

Workshop Manual

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D3-110i-B, D3-130i-B

D3-160i-B, D3-190i-B

D3-130A-B, D3-160A-B, D3-190A-B

Workshop manual

Group 21–26

Marine engines

D3-110i-B, D3-130i-B, D3-160i-B, D3-190i-B D3-130A-B, D3-160A-B, D3-190A-B

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Safety information

Introduction

This workshop manual contains technical data, descriptions and repair instructions for the Volvo Penta products or product versions noted in the table of contents. Check that you have the correct Workshop Manual for your engine.

Read the available safety information, "General Information" and "Repair Instructions" in the workshop manual before you start to do any service work.

Important

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



WARNING! Warns for the risk of personal injury, major damage to product or property, or serious malfunctions if the instruction is ignored.



IMPORTANT! Is used to call attention to things which could cause damage or malfunctions to product or property.

NOTE! Is used to call attention to important information, to facilitate work processes or operation.

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



Make it impossible to start the engine by cutting system current with the main switch(es) and lock it (them) in the off position before starting service work. Set up a warning notice by the helm station.



As a general rule all service operations must be carried out with the engine stopped. Some tasks, such as adjustments, need the engine to be running, however. Approaching an engine which is operating is a safety hazard. Remember that loose clothing or long hair can fasten in rotating parts and cause serious personal injury. If work is done adjacent to a running engine, a careless movement or a dropped tool can lead to personal injury in the worst case.

Take care to avoid contact with hot surfaces (exhaust pipes, Turbocharger, air intake pipe, starter heater etc.) and hot fluids in pipes and hoses in an engine which is running or has just been stopped. Reinstall all protective parts removed during service work 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 filter. The rotating compressor turbine in the turbocharger can cause severe injury. Foreign objects entering the intake ducts can also cause mechanical damage.



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



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

-  Hot oil can cause burns. Avoid skin contact with hot oil. 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 and close the sea cocks before doing any work on the cooling system.
-  Only start the engine in a well-ventilated area. When operated in a confined space, exhaust fumes and crankcase gases must be ventilated from the engine bay or workshop area.
-  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. Your eyes are extremely sensitive, injury could cause blindness!
-  Avoid getting oil on your 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 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.
-  Most chemicals intended for the product (e.g. engine and transmission oils, glycol, petrol (gasoline) and diesel oil) or chemicals for workshop use (e.g. degreasers, paints and solvents) are hazardous. 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 inadvertently 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 which comes from a fuel injector has very high pressure and considerable penetration ability. Fuel can force its way deep into body tissue and cause severe injury. Danger of blood poisoning (septicemia).
-  All fuels, and many chemicals, are flammable. Do not allow naked flame or sparks in the vicinity. Petrol (gasoline), some thinners and hydrogen gas from batteries are extremely flammable and explosive when mixed with air in the correct ratio. 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.
-  Make sure that oil and fuel soaked rags, and used fuel and oil filters are stored in a safe place. Rags soaked in oil can spontaneously ignite under certain circumstances. Used fuel and oil filters are polluting waste and must be handed to an approved waste management facility for destruction, together with used lubrication oil, contaminated fuel, paint residue, solvents, degreasers and wash residue.
-  Batteries must never be exposed to open flames or electric sparks. Never smoke close to the batteries. The batteries generate hydrogen gas when charged, which forms an explosive gas when mixed with air. This gas is easily ignited and highly volatile. A spark, which can be caused by incorrect battery connection, can cause a single spark which is sufficient to cause an explosion with resulting damage. Do not move the connections when you attempt to start the engine (risk of arcing), and do not stand and lean over one 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 you get battery acid in your eyes, flush at once with a generous amount of water, and get 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.

 The existing lugs on the engine/reversing gear should be used for lifting the assembly. Always check that the lifting devices are in good condition and that they have the correct capacity for the lift (the weight of the engine plus the reversing gear and extra equipment). The engine should be lifted with a customized or adjustable lifting boom for safe handling and to avoid damaging components on top of the engine. All chains or cables should be parallel to each other and should be as square as possible to the top of the engine. If other equipment connected to the engine has altered its center of gravity, special lifting devices may be needed to obtain the correct balance and safe handling. Never do any work on an engine which just hangs from a lifting device.

 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.

When you work aboard a boat, always make sure that there is enough space for disassembly where you are working, with no risk of personal injury or material damage.

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

 Remember the following when washing with a power washer: Never aim the water jet at seals, rubber hoses or electrical components. Never use a power washer for engine cleaning.

 Only 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 bind and the engine to overrev with resulting risk of damage to the engine and personal injury. Poor fuel can also lead to higher maintenance costs.

General information

About this Workshop Manual

This workshop manual contains technical data, descriptions and repair instructions for the following marine diesel engines: D3-110i-B, D3-130i-B, D3-160i-B, D3-190i-B, D3-130A-B, D3-160A-B, D3-190A-B.

The engine designation and number are noted on the number plate and engine decal. The engine designation and number must always be given in all correspondence about any product.

The Workshop Manual is produced primarily for the use of Volvo Penta workshops and service technicians. This assumes that people who use the Manual have basic knowledge of marine drive systems and can do the tasks of a mechanical or electrical nature associated with the trade.

Volvo Penta constantly improves its products, so we reserve the right to make modifications without prior notification. All information in this manual is based on product data which was available up to the date on which the manual was printed. Any material changes introduced into the product or service methods after this date are notified by means of Service Bulletins.

Standard times (Flat Rate)

In instructions where operation numbers are found in the headings, this is a reference to the Volvo Penta standard times list ("Flat Rate").

Spare parts

Spare parts for electrical- and fuel systems are subject to various national safety requirements, such as U.S. Coast Guard Safety Regulations. Volvo Penta Original Spare Parts meet these specifications. Any damage, occasioned by use of non--original Volvo Penta spares for the product, will be not be compensated by the warranty offered by Volvo Penta.

Certified engines

When doing service and repair on emission certified engines, it is important to be aware of the following:

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

This makes special demands on service and repair work, as follows:

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

The general advice in the instruction book about operation, care and maintenance applies.



IMPORTANT! Late or inadequate maintenance/ service or the use of spare parts other than by Volvo Penta approved spare parts will invalidate AB Volvo Penta's responsibility for the engine specification being in accordance with the certificated variant.

Volvo Penta accepts no responsibility or liability for any damage or costs arising due to the above.

Repair instructions

The working methods described in the Workshop Manual apply to work carried out in a workshop. For this reason, the engine is lifted out of the boat and mounted on an engine support. Unless otherwise stated, re-conditioning work which can be carried out with the engine in place follows the same working method.

The warning signs which occur in the workshop manual (please refer to “Safety information” for their meanings).



NOTE!

are not comprehensive in any way, since we can not of course foresee everything, because service work is done in highly varying circumstances. For this reason, all we can do is to point out the risks which we believe could occur due to incorrect work in a well-equipped workshop, using work methods and tools tested by us.

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 the most safe and rational working methods 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. These rules must always be observed, so there are no special instructions about this 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 workplace and a clean engine will eliminate many risks of personal injury and engine malfunction.

Above all, when work on fuel systems, lubrication systems, induction systems, turbocharger, bearing caps and seals is done, it is extremely important that no dirt or other kinds of foreign particles are able to get in, since this would otherwise cause malfunctions or shortened repair life.

Our common responsibility

Each engine consists of many interacting systems and components. The deviation of one component from the technical specification can dramatically increase the environmental impact caused by an otherwise good engine. For this reason, it is important that the specified wear tolerances are observed, that systems which are adjustable are correctly adjusted and that Volvo Penta Original Spares are used for the engine. The stated service intervals in the Maintenance Schedule must be observed.

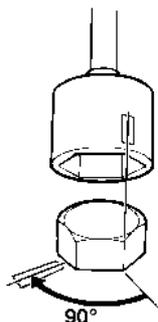
Some systems, such as the components in the fuel system, require special expertise and special testing equipment for service and maintenance. For environmental reasons etc., some components are sealed at the factory. It is only permissible to work on sealed components if you are authorized to do such work.

Remember that most chemical products, incorrectly used, damage the environment. Volvo Penta recommends the use of biodegradable degreasers whenever engine components are de-greased, unless otherwise specified in the workshop manual. When working aboard a boat, be careful to ensure that oils, wash residue etc. are processed for destruction, and are not inadvertently discharged with bilge water into the environment.

Torque

The tightening torque for vital fasteners, which should be tightened with a torque wrench, are listed in “Technical Data: Special tightening torques” and noted in the job descriptions in the book. All torque specifications apply to clean screws, screw heads and mating faces. Torque data stated apply to lightly oiled or dry threads. If lubricants, locking fluids or sealants are needed on a fastener, the type of preparation to be used will be noted in the job description. For fasteners where specific torque values are not given, please refer to “Technical data, General Tightening Torque”.

Torque-angle tightening



In torque/angle tightening, the fastener is tightened to the specified torque, and tightening then continues through a pre-determined angle. Example; for 90° angle tightening, the fastener is tightened a further 1/4 turn in one sequence, after the specified tightening torque has been achieved.

Lock nuts

Disassembled locknuts shall not be re-used, they shall be replaced by new ones, since the locking properties are impaired or lost when the nut is used several times. On locknuts with plastic inserts, such as Nylock®, the tightening torque specified in the table must be reduced if the Nylock® nut has the same nut height as a standard fully metallic hexagonal nut. Reduce the torque by 25% for screw size 8 mm or larger. On Nylock® nuts with higher nut height, where the fully metallic thread is as high as on a standard hexagonal nut, use the tightening torques in the table.

Strength classes

Screws and nuts are sub-divided into different strength classes. The classification is shown by a marking on the screw head. Markings of a higher number indicate stronger material. For example, a screw marked 10-9 is stronger than one marked 8-8. For this reason, it is important when fasteners are dismantled, that the screws are put back in the correct places when they are re-installed. If a screw must be replaced check in the spare parts catalogue to make sure the correct screw is used.

Sealant

The sealants and locking fluids noted below shall be used on the engines covered by this manual.

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.

When sealants and locking fluids are used, it is important that the surfaces are free from oil, grease, paint and rust-protection, and that they are dry. Always follow the manufacturer's instructions use regarding temperature range, curing time and any other instructions for the product,

Two different basic types of agent are used on the engine. These are:

RTV preparations (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 preparations are used on the engine:

Volvo Penta sealant (cartridge 0.31 l, part. no. 1161231-4, or tube 20 g., part. no. 1161277-7) and part. no. 840879-1 (tube 25 g).

Remove old sealant with denatured alcohol.

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

Hardened anaerobic preparations are glassy and for this reason, the preparations are colored to make them visible.

Hardened anaerobic preparations are highly resistant to solvents, and old compound must be removed mechanically. On re-assembly, it is important to degrease components carefully first, wipe off and apply new sealant in accordance with the instructions.

The following anaerobic preparations are used on the engines: Volvo Penta thread locking fluid (part. no. 1161053-2) and liquid gasket (part. no. 1161059-9).

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

 **WARNING!** Observe the greatest care in working on engines which might have been exposed to high temperatures, such as overheating during flame cutting or a fire. Seals must never be cut with a flame torch during disassembly, or burned in uncontrolled circumstances afterwards.

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

- Handle the removed seal in the same way as corrosive acid. All residue, including ash, can be highly corrosive. Never use compressed air to blow anything clean.
- Put the remains in a plastic container, seal it and apply a warning label. Wash the gloves under running water before removing them.

The following seals are most probably made from fluorocarbon rubber:

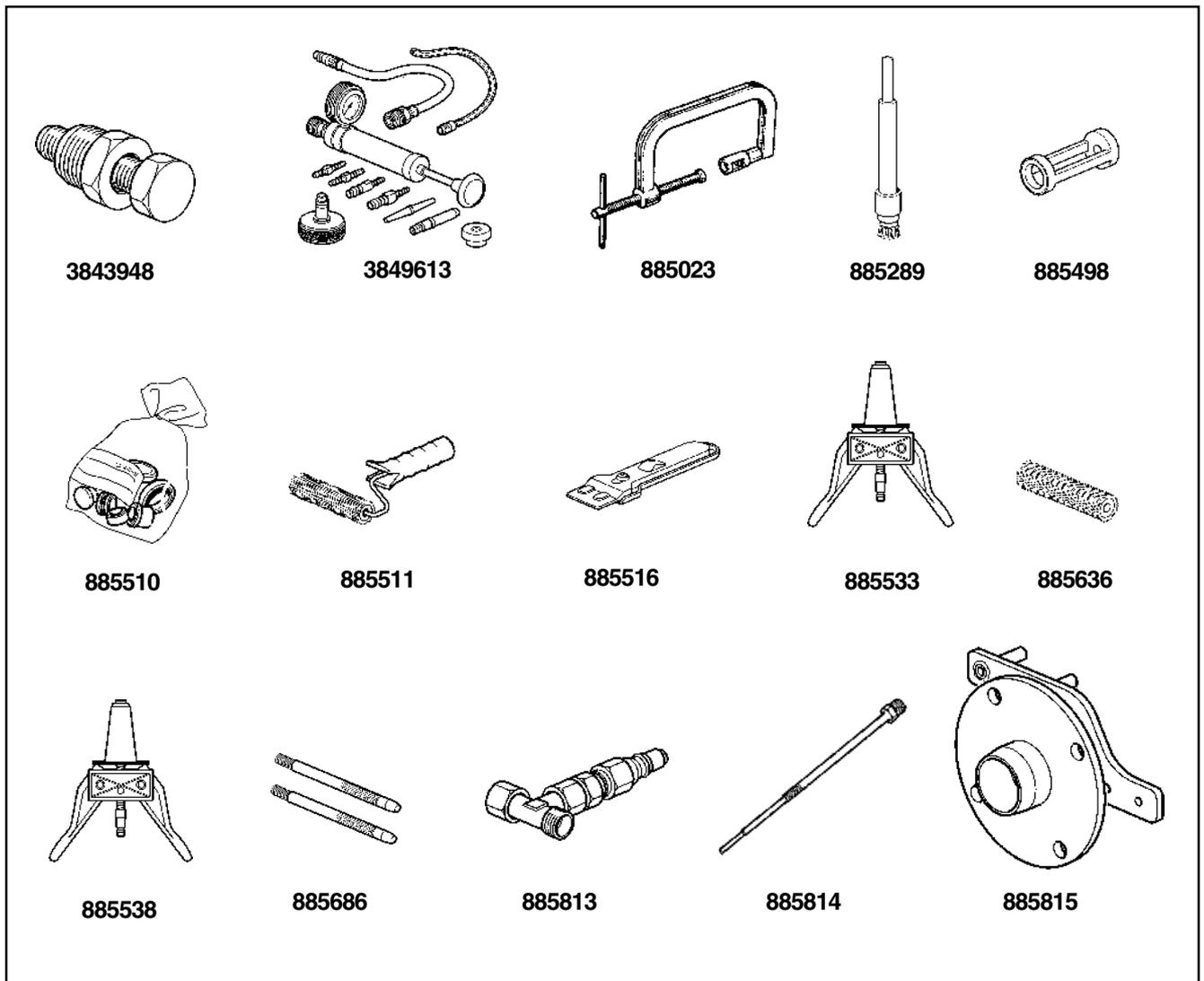
Seal rings for the crankshaft, camshaft, drive shafts.

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

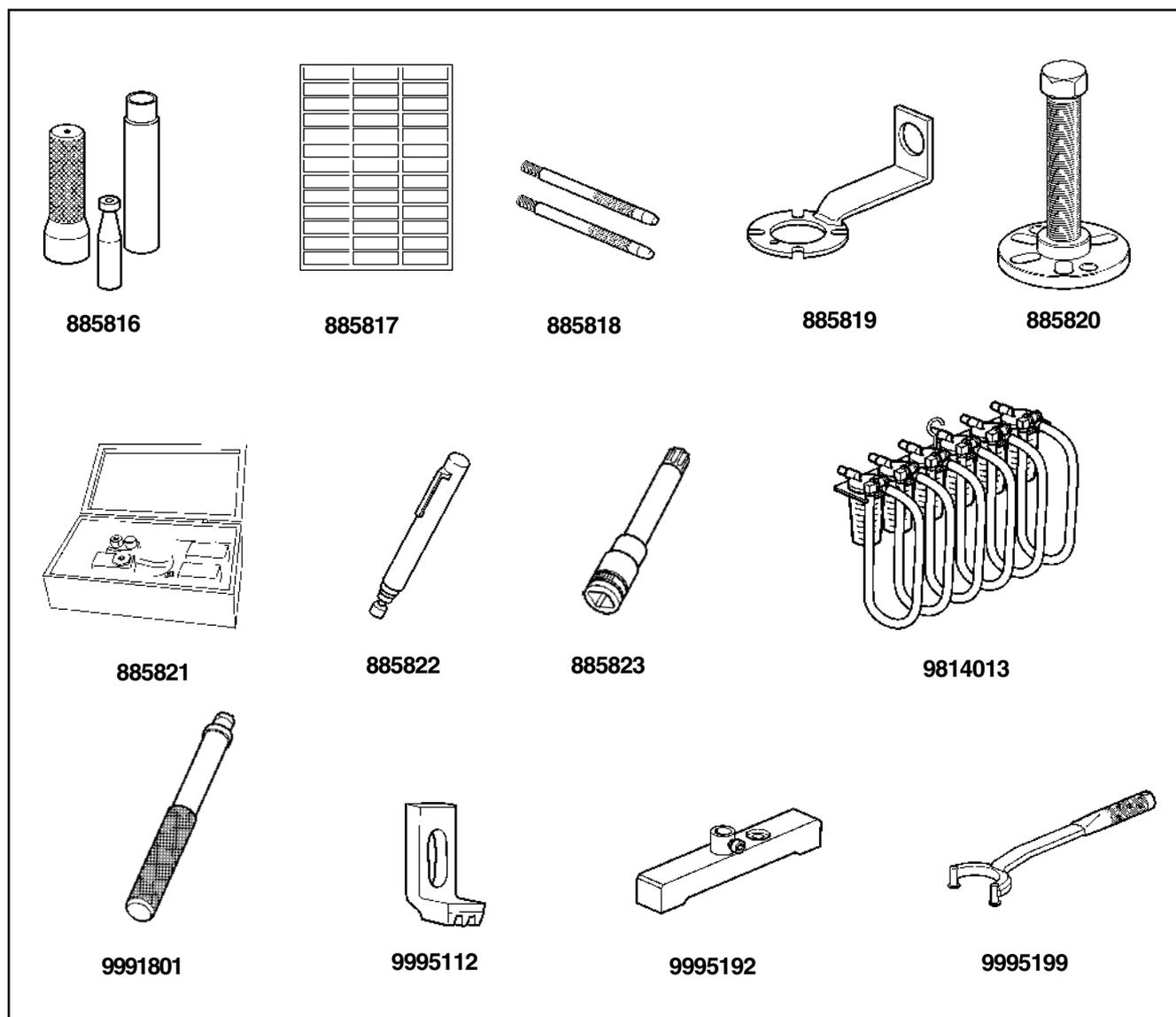
Please note that seals which have not been exposed to high temperature can be handled normally.

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

Special tools



3843948	Puller, for changing the impeller	885533	Expansion plug (used together with pressure testing kit 885531)
3849613	Pressure testing kit	885636	Exchange roll, roller
885023	Valve spring compressor	885538	Expansion plug
885289	Brush, clean seat in copper sleeve	885686	Guide dowels, valve housing
885498	Adapter (used together with valve spring compressor 885023)	885813	Nipple for vacuum hose, fuel suction
885510	Protective caps, fuel system	885814	Adapter for compression test
885511	Roller, sealant application	885815	Engine fixture
885516	Gasket scraper		



885816 Mandrel for installing seal, sea water pump

885817 Decal kit, upgrade

885818 Dowels, sump

885819 Counterhold, vibration damper

885820 Puller, tooth belt pulley

885821 Tool kit, upgrade

885822 Magnetic pen

885823 12-point bit XZN 12-100, flywheel

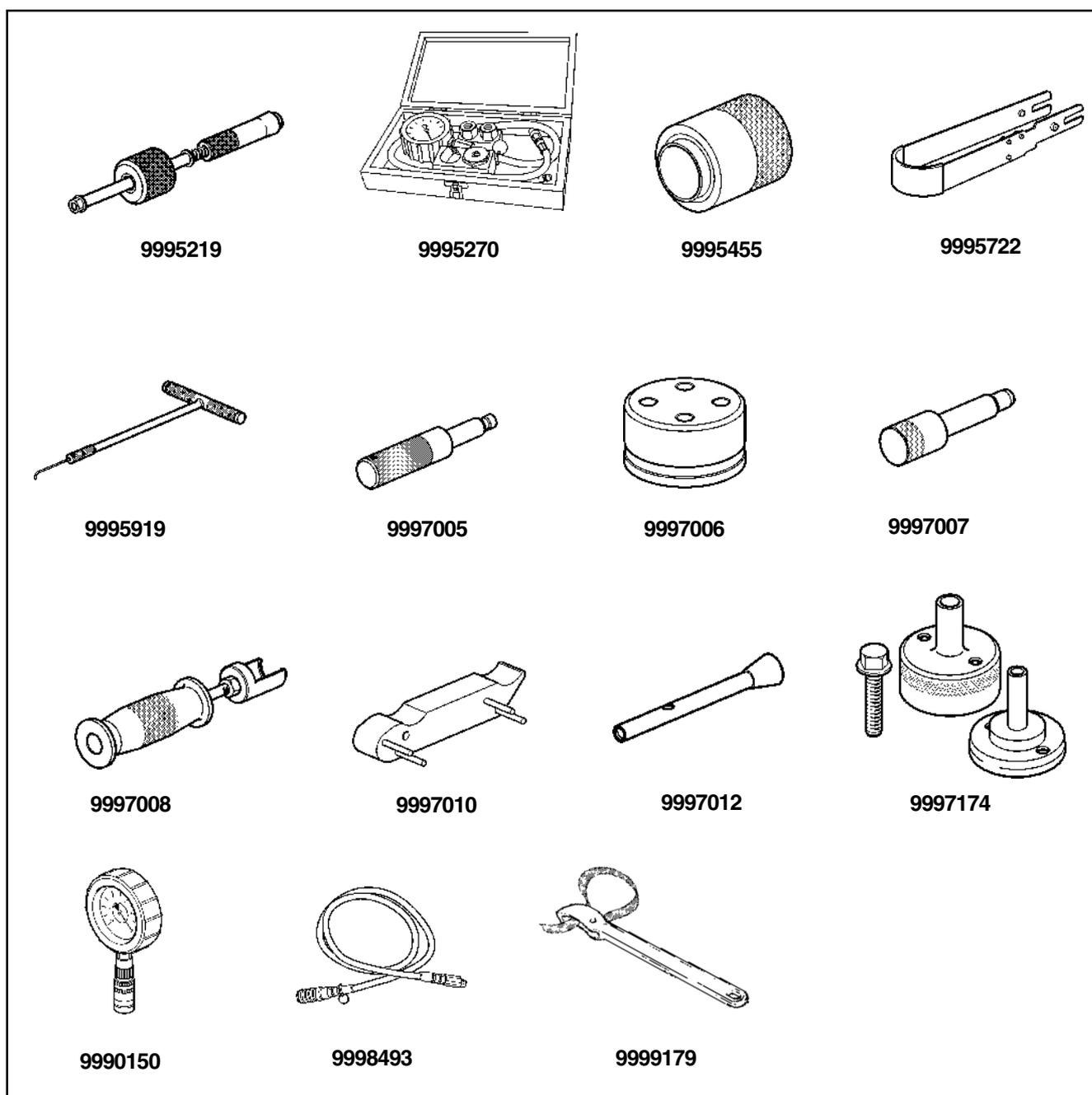
9814013 Check return flow from injectors

9991801 Mandrel for rear crankshaft seal tool 9995676

9995112 Locking tool for flywheel

9995192 Holder, dial gauge, piston height measurement

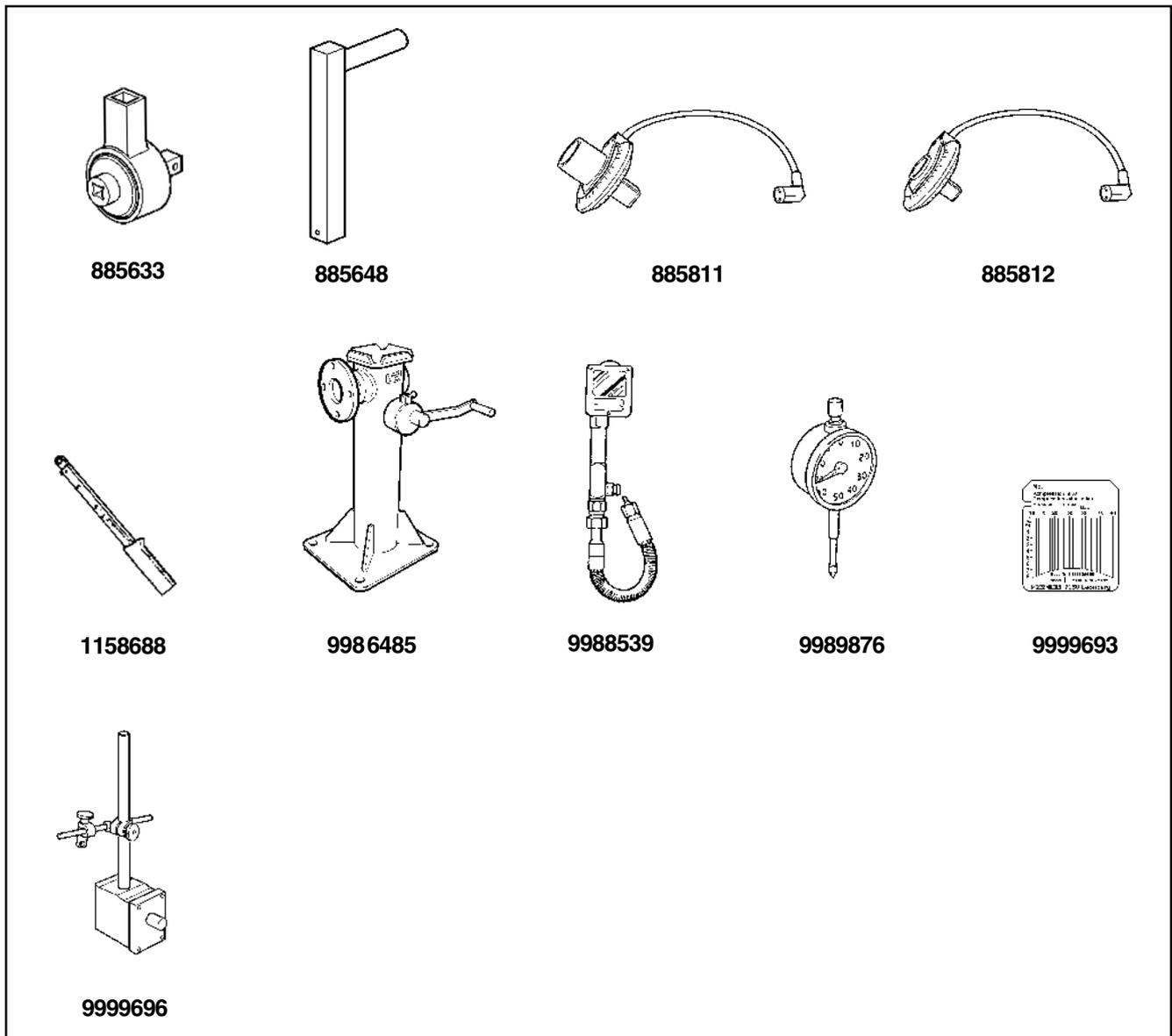
9995199 Counterhold, camshaft pulley



9995219 Removal/installation, valve shaft seal
9995270 Pressure gauge with unions, oil pressure check
9995455 Crankshaft seal tool, oil pump
9995722 Puller, engine control unit
9995919 Puller, seals
9997005 Lock pin, crankshaft
9997006 Camshaft seal tool

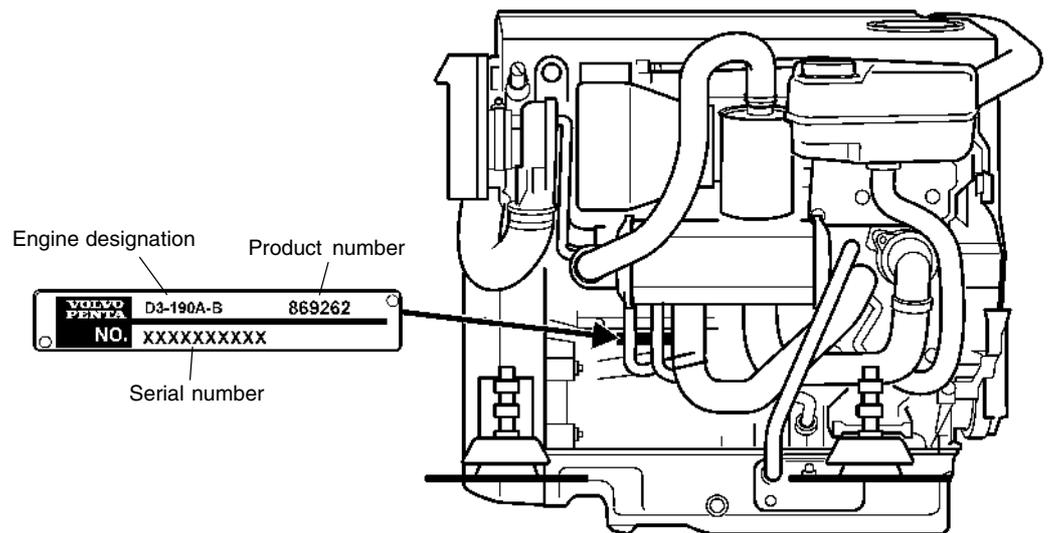
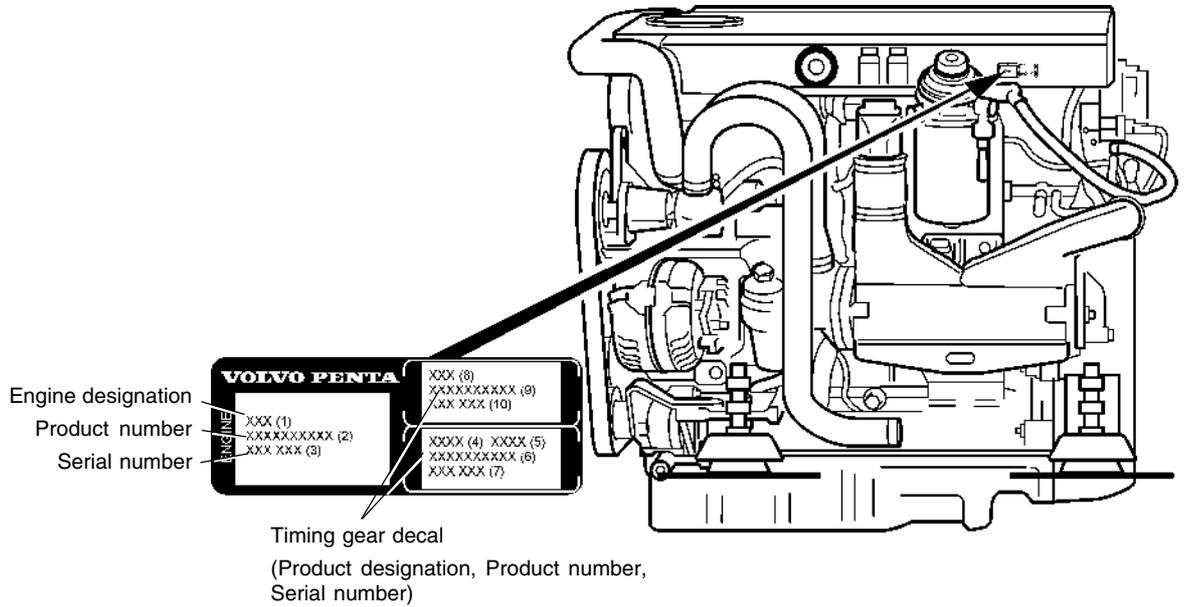
9997007 Lock pin, camshaft
9997008 Puller, injector
9997010 Fixture, injector
9997012 Mandrel, installation, valve shaft seal
9997174 Crankshaft seal tool, rear
9990150 Vacuum gauge, fuel pipe
9998493 Hose for vacuum gauge 9990150
9999179 Filter extractor

Other special tools



885633	Torque amplifier	9986485	Equipment stand
885648	Counterhold, used together with 885633	9988539	Compression gauge, use diagram card 9999693
885811	Angle gauge, 3/4"	9989876	Dial gauge
885812	Angle gauge, 1/2"	9999693	Diagram card for compression test
1158688	Torque wrench	9999696	Magnetic stand

Location of engine signs



Design and function

Group 21 Short block

Engine, general

D3 is an in-line, 5-cylinder, 2.4-liter, 4-cycle marine diesel engine for propulsion. It has four valves per cylinder, twin overhead camshafts and has direct injection via a common rail supply manifold.

The D3 engine is lubricated by a pressure lubrication system, in which an oil pump mounted on the crankshaft supplies oil under pressure to all lubrication points. The pistons are cooled by lubrication oil supplied through piston cooling nozzles. Lubrication oil is cooled by a fresh-water cooled oil cooler.

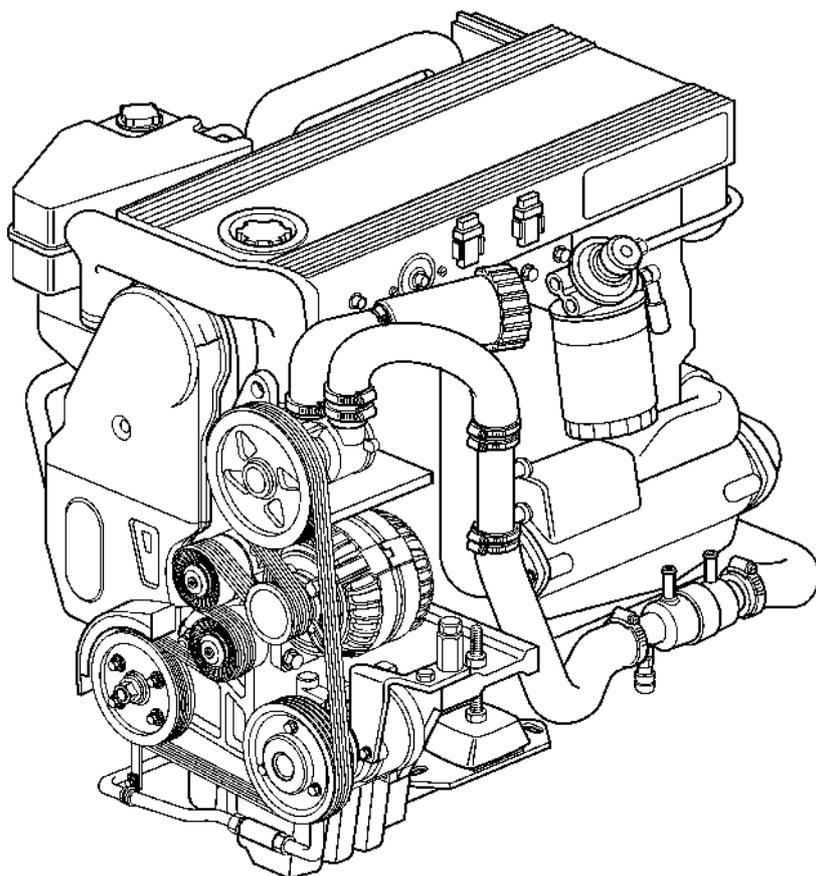
The engine has a turbocharger which is lubricated and cooled by engine oil. The turbocharger has a Variable Nozzle Turbine (VNT) in which a vacuum-operated circuit adjusts the inlet area and the angle of incidence on the exhaust turbine. This gives the turbocharger fast response and high capacity.

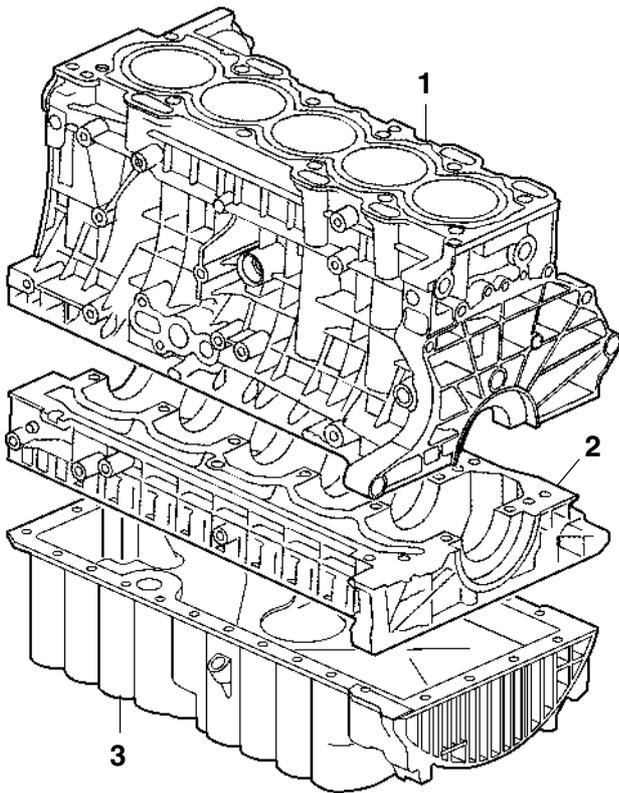
The engine has a sea water cooled heat exchanger for thermostatically controlled fresh water cooling. The engine also has a sea water cooled intercooler which reduces the temperature of the inlet air, thereby permitting higher power output.

The crankshaft drives the auxiliary equipment, sea water pump, servo pump (only AQ) and alternator via a toothed belt. The hydraulic oil in the servo system is cooled by a sea water cooled oil cooler.

The engine is controlled and monitored by the EVC^{MC} electronic control system.

D3 for Aquamatic propulsion





Engine block

The engine block consists of two sections: engine block (1) and spacer block (2).

The engine block is made from pressure die-cast aluminum alloy, and has cast in cylinder liners. The upper parts of the cylinders have open water jackets, where coolant can flow freely.

The spacer block is made from aluminum alloy and serves as the crankshaft bearing caps and also as a stiffener for the engine block.

Sump

The sump (3) is made from aluminum alloy and is installed underneath the spacer block. The sump contains a safety valve for the oil cooler and a number of galleries which direct the lubrication oil.

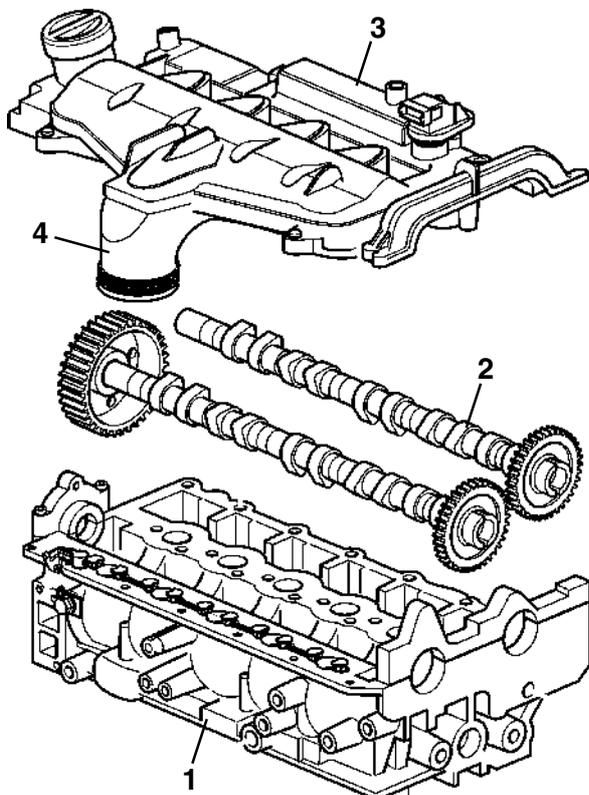
Cylinder head

The cylinder head (1) is made from aluminum alloy and has twin overhead camshafts (2) which use cylinder head casting as a bearing, together with bearing caps.

There are four valves per cylinder. The inlet ducts are doubled for each cylinder, and have different lengths and geometry. The camshafts operate the valves via rockers with roller cam followers. Valve clearance is adjusted hydraulically. The injector nozzles are mounted centrally in the combustion chamber.

The inlet camshaft is driven by the crankshaft, via a toothed belt. The exhaust camshaft is driven by the inlet camshaft, via a gear wheel.

The butterfly in the inlet pipe is fixed in the open position.



Camshaft

The camshafts consist of several components. The cam lobes and gear wheels have been made separately, and are then pressed onto a hollow shaft. This offers the advantages of lower weight and that different materials can be used in the camshaft.

Valve housing / inlet manifold

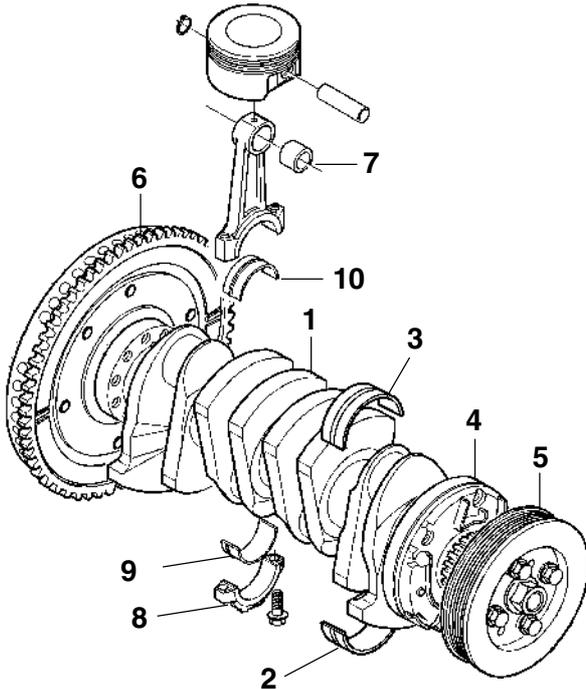
The valve housing (3) is integrated with the inlet manifold (4). The induction air from the air to the cylinders is directed through the inlet manifold.

Crankshaft

The crankshaft (1) has 6 bearings and is made of forged steel. Its main bearings have different materials in the upper and lower bearing halves. The lower half (2), which is subjected to greater loading, has a lead bronze bearing shell, and the upper bearing shell (3) is coated with aluminum.

The rear crankshaft seal consists of a ring-shaped lip seal. The front seal is of the same type, and is integrated with the oil pump (4). The oil pump is driven directly by the crankshaft.

The crankshaft has a vibration damper (5) at the front end and a flywheel (6) at the rear.



Con rods

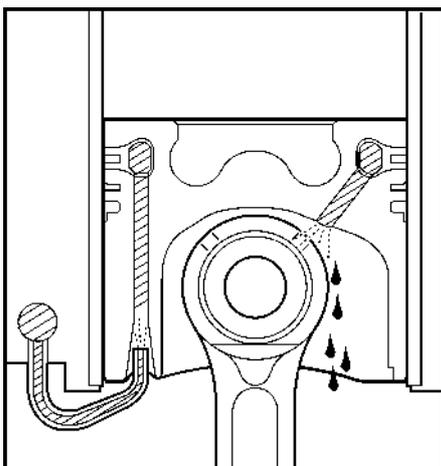
The gudgeon pin bearing (7) in the con rod is trapezoidal in shape, to give greater area where the loading is greatest. The con rod has a split bearing cap (8), which gives a stable joint.

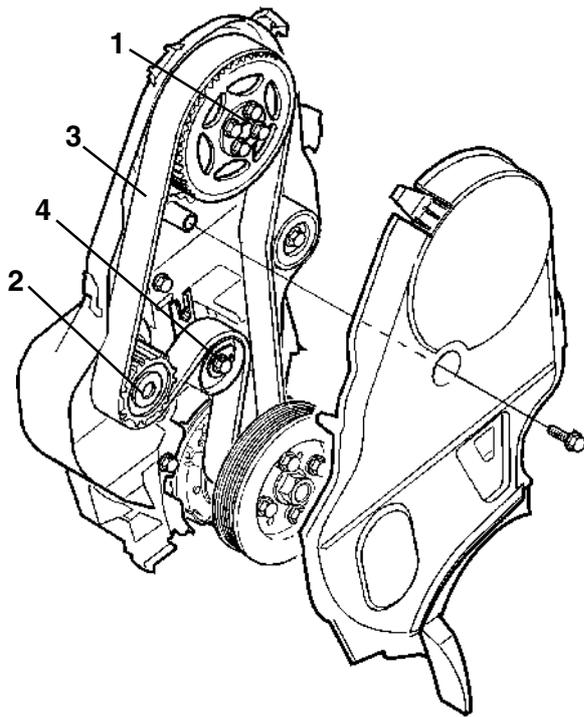
There are different materials in the upper (9) and lower (10) bearing shells. The upper shell, which is subjected to the greater loading, is coated with a thin and very hard aluminum coating, a so-called sputter coating. The lower bearing shell is coated with lead bronze.

Pistons

The pistons are made of a light metal alloy and have a graphite coated piston skirt to guarantee low friction. The piston has two compression rings and one oil scraper ring. The upper compression ring has a cast steel ring bearer which is cooled by the oil aimed at a duct in the piston. The heat is transported away with the oil which returns to the sump.

The combustion chambers in the piston crowns are undercut. This design gives a better mixture of fuel-air and thus contributes to more effective combustion.

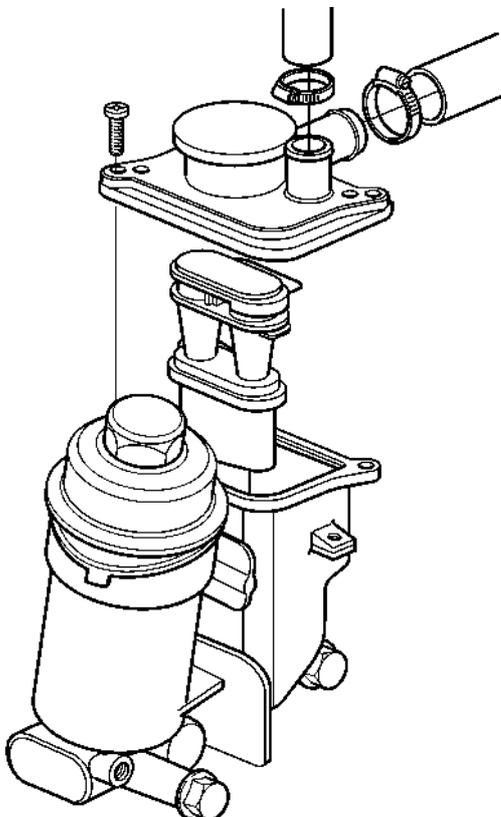




Timing gear

The inlet camshaft (1) and coolant pump (2) are driven by the crankshaft, via a toothed belt (3). The toothed belt is tensioned by a mechanical belt tensioner (4).

The crankshaft also drives the sea water pump, servo pump (if servo steering is installed) and the alternator, using a drive belt. The drive belt is tensioned by a mechanical/automatic belt tensioner.



Crankcase breather

Crankcase ventilation is pressure controlled and has a cyclone type oil separator. Crankcase gases from the crankcase and crankcase are lead into the oil separator where the oil condenses, after which the oil is returned to the sump. The crankcase gas, when stripped from its oil mist, is transferred to the turbo-charger inlet section, to be incinerated in the cylinders.

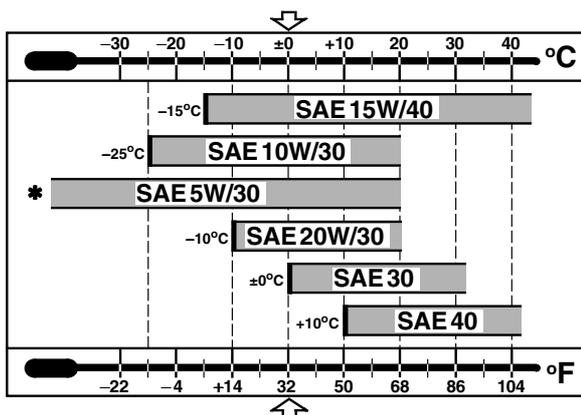
Group 22 Lubrication system

Oil grades

D3	Sulfur in fuel, percentage by weight	
	<1%	> 1.0% ¹⁾
Oil grade ²⁾	Oil change interval reached first in operation	
VDS-2 and ACEA E7 ³⁾ or VDS-2 and Global DHD-1 or VDS-2 and API CH-4 or VDS-2 and API CI-4	200 h or 12 months	100 h or 12 months

- 1) If sulfur content is > 1.0% by weight, use oil with TBN > 15.
- 2) Contains the specifications for oil grades “**and**” the engine oil must comply with both requirements.
- 3) ACEA E7 has replaced ACEA E5. If ACEA E5 is available, it can be used.

VDS = Volvo Drain Specification
ACEA = Association des Constructeurs Européenne d’Automobiles
API = American Petroleum Institute
Global DHD = Global Diesel Heavy Duty
TBN = Total Base Number



Viscosity

Select the viscosity from the adjacent table, for the appropriate continuous ambient air temperature.

* Refers to synthetic or semi-synthetic oils.

Oil change volume

Please refer to the “Technical Data” chapter.

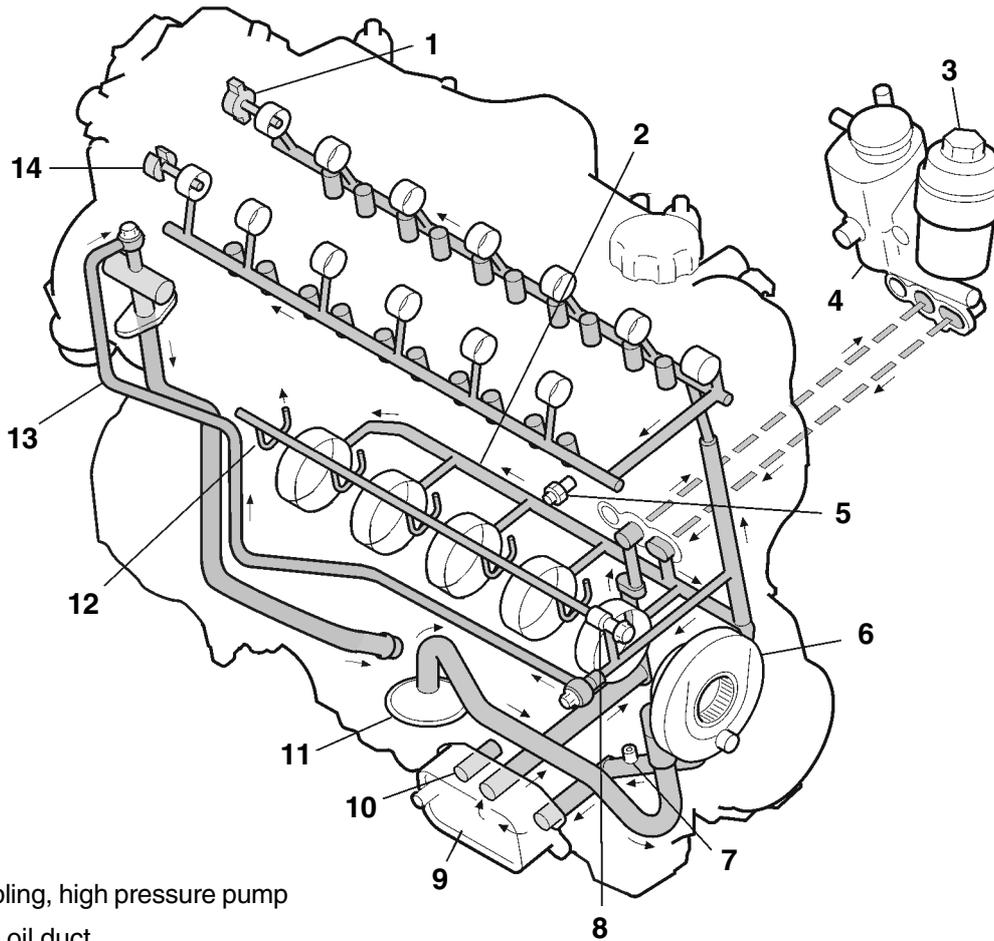
Lubrication oil system

The engines are provided with a complete pressure lubrication system. The lube oil pump is an internal gear pump with built-in safety valve, and is driven directly from the crankshaft.

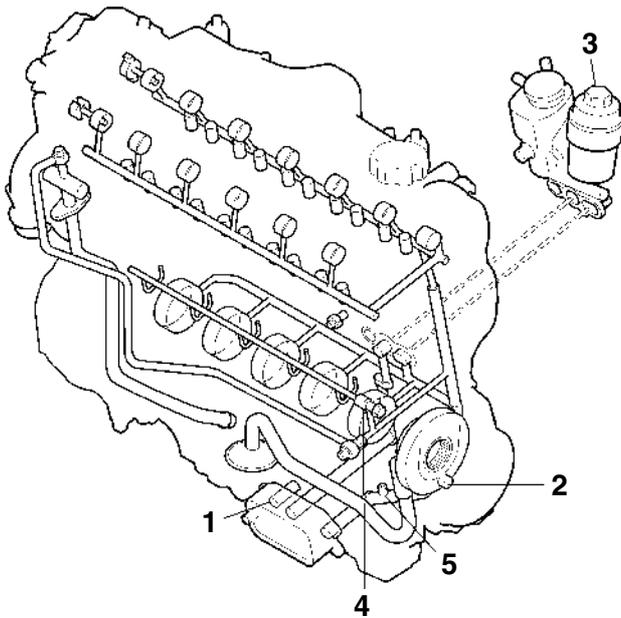
The oil filter is a replaceable filter element located in a housing. A bypass valve is located in the housing cover, in case the filter is blocked.

The pressure lubrication system supplies units such as the turbocharger, fuel pump, vacuum pump and the hydraulic units in the valve system with lubrication.

The lube oil is cooled by a plate heat exchanger beside the sump.



1. Coupling, high pressure pump
2. Main oil duct
3. Oil filter
4. Crankcase ventilation, oil separator
5. Oil pressure monitor
6. Oil pump with safety valve
7. Vent valve
8. Inlet valve, piston cooling duct
9. Oil cooler
10. Pressure reduction valve
11. Inlet pipe with strainer
12. Piston cooling nozzles
13. Inlet pipe to turbocharger
14. Lubrication, vacuum pump



Oil valves

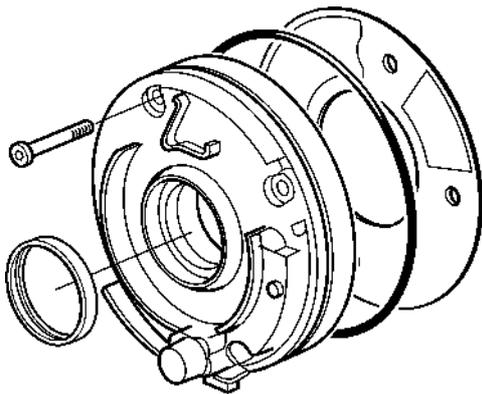
The lubrication oil system has a reduction valve (1) which limits the maximum oil pressure in the engine. Since it is located downstream from the oil cooler, the bypassed oil is also cooled. It opens at about 550 kPa.

A safety valve (2) is installed in the oil pump to prevent high pressure which could damage the oil cooler etc. It opens at about 800 kPa.

A bypass valve (3) located on the oil filter cover opens if the resistance in the filter rises too high. Oil supply to the lubrication points is ensured in this way, even if the filter is blocked, but the oil is no longer cleaned.

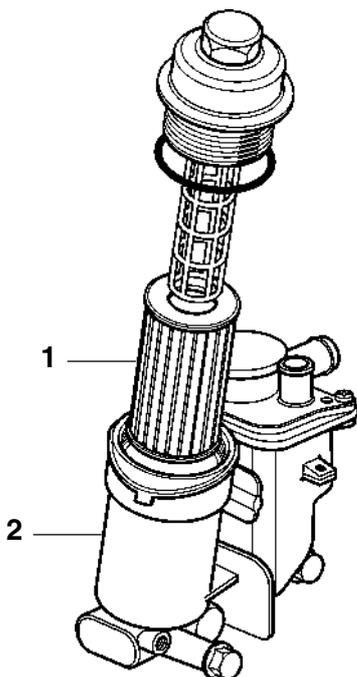
An inlet valve (4) in the piston cooling duct opens and closes at a set pressure to provide piston cooling, to avoid engine damage. It opens/closes at about 135 kPa.

An air vent valve (5) is located between the oil pump and the oil cooler. This ensures that air is removed from the lubrication system during pressure build-up. It closes at about 40 kPa.



Oil pump

The oil pump is an internal gear wheel pipe of the “Duocentric” type, and has a built-in safety valve. The oil pump is directly driven from the crankshaft and has a crankshaft seal in its centre.



Oil filter

The oil filter removes contamination from the oil and consists of a replaceable filter element (1) located inside a housing (2). When the filter has been in use for a pre-determined time, it must be replaced by a completely new filter insert.

Group 23 Fuel system

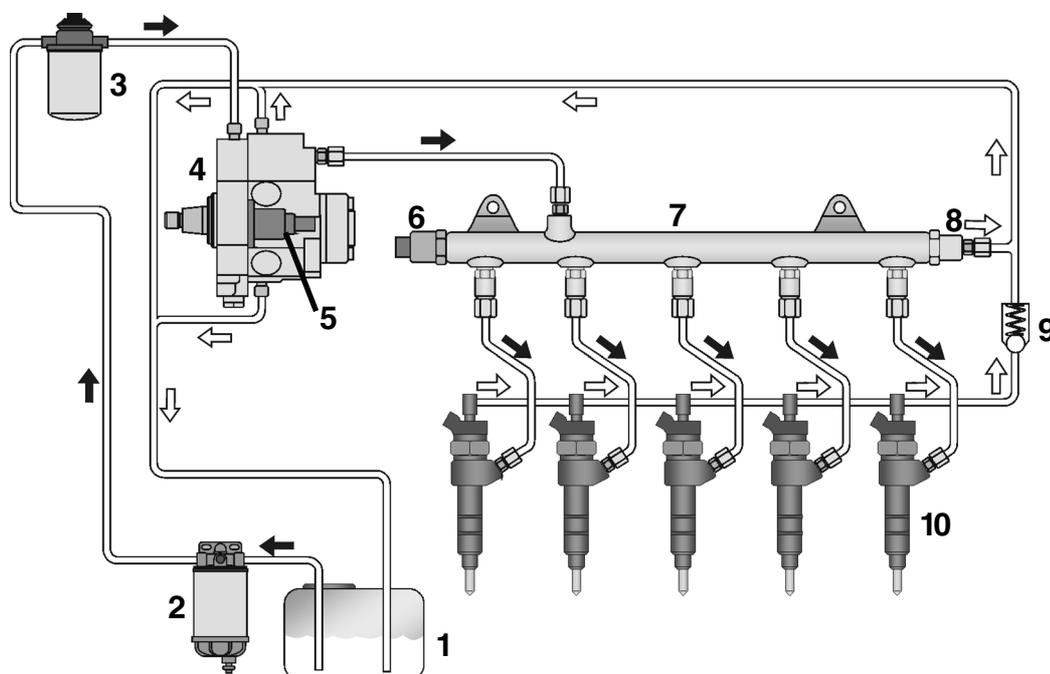
Fuel system

The fuel system has an injection pump which consists of a low pressure pump and a high pressure pump. The fuel is sucked out of the fuel tank by the low pressure pump, through the primary filter and secondary filter. The low pressure pump then transfers the fuel to the high pressure pump, via a fuel regulation valve. The high pressure pump then pressurizes the fuel in the distribution manifold (common rail) at a pressure which varies with engine speed and loading. The injectors which are connected to the common rail open sequentially and are controlled by the engine control unit.

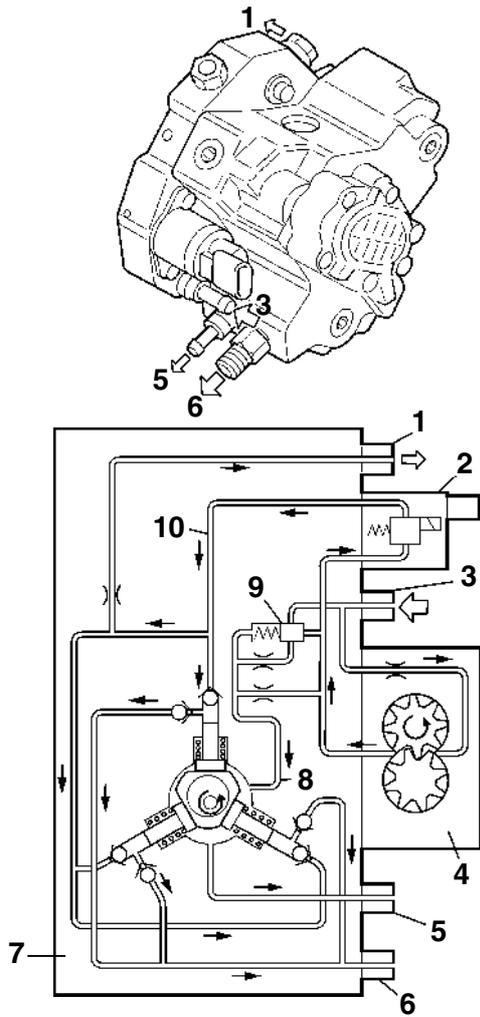
The fuel is then forced through the injector nozzles into the cylinder at high pressure and enters the combustion chambers in the pistons, where high speed air rotation contributes to even combustion.

Fuel returning from the common rail, high pressure pump and fuel leakage from the injectors is returned to the base of the fuel pump.

The secondary filter in the engine removes contamination which might be left in the fuel, despite the primary filter.



1. Fuel tank
2. Primary filter
3. Fuel filter
4. Low and high pressure pump
5. Fuel pressure regulation valve
6. Fuel pressure sensor
7. Distribution manifold
8. Relief valve
9. Non-return/restriction valve
10. Injector



- 1. Return, ventilation circuit
- 2. Fuel pressure regulation valve
- 3. Inlet from tank
- 4. Low pressure pump
- 5. Return, cooling and lubrication circuit
- 6. Outlet to distribution manifold
- 7. High pressure pump
- 8. Cooling and lubrication ducts
- 9. By - pass valve
- 10. Inlet duct, high pressure pump

Injection pump

The injection pump is directly driven by the inlet camshaft. The pump unit contains:

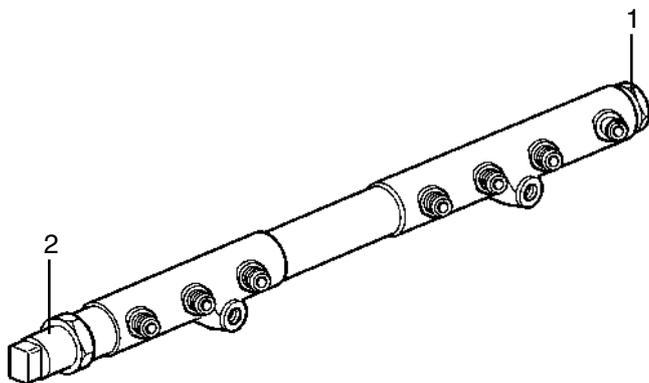
Low pressure pump which is a gear pump. It sucks fuel up from the tank and provides the rest of the pump with fuel.

High pressure pump which consists of three pistons bearing on a cam. The forward and return motion of the pistons is achieved by driving the cam by an eccentrically mounted flange. A return spring ensures that the pistons always rest against the cam. The high pressure pump provides the common rail with fuel at varying pressure.

Fuel pressure regulation valve is an electro-hydraulic valve controlled by the engine control unit. This regulates the amount of fuel going to the high pressure pump.

By - pass valve is a mechanical/hydraulic valve. This evacuates surplus fuel which the low pressure valve supplies, back to the inlet.

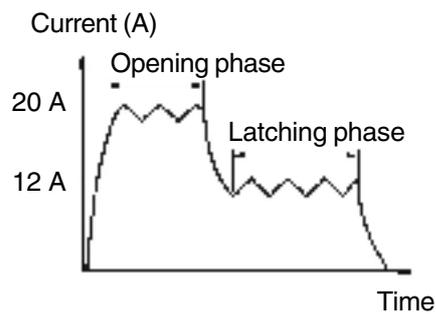
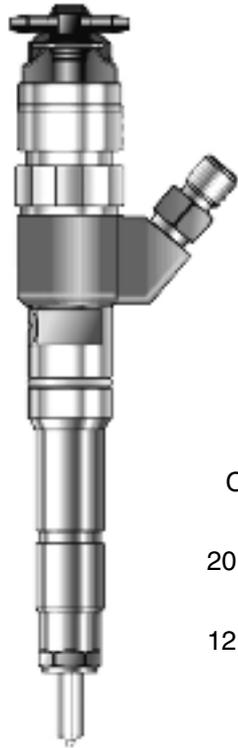
The injection pump has automatic venting since the high pressure pump's inlet duct has an inner, restricted duct in the pump unit that leads return fuel back to the tank. Its task is to release any air that might be left in the fuel. Due to its location high up in the pump unit, this guarantees that any remaining air goes back to the tank together with the fuel.



Distribution manifold

Stores fuel for the injectors at high pressure, between 30-160 MPa. There is a relief valve (1) at the other end which opens if the pressure exceeds 190 MPa. If this valve has tripped, it must be replaced by a new one.

There is a fuel pressure sensor (2) at the other end, which sends information to the engine control unit.

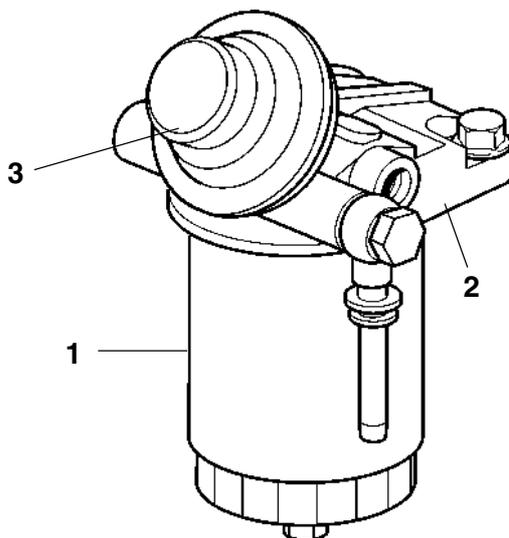


Injectors

The task of the injectors is to distribute the jets of fuel with the turbulent air in the combustion chamber, to give a mixture of fuel and air.

The built-in solenoid is supplied with a voltage of about 80 V and a current during the opening phase of about 20A, so as to lift the fuel needle in the injector quickly. During the latching phase, the current density falls to about 12 A.

A non-return valve is installed in the common return pipe to the tank, to retain a certain amount of pressure in the return pipes from the injectors.



Fuel filter housing

The fuel system is provided with a disposable primary filter (1). The fuel filter is located in a bracket (2) together with a hand pump (3).

The hand pump has a built-in valve and does not need to be undone or tightened when used.

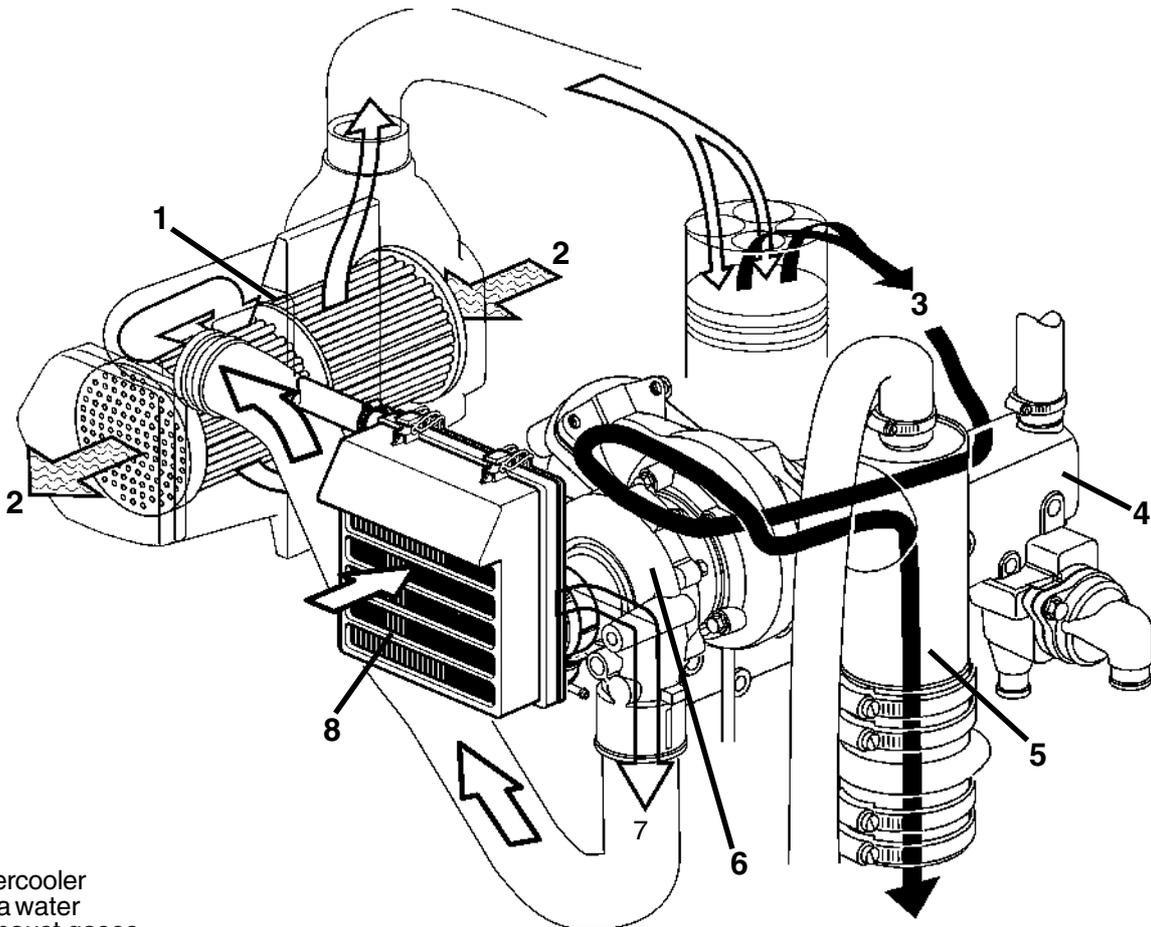
Group 25 Inlet and exhaust system

Inlet and exhaust system

The engine has a turbocharger which provides the cylinders with compressed induction air. This increases the amount of oxygen supplied to the engine and more fuel can be burned at the same time as combustion becomes more efficient. The result is higher power, lower specific fuel consumption and cleaner exhaust emissions.

A sea water cooled intercooler reduces the temperature of the compressed induction air. This means that a larger amount of oxygen enters the combustion cylinders of the engine which, together with the increased fuel supply, gives more engine power.

The induction and exhaust system also includes a vacuum pump mounted on the exhaust camshaft, a vacuum regulator, an air filter directly adjacent to the turbocharger and an exhaust bend with sea water connection, for wet exhaust.



1. Intercooler
2. Sea water
3. Exhaust gases
4. Exhaust manifold
5. Exhaust pipe elbow, sea water cooled
6. Turbo
7. Compressed induction air
8. Air filter

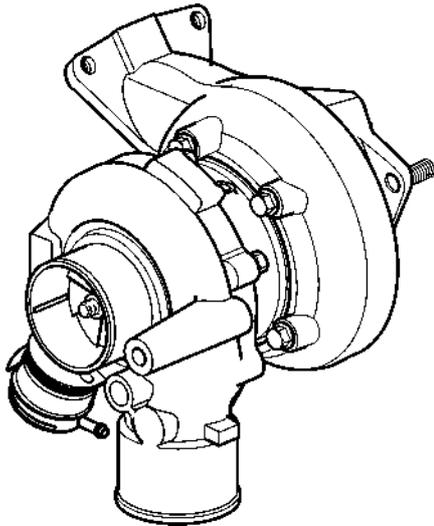
Turbocharger

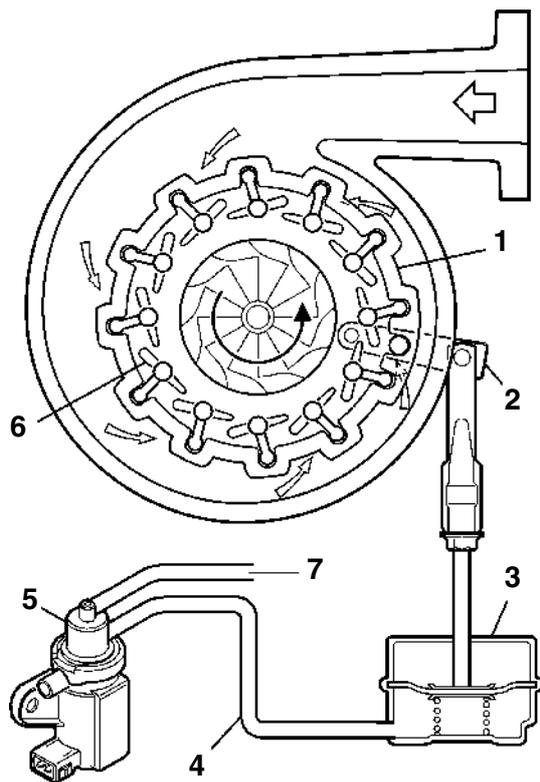
The turbocharger consists of an exhaust turbine section, bearing housing, compressor and a vacuum capsule.

When exhaust gas flows into the turbine housing on its way out of the exhaust system, it causes the turbine wheel to move. The turbine wheel then drives the compressor turbine since it is installed on the same shaft.

When the compressor turbine rotates, air is sucked in from the air filter, after which is compressed by the compressor turbine and is forced under pressure (charge pressure) into the cylinders of the engine, via an intercooler. The additional air allows the quantity of fuel injected to be increased, at the same time as combustion of the fuel becomes more efficient.

The turbocharger is lubricated and cooled by the engine lubrication system. Oil is supplied and drained via external pipe connections. The turbine housing is provided with an external heat shield.





1. Ring
2. Lever
3. Vacuum capsule
4. Vacuum circuit
5. Vacuum regulator
6. Guide rail
7. Vacuum circuit, vacuum pump

VNT (Variable Nozzle Turbine)

The turbocharger is equipped with VNT technology, which makes it possible to combine the fast response of a small turbocharger with the high capacity of a large unit.

The positions of the vanes in the turbine housing are varied by means of a vacuum generated by a vacuum pump which is driven by the exhaust camshaft. This means that the turbine inlet area, and the gas speed and angle of incidence against the turbine are varied for best effect.

- A small flow area gives high exhaust gas speed and an angle of incidence which gives good low speed torque. The vane opening is at a minimum.
- When the vane opening is at a maximum, this gives large flow area, which permits a wide working range for the turbo. The exhaust mass flow is now at its greatest.
- The vacuum capsule rod is joined to a movable ring. The movable vanes are installed on the moving ring. When the ring moves, the position of the vanes is affected.
- The vacuum capsule is connected to the vacuum circuit. The pressure supplied to the capsule is regulated by a solenoid valve controlled by a signal from the engine control unit.

Group 26 Cooling system

Cooling system

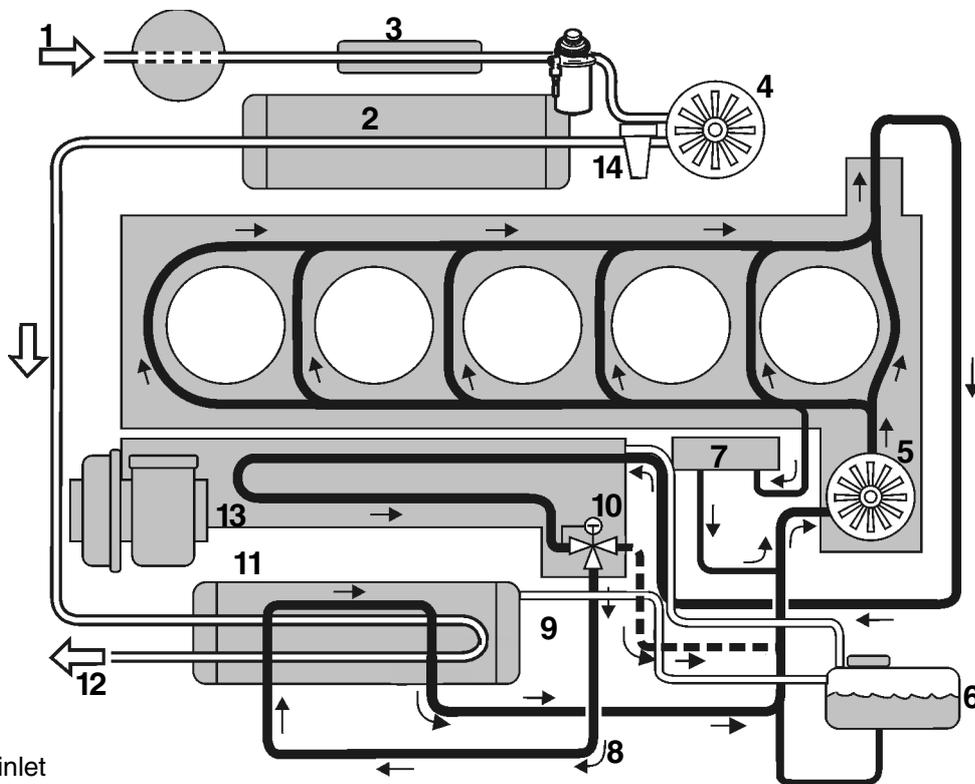
The engine is water cooled and has a sea water cooled heat exchanger. In the fresh water system, which functions on the cross-flow principle, fluid is pumped round by a toothed-belt driven circulation pump. The coolant flows backwards in the engine block, is distributed laterally by the slots between the cylinders, then flows up in the ducts around the exhaust valves. Heat peaks, especially around the exhaust valve seats, are thus transported away.

When the engine is cold, a thermostat directs the coolant round an internal circuit in the engine. When operating temperature begins to be reached, the coolant is progressively directed out through the entire heat exchanger, where the surplus heat is removed.

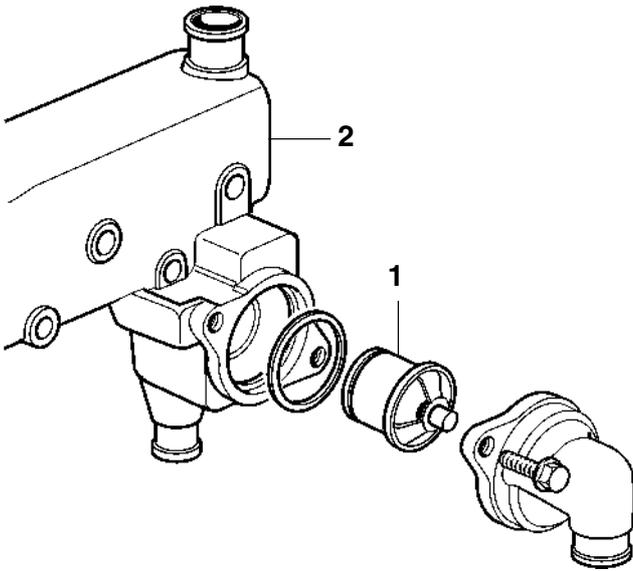
The coolant also cools the engine lubrication oil in the oil cooler.

The sea water pump sucks cooling water in through a sea water inlet, and after it has passed through the servo system oil cooler (if an AQ is fitted), it is then forced through the sea water circuit in the engine.

The sea water system cools the intercooler and the heat exchanger. The sea water is returned together with the exhaust gas, via a connection in the exhaust bend.



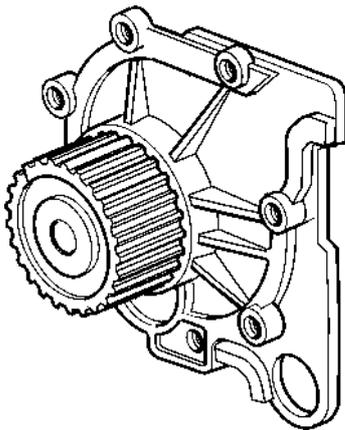
1. Sea water, inlet
2. Intercooler
3. Oil cooler, reversing gear
4. Sea water pump
5. Circulation pump
6. Expansion tank
7. Oil cooler
8. Open thermostat
9. Closed thermostat
10. Thermostat
11. Heat exchanger
12. Sea water, connection
13. Exhaust manifold
14. Sea water filter



Thermostat

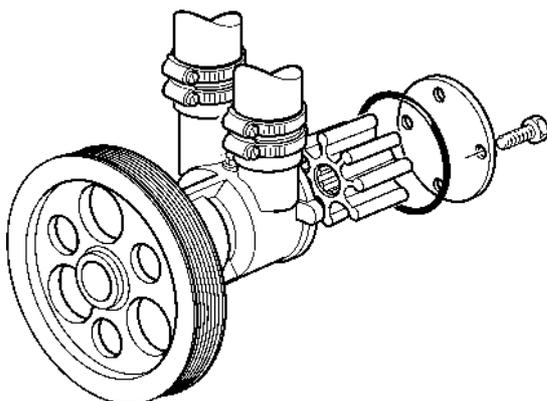
The engine has a thermostat (1) with by-pass control. When the engine is cold, the thermostat keeps the cooling path to the heat exchanger closed. The coolant is then led through a short, uncooled passage in the heat exchanger and back to the engine. As the engine warms up, the thermostat progressively opens the cooling duct in the heat exchanger, at the same time as the by-pass duct is closed.

The thermostat is located in a housing which is integrated in the exhaust manifold (2).



Circulation pump

The circulation pump is mounted on the engine block and is driven by the crankshaft by means of a toothed belt.



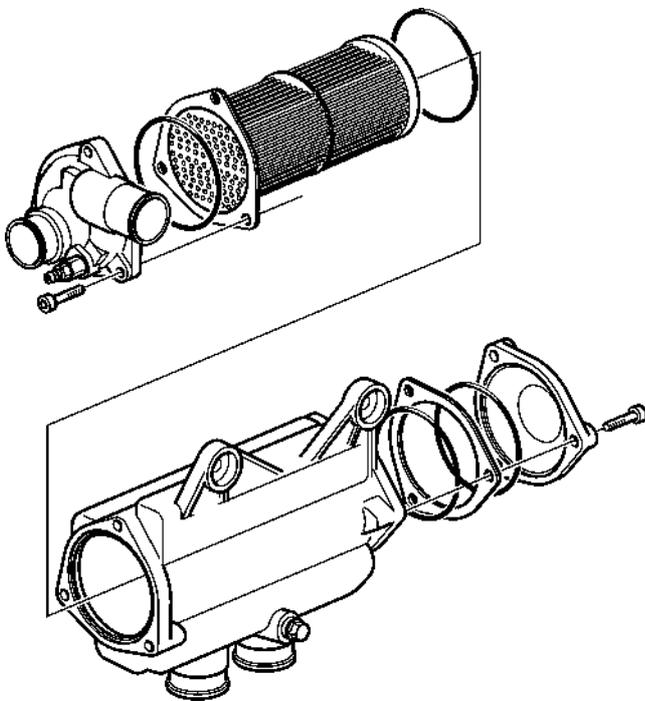
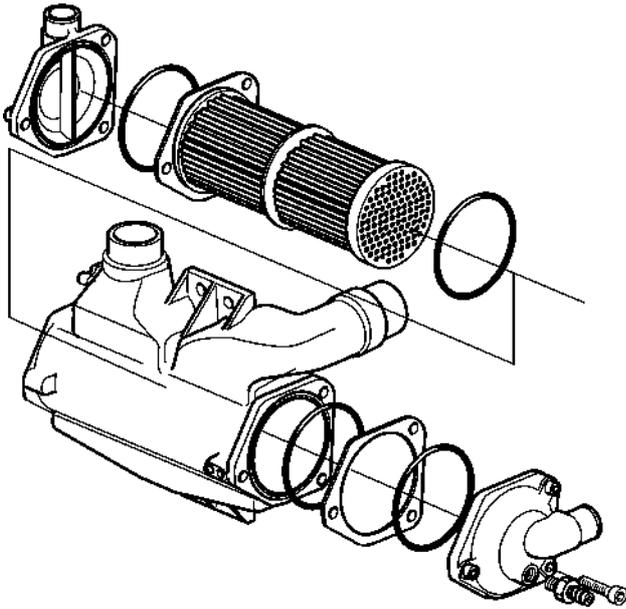
Sea water pump

The sea water pump is a rubber impeller type pump, and is mounted on the front of the engine. The pump is driven by the crankshaft via a drive belt.

The sea water pump forces cooling water out to the engine intercooler and heat exchanger.

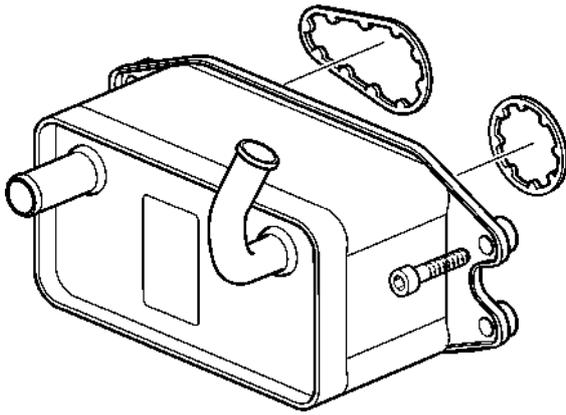
Intercooler

The engine has an intercooler, in which the engine induction air is cooled by the passing sea water. The intercooler is supplied with sea water directly from the sea water pump.



Heat exchanger

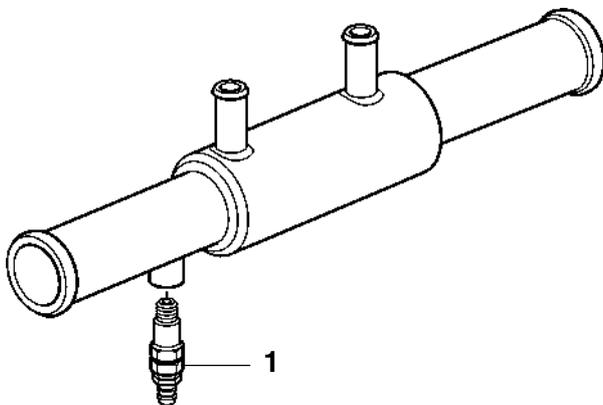
Sea water passes on through the intercooler outlet, to the heat exchanger at the other side of the engine. In the heat exchanger, heat is transferred from the internal cooling circuit in the engine (fresh water system) to the outer circuit (sea water). When the thermostat has not yet opened, the coolant is lead through a short, uncooled passage in the heat exchanger and back to the engine.



Oil cooler

The lubrication oil transports heat away from the hottest parts of the engine and evens out the temperature differences in the engine as it circulates. Heat is removed from the oil in the oil cooler. Oil temperature can thus be maintained at a lower level under heavy loading and high engine speeds.

The lube oil is cooled by a plate heat exchanger beside the sump. The lubrication oil circulates inside the oil cooler package whereas the coolant passes through the cell plates. The cooler is protected from excess pressure by the reduction valve in the engine.



Oil cooler, steering servo

If the engine has an Aquamatic drive, a steering servo system is used.

Heat generation in the servo system is transported away with the hydraulic oil. The hydraulic oil is cooled by flowing through an oil cooler which is connected to the sea water system.

If the **D3** engine is used as an inboard engine, it has an oil cooler on the reversing gear to cool the gearbox oil in the reversing gear.

There is a sea water drain valve (1) underneath the oil cooler.

Group 64 Servo system

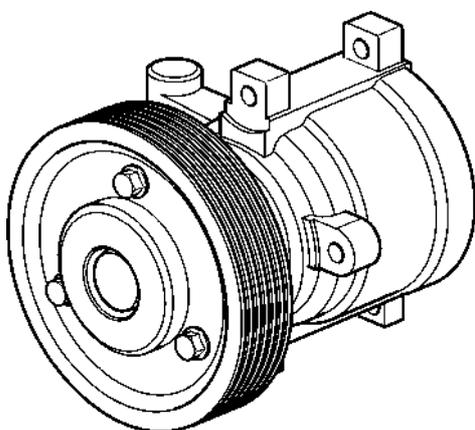
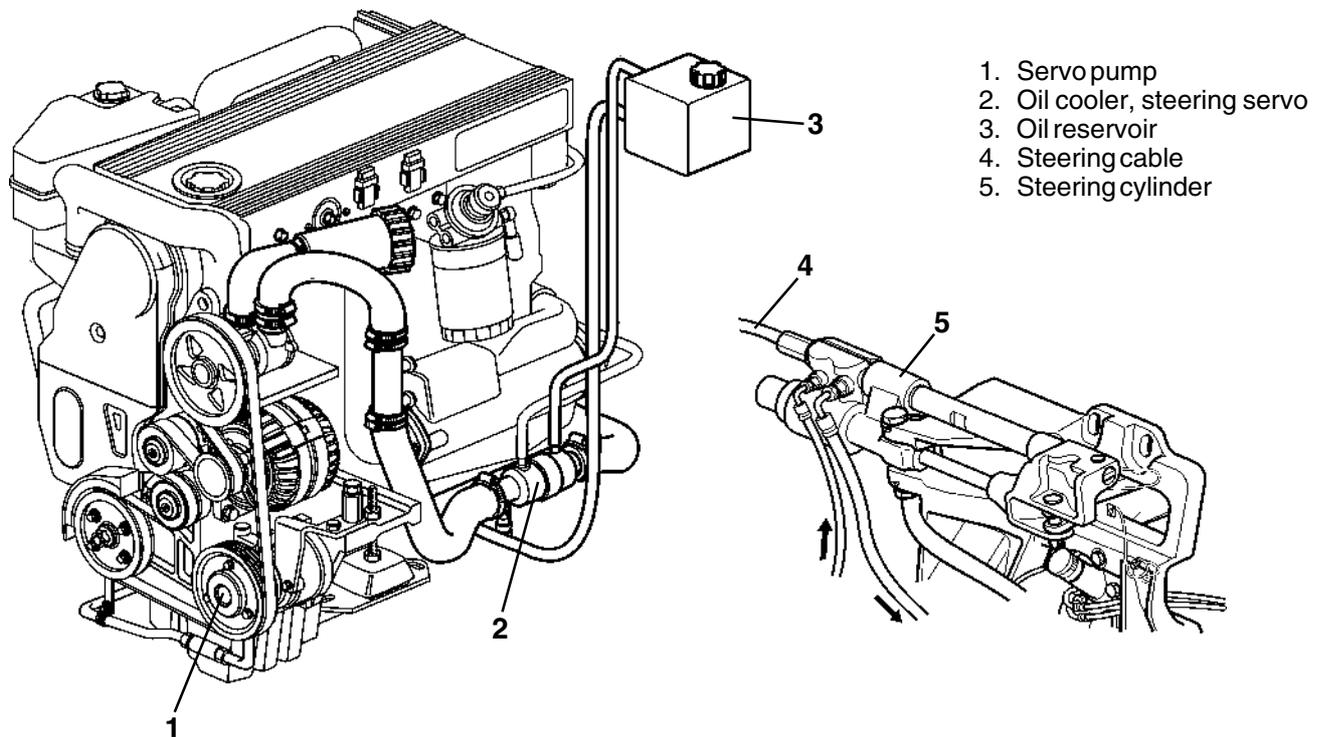
Servo system

In many cases, the D3 engine is used for boats with a stern drive. A servo system is then used to provide comfortable steering of the drive unit.

A servo pump operates a control cylinder with pressurized hydraulic oil. The steering cable from the steering wheel, which is connected to the cylinder, is thus given servo-assisted power. The steering cylin-

der is installed on the inner shield and is connected to the steering arm of the drive. The hydraulic oil which returns to the servo pump is cooled by a sea water cooled oil cooler.

The steering servo system consists of a servo pump, oil reservoir, steering cylinder and oil cooler.



Servo pump

The servo pump is installed on the front of the engine and is driven by the crankshaft, via a drive belt. The pump provides the servo system with pressurized hydraulic oil directly to the steering cylinder.

Fault tracing

A number of symptoms and possible causes of engine problems are described in the table below.

Symptoms and possible causes	
Starter motor does not operate (or runs slow)	1, 2, 3
Engine does not start	4, 5, 6, 7
Engine starts, but stops again	6, 7
Engine is difficult to start	4, 5, 6, 7
Engine does not reach full speed at full throttle.	5, 6, 7, 8, 9, 10, 11, 15, 18, 19, 20, 21
Engine knocks	4, 5, 6, 7
Engine runs roughly	4, 5, 6, 7, 10, 11
Engine vibrates	15, 16
High fuel consumption	8, 9, 10, 12, 15
Black exhaust smoke	10
Blue or white exhaust smoke	12, 22
Low oil pressure	13, 14
Engine coolant is too hot	17, 18, 19, 20, 21
No, or low charge	2, 23

- | | | |
|---|---|---|
| 1. Flat battery | 10. Insufficient air supply | 17. Not enough coolant |
| 2. Intermittent contact/open circuit | 11. Engine coolant constantly at too high temperature | 18. Blocked sea water inlet/pipe/filter |
| 3. Blown fuse/tripped circuit breaker | 12. Engine coolant constantly at too low temperature | 19. Circulation pump drive belt slips |
| 4. Lack of fuel | 13. Too low oil level. | 20. Faulty impeller |
| 5. Blocked air filter. | 14. Blocked oil filter | 21. Faulty / wrong thermostat |
| 6. Air in injection system | 15. Faulty / wrong propeller | 22. Oil level too high |
| 7. Water/contamination in fuel | 16. Faulty engine mounting | 23. Alternator drive belt slips |
| 8. Boat too heavy or incorrectly loaded | | |
| 9. Fouling on hull/drive/propeller | | |

Malfunctions

If there is a malfunction, first check the following points:

- Check that the coolant level is between the markings on the expansion tank (at 20°C). If the level in the expansion tank is too low, top up and start the engine. If the coolant disappears, there is inner or outer leakage.
- Check that the coolant is not contaminated. If the coolant is contaminated, this indicates inner leakage (oil) **or** that the cooling system is partially blocked (deposits). Blockage in the cooling system is caused by one or more of the following factors:
- The coolant has not been changed at the specified intervals.
- Incorrect mixture of coolant and water.
- Contaminated water has been used.

Blockage

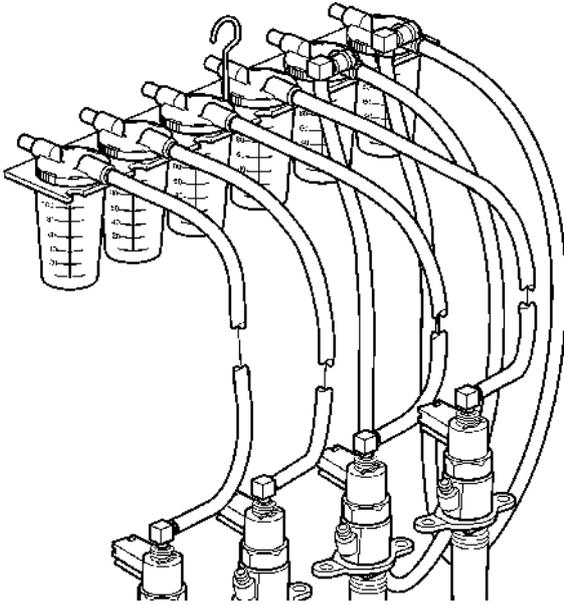
Is often caused by high coolant temperature, inner or outer blockage of the cooling system, or a combination of both. If the cooling system is blocked, it must be cleaned.

- **External contamination:** Check that the cooler and/or the charge air cooler are not clogged.
Check if there is any inner or outer leakage in the cooling system.
- **Inner contamination:** Check that the cooler and/or the charge air cooler are not clogged.
- **Inner or outer leakage in the cooling system:** Check if there is leakage in the system.
- **Coolant circulation:** Check that coolant circulates by letting the engine run at high speed. Also check the expansion tank to see that coolant circulates. This can be a clue if there is a fault in the cooling system.
- **Thermostat:** Check thermostat function. Drain enough coolant to allow the thermostat to be removed. Check the thermostat, please refer to "Thermostat, testing"
- **Sea water filter:** Check/clean.

Check return flow from injectors

Used if an injector fault is suspected

Special tools: 9814013



1. Remove the fuel leakage pipes from the injectors and connect the hoses from tool 9814013 to the injectors.
Hang the tool up over the engine.
2. Start the engine and let it idle.
3. Observe the amount of fuel that comes out of the injectors and compare each injector with the others. The amount of fuel leakage can be too small or too large. This indicates whether an injector might be faulty.

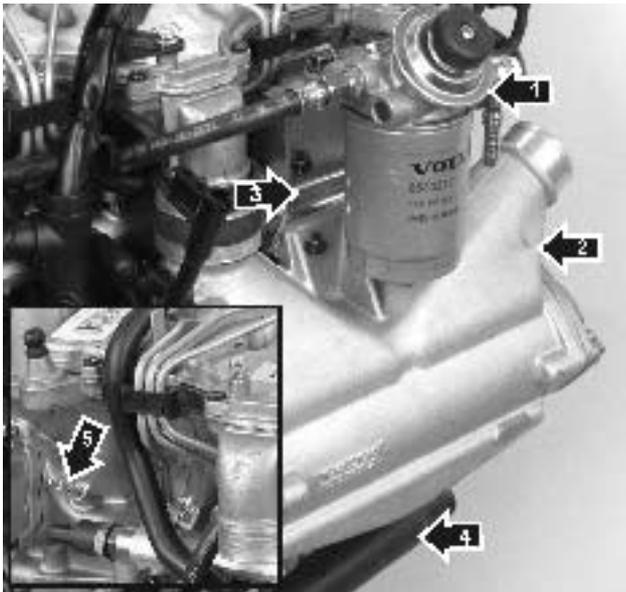
Service work

Flat Rate: 21002

Compression test

Sea water drained

Special tools: 885814, 9988539



1. Remove the cover, fuel filter housing (1), inter-cooler (2) and bracket (3), please refer to "Engine, disassembly". Unhook the servo system oil cooler (4).

Clean round the plugs (5) and then unscrew them.



2. Start with no. 1 cylinder and install adapter no. 885814 in the tapped hole for the plug. Torque the adapter to 11 Nm. Connect compression tester 9988539 to the adapter.

Crank the engine with the starter while at the same time holding the stop button on the cover depressed. Read the compression pressure for each cylinder.

Please refer to the "Technical Data" chapter for permissible values.

- ⚠ WARNING!** Moving components. Be careful if you are close to the engine when it is cranked.



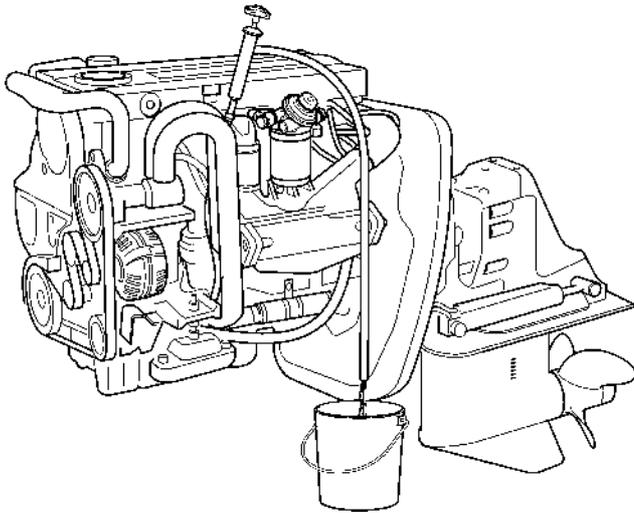
3. **Finishing off**

Install all plugs. Torque them to 11 Nm.

Install the intercooler with bracket, fuel filter housing and cover, please refer to "Engine, assembly". Install the servo system oil cooler.

Engine oil. Change

Always observe the recommended oil change interval.



⚠ WARNING! Working with, or close to a running engine is a safety risk. Watch out for rotating components and hot surfaces.

⚠ WARNING! Hot oil and hot surfaces can cause burns.

⚠ IMPORTANT! Only use oil of the recommended grade. Please refer to “Design and function, Lubrication system”.

NOTE! Change the oil filter during every oil change. Please refer to the “Oil filter, change” section in this chapter.

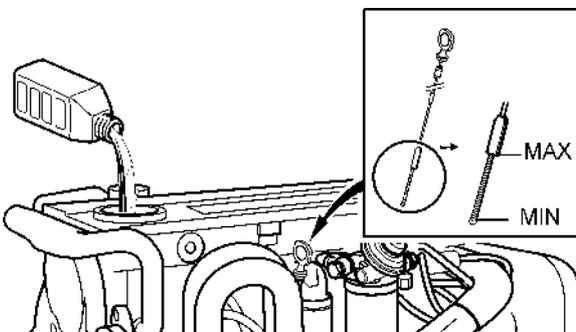
1. Start the engine (heating it up makes the oil easier to suck up out of the oil pan). Run the engine until it has reached working temperature (the temperature gauge shows a value of between 75 and 100°C).
2. Stop the engine. Wait for ten minutes before pumping the oil out.
3. Connect the oil drain pump to the dipstick pipe and pump the oil out.
4. Fill the volume of oil specified in Technical Data, Oil Volume, through the cap in the valve cover.
5. Start the engine, check that the warning lamp for low oil pressure has gone out. Run the engine until it has reached working temperature (the temperature gauge shows a value of between 75 and 100°C).

Check if there are any leaks beside the filter.

Stop the engine. Check the oil level and top up as necessary, about 10 minutes after the engine has stopped.

NOTE! Hand the waste oil to a recycling depot.

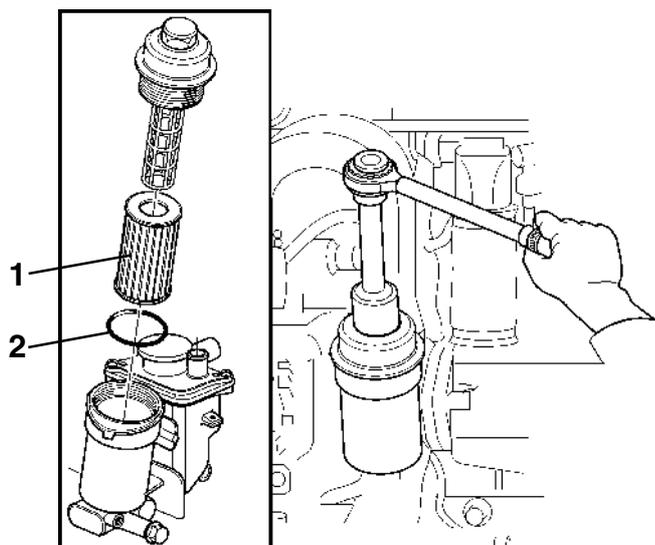
⚠ IMPORTANT! The engine must not be over-filled. The engine must have been stopped for long enough to allow the oil to run back into the sump, for the correct level to be indicated when the oil level is checked. If the engine is cold, this may take 24 hours, whereas if the engine is hot, 10 minutes should be enough.



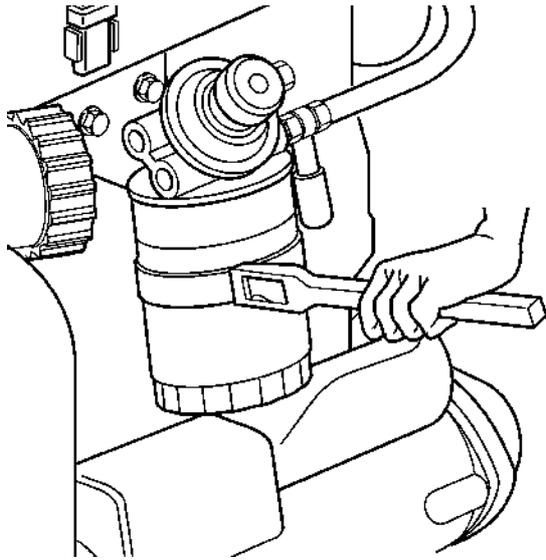
Oil filter. Change

NOTE! Change the filter during each oil change.

⚠ WARNING! Hot oil and hot surfaces can cause burns.



1. Put a suitable container under the filter to collect any spilled oil.
2. Unscrew the cover from the oil filter.
3. Wait a few minutes to allow the oil to run out of the filter.
4. Change the filter insert (1).
5. Install a new O-ring (2), tighten the cap by hand. Please refer to the oil filter cover for the correct torque.
6. Start the engine (low idle) and check that there are no oil leaks. Stop the engine and check the oil level again. Please refer to "Engine oil, change".



Fuel filter. Change

1. Close the fuel tap(s).
2. Clean the filter bracket and install a suitable vessel under the filter.
3. Unscrew the filter. Use a filter wrench if necessary.
4. Clean the sealing surfaces on the filter bracket. Make sure that the filter is absolutely clean and that the sealing surfaces are undamaged. Moisten the seal rings with engine oil.

NOTE! Do not fill the new filter with fuel before installation. Contamination might get into the system and cause damage and malfunctions.

5. Screw the filter on by hand until the seals just touches the mating surfaces. Then tighten a further 1/2 turn.
6. Open the fuel tap.
7. Vent the system. Please refer to "Venting the fuel system" in this chapter.
8. Start the engine and check if there is any leakage.

Flat Rate: 23080**Venting the fuel system**

⚠ WARNING! Never loosen a fuel pipe or component downstream from the high pressure pump to vent air. The fuel is under very high pressure and can force its way through your skin.

1. Open the vent screw (1) located above the fuel filter bracket.

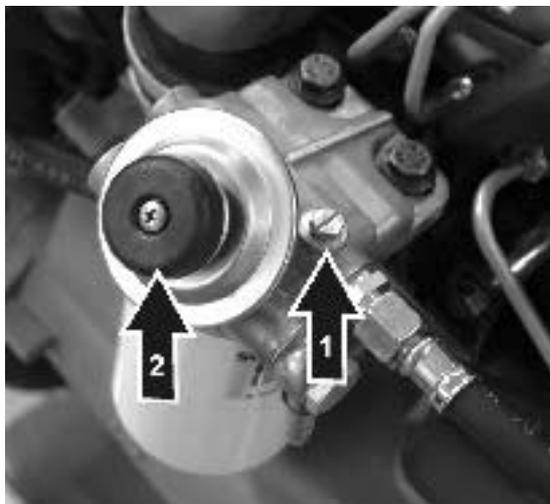
NOTE! Check whether the copper washer on the vent screw needs to be changed.

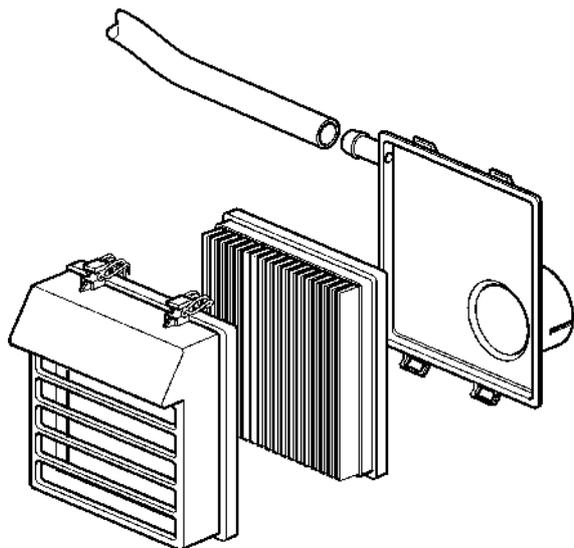
2. Press the hand pump (2) located on the fuel filter bracket until fuel with no air bubbles comes out of the vent screw. Keep pumping at the same time as the vent screw is closed.

Pump another 10 strokes.

3. Wipe up the fuel that has run out.

Start the engine and check for leakage.





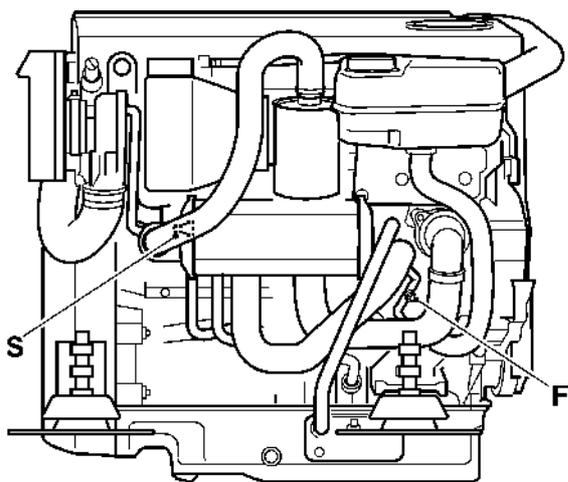
Air filter. Change

1. Remove the air filter housing.
2. Remove the old filter.
3. Clean the filter cover/housing as necessary. Be careful to prevent contamination from getting into the engine.
4. Install the new air filter.
5. Install the air filter housing.

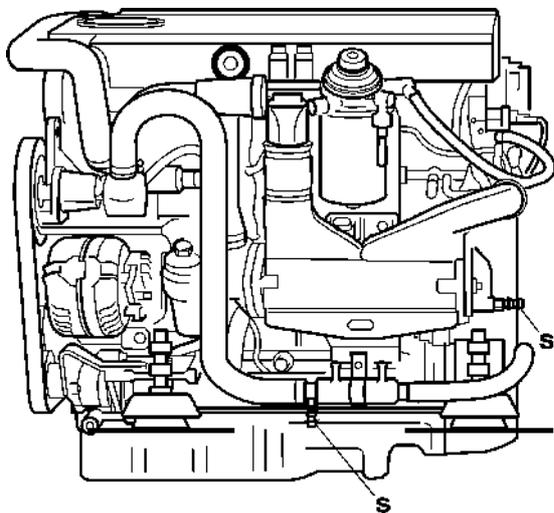
Cooling system, draining

NOTE! Remove the expansion tank filler cap and close the hull fitting before draining the cooling system.

⚠ WARNING! Open the pressure cap very carefully if the engine is hot. Steam or hot coolant can spray out and cause burns.



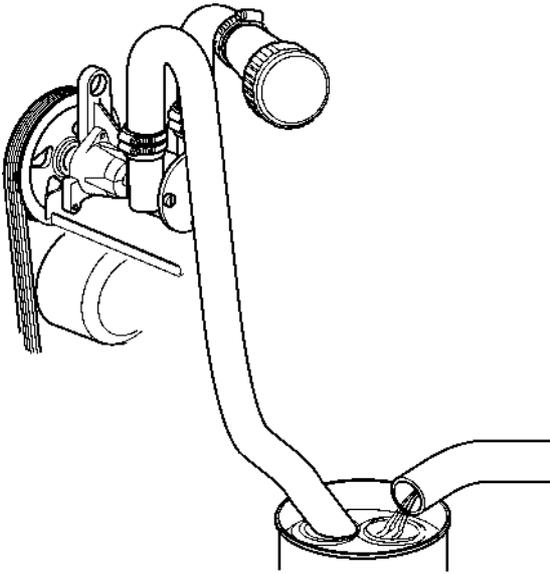
1. Connect drain pipes. Open all drain points.
2. Check that all water drains out.
Check whether the installation has any further taps or plugs at the lowest points of the cooling water pipes and exhaust pipe.
3. Close the taps.
4. Pump the bilges out as necessary. Check that no leakage occurs.



F = Fresh water drain tap
S = Sea water drain tap

Sea water system, cleaning and conserving

The sea water system must be flushed with fresh water, to prevent deposits and salt crystals from building up inside it. It must also be conserved when the boat is laid up.



⚠ WARNING! Risk of water entry. Cleaning and conservation of the sea water system must always be done when the boat has been drawn up on land.

1. Disconnect the hose from the sea water pump and install a hose which goes to a bucket filled with fresh water. Check that there is nothing beside the exhaust outlet that could be splashed.

2. Fill up carefully.

3.

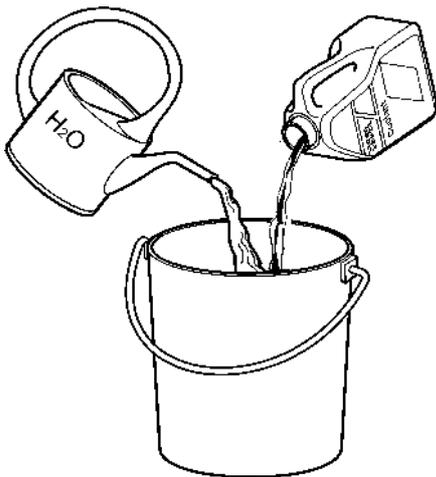
⚠ WARNING! Coming close to a running engine is a safety risk. Watch out for rotating components and hot surfaces.

⚠ IMPORTANT! The impeller will be damaged if it is run dry.

Put the gear selector in neutral. Check that there is nobody close to the propellers.

Start the engine. Let it run at fast idle for a few minutes.

Stop the engine.



4. Fill a bucket with a mixture of 40% glycol and 60% percent fresh water, to conserve the system.

Put a suitable vessel under the exhaust outlet.

Repeat stage 3.

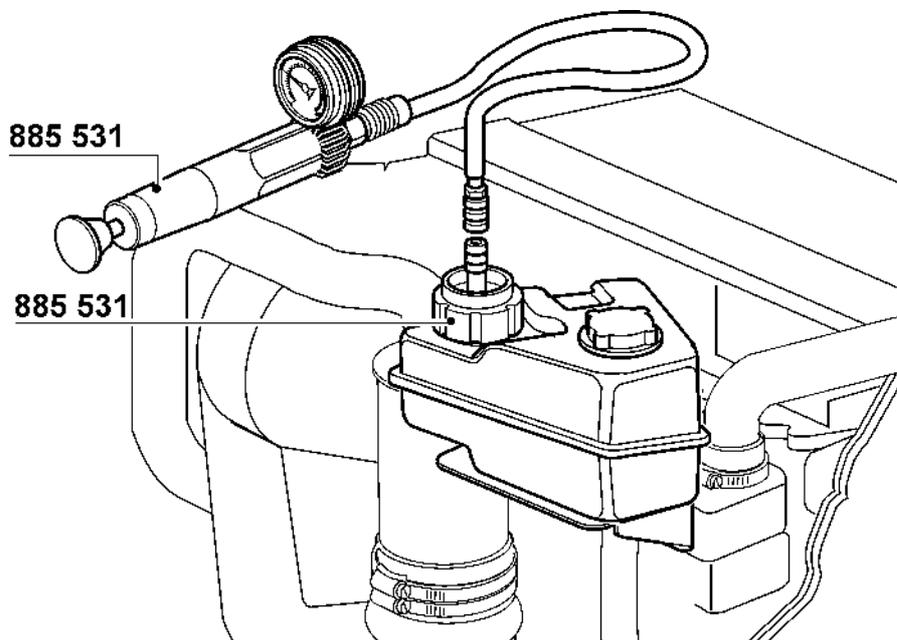
5. Put the sea water hose back.

6. The system has now been conserved. The glycol mixture should remain in the system during storage.

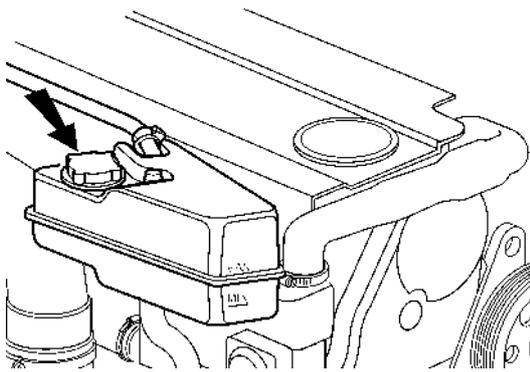
Drain the mixture before the boat is launched. Hand the mixture to a recycling depot.

Fresh water system, pressure testing

Special tools: 885 531



1. Unscrew the lid on the expansion tank.
Screw on the cover from pressure testing kit **885 531**.
Connect the hand pump in pressure testing kit **885 531**.
2. Pump up a pressure of about **100 kPa**.
The pressure must not fall for two minutes, to ensure that the fresh water system and unions seal correctly.
NOTE! If the pressure drops, spray or brush water and washing up liquid on the unions and hoses to determine the source of the leakage.
3. Rectify the cause of the leakage. Repeat pressure testing after repairs.



Cooling system, filling

Volvo Penta recommends that you use “**Volvo Penta Coolant, Ready Mixed**” or “**Volvo Penta Coolant**” (concentrated) mixed with water, please refer to “Mixing ratio”. This grade of coolant is the only one that is suitable for and approved by Volvo Penta.

Coolant must contain ethylene glycol of the correct chemical composition to give sufficient protection to the engine. Anti-corrosion additives are not permissible in Volvo Penta engines. Never use water by itself as the coolant.

⚠ IMPORTANT! Coolant of the correct mixture ratio must be used all year round. This applies even if there is never a risk of freezing, to ensure that the engine has enough corrosion protection. Future warranty claims related to engine and accessories may be refused if an unsuitable coolant has been used, or if the recommendation for coolant mixture has not been observed.

Mixture ratio

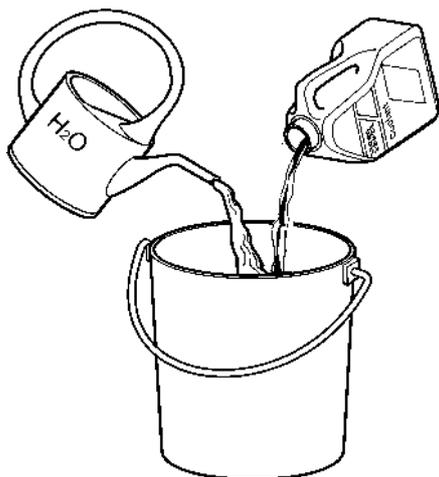
⚠ WARNING! All glycol is hazardous and damaging to the environment. Do not drink it! Glycol is flammable.

⚠ IMPORTANT! Different kinds of coolant must not be mixed with each other.

Mix:

40% “Volvo Penta Coolant” (conc. coolant)

60% water



This mixture prevents against internal corrosion, cavitation and frost bursting down to about -28°C (-18°F). (With 60% glycol in the coolant, the freezing point is lowered to -54°C (-65°F). Never mix more than 60% concentrate (Volvo Penta Coolant) in the coolant, since this will give reduced frost protection and poorer cooling effect, with a consequent risk of overheating.

⚠ IMPORTANT! The coolant must be mixed with **pure water**. Use **distilled, de-ionized water**. The water must comply with Volvo Penta’s requirements. Please refer to “Water quality”.

⚠ IMPORTANT! It is very important that the cooling system is filled with coolant of the correct concentration. Mix in a separate clean vessel before you fill the cooling system. Make sure that the fluids are well mixed.

Water quality

ASTM D4985:

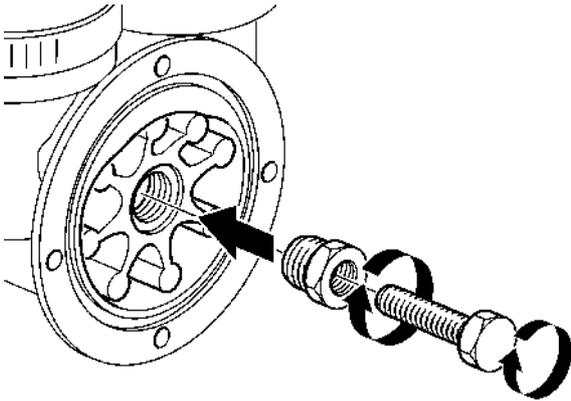
Solid particles, total	< 340 ppm
Total hardness:	< 9.5° dH
Chloride	< 40 ppm
Sulfate	< 100 ppm
pH value	5,5–9
Silicon dioxide (to ASTM D859)	< 20 mg SiO ₂ /l
Iron (to ASTM D1068)	< 0.10 ppm
Manganese (to ASTM D858)	< 0.05 ppm
Conductivity (to ASTM D1125)	< 500 μS/cm
Organic content, COD_{Mn} (to ISO8467)	< 15 mg KMnO ₄ /l

Flat Rate: 26215

Sea water pump, impeller, change

Special tools: 3843948

Sea water drained

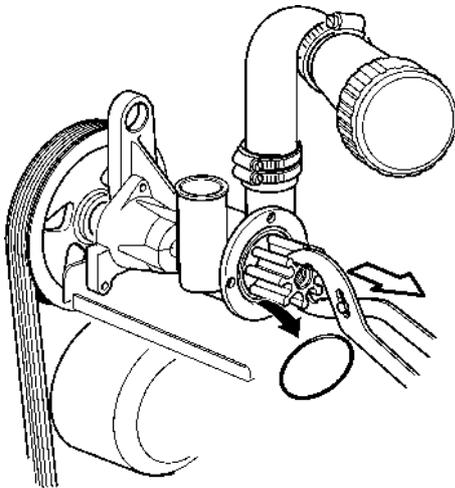


1. Undo the outer hose and fold it to one side for better access.

Unscrew the cover Remove the O-ring.

2. Use tool no. 3843948 to pull the impeller out.

⚠ IMPORTANT! Make sure that the inner edge of the housing is not damaged.



NOTE! On engines where the impeller does not have threads, prise the impeller out carefully with a pair of pliers.

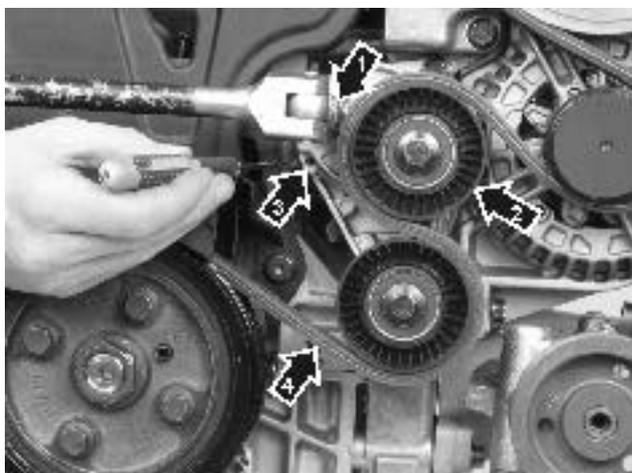
3. Grease (included in the renovation kit) the new impeller and O-ring.

Insert the impeller on the pump shaft and install the cover together with the O-ring. Torque the screws to the specified values. Connect the hose.

⚠ IMPORTANT! Check the inside of the cover. If there is any wear damage, it must be changed.

Drive belt/Alternator belt, inspection

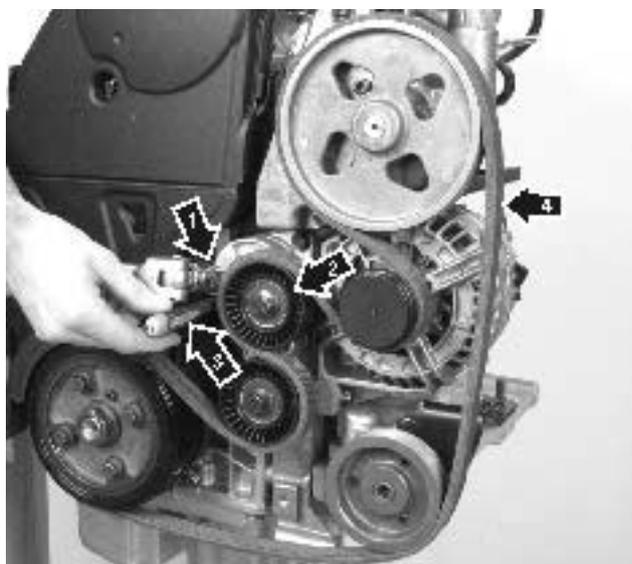
Check belts after running when they are warm. Both the alternator belt and the drive belt has an automatic belt tensioner and need not be adjusted. Check that the belt tensioner does not bottom.



Drive belt/Alternator belt, change

1. Apply a tool with a T60 Torx bit (1) to the cutout in the belt tensioner (2). Turn the belt tensioner and insert a screwdriver or similar into the hole (3) which opens up and secure the belt tensioner.

2. Remove the drive belt (4).



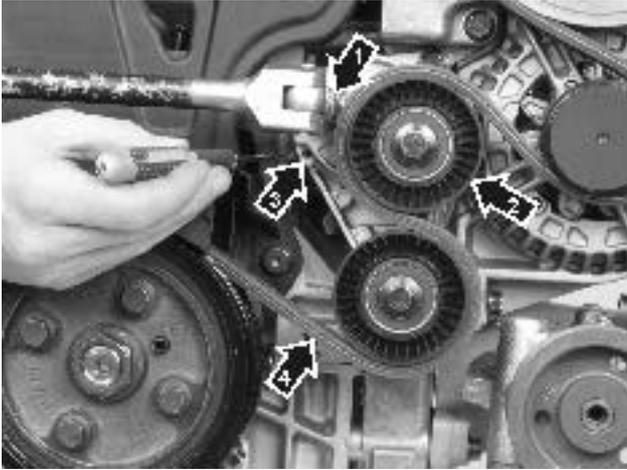
3. Install the drive belt (4) and then release the locking of the belt tensioner.

NOTE! Make sure that the drive belt has not slid out of its grooves.

Cam belt, change

Removal

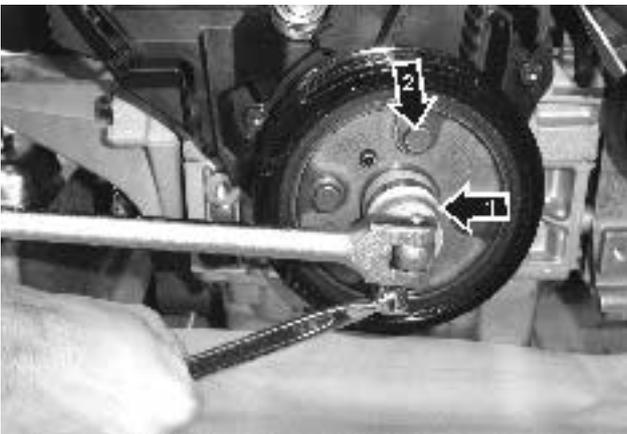
1. Apply a tool with a T60 Torx bit (1) to the cutout in the belt tensioner (2).
Turn the belt tensioner and insert a screwdriver or similar into the hole (3) which opens up and secure the belt tensioner.
Remove the drive belt (4).

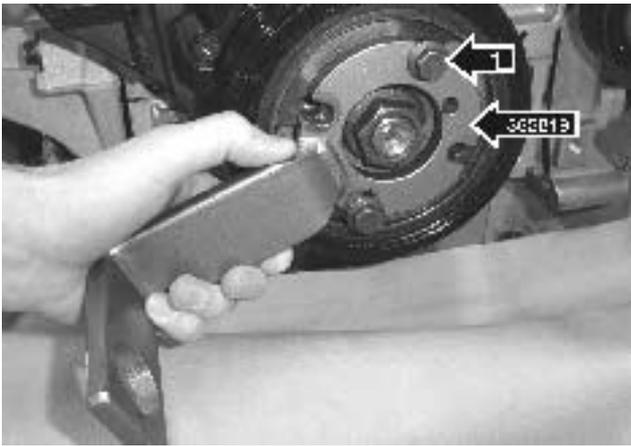


2. Undo the outer trimming gear cover screw (1) and the four hooks (2).
Fold the top of the cover forwards and then lift the cover upwards.



3. Use a socket (1) as a counterhold on the center nut.
Then undo all the screws on the vibration damper (2).

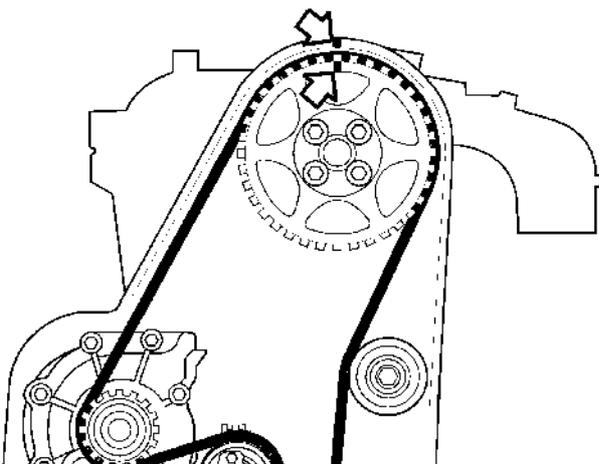




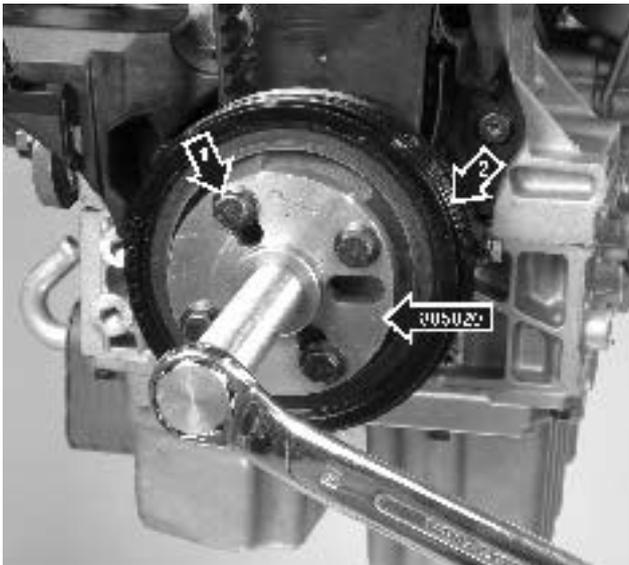
4. Install the counterhold tool 885819, using the four screws (1) for the vibration damper.



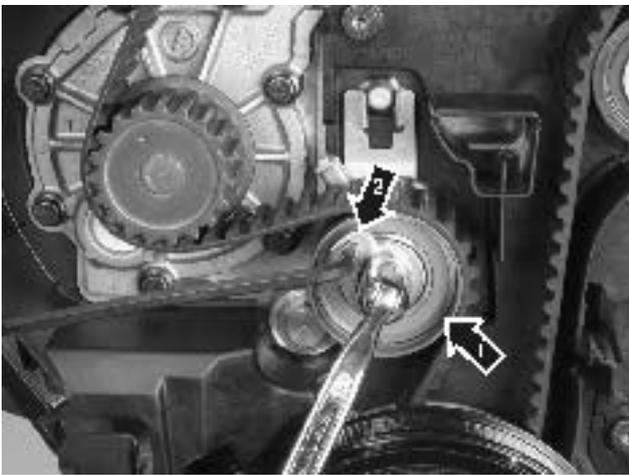
5. Install the torque amplifier (885633), together with 885648, as shown in the illustration.
Unscrew the center nut on the crankshaft.



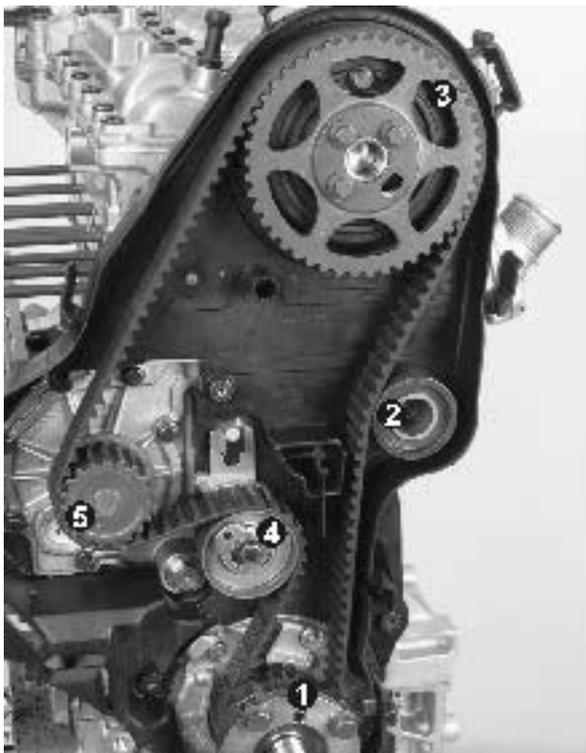
6. Turn the crankshaft so that the marking on the camshaft is correct, please refer to the figure.
Turn the crankshaft a further quarter turn anti-clockwise.
Remove the counterhold.



7. Install puller 885820 and undo the pulley, so that it comes away from the crankshaft gear.
Disassemble the tool.
Tap the gear wheel back on with a plastic faced mallet.



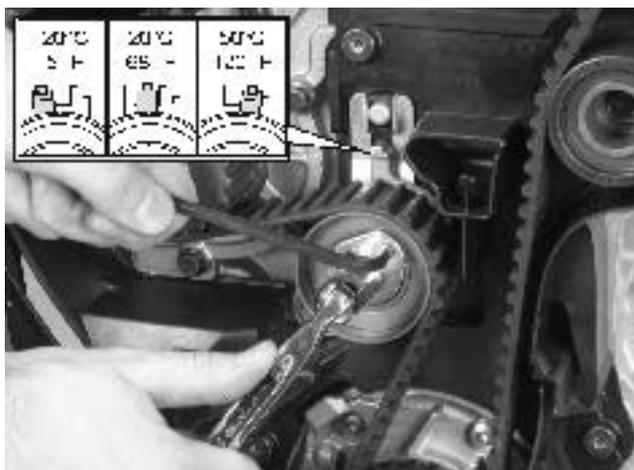
8. Undo the center screw on the belt tensioner (1) so that the eccentric washer (2) is released and can be put in the "10 o'clock" position.
Remove the toothed belt.



Installation

1. Install the toothed belts in the following order:
 1. Crankshaft
 2. Jockey pulley
 3. Camshaft gear
 4. Belt tensioner
 5. Coolant pump

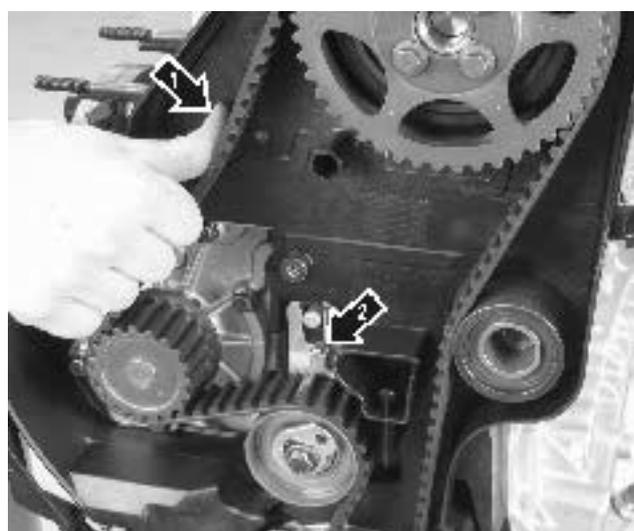
NOTE! Make sure that the belt is correctly seated on the toothed pulley.



- Set the belt tensioner in relation to the temperature of the engine block, please refer to the figure.

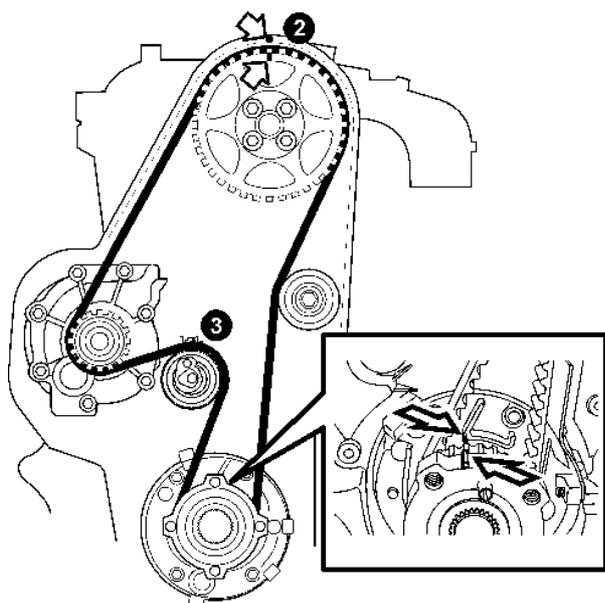
NOTE! The illustration shows the temperature of the engine block when the belt tensioner is set up.

- Install the counterhold on the crankshaft gear and turn the crankshaft a quarter turn clockwise. Check the marking on the crankshaft pulley and the marking on the camshaft pulley.
- Adjust the belt tensioner, as above.



- Apply pressure (1) to the toothed belts and check that the belt tensioner (2) moves.

NOTE! The belt tensioner must be changed if it does not move.

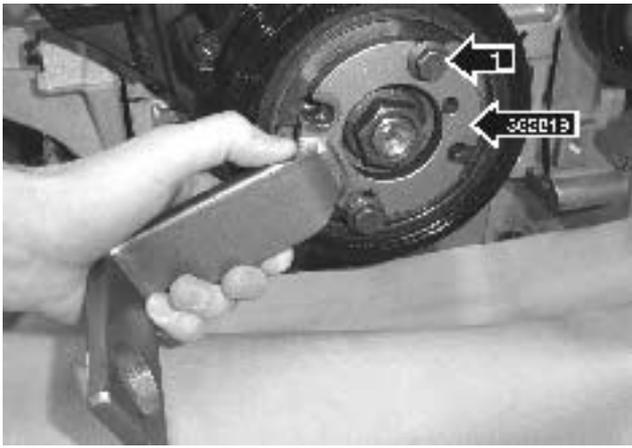


- Turn the crankshaft round two rotations.

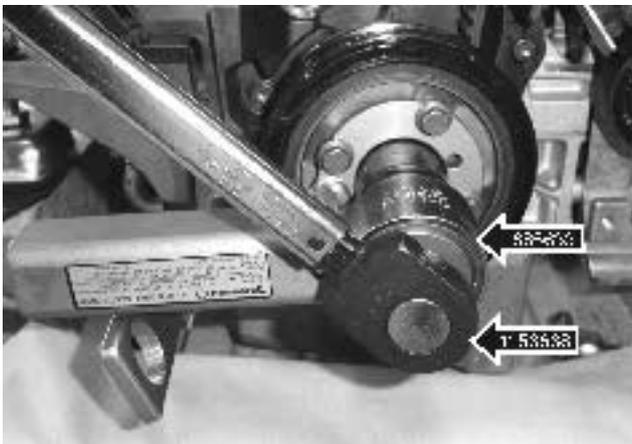
Check the marking on the crankshaft pulley (1) and the marking on the camshaft pulley (2).

Check that the belt tensioner indicator (3) is within the marked range. If necessary, adjust as above.

⚠ IMPORTANT! Check that the engine can be cranked without any unwanted noise or complications.



7. Install the pulley/vibration damper (1) on the crankshaft. Screw counterhold 885819 to the vibration damper, use the four screws (2) for the vibration damper.

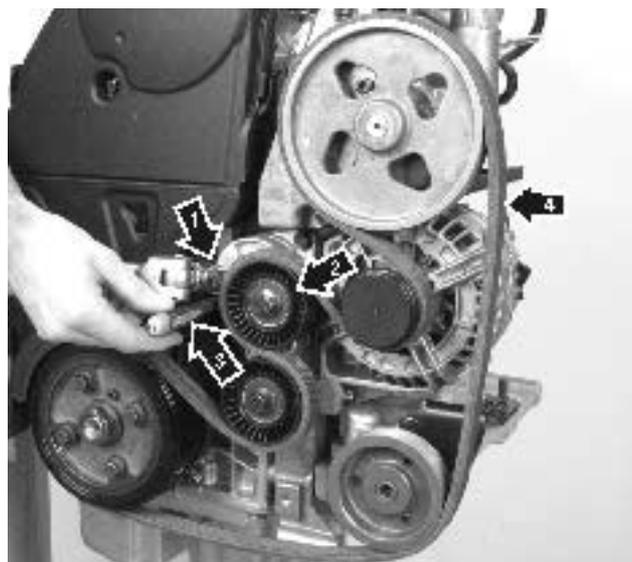


8. Torque a **new** center nut to the crankshaft, as specified in "Technical Data". Use torque amplifier 885633.

NOTE! If a torque of 86 Nm is applied to torque amplifier 885633, this gives a torque of 300 Nm (71 ft. lb gives 250 ft. lb).

Remove counterhold (885819) from the vibration damper. Tighten **new** screws on the vibration damper alternately in two stages as specified in "Technical Data".

Install the front timing gear cover.



9. Install the drive belt (4) and then release the locking of the belt tensioner.

NOTE! Make sure that the drive belt has not slid out of its grooves.

Repair instructions

When working with chemicals, fuel and lubricating oil

-  **IMPORTANT!** Always use protective gloves for work which includes contact with oil, fuel etc. Constant skin contact with engine oil can be very harmful.

Before lifting the engine

Boat removed from the water

1. Turn the main switch off. Undo the battery connections to the engine.
2. Remove the connectors for the secondary fuel filter and the trim pump. Undo the throttle cable from the engine control unit. Remove the box containing the engine control unit from the bulkhead. Undo the earth cable from the shield.
3. Remove the sea water union.
4. Remove the exhaust pipe (baffle).
5. **(only AQ)**
Drain the servo system hydraulic oil via the drain valve under the servo oil cooler.
Undo the hydraulic unions on the steering cylinder.
Remove the servo oil reservoir.
6. Close the fuel taps.
Remove the fuel connections.
7. Undo the drive from the shield (if an AQ is fitted) or undo the propeller shaft by the reversing gear (inboard).
8. Undo the engine pads from the beds and the fly-wheel housing. Lift the engine out.

Before working in a boat

1. Disconnect the current with the main switch and check that the engine is not connected to system voltage.

2. Clean the outside of the engine.

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

3. The work includes the following actions on the cooling system:

Close the sea cocks and drain the coolant from the sea water- and fresh water systems.

-  **IMPORTANT!** Make sure that all sea water inlets are securely closed, so that water can not find its way in during removal of cooling system sub - components.

Actions after lifting the engine

1. Clean the engine.

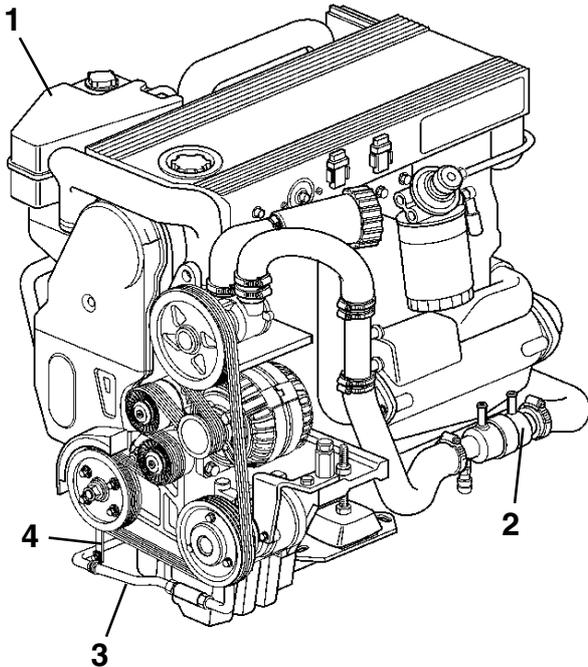
 **IMPORTANT!** Do not use a power washer. There is a risk that the engine components could be subjected to water entry.

2. Pump the engine oil out (if necessary).

Installing, fixture

Drained cooling system and engine oil. Engine removed.

Special tools: 885510, 885815, 9986485



1. Remove the expansion tank (1) by undoing its hose unions and through-going screws.

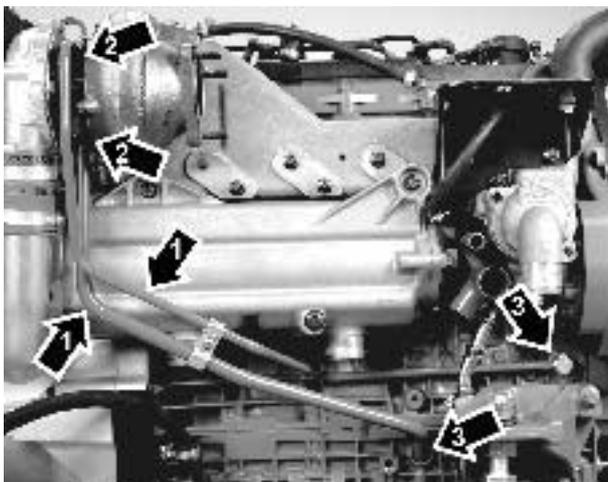
Remove the servo system oil cooler (2) and coolant hose.

Undo all remaining coolant hoses and remove the charge air pipe and hydraulic hose (3).

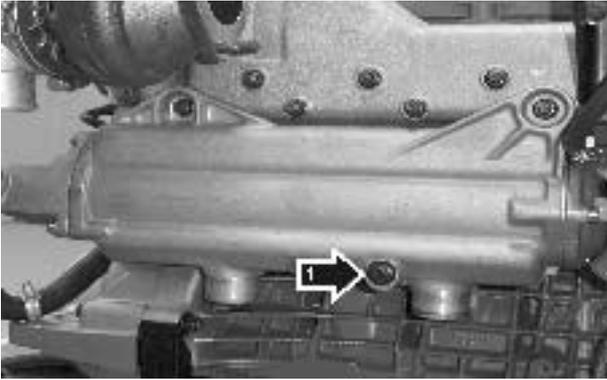
NOTE! Leave the short hose between the intercooler and the induction manifold in place.

NOTE! Later, when the hydraulic hose bracket (4) is installed on the engine, Volvo Penta sealant part no. 840879-1 must be applied to the screw.

2. Remove the turbocharger heat shield and air filter housing. Unscrew the exhaust bend and remove the gasket.

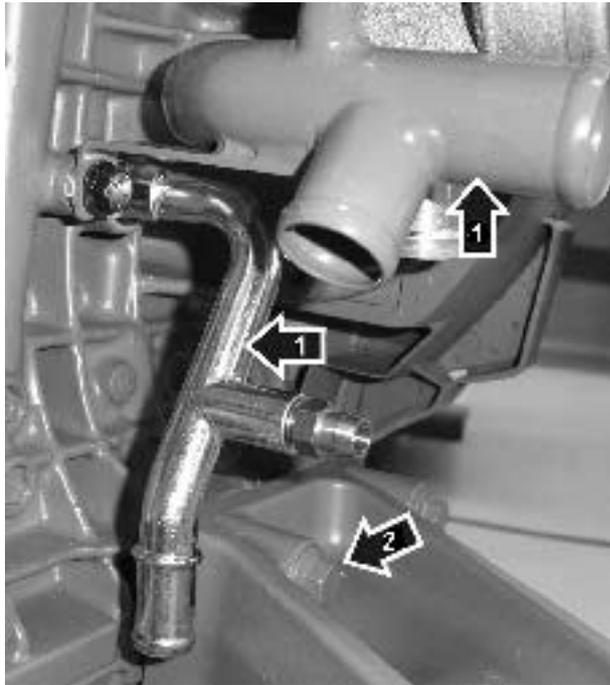


3. Remove the turbocharger oil pipe (1). Plug all openings on the turbocharger (2) and the engine (3) with protective plugs 885510.



4. Unscrew the heat exchanger and remove it.

NOTE! There are two washers on the screw (1), one on the outside and one on the inside of the heat exchanger.



5. Unscrew and remove the two coolant pipes (1).
Remove the right-hand engine mounting (2).



6. Install engine fixture 885815 on the engine.
Set the engine up in stand 9986485.

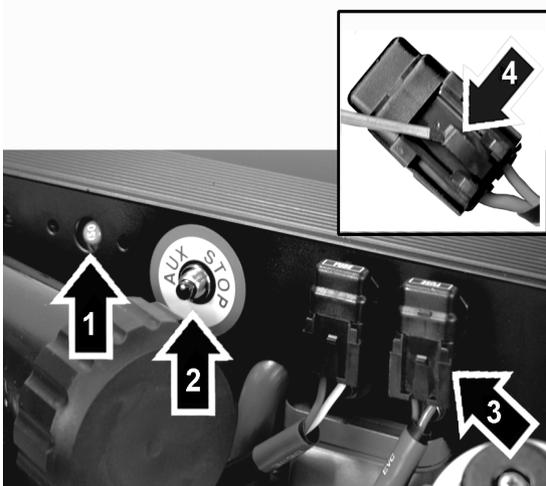
NOTE! Use spacer washers as necessary.

Engine, full overhaul

Disassembly, engine

Special tools: 885510, 885516, 885633, 885819, 885820, 885823, 9995919, 9997005, 9997007, 9997008, 9999179

Engine on stand

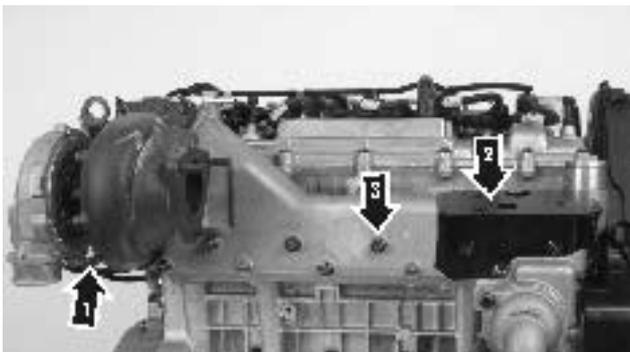


1. Cover

Unscrew the trim pump fuse (1) and emergency stop (2). Remove the fuse holders (3).

NOTE! Be careful when removing the fuse holders, to ensure that they are not damaged. The illustration shows how the catch (4) on the rear of the fuse is undone.

Remove the oil filler cap and lift the cover away.

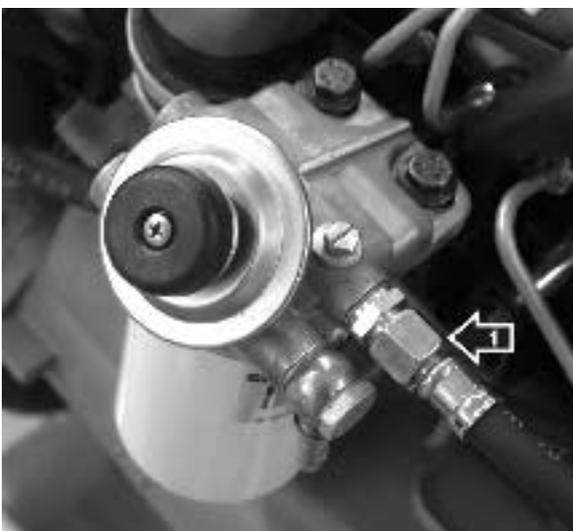


2. Exhaust manifold and turbocharger

Undo the vacuum hose (1) to the turbocharger. Unscrew the expansion tank bracket (2).

Then unscrew all remaining nuts (3) on the exhaust manifold and remove it, together with the turbocharger. Remove the gasket between the cylinder head and the exhaust manifold.

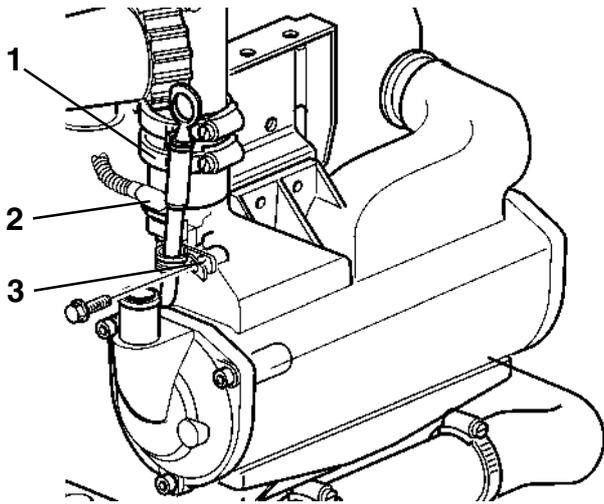
NOTE! If only the turbocharger is to be removed, please refer to "Turbocharger, changing".



3. Fuel filter and housing

Unscrew the fuel filter with tool no. 9999179.

Undo the fuel union (1) on the fuel filter housing and install protective plugs 885510 on all unions. Unscrew the fuel filter housing.



4. Intercooler, bracket and dipstick

Undo the clamps for the inlet manifold (1).

Undo the connector for the intercooler sensor (2).

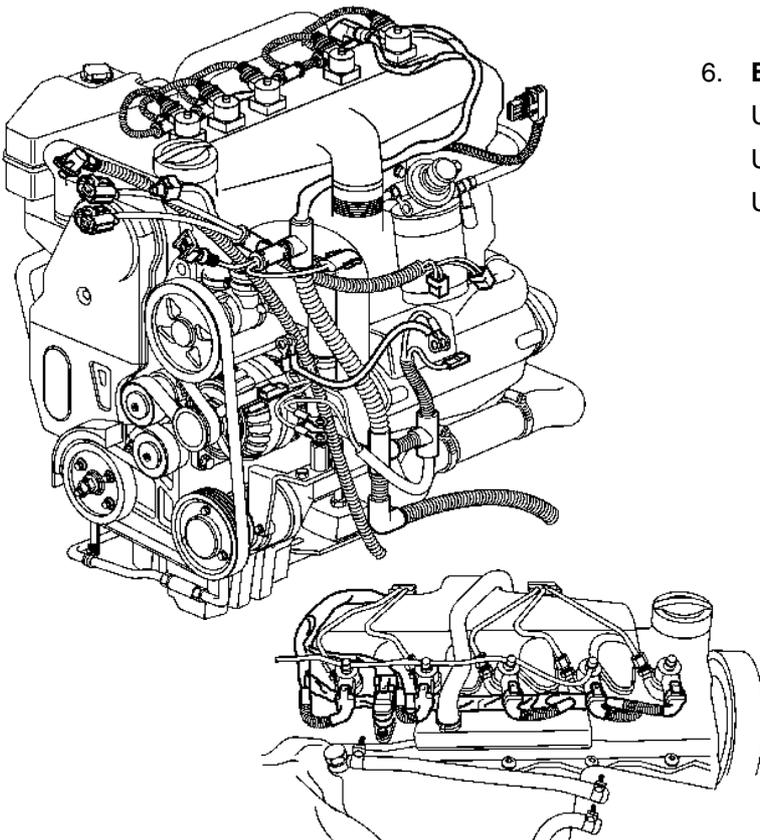
Undo the clamp on the dipstick (3) and the clamp on the return fuel hose.

Unscrew the intercooler and remove it.



5. Unscrew the intercooler bracket (1).

Unscrew the dipstick (2).

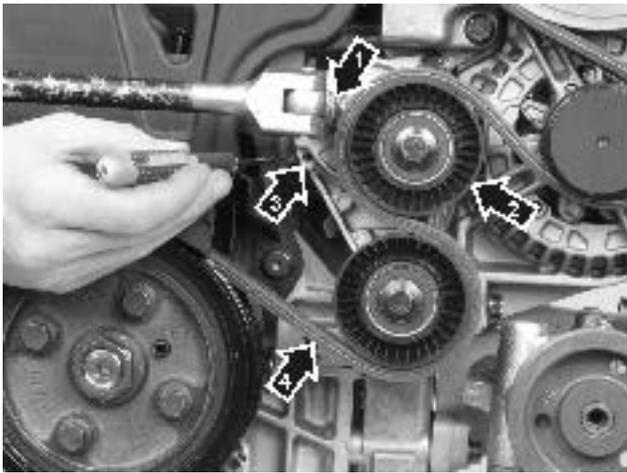


6. Engine cables

Undo all connectors on the engine cables.

Unscrew the engine cables and remove them.

Undo and remove other electric cables.



7. Drive belt

Apply a tool with a T60 Torx bit (1) to the cutout in the belt tensioner (2). Turn the belt tensioner and insert a screwdriver or similar into the hole (3) which opens up and secure the belt tensioner.

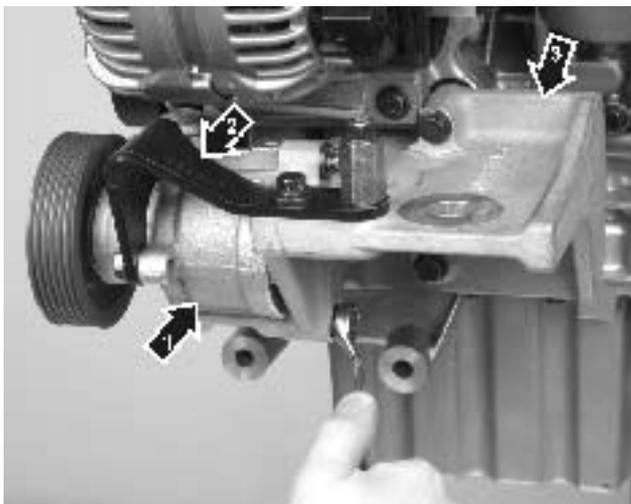
Remove the drive belt (4).



8. Sea water pump

Undo the screws (1) through the drive pulley, that hold the sea water pump (2) to the mounting bracket (3).

Remove the pump.

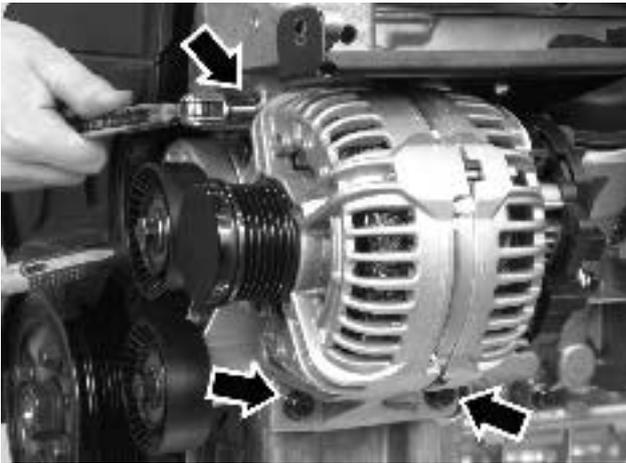


9. Servo pump or jockey wheel, left-hand engine mounting.

Unscrew the servo pump (1) together with the bracket (2) or unscrew the jockey wheel.

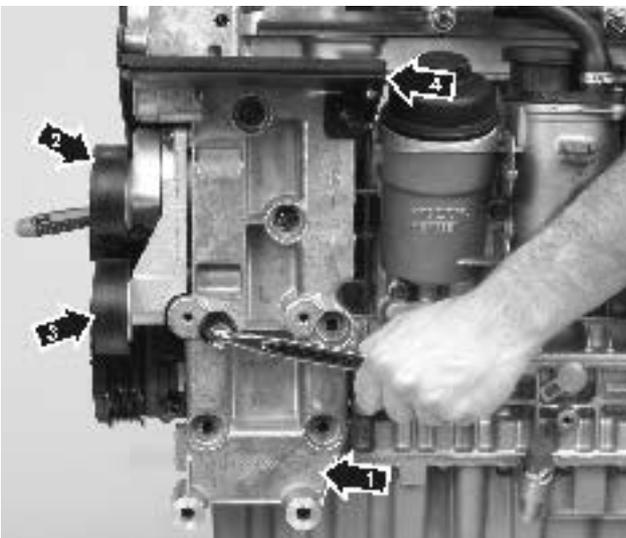
Unscrew the left-hand engine mounting (3).

(Or remove the servo pump together with the engine mounting.)



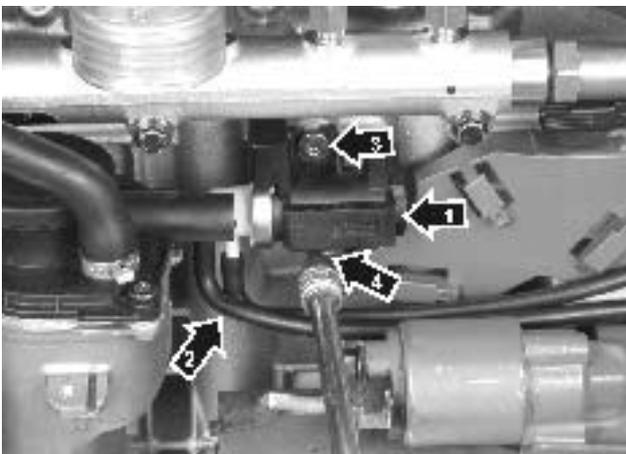
10. Alternator

Unscrew the alternator and remove it.



11. Mounting bracket

Unscrew the mounting bracket (1) and remove it together with its associated belt tensioner (2), jockey wheel (3) and alternator shield plate (4).



12. Vacuum regulator

Remove the electronic vacuum regulator (1).

Undo the vacuum hoses (2).

NOTE! Remove the top screw (3) and undo the bottom screw (4), then it will be possible to unhook the regulator.



13. Sensors and monitors

Remove the gear sensor (1), camshaft sensor (2), coolant sensor (3) and oil pressure monitor (4).

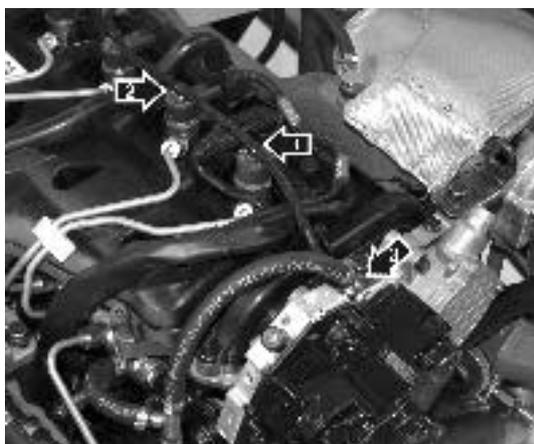
NOTE! Undo the coolant sensor with a long 19 mm socket.

NOTE! Plug the holes for the oil pressure monitor and camshaft sensor.



14. Starter motor

Unscrew the starter motor (1), note the guide pin (2).



15. Fuel leakage hose

Remove the crankcase ventilation hose from the valve housing.

Undo the fuel leakage hose (1) unions from the injectors by pressing the clip (2) on each injector.

Remove the hollow screw (3) for the fuel hose union to the high pressure pump.

NOTE! Install protective caps 885510 on the injector openings and the high pressure pump.

Undo the fuel pipes.



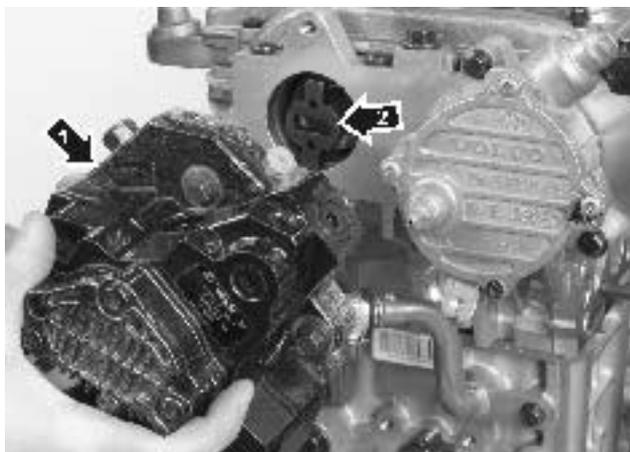
16. Delivery pipes

Undo all fuel delivery pipes (1).

NOTE! Install protective caps 885510 on the injector openings and the high pressure pump.

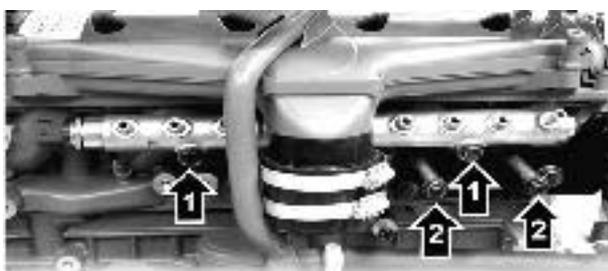
⚠ IMPORTANT! Only the nipple (2) closest to the fuel delivery pipe cap nut may be used as a counterhold for the injectors.

⚠ IMPORTANT! The fuel delivery pipes must not be re-used.



17. High pressure pump

Remove the high pressure pump (1) and make sure that the flange (2) comes with it.

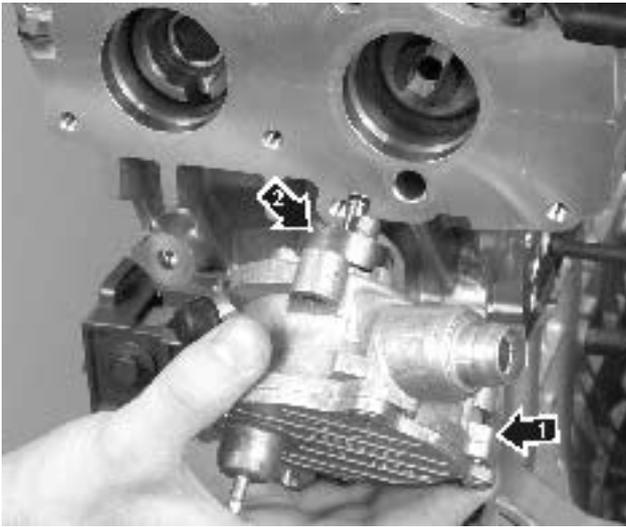


18. Distribution manifold

Unscrew the distribution manifold (1).

Remove the bracket (2).

NOTE! Plug the inlet on the distribution manifold to prevent dirt from getting into the system.



19. Vacuum pump

Unscrew the vacuum pump (1) and remove it.
Make sure that the flange (2) comes with it.

NOTE! A vacuum pump which has been dropped or damaged in any other way must not be re-installed under any circumstances.

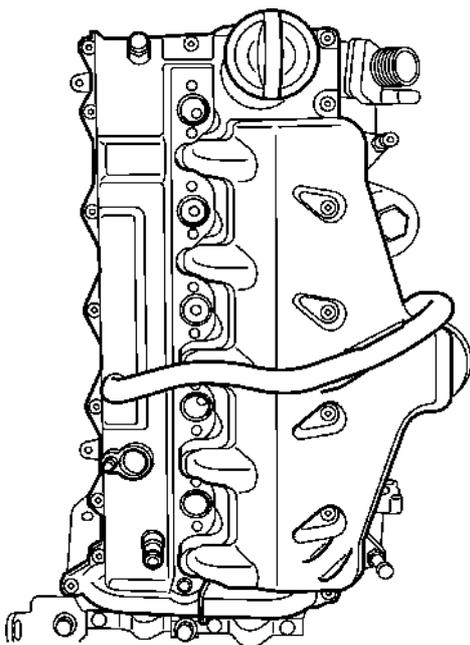


20. Injectors

Unscrew the tension braces on the injectors.
Then use tool no. 9997008 if necessary, to pull each injector off its seat.

NOTE! Make sure that the copper washer comes with the injector.

NOTE! Mark the injectors for identification, to facilitate any fault tracing. Install protective caps 885510 on them.



21. Valve cover/inlet manifold

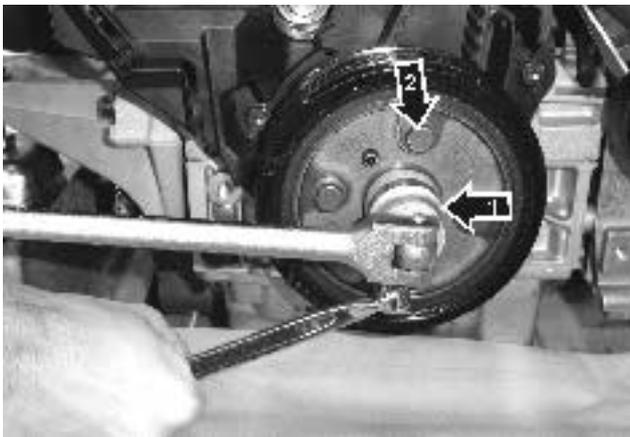
Unscrew all Torx screws and hex head screws which hold the valve housing to the edge of the cylinder head, please refer to the illustration.

Lift the valve cover off and remove the gaskets.

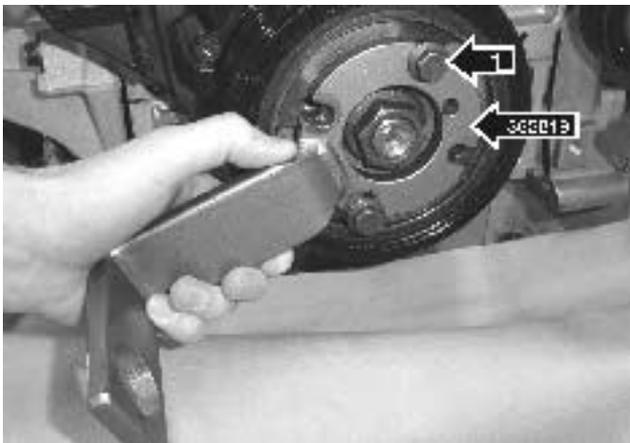


22. Timing gear

Undo the outer timing gear cover screw (1) and the four hooks (2). Fold the top of the cover forwards and then lift the cover upwards.



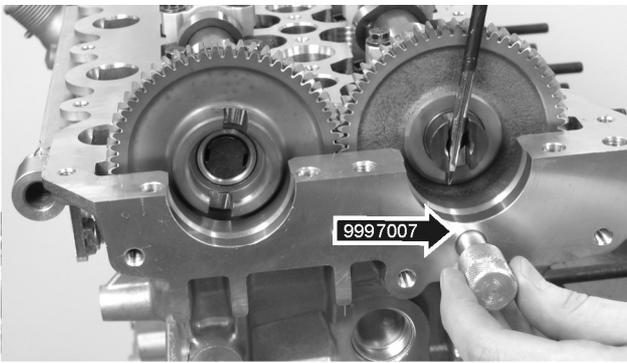
23. Use a socket (1) as a counterhold on the center nut. Then undo all the screws on the vibration damper (2).



24. Install the counterhold tool 885819, using the four screws (1) for the vibration damper.

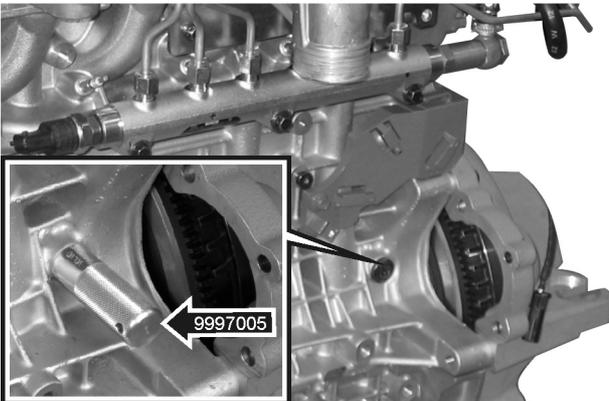


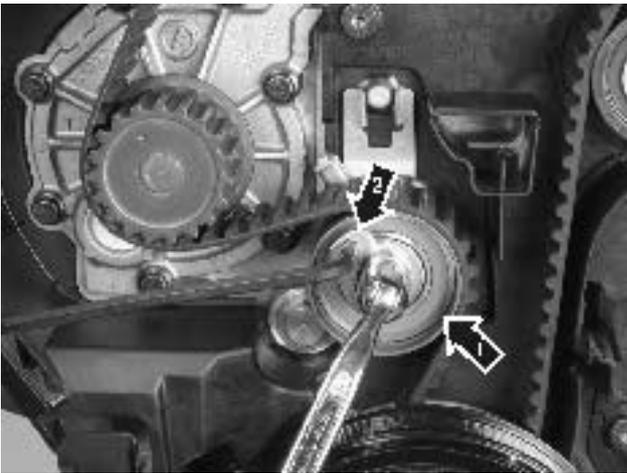
25. Install the torque amplifier (885633), together with 885648, as shown in the illustration.
 Unscrew the center nut on the crankshaft.



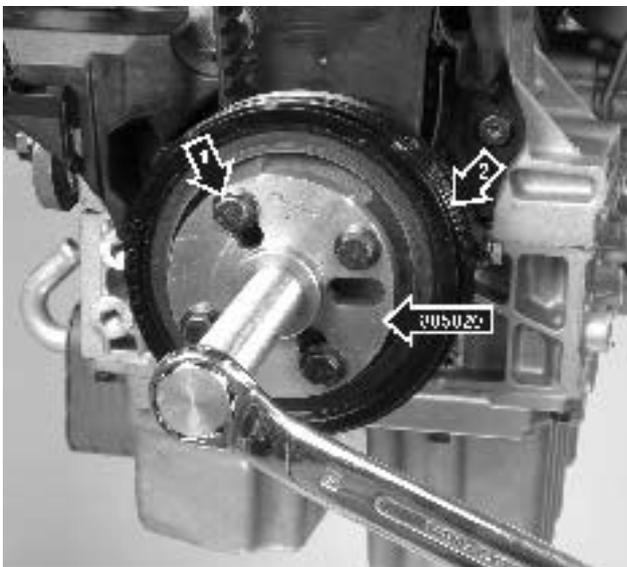
26. Put the lock pin 9997007 into the hole under the exhaust camshaft.
 Unscrew the plug on the engine block behind the starter motor position. Install lock pin 9997005 and make sure it bottoms against the block. Also refer to "Crankshaft, locking".

NOTE! It may be necessary to crank the engine to allow the tool to assume the correct position.

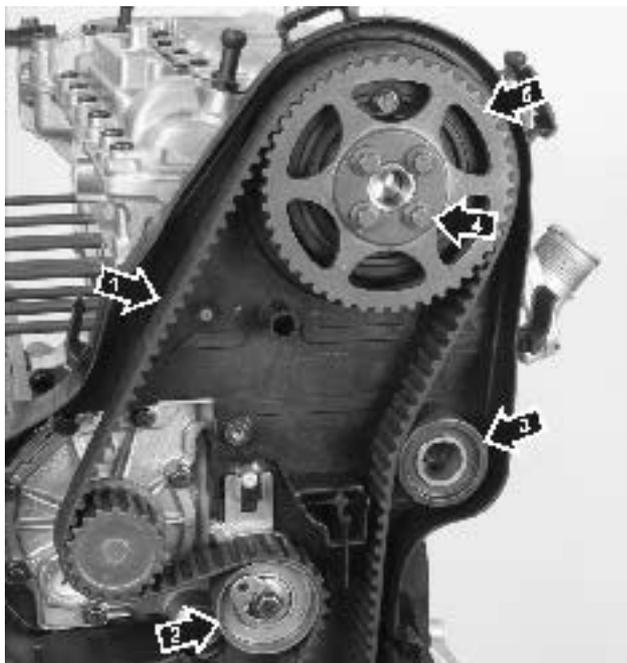




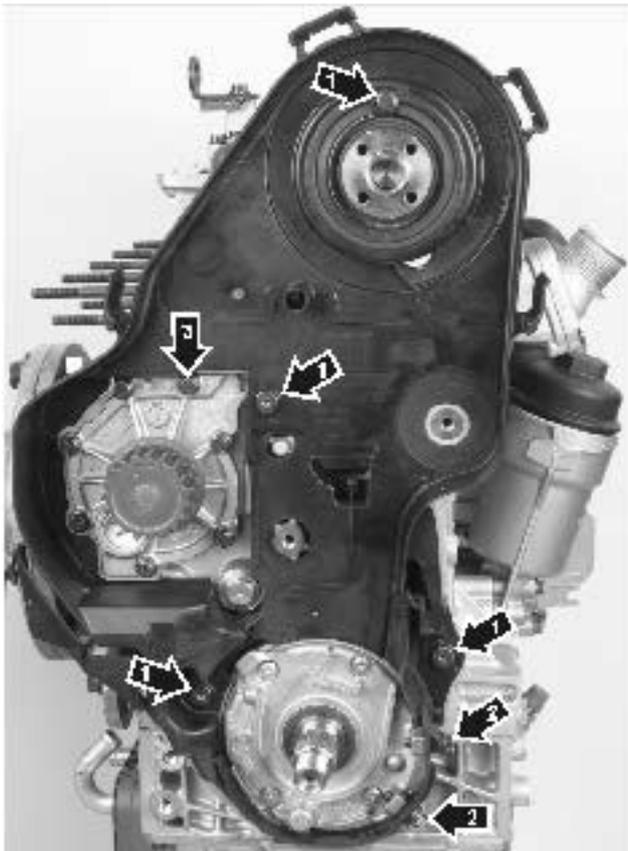
25. Undo the center screw on the belt tensioner (1) so that the eccentric washer (2) is released and can be put in the position shown in the illustration.
Undo the toothed belt.



26. Undo the screws on the counterhold tool 885819 and remove it.
Install puller 885820 using M10 screws (1) on the crankshaft toothed belt pulley.
Remove the toothed belt and pull the toothed belt pulley off together with the vibration damper (2).



27. Unscrew the belt tensioner (2) and jockey pulley (3).
Undo the screws (4) on the camshaft toothed belt pulley (5) and remove the pulley.

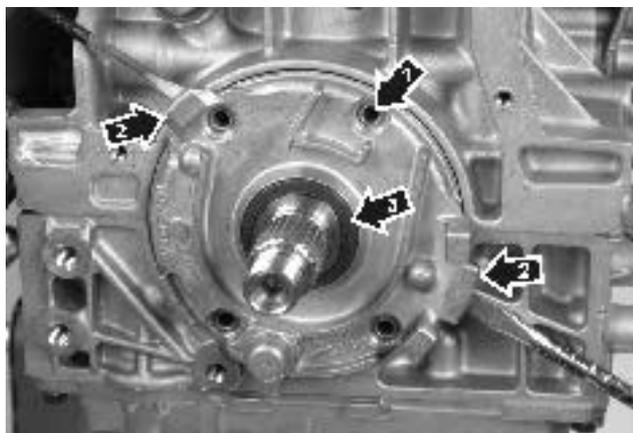


28. Circulation pump

Unscrew the four screws (1) on the rear timing gear cover and remove the timing gear cover.

Unscrew the two screws (2) on the lower belt guard and remove the belt guard.

Unscrew the seven screws for the circulation pump (3) and remove the circulation pump together with the gasket.

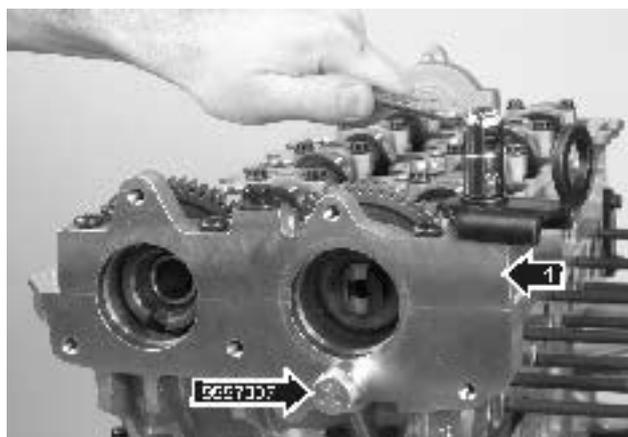


29. Oil pump

Undo the Torx screws (1) for the oil pump and carefully prise the pump up under the prising lugs (2). Remove the gasket, O-ring and seal ring (3) from the oil pump.

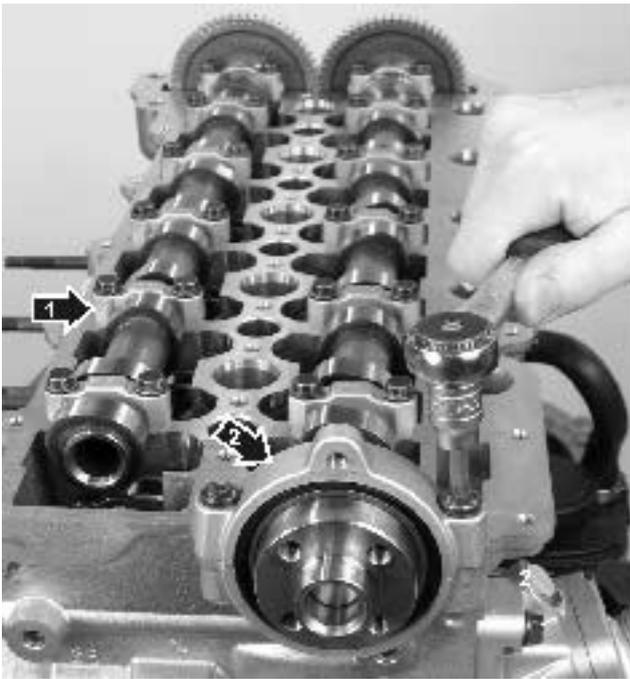
Clean the gasket plane and mating surfaces with scraper 885516.

⚠ IMPORTANT! The Torx screws must not be reused, since they have been in contact with sealant.



30. Cylinder head

Remove the rear camshaft bearing caps (1) and remove the camshaft locking pin 9997007.

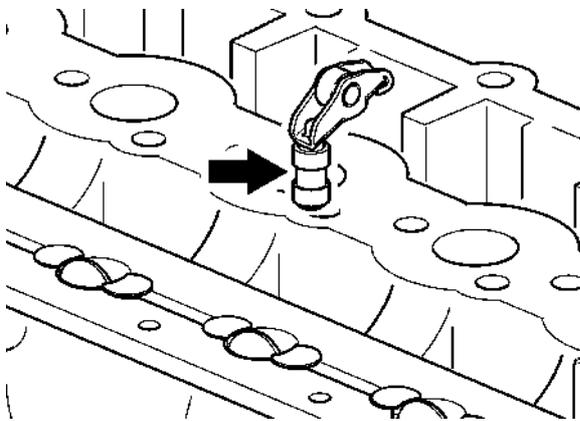


31. Undo the screws for all camshaft bearing caps (1) and the front oil seal clamp (2), working from the outside towards the center.

⚠ IMPORTANT! Undo each screw one turn at a time until the camshafts longer spring upwards.

Remove the screws, bearing caps and camshafts.

⚠ IMPORTANT! Put the bearing caps and camshafts on a clean, dry surface. The bearing caps are marked and must be re-installed in the same places. If the bearing caps are wrongly installed, this can cause engine failure.

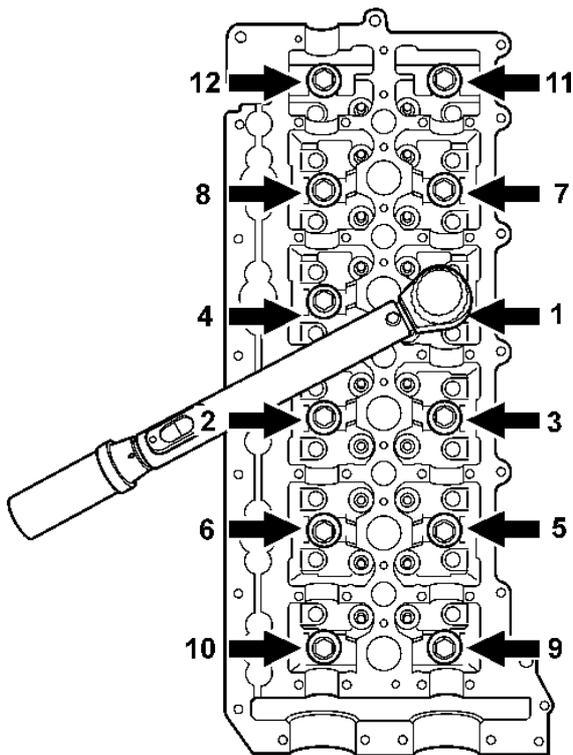


32. Pull all hydraulic valve lifters up out of the cylinder head.

NOTE! The valve lifters might come to pieces, but are easy to re-assemble.

⚠ IMPORTANT! Mark the valve lifters and store them in a vessel containing clean engine oil until they are installed.

⚠ WARNING! The cylinder head has very sharp edges. Be careful when working with it.



33. Undo the cylinder head screws. Start to undo them, working from the outside towards the center.

Undo the cylinder head and put it on a clean, dry, soft surface.

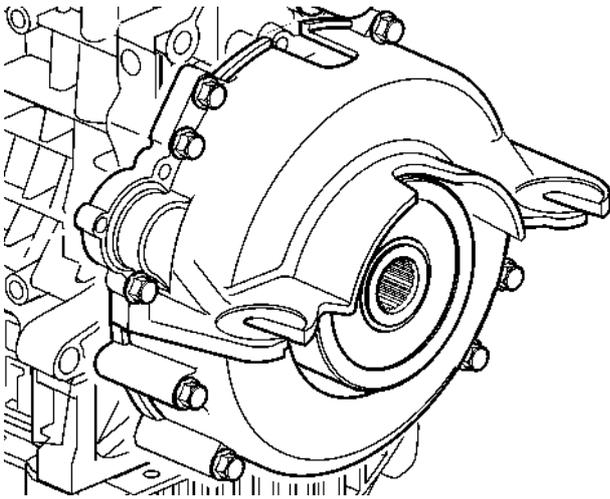
NOTE! Save the gasket or note its marking, please refer to "Engine, assembly, cylinder head".

⚠ IMPORTANT! The gasket plane and the plugs beside the valve heads must not be damaged. The gasket is basically unable to seal a scratch or other damage to the sealing plane.



34. **Flywheel with cover and coupling.**

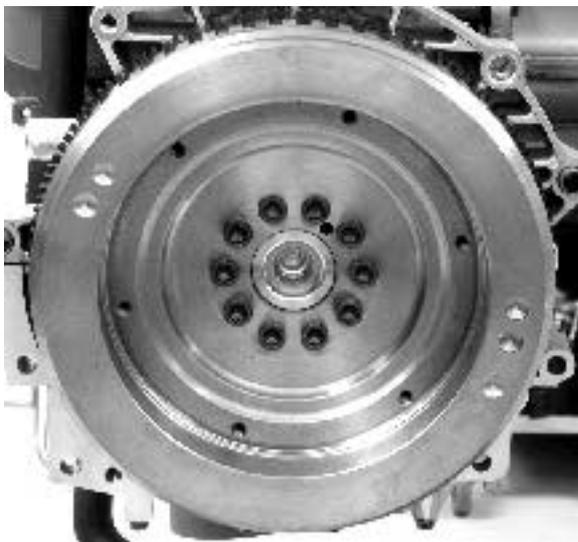
Unscrew the hot water outlet (1).



35. Unscrew the flywheel housing and remove it.

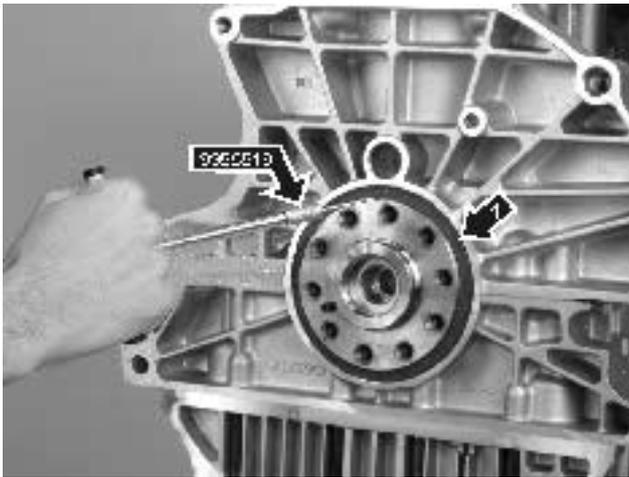


36. Unscrew the clutch (1) screws (2) and remove the clutch.



37. Unscrew the flywheel, using 12-tooth bit 885823 and remove the flywheel.

NOTE! The flywheel is heavy. Be careful when handling it.



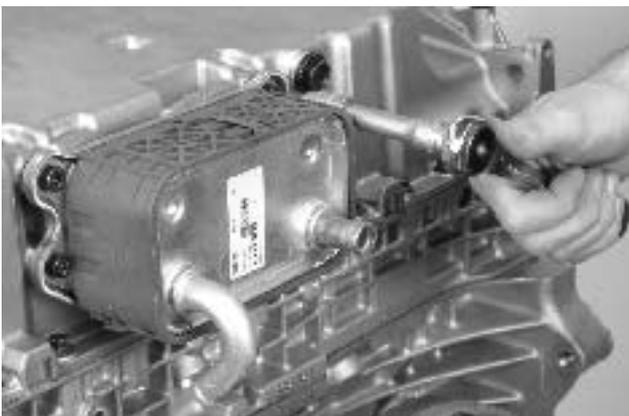
38. Remove the crankshaft seal ring (1) with tool no. 9995919. Clean the seal surfaces with a soft rag and denatured alcohol.

⚠ IMPORTANT! Be careful not to damage the seal surfaces.



39. Oil filter housing

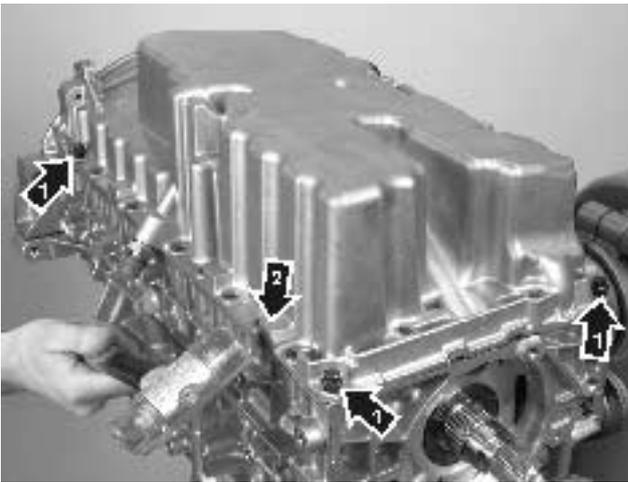
Unscrew the oil filter housing and remove it.



40. Oil cooler

Turn the engine upside down. Unscrew the oil cooler and remove the seals.

Clean the sealing surface.



41. Sump

Undo all the screws that hold the sump. Remove all of them except one screw (1) in each corner.

Carefully tap the sump heels (2) with a plastic faced mallet until the liquid gasket joint separates.

Remove the remaining screws (1) from the sump.

NOTE! The remaining screws are to protect the sump from falling away in an uncontrolled manner and being damaged while it is being tapped to remove it.



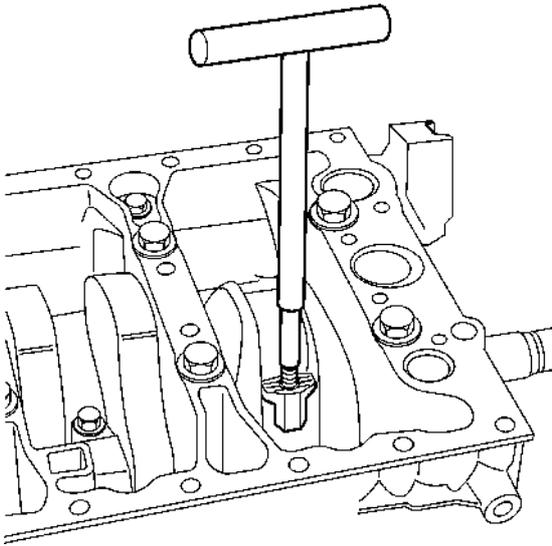
42. Oil suction pipe

Unscrew the oil suction pipe from the engine block. Remove the oil suction pipe together with its seal (1).

Remove the seals (2) between the sump and the engine block. Clean the gasket plane on the sump and the engine block carefully, using scraper no. 885516 and denatured alcohol.



43. Remove the piston cooling nozzles. Rotate the crankshaft to access all the nozzles. Use magnetic pen, part no. 885822, to lift the nozzles out.



44. Pistons and con rods

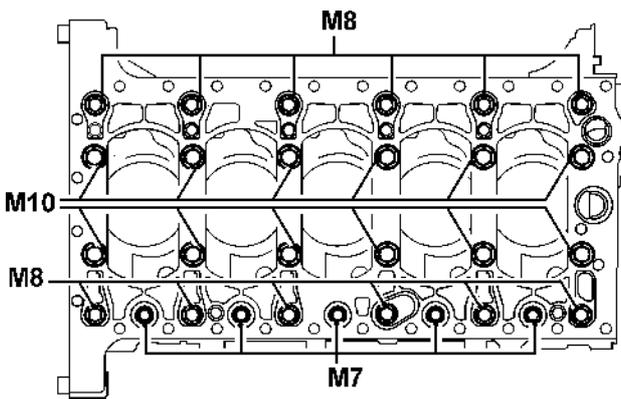
Mark up the main bearing caps.

Undo the main bearing caps.

Install guide dowel 9995746 and carefully tap out the piston with con rod.

NOTE! If necessary, the top turning point should be carefully scraped free from carbon before the piston is pressed out of the bore.

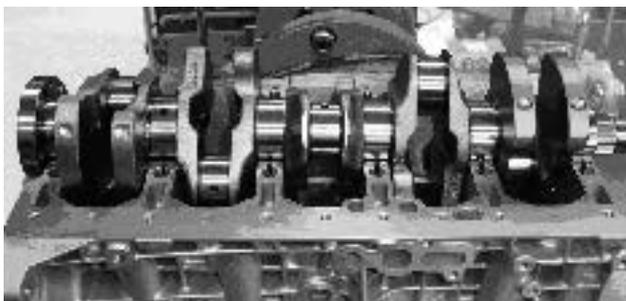
⚠ IMPORTANT! Re-install each bearing cap on its own con rod, to avoid damage to the split surface, which is very sensitive.



45. Remove the joining piece. Start by undoing the M7 and M8 screw first, then undo the M10 screw.

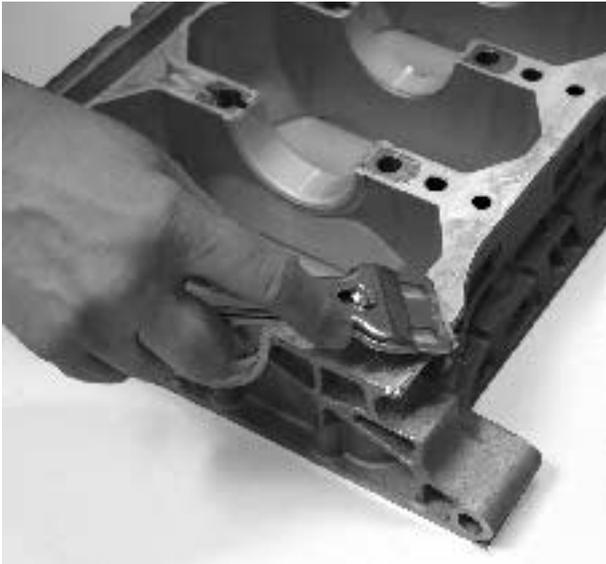
Tap away the joining piece with a rubber faced mallet on the exhaust side, since the joining piece guide dowels are installed on this side.

Lift off the joining piece and put it in a clean, dry place to avoid damaging the gasket plane of the joining piece.



46. Crankshaft

Lift out the crankshaft and remove the bearing shells.



47. Scrape the gasket plane on the block clean. Use gasket scraper 885516 and clean the block and joining piece thoroughly.

Assembly, engine

Cleaned engine and sealing surfaces

Special tools: 885500, 885511, 885633, 885686, 885818, 885819, 885823, 1158688, 9995199, 9995455, 9995676, 9997005, 9997006, 9997007, 9997010, 9997174

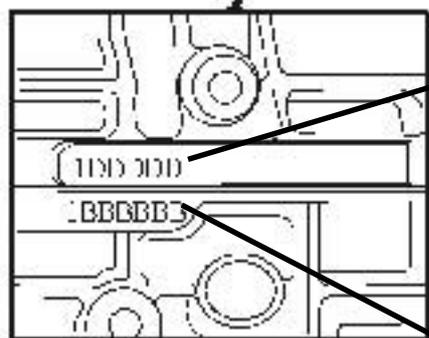
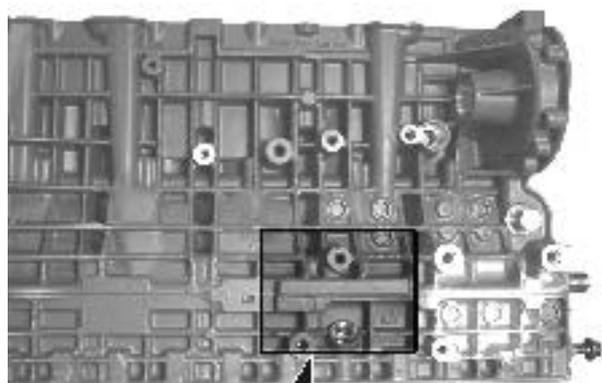
Classification of main bearings

NOTE! Always use new bearings. Bearing shells with grooves are always installed in the engine block.

There are markings for classification of the engine block and the pistons/bores beside the split plan between the joining piece and engine block, on the exhaust side of the engine, please refer to the figure.

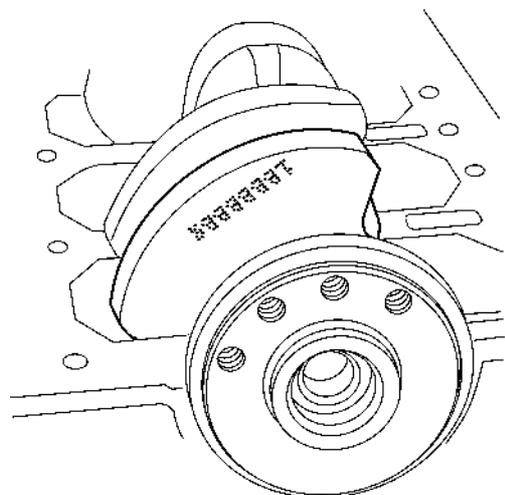
The classification mark for the crankshaft is on the crankshaft itself, please refer to the figure.

The first letter, or number "1" corresponds with main bearing no. 1, starting from the front of the engine. Please refer to the table on next page for color marking of the main bearings.



piston/bore

engine block



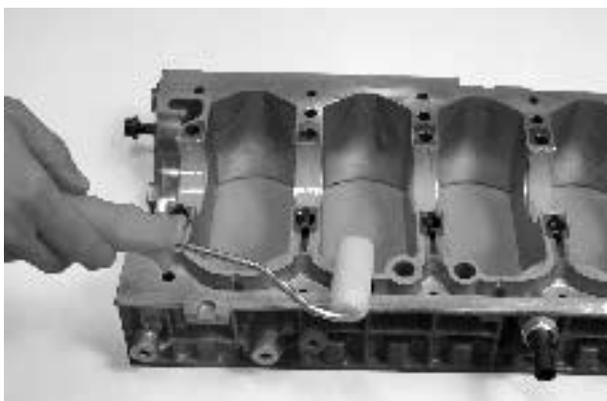
		Classification of engine block/main bearing seats					
		A		B		C	
		Block	Mellandel	Block	Mellandel	Block	Mellandel
Classification of crankshaft / main bearings	A	Yellow	Yellow	Yellow	Blue	Blue	Blue
	B	Red	Yellow	Yellow	Yellow	Yellow	Blue
	C	Red	Red	Red	Yellow	Yellow	Blue

Example

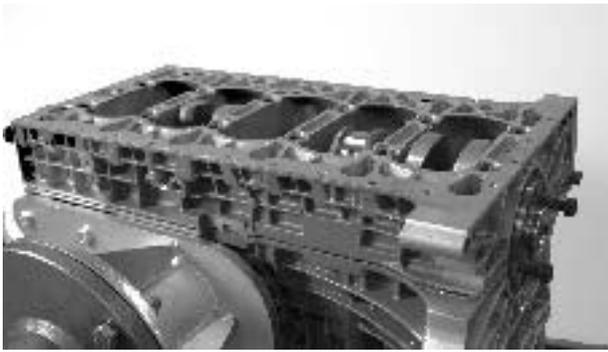
The first main bearing (after "1") is marked B and the crankshaft is marked C, will this give a red bearing in the engine block and a yellow in the joining piece.



1. Put new main bearing shells in place in the engine block and joining piece, put a thin film of oil on the bearing surface.



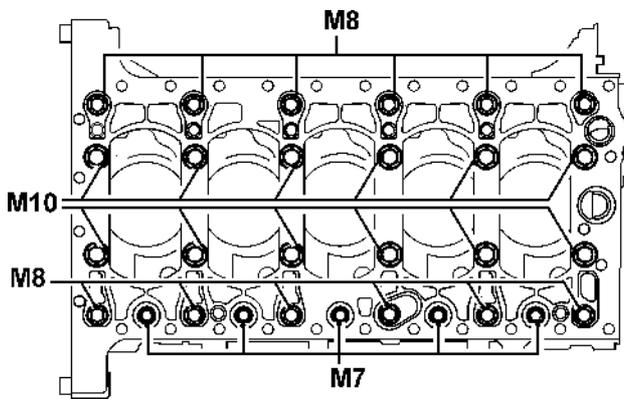
2. Use tool no. 885511 to roll a film of Loctite 510 over the gasket plane of the block. Leave a gap of about 5 mm around the bearing shells. This is because the sealant is pressed out when the joining piece is installed and the compound must not be forced down into the bearings.



3. Crankshaft

Put the crankshaft in place, and make sure that the bearing shells are not moved away from their seats.

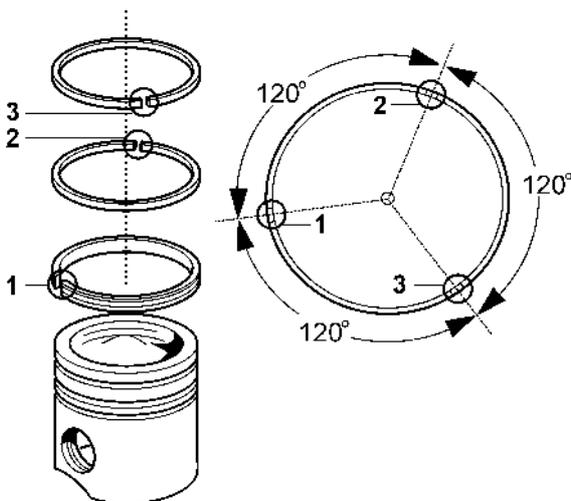
Put the joining piece in place and carefully press the joining piece down over the guide dowels, parallel with the engine block.



4. Tighten all screws lightly and then torque them from the center and outwards, as follows:

- stage 1, M10 screws 20 ± 2 Nm
- stage 2, M10 screws 40 ± 2 Nm
- stage 3, M8 screws 25 ± 3 Nm
- stage 4, M7 screws 16 ± 2 Nm
- stage 5, M10 screws 110° ± 5°

⚠ IMPORTANT! After torquing, the rotation of the crankshaft must be checked to ensure that it has not been “pinched”.

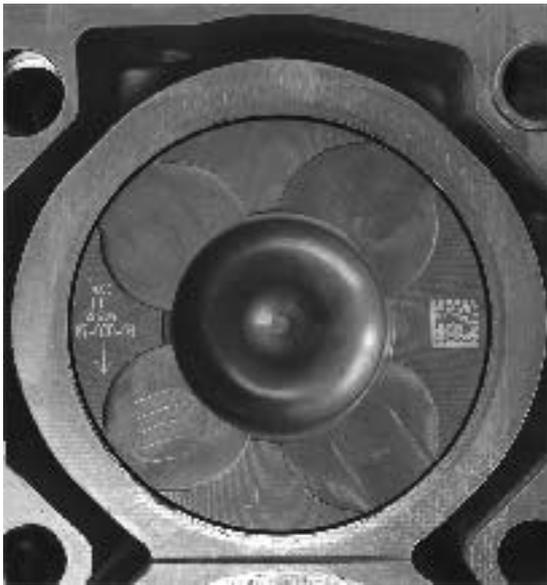


5. Piston rings

Install the piston rings. Use a piston ring compressor. The openings in the piston rings must be installed with the gaps rotated 120° to each other.

NOTE! The piston rings are color marked and must be correctly aligned, with the marking on the left of the gap.

- Top ring yellow marking
- Oil scraper ring blue marking
- Oil scraper ring: white marking



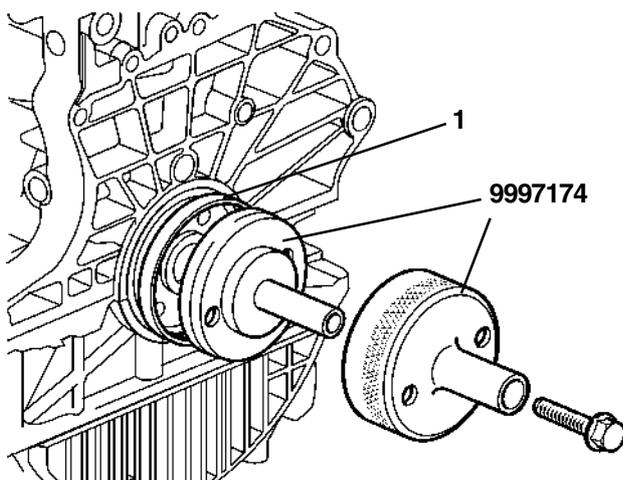
6. Piston cooling nozzles, pistons, con rods

Install the piston cooling nozzles.

Install the pistons complete with con rod. Use tool 9995746 (guide pin, con rod).

NOTE! The con rods have bosses on them, to prevent incorrect assembly.

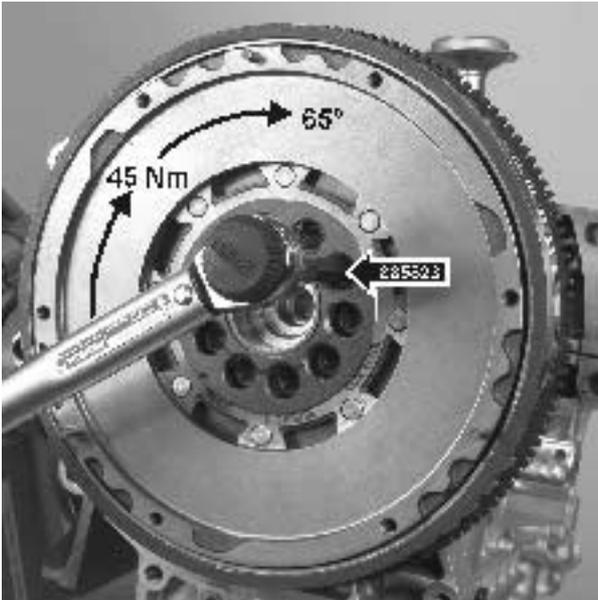
Pistons and bores are classified as C, D or E, and are marked with an arrow which should point towards the front of the engine.



7. Flywheel, seal ring, clutch and flywheel housing

Install the crankshaft seal ring (1) on tool no. 9997174. Install the tool on the crankshaft using two screws, and press the seal in with the centre screw until it is in the correct position, level with the cylinder head.

⚠ IMPORTANT! The seal ring dust lip is easily stretched and does not spring back again. If it has been incorrectly aligned or has been forced in, it must be changed.



8. Install lock pin 9997005 for the crankshaft in the engine block, please refer to “Engine, disassembly, timing gear”.

Carefully clean the crankshaft and flywheel mating faces.

Turn the engine round and install the flywheel. Tighten the screws with socket no. 885823 alternately in two stages as specified in “Technical Data”.

NOTE! The flywheel is heavy. Be careful when handling it.

Install the clutch and tighten the screws alternately as specified in “Technical data”.

Install the flywheel housing and tighten the screws alternately as specified in “Technical data”. The screws which are fixed to the sump must be torqued later on, when the sump is in place.

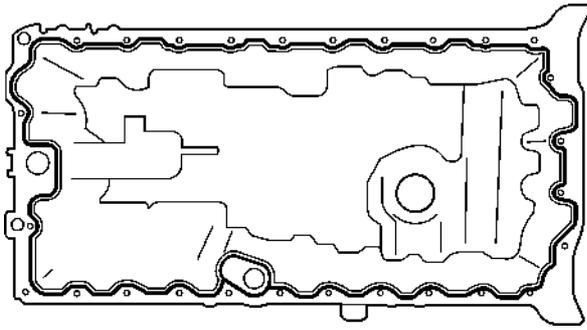


9. **Oil suction pipe and sump**

Install a new, oiled O-ring on the oil suction pipe.

Put the pipe in place. Ensure that the O-ring (1) goes down into the engine block. Then screw the pipe in place.

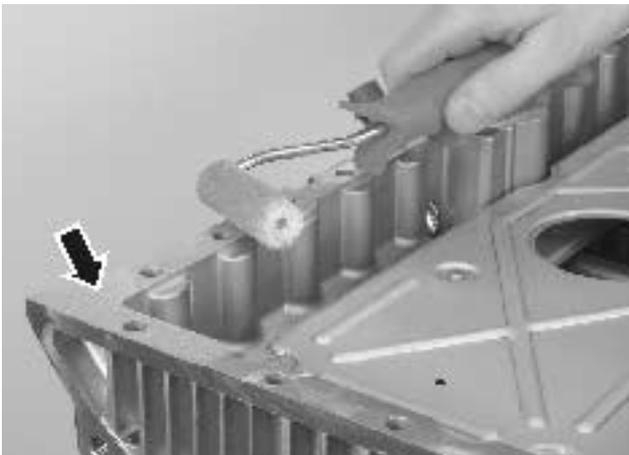
Install new, oiled seal rings (2) in the grooves that seal between the sump and the engine block.



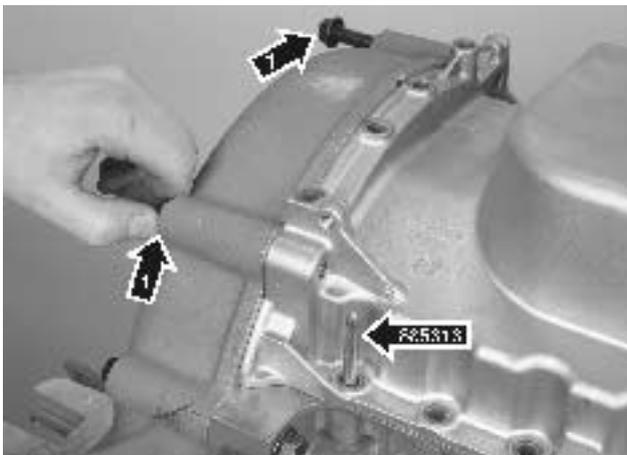
10. Clean the gasket plane with denatured alcohol.
Apply sealant no. 30731319 as in the figure, using a **min 2 mm** wide line.

NOTE! The sump must be installed within 5 minutes after applying the seal.

⚠ IMPORTANT! Old gasket residue must have been fully removed before a new seal is applied.



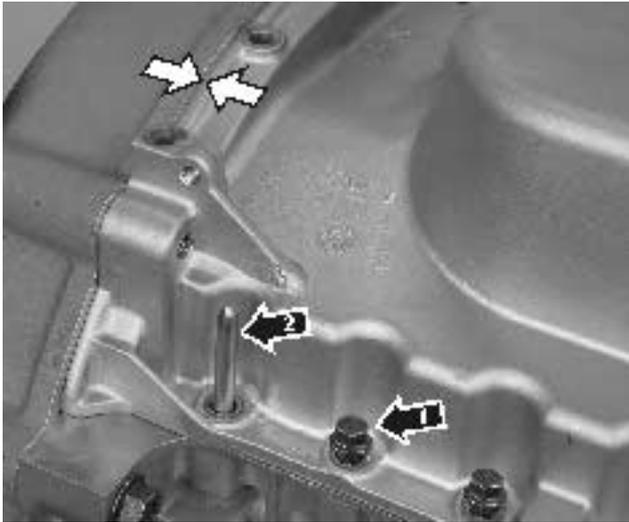
NOTE! On engines with serial number before 334747, sealant 1161059 must be used, which is rolled on.



11. Insert two guide dowels, 885818, into diagonally opposed holes in the corners of the engine block gasket plane.

Install the sump and press it against the flywheel housing at the same time, before it reaches the gasket plane. Screw the remaining flywheel housing screws (1) in until they bottom. Torque them later on.

⚠ IMPORTANT! Liquid gasket is easily damaged if the sump is slid when put in place. If this happens, new liquid gasket must be applied.



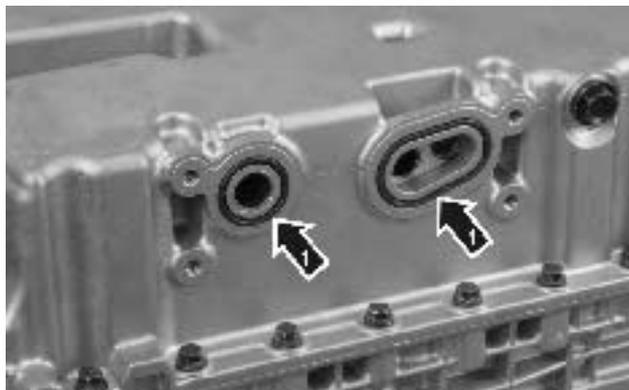
12. Install new screws (1) in all open screw holes in the sump and tighten them loosely.

Remove the guide dowels (2) and install the remaining screws.

First tighten the four corner screws, as specified in "Technical Data", and then the other screws.

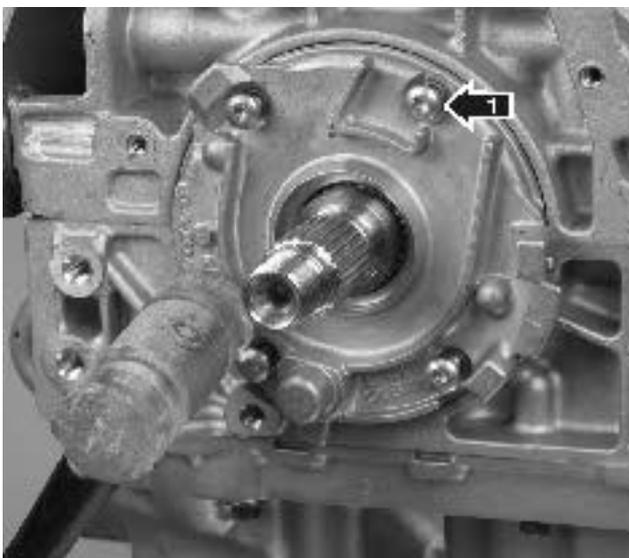
Tighten the flywheel housing screws as specified in "Technical data".

- ⚠ IMPORTANT!** Make sure that the sump is in contact with the flywheel housing before the sump screws are torqued.



13. Oil cooler

Put new, oiled seal rings (1) in the grooves on the sump. Screw the oil cooler in place.



14. Oil pump

Install the oil pump with a new gasket, new oiled O-ring and **new** Torx screws (1).

Put the oil pump up in the correct position, use the screws as guides, then carefully tap the oil pump with a rubber-faced mallet.

Torque the screws alternately to the specified value.



15. Install a new seal (1) on tool 9995455.

Install the tool with the seal on the crankshaft.

Turn the center nut until the seal is in place.

NOTE! The crankshaft must not rotate during the pressing operation, or the seal ring could be damaged.



16. Check that the seal ring is level with the outer edge of the swage on the oil pump.

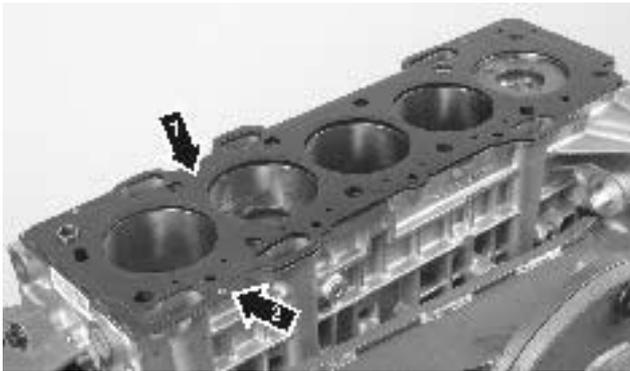
⚠ IMPORTANT! The seal ring dust lip is easily stretched and does not spring back again. If it has been incorrectly aligned or has been forced in, it must be changed.



16. Toothed belt pulley

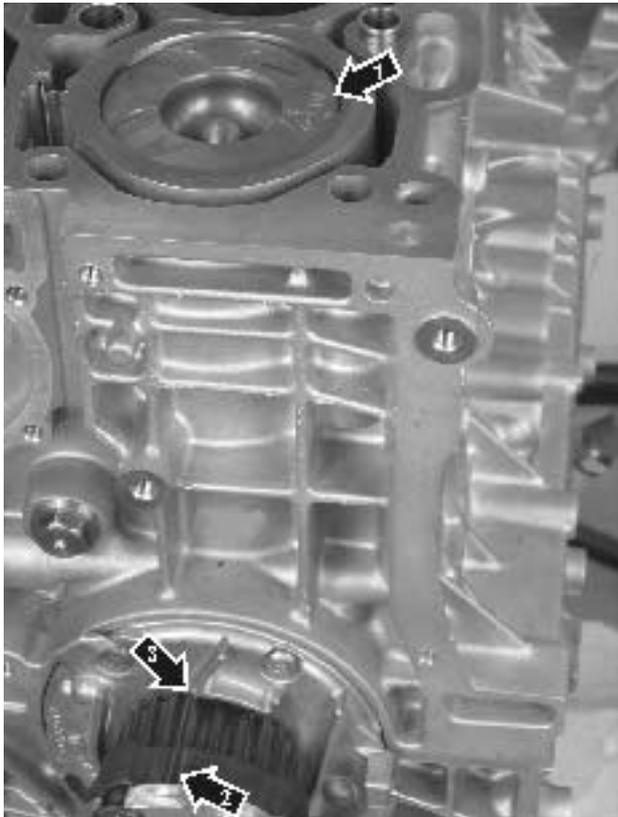
Install the toothed belt on the crankshaft. The pulley and the crankshaft have specially designed splines and can only be installed one way round. Tap the toothed belt pulley on with a plastic faced mallet.

The toothed belt pulley can be pre-heated to 100°C to facilitate assembly.



18. Cylinder head

Put a new gasket (1) on the engine block. Make sure that a gasket of the correct thickness is used. This is indicated by a combination of holes (2) on the edge of the gasket, please refer to “Cylinder head gasket, measurement”.

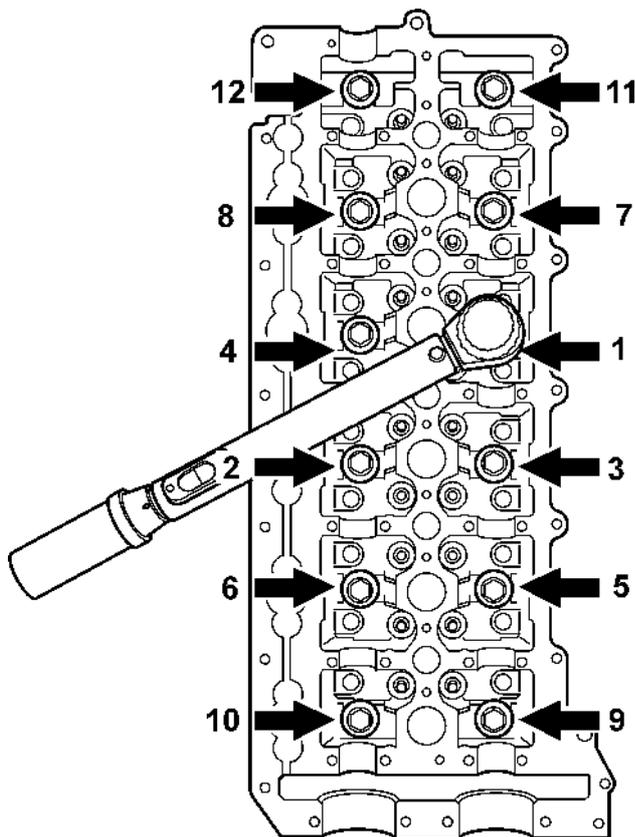


19. Move no. 1 piston to Top Dead Center. Make sure that lock pin no. 9997005, for locking the crankshaft, bottoms against the block.

Turn the crankshaft counter-clockwise until the crankshaft counterweight rests against the lock pin. No. 1 piston (1) is now about 2 mm before Top Dead Center.

The crankshaft is now in the correct position, which can also be checked on the crankshaft's toothed belt pulley (2) and the oil pump marking (3).

Also refer to “Crankshaft, locking”.

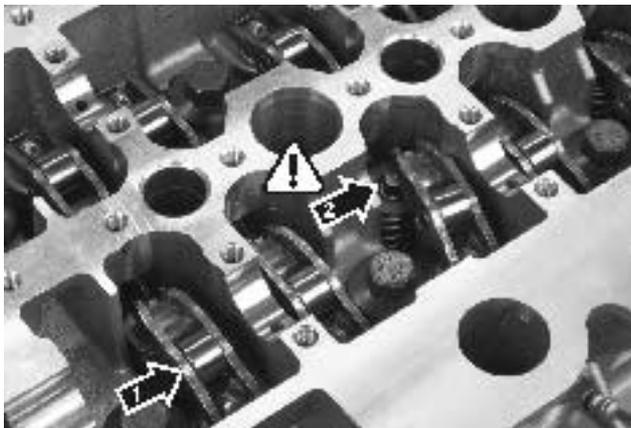


20. Oil all the cylinder head screws with engine oil and leave them to drain on paper for about 10 minutes.

Put cylinder head in place and install the screws lightly (1-12) by hand.

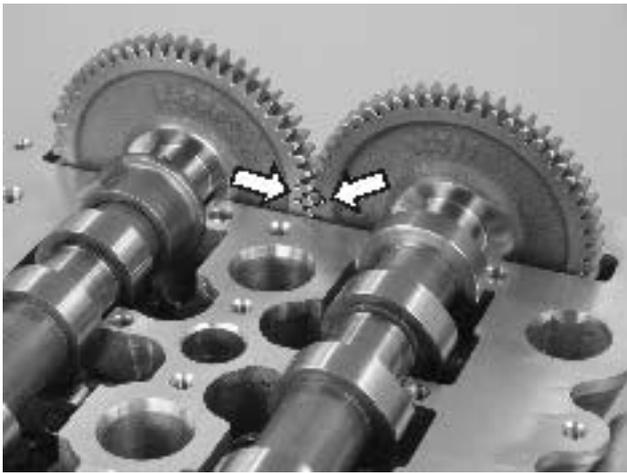
Torque the screws alternately, from the center and out, as specified in "Technical data".

⚠ IMPORTANT! Use the greatest care during assembly, to avoid damaging the gasket plane and the plugs by the valve heads.



21. Oil the valve lifters (1) and install them in the order they were marked.

NOTE! Check that the valve lifters are in contact with the valve stems. The illustration shows a valve lifter (2) in the wrong position.

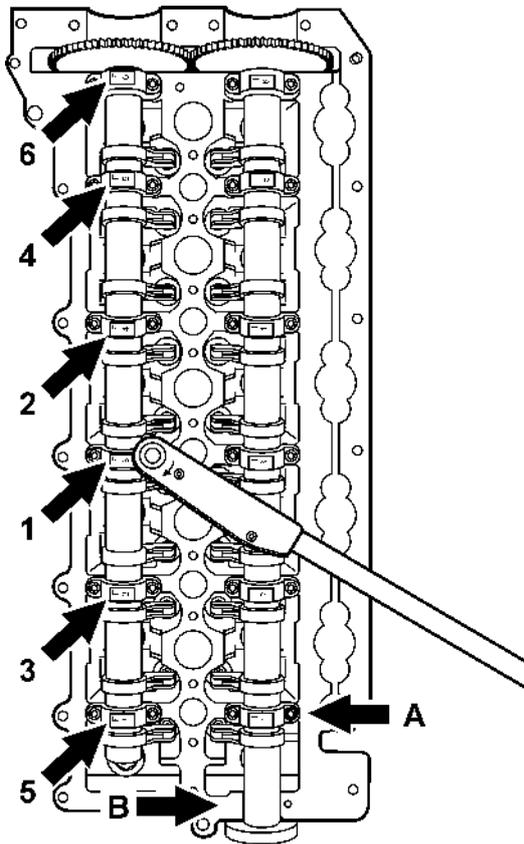


22. Check that all the bearing surfaces on the camshafts, camshaft bearing caps and cylinder head have been carefully cleaned.

Lubricate the following:

- Camshaft bearing surfaces and lobes
- Cylinder head bearing surfaces
- Camshaft bearing caps
- Valve lifter rollers

Install the camshafts with markings (1) on the camshaft drive gears facing each other.



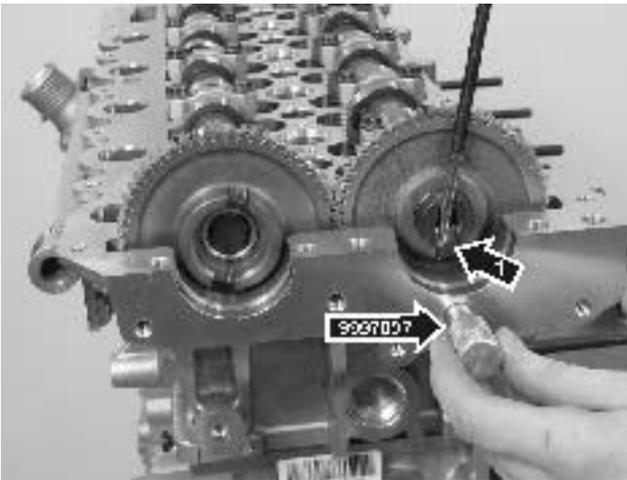
23. Install all camshaft bearing caps (A) as marked, except the front bearing cap (B) on the inlet camshaft. Tighten the screws until the bearing caps touch the camshafts.

NOTE! The bearing caps are marked “I” (inlet) and “E” (Exhaust), and numbered 1-6 to facilitate assembly.

Carefully tighten the screws for caps 1-6 alternately, working from the center and outwards as in the figure, one turn at a time until the camshafts are fixed against the cylinder head.

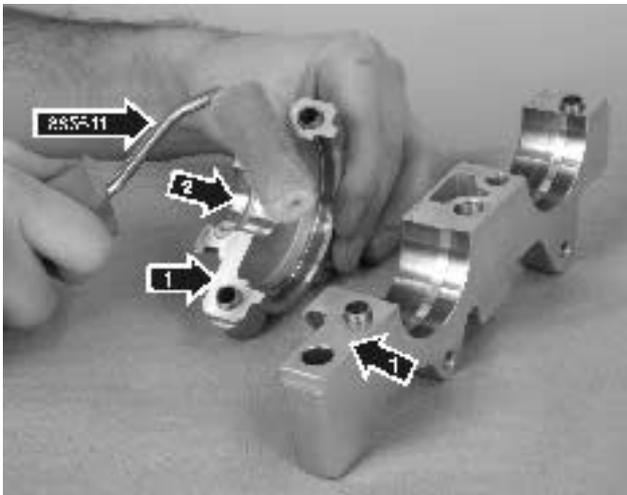
Torque the screws as in the specification in “Technical data”.

⚠ IMPORTANT! Make sure that the camshafts do not rotate during installation of the bearing caps.



24. Put locking pin no. 9997007 in the cutout for the exhaust camshaft. Carefully turn the camshafts with a screwdriver in the high pressure or vacuum pump grooves (1) to facilitate installation of the lock pin.

⚠ IMPORTANT! The camshafts must not be turned more than needed to install the lock pin. There is a risk that the valves could be damaged.

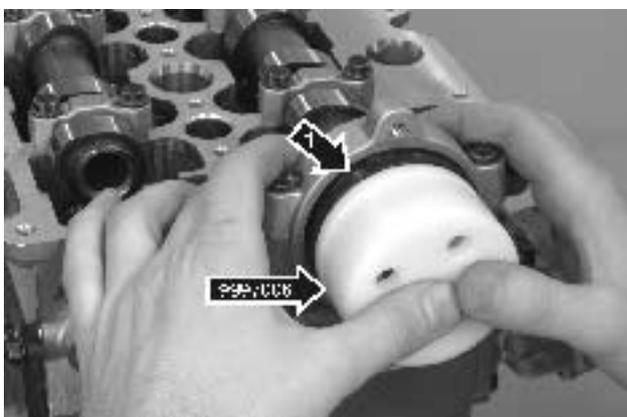


25. Clean the front and rear bearing caps.

Apply liquid gasket 1161059-9, using roller no. 885511 on the gasket plane (1). The surface should be completely covered, without surplus.

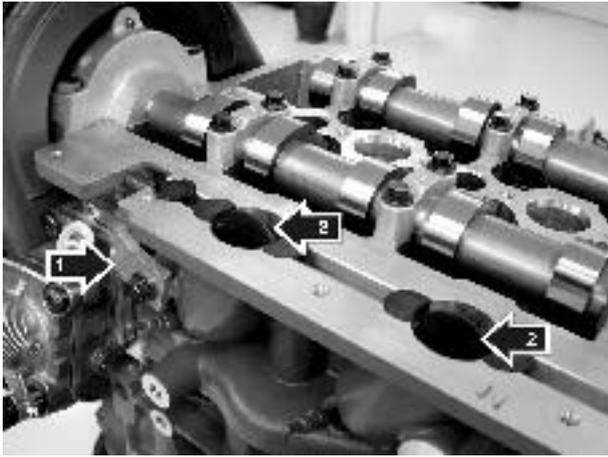
Grease bearing race (2) on the front bearing caps.

Install the caps and torque the M10 and M6 screws to the values specified on the torque table in the "Technical Data".



26. Install the inlet camshaft seal ring (1). Use tool no. 9997006 to press the seal ring in until the tool bottoms against the camshaft.

⚠ IMPORTANT! The seal ring dust lip will be damaged if it is stretched. If it has been incorrectly aligned or has been forced in, it must be changed.



27. Valve cover.

Install the shaft with butterfly. Press the rubber seal down all the way.

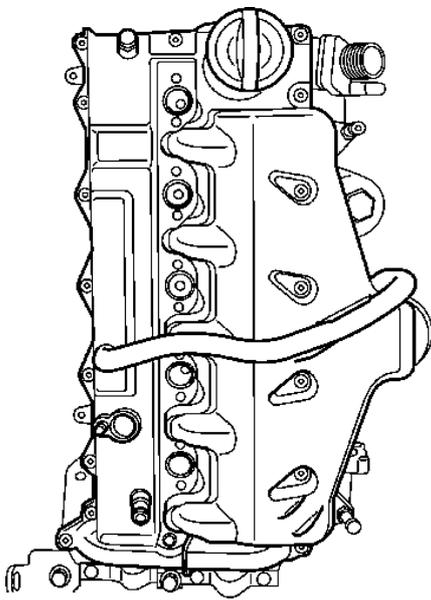
Install the rubber tape inside the control arm.

Install the lock washer (1) so that the butterfly (2) remains open.

Scrape the valve housing seal surfaces clean and wipe them off.

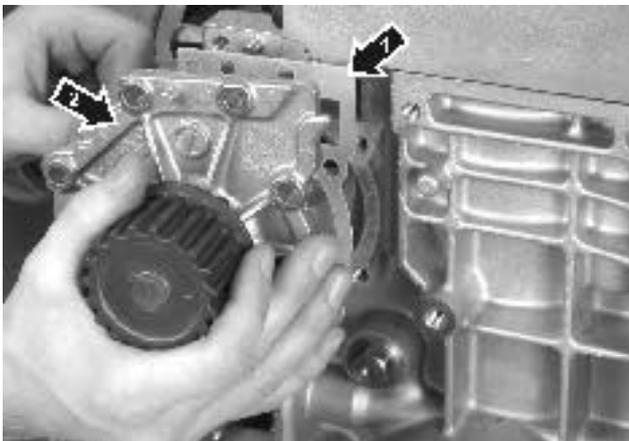
Check that the camshaft lobes are fully covered with an oil film, lubricate if necessary.

Press the valve cover gasket into the groove in the valve cover.



28. Carefully put on the valve housing/inlet pipe (1) without disturbing the position of the gasket during assembly.

Torque the valve housing screws alternately.



29. Circulation pump

Make sure that the sealing surfaces are clean. Install a new gasket (1) and circulation pump (2).

Install new screws and torque them alternately as specified in "Technical data".

⚠ IMPORTANT! The screws must not be re-used, since they have been in contact with sealant.



30. Timing gear

Install the rear timing gear cover (1). Check that it comes into the correct groove (2) behind the coolant pump.

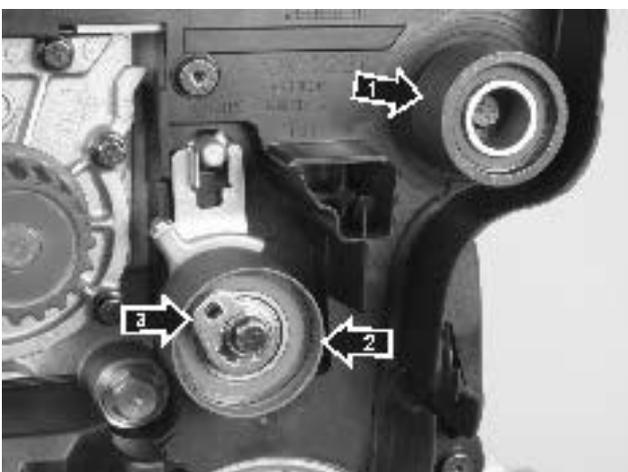
Install the lower belt guard.



31. Fix the camshaft toothed belt pulley with one of the three screws (1). Check through the open screw hole (2) that the screws are not in their end positions in the elongated holes (3) on the toothed belt pulley. If the screws are in their end position, it may be impossible to tension the toothed belt.

Make sure that the marking on the pulley (4) and the timing gear cover (5) line up.

Loosen the screws until the pulley can slide in the elongated screw holes.



32. Install the toothed belt jockey pulley (1). Torque the screw as in the specification in "Technical data".

Screw the belt tensioner (2) down. Undo the center screw about one turn and turn the eccentric washer (3) with a 6 mm Allen key until it is in the position shown in the illustration. It is easiest to install the toothed belt in this position.

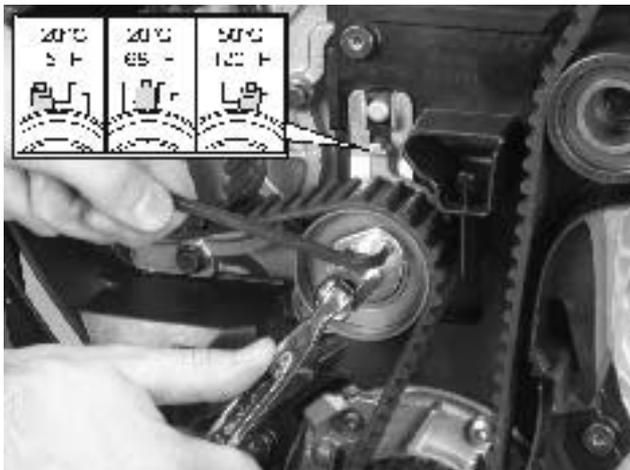


33. Install the toothed belts in the following order:

1. Crankshaft
2. Jockey pulley
3. Camshaft gear
4. Belt tensioner
5. Circulation pump

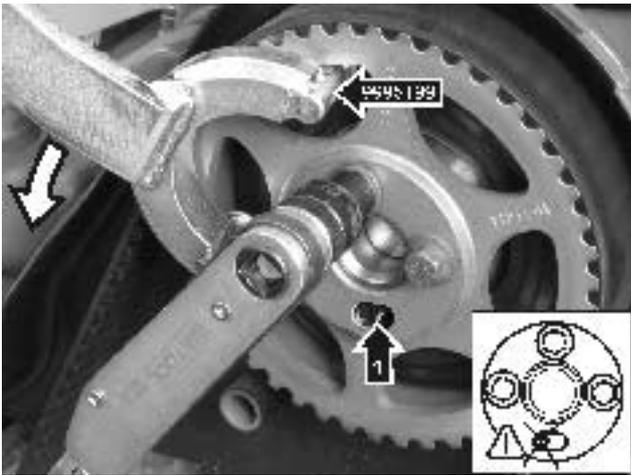
⚠ IMPORTANT! The toothed belts must be kept taut during installation.

NOTE! Also observe the replacement interval for toothed belts, please refer to "Technical data, Engine body".



34. Set the belt tensioner to the tensioned position. Then tighten the screw. No fine adjustment is necessary at this point. The illustration shows the position of the belt tensioner at various temperatures of the engine block.

Check that lock pins 9997007 for the exhaust camshaft and 9997005 for the crankshaft are in place, please refer to "Crankshaft, locking".

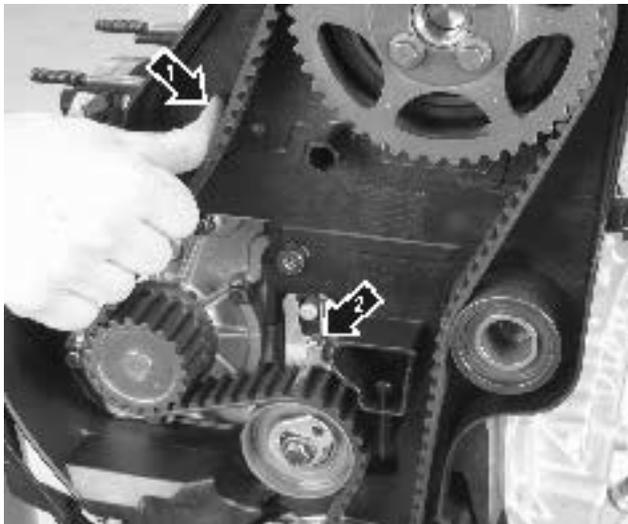


35. Check that the open screw hole (1) is not in the end position in relation to the elongated hole. If the screws are in their end position, it will not be possible to tension the toothed belt correctly.

Tension the toothed belt in the direction of the arrow, using counterhold 9995199 and fix the camshaft pulley with the three screws. Torque the screws as specified in "Technical data."

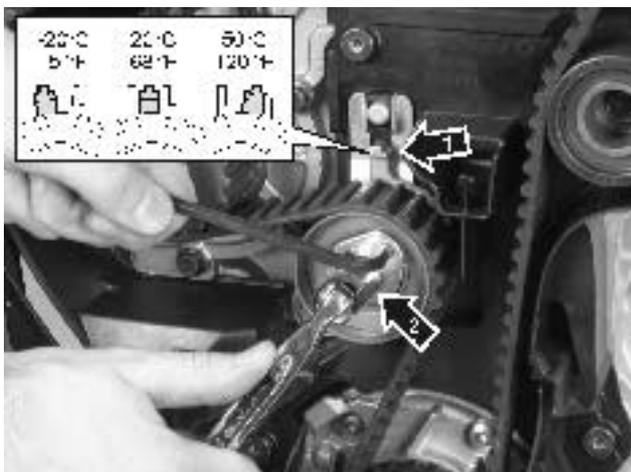
Fit the last screw and torque as specified in "Technical data."

⚠ IMPORTANT! Make sure that the toothed belts are taut between the crankshaft, jockey wheel and camshaft pulley during tightening.



36. Apply pressure (1) to the toothed belts and check that the belt tensioner (2) moves.

NOTE! The belt tensioner must be changed if it does not move.

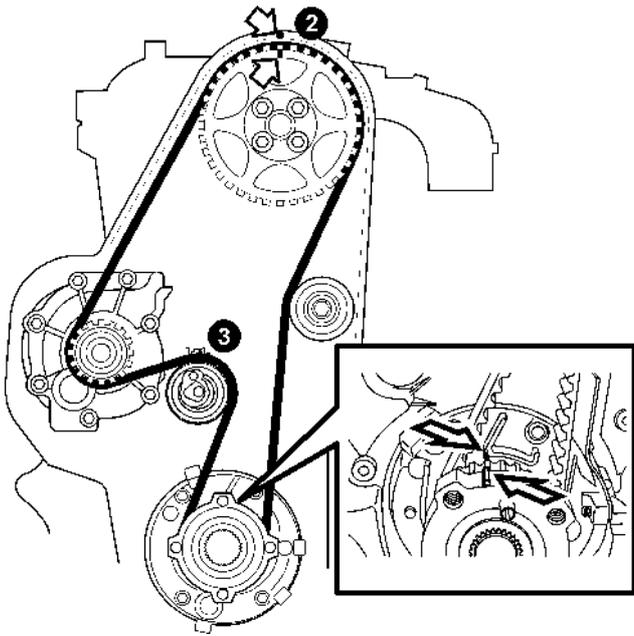


37. Remove locking pins 9997005 and 9997007 and install the plug in the block.

Set the belt tensioner in relation to the temperature of the engine block, please refer to the figure.

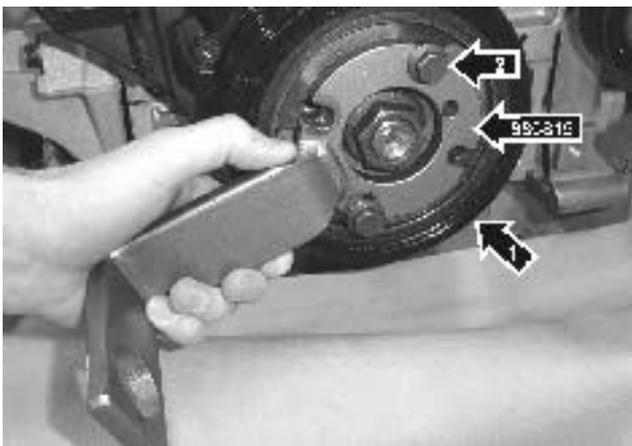
Torque the belt tensioner as specified in "Technical data".

NOTE! The illustration shows the temperature of the engine block when the belt tensioner is set up.



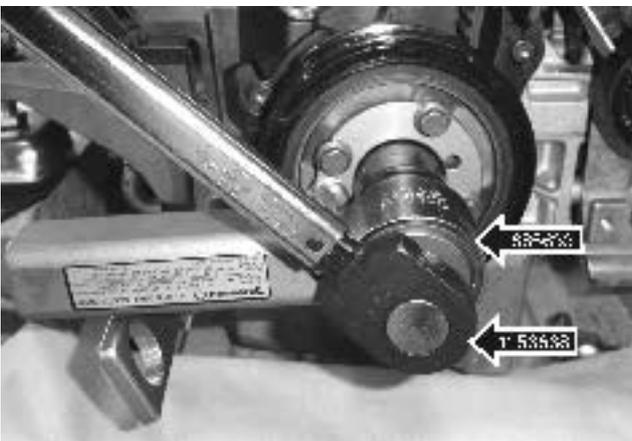
38. Turn the crankshaft round two rotations. Check the marking on the crankshaft pulley (1) and the marking on the camshaft pulley (2).
 Check that the belt tensioner indicator (3) is within the marked temperature range. If necessary, adjust as above.

⚠ IMPORTANT! Check that the engine can be cranked without any unwanted noise or complications.



39. Install the vibration damper (1) on the crankshaft. Screw counterhold 885819 to the vibration damper, use the four screws (2) for the vibration damper.

⚠ IMPORTANT! Check that lock pins 9997007 for the exhaust camshaft and 9997005 for the crankshaft are removed. There is a strong risk of engine damage if the pins are left in place.

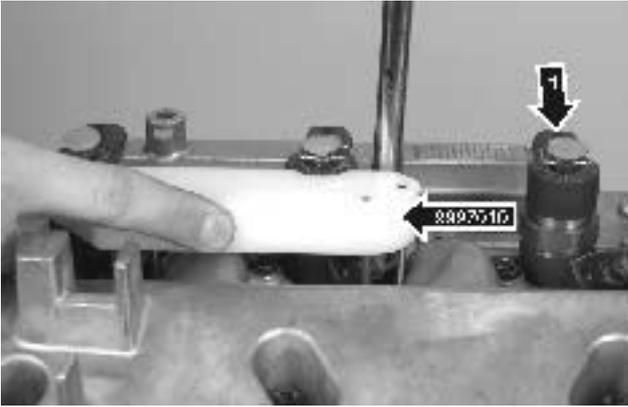


40. Torque a **new** center nut to the crankshaft, as specified in "Technical Data". Use torque amplifier 885633.

NOTE! If a torque of 86 Nm is applied to torque amplifier 885633, this gives a torque of 300 Nm (71 ft. lb gives 250 ft. lb).

Remove counterhold (885819) from the vibration damper. Tighten **new** screws on the vibration damper alternately in two stages as specified in "Technical Data".

Install the front timing gear cover.



41. Injectors

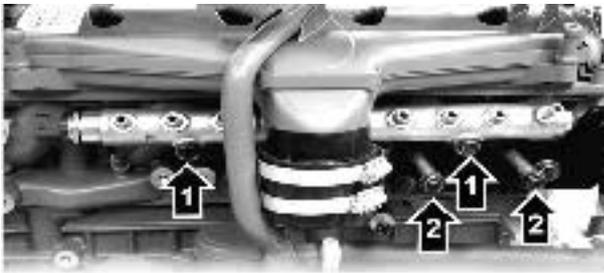
Install all injectors (1) in place, as marked. The tension brace and copper washer for each injector must be changed.

Screw the tension braces down so much that the injectors can still be rotated slightly. Put tool no. 9997010 against two injectors and turn them to the correct positions. Torque the tension brace screws as specified in "Technical data".

Repeat the procedure with the other injectors.

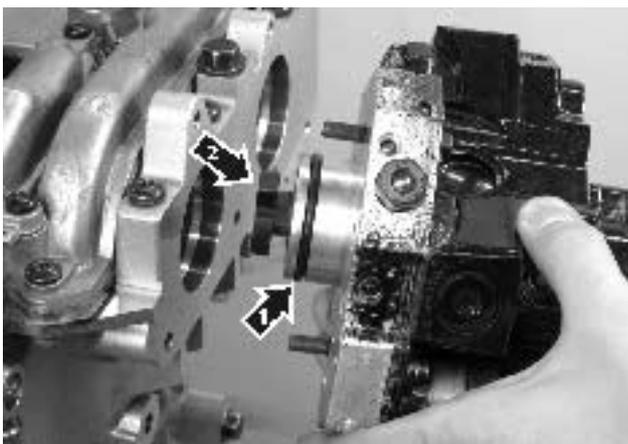


IMPORTANT! Handle the injectors carefully. They are easily damaged, which could cause incorrect combustion and engine failure.



42. Distribution manifold

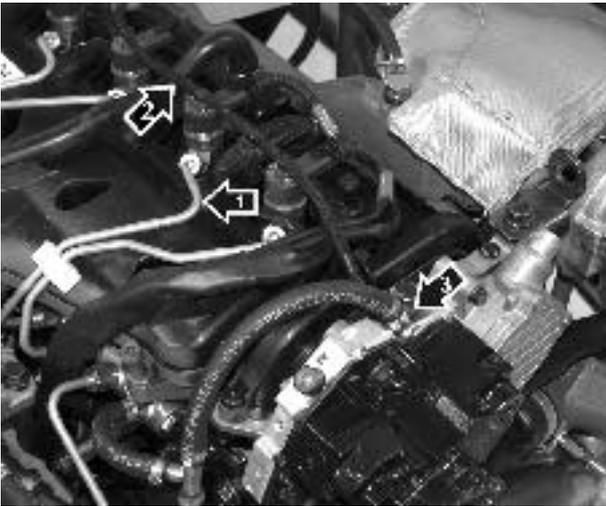
Torque the distribution manifold (1) and bracket (2) for the intercooler to the cylinder head, as specified in "Technical Data".



43. High pressure pump

Install a new O-ring (1) on the high pressure pump and install it together with its flange (2).

Screw the high pressure pump down as specified in "Technical data."

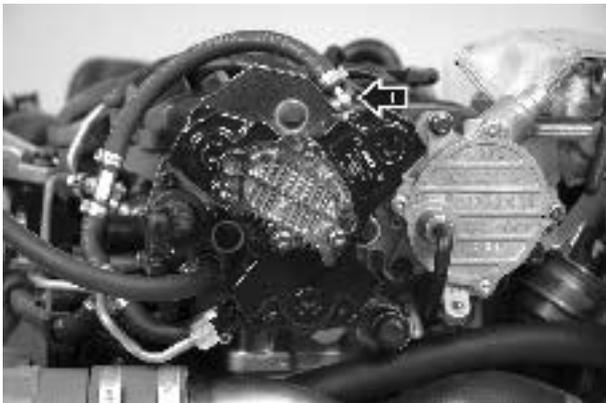


44. Fuel supply pipes, fuel leakage hose

Install new fuel supply pipes (1) between the injectors and the distribution manifold. Tighten the cap nuts as in "Injectors and fuel supply pipes, change", steps 6 to 8.

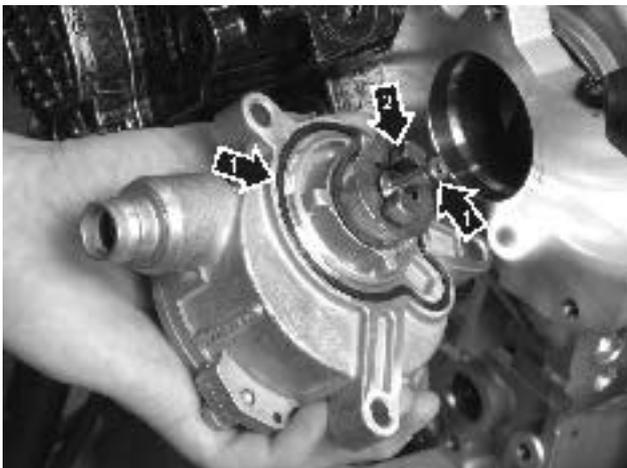
Install the fuel leakage hose (2) as in "Injectors and fuel supply pipes, change" step 9.

Install the hollow screw (3) together with the return hose, fuel leakage hose and new copper washers on the high pressure pump. Tighten it loosely.



45. Fuel union

Tighten the hollow screw (1) on the high pressure pump as specified in "Technical data."

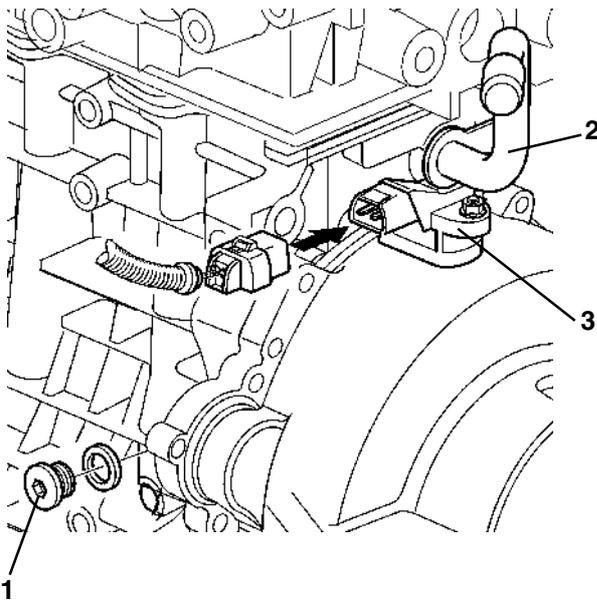


46. Vacuum pump

Install new O-rings (1) on the vacuum pump. Make sure that flange (2) enters the exhaust camshaft.

Torque the screws as specified in "Technical data."

NOTE! Handle the vacuum pump carefully. A vacuum pump which has been dropped or damaged in any other way must not be re-installed under any circumstances.

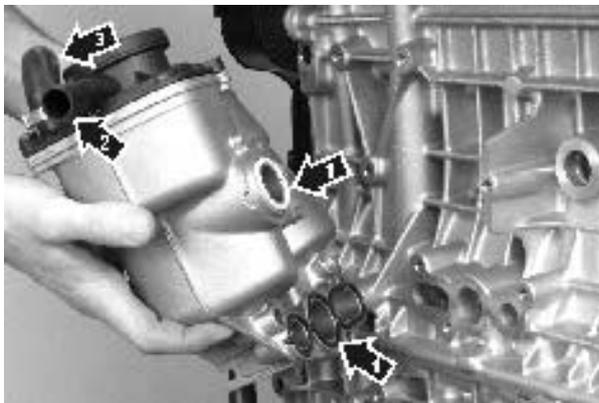


47. Plug, hot water outlet

Install a new copper washer and torque the plug (1) for the crankshaft lock pin as specified in "Technical Data".

Install the sealed hot water union (2) with a new O-ring. Torque the screw to the specified value.

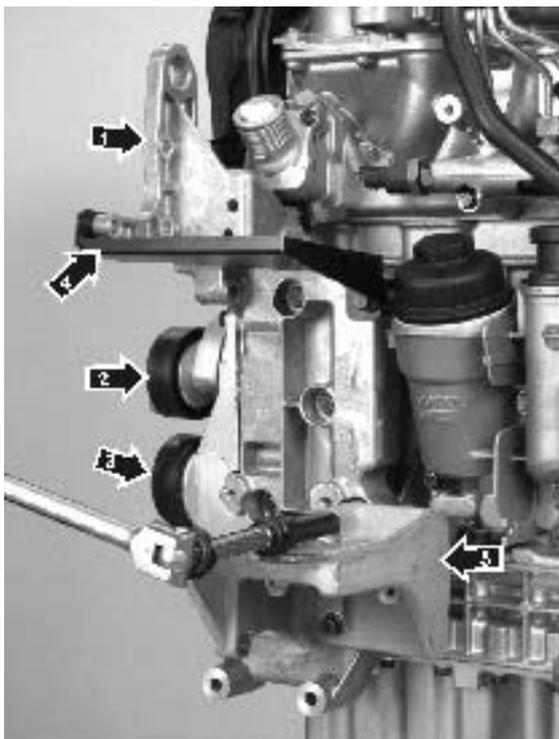
Install the crank position indicator (3) with holder. Torque the screws as specified in "Technical Data".



48. Oil filter housing

Check that the sealing surfaces are clean. Install new, oiled seals (1). Screw the oil filter housing down and torque the screws to the specified value.

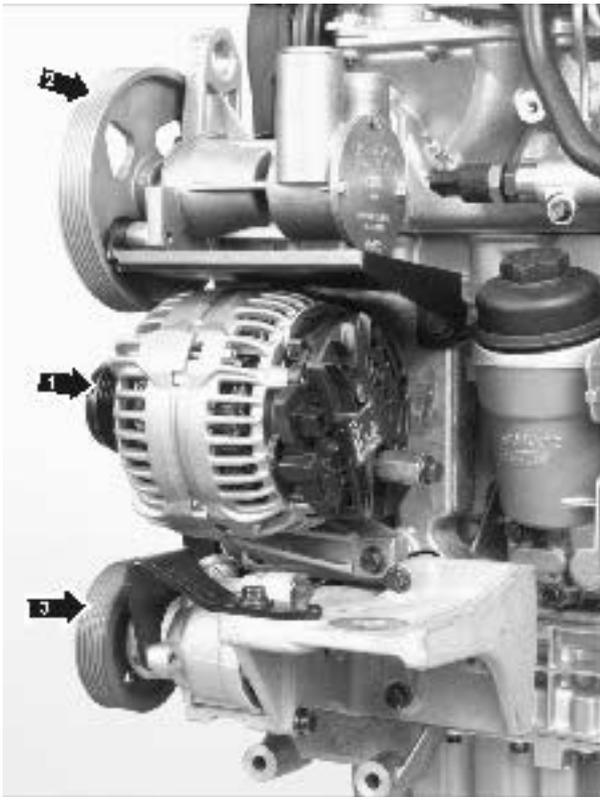
Connect the crankcase ventilation hoses to the oil filter housing (2). Also connect the hose (3) to the crankcase ventilation union on the valve housing.



49. Mounting bracket

Tighten the mounting bracket (1) and remove it together with its associated belt tensioner (2), jockey wheel (3) and alternator shield plate (4). Torque the screws as specified in "Technical data."

NOTE! Apply Volvo Penta sealant part. no. 840879-1 to the engine mounting screws.



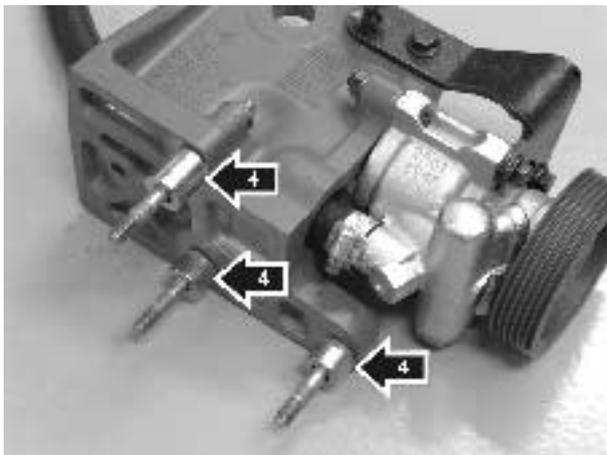
50. Alternator, sea water pump and engine mountings

Install the alternator (1) and sea water pump (2).

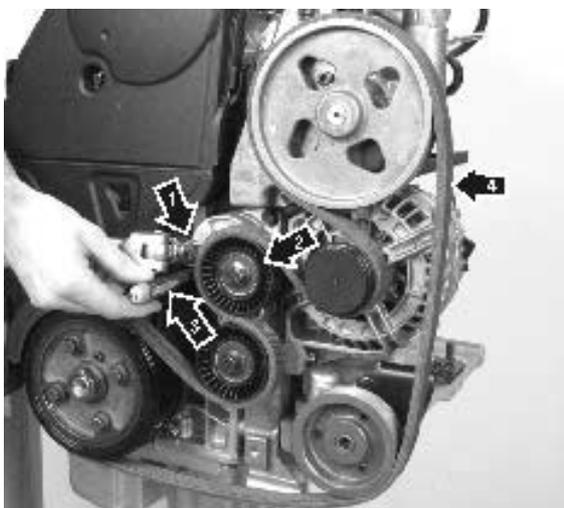
NOTE! There is a special nut for the lower, inner screw.

Install the engine mounting with servo pump (3) on the mounting bracket in the order mentioned.

Torque all the screws as specified in "Technical data."



NOTE! Do not forget the spacers (4) on the engine mountings.

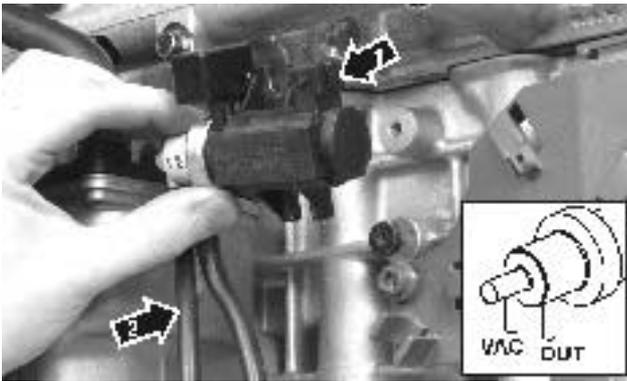


51. Drive belt/Alternator belt

Apply a tool with a T60 Torx bit (1) to the cutout in the belt tensioner. Turn the belt tensioner (2) and insert a screwdriver (3) or similar into the hole which opens up and secure the belt tensioner.

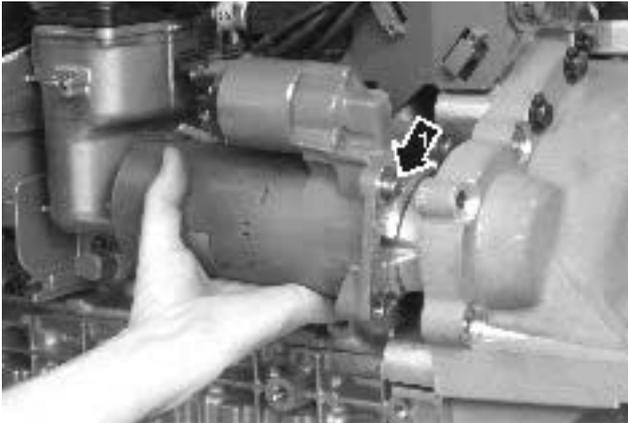
Install the drive belt (4) and then release the locking of the belt tensioner.

NOTE! Make sure that the drive belt has not slid out of its grooves.



52. Vacuum regulator

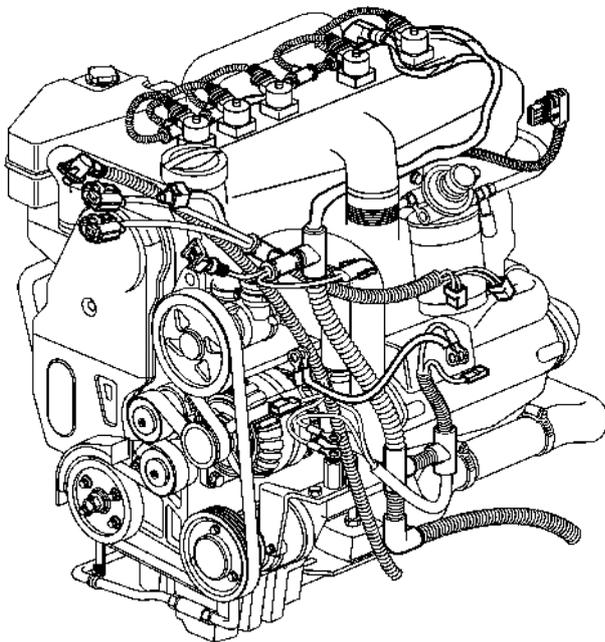
Install the vacuum regulator (1). Connect a new vacuum hose (2) between the vacuum pump and the regulator union marked "VAC".



53. Starter motor

NOTE! Check that the crankshaft lock has been removed and the plug is installed.

Install the starter motor and screw it in place. Note the guide pin (1). Install the long screw first, furthest down and install the earth (ground) cable on it.



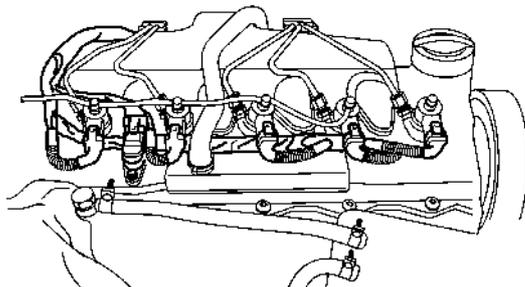
54. Sensors and cables

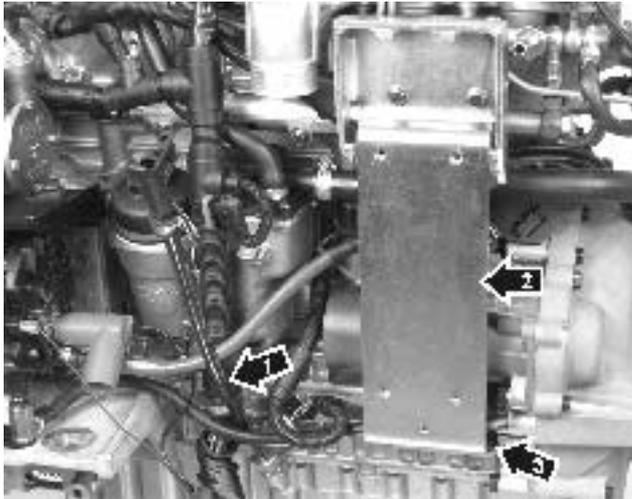
Install the camshaft sensor, coolant sensor and oil pressure monitor. For tightening torque, please refer to the "Technical Data" chapter. Install the coolant sensor with a long 19 mm socket.

Install the trim pump cables.

Install the engine cable harness and join its connectors up.

Install the electrical connections for the starter motor, alternator and left-hand engine mounting.



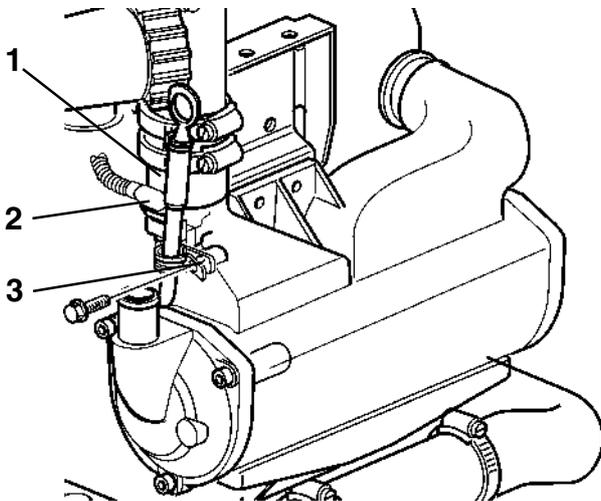


55. Intercooler, dipstick

Install the dipstick (1) in the sump.

Screw the intercooler bracket (2) in place.

NOTE! Apply Volvo Penta sealant part. no. 840879-1 to the threads of the two lowest screws (3).

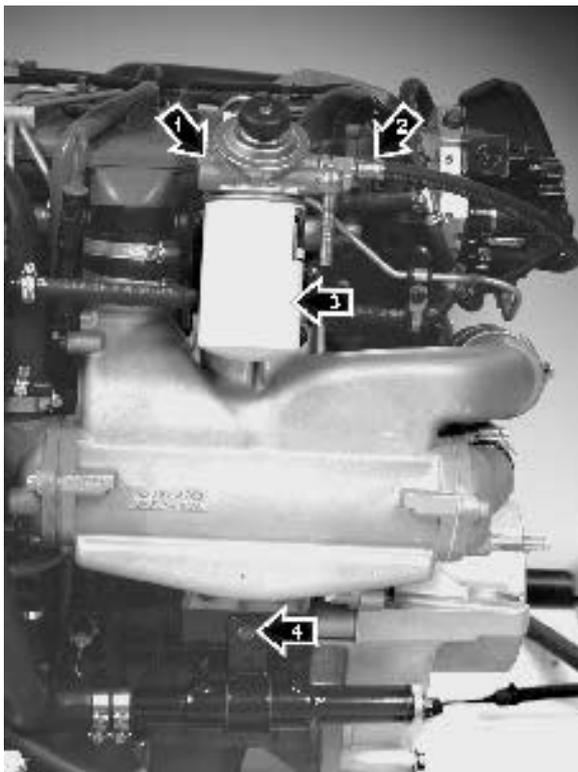


56. Install the intercooler on the bracket. Insert the short hose (1) between the induction manifold and the intercooler before the screws are tightened.

Join up the connector for the intercooler sensor (2) and screw the dipstick clamp (3) in place on the intercooler.

NOTE! Install the fuel return hose on one of the intercooler screws.

⚠ IMPORTANT! Make sure that the hoses are installed so they do not chafe against anything.



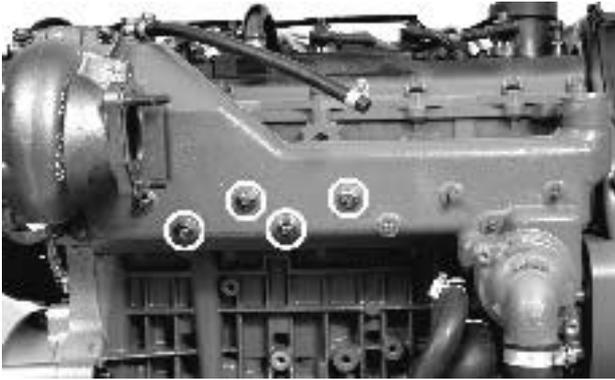
57. Fuel filter housing

Screw the fuel filter housing (1) in place. Connect the fuel pipe (2) between the high pressure pump and the fuel filter housing.

Install a new fuel filter (3).

Install the oil cooler (servo) or joining pipe to the bracket (4) under the intercooler.

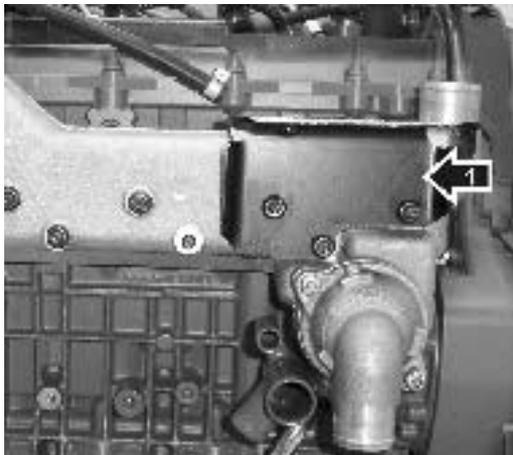
Install new tie wraps on the cables and hoses, as previously noted.



58. Exhaust pipe with turbocharger

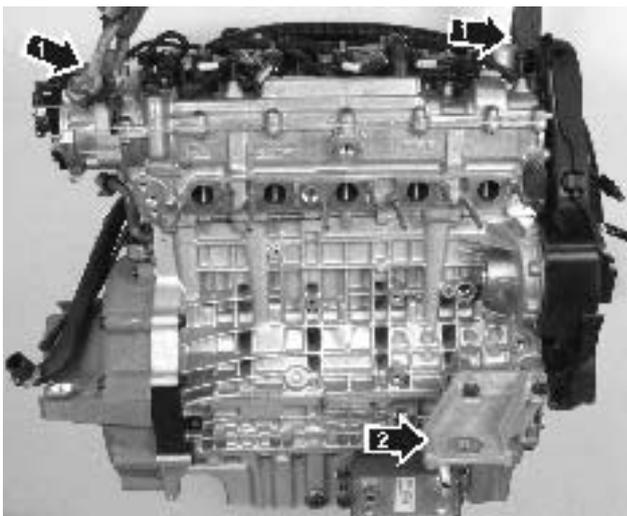
Install a new gasket on the cylinder head with the swage facing outwards. Install the exhaust manifold with turbocharger. Install five nuts (1) as in the illustration and tighten them lightly.

NOTE! If the turbocharger has been removed from the exhaust manifold, it should preferably be screwed to the exhaust manifold before the manifold is installed on the cylinder head. Also refer to "Turbocharger, change".



59. Install the expansion tank bracket (1) on the exhaust manifold.

Install the hose for the turbo vacuum box.



60. Fixture, right engine mounting

Fix the tap to the engine lifting lugs (1). Undo the engine from the stand and unscrew the engine fixture.

⚠ WARNING! Incorrect handling during loosening of the engine and engine stand can mean a very great risk of personal injury.

NOTE! Since the engine stand is very heavy, be careful when undoing the screws to avoid oblique loading on the engine block screws.

Screw the right-hand engine mounting (2) in place on the engine block. Torque the engine mounting screws as specified in "Technical data."

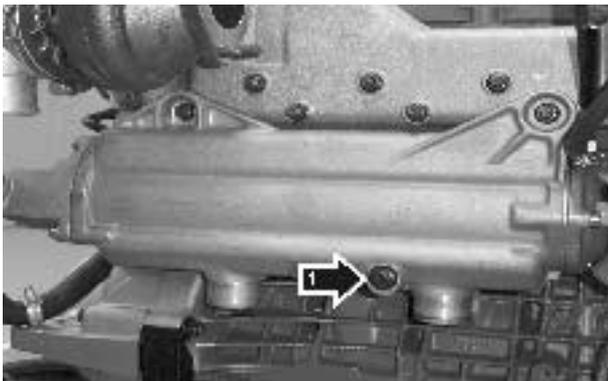
Then set the engine up in an engine stand which suits the four engine mountings.



61. Coolant pipe

Install both coolant pipes with new O-rings. Install the smaller pipe (1) first.

NOTE! Make sure that the sealing surfaces are clean before the pipes are installed.

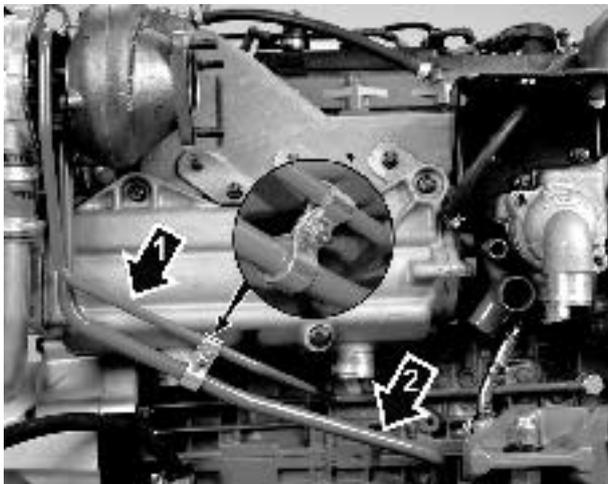


62. Heat exchanger

Install the heat exchanger.

Torque all the screws on the manifold and the screw on the heat exchanger (1) as specified in "Technical Data".

NOTE! The screws (1) must have a washer on each side of the heat exchanger.



63. Oil pipe, turbocharger

Install the oil pipes on the turbocharger (1) and the engine block loosely.

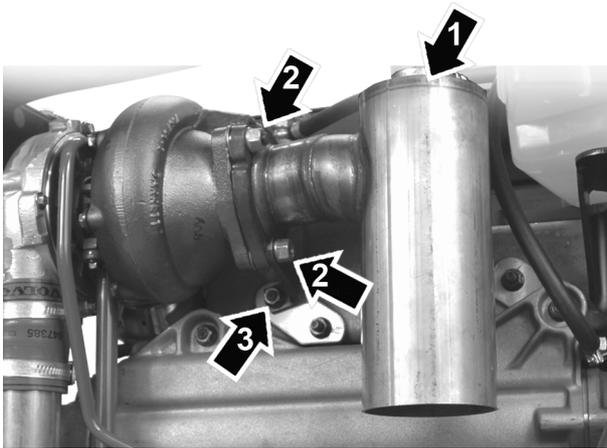
Install the two O-rings on the oil return hose where the clamp should be.

Install the oil return pipe (2) for the turbo.

Torque the screws as in the specification in "Technical data".

Fix the clamp which holds the pipe, over the O-rings.

NOTE! The hollow screw leading in to the turbo should have a restriction. Use a new gasket and copper washers.



64. Exhaust pipe elbow

Install a new gasket with the swage facing outwards, and install the exhaust pipe elbow (1). Use new nuts (2) and torque them to 30 Nm.

NOTE! An anchorage (3) for the manifold is fixed to the lower nut.

Install the turbocharger heat shield, please refer to "Turbocharger, changing".



65. Expansion tank

Install the expansion tank on its bracket.

NOTE! Do not forget the spacer tube for the fixing screw.

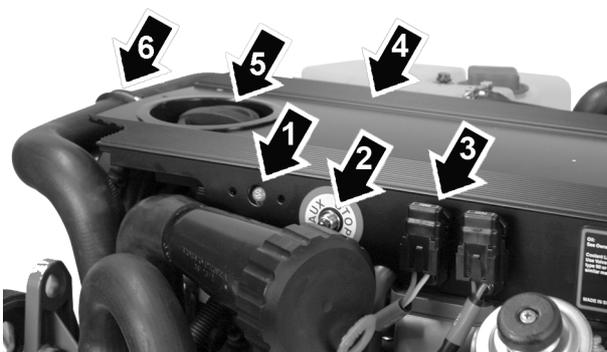
66. Hose connections, air filter housing

Install the air filter housing on the turbocharger.

Connect the turbocharger vacuum hose and crankcase ventilation.

Install the charge air pipe between the turbo and the intercooler.

67. Install all coolant hoses to the sea water pump, intercooler, heat exchanger, exhaust pipe elbow, exhaust manifold, expansion tank, oil cooler, thermostat housing and coolant pipes.



68. Cover

Screw the trim pump fuse (1) and emergency stop button (2) to the cover. Hook the two catches in place (3).

Press the cover (4) to fix it. Install the oil filler cap (5) and coolant hose clamp (6).

Overhaul / Change components

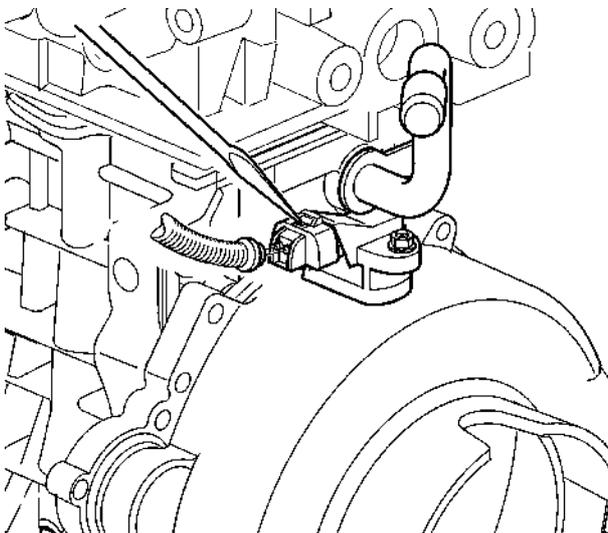
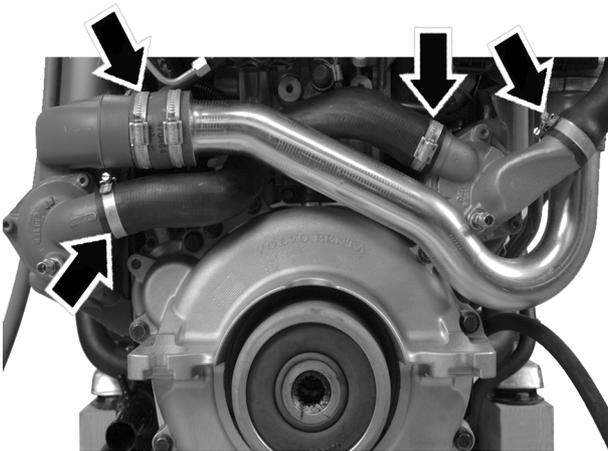
Group 21: Short block

Flywheel, change

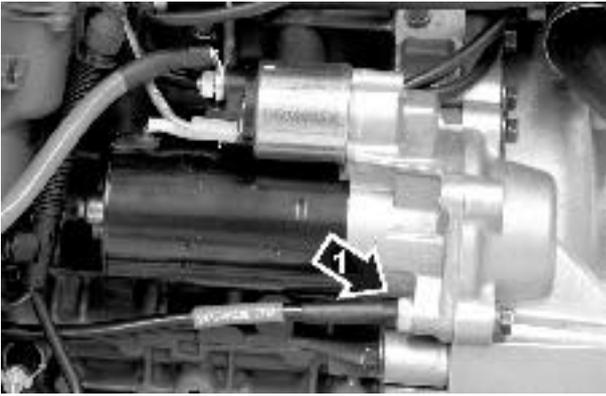
Current disconnected. Sea-water system drained.

Removal

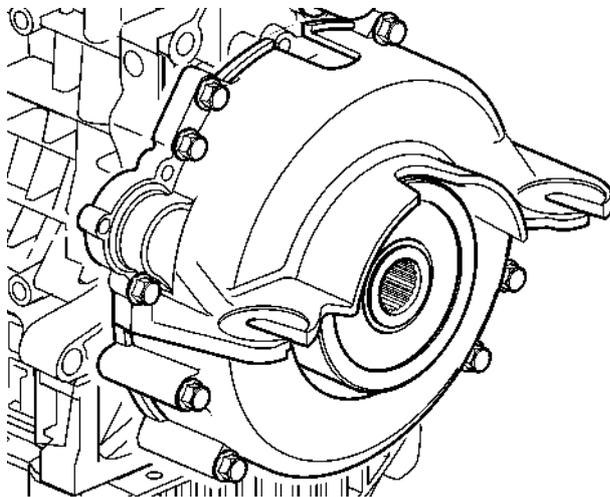
1. Remove the charge air pipe from the turbo and the cooling hose over the flywheel housing.



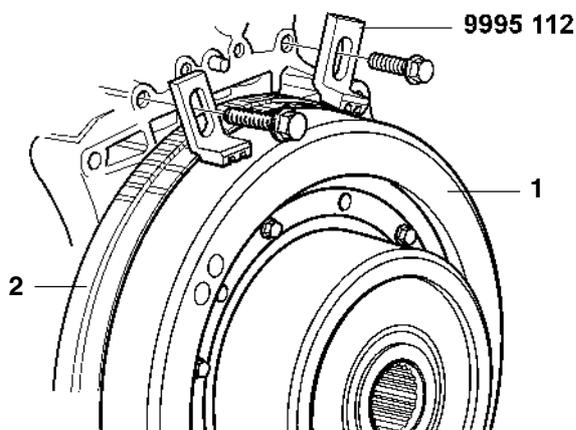
2. Undo the connector for the flywheel sensor and remove the flywheel sensor with anchorage.



3. Undo the earth (ground) cable (1) on the starter motor.
Unscrew the starter motor and move it forwards slightly.



4. Undo the screws on the flywheel housing and remove the housing.



5. Install the locking tool 9995112 for the flywheel.
Undo the vibration damper (1) and flywheel (2).
Use socket no. 885823 to undo the flywheel screws.

NOTE! The flywheel is heavy. Be careful when handling it.

6. Remove the screws from the flywheel and remove it.

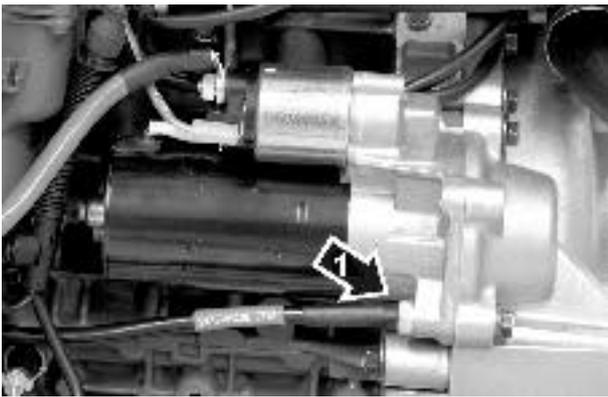
**Installation**

1. Carefully clean the crankshaft and flywheel mating faces.

Install the new flywheel and torque the screws as specified in "Technical data."

NOTE! Check that the starter motor is not pinched.

2. Install the vibration damper and tighten the screws as specified in "Technical data".
3. Install the flywheel housing and torque the screws to the value specified on the torque table in the "Technical Data".



4. Fix the starter motor and the earth (ground) cable with the lowest screw (1). Tighten it as specified in "Technical data".

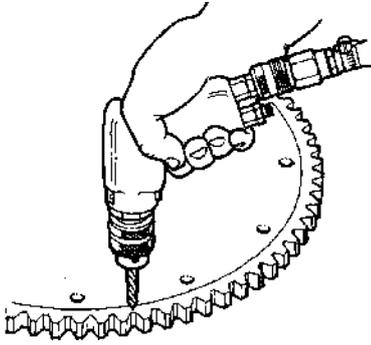
NOTE! The longest screw must be lowest down, for the earth (ground) cable.

5. Install the flywheel sensor and put the connector back.
6. Install the coolant hose over the flywheel housing and the charge air pipe to the turbocharger.

Gear ring, change

Flywheel, removed.

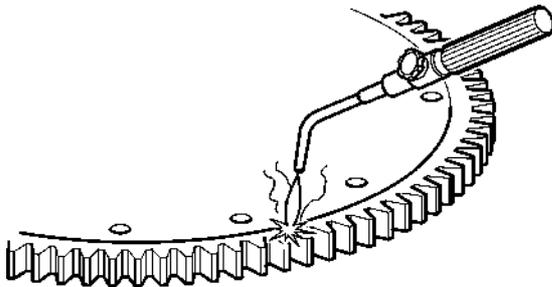
1. Drill 1–2 holes between two teeth on the ring gear.
Use a cold chisel to split the ring gear at the drill site and remove the gear ring.



2. Brush the flywheel bed clean with a steel wire brush.

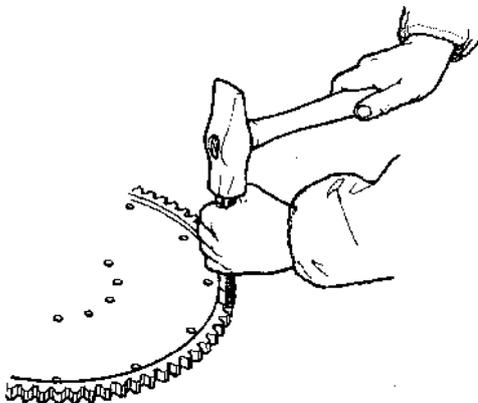
Heat up the new ring gear with a welding torch or in an oven, **max. 180–200°C**.

- ⚠ IMPORTANT!** Be careful to ensure that the gear ring is evenly heated, and not too hot in places, which could anneal it. Polish the gear ring in a number of places, to check the heating process. Stop heating when these surfaces have become blued.



3. Put the heated gear ring onto the flywheel and tap it into place with a soft mandrel and hammer.
Let the gear ring cool in the fresh air.

Flywheel installation, please refer to the “Engine, assembly” chapter.

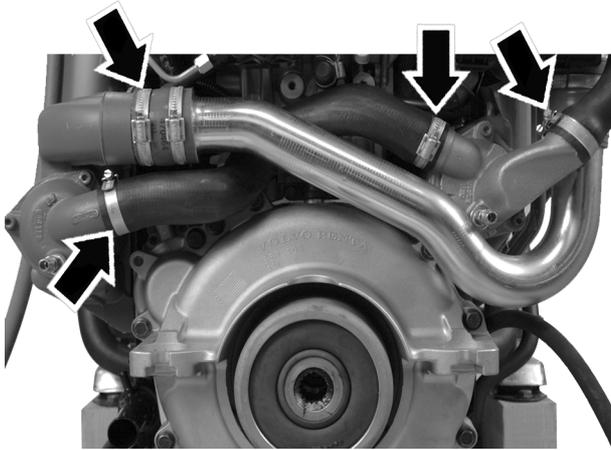


Flat Rate: 21671

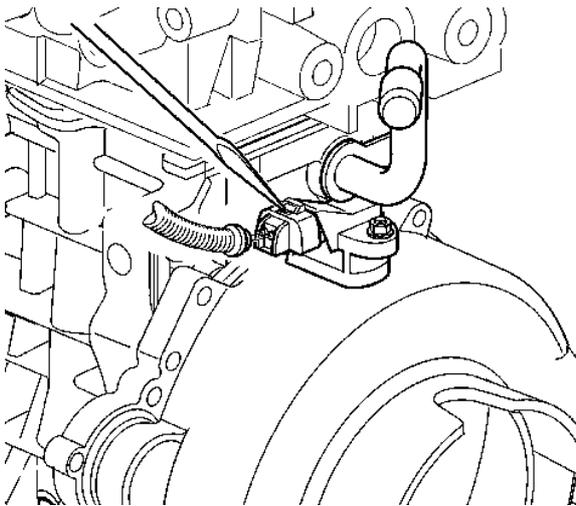
Crankcase seal, rear, change

Engine on stand. Current disconnected. Sea-water system drained.

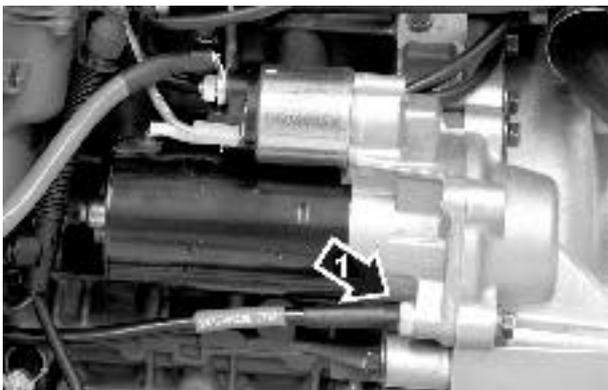
Special tools: 885823, 9991801, 9995112, 9995676



1. Remove the charge air pipe from the turbo and the cooling hose over the flywheel housing.



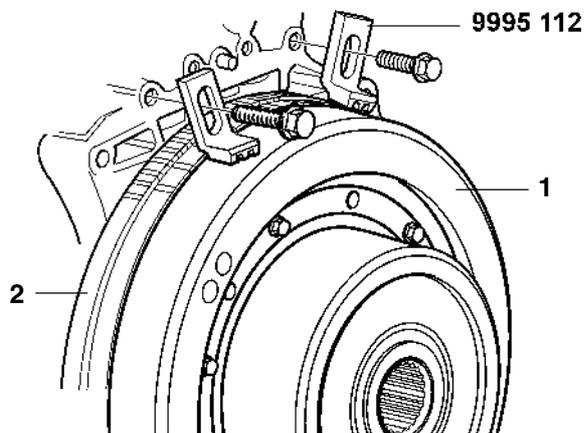
2. Undo the connector for the flywheel sensor and remove the flywheel sensor with anchorage.



3. Undo the earth (ground) cable on the starter motor. Unscrew the starter motor and move it forwards slightly.

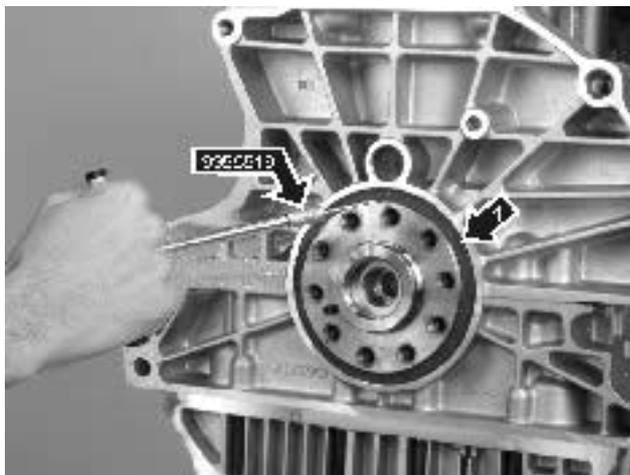


4. Undo the screws on the flywheel housing and remove the housing.
5. Undo the screws on the vibration damper and remove it.



6. Install the locking tool 9995112 for the flywheel. Undo the clutch (1) and flywheel (2). Use socket no. 885823 to undo the flywheel screws.

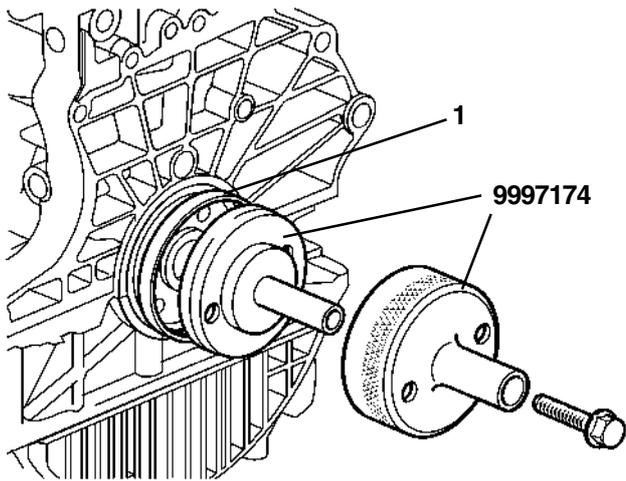
NOTE! The flywheel is heavy. Be careful when handling it.



3. Remove the crankshaft seal ring (1) with tool no. 9995919. Clean the seal surfaces with a soft rag and denatured alcohol.

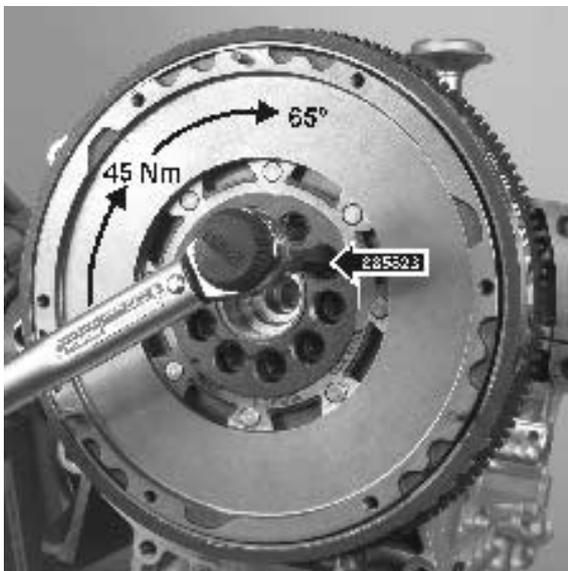


IMPORTANT! Be careful not to damage the seal surfaces.



4. Install the crankshaft seal ring (1) on tool no. 9997174. Align the seal ring and then press it in until it ends up in the correct position, level with the engine block (2).

⚠ IMPORTANT! The seal ring dust lip is easily stretched and does not spring back again. If it has been incorrectly aligned or has been forced in, it must be changed.



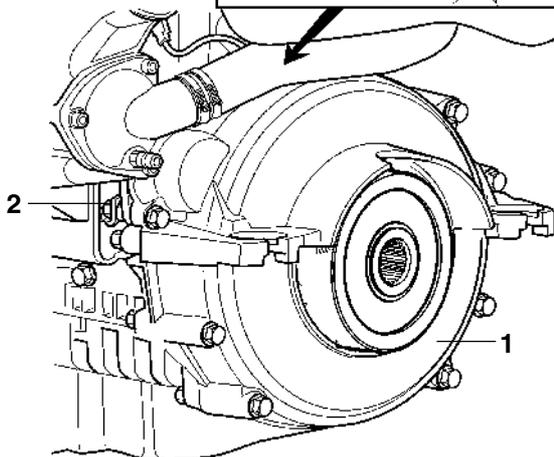
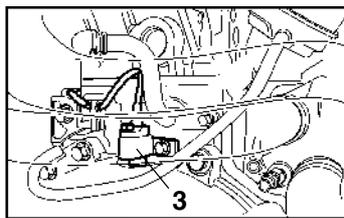
5. Undo locking tool no. 9995112 slightly and put it in its top position.

Carefully clean the crankshaft and flywheel mating faces.

Put the new flywheel in place. Lock the flywheel with the locking tool. Tighten the flywheel with new screws. Use socket no. 885823 and tighten alternately in two stages as specified in "Technical Data".

Install the new clutch and torque the new flange screws alternately to 25 Nm as specified in "Technical Data".

Remove the locking tool.



6. Install the flywheel housing (1) and torque the screws alternately to the value specified in "Technical Data".

Install the starter motor and earth (ground) cable (2).

Install the crankshaft sensor (3).

NOTE! Clean the crankshaft sensor before installation.

7. Install the coolant hose over the flywheel housing and the charge air pipe from the turbocharger.

Crankshaft seal, front, change

Cam belt removed

1. Remove the crankshaft gear.
2. Pull the crankshaft seal out with tool no. 9995919.



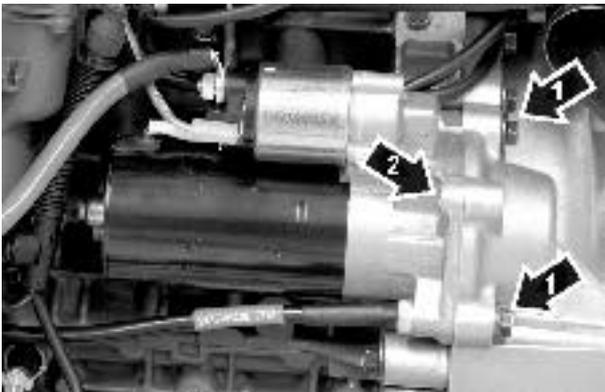
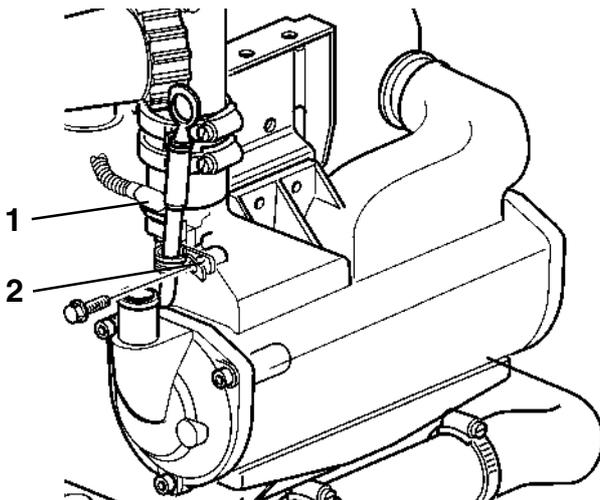
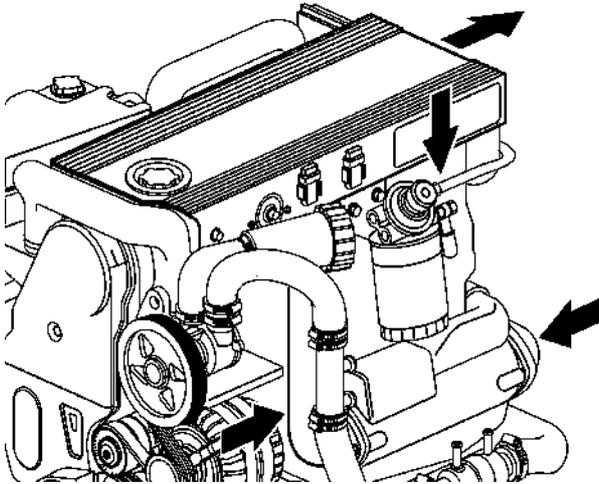
3. Install a new seal on tool 9995455.
Install the tool with the seal on the crankshaft.
Turn the center nut until the seal is in place.
4. Install the crankshaft gear.
Install the cam belt.

Cylinder head, change

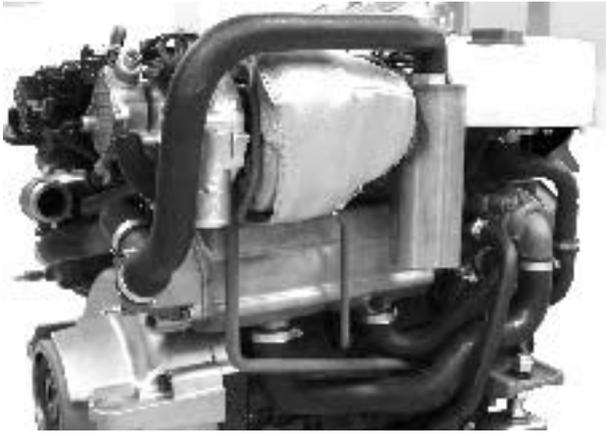
Current cut. Drained cooling system and sea water.

Removal

1. Remove the cover and the fuel filter bracket.
2. Undo the sea water hoses and all the intercooler hose connections to inlet and turbo pipes.
3. Remove the electric connector (1) on the intercooler, together with the dipstick bracket (2).
4. Remove the intercooler, 4 screws, and the mounting bracket.
Remove the reverse gearbox oil cooler.



5. Undo the cables on the starter motor.
Unscrew the starter motor (1), note the guide pin (2).

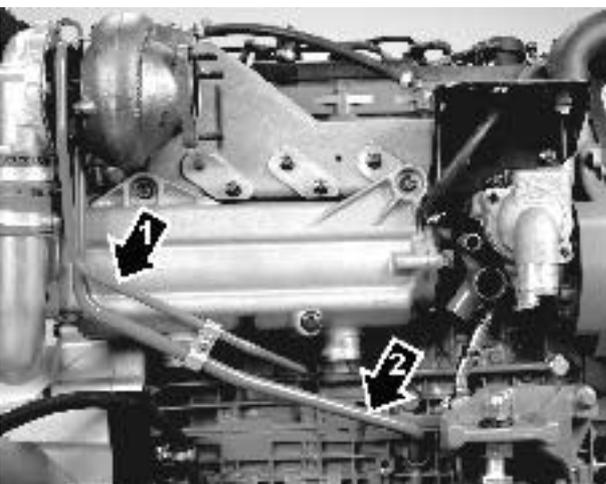


6. Remove the expansion tank and its bracket, air filter, vacuum hose, turbo pipe and coolant hose.

Remove the exhaust elbow and the hose for the heat exchanger.



7. Remove the hose anchorage (1) on the thermostat housing and the inner hose connection (2) on the thermostat housing.



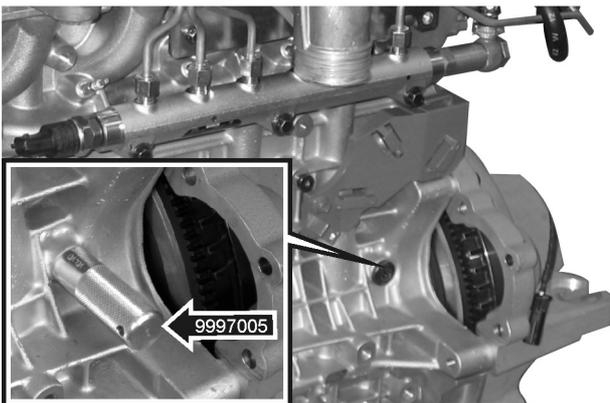
8. Remove the oil pipes and the heat exchanger, then remove the manifold together with turbo-charger.

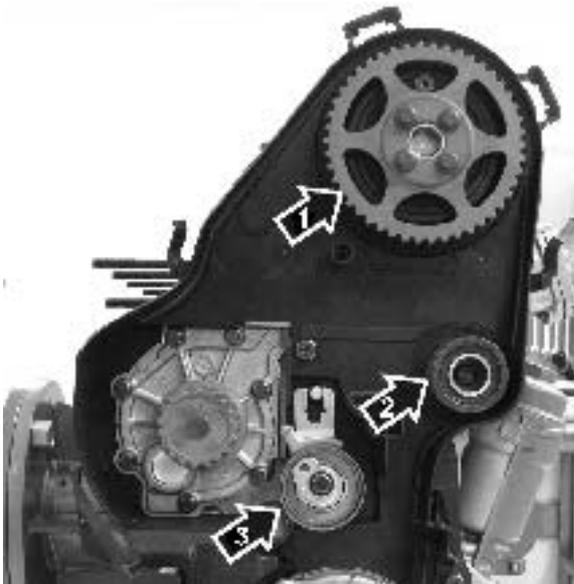


9. Undo the connectors for the injectors, and put the cable harness to one side.
10. Remove the cam belt, please refer to "Cam belt, change" under "service work".



11. Put the lock pin 9997007 into the hole under the exhaust camshaft.
Unscrew the plug on the engine block behind the starter motor position. Install lock pin 9997005 and make sure it bottoms against the block. Also refer to "Crankshaft, locking".

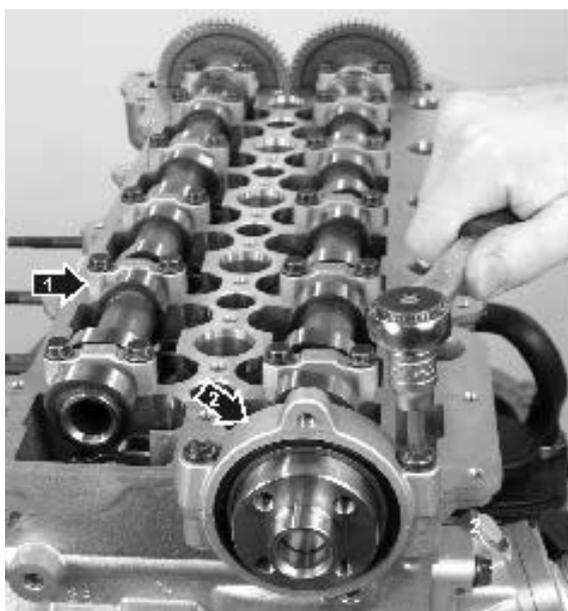




12. Remove the camshaft gear (1), jockey pulley (2) and belt tensioner (3).
Remove the rear cover.



13. Remove the fuel injector pipes and the injectors.
14. Undo the hose from the crankcase ventilation to the valve cover.
Remove the valve cover.

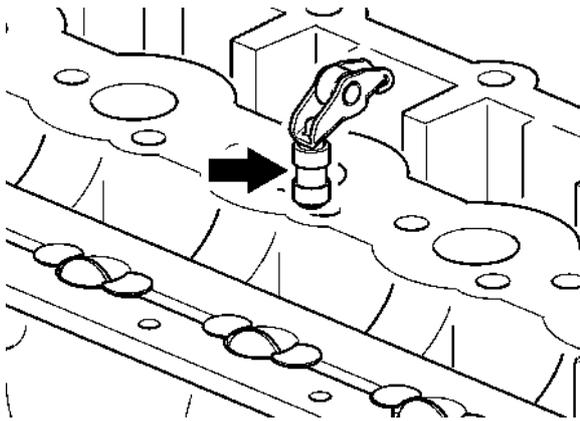


15. Remove the rear camshaft bearing caps and remove the camshaft locking pin 9997007.
Remove the front seal retention cap (2).
Undo the screws for all camshaft bearing caps (1), working from the outside towards the center.

⚠ IMPORTANT! Undo each screw one turn at a time until the camshafts longer spring upwards.

Remove the screws, bearing caps and camshafts.

⚠ IMPORTANT! Put the bearing caps and camshafts on a clean, dry surface. The bearing caps are marked and must be re-installed in the same places. If the bearing caps are wrongly installed, this can cause engine failure.

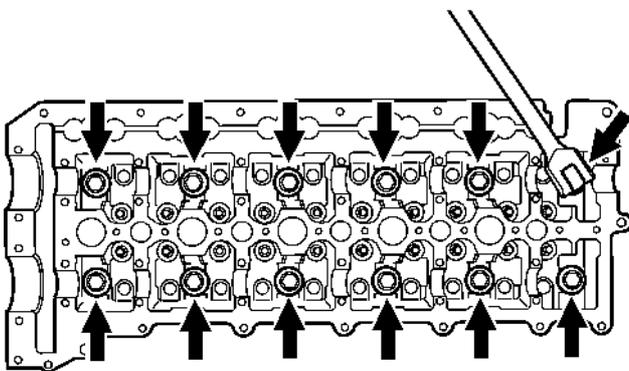


17. Pull all hydraulic valve lifters (1) up out of the cylinder head.

NOTE! The valve lifters might come to pieces, but are easy to re-assemble.

⚠ IMPORTANT! Mark the valve lifters and store them in a vessel containing clean engine oil until they are installed.

⚠ WARNING! The cylinder head has very sharp edges. Be careful when working with it.

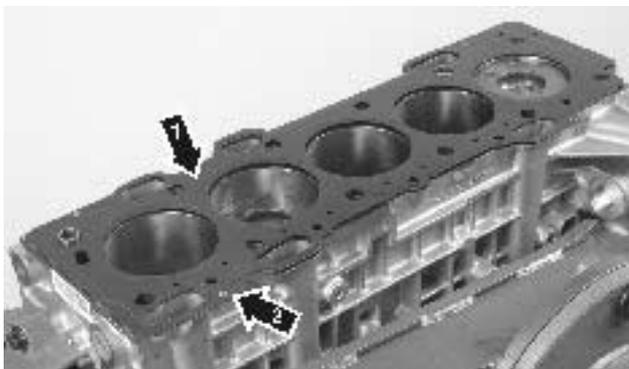


18. Undo the cylinder head screws. Start to undo them, working from the outside towards the center.

Undo the cylinder head and put it on a clean, dry, soft surface.

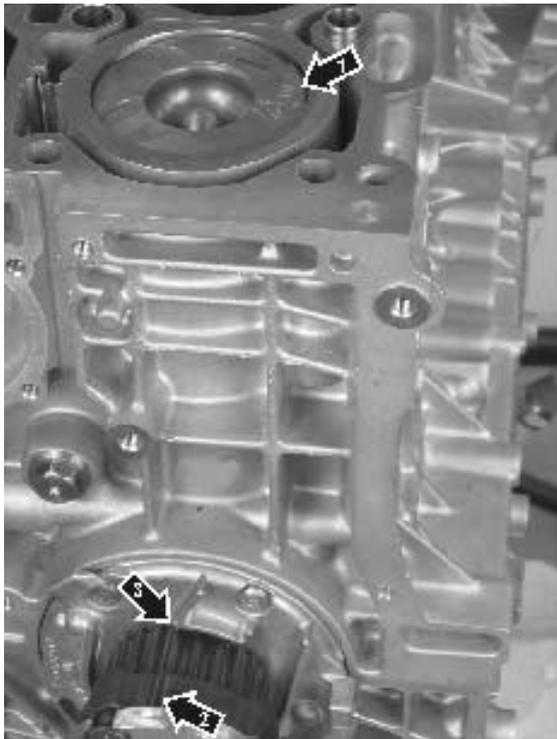
NOTE! Save the gasket or note its marking, please refer to “Engine, assembly, cylinder head”.

⚠ IMPORTANT! The gasket plane and the plugs beside the valve heads must not be damaged. The gasket is basically unable to seal a scratch or other damage to the sealing plane.



Installation

19. Put a new gasket (1) on the engine block. Make sure that a gasket of the correct thickness is used. This is indicated by a combination of holes (2) on the edge of the gasket, please refer to “Cylinder head gasket, measurement”.

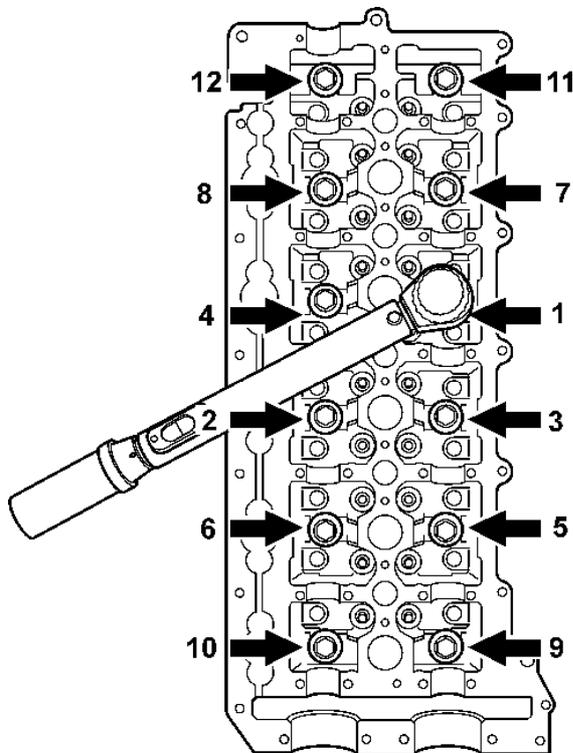


20. Move no. 1 piston to Top Dead Center. Make sure that lock pin no. 9997005, for locking the crankshaft, bottoms against the block.

Turn the crankshaft counter-clockwise until the crankshaft counterweight rests against the lock pin. No. 1 piston (1) is now about 2 mm before Top Dead Center.

The crankshaft is now in the correct position, which can also be checked on the crankshaft's toothed belt pulley (2) and the oil pump marking (3).

Also refer to "Crankshaft, locking".

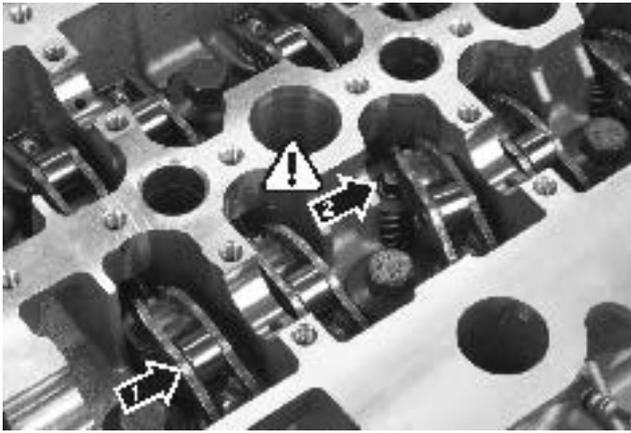


21. Oil all the cylinder head screws with engine oil and leave them to drain on paper for about 10 minutes.

Put cylinder head in place and install the screws lightly (1-12) by hand.

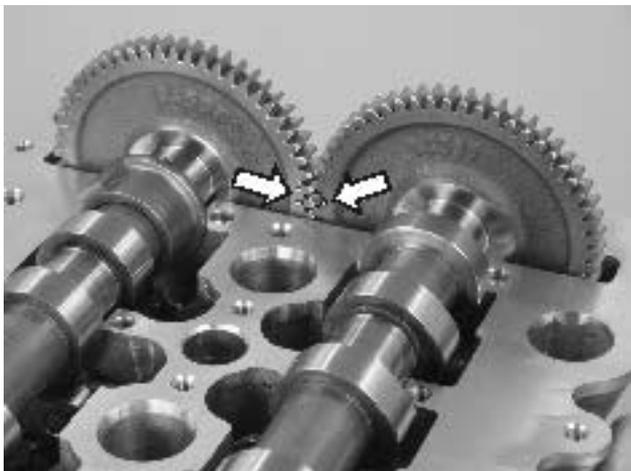
Torque the screws alternately, from the center and out, as specified in "Technical data".

- ⚠ IMPORTANT!** Use the greatest care during assembly, to avoid damaging the gasket plane and the plugs by the valve heads.



22. Oil the valve lifters (1) and install them in the order they were marked.

NOTE! Check that the valve lifters are in contact with the valve stems. The illustration shows a valve lifter (2) in the wrong position.

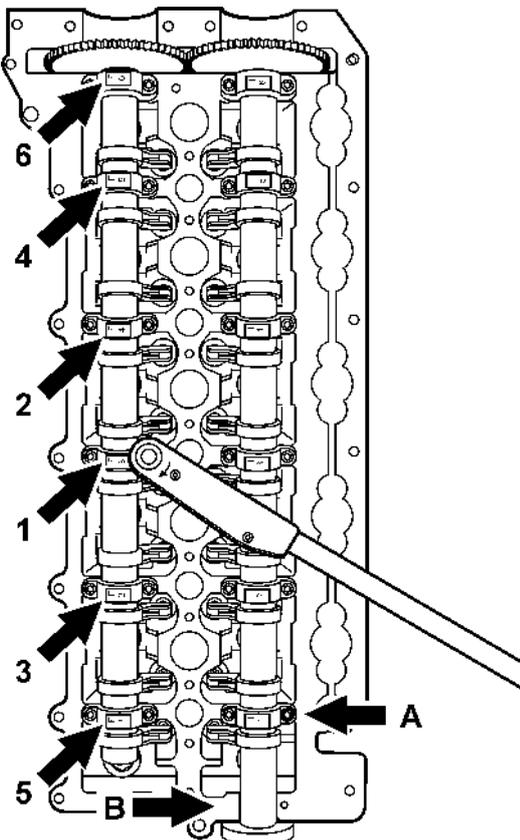


23. Check that all the bearing surfaces on the camshafts, camshaft bearing caps and cylinder head have been carefully cleaned.

Lubricate the following:

- Camshaft bearing surfaces and lobes
- Cylinder head bearing surfaces
- Camshaft bearing caps
- Valve lifter rollers

Install the camshafts with markings (1) on the camshaft drive gears facing each other.



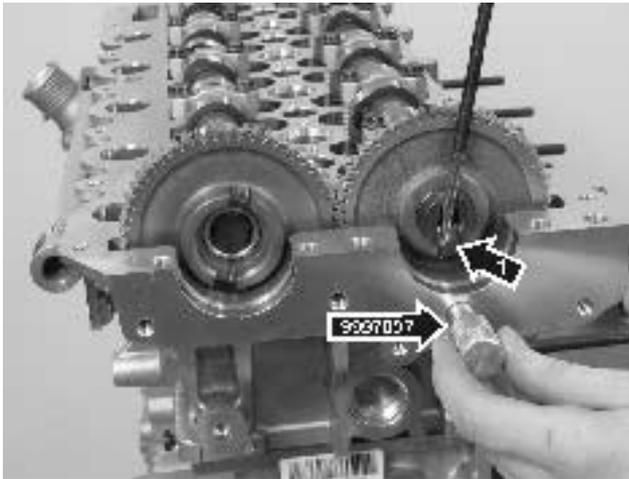
24. Install all camshaft bearing caps (A) as marked, except the front bearing cap (B) on the inlet camshaft. Tighten the screws until the bearing caps touch the camshafts.

NOTE! The bearing caps are marked "I" (Inlet) and "E" (Exhaust), and numbered 1-6 to facilitate assembly.

Carefully tighten the screws for caps 1-6 alternately, working from the center and outwards, one turn at a time, until the camshafts are fixed against the cylinder head.

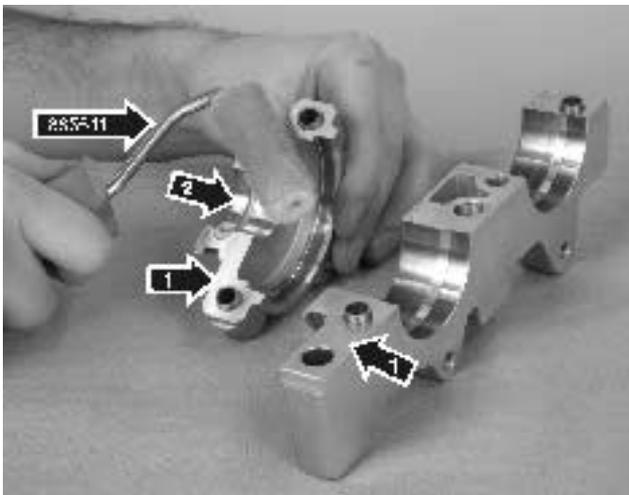
Torque the screws as in the specification in "Technical data".

⚠ IMPORTANT! Make sure that the camshafts do not rotate during installation of the bearing caps.



25. Put locking pin no. 9997007 in the cutout for the exhaust camshaft. Carefully turn the camshafts with a screwdriver in the high pressure or vacuum pump grooves (1) to facilitate installation of the lock pin.

⚠ IMPORTANT! The camshafts must not be turned more than needed to install the lock pin. There is a risk that the valves could be damaged.

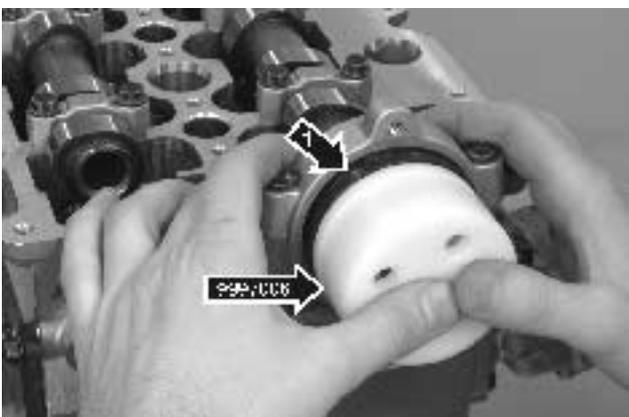


26. Clean the front and rear bearing caps.

Apply liquid gasket 1161059-9, using roller no. 885511 on the gasket plane (1). The surface should be completely covered, without surplus.

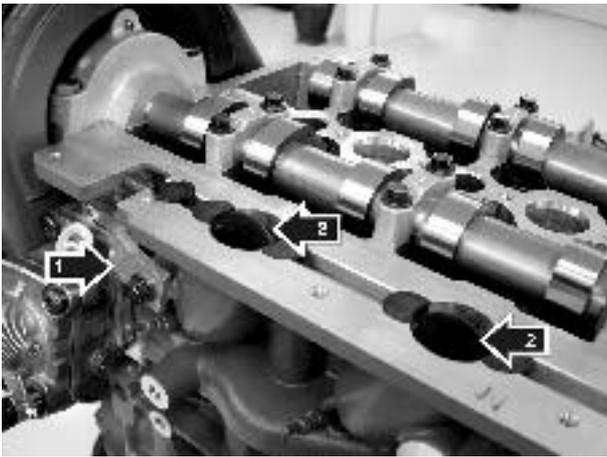
Grease bearing race (2) on the front bearing caps.

Install the caps and torque the M10 and M6 screws to the values specified on the torque table in the "Technical Data".

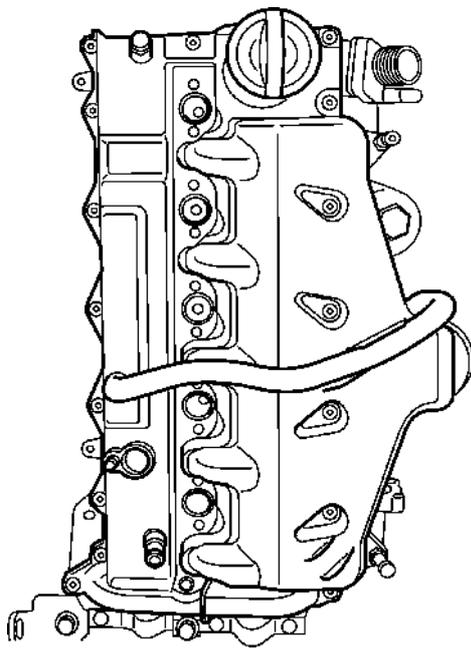


27. Install the inlet camshaft seal ring (1). Use tool no. 9997006 to press the seal ring in until the tool bottoms against the camshaft.

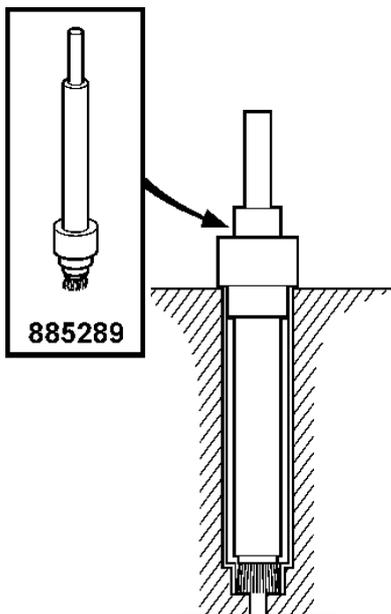
⚠ IMPORTANT! The seal ring dust lip will be damaged if it is stretched. If it has been incorrectly aligned or has been forced in, it must be changed.



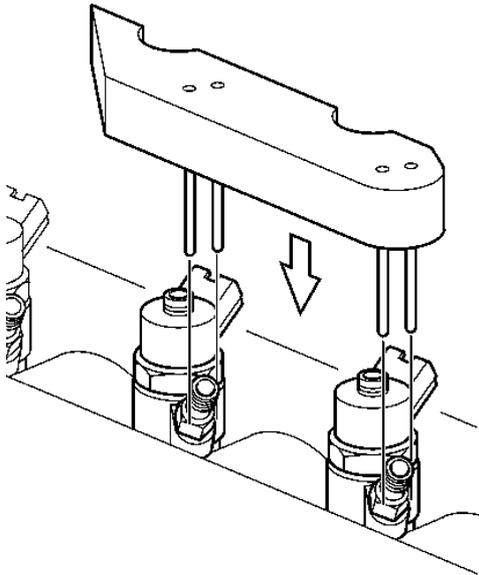
- 28. Install the shaft with butterfly. Press the rubber seal down all the way.
 Install the rubber tape inside the control arm.
 Install the lock washer (1) so that the butterfly (2) remains open.
 Scrape the valve housing seal surfaces clean and wipe them off.
 Check that the camshaft lobes are fully covered with an oil film, lubricate if necessary.
 Press the valve cover gasket into the groove in the valve cover.



- 29. Carefully put on the valve housing/inlet pipe without disturbing the position of the gasket during assembly.
 Torque the valve cover screws alternately as specified in "Technical data".



- 30. Clean the injector's nozzle seats using brush 885289.
⚠ IMPORTANT! Make sure that the surface where the injectors reach the lower part against the cylinder head are thoroughly cleaned. No deposits are allowed.
 Make sure that the tool end of the brush has been carefully cleaned. Use compressed air to blow the nozzle seat clean.
 Turn the brush a few times with the rod until the nozzle seat surface is completely free from soot. Blow clean from time to time and check cleanliness.



31. Refitting of injectors and delivery pipes

Fit the injectors and screw new tension braces down so much that the injectors still can be rotated slightly.

Use tool 999 7010 to place the injectors in the correct position. Torque the screws to 13 Nm.

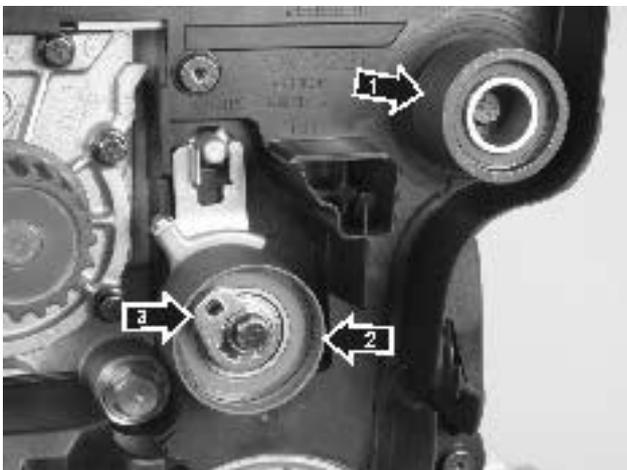
⚠ IMPORTANT! When installing new or old injectors, you must use new tension yokes, spacers, lock rings, copper washers and screws.

32. Fit the new delivery pipes. Screw all cap nuts all the way down by hand.



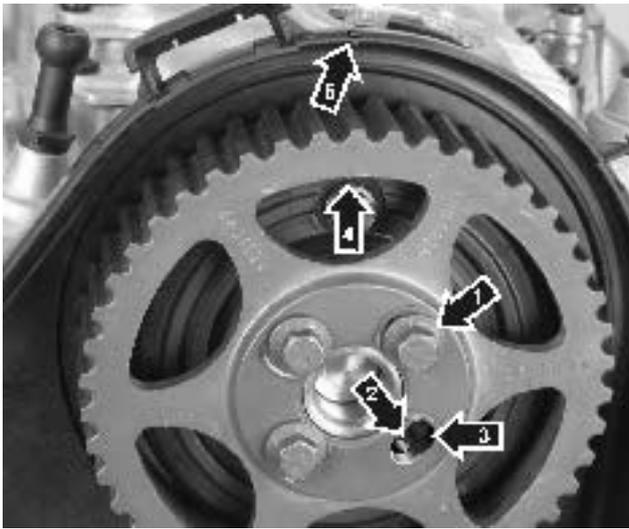
33. Install the rear timing gear cover (1). Check that it comes into the correct groove (2) behind the coolant pump.

Install the lower belt guard.



34. Install the toothed belt jockey pulley (1). Torque the screw as in the specification in "Technical data".

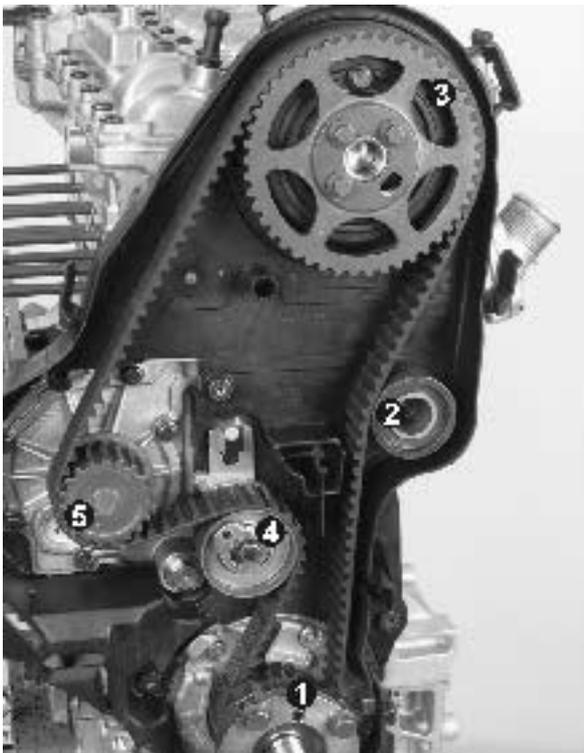
Screw the belt tensioner (2) down. Undo the center screw about one turn and turn the eccentric washer (3) with a 6 mm Allen key until it is in the position shown in the illustration. It is easiest to install the toothed belt in this position.



35. Fix the camshaft toothed belt pulley with one of the three screws (1). Check through the open screw hole (2) that the screws are not in their end positions in the elongated holes (3) on the toothed belt pulley. If the screws are in their end position, it may be impossible to tension the toothed belt.

Make sure that the marking on the pulley (4) and the timing gear cover (5) line up.

Loosen the screws until the pulley can slide in the elongated screw holes.

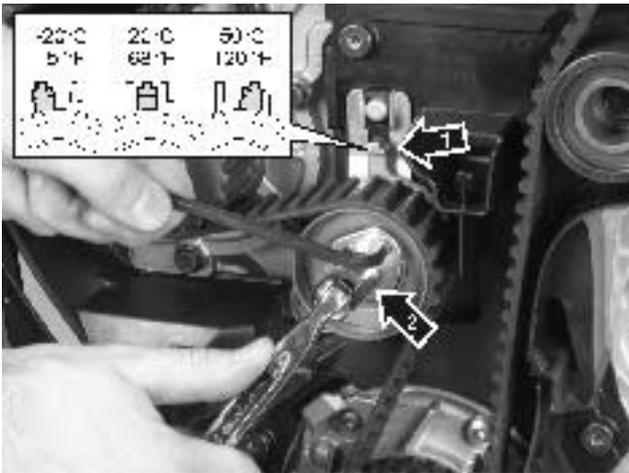


36. Install the toothed belts in the following order:

1. Crankshaft
2. Jockey pulley
3. Camshaft gear
4. Belt tensioner
5. Circulation pump

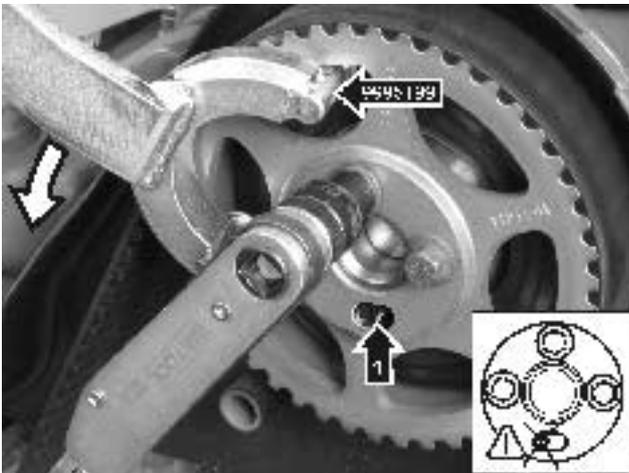
⚠ IMPORTANT! The toothed belts must be kept taut during installation.

NOTE! Also observe the replacement interval for toothed belts, please refer to "Technical data, Engine body".



37. Set the belt tensioner to the tensioned position (1). Then tighten the screws (2). No fine adjustment is necessary at this point. The illustration shows the position of the belt tensioner at various temperatures of the engine block.

Check that lock pins 9997007 for the exhaust camshaft and 9997005 for the crankshaft are in place, please refer to "Crankshaft, locking".

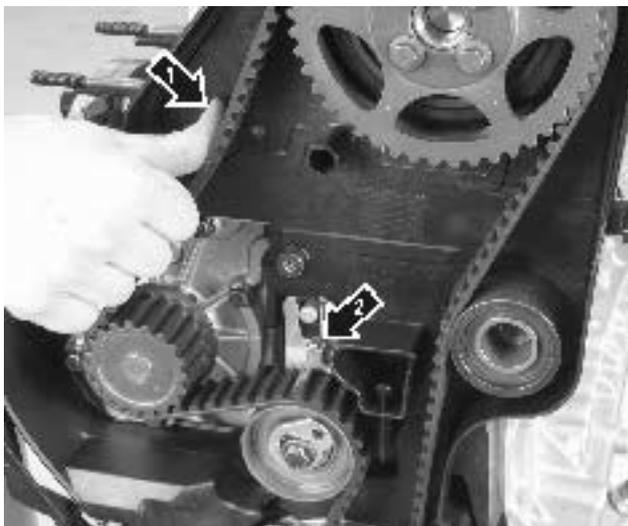


38. Check that the open screw hole (1) is not in the end position in relation to the elongated hole. If the screws are in their end position, it will not be possible to tension the toothed belt correctly.

Tension the toothed belt in the direction of the arrow, using counterhold 9995199 and fix the camshaft pulley with the three screws. Torque the screws as specified in "Technical data."

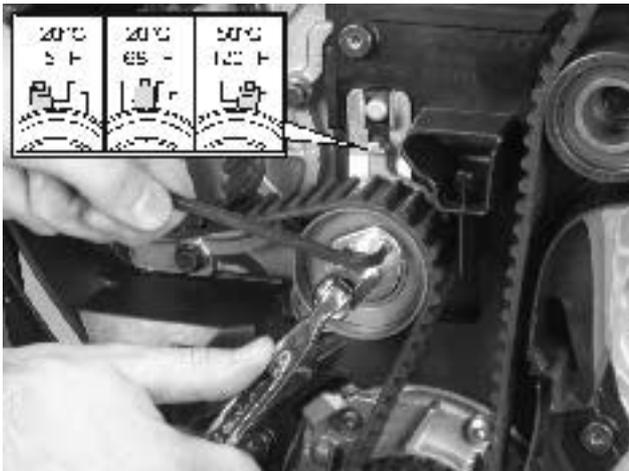
Fit the last screw and torque as specified in "Technical data."

- ⚠ IMPORTANT!** Make sure that the toothed belts are taut between the crankshaft, jockey wheel and camshaft pulley during tightening.



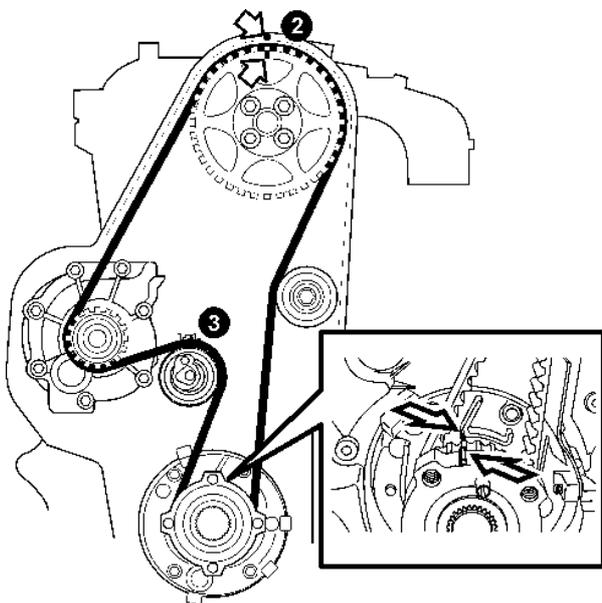
39. Apply pressure (1) to the toothed belts and check that the belt tensioner (2) moves.

NOTE! The belt tensioner must be changed if it does not move.



40. Remove locking pins 9997005 and 9997007 and install the plug in the block.
- Set the belt tensioner in relation to the temperature of the engine block, please refer to the figure.
- Torque the belt tensioner as specified in "Technical data".

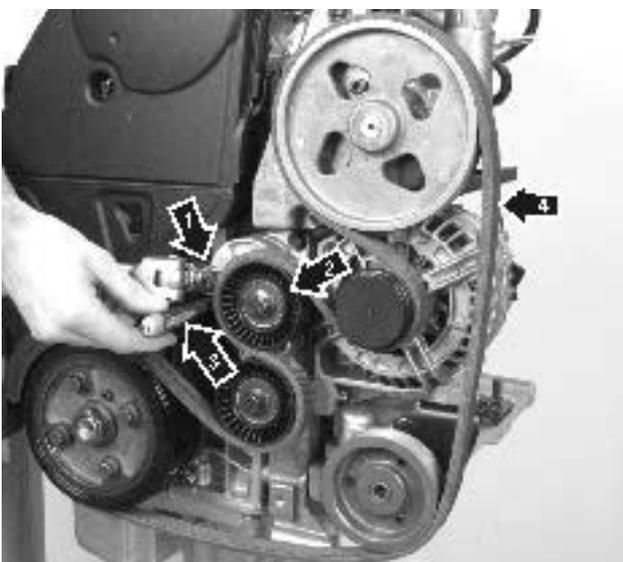
NOTE! The illustration shows the temperature of the engine block when the belt tensioner is set up.



41. Turn the crankshaft round two rotations. Check the marking on the crankshaft pulley (1) and the marking on the camshaft pulley (2).
- Check that the belt tensioner indicator (3) is within the marked temperature range. If necessary, adjust as above.

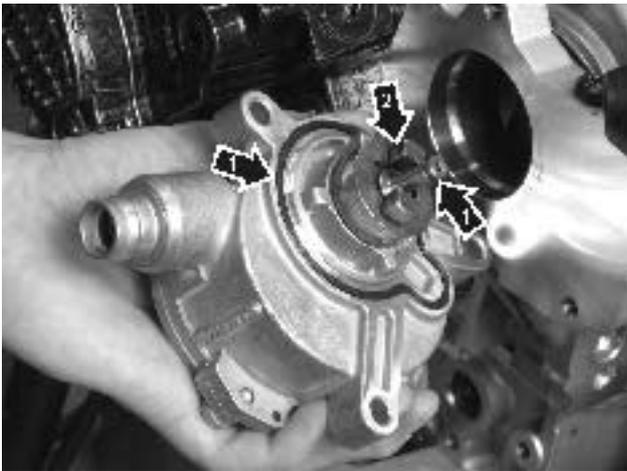
⚠ IMPORTANT! Check that the engine can be cranked without any unwanted noise or complications.

Install the front timing gear cover.



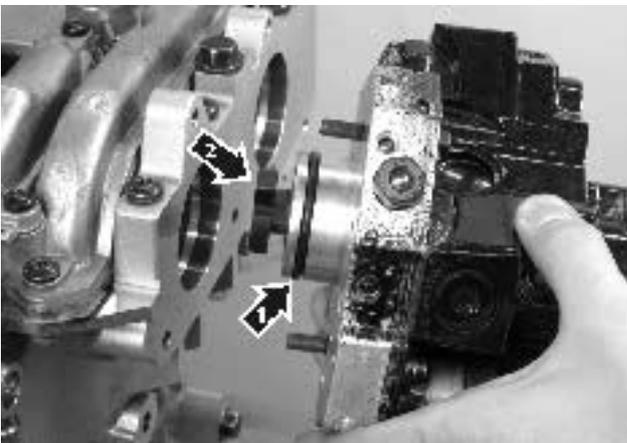
42. Apply a tool with a T60 Torx bit (1) to the cutout in the belt tensioner. Turn the belt tensioner (2) and insert a screwdriver (3) or similar into the hole which opens up and secure the belt tensioner.
- Install the drive belt (4) and then release the locking of the belt tensioner.

NOTE! Make sure that the drive belt has not slid out of its grooves.



43. Install new O-rings (1) on the vacuum pump. Make sure that flange (2) enters the exhaust camshaft.
Torque the screws as specified in "Technical data."

NOTE! Handle the vacuum pump carefully. A vacuum pump which has been dropped or damaged in any other way must not be re-installed under any circumstances.



44. Install a new O-ring (1) on the high pressure pump and install it together with its flange (2).

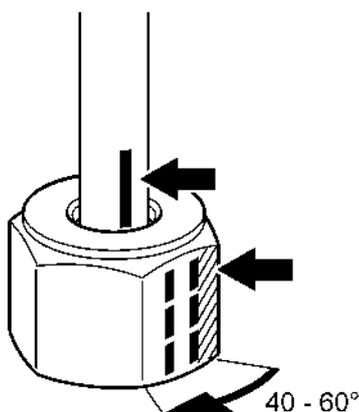
Screw the high pressure pump down as specified in "Technical data."

45. Install the fuel return pipe and join up the electric connector.

46. Angle tightening of cap nuts

⚠ IMPORTANT! When torquing nuts to 40° - 60° angle, a torque wrench must be used, adjusted to 45 Nm. It is important that you do **not** exceed 45 Nm.

⚠ IMPORTANT! If the torque becomes too great before reaching the correct angle, the connection must be removed and lubricated with engine oil before it is torqued again. If the torque again exceeds 45 Nm, the delivery pipes must be replaced with new ones.

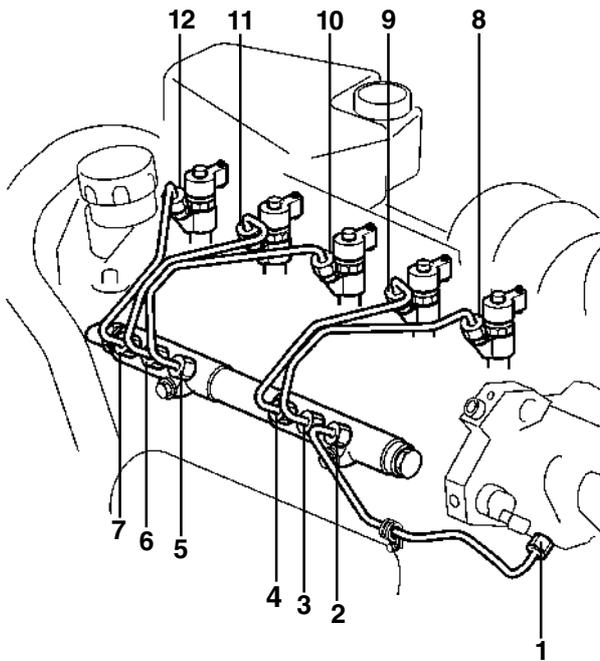


The nut is hexagonal and each corner is 60°.

Mark the pipe and one side of the nut using a pen as illustrated. The side of the nut is divided into three equal parts, which correspond to 20° each.

NOTE! The mark should not be made until the nut has been torqued to 28 Nm.

When the line on the pipe faces the right section, the torque angle will be between 40° and 60°.



47. Torquing cap nuts

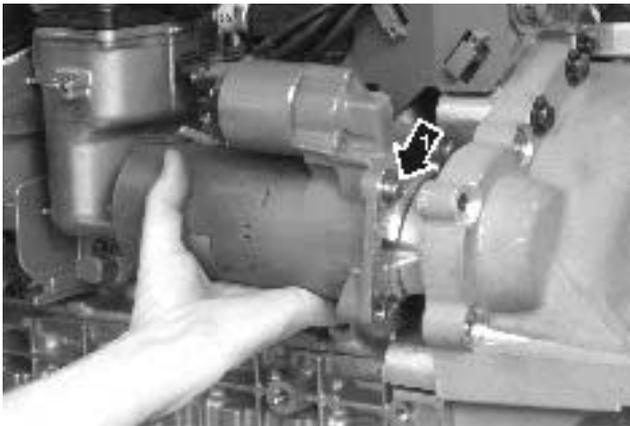
Torque all cap nuts (1-12) to 28 Nm.

Set torque wrench to 45 Nm and torque the cap nuts (1-7) to 40° - 60° angle.

NOTE! Do not torque the cap nuts (8-12) using angle tightening.

Tightening torque **must not** exceed 45 Nm.

48. Join up the injector connectors.



49.

NOTE! Check that the crankshaft lock has been removed and the plug is installed.

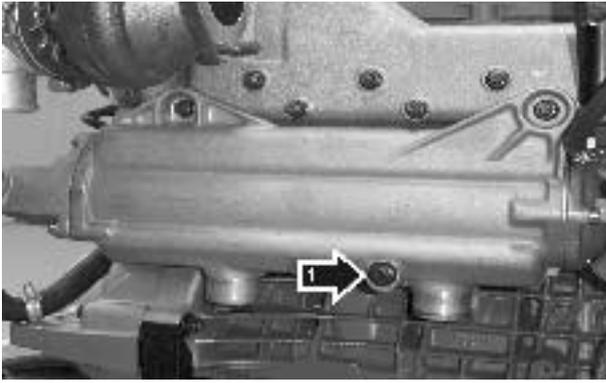
Install the starter motor and screw it in place.

Note the guide pin (1). Install the long screw first, furthest down and install the earth (ground) cable on it.



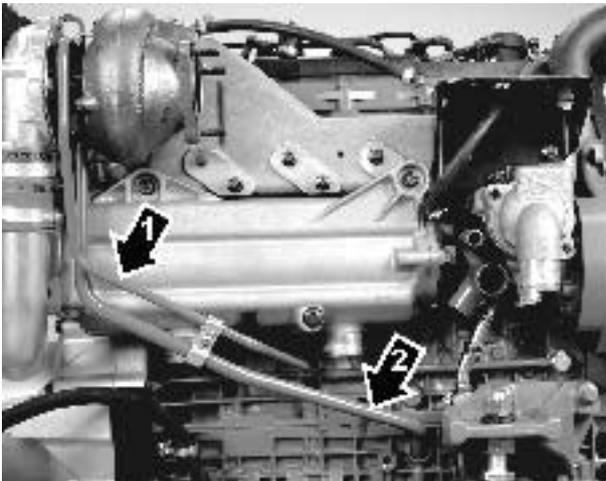
50. Install the manifold with a new gasket, tighten the 4 nuts as in the illustration.

Install the hoses and anchorage on the thermostat housing, together with the turbo pipe, vacuum hose, air filter and coolant hose.



51. Install the heat exchanger. Loosely tighten the nuts and screws.

NOTE! The screws (1) must have a washer on each side of the heat exchanger.

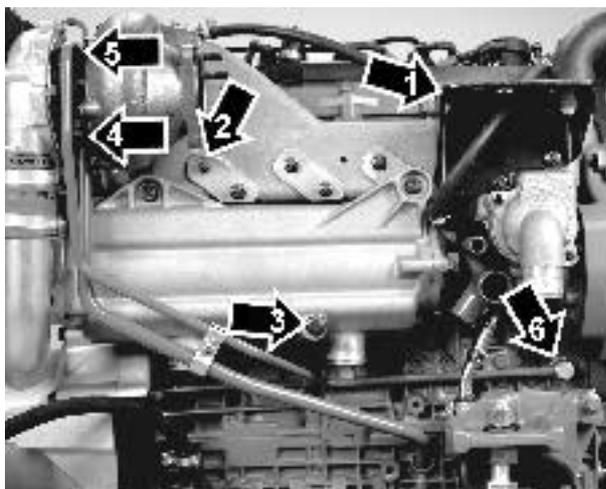


52. Install the oil pipes on the turbocharger (1) and the engine block loosely.

Install the oil return pipe (2) on the turbo, and secure it with the bracket on the engine block.

Tighten the screws loosely.

NOTE! The hollow screw leading in to the turbo should have a restriction. Use a new gasket and copper washers.

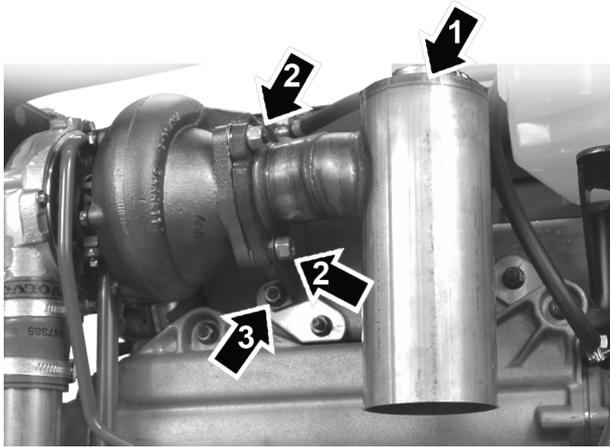


53. Install the bracket for the expansion tank.

Torque all the nuts on the exhaust manifold, except the one that holds the bracket for the exhaust bend (2), to 20 Nm.

Torque the heat exchanger screws (3) to 25 Nm.

Torque the turbo oil drain pipe (4), hollow screw (5) for the oil supply pipe to the turbo and the hollow screw (6) to the engine block, to the values specified in "Technical Data".



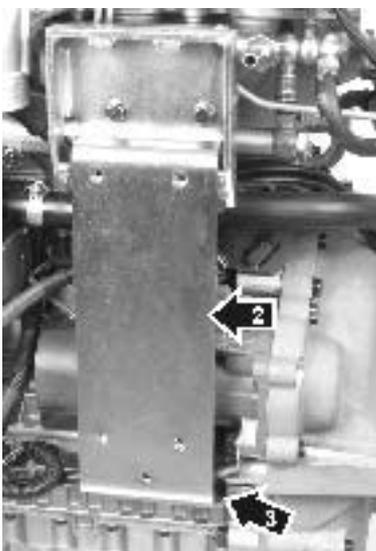
54. Install a new gasket with the swage facing outwards, and install the exhaust pipe elbow (1). Use new nuts (2) and torque them to 30 Nm.

NOTE! An anchorage (3)+ for the manifold is fixed to the lower nut.



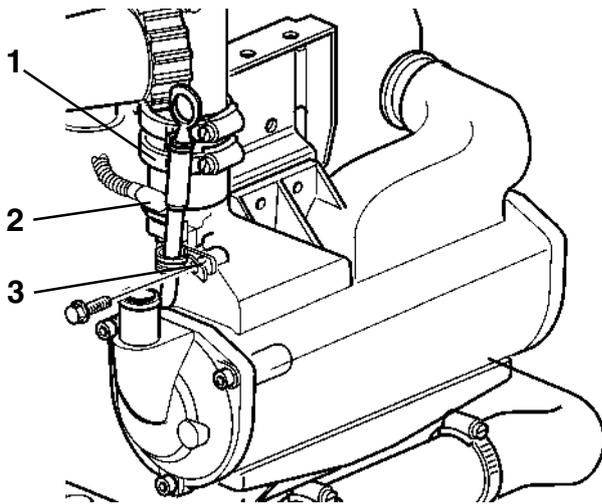
55. Install the expansion tank on its bracket.

NOTE! Do not forget the spacer tube for the fixing screw.



56. Screw the intercooler bracket (2) in place.

NOTE! Apply Volvo Penta sealant part. no. 840879-1 to the threads of the two lowest screws (3).



57. Install the intercooler on the bracket. Insert the short hose (1) between the induction manifold and the intercooler before the screws are tightened.

Join up the connector for the intercooler sensor (2) and tighten the dipstick clamp (3) to the intercooler.

NOTE! Install the fuel return hose on one of the intercooler screws.

⚠ IMPORTANT! Make sure that the hoses are installed so they do not chafe against anything.

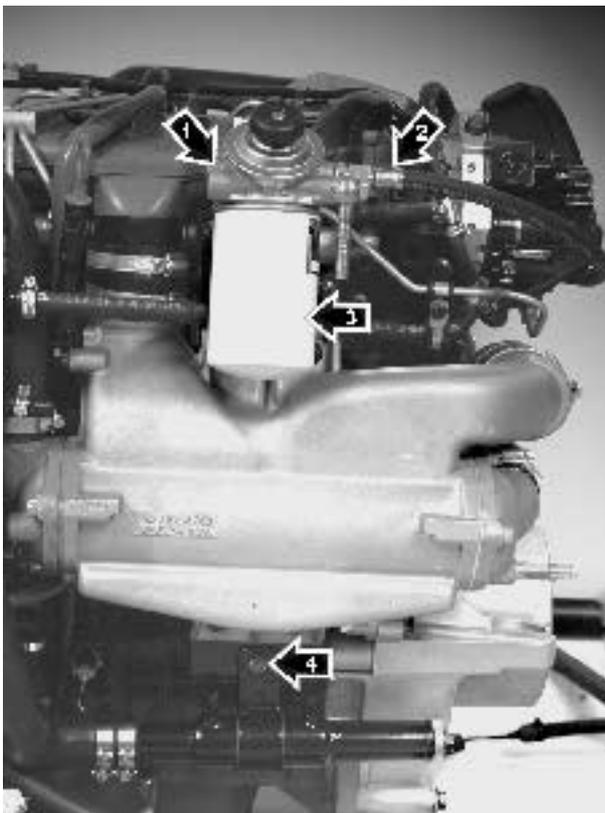
58. Install the oil cooler (servo) or joining pipe.

Install the air filter housing (1) on the turbocharger.

Connect the turbocharger vacuum hose and crankcase ventilation (2).

Install the charge air pipe (3) between the turbocharger and the intercooler.

59. Install all coolant hoses (4) to the sea water pump, intercooler, heat exchanger, exhaust pipe elbow, exhaust manifold, expansion tank, oil coolers, thermostat housing and coolant pipes.



60. Screw the fuel filter housing (1) in place. Connect the fuel pipe (2) between the high pressure pump and the fuel filter housing.

Install a new fuel filter (3).

Install the oil cooler (servo) bracket (4) or joining pipe to the bracket under the intercooler.

Install new tie wraps on the cables and hoses, as previously noted.



61. Insert the spring (1) from underneath between the turbocharger exhaust turbine and the vacuum capsule bracket. Hook the spring on. Make sure that the heat shield (2) goes in between the oil pipe and the exhaust turbine.

Fix the row of hooks (3) with the steel wire.

Fold over the rest (4) of the heat shield and fix the remaining rows of hooks with steel wire.

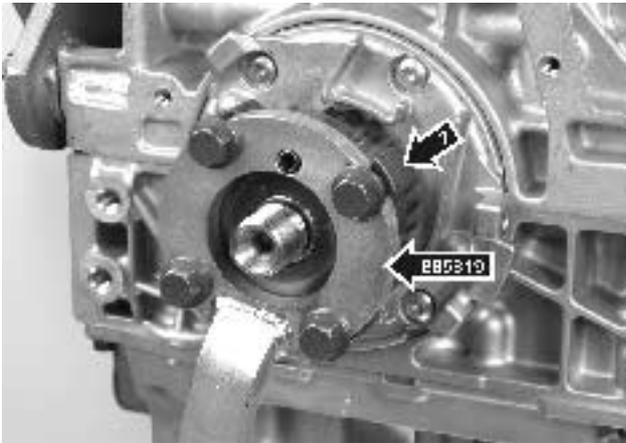
Join the sea water hose up to the exhaust pipe elbow.

-  **IMPORTANT!** Check that the heat shield or spring (1) do not obstruct the vacuum capsule control arm.

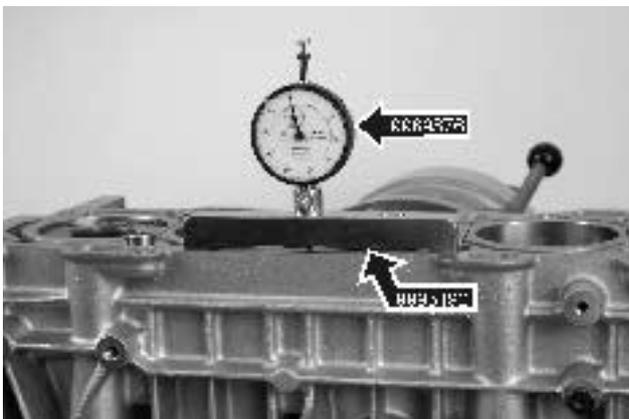
Cylinder head gasket, measurement

Cylinder head removed

Special tools: 885819, 9989876, 9995192



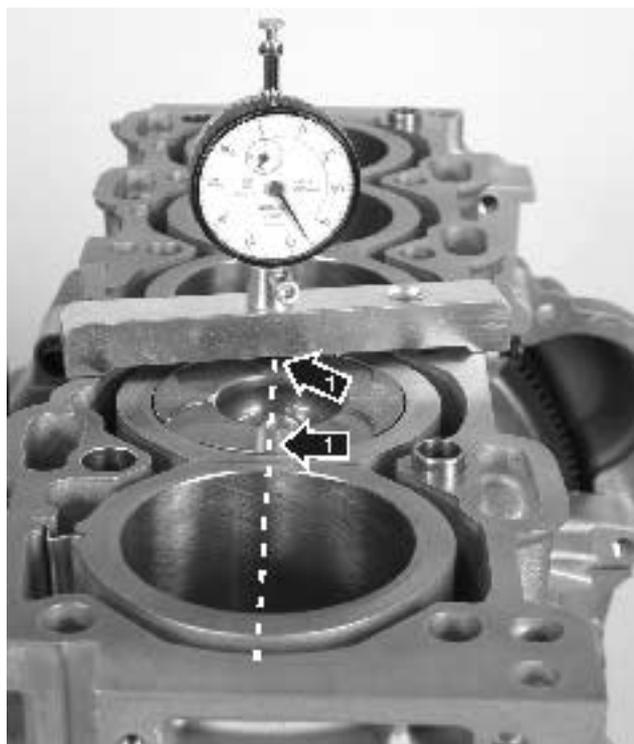
1. Install counterhold tool 885819 on the crankshaft toothed belt pulley (1) to rotate the crankshaft.



2. Make sure that the engine block gasket plane and piston crowns are thoroughly cleaned.

Put holder 9995192 with dial gauge 9989876 on the gasket plane. Zero the dial gauge against the gasket plane.

- ⚠ IMPORTANT!** Be careful to avoid damage to the engine block gasket plane.



3. Crank the engine and measure the top dead center of each piston, on both sides (1) of each piston. Measurements must be done in line with the gudgeon pin, and as close to the cylinder walls as possible.

NOTE! If a piston has different measurement values, the highest value must be used when calculating the gasket thickness.

NOTE! Do not measure inside the valve cutouts in the piston crown.

Distance between piston and gasket plane	No. of holes in cylinder head gasket
0.26—0.47 mm	1
0.47—0.52 mm	2
0.52—0.57 mm	3
0.57—0.62 mm	4
0.62—0.74 mm	5

4. Use the highest measured piston height and determine the correct gasket thickness with the aid of the table.

Crankshaft, locking

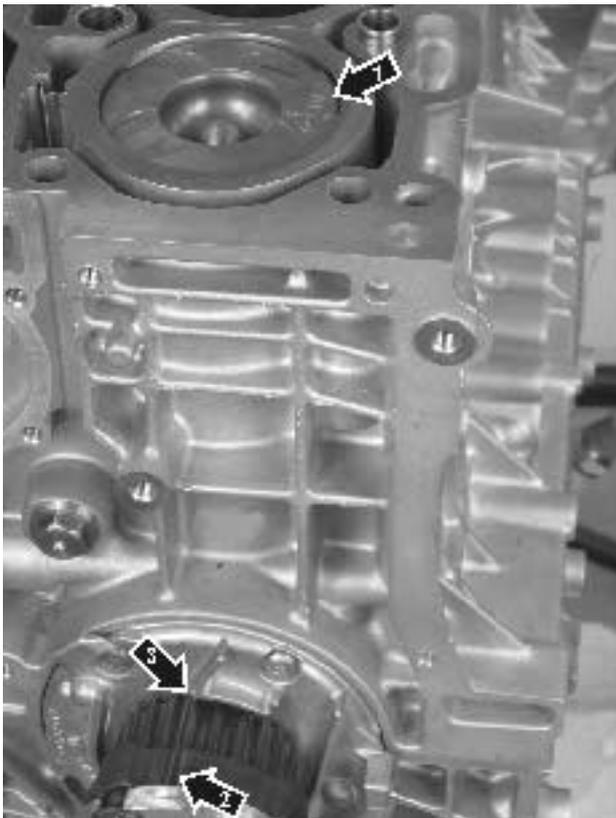
Starter motor removed

Special tools: 9997005



1. Unscrew the plug in the engine block and install locking pin 9997005 to lock the crankshaft. Make sure that the pin bottoms against the block.

⚠ IMPORTANT! The crankshaft can be locked in two positions, only one of which is the correct position for installing the cylinder head and toothed belt pulley.



2. Crank the engine clockwise until the crankshaft locks. Be careful to ensure that it is locked in the correct position.

The illustration shows the correct position for locking. No. 1 piston (1) should now be about 2 mm away from Top Dead Center.

⚠ IMPORTANT! Also check that the marking (2) on the crankshaft toothed belt pulley coincides with the marking (3) on the oil pump.

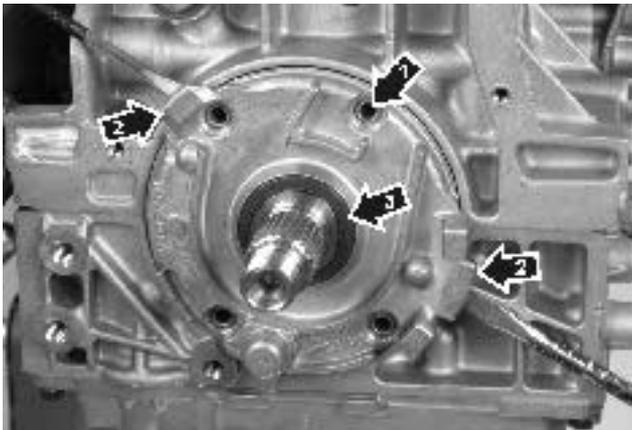
Group 22: Lubrication system

When working with chemicals, fuel and lubricating oil

- ⚠ IMPORTANT!** Always use protective gloves for work which includes contact with oil, fuel etc. Constant skin contact with engine oil can be very harmful.

Oil filter, change

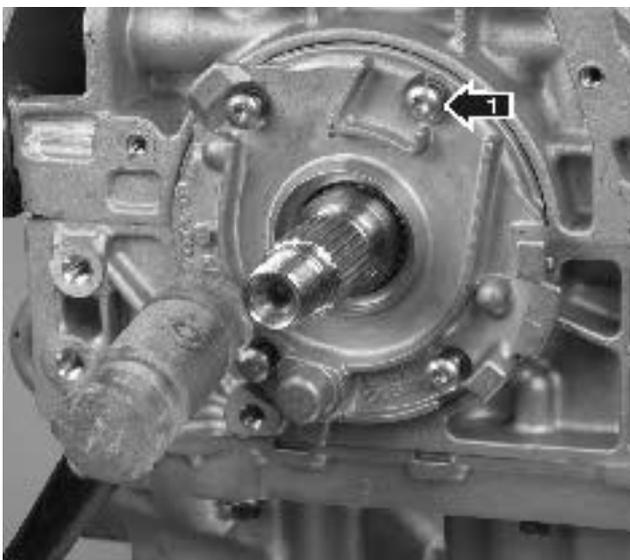
Cam belt and crankshaft gear removed.



1. Undo the Torx screws (1) for the oil pump and carefully prise the pump up under the prizing lugs (2). Remove the gasket, O-ring and seal ring (3) from the oil pump.

Clean the gasket plane and mating surfaces with scraper 885516.

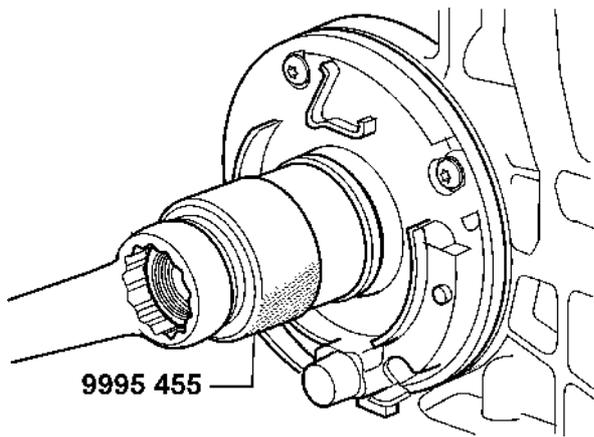
- ⚠ IMPORTANT!** The Torx screws must not be re-used, since they have been in contact with sealant.



2. Install the oil pump with a new gasket, new oiled O-ring and **new** Torx screws (1).

Put the oil pump up in the correct position, use the screws as guides, then carefully tap the oil pump with a rubber-faced mallet.

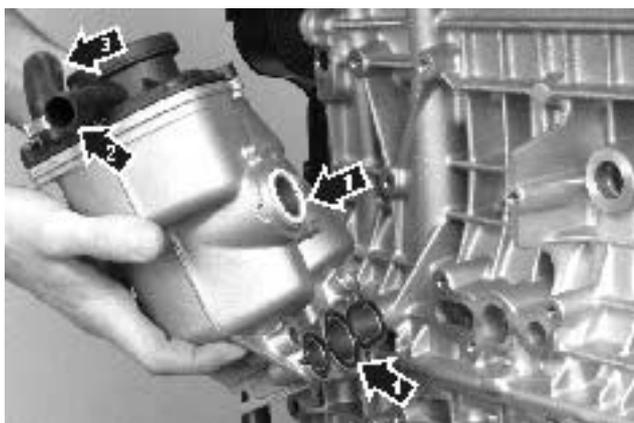
Torque the screws alternately to the specified value.



3. Install a new seal on tool 9995455.
Install the tool with the seal on the crankshaft.
Turn the center nut until the seal is in place.
NOTE! The crankshaft must not rotate during the pressing operation, or the seal ring could be damaged.
4. Install the crankshaft gear and cam belt.

Oil filter housing, change

1. Remove the charge air cooler. Install hoses between the oil filter housing and the crankcase ventilation.
2. Unscrew the oil filter housing and remove it.

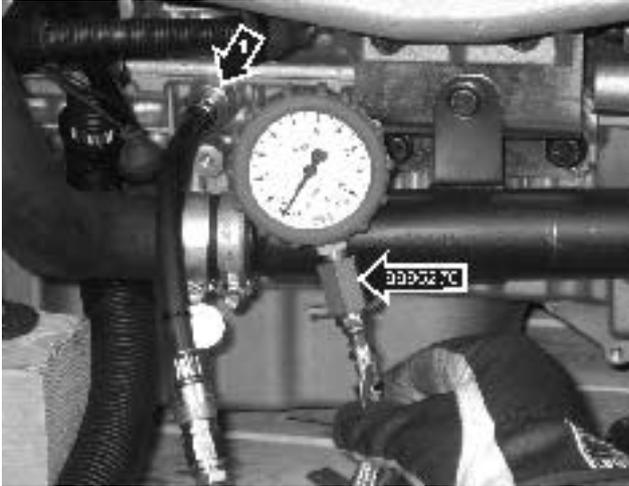


3. Check that the sealing surfaces on the new filter housing are clean and install oiled seal rings (1). Torque the filter housing as specified in "Technical data."
4. Connect the hoses from the crankcase ventilation to the filter housing and install the intercooler.

Flat Rate: 22002

Lube oil pressure, check

Special tools: 9995270



1. Unscrew the oil pressure monitor and install a suitable adapter (1) in its place, taken from measurement equipment 9995270, together with a copper washer. Torque the adapter to 27 Nm. Connect up the remainder of the measurement equipment.
2. Start the engine and read off the oil pressure during both normal loading and idling. Compare the measured values with the "Technical data".

Group 23: Fuel system

Flat rate: 34300

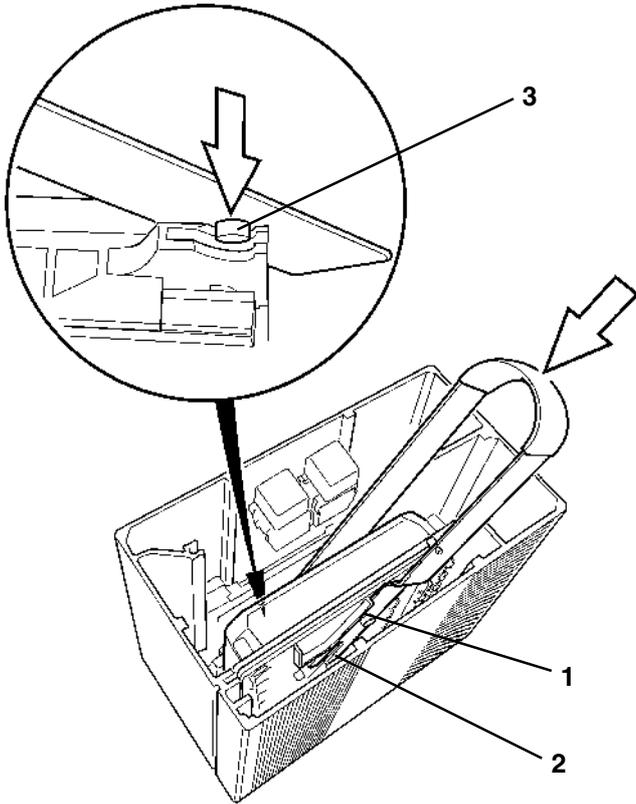
Engine control unit, changing

Current cut with the main switch.

Special tools: 9995722

⚠ IMPORTANT! The system must be disconnected from system voltage and the starter key must be in position 0 when the engine control unit connectors* are disconnected or connected*.

***Note.** Check that the seal is in position before each connector is joined up.



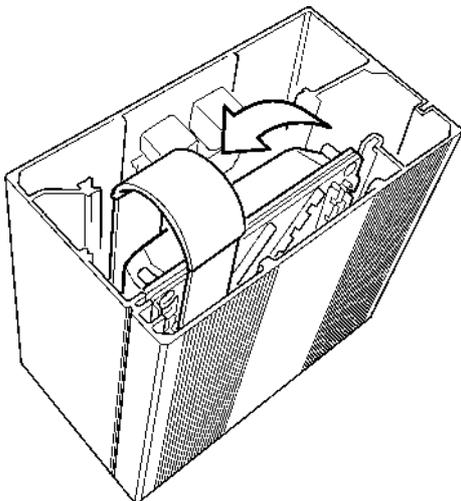
Removal

1. Unscrew the top cover on the engine control unit box. The accelerator control and connector on the cover do not need to be undone.

Insert tool no. 9995722 in the grooves (1) in the control unit. Make sure that the tool grooves (2) and heels (3) engage correctly.

2. Release the control unit by making a rocking movement with the tool.

Pull the control unit up out of the box.



Installation

3. Press the control unit in place, in the grooves in the box (1).

Insert tool no. 9995722 in the grooves (2) in the control unit. Make sure that the tool grooves and heels engage correctly.

Lock the control unit by making a rocking movement with the tool in the opposite direction.

Put the cover back on the box and tighten the screws.



IMPORTANT! Make sure that the engine control unit box is dry inside.

Identifying the engine control unit

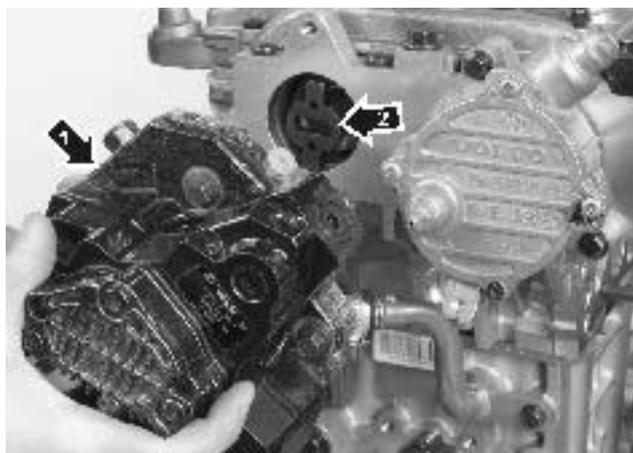
Identification is done via the CHASSIS ID number.



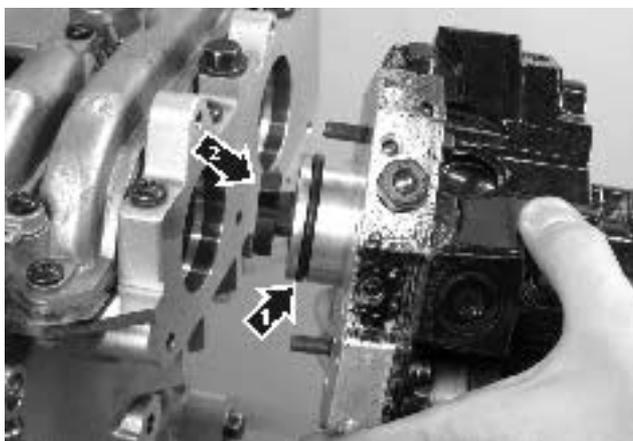
IMPORTANT! The CHASSIS ID number on the decal must coincide with the CHASSIS ID number on the decal on the protective cover above the engine, and the decals on each HIU.

Injection pump, changing

Fuel pipes and electric connectors disassembled



1. Remove the injection pump (1) and make sure that the flange (2) comes with it.



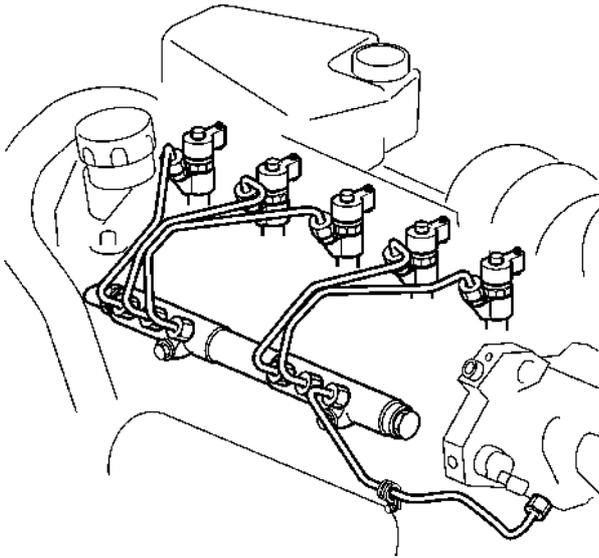
2. Install a new O-ring (1) on the high pressure pump and install it together with its flange (2).
Screw the high pressure pump down as specified in "Technical data."
3. Install electric connectors and fuel pipes.

Flat Rate: 23711

Injectors and fuel supply pipes, change

Removed cover and fuel filter bracket

Special tools: 885289, 9997008, 9997010



1. Removal of injectors and delivery pipes

Clean the area around injectors and the delivery pipe connections prior to removal.

⚠ WARNING! FIRE HAZARD. Be very careful to make sure that no sparks occur when working with the injection system.

Use paper to suck up any spilled fuel as work progresses.

2. Remove the delivery pipes.

⚠ IMPORTANT! Only use the connecting nipple (1) as the counterhold for injectors.

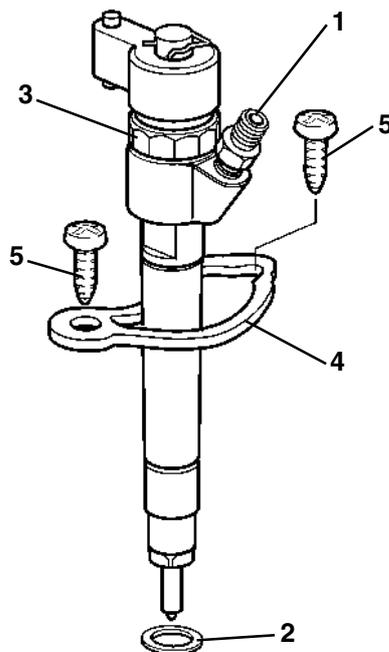
⚠ IMPORTANT! The delivery pipes must not be re-used.

NOTE! If the delivery pipe between the high pressure pump and manifold has been removed, it must be replaced.

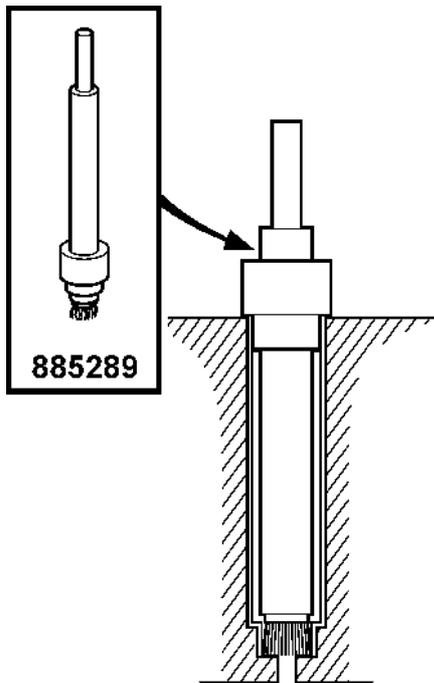
3. Remove:

- The fuel return hose and the contacts from the injectors
- The injectors. Remove the mounted injectors using tool 999 7008.

NOTE! Make sure that copper washer (2) is not left in the cylinder head nozzle seat.



- 1: Junction nipple
- 2: Copper washer
- 3: Nut on injector
- 4: Tension yoke
- 5: Screw

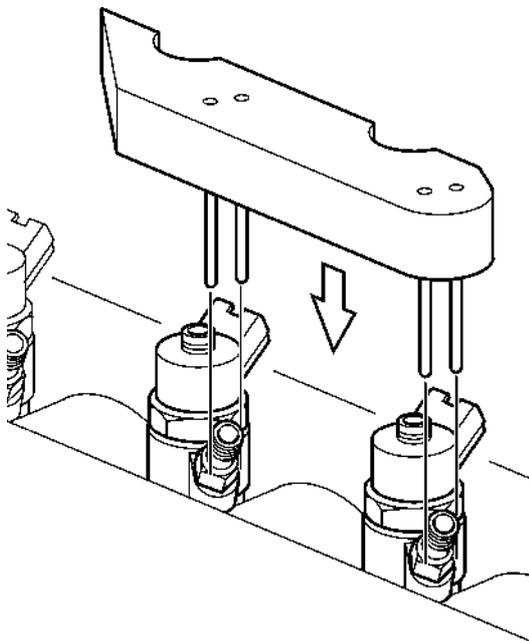


4. Clean the injector's nozzle seats using brush 885289.

⚠ IMPORTANT! Make sure that the surface where the injectors reach the lower part against the cylinder head are thoroughly cleaned. No deposits are allowed.

Make sure that the tool end of the brush has been carefully cleaned. Use compressed air to blow the nozzle seat clean.

Turn the brush a few times with the rod until the nozzle seat surface is completely free from soot. Blow clean from time to time and check cleanliness.



5. **Refitting of injectors and delivery pipes**

Fit new injectors and screw the tension braces down so much that the injectors still can be rotated slightly.

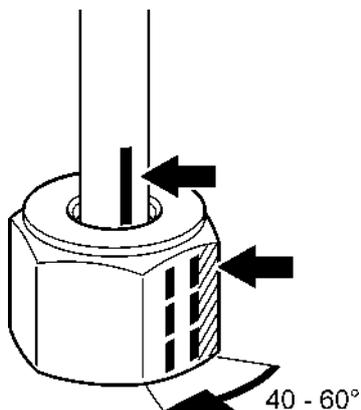
Use tool 999 7010 to place the injectors in the correct position. Torque the screws to 13 Nm.

⚠ IMPORTANT! When installing new or old injectors, you must use new tension yokes, copper washers and screws.

6. Fit the new delivery pipes. Screw all cap nuts all the way down by hand.
7. Angle tightening of cap nuts

⚠ IMPORTANT! When torquing nuts to 40° - 60° angle, a torque wrench must be used, adjusted to 45 Nm. It is important that you do **not** exceed 45 Nm.

⚠ IMPORTANT! If the torque becomes too great before reaching the correct angle, the connection must be removed and lubricated with engine oil before it is torqued again. If the torque again exceeds 45 Nm, the delivery pipes must be replaced with new ones.

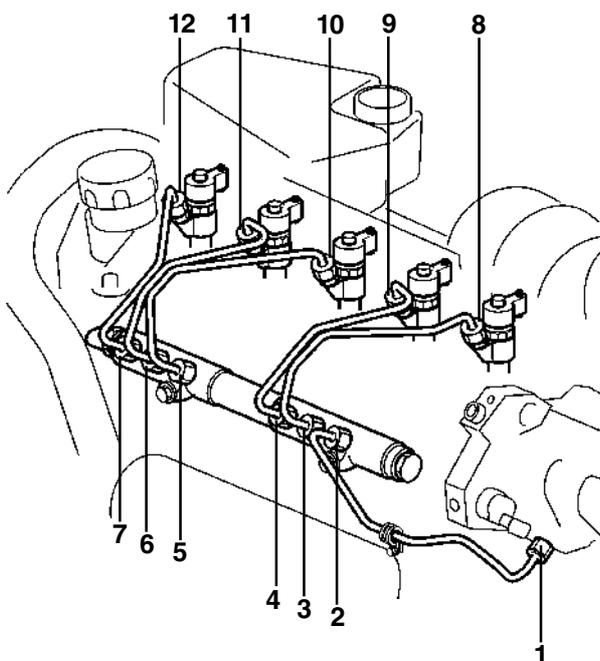


The nut is hexagonal and each corner is 60°.

Mark the pipe and one side of the nut using a pen as illustrated. The side of the nut is divided into three equal parts, which correspond to 20° each.

NOTE! The mark should not be made until the nut has been torqued to 28 Nm.

When the line on the pipe faces the right section, the torque angle will be between 40° and 60°.



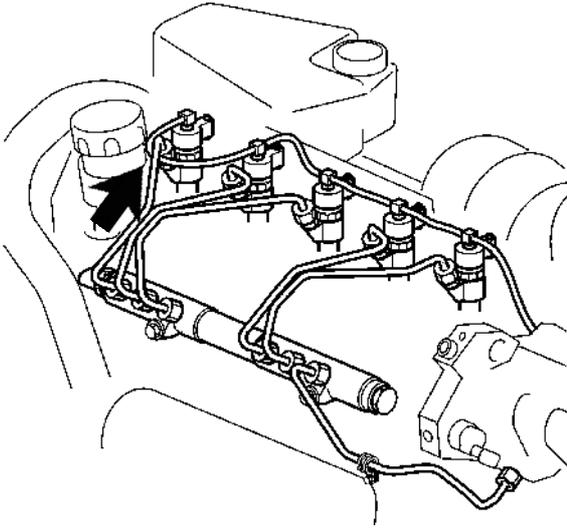
8. Torquing cap nuts

Torque all cap nuts (1-12) to 28 Nm.

Set torque wrench to 45 Nm and torque the cap nuts (1-7) to 40° - 60° angle.

NOTE! Do not torque the cap nuts (8-12) using angle tightening.

Tightening torque **must not** exceed 45 Nm, see step 7.



9. Reinstall the return hose on the injectors.

⚠ IMPORTANT! Place the return hose between cylinder 1 and 2 below the delivery pipe as shown in the picture.

10. Wipe clean and check the engine.

Re-install the fuel filter bracket and cover.

Bleed the fuel system, see "Fuel system, bleeding."

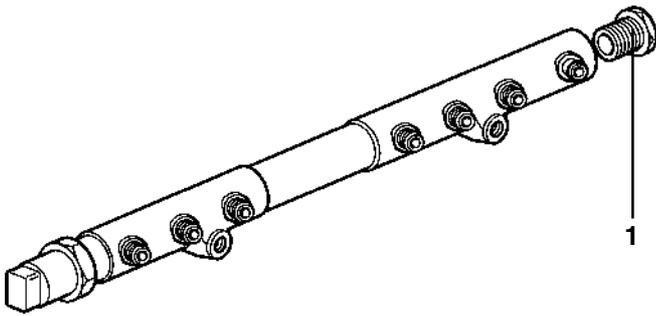
Test run the engine and check that there is no leakage.

Pressure limiting valve, change

Cover removed

1. Carefully clean the area on the engine around the pressure limiting valve.

⚠ IMPORTANT! Be very careful with cleanliness during the entire job. Be careful to ensure that no dirt particles get into the fuel system.



2. Unscrew the pressure limiting valve (1) and remove it.
3. Check that the contact surfaces on the pressure limiting valve are not scratched.
4. Install the pressure limiting valve and torque it to 85 Nm.
5. Wipe up the fuel that has run out.
Start the engine and check for leakage.

Flat Rate: 23315**Fuel suction pressure, checking**

Special tools: 885813, 9990150, 9998493



1. Unscrew the fuel union (1) on the fuel filter pump.
Screw nipple 885813 onto the fuel filter bracket and screw fuel union (1) onto the nipple.
Connect pressure gauge 9990150 to the nipple.
Hose 9998493 can be connected between the pressure gauge and the nipple.

NOTE! A new fuel filter should be used during this check.

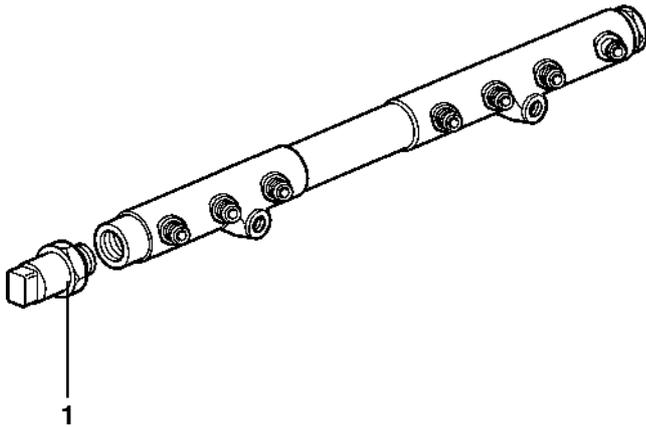
2. Start the engine and read off the fuel suction pressure across the entire engine speed range.
Compare the measured values with the "Technical data".

Fuel pressure sensor, change

Cover removed

1. Carefully clean the area on the engine around the fuel pressure sensor.

⚠ IMPORTANT! Be very careful with cleanliness during the entire job. Be careful to ensure that no dirt particles get into the fuel system.



2. Undo both the hoses for the sea water pump and fold them to one side.

Undo the connector for the fuel pressure sensor (1). Fold the cables to one side.

Unscrew the fuel pressure sensor.

3. Install the fuel pressure sensor and torque it to 20 Nm.

Install the sensor connectors and hoses on the sea water pump.

4. Wipe up the fuel that has run out.

Start the engine and check for leakage.

Group 25: Inlet and exhaust system

Flat Rate: 25507

Turbocharger, inspection

Special tools: 885531



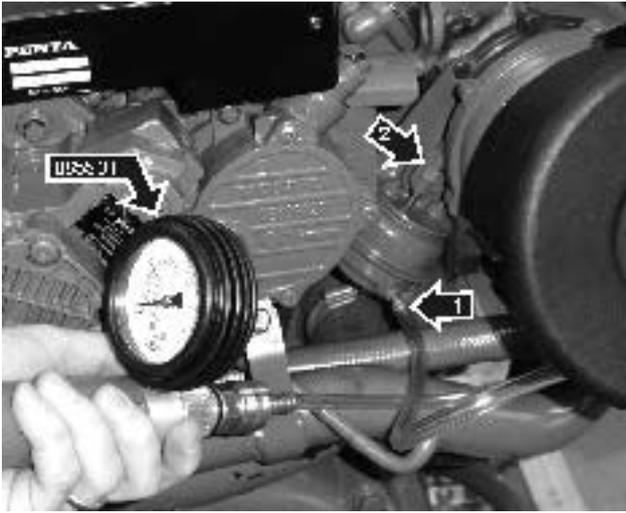
1. Quick check

Shut the engine off and listen to the turbo just as it stops. The rotating components in the turbocharger should normally stop somewhat later than the engine.

If this is not the case, remove the air filter housing and check the following points on the engine:

- That the compressor wheel rotates easily when turned
- That the compressor wheel does not scrape in the compressor housing

NOTE! The turbine spindle floats on an oil film and is thus subject to a certain amount of play.



2. Check VNT

Check in the following order:

- That the vacuum hoses between the turbocharger and vacuum pump are intact
- That the vacuum regulator works, this is located under the fuel distribution pipe. Change to another vacuum regulator to check that the original one is not faulty.
- That the turbocharger control arm can reach its end position. Remove the hose from the turbocharger vacuum box (1) and connect vacuum pump 885531 instead. Create a negative pressure of 64 ± 3 kPa. In this position, the control arm (2) on the turbo (VNT) should reach its end position.

If the control arm does not reach its end position, when the vacuum hoses and vacuum regulator are found to be intact, change the turbocharger.

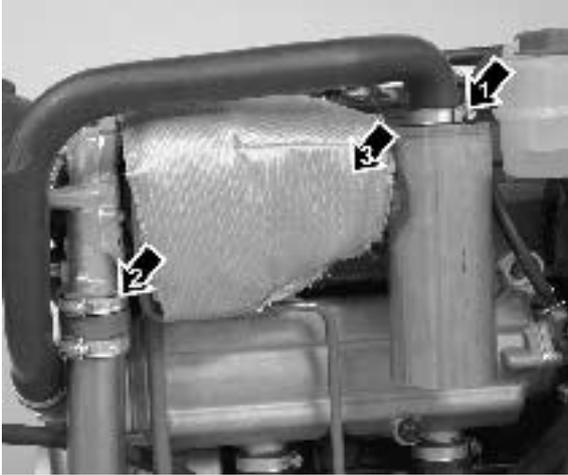
⚠ IMPORTANT! The control arm adjustment nut is calibrated with the turbocharger and must **not** be undone. If its position is changed, a fault code will be generated. The engine warranty does **not** apply if the adjustment nut is loosened.

Flat Rate: 25512

Turbo, replacing

Coolant drained, expansion tank removed

Special tools: 885510



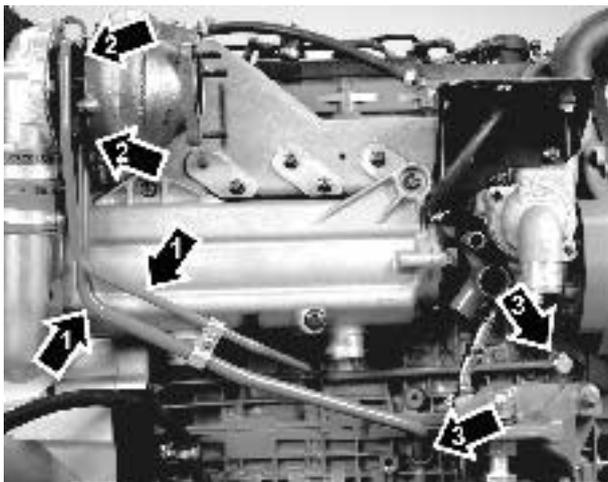
1. Undo the hose union (1) on the exhaust pipe elbow.

Undo the charge air pipe (2) between the turbocharger inlet section and the intercooler.

Remove the turbocharger heat shield (3).

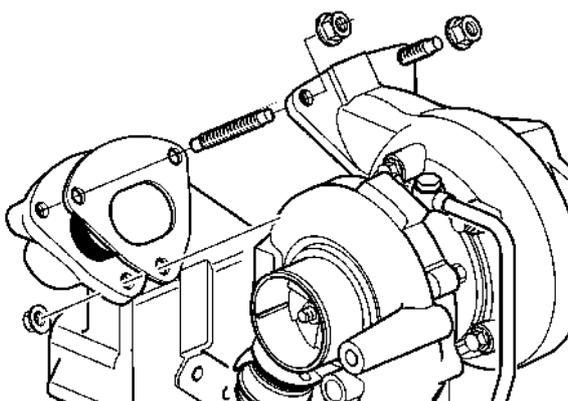
Unscrew the exhaust pipe elbow.

Undo the hose clamp closest to the turbocharger air inlet and remove the air filter housing (4) with the adapter from the turbocharger.



2. Remove the turbocharger oil pipe (1). Plug all openings on the turbocharger (2) and the engine (3) with protective plugs 885510.

Undo the vacuum hose from the turbocharger vacuum capsule.



3. Unscrew the turbocharger from the exhaust manifold.



4. Installation

Install a new gasket (1) on the exhaust manifold with the swage (2) facing outwards.

Install the turbocharger and torque the nuts to 25 Nm.

5. Install the vacuum hose.

Install the oil pipes, please refer to "Engine, assembly".

Install the air filter housing and charge air pipe.

Screw the exhaust pipe bend down, together with the bracket on the lower nut.



6. Heat shield

Insert the spring (1) from underneath between the turbocharger exhaust turbine and the vacuum capsule bracket. Hook the spring on. Make sure that the heat shield (2) goes in between the oil pipe and the exhaust turbine.

Fix the row of hooks (3) with the steel wire.

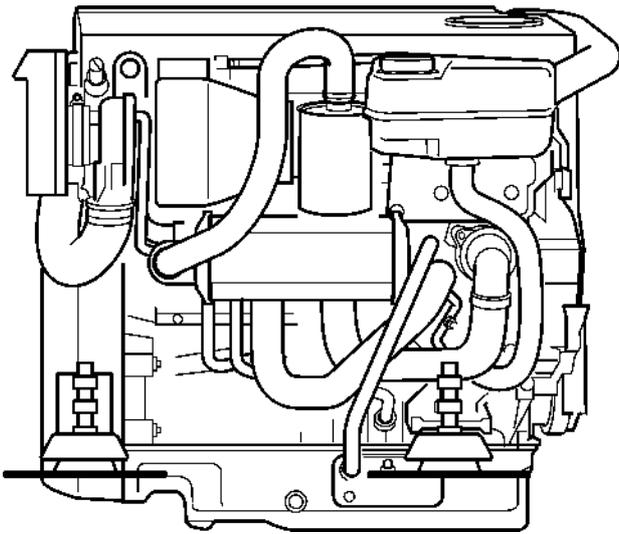
Fold over the rest (4) of the heat shield and fix the remaining rows of hooks with steel wire.

Join the sea water hose up to the exhaust pipe elbow.

⚠ IMPORTANT! Check that the heat shield or spring (1) do not obstruct the vacuum capsule control arm.

Exhaust manifold, change

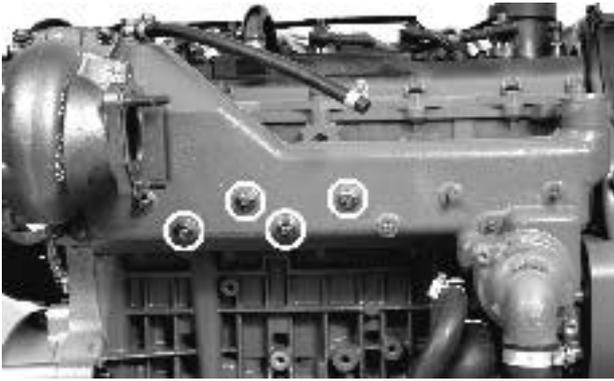
Heat exchanger, exhaust pipe bend and heat shield removed



Removal

1. Remove the expansion tank and its bracket.
2. Remove the air filter, vacuum hose, turbo pipe and coolant hose.
3. Remove the hose anchorage (1) on the thermostat housing and the inner hose connection (2) on the thermostat housing.
Remove the thermostat cover and thermostat.
4. Remove the manifold together with the turbo.
5. Remove the turbo from the manifold.
6. Remove the thermostat cover and thermostat housing.

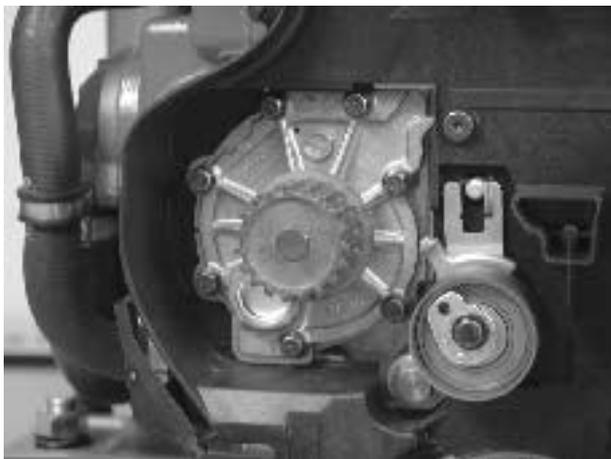


**Installation**

1. Install the manifold with a new gasket, tighten the 4 nuts as in the illustration.
2. Install hoses and bracket on the thermostat housing.
3. Install turbo pipe, vacuum hose, air filter and coolant hose.
4. Install the heat exchanger. Note the washers by the lower screw.
5. Install the expansion tank bracket.
6. Install the turbocharger with a new gasket.
Install the exhaust pipe bend, bracket and turbo heat shield.
7. Install the expansion tank.
Install the thermostat, thermostat cover and hose union on the thermostat housing.
8. Fill the cooling system up and check that there is no leakage.

Group 26: Cooling system

Coolant pump, change

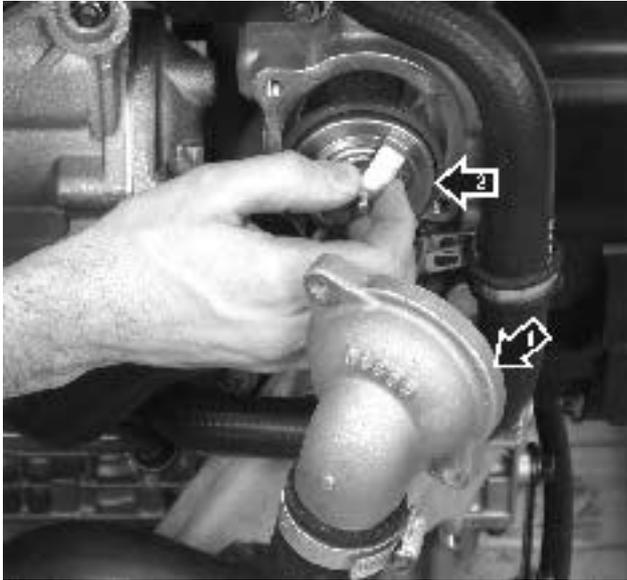


1. Drain the coolant, see "Cooling system, draining".
2. Remove the cam belt, please refer to "Cam belt, change" under "service work".
3. Remove the screws for the coolant pump and remove the pump.
4. Install the coolant pump with a new gasket.
5. Remove the cam belt, please refer to "Cam belt, change" under "Service work".
6. Fill the cooling system up and check that there is no leakage.

Flat Rate: 26271 R & R**Flat Rate: 26273 Test**

Thermostat, function check/ change

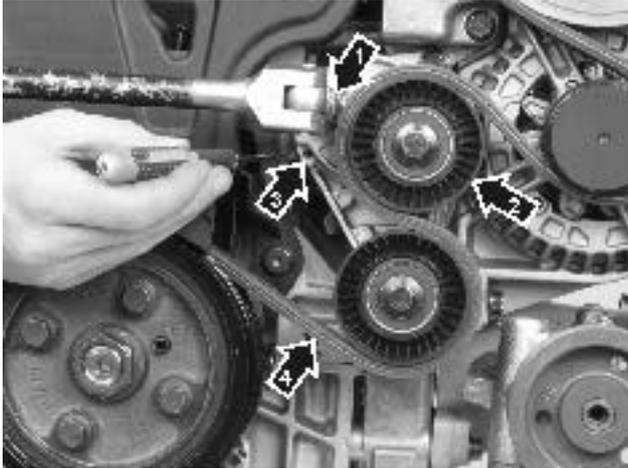
Drained coolant



1. Undo the thermostat housing (1).
Remove the thermostat (2) and seal.
 2. If inspection is to be done:
Put the thermostat in a water filled glass beaker. Heat the water to boiling point and use a thermometer to check the temperature at which the thermostat opens.
The thermostat should start to open at 80°C and should be fully open at 95°C.
 3. Clean the sealing surfaces of the thermostat housing and the cover.
- ⚠ IMPORTANT!** Be careful not to damage the sealing surfaces during cleaning.
4. Place a new or checked thermostat in the housing together with a new seal.
Torque the cover to the specified value.
 5. Fill the cooling system up and check that there is no leakage.

Sea water pump, change

Seawater drained and hoses removed.



1. Drive belt

Apply a tool with a T60 Torx bit (1) to the cutout in the belt tensioner (2). Turn the belt tensioner and insert a screwdriver or similar into the hole which opens up and secure the belt tensioner.

Remove the drive belt (4).



2. Sea water pump

Undo the screws (1) through the drive pulley, that hold the sea water pump (2) to the mounting bracket (3).

Remove the pump.

3. Install the new seawater pump and tighten the screws as specified in "Technical data".

Install the belt.

NOTE! Make sure that the drive belt has not slid out of its grooves.

4. Install the seawater hoses.

Flat Rate: 26214**Sea water pump, seal, change****Sea water pump removed**

Special tools: 885816, 9995919

1. Unscrew the cover. Remove the O-ring and carefully prise the rubber impeller out, please refer to "Sea water pump, impeller, change".

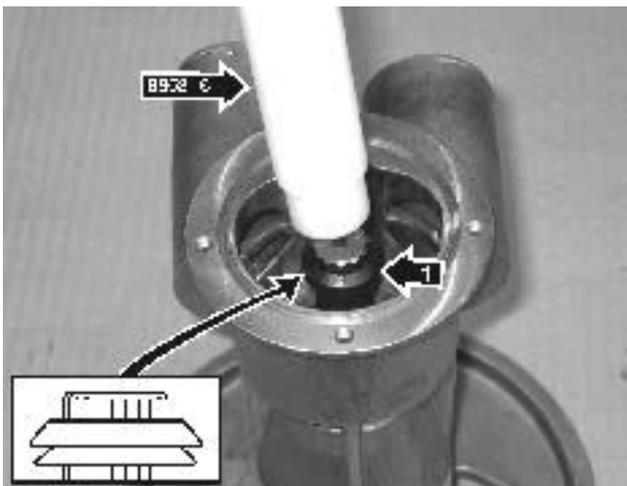
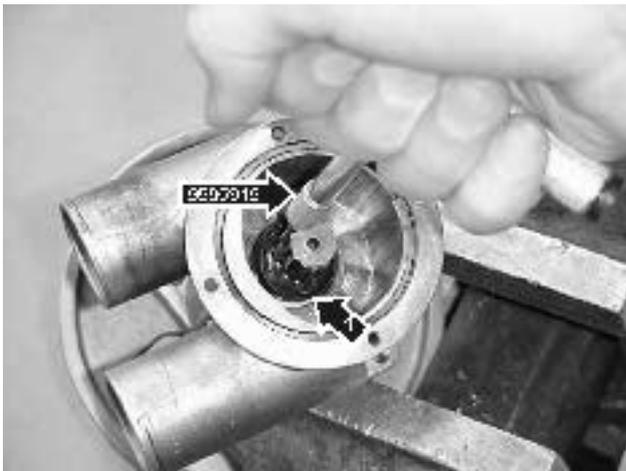
⚠ IMPORTANT! Make sure that the inner edge of the housing is not damaged.

2. Fix the pump to a vice or similar. Put the hook on tool no. 9995919 under the seal (1) and pull it away.

Remove the seal located closest to the bearing in the housing.

3. Check the sea water pump bearing and the impeller housing.

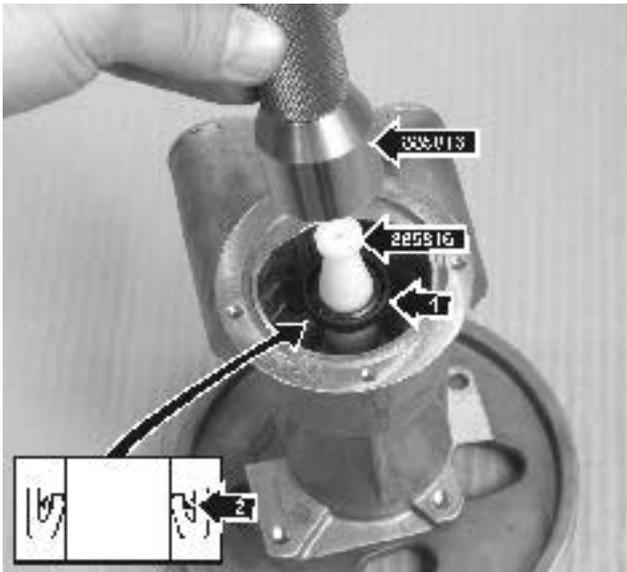
⚠ IMPORTANT! If any damage is discovered, which could cause leakage or rotation problems, the sea water pump must be changed.



4. **Installation**

Grease the new seal (1) with white Vaseline, part. no. 1161150 and put it on the shaft.

Press the seal into place with mandrel no. 885816.



5. Grease the new seal (1) with white Vaseline, part no. 1161150 and install it on sleeve 885816 with the spring (2) visible from outside. Put the sleeve with the seal on the shaft.

Put mandrel 885816 over the seal and tap it into place.

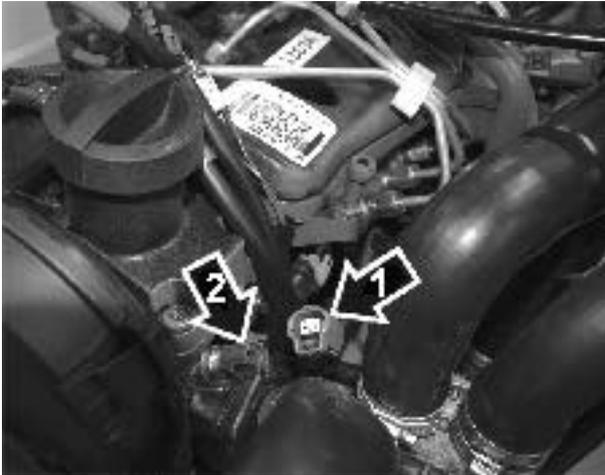
NOTE! The shape of the mandrel ensures that the seal ends up in the correct position.

7. Grease (included in the renovation kit) the new impeller and O-ring.

Thread the impeller onto the pump shaft. Make sure that the impeller vanes are aligned to suit the direction of rotation. Install the lid together with a new O-ring. Torque the screws to the specified values.

⚠ IMPORTANT! Check that the sealing surfaces are clean.

Coolant temperature sensor, replacing



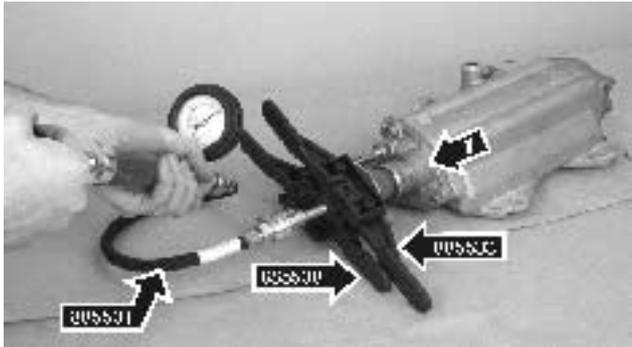
1. Drain the coolant until it is below the sensor level, please refer to "Cooling system, draining".
2. Remove the cover and fold the hose away beside the sensor.
3. Undo the connector (1).
4. Use a long socket, 19 mm, to install and remove the coolant sensor (2).
5. Install the electric connector and cover.
6. Fill the cooling system up and check that there is no leakage.

Flat Rate: 26010

Heat exchanger, pressure testing

Heat exchanger removed

Special tools: 3849613, 885533, 885538



1. Install plugs 885533 and 885538 on the heat exchanger's sea water unions on the cover (1).

Connect pressure test equipment 885531 to plug 885533.

Pump the pressure up to 150 kPa. Leave the equipment under pressure to ensure that the heat exchanger and its O-rings seal correctly.

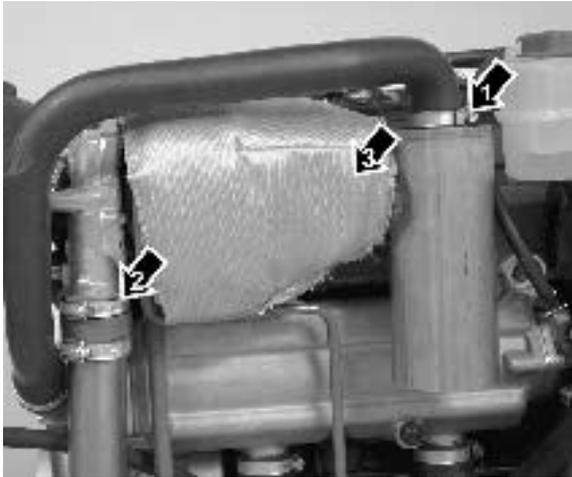
- ⚠ IMPORTANT!** If the pressure falls, the heat exchanger connection must be checked with leak testing compound (such as soapy water) to determine where the leakage comes from.

2. If the pressure falls, although you have determined that the connections are tight, the heat exchanger must be changed.

Heat exchanger, replacing

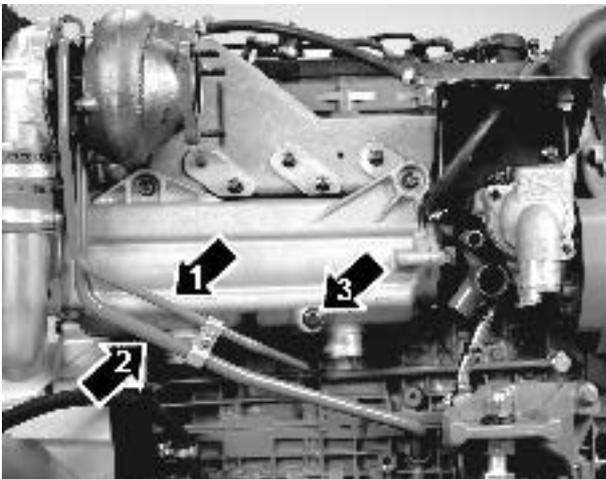
Removal

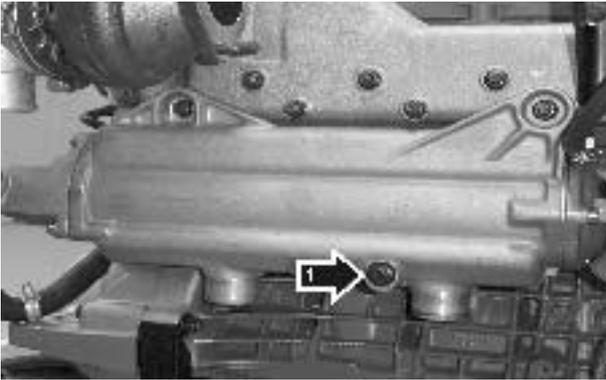
1. Remove the turbo heat shield.
2. Remove the exhaust pipe bend. Leave the hose in place.
Undo the hose union from the expansion tank to the heat exchanger.
Undo the expansion tank.



3. Remove the turbo oil pressure pipe and return pipe (1 and 2).
4. Undo the hose connections (1) for the heat exchanger.
5. Remove the heat exchanger.

NOTE! Note the washers for the lower screw (3) on the heat exchanger.



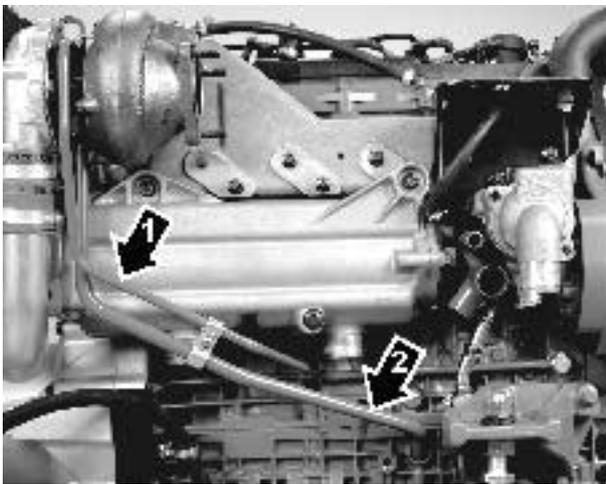


Installation

1. Install the heat exchanger.

NOTE! Do not forget the washers for the lower screw (1), one on each side of the screw, on the heat exchanger.

2. Torque all the nuts on the manifold and the lower screw on the heat exchanger (1) as specified in "Technical Data".



3. Install the oil return pipe (2) for the turbo, then the oil supply pipe (1). Tighten it as in the specification in "Technical data".

NOTE! Install the pipes with a new gasket.

4. Install all coolant hoses to and from the heat exchanger.
5. Install the exhaust pipe bend.
6. Install the expansion tank.
7. Re-install the turbocharger heat shield, please refer to "Turbocharger, changing".

Flat Rate: 26114

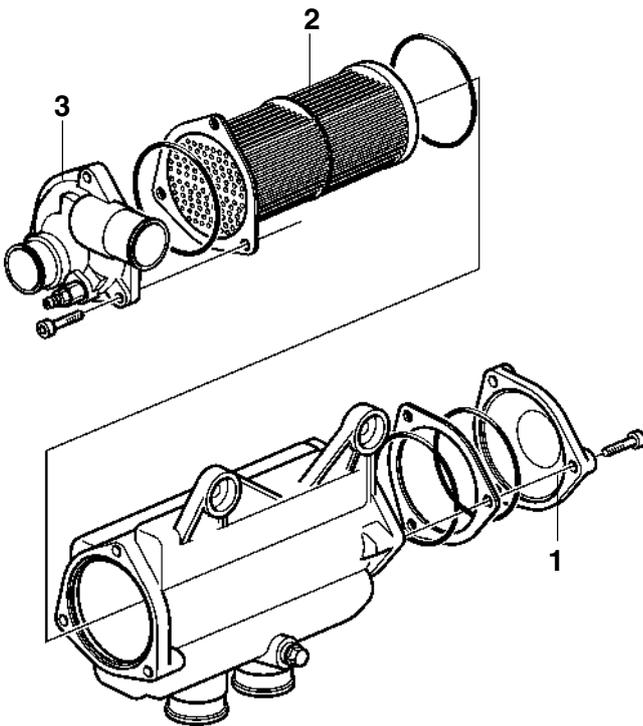
Heat exchanger, cleaning/ renovation

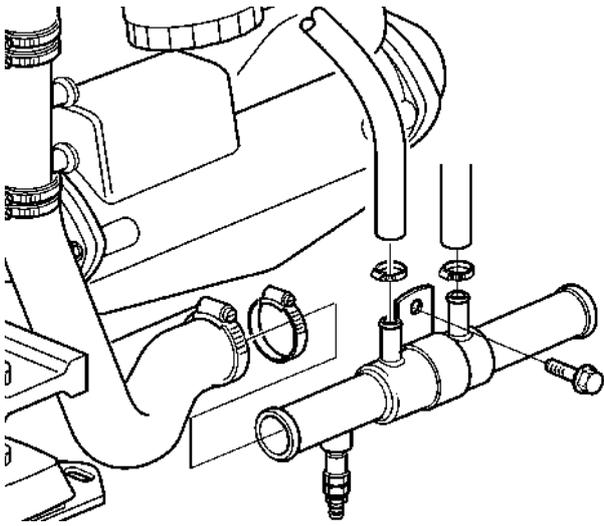
Heat exchanger removed

1. Unscrew the cover (1) with washer and O-rings.
2. Unscrew the cover (3) and O-ring.
Remove the insert (2).
3. Clean all components. Use a bottle brush etc. to clean the insert ducts.

⚠ IMPORTANT! The heat exchanger sealing surfaces and the soldered joints in the insert must not be subjected to mechanical wear during cleaning.

4. Re-install the components with new O-rings.
Do a pressure test, please refer to "Heat exchanger, pressure testing".





Oil cooler, steering servo, change

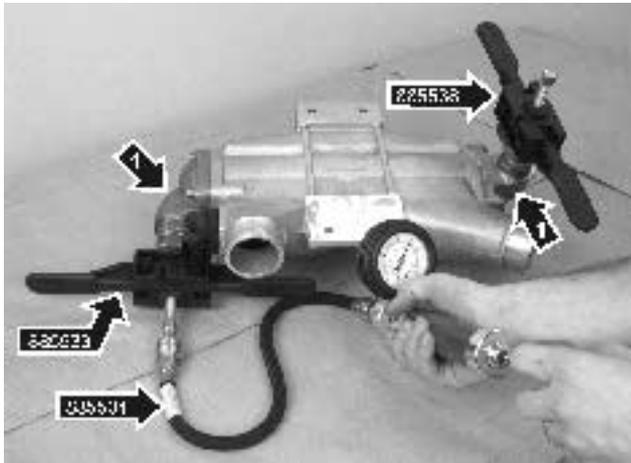
1. Undo the hose unions to the oil cooler.
2. Undo the oil cooler bracket.
Remove the oil cooler.
3. Install the new oil cooler, with the bracket and hose unions.
Tighten it as in the specification in "Technical data".

Flat Rate: 25012

Intercooler, pressure testing

Intercooler removed

Special tools: 3849613, 885533, 885538



1. Install plugs 885533 and 885538 on the intercooler's sea water unions on the covers (1).

Connect pressure test equipment 885531 to plug 885533.

Pump the pressure up to 150 kPa. Leave the equipment under pressure to ensure that the intercooler and its O-rings seal correctly.

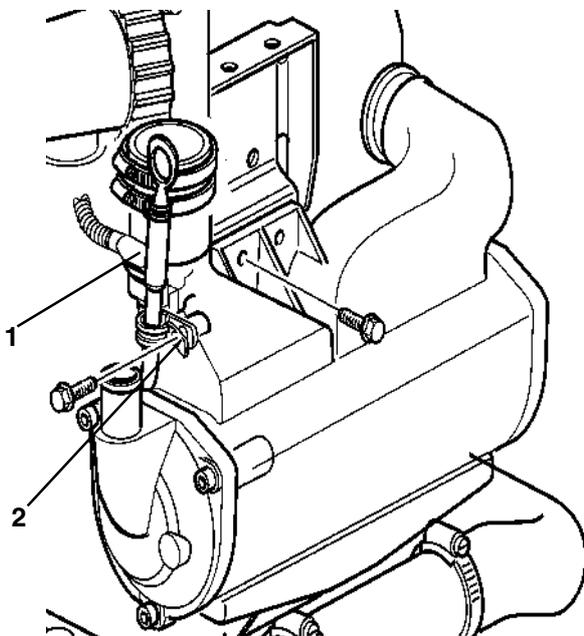
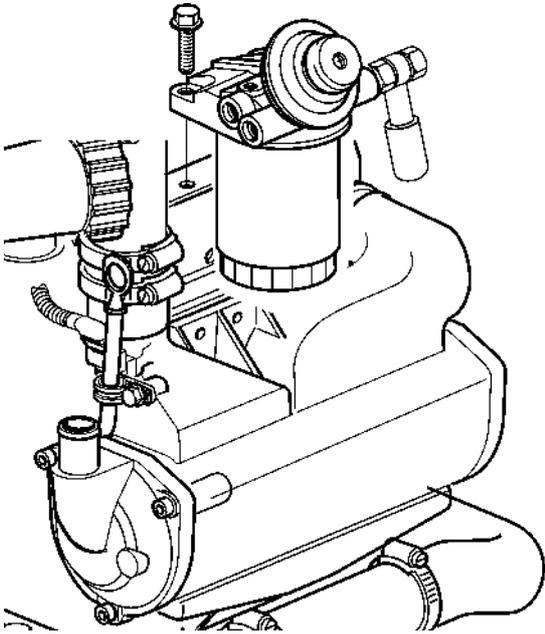
- ⚠ IMPORTANT!** If the pressure falls, the intercooler connection must be checked with leak testing compound (such as soapy water) to determine where the leakage comes from.

2. If the pressure falls, although you have determined that the connections are tight, the intercooler must be changed.

Intercooler, change

Remove

1. Close the seawater inlet and drain the coolant, see "Cooling system, draining."
Remove the fuel filter bracket.



2. Undo the seawater hoses.
3. Remove the electric connector (1) on the intercooler, together with the dipstick bracket (2).
4. Undo the intercooler hose connections to inlet and turbo pipes.
5. Disassemble the intercooler, 4 screws.
6. Clean the intercooler, please refer to "Intercooler, cleaning".

Installation

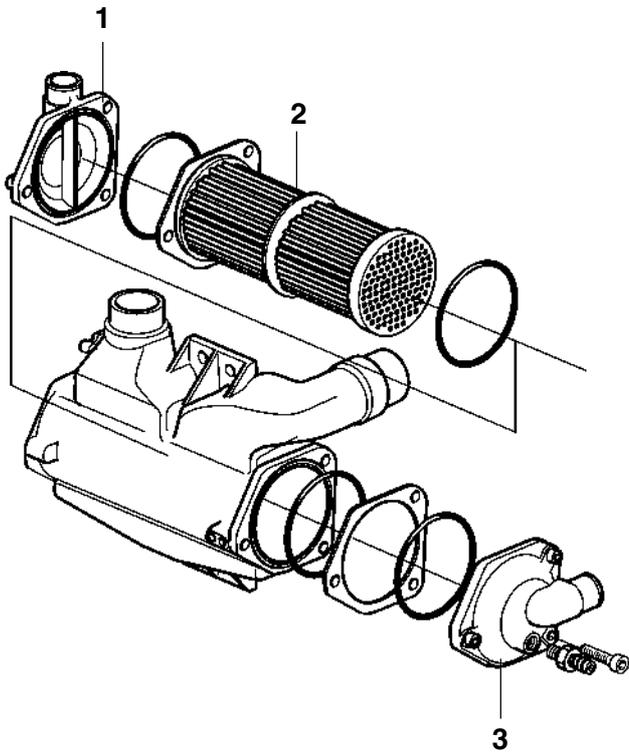
1. Lift the intercooler and guide the hose in towards the inlet pipe. Install the 4 screws.

2. Install the hose unions on the inlet and turbo pipes.
Install the dipstick bracket and the intercooler connector.
Install the seawater hoses.
Install the fuel filter bracket.

3. Fill the cooling system up and check that there is no leakage.

Flat Rate: 25061

Intercooler, cleaning/ renovation

**Intercooler removed.**

1. Unscrew the cover (1) with washer and O-rings.
Unscrew the cover (3).
Remove the insert (2), and all O-rings.

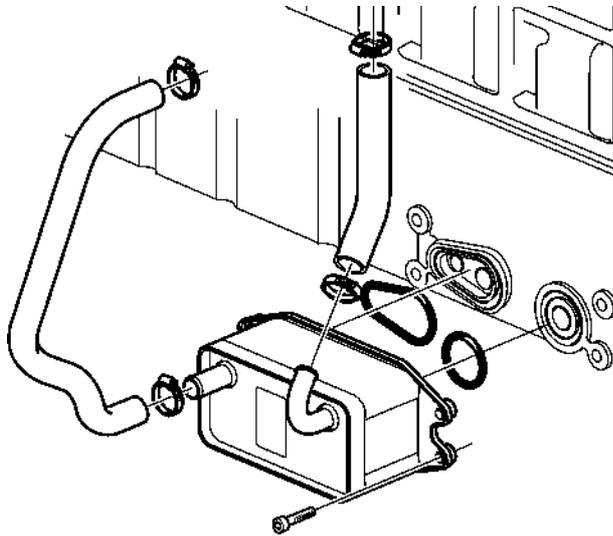
2. Clean all components. Use a bottle brush etc. to clean the insert ducts.

⚠ IMPORTANT! The intercooler sealing surfaces and the soldered joints in the insert must not be subjected to mechanical wear during cleaning.

3. Re-install the components with new O-rings.
Do a pressure test, please refer to "Intercooler, pressure testing".

Oil cooler, engine, change

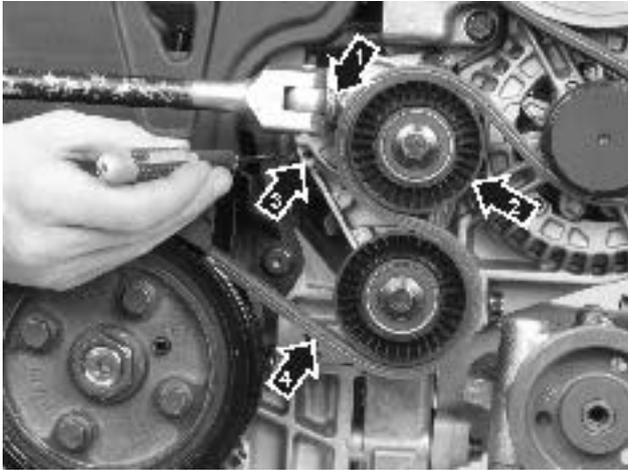
Engine oil and coolant drained.



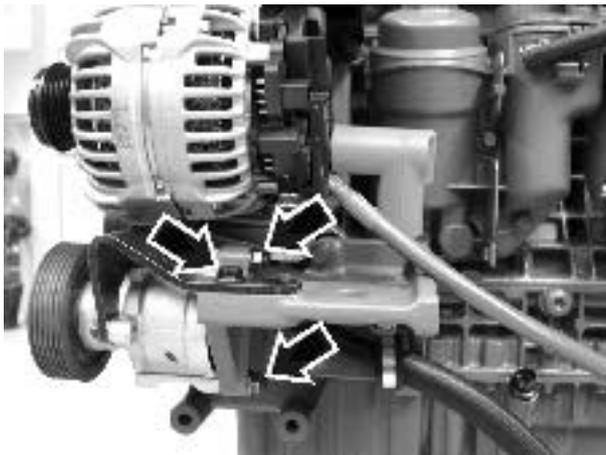
1. Undo the hose unions to the oil cooler.
2. Remove the oil cooler and remove the seals.
3. Clean the mating surfaces.
Put new, oiled seal rings (1) in the grooves on the sump.
Install the oil cooler.
4. Install the hose connections.
5. Fill up with coolant and engine oil.
Vent the cooling system.
Check the oil level and check that there is no leakage.

Group 30: Electrical

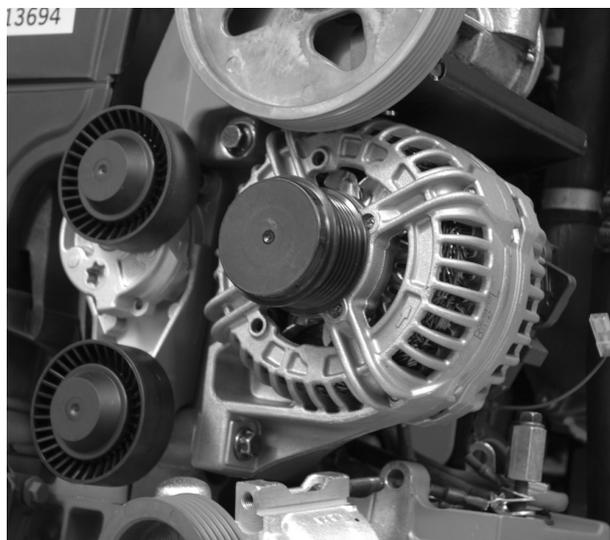
Alternator, changing



1. Disconnect the current and remove the cables from the alternator.
2. Apply a tool with a T60 Torx bit (1) to the cutout in the belt tensioner (2). Turn the belt tensioner and insert a screwdriver or similar into the hole which opens up and secure the belt tensioner.
Remove the drive belt (4).



3. Remove the servo pump bracket, unto the pump and pull it forwards slightly.
Remove the alternator.



5. Install the new alternator and join up the electric connectors.
6. Install the servo pump and tighten the bracket.
Install the drive belts.

Starter motor, changing

Intercooler and its bracket removed



1. Undo all cables from the starter motor.
2. Unscrew the starter motor and move it forwards to undo it.
3. Install the new starter motor. Note the guide pin and the long screw, which should be furthest down because of the earth (ground) cable (1).
4. Tighten the screws for the electric cables.

Technical data

General

Type designation	D3-160A-B, D3-160i-B, D3-130A-B, D3-190A-B D3-130i-B, D3-110i-B, D3-190i-B
No. of cylinders	5
Bore (mm/inch)	81 mm
Stroke	93.2 mm
Cylinder volume, total	2.4 liter
Direction of rotation (seen from front)	clockwise
Injection sequence	1-2-4-5-3
Low idle	700±10 rpm
Full throttle range:	
Rating 5	4000 rpm (D3-160, D3-130, D3-190) 3000 rpm (D3-110)
No. of valves per cylinder	4
Compression ratio	17.3:1
Compression pressure at starter motor speed, 240-300 rpm	24-31 bar
Compression pressure, min.	22 bar
Max. permissible compression difference between cylinders	5 bar
Weight, engine only (dry without timing gear)	227 kg

Short block

Cylinder head	
Material	Aluminum
Valve lifters	Hydraulic

Toothed belt (timing gear)	
Change interval	1500 hours operation/10 years

Inlet and exhaust system

Turbocharger

Make and type	Garret, VNT
Type of lubrication system	Pressure lubrication (engine)

Charge pressure

Charge pressure (measured at engine inlet manifold)
at propeller loading, and app. +25°C air temperature

Min charge pressure (kPa excess pressure) at power level:	D3-190	D3-160	D3-130	D3-110
1400 rpm	5	5	5	5
2000 rpm	23	25	20	30
3000 rpm	64	95	95	110
4000 rpm	137	115	110	-

Exhaust temperature (°C) at power level:

Rating 5,

3000 rpm. (directly after the turbocharger)	-	475	-	500
4000 rpm. (directly after the turbocharger)	466	425	-	534

Exhaust back pressure (kPa) at power level:

Max. permissible back pressure in exhaust pipe	30	20	15	30
Min. rec. back pressure in exhaust pipe	25	15	10	25
Max. permissible suction on induction side (with new air filter)	2	2	2	2
Max. permissible suction on induction side (with blocked air filter)	2	2	2	2

Fuel system

Supply pressure (suction)	0 to -50 kPa
Fuel grade, lowest	EN 590, ASTM D 975 No. 1-D and 2-D, JIS KK 2204

Injector

Type	Bosch CRIN 1.6
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High pressure pump

Type	Bosch CP 3.3
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Lubrication system

Viscosity	SAE 15W/40
Lube oil pump, type	Gear wheel pump
Crankcase ventilation, type	Closed
Reduction valve, oil pump, max.	800 kPa
Reduction valve, sump, max.	550 kPa
Oil pressure, hot engine at operating speed, min	350 kPa
at idle, min.	100 kPa
Oil change volume incl. oil filter, app:	6.8 liter (1.8 US gal.)
Oil volume between Min and Max markings	2 liter (0.5 US gal.)
Oil filter, type	Replaceable filter element

Cooling system

Type	Sealed/fresh water cooled
Heat exchanger, type	Sea water cooled
Volume, incl. heat exchanger, app.	8.2 liter (2.2 US gal.)

Thermostat

Type	Thermostat with bypass control
Quantity	1
Starts to open at	80°
Fully open at	95°

Coolant

Glycol/water, mixing ratio	40/60
----------------------------------	-------

Electrical system

System voltage	12 V
Battery capacity (start batteries):	
With 12 V system voltage	1x88 Ah, 800 cca
Fuses, 12 V system	
protects	Engine control unit, EVC system
type	Blade fuse
quantity	1+1
Ampere	20 A
location	Engine cover
protects	Trim pump
type	Circuit breaker
quantity	1
Ampere	50 A
location	Engine cover

Alternator

Type	Alternator
Voltage/max. current density	14 V/140 A

Starter motor

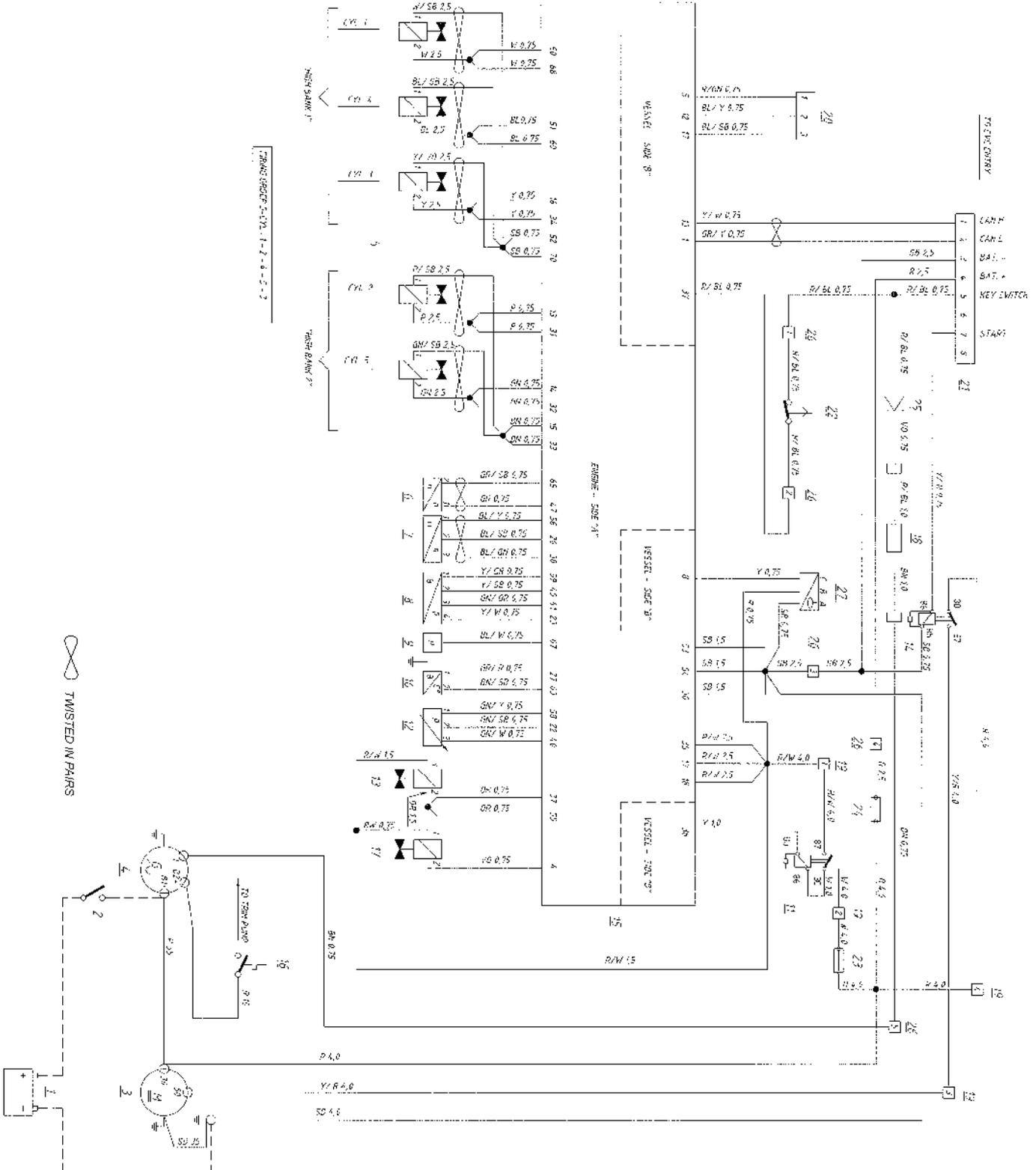
Starter motor, power app.	2.2 kW
Cranking speed with starter motor engaged, app.	300 rpm

Wiring diagram

1. Battery, main switch
2. Starter motor
3. Alternator
4. Injector
5. Inductive sensor, engine, rpm engine
6. Pulse sensor-camshaft, rpm
7. Pressure/Temperature sensor, charge air
8. Oil pressure monitor, engine
9. Temperature sensor, coolant
10. Main relay
11. Fuel pressure sensor, distribution pipe
12. High pressure pump
13. Starter relay
14. Engine control unit – EDC15C11
15. Fuse, trim pump, 50 A
16. Vacuum regulator
17. Resistor, 33 Ohm
18. Connector, 4-pin
19. Accelerator butterfly, potentiometer
20. Connector, engine control unit
21. Stop button, engine room
22. Blade fuse, EDC15, 20 A
23. Blade fuse, EVC, 20 A
24. Diode
25. Connector, 6-pin
26. Monitor, water in fuel
27. Monitor, water in fuel

Cable colors

BL	Blue
GN	Green
GR	Gray
LBL	Light blue
LBN	Light brown
R	Red
SB	Black
VO	Violet
W	White
Y	Yellow



Torque

General tightening torque values

M5	5 Nm
M6	10 Nm
M7	17 Nm
M8	24 Nm
M10	50 Nm
M12	80 Nm
M14	130 Nm

Important tightening torques

Exhaust manifold	25 Nm
Exhaust pipe elbow	50 Nm
Fuel distribution pipe	17 Nm
Fuel pressure sensor	20 Nm
Fuel delivery pipe:	
step 1 (all cap nuts)	28 Nm
step 2 (not on injectors)	+(40°-60°)
Jockey pulley (toothed belt)	25 Nm
Center nut, crankshaft	300 Nm
Circulation pump	16 Nm
Cylinder head:	
stage 1	20 Nm
stage 2	Loosen
stage 3	20 Nm
stage 4	50 Nm
stage 5	+90°
stage 6	+90°
Injector, brace	13 Nm
High pressure pump	20 Nm
High pressure pump, hollow screw	10.5 Nm
Camshaft sensor	10 Nm
Camshaft bearing cap	10 Nm
Camshaft gear	30 Nm
Coolant sensor	22 Nm
Engine mounting, left and right:	
M10	60 Nm
M8	30 Nm
Oil drain pipe/turbocharger	12 Nm
Oil filter (cover)	35 Nm
Oil pump, socket cap M6x20	6 Nm
Oil supply pipe/turbocharger, hollow screw	18 Nm
Oil supply pipe/engine block, hollow screw	38 Nm
Oil pressure monitor	27 Nm
Plug, gauge hole/crankshaft	38 Nm

Technical data

Belt tensioner, drive belt	35 Nm
Belt tensioner, toothed belt	27 Nm
Flywheel:	
stage 1	45 Nm
stage 2	+65°
Vibration damper, flange screws:	
stage 1	35 Nm
stage 2	+50°
Turbo	25 Nm
Pressure relief valve, fuel	85 Nm
Crank position indicator	10 Nm

Conversion table

Metric to American or UK units:

American or UK to Metric units:

	To convert from	To	Multiply by	To convert from	To	Multiply by
Length	mm	inch	0.03937	inch	mm	25.40
	cm	inch	0.3937	inch	cm	2.540
	m	foot	3.2808	foot	m	0.3048
Area	mm ²	sq.in.	0.00155	sq. in.	mm ²	645.2
	m ²	sq. ft.	10.76	sq. ft.	m ²	0.093
Volume	cm ³	cu. in.	0.06102	cu. in.	cm ³	16.388
	liter, dm ³	sq. ft.	0.03531	cu. ft.	liter, dm ³	28.320
	liter, dm ³	cu. in.	61.023	cu. in.	liter, dm ³	0.01639
	liter, dm ³	imp. gallon	0.220	imp. gallon	liter, dm ³	4.545
	liter, dm ³	U.S. gallon	0.2642	U.S. gallon	liter, dm ³	3.785
	m ³	cu. ft.	35.315	cu.ft.	m ³	0.0283
Power	N	lbf	0.2248	lbf	N	4.448
Weight	kg	lb.	2.205	lb.	kg	0.454
Power	kW	hp (metric) ¹⁾	1.36	hp (metric) ¹⁾	1.36	0.735
	kW	bhp	1.341	bhp	kW	0.7457
	kW	BTU/min	56.87	BTU/min	kW	0.0176
Torque torque	Nm	lbf ft	0.738	lbf ft	Nm	1.356
Pressure	Bar	psi	14.5038	psi	Bar	0.06895
	MPa	psi	145.038	psi	MPa	0.006895
	Pa	mm Wg	0.102	mm Wg	Pa	9.807
	Pa	in Wg	0.004	in Wg	Pa	249.098
	kPa	in Wg	4.0	in Wg	kPa	0.24908
	mWg	in Wg	39.37	in Wg	mWg	0.0254
Energy	kJ/kWh	BTU/hph	0.697	BTU/hph	kJ/kWh	1.435
Work	kJ/kg	BTU/lb	0.430	BTU/lb	kJ/kg	2.326
	MJ/kg	BTU/lb	430	BTU/lb	MJ/kg	0.00233
	kJ/kg	kcal/kg	0.239	kcal/kg	kJ/kg	4.184
Fuel consumption	g/kWh	g/hph	0.736	g/hph	g/kWh	1.36
	g/kWh	lb/hph	0.00162	lb/hph	g/kWh	616.78
Inertia	kgm ²	lbft ²	23.734	lbft ²	kgm ²	0.042
Flow, gas	m ³ /h	cu.ft./min.	0.5886	cu.ft./min.	m ³ /h	1.699
Flow, fluid	m ³ /h	US gal/min	4.403	US gal/min	m ³ /h	0.2271
Speed	m/s	ft./s	3.281	ft./s	m/s	0.3048
	mph	knot	0.869	knot	mph	1.1508
Temp.	°F=9/5 x °C+32			°C=5/9 x (°F-32)		

1) All power noted in the catalogue refers to metric horsepower.

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