bead of sealant on the engine block as illustrated

2. Install the transmission plate. Use new screws that are pre-treated with locking compound. Torque as specified in “Technical data”.

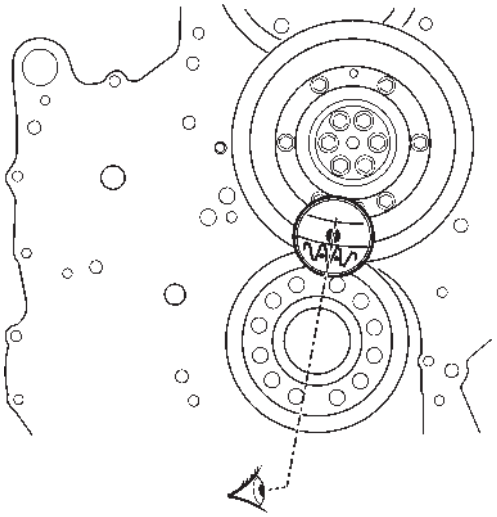
NOTE: Make sure that the plate is aligned with the bottom edge of the block.
NOTE! Torque within 20 minutes after sealant has been applied.

3. Oil the spacer plate and place it together with the upper intermediate gear (2). Torque gently, max 10 Nm (7,38 lbf ft).



4. Install a new o-ring on the crankshaft.

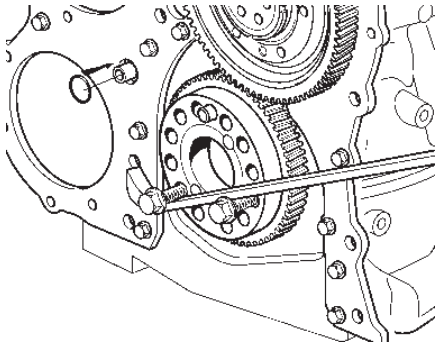
5. Fit the camshaft drive (5) and torque socket head cap screws as specified in “Technical data”.



6. Install the double intermediate gear (3) with the hole marking between the two hole markings on the crankshaft drive.

NOTE: The double drive inner and outer gears, respectively, have different gear pitch. For the camshaft to be set correctly, the markings must be correct.

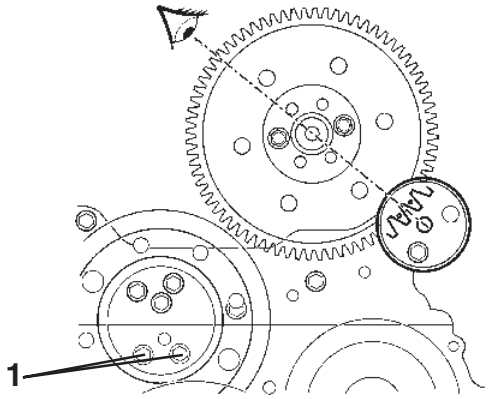
Torque the screws as specified in “Technical data”.



7. Install the bottom intermediate gear (4) with a new O-Ring.

8. Install the lubricating oil pump together with the rear main bearing.

9. Place two screws in the crankshaft drive so you can attach a crowbar and thus be able to turn the crankshaft as needed.

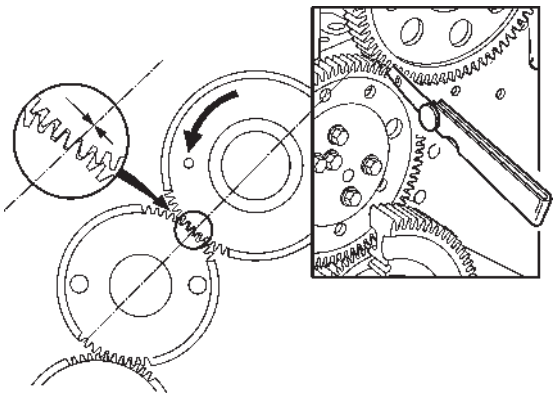


10. Fit the camshaft drive (5) without the vibration damper, use nuts for spacers.

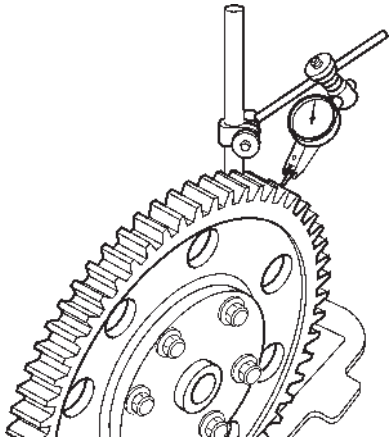
11. Place the drive so that the reference hole in the transmission plate lies between the drive markings.

    Tighten two screws temporarily with low torque, max 10 Nm (7.376 lbf ft).

12. Remove the 2 lower screws (1) in the adjustment wheel. Check that the upper screws are not tightened.



13. Place a 0.1 mm feeler gauge on the pressure side.
    Turn the camshaft drive counter-clockwise. This will move the adjustable intermediate gear to the correct position.
    Torque the adjustable intermediate gear per step 1 in "Technical data" and check axial play per previous point. Remove the feeler gauge.

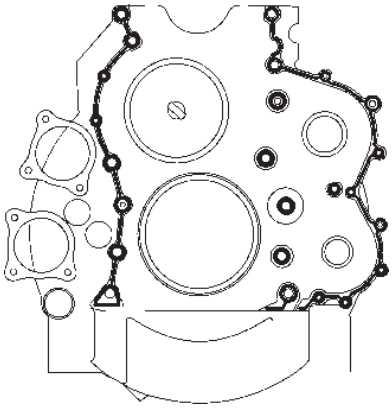


14. Fix the adjustment wheel.

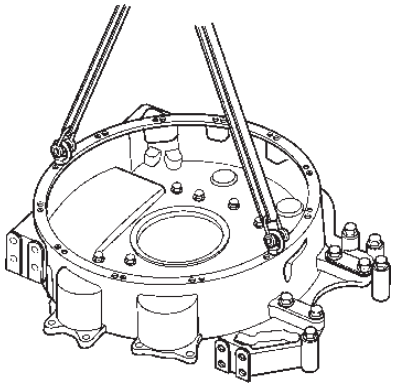
    Place a dial indicator on the camshaft drive, as illustrated.

    Turn the drive back and forth and compare the result against the specification for gear backlash in ”Technical data”.

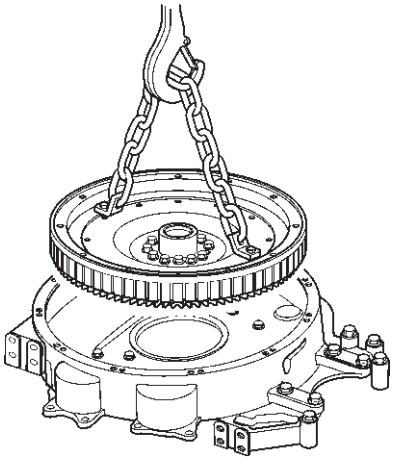
15. If gear backlash is correct; torque the screws on the intermediate gear (1) per step 2 in ”Technical data”.



16. Apply new sealing compound to the flywheel casing, towards the engine block.



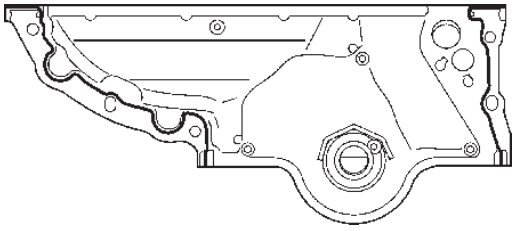
17. Install the flywheel casing. Check that the casing is aligned with the engine block plane. See ”Flywheel casing, checking for warp”.



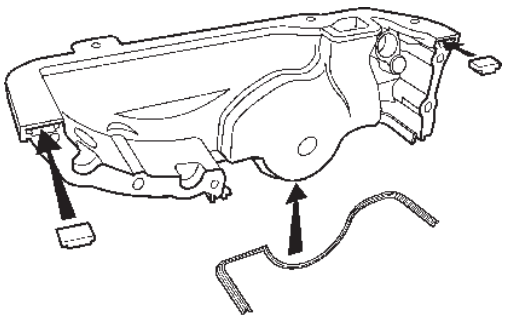
18. Install new crankshaft seal.

19. Install the flywheel and torque as specified in Technical data.

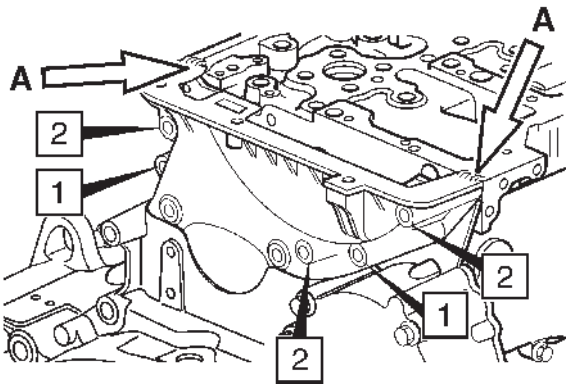
20. Fit the vibration damper. Torque as specified in Technical data.



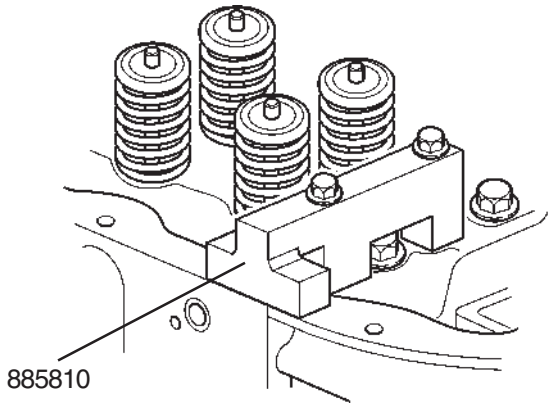
21. Apply a 2 mm (0.080") thick bead of sealant to the upper transmission gear casing contact surface, as shown.



22. Fit the rubber seals and install the upper transmission gear casing.



23. Only fit the screws (1) and tighten by hand. (The holes are oblong so that you can press the casing down towards the rubber seal.)



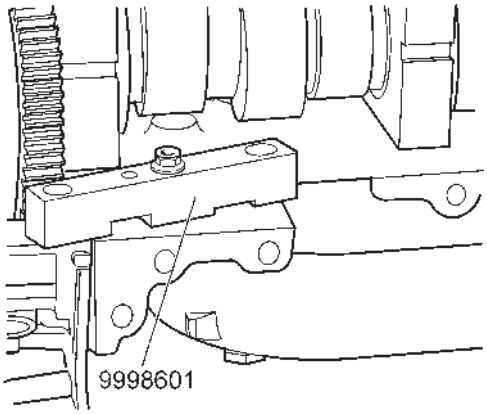
24. Remove the mounting bracket for the distribution house.

    Press the casing down with the tools 885810 and 998601 so that the cylinder head and the upper transmission gear casing sealing surfaces are aligned.

    Refit the other bolts (2).

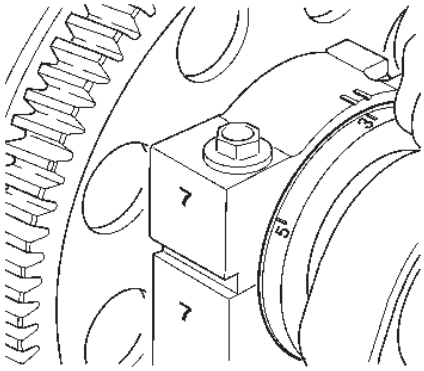
    Torque as specified in “Technical data”.

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



25. Install camshaft sensor and adjust per ”Camshaft sensor, checking”.

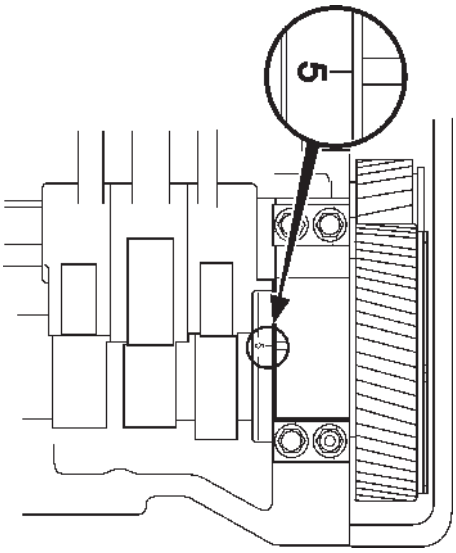
Adjustment, general



Timing marks

The camshaft has six markings, 1-6 for each cylinder, for adjustment of the inlet and exhaust valves, double rocker arm and unit injectors.

NOTE! It is important that the line marked on the camshaft is centred between the two markings on the bearing cap when adjustment is done.



Adjustment

NOTE! Inlet valves, exhaust valves, double rocker arm and unit injectors are adjusted at the same time for each cylinder.

This instruction covers adjustment of valves, double rocker arm and unit injectors in the following order:

1. Inlet valves
2. Exhaust valves
3. Double rocker arm (only TAD950-952VE)
4. Unit injector

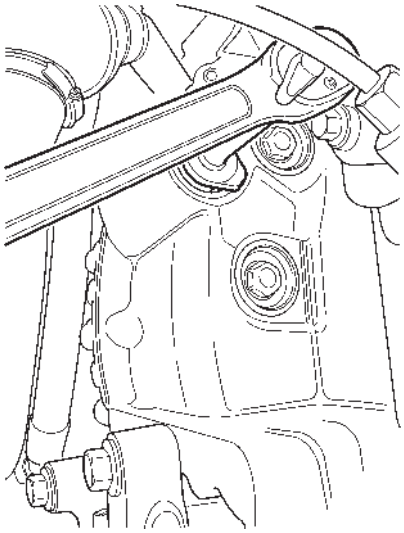
Adjustment should be done in the order marked on the camshaft when the engine is turned in the direction of rotation.

By doing adjustments in this order, the crankshaft does not need to be rotated more than two turns to adjust all valves and unit injectors.

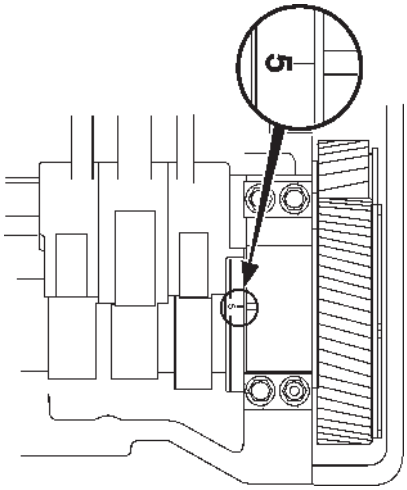
It is a good idea to use a marker pen to mark the rockers which have been checked or adjusted.

Valves, adjustment

Special tools:
Turning tool 9993590



1. Remove the protective cover from the flywheel housing and install turning tool 9993590, an extension and a ratchet handle.

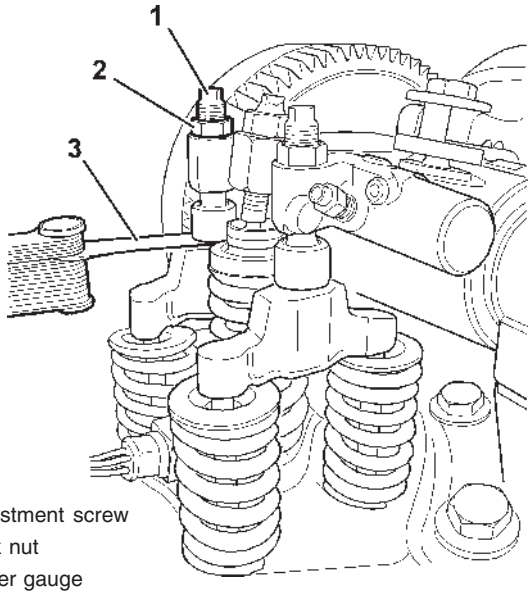


2. **Inlet valve**

   Turn the flywheel with turning tool 9993590 until the first marking on the camshaft is centered between the markings on the bearing cap.

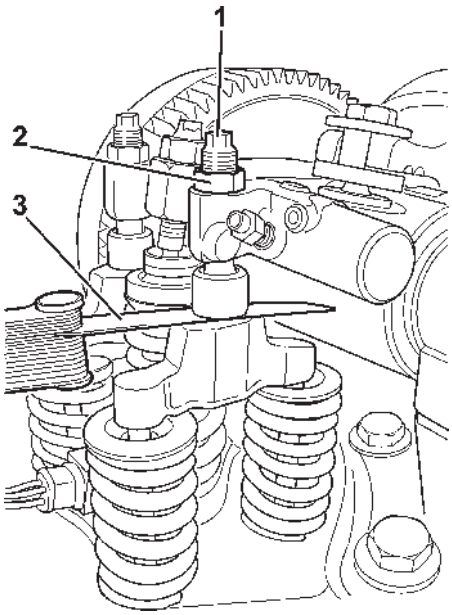
NOTE! The figure corresponds with the cylinder for which the inlet and exhaust valves are in the correct positions for adjustment.

NOTE! Cylinder no 6 is closest to the flywheel.



1. Adjustment screw
2. Lock nut
3. Feeler gauge

3. Undo the locknut and adjust to give the correct valve clearance. Tighten the lock nut.

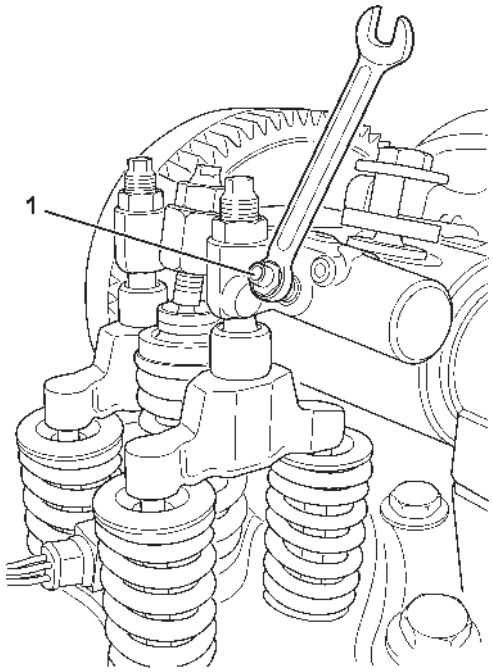


1. Adjustment screw
2. Lock nut
3. Feeler gauge

4. **Exhaust valve**

   Undo the lock nut on the rocker arm and adjust to give the correct valve clearance.
   Tighten the lock nut.

5. Check the valve clearance again after the first 1000 hours and then check every 4000 hours.

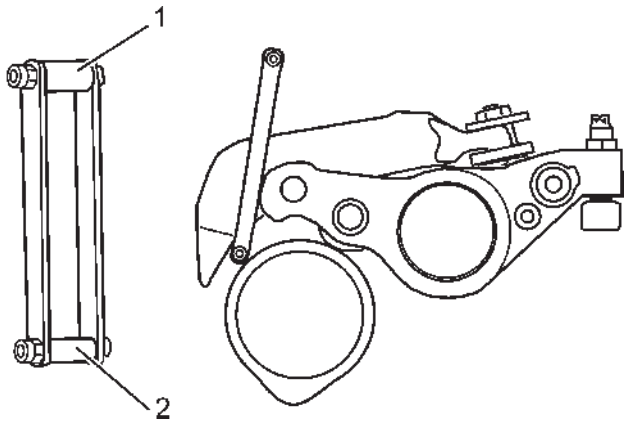


Double rocker arm, inspection (IEGR)

Special tools:
Gauges 88820016

NOTE! The exhaust valve must be correctly adjusted.

1. Undo the drain nipple and drain the air and oil out of the rocker arm.



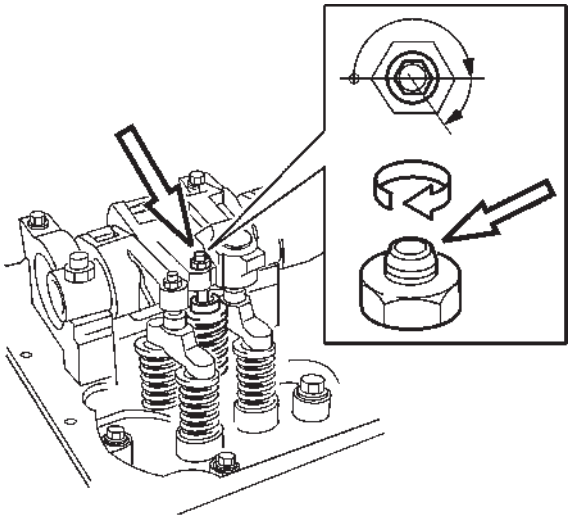
2. Insert the “go” side of gauge no. 88820016 between the mating surface of the double rocker arm and the camshaft base circle. The gauge **must be able to pass** between. If it can not, the “iEGR” lift is too great.

3. Insert the “stop” side of gauge no. 88820016 between the mating surface of the double rocker arm and the camshaft base circle. The gauge **must not be able to pass** between. If it can, the “iEGR” lift is too small.

4. Correct clearance for double rocker arm (between rocker arm mating surface and camshaft base circle) measured with gauge no. 88820016:
   - “go” side passes
   - “stop” side does not pass

   If the clearance is not correct, please refer to ”Double rocker arm, adjustment”.

5. Tighten the drain nipple as in the specification in “Technical data”.



6. Adjust the unit injector rocker arm to zero clearance. Tighten the adjustment screw a further 3-4 spanner flats (180°-240°).

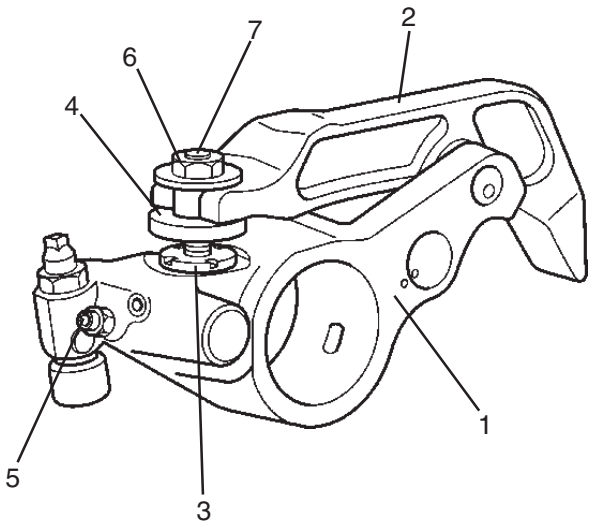
   Tighten the nut on the adjustment screw.

7. Turn the engine to the next timing mark, adjust the other valves and check the double rocker arm clearance in the same way.

Double rocker arm, adjustment

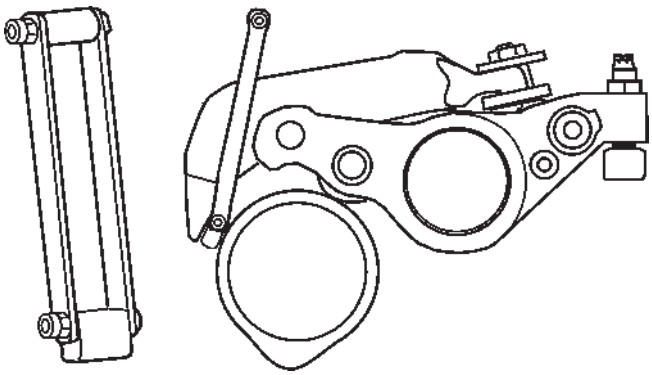
Special tools:
Gauges 88820016

NOTE! The drain nipple on the double rocker arm must be open during adjustment.



1. Exhaust rocker arm
2. Following arm
3. Stop nut
4. Sleeve
5. Drain nipple
6. Lock nut
7. Piston

8. Keep the camshaft in the same position as for adjusting the valve clearance.
   Undo the locknut and retain the piston with an Allen key.



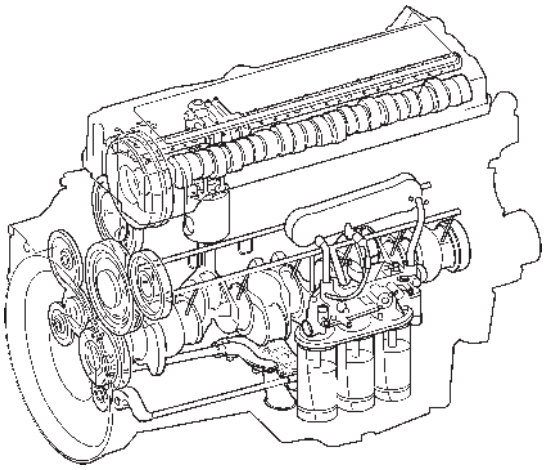
9. Insert gauge no. 88820016 between the mating surface of the double rocker arm and the camshaft base circle. Turn the piston with the Allen key to give zero clearance between the double rocker arm, gauge and camshaft.

NOTE! Zero clearance means that the gauge slides slowly between the double rocker arm and the camshaft.

10. Tighten the locknut at the same time as the piston is retained in its correct position. Please refer to the “Technical Data” chapter for specifications.

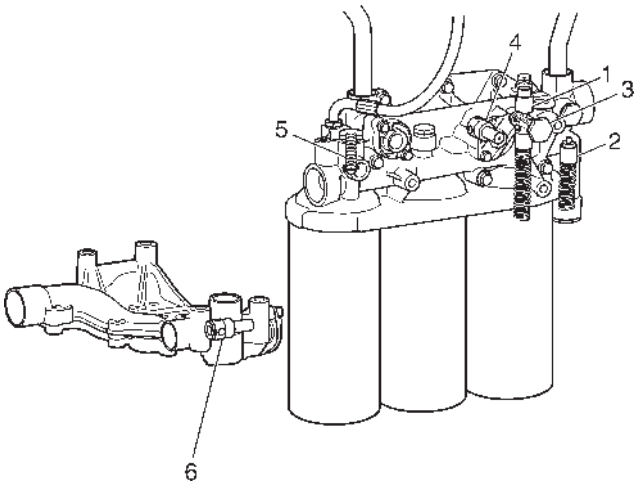
11. Check, please refer to “Double rocker arm, checking”.

Group 22: Lubrication system



When working with chemicals, fuel and lubricating oil

⚠ **Important!** Lubricate hands with a barrier cream and always use protective gloves during work where you risk contact with oil, fuel, etc. Continuous skin contact with engine oil dries the skin and can be damaging.

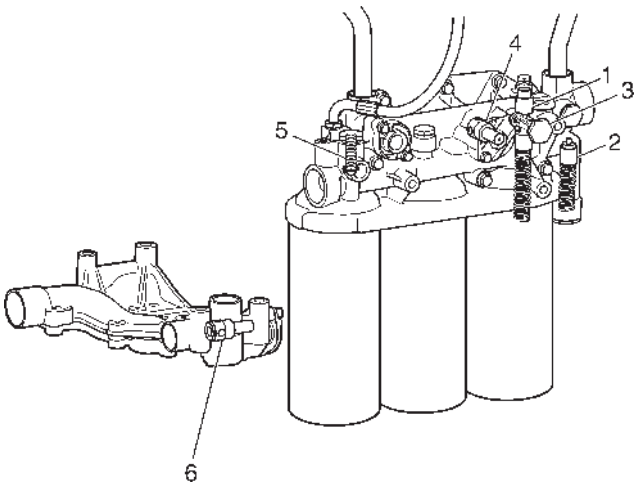


Overview, control valves

1. Control valve for piston cooling
2. Opening valve for piston cooling
3. By-pass valve for oil filter
4. Reduction valve, oil (marked with blue dot)
5. Bypass valve, oil filter by-pass
6. Safety valve, oil pressure (marked with purple dot)

Pressure reduction valve, replacing

1. Clean the area around the reducing valve (4).
2. Remove the pressure reduction valve.
3. Clean the valve contact surface in the oil filter housing. Check that the old seal is not left.
4. Check that the color marking on the new valve matches the old.
5. Fit the new the valve with a new seal ring. Check that the internal seal does not come loose when the valve is installed.
   Torque the screws as specified in “Technical data”.
6. Start the engine and check for leaks.



By-pass valve oil filter, replacing

1. Remove the pressure pipe to the turbo.
2. Clean the area around the bypass valve (5).
3. Remove the bypass valve.
4. Clean the valve contact surface in the oil filter housing.
5. Fit the new the valve with a new seal ring and tighten the nut as specified in Technical data.
6. Tighten the turbo pressure pipe.
7. Start the engine and check for leaks.

Oil pressure safety valve, replacing

1. Remove dipstick bracket.

2. Disconnect the oil level sensor and remove the cable harness from the holders on the oil pan.

3. Drain the oil and remove the oil pan.

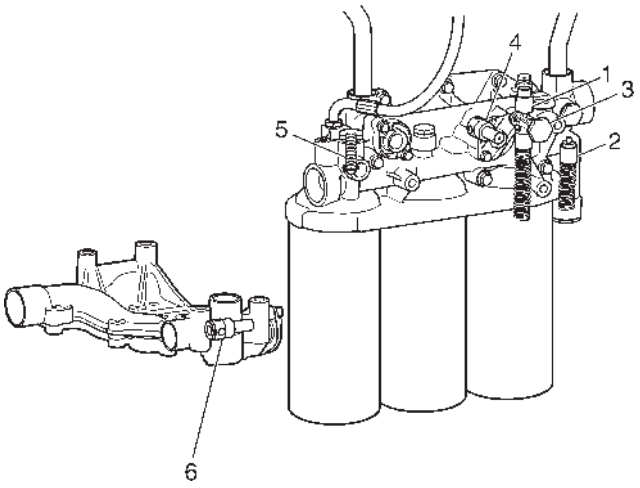
4. Clean the area around the valve (6) and remove it.

5. Clean the valve contact surface.

6. Check that the color marking on the new valve matches the old.
   Fit the new valve and torque as specified in ”Technical data”.

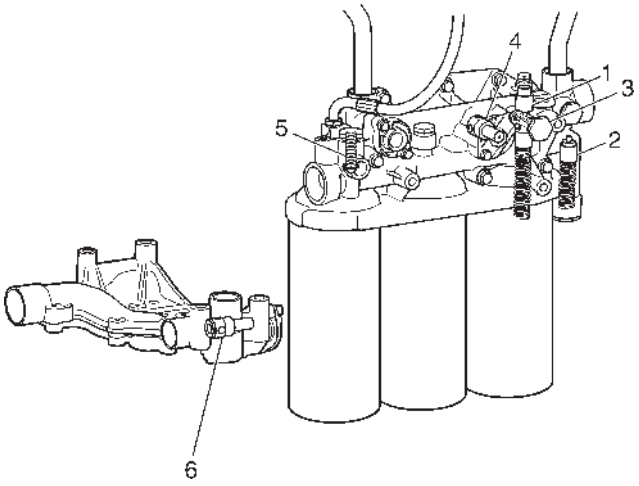
7. Check the oil pan seal.
   Install oil pan, dipstick and oil level sensor cable

8. Add motor oil and start the engine. Check that there is no fuel leakage.
   Check the oil pressure, see ”Oil pressure, checking”



Piston cooling valves, replacing

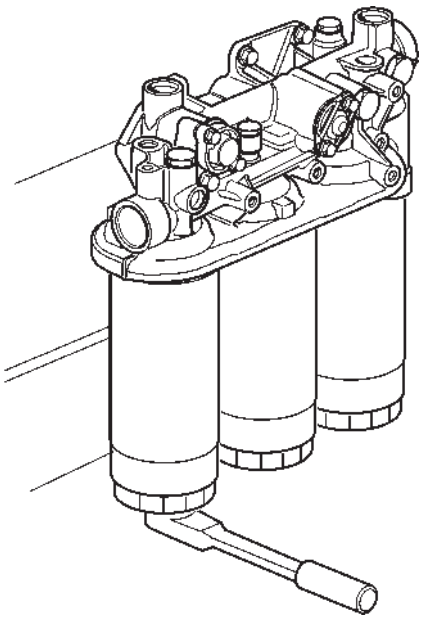
1. Clean around the oil filter bracket and the piston cooling valves.
2. Remove the filter bracket.
3. Remove the two piston cooling valves: control valve (1) and opening valve (2).
4. Clean valve seats in the oil filter bracket.
5. Fit new valves with new seal ring, torque as specified in “Technical data”.
6. Re-install the oil filter bracket, with new gasket and new sealing rings.
7. Start the engine and check for leaks.



By-pass valve oil filters, full flow, replacing

1. Clean the area around the bypass valve (3).
2. Remove the valve and clean the valve seat in the oil filter bracket.
3. Fit a new valve with a new seal ring.
   Torque as specified in ”Technical data”.
4. Start the engine and check for leaks.

Engine oil and oil filters, replacing 22231



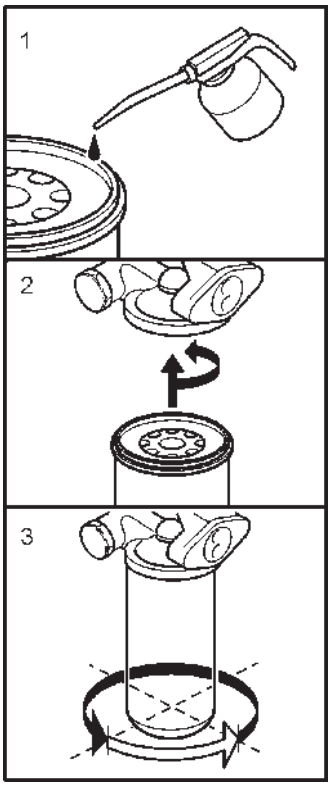
Special tools:

Socket 9998487
Filter pliers 9999179

1. Remove the drain plug and drain engine oil into an appropriate container immediately after running when oil is warm and flows more easily.

⚠ **WARNING!** warm oil and hot surfaces can burn your skin!

2. Clean around the filter bracket and remove the filters. Use 9998487 or filter pliers



3. Fill the new the filters with engine oil and apply some to the gaskets (1).

4. Tighten the filters by hand until they touch the bracket contact surface (2).
   Tighten them by hand another **3/4 to one full turn** (3).

5. Re-install the drain plug. Add engine oil to correct level.

6. Connect a switch to the starter motor and use it to crank the engine until the oil pressure is registered by the oil pressure gauge. This means that the oil filters are full.

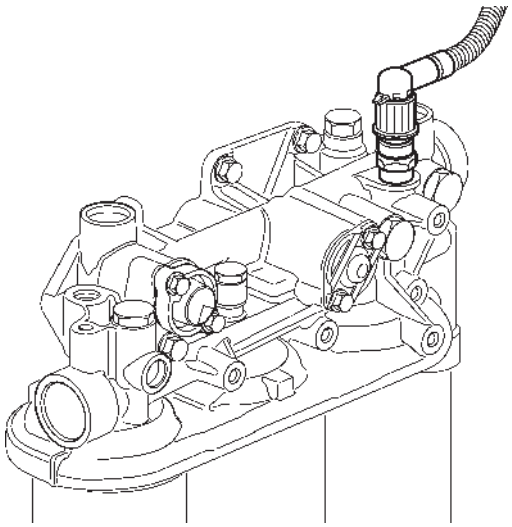
OBS! See chapter “Troubleshooting / Tests and adjustments; Compression test” how to connect the starter motor.

7. Start the engine and check for any leakage around filter bracket and filter.

8. Check the oil level. Add oil as needed.

Oil pressure sensor, checking

Special tools:
Nipple 9992873
Pressure gauge 9996398



If you suspect that the oil pressure sensor reads incorrectly, check the oil pressure with a external **pressure sensor.**

1. Check the oil pressure with a external pressure sensor and compare the values against specification in “Technical data”.

2. Remove pressure sensor.

3. Install nipple 9992873 and pressure gauge 9996398

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.

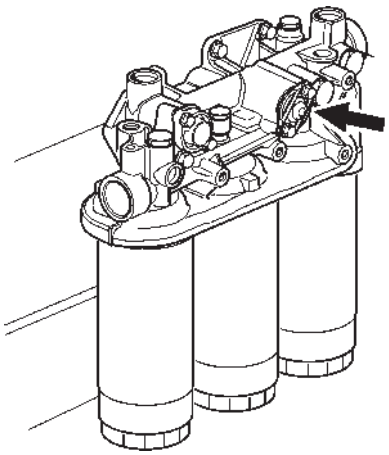
5. Remove nipple and pressure gauge.

6. Install the oil pressure sensor. Connect the sensor to the wiring.

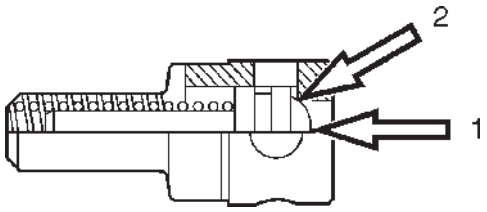
Oil filters, checking

1. Check that oil filters are not faulty or blocked.
   If the filters have outside damage, oil flow through the filters may be prevented. This may cause the oil pressure to deteriorate.

Checking the pressure limiting valve



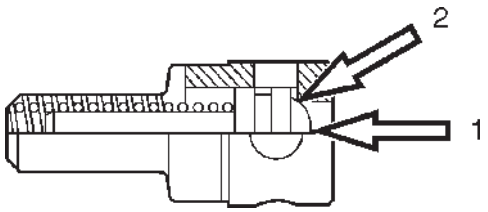
1. Check that the pressure limiting valve features a **blue** color marking.



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

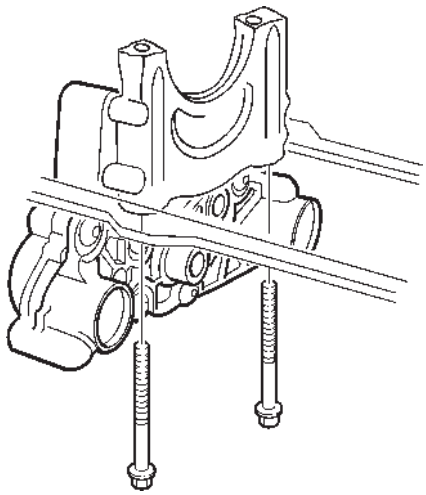
Safety valve, checking

The oil pan removed.



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

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



Oil pump, checking

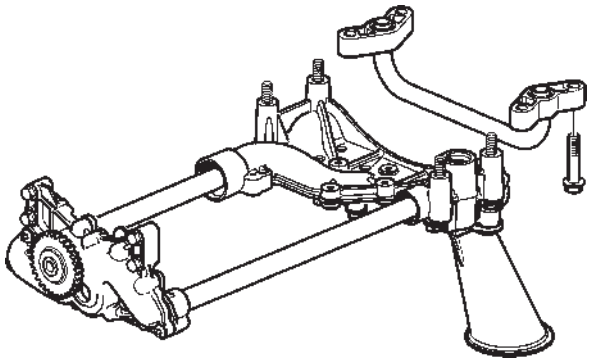
1. Remove the oil pump. See ”Oil pump, replacing”

2 . Check the pump drives.

NOTE: If the reason for the error can be traced to poor oil quality, clean the oil system thoroughly before new oil is filled.

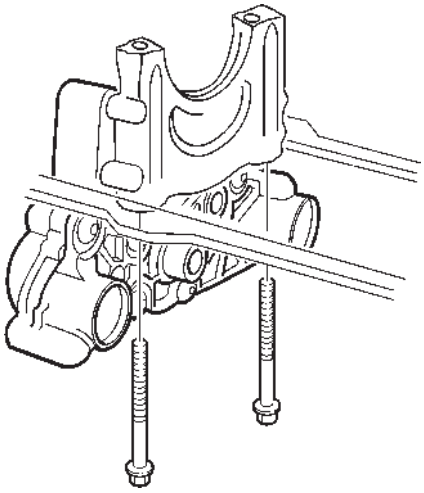
Oil pump, replacing

22111



1. Remove the oil filler pipe.
   Remove terminal to the oil level sensor.
   Remove the dip stick pipe from the bracket.
   Remove the pan.

2. Remove the 4 screws that hold the oil pipes to the engine.
   Remove the oil pipes, the oil strainer and the bracket together.



3. Remove the screws from the main bearing cap.
   Remove the oil pump together with the main bearing cap.

4. Remove the oil pump from the main bearing cap.

5. Clean the oil suction pipe and the oil delivery pipe. Check for damage.

6. Remove and clean the oil strainer. Check for damage.

7. Install the new oil pump on the main bearing cap and torque the screws as specified in ”Technical data”.

8. Clean the main bearing cap and lubricate the main bearing with oil.

   Fit thrust bearing caps together with oil pump. Make sure that the plugs fit the camshaft drive.

   Torque the caps as specified in ”Technical data”.

9. Assemble the oil pipes and the oil strainer on the bracket with new oil seals. The strainer should be installed so that it points to the engine’s front edge.

   Torque the screws as specified in ”Technical data”.

10. Assemble the oil pipes with the oil pump.

    Torque the screws as specified in ”Technical data”.

11. Check if the seal is needs to be replaced.

    Fit the pan.

12. Attach the dipstick pipe to the bracket.

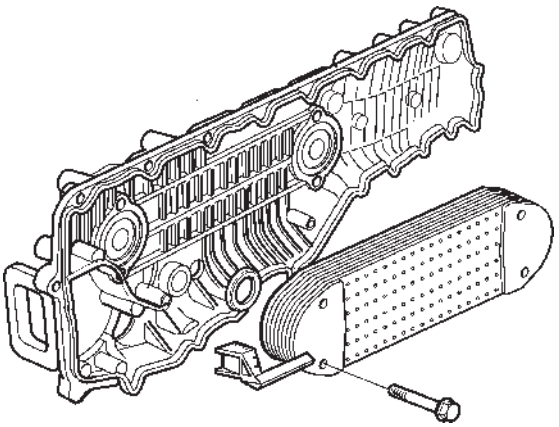
    Install oil filler pipe and the cable harness to the oil level sensor.

    Top up with engine oil.

13. Start the engine. Check the oil pressure and check for leakage.

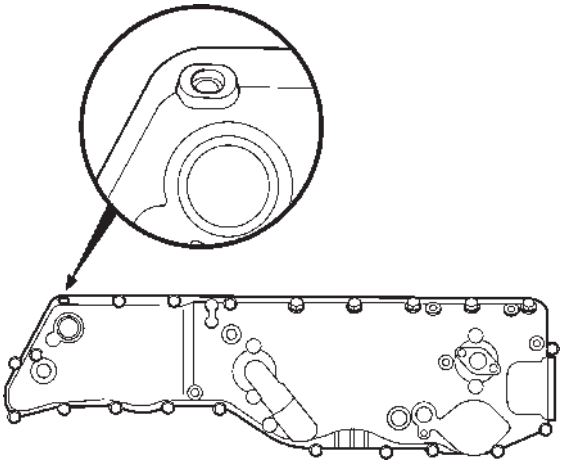
Oil cooler, replacing

22311



Removal

1. Clean around the oil pipe connections.
2. Drain the coolant, see ”Cooling system, draining”.
3. Remove turbo unit, see ”Turbo, replacing”.
4. Remove the oil pressure sensor contact piece.
5. Remove the front oil pipe, plug the oil filter housing.
6. Remove the casing screws and the rear oil pipe. Lift out the casing and plug the oil filter housing.
7. Remove the oil cooler from the casing.



Fitting

1. Clean the casing contact surface on the engine block.
2. Install the oil cooler in the casing with new rubber gaskets. Torque the screws as specified in Technical data.
3. Install new gaskets in the casing and in the water pump housing.
4. Lift the casing in place and install the rear oil pipe with new o-rings. Check that the casing rubber gaskets does not get out of its groove.
5. Install a screw in the oblong screw hole and press the casing, using appropriate tool, against the water pump housing.
6. Install casing screws and torque as specified in Technical data.
7. Install the front oil pipe with new o-rings.

8. Install the oil pressure sensor contact piece, install the cable in the clips.

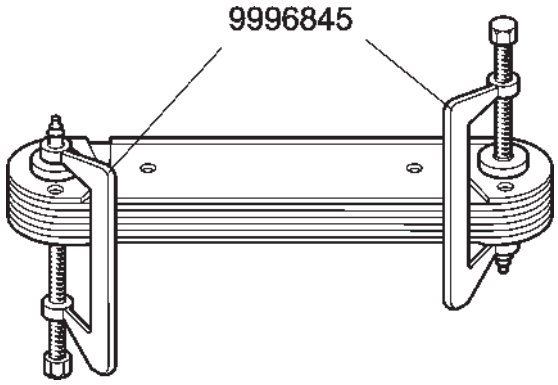
9. Fit the turbocharger. See ”Turbo, replacing”.

10. Add coolant. See “Cooling system, filling” and “Cooling system, general”.

NOTE: If the oil cooler has leaked engine oil to the cooling system, the coolant filter must be replaced and the cooling system cleaned. See cooling system, cleaning.

11. Start the engine and check for leakage when the it has reached normal temperature.
    Check coolant level.

Oil cooler, leakage test
22312



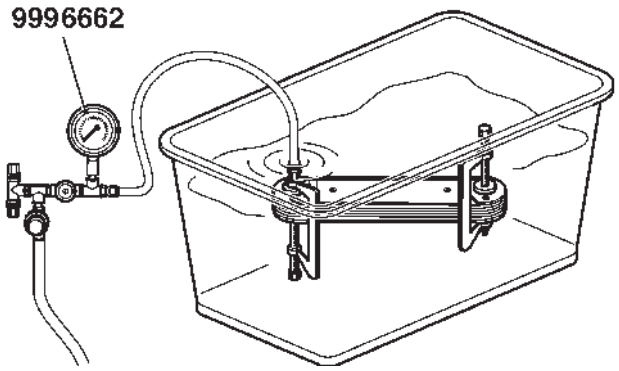
1. Remove the oil cooler. See ”oil cooler, removal/ refitting”**.**

2. Clean the oil cooler coolant fluid side with water soluble degreaser.

   Clean the oil side of the oil cooler with degreaser.

3. Check the pressure testing device 9996662 before using it. See ”Checking pressure testing device” in section ”Cylinder head, pressure testing”.

4. Install the screw clamps 9996845 and check that they are placed correctly.



5. Check that the pressure reduction valve knob on the pressure testing device 9996662 is fully opened and that the pressure gauge shows 0.

   Connect the pressure testing device to a screw clamp 9996845.

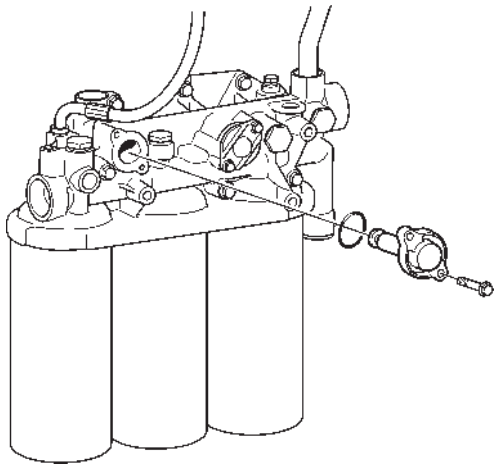
6. Lower the oil cooler into a container with water at room temperature.

   Increase the pressure to 250 kPa (2.5 bar) with the pressure reduction valve knob.

   Wait **at least one minute.**

NOTE: If an even stream of air bubbles come from the oil cooler element, it leaks and the oil cooler must be replaced.

By-pass valve oil cooler, replacing



1. Clean the area around the bypass valve and remove it.
   Clean the valve seat.

2. Fit the new the valve with a new seal ring.
   Torque as specified in ”Technical data”.

3. Start the engine and check for leaks.

Group 23: Fuel system

Draining, fuel channel in cylinder head

1. Clean around the fuel connections on the cylinder head and the fuel filter bracket.

2. Loosen the hose from the outlet on the fuel filter bracket and bend down the hose in a suitably vessel.

3. Remove the fuel return line at the front end of the cylinder head

4. Use a suitably hose and blow the fuel through the fuel channel in the cylinder head so that the fuel pours out in the vessel.

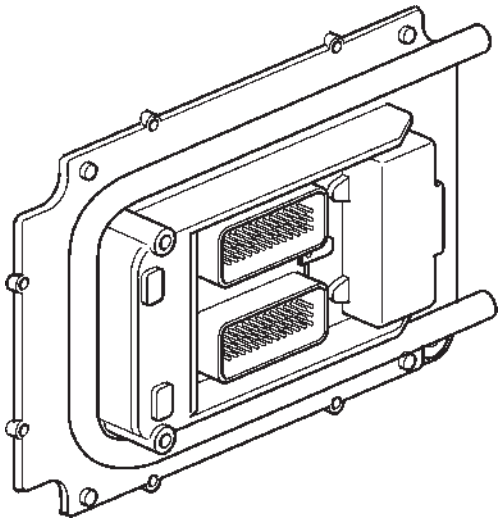
⚠ **IMPORTANT!** Be careful so that no dirt will come in to the fuel channel.

Control module, replacing

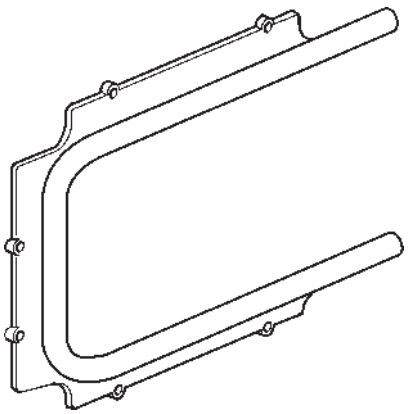
NOTE: Before the control module is replaced and any warranty claim made, all checks in the check list should be performed, to exclude any defect in engine control system. If the measurements of the flat cables show defects, it is highly likely that the control module is OK. See ”Workshop Manual, EMS 2”

⚠ **WARNING!** Faulty individual adjustments of the control module may result in damage to people or the engine. For information about reprogramming and reading of software see ”Workshop Manual, EMS 2”

⚠ **WARNING!** Exchange of control modules between engines, for troubleshooting or repair, must never be performed under any circumstances.



1. Clean thoroughly around the control module fuel connections.
2. Remove electricity from the engine by disconnecting the negative battery terminal.
3. Remove the lower part of the crankcase ventilation pipe.
4. Remove upper and lower cable harnesses clamps.
5. Remove the control module’s cable harness by moving the retaining clip gloves out.
6. Remove upper and lower fuel connections with the cooling element, plug the fuel lines.
7. Remove the screws that hold the control module and remove the control module.

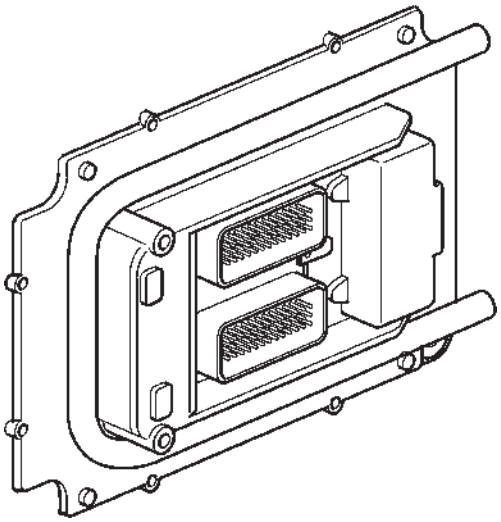


8. Transfer the cooling element to the new control module. Make sure that the surface between the cooling element and the control module is clean.

9. Install the new control module. Torque as specified in Technical data.

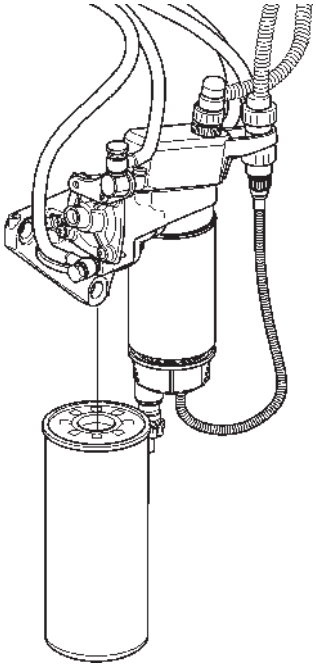
10. Install upper and lower fuel connections to the cooling element with new sealing washers.

11. Install the cable harness and clamps.



12. Install the lower crankcase ventilation pipe.

13. Vent the fuel system, see “Fuel System, bleeding”. Start the engine and check for error codes. See ”Workshop Manual, EMS 2”.



Fuel filters, replacing

23341

NOTE: Do not fill the new filter with fuel before installation. There is a risk that contamination enters the system and cause operational disturbances or damage.

⚠ **WARNING!** The fuel filter should be replaced when the engine is cold, to prevent any fire hazard if fuel is spilled on hot surfaces.

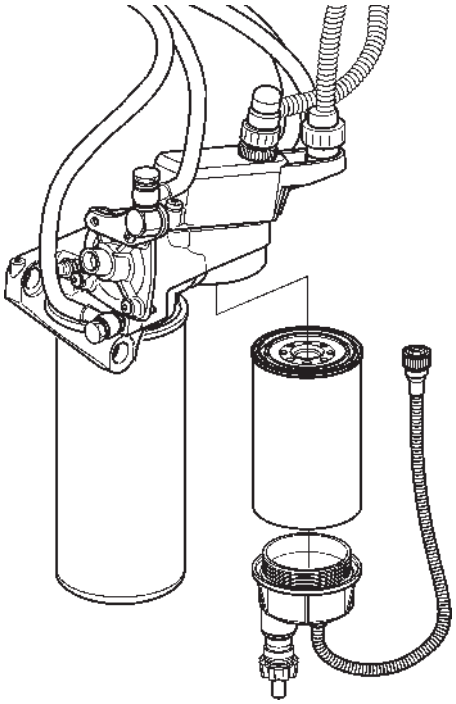
1. Clean around the fuel filter.

2. Remove the fuel filter. Use appropriate filter puller. Collect any spilled fuel in a container.

3. Clean around the filter housing sealing surface.

4. Lubricate the seal with diesel fuel and install the new fuel filter. Torque the filter per instructions on the filter.

5. Vent the fuel system, refer to “Fuel System, bleeding” .



Primary fuel filter, change

23341

1. Disconnect cable harness at the water trap sensor.

2. Remove the water trap filter from the filter housing. Collect any spilled fuel in a container.

3. Remove the lower part of the water trap from the filter.

4. Clean the water trap the bottom part with a soft rag. Check that the strainer and drain hole in the bottom part are not clogged.

5. Install a new seal on the lower part and lubricate the seal with diesel fuel.

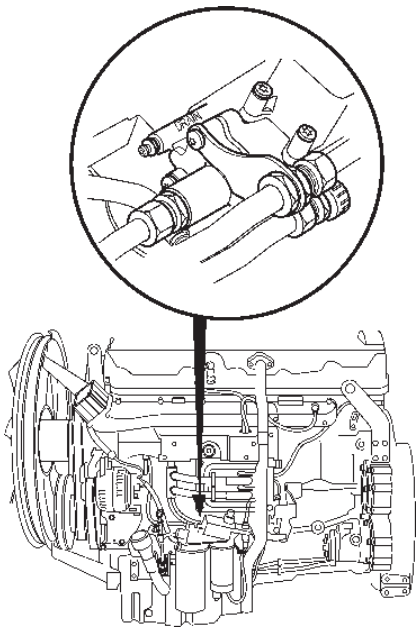
   Re-install the lower part of the filter.

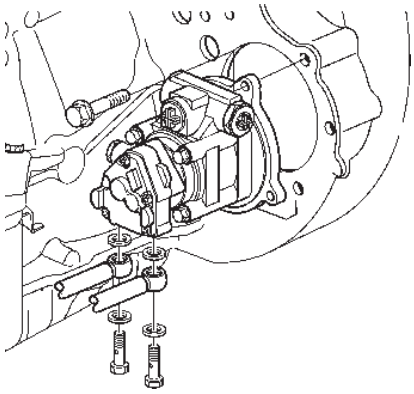
6. Lubricate the seal with diesel fuel.

   Screw the filter onto the filter bracket by hand until the rubber seal just touches the mating surface. Then tighten a further half turn, no more.

7. Connect cable harness to the water trap sensor.

8. Vent the fuel system, refer to “Fuel System, bleeding” .





Fuel feed pump, replacing

23311

Removal

1. Close any fuel cocks between tank and feed pump, to avoid unnecessary fuel spills.

2. Connect an appropriate hose and drain the engine fuel system, by opening the nipple marked "DRAIN".

3. Clean thoroughly around the feed pump and its connections.

4. Place a suitable container under the feed pump and remove the fuel lines' banjo screws.

NOTE: Plug the lines! Note suction or pressure, respectively.

5. Remove the feed pump together with the servo pump.

6. Remove the feed pump from the servo pump, 3 torx screws.

7. Remove the feed pump by carefully pulling the pump straight out, making sure that the interconnection on the servo pump shaft does not come out with it.

Fitting

8. Replace o-ring on the servo pump flange and check that the interconnection fits in its groove on the servo pump shaft.

9. Install the feed pump on the servo pump, facilitate installation by turning the servo pump shaft so that it fits in its groove in the interconnection. Torque the screws as specified.

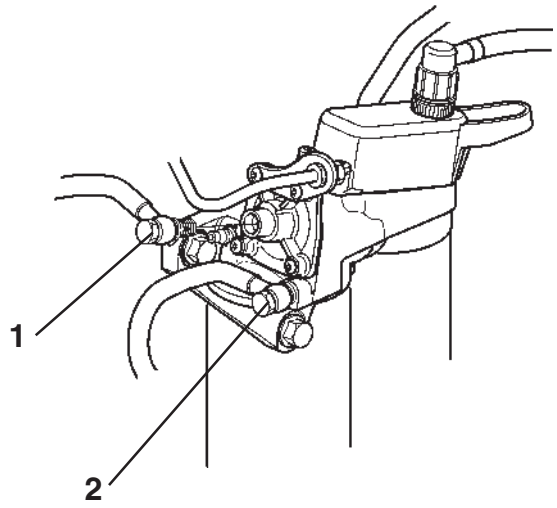
10. Install feed pump/servo pump on the engine.

11. Replace the sealing washers, remove the plugs and install the fuel lines.

12. Open the fuel cocks, check that the drain nipple is closed. Bleed the fuel system. See section Fuel system, venting.

13. Start the engine and check for function and leakage.

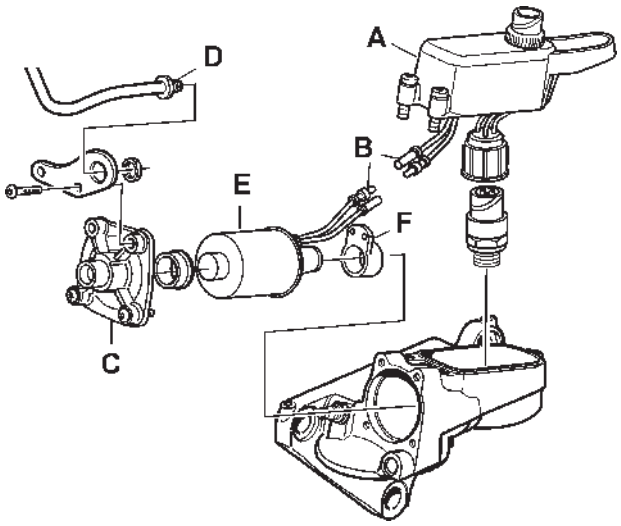
Electric pump, replacing



Removal

1. Clean thoroughly around the electric pump and its connections.

2. Loosen the fuel lines (1) and (2).



3. Remove the electrical connection for the pump.

4. Remove the three screws and remove the fuel pressure sensor casing (A).

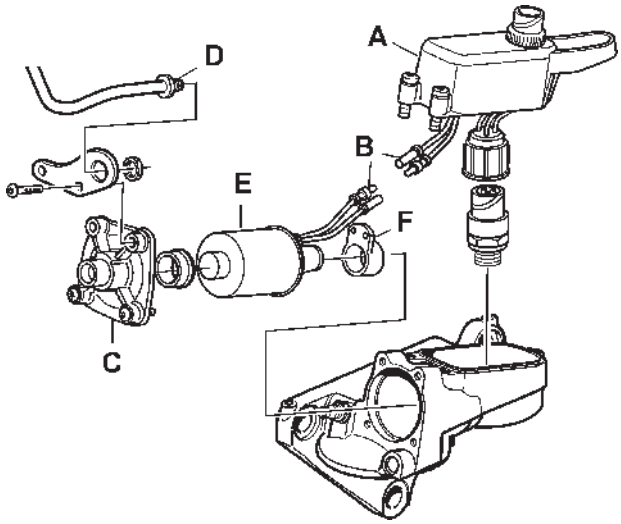
5. Remove the feed pump cables (B).

6. Remove the four screws, remove the electric pump cover (C) and the bracket for fuel return line (D).

7. Remove feed pump (E), rubber seal (F) and the seal in the lid.

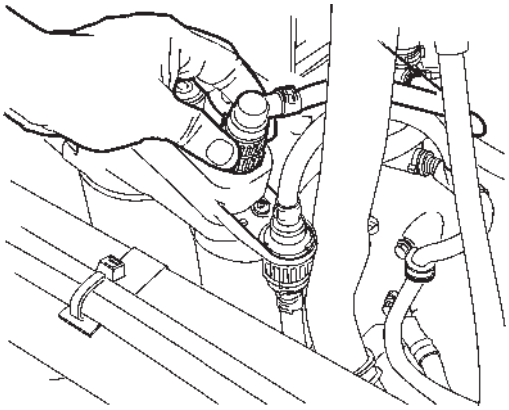
A. Casing, fuel pressure sensor
B. Cables, feed pump
C. Front cover, feed pump
D. Bracket for fuel return line
E. Feed pump
F. Rubber seal, feed pump

Fitting



1. Fit rubber seal (F) and the electric pump (E).
2. Fit the electric pump cover (C) the seal and the bracket for the fuel return line (D).
   Torque the four screws.
3. Connect the feed pump cables (B).
4. Fit fuel pressure sensor casing (A).
   Torque the three screws.

A. Casing, fuel pressure sensor
B. Cables, feed pump
C. Front cover, feed pump
D. Bracket for fuel return line
E. Feed pump
F. Rubber seal, feed pump



5. Connect the flat cable to the electric pump.
6. Replace sealing washer and connect the fuel lines.
7. Bleed the fuel system, start the engine and check for leakage.

Unit injector, replacing

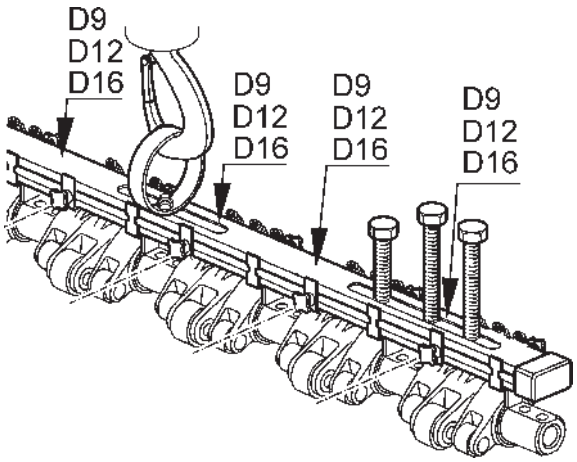
23710

Special tools:

Puller 9990006
Slide hammer 9990013
Protective sleeve 9998249
Socket * 9998580
Handle* 9808616

* included in cleaning kit 9998599

NOTE! If a new unit injector is fitted, a new injector code must programmed into the control unit, see "Workshop manual EMS 2". The injector code is stamped onto the unit injector.



Removal

1. Remove the valve cover.

2. Remove electrical connections with unit injectors. Cut off cable ties that hold the cable harness and fold it aside.

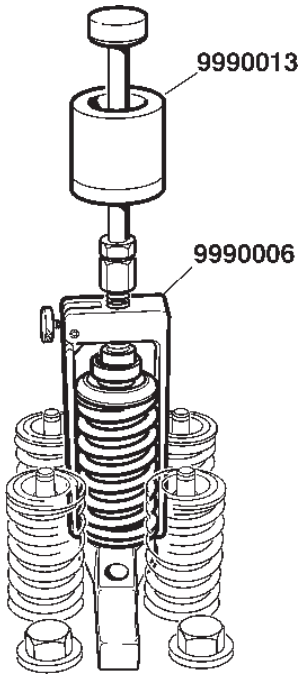
3. Remove the delivery pipe and the distribution house for the rocker arm shaft lubricating oil supply.

4. Remove the rocker arm shaft screws equally in stages so that the rocker arm shaft is not bent.

   Carefully lift the rocker arm shaft using tool 9990185 (for TAD950-952VE also use 88880003).

NOTE! The marks on the tool indicates the fastening points for the rocker arm onto the engine.

5. Remove the floating valve yokes.



6. Empty the fuel channel in the cylinder head, see “Draining, fuel channel cylinder head” in chapter “Reconditioning / replacing components”.

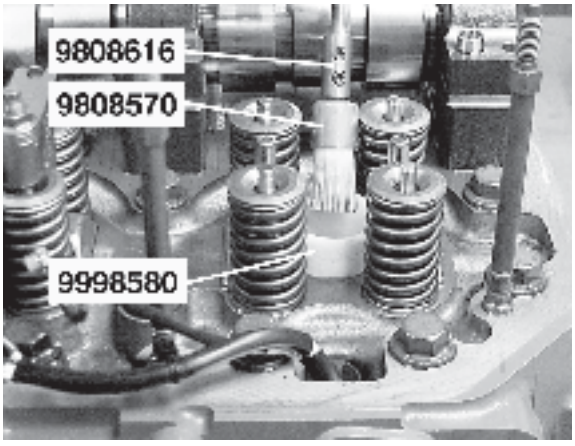
7. Remove the screws for the unit injector retainer.

   Place puller 9990006 on the injector.

   Place the puller fork in the groove on the injector and lock the arm with the screw on the side. Fix the puller by turning the screw down towards the injector’s ball holes.

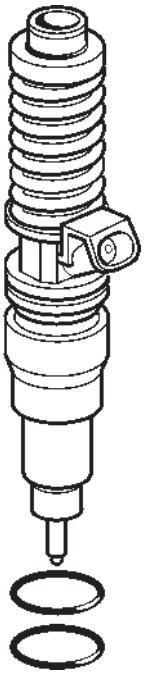
   Fit a slide hammer 9990013 and remove the injector.

8. Place protective sleeve 9998249 on the injector that was removed.



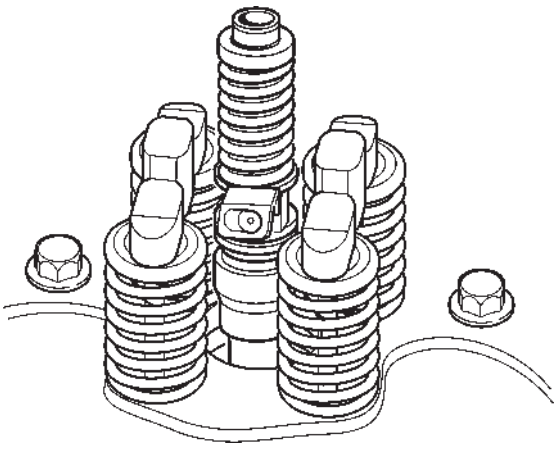
9. Install protective sleeve 9998580 and clean thoroughly with brush 9808570 and extender 9808616.

Fitting



10. Install new o-rings on unit injector.
    Upper ring - large diameter, purple
    Lower ring - small diameter, purple

NOTE! To not damage the o-rings, use installations-sleeves 3883671 and 3883672.



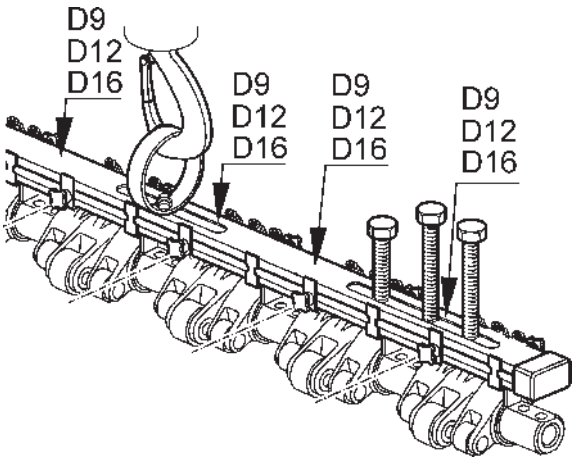
11. Install the retainer on unit injector and center it between the valve springs.
    Torque the screw as specified in ”Technical data”.

12. Connect the contact, press in until you hear a ”click”.
    Mount new straps.

⚠ **IMPORTANT!** Use Volvo Penta Original oil and heat resistant tie wraps (983472) and holders (28429850).

13. Mount the valve calipers.

14. Oil valve yokes and cam shaft ridges with engine oil.



15. Lift the rocker arm shaft in place using lifting tool 9990185 (for TAD950-952VE also use 88880003). Check that guide pins are positioned correctly in the bearing blocks.

NOTE! The marks on the tool indicates the fastening points for the rocker arm onto the engine.

Torque the rocker arm shaft screws as specified in ”Technical data”, so that the shaft rests against the bearing blocks.

NOTE: Tighten alternately as specified in "Technical data," to prevent the rocker arm shaft from bending.

16. Clean the cylinder head at the place for the distribution house and check that there is no dirt in the cylinder head oil channel.

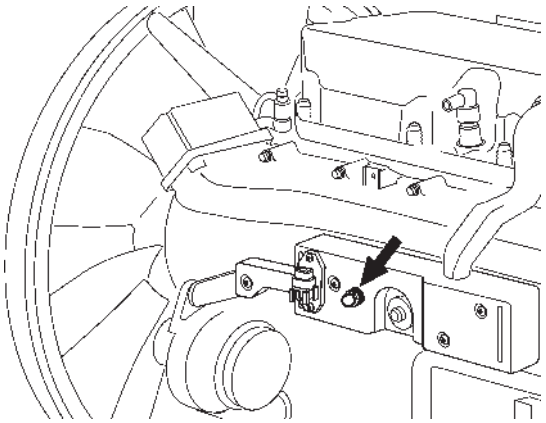
Fit new seal rings to the delivery pipe and distribution house. Apply a thin layer of petroleum jelly on the pipe sealing rings and install the pipe in the distribution house.

17. Install the piece in between and torque as specified in ”Technical data”.

18. Adjust valves and unit injector, see ”Valves and injectors, adjusting” in chapter ”Engine body, general overhaul”.

19. Install the cable harness to the unit injectors and the valve cover.

20. Vent the fuel system, see “Fuel System, bleeding”



Venting the fuel system

23080

1. Check whether there is enough fuel in the tank, and that any fuel taps are open.

2. Turn the ignition on.

3. The fuel system is vented by holding the fuel venting switch (see ”Component location”) on the left side of the engine block depressed for about four minutes. Air is vented to the tank via the fuel return pipe. No venting nipples need to be opened.

4. Start the engine and let it idle fast for about 10 minutes.

5. Do a leakage and function check.

Group 25: Inlet and exhaust systems

Turbo, replacing

25512

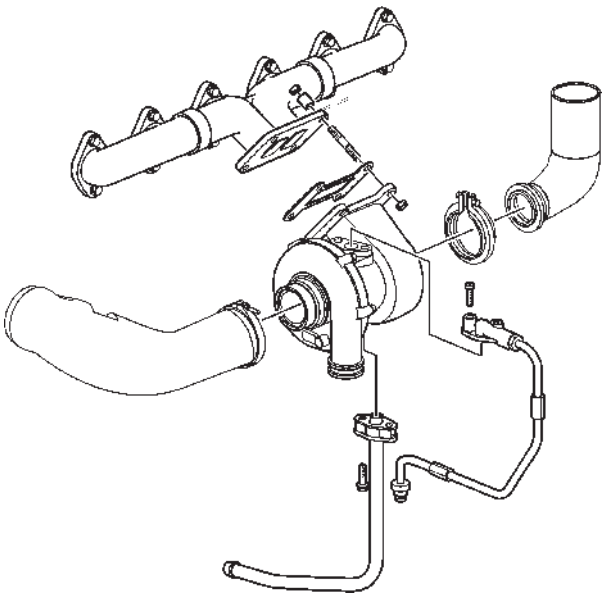
Always determine and remedy the reasons why the turbocharger has been wrecked before a new turbocharger is installed.

One condition for the turbocharger to work satisfactorily is that the engine's lubrication and inlet systems are kept in good condition, i.e. that oil and filter changes are completed as scheduled, that the right kind of oil is used and that the air filter is managed correctly.

A first remedy should be checking the engine oil and replace the oil filters if needed, and preferably to run the engine a few minutes with the new oil before the new turbo unit is installed.

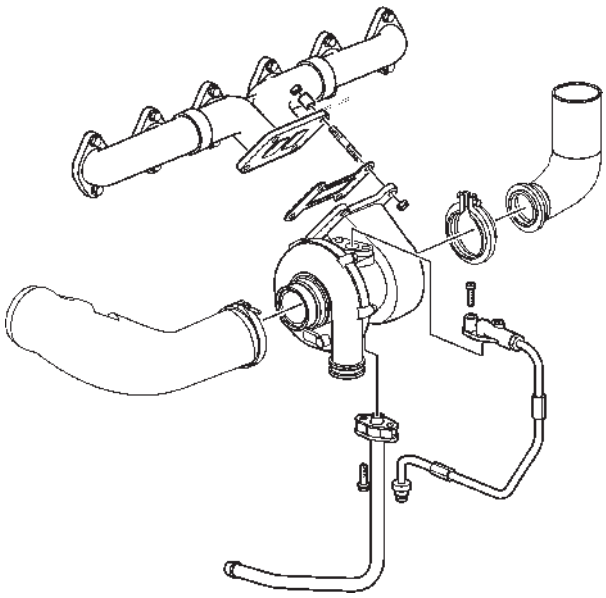
Blow out any rust- and soot flakes from the exhaust manifold when replacing turbocharger. The soot flakes could damage the turbine wheel of the new unit.

It is import to clean the intake line from the air cleaner as well. Parts from a wrecked compressor wheel may remain and cause an immediate wreck of the new turbo.



Removal

1. Remove the air hose between the turbo and the air filter housing.
2. Remove screws (1) and remove the exhaust pipe (2) from the turbo.
3. Remove the oil delivery pipe and return oil pipe.
4. Remove the nuts (4) and the spacer sleeves.
5. Remove the turbo.



Fitting

6. Clean the turbo contact surface on the exhaust manifold.

7. Fit return oil pipe with a new seal ring.

8. Place a new gasket on the exhaust manifold (6).
   Fit the turbo (5).
   Torque the nuts (4) as specified in ”Technical data”.

9. Connect return oil pipe using a new gasket.

10. Fill the turbo with clean engine oil through the oil delivery pipe connection.

NOTE: Make sure no contaminants enter the connection. Use a strainer when filling oil.

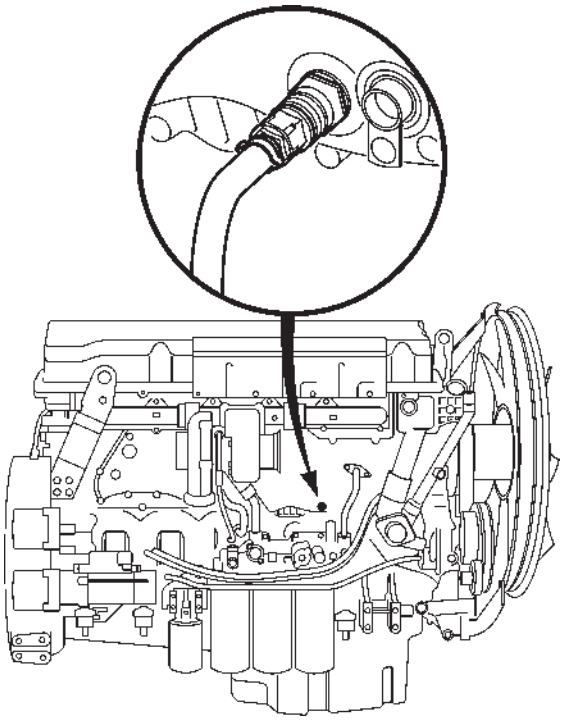
11. Fit the oil delivery pipe with a new gasket.

12. Fit the exhaust pipe (2) to the turbo.

13. Fit the hose between air filter and turbo.

14. Start the engine and check for leaks.

Group 26: Cooling system



Cooling system, draining

⚠ **WARNING!** Be careful when opening the coolant filler cap when the engine is hot. Steam or hot coolant can spray out.

NOTE: Before draining the cooling system, remove the expansion tank cover.

For engines to be mothballed or stored, the engine cooling system should not be drained. The coolant contains additives that protect against corrosion

1. Open all drain points.
   Drain the coolant from the radiator and the engine block with coolant drain tube 9996049. Drain nipples are located under the radiator and on the right-hand side of the block.

2. Check that all coolant drains out. Deposits may be found inside the drain plug/tap, and need to be cleared away. Otherwise, there is risk for coolant to remain standing, causing serious damage.

3. Close any cocks and check that the spring-loaded nipple covers close completely, install the rubber plugs.

Cooling system, cleaning

Cooling performance is reduced by deposits in the radiator and cooling galleries. The cooling system should be flushed when the coolant is changed.

⚠ **IMPORTANT!** Flushing should not be performed if there is a risk of frost, since the flushing solution has no anti-freeze properties.

1. Drain the cooling system. See “Cooling system, draining.”
2. Put a hose into the expansion tank filling hole and flush with **clean** water, as specified by Volvo Penta - refer to section “Water quality”, until the water draining out is completely clear.
3. If there are still contaminants left after much flushing, then flushing with coolant can be performed.

   Otherwise continue with point 8 below.
4. Fill the cooling system with 15-20 % concentrated coolant mixture. Use only Volvo Penta recommended concentrated coolant mixed with **clean** water.
5. Drain the coolant after 1-2 days use.

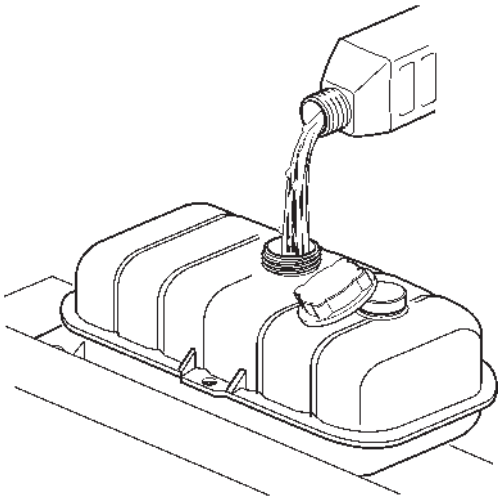
NOTE! To prevent dislodged material from fastening in the system, draining should be done rapidly within 10 minutes, without allowing the engine to stand for any length of time.

Remove the filler cap and possibly the lower radiator hose to increase drain speed.

6. Flush the system immediately and thoroughly with **clean** hot water to prevent dirt from settling in the inner areas. Flush until the drained water is completely clear.

   Check that the heater controls are on full heat while draining.
7. If there are still contaminants left after much flushing, then flushing with Volvo Penta radiator flushing agent can be performed, followed by treatment with Volvo Penta neutralizer. Follow the instructions on the packet carefully. Otherwise continue with point 8 below.
8. Once the cooling system is completely free from contaminants, close the drain stopcock and plugs.
9. Fill with new Volvo Penta recommended coolant according to the instructions in sections “Coolant, mixing” and “Cooling system, filling”.

⚠ **IMPORTANT!** It is extremely important that the correct concentration and volume of coolant is filled into the system. Mix in a separate, clean vessel before adding to the cooling system. Ensure that the liquids mix properly.



Cooling system, filling

⚠ **WARNING!** Be careful when opening the coolant filler cap when the engine is hot. Steam or hot coolant can spray out.

NOTE: If a big volume of coolant must be filled, the system should be pressure tested, see ”Cooling system, pressure-testing”.

NOTE: When working on an engine where more a five liters (5.3 quarts) new coolant are being added, a new coolant filter should always be installed.

NOTE: Filling should be carried out with the engine stopped. Premix the right coolant volume so that you are sure the cooling system will be full. Filling must not be done so fast that an air lock is formed in the system. Air should be able to flow out through the fill opening and the vent cocks. Use only of Volvo Penta recommended coolant and mix.

NOTE: The engine must not be started until the system has been vented and completely filled.

1. Fill coolant to about 50 mm (2 inches) under the coolant filler cap sealing surface.

2. Start the engine and let it run until it reaches normal operating temperature and the thermostat has opened.

3. Stop the engine, check coolant level and top up with coolant as needed.

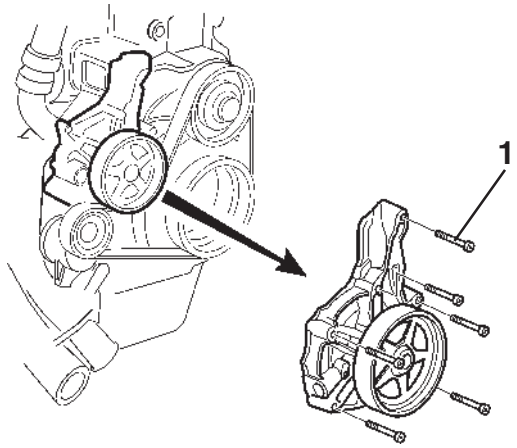
Coolant pump, replacing

26211

Removal

⚠ **IMPORTANT!** Break the current or use some other means to prevent the engine from starting during the work.

1. Drain the coolant into a suitable container. see ”Cooling system, draining”



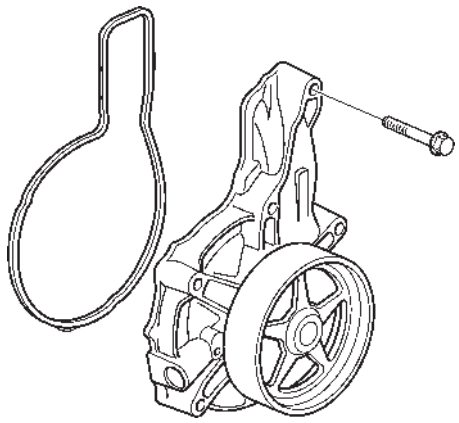
2. Remove drive belt shield installed above the coolant pump.

3. Remove the coolant pump drive belt by placing a pulling handle in the belt tensioner and ease the belt tension.

   Remove the drive belt from the coolant pump.

4. Remove the coolant pump.
   Press the belt tensioner down so it is easier to access the lower screw in the coolant pump. Allow screw ”1” to stay in the housing.

Fitting



5. Fit coolant pump with a new seal. Use petroleum jelly to hold the seal in place during installation.

   The screw ”1” must be in place in the housing during installation. Torque the screws as specified in ”Technical data”

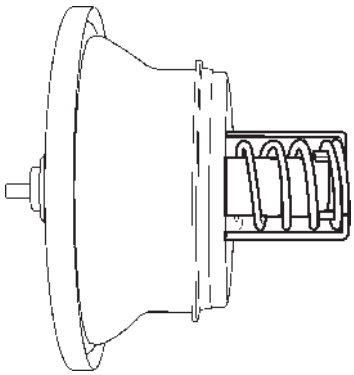
6. Install the coolant pump drive belt.

7. Install the engine drive belt shield.

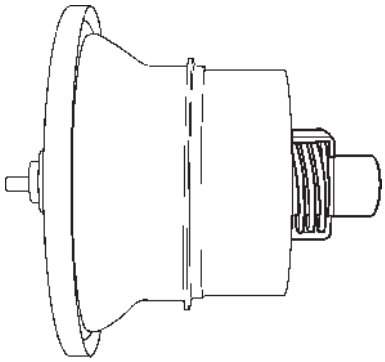
8. Add back the engine coolant, see ”Cooling system, filling”.

9. Start the engine and let it run until it reaches normal operating temperature.

   Check that there is no fuel leakage. Top up with coolant as needed.



Closed thermostat



Open thermostat

Thermostat, functional check

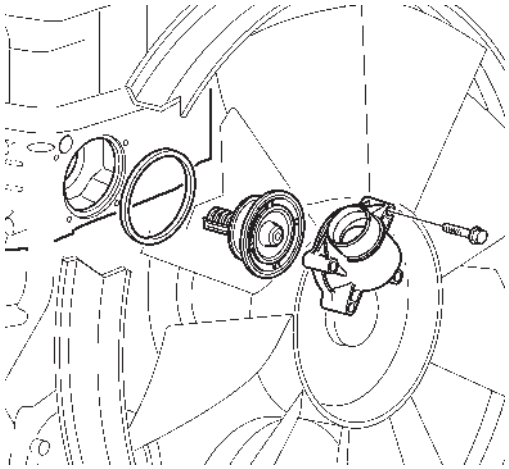
26273

1. Remove the thermostat, see “Thermostat, replacing”.
2. Place the thermostat in a big pot with water and heat it to the opening temperature as specified in “Technical data, Thermostat”.
3. If the thermostat does not open at specified temperature, replace it.
4. Install the thermostat, see “Thermostat, replacing”.

NOTE: Always use a new seal, even if the thermostat is not replaced.

Thermostat, replacing

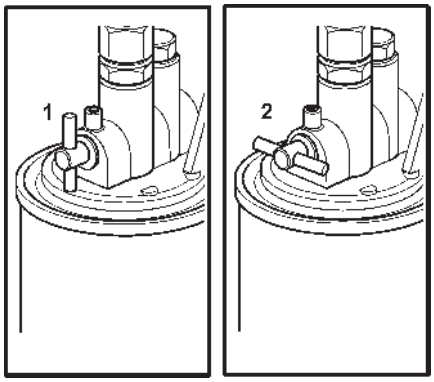
26271



1. Drain the cooling system. See “Cooling system, draining”.
2. Clean the area around the thermostat housing.
   Remove the radiator hose from the thermostat housing and unscrew it from the cylinder head.
3. Remove the thermostat and clean the inside of the housing.
4. Install a new thermostat and seal.
5. Torque the thermostat housing as specified in “Technical data”.
   Attach the radiator hose.
6. Refill the cooling system. See “Cooling system, filling”.
7. Start the engine and check for leaks. Pressurize the cooling system to test it, see ”Cooling system, pressure testing”.

Coolant filter, changing

NOTE: The coolant filter should be replaced at stated intervals, if this is not done, the engine may last a lot less. When working on an engine where more a five liters (5.3 quarts) new coolant are being added, a new coolant filter should always be installed.



1. Tap open
2. Tap closed

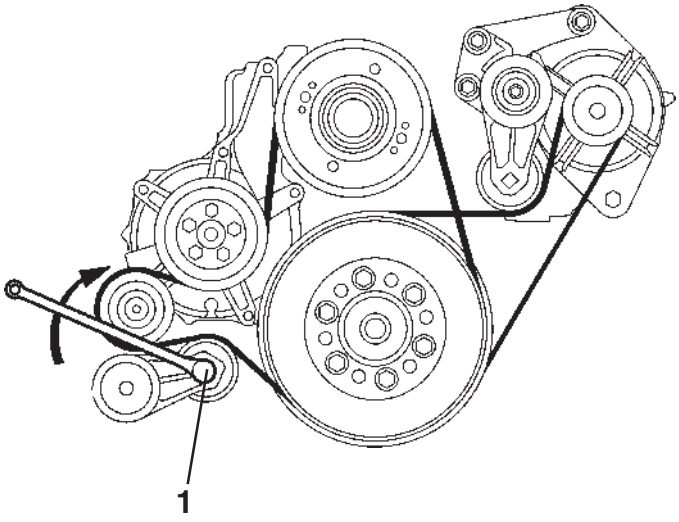
1. Shut the filter housing valve.
2. Clean around the filter and remove it using a pair of filter pliers.
3. Lubricate the filter gasket with petroleum jelly, or soapy water, and fit the new filter.
   Screw the filter down until the gasket just touches the sealing surface. Then turn a further ½ turn.
4. Open the cock on the filter housing.
5. Start the engine and check for leaks.

Drive belt / Alternator belt, inspection

Check belts after running when they are warm.

Both the alternator belt and the drive belt has an automatic belt tensioner and need not be adjusted. Check that the belt tensioner does not bottom.

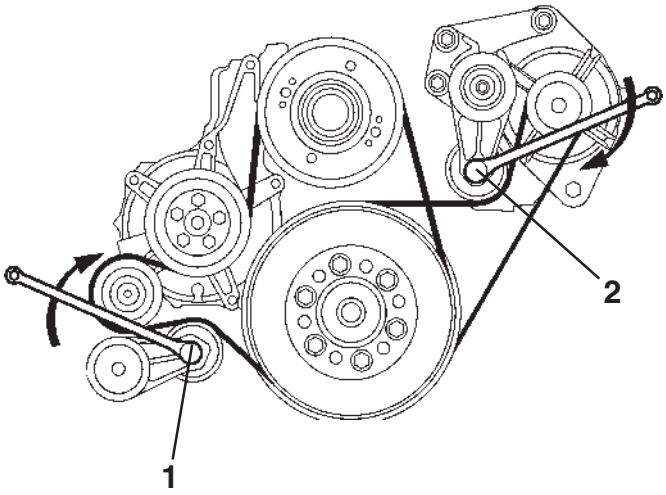
Drive belt, change



1. Turn off the main circuit breaker and check that the engine has no voltage.
2. Remove the protective grating and the outer fan ring round the cooling fan.

   Remove the protective plates around the drive belts.
3. Place a 1/2" span wrench in belt tensioner (1). Lift the spanner and remove the drive belt.
4. Thread the drive belt round the fan and remove it.
5. Check that the pulleys are clean and undamaged.
6. Thread the new drive belt over the fan.
7. Lift the 1/2" spanner and install the new drive belt.
8. Install the protective plates around the drive belts.
9. Install the protective grating and the outer fan ring round the cooling fan.
10. Start the engine and check its functions.

Alternator belts, change



⚠ **IMPORTANT!** Always replace a drive belt that seems worn or is cracked.

1. Turn off the main circuit breaker and check that the engine has no voltage.

2. Remove the protective grating and the outer fan ring round the cooling fan.

   Remove the protective plates around the drive belts.

3. Place a 1/2" span wrench in belt tensioner (1).

   Lift the spanner up and lift the water pump drive belt off.

4. Place a 1/2" span wrench in belt tensioner (2).

   Press the spanner down and remove the alternator belt.

5. Check that the pulleys are clean and undamaged.

6. Press down the 1/2" spanner to belt tensioner (2) and install the new alternator drive belt.

7. Lift the 1/2" spanner to belt tensioner (2) and reinstall the new water pump drive belt.

8. Install the protective plates around the drive belts.

9. Install the protective grating and the outer fan ring round the cooling fan.

10. Start the engine and do a function check.

Technical data

General

Type designation	**TAD940GE**	**TAD941GE**
Power, Prime/Stand-by	Please refer to the sales literature	
Torque, Prime/Stand-by	Please refer to the sales literature	
Compression ratio	20.2:1	17.4:1
Low idle (rpm)	600-1200	600-1200
High idle (rpm)	1500-1620 1800-1920	1500-1620 1800-1920
Highest full load speed (rpm)	1500/1800	1500/1800
No. of valves	24	24
No. of cylinders	6	6
Cylinder bore, mm (inch)	120 (4.72)	120 (4.72)
Stroke, mm (inch)	138 (5.43)	138 (5.43)
Swept volume, dm^3 (US quart)	9.36 (9.89)	9.36 (9.89)
Weight, dry, kg (lb)	1015 (2238)	1015 (2238)
Weight, wet, kg (lb)	1065 (2348)	1065 (2348)
Injection sequence	1-5-3-6-2-4	1-5-3-6-2-4

Type designation	**TAD940VE**	**TAD941VE**	**TAD942VE**	**TAD943VE**
Power	Please refer to the sales literature			
Torque	Please refer to the sales literature			
Compression ratio	20.2:1	20.2:1	20.2:1	20.2:1
Low idle (rpm)	600	600	600	600
High idle (rpm)	2250	2250	2250	2250
No. of valves	24	24	24	24
No. of cylinders	6	6	6	6
Cylinder bore, mm (inch)	120 (4.72)	120 (4.72)	120 (4.72)	120 (4.72)
Stroke, mm (inch)	138 (5.43)	138 (5.43)	138 (5.43)	138 (5.43)
Swept volume, dm^3 (US quart)	9.36 (9.89)	9.36 (9.89)	9.36 (9.89)	9.36 (9.89)
Weight, dry, kg (lb)	1015 (2238)	1015 (2238)	1015 (2238)	1015 (2238)
Weight, wet, kg (lb)	1065 (2348)	1065 (2348)	1065 (2348)	1065 (2348)
Injection sequence	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4

Type designation	**TAD950VE**	**TAD951VE**	**TAD952VE**
Power	Please refer to the sales literature		
Torque	Please refer to the sales literature		
Compression ratio	20.2:1	20.2:1	20.2:1
Low idle (rpm)	600	600	600
High idle (rpm)	2250	2250	2250
No. of valves	24	24	24
No. of cylinders	6	6	6
Cylinder bore, mm (inch)	120 (4.72)	120 (4.72)	120 (4.72)
Stroke, mm (inch)	138 (5.43)	138 (5.43)	138 (5.43)
Swept volume, dm^3 (US quart)	9.36 (9.89)	9.36 (9.89)	9.36 (9.89)
Weight, dry, kg (lb)	1015 (2238)	1015 (2238)	1015 (2238)
Weight, wet, kg (lb)	1065 (2348)	1065 (2348)	1065 (2348)
Injection sequence	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4

Torque

General tightening torque values

	Nm	(kpm)
M6 standard screw 8.8	10±1.5	(1.0±0.15)
M8 standard screw 8.8	24±4	(2.4±0.4)
M10 standard screw 8.8	48±8	(4.8±0.8)
M12 standard screw 8.8	85±15	(8.5±1.5)
M14 standard screw 8.8	140±25	(14.0±2.5)

Only torqued screws can be re-installed.
Torque and angle tightened / plastic limit tightened screws:

- 8.8 ..... should not be re-installed
- 10.9 ..... can be re-installed
- 12.9 ..... can be re-installed

⚠**IMPORTANT!** Check screws which are to be re-installed. Damaged screws, with marks of seizure etc. under the heads, must be scrapped.

Special tightening torques

NOTE! Please refer to “Technical data TAD940GE, TAD941GE, TAD940VE, TAD941VE, TAD942VE, TAD943VE, TAD950VE, TAD951VE, TAD952VE” for tightening schedules and application of sealant.

	Nm	(kpm)
Group 21: Engine		
Front engine mounting, engine block	275 ±45	(28.0±4.5)
Front engine mounting, front engine pad	150 ±30	(15.0±3.0)
Main bearing caps		
Stage 1	150 ±20	(15.0±2.0)
stage 2, angle tightening	120° ±5°	
Big end bearing cap		
Stage 1	20 ±3	(2.0±0.3)
Stage 2	35 ±3	(3.5±0.3)
stage 3, angle tightening	90° ±5°	
Stiffening frame		
(please refer to tightening schedule, “Stiffening Frame”)	48 ±8	(4.8±0.8)
NOTE! Tighten the screws in sequence, from the center and outwards.		
Flywheel		
(please refer to tightening schedule, “Flywheel”)		
Stage 1	60 ±5	(6.0±0.5)
stage 2, angle tightening	120° ±10°	
Flywheel housing		
(Please refer to “Flywheel housing” for application of sealant)		
M12 screws	85 ±15	(8.5±1.5)
M14 screws	140 ±25	(14.0±2.5)

	Nm	(kpm)
Vibration damper		
(please refer to “Flywheel” tightening schedule)		
Stage 1	45 ±5	(4.5±0.5)
stage 2, angle tightening	90° ±5°	

NOTE! The 8.8 screws for the vibration damper must **not** be re-used.

Housing, crankcase seal		
(Please refer to “Crankshaft seal housing” for application of sealant)	24 ±4	(2.4±0.4)

NOTE! Apply a 2 mm string of silicone sealer as in the illustration.

Valve cover.		
(please refer to “Flywheel” tightening schedule)	24 ±4	(2.4±0.4)
Oil cooler, housing		
(please refer to “Oil cooler, housing” tightening schedule)	24 ±4	(2.4±0.4)
Cylinder head		
(please refer to “Flywheel” tightening schedule)		
Stage 1	60 ±10	(6.0±1.0)
stage 2 (check tightening)	60 ±10	(6.0±1.0)
stage 2, angle tightening	120° ±5°	
stage 3, angle tightening	90° ±5°	
Core plugs, cylinder head	60 ±10	(6.0±1.0)
Bearing caps, camshaft/rocker arm spindle		
(Please refer to “camshaft bearing cap/rocker shaft” tightening schedule).		
Stage 1: Torque screws 1-7 to	15 ± 3	(1.5±0.3)
Stage 2: Torque screws 9, 11, 13 (start with screw 11)	60 ± 5 Nm	
Stage 3: Torque screws 8, 10, 12, 14	60 ±5	(6.0±0.5)
Stage 4: Loosen screws 9, 11, 13	–	
Stage 5: Torque screws 9, 11, 13	60 ±5	(6.0±0.5)
Stage 6: Torque screws 1-7, angle tightening	90° ±5°	
Stage 7: Torque screws 8-14, angle tightening	120° ±5°	
Timing gear plate		
(Please refer to “Timing gear plate” for tightening schedule and application of sealant)	24 ±4	(2.4±0.4)
Timing gear cover, upper		
(Please refer to “Timing gear cover, upper” for application of sealant)	24 ±4	(2.4±0.4)

	Nm	(kpm)
Transmission		
(please refer to “Timing gear” tightening schedule)		
Drive gear, crankshaft	24 ±4	(2.4±0.4)
Idler wheel, bull gear outer (apply thread locking fluid 1161053 to the threads)		
stage 1	35 ±4	(3.5±0.4)
stage 2, angle tightening	60° ±5°	
Idler wheel, adjustable		
stage 1	35 ±4	(3.5±0.4)
stage 2, angle tightening	120° ±5°	
Drive gear, camshaft		
stage 1	45 ±5	(4.5±0.5)
stage 2, angle tightening	90° ±5°	
Drive wheel, steering servo and fuel feed pump	100 ±10	(10.0±1.0)
Drive wheel, air compressor	200	(20.0)

Group 22: Lubrication system

Sump		
(tighten the screws in sequence, from the center and outwards)	24 ±4	(2.4±0.4)
-0		
Drain plug, sump	60 ±5	(6.0±0.5)
Bracket, oil pump/main bearing caps	24 ±4	(2.4±0.4)
Oil strainer, retaining screws	24 ±4	(2.4±0.4)
Oil cooler, retaining screws	27 ±4	(2.7±0.4)

Group 23: Fuel system

Feed pump - steering servo pump	24 ±4	(2.4±0.4)
Fixing yoke, unit injector (new copper sleeve)		
First tightening		
Stage 1	20 ±5	(2.0±0.5)
stage 2, angle tightening	180° ±5°	
Loosen the fastening yoke screw before doing the second tightening.		
Second tightening		
Stage 1	20 ±5	(2.0±0.5)
stage 2, angle tightening	60° ±5°	
Fixing yoke, unit injector (re-used copper sleeve)		
Stage 1	20 ±5	(2.0±0.5)
stage 2, angle tightening	60° ±5°	
Locknut for adjuster screw, unit injector		
Stage 1	tighten until it just touches	
stage 2, angle tightening	45° ±5°	
Hollow screw M16x1.5	50 ±8	(5.0±0.8)
Hollow screw M10x1	25 ±4	(2.5±0.4)

	Nm	(kpm)
Group 25: Inlet / exhaust system		
Inlet pipe		
(Please refer to “Inlet pipe” for application of sealant)	24 ±4	(2.4±0.4)
Plug, M10	20 ±3	(2.0±0.3)
Pressure/temperature sensor, charge air	12 ±2	(1.2±0.2)
Exhaust manifold		
stage 1: Tighten the screws until they just touch	5 ±1.5	(0.5±0.15)
stage 2: Torque screws 1 and 8	10 ±1.5	(1.0±0.15)
stage 3: Torque screws 3 and 10	10 ±1.5	(1.0±0.15)
stage 4: Torque screws 5 and 12	10 ±1.5	(1.0±0.15)
stage 5: Torque screws 2 and 7	48 ±8	(4.8±0.8)
stage 6: Torque screws 4 and 9	48 ±8	(4.8±0.8)
stage 7: Torque screws 6 and 11	48 ±8	(4.8±0.8)
stage 8: Torque screws 1 and 8	48 ±8	(4.8±0.8)
stage 9: Torque screws 3 and 10	48 ±8	(4.8±0.8)
stage 10: Torque screws 5 and 12	48 ±8	(4.8±0.8)

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Notes

Notes

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AB Volvo Penta
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7745292 English 11-2007